Roots

Botanic Gardens Conservation International Education Review

Volume 15 • Number 1 • May 2018

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Liliana Derewnicka

FIRST WORD
IN SUPPORT OF EVIDENCE-BASED PRACTICE

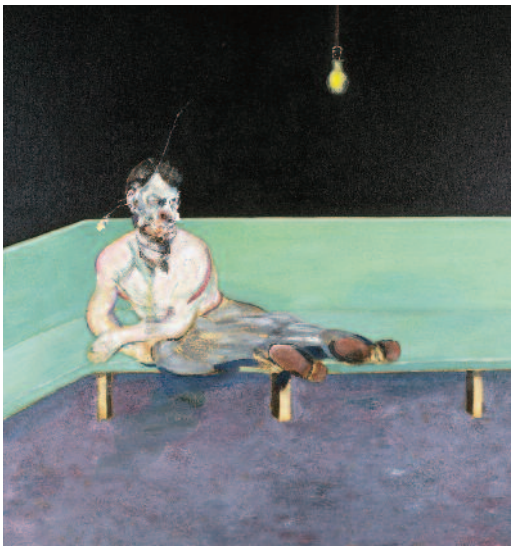
I have been spending a lot of time recently reading and thinking about learning theories and their importance and it has begun to seep into my consciousness wherever I go. I have begun to assimilate this new knowledge into my internal representation of the world, to take a constructivist view of it.

I first noticed this at Southbank Centre seeing the *Concrete Dreams* exhibition, which looks at the history and development of that most imposing, Brutalist presence on the Thames. I was bowled over by the range of mixed media and immersive mise en scène. The combination of these induced the visitors, including me, to interact with each space and object differently eliciting different styles of learning through thinking and doing as well as visual, auditory and kinaesthetic stimulation. Although the idea that individuals have one dominant learning style is becoming discredited (Pasher *et al* 2008), there is evidence to suggest that all people learn best when they are offered a variety of physical and sensory avenues to access information (Hohenstein and Moussouri, 2018). A powerful tool in the museum and botanic garden educators' tool box with all the freedom and flexibility their sites and collections offer.

Then, at the Tate Britain seeing the *All Too Human: Bacon, Freud and a Century of Painting Life* exhibition, I was highly aware of how my conversations with my friend were helping us to make sense of what we were looking at. We switched between talking about how the paintings made us feel, to how they linked to things we had seen before and to things we thought were interesting in the interpretation. This provided a wonderful real life example of how adults create meaning in informal learning settings. As Hohenstein and Moussouri outline in their (2018) book *Museum Learning*, adults draw on a wide range of external and internal influences when making sense of an exhibition. These include memories, emotional and aesthetic response, prior knowledge of period or other context, any written information provided as well as the conversations between them, highlighting how important the social-constructivist view of learning is.

← *The Southbank Centre, London (N Chadwick)*

"Constructivism is a theory on learning, which suggests that people acquire knowledge by experiencing things and in conjunction with knowledge that they already possess, "construct" their own understanding of these things. In simple terms, it suggests that we never learn anything from scratch, but rather that new information that we acquire builds on knowledge that we already have, and this constructs a new, broader understanding of the world around us." *(Wikispaces, n.d.)*



↑ *From the All Too Human Exhibition - Francis Bacon, 1909-1992 Study for Portrait of Lucian Freud 1964 Oil paint on canvas 1980 x 1476 mm The Lewis Collection ©The Estate of Francis Bacon. All rights reserved. DACS, London Photo: Prudence Cuming Associates Ltd.*

But why does it matter? Let's think about the aim of public engagement in botanic gardens. Most, if not all, botanic gardens and outdoor learning sites seek to support conservation and sustainability, through all areas of their work. In education we seek to do this by encouraging environmental actions in our visitors. What we are talking about here is behaviour change. This can be seen to result from attitude change, contextual support, social norms and the apparent difficulty of related actions and habits (Arbuthnott, 2009). There is also the idea of democratisation and power dynamics in education and museology. We have moved beyond a time where educators and the holders of collections possessed knowledge to be imparted on our visitors. We now understand that true engagement works both ways and creates spaces for equality and knowledge exchange. However, developing interventions that combine these factors and actualise our very noble cause is no mean feat and this is where, I think, evidence-based practice comes in.

In his recent keynote speech at Eurogard VIII, Dr Chen Jin from Xishuangbanna Tropical Botanical Garden, China, explained the need for carrying out extensive evaluation programmes grounded in psychological and educational theory. He argues that by doing this we can understand not only "whether it [an educational activity] works, but also how it works"(Chen, 2018).

If we are to achieve our aims we need to ensure that the learning experiences we are offering to our visitors maximise their learning, both affective and cognitive. We need to ensure they go away with a greater emotional connection to the world, an understanding of their position within it, appreciation of the actions they can take to protect it and willingness, skill and sense of autonomy required to carry them out. If we know how and why we have been successful, or not, in the past then we can improve our work in the future, maximise our impact and reach our goals.

In this issue of Roots, we present botanic gardens and museums that are driving their educational work by grounding it in theory. We take a look outside the botanic garden world and explore how the Natural History Museum in London is combining constructivism and co-creation to develop new educational activities and how the virtual world of Minecraft can offer immersive experiences that make use of anchored instruction to engage children with ecology at Lancaster Environmental Centre. From within the botanic garden world we learn how Beijing Teaching Botanical Garden are applying self-regulated and cooperative learning approaches and how considering constructivism, active learning and personal agency is helping Marie Selby Botanical Gardens to develop insipirational exhibitions at the cross-roads between art and science, to name but a few. You will also see that each of our authors has summarised relevant learning theories. We, not only, wanted to offer you ideas of how theory can be applied, but also an idea of what these ideas mean and where you can read more about them to support you to ground your work in education theory.

What we hope to show is that learning theories can be situational; what can be seen as a dominant or effective approach in one situation may not be in another. What is important is that we consider not only what we want our visitors to learn, but also why and how they will go about doing this. By doing this, we can offer transformational experiences to our visitors that can help them to become the environmental advocates that we so ungently need.

↑ *Tate Britain, London*

There is a need for carrying out extensive evaluation programmes grounded in psychological and educational theory. By doing this we can understand not only "whether it [an educational activity] works, but also how it works"
(Chen, 2018)

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Author: Theano Moussouri

LEARNING THEORY AND BOTANIC GARDEN EDUCATION PRACTICE

Learning theories guide our education practice either consciously or unconsciously. This paper discusses how botanic garden education practitioners can utilise learning theory to plan for meaningful and enriching learning experiences. These experiences can focus both on the learner as an individual and the impact they have on his or her life, as well as on groups as social units and the process of participation in these groups. The paper traces the roots of key theoretical approaches to two learning metaphors: the acquisition metaphor and the participation metaphor.

One of the central debates in the field of learning is whether the learner is to be understood as an individual or as a community. These are two of the dimensions of learning that have been inspired by two different approaches to learning respectively: a cognitive approach, which sees learning as an acquisition of concepts or knowledge, and a participation approach, which places emphasis on the activity or practice of a community (Sfard 1998). These approaches to learning or learning metaphors dominate learning theory, research and practice across disciplines. They also guide our practice as educators, researchers and learners. In fact, each of those metaphors can offer us different insights into the mechanisms of learning as an individually constructed and socially mediate process.

↑ *BigPicnic co-creators developing digital stories. ©RBGE*

Using theory in a conscious or purposeful manner can become a very powerful tool in shaping our practice.

This paper aims to show how a theory-based practice can help botanic garden educators plan and run educational provision purposefully and proactively. The paper begins by explaining why learning theory is important. It then examines two of the dominant learning theories in science education – namely constructivism and sociocultural learning theories - the roots of which can be traced back to the acquisition and the participation metaphors. The paper concludes with a case study which illustrates some of the key principles of these theories.

Learning theories guide all education practice either consciously or unconsciously. Using theory in a conscious or purposeful manner can become a very powerful tool in shaping our practice. As Suppes (1974, p 4) stated in his presidential address to the American Educational Research Association, 'A powerful theory changes our perspective on what is important and what is superficial'. It can also help us build evidence-base links to our practice which has a two-fold benefit. On the one hand, it can better meet the expectations and learning needs of your visitors. On the other, it can help us reflect on our practice and improve or even change it (Hohenstein and Moussouri, 2018).

The term learning theory tends to be used to refer to any theoretical approach that tries to explain how people learn. Learning theories consider 'what type of changes take place in the minds, brains, and bodies of the learners.' (Hohenstein and Moussouri 2018, p. 20). In the context of informal learning environments, such as botanic gardens, the most commonly used learning theories are constructivism and, more recently, sociocultural learning theories. It is worth keeping in mind that both of these theories are 'umbrella' theories that have different branches and their interpretation may well differ as they may emphasise particular aspects of learning, e.g. the role of the individual or the environment, the learning process or the outcomes of learning, the role of emotions/affect or the role of motivation.

Constructivism views learning as a process of concept development driven or constructed by the learner. Concepts are seen as the basic units or building blocks of knowledge. Concepts are further developed and combined leading to more complex and richer cognitive structures. Through their interaction with their environment and personal experience, learners construct their understanding of any given subject (Hein, 1998). In other words, they are able to internalise knowledge, to make it their own. Sociocultural theories of learning argue that it is not possible to separate leaning from its social and cultural context (Rogoff, 2003). Instead, learning is seen as the process by which learners become participants in knowledge communities (such as the community of botanists or archaeology enthusiasts). So, the focus here shifts to the group/community as a social unity.

In practice, the two learning metaphors on which these theoretical approaches to learning are based are not as mutually exclusive as they may seem. They can be combined and applied in science education practice because of the differing perspectives they offer. Consider the following illustrative case study. Bigpicnic [https://www.bigpicnic.net/] is an EC-funded project that brings together different stakeholder (scientists, policy-makers, citizens, etc) to find ways to tackle food security. Coordinated by BGCI, fourteen botanic gardens, with help from other partners, co-create exhibitions and events about food security in collaboration with different visitor groups and other communities. Learning and development is at the heart of this project and involves not only visitors or community members, but also the botanic garden professionals, their colleagues and the botanic gardens as organisations themselves. For example, the Royal Botanic Garden Edinburgh (RBGE) developed a digital storytelling project aimed at giving a voice to disadvantaged communities about access to nutritious food.

↑ Digital storytelling has been helping Royal Botanic Gardens Edinburgh to engage their local community with food security. ©RBGE

Learning theories guide all education practice either consciously or unconsciously.

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Each participant was supported in creating their own short digital story which consists of an audio track supported by still images. Evidence collected through evaluation has shown different aspects of learning including particular learning outcomes such as having more knowledge about the health benefits of nutritious food and making the right food choices for themselves and their families. This is a good example of the constructivist idea of facilitating the development of (conceptual) understanding by way of experience. Another impact of the project involved the garden staff who run the project. They found that the great strength of the digital story format is the emotional power of personal stories. These then provide ideal material to stimulate discussions with people at subsequent events and exhibitions. These findings led them to reflect on the role of emotions in the interpretation of their collection.

Beyond the impact that the experience had on its participants, the process of developing a digital story itself was an important aspect of the learning process. One of the participants, an asylum seeker, found the community/group element of the project to be an important aspect of the experience. Although he had lived in Scotland for five years, his interactions with his Scottish neighbours had previously been extremely limited. Understanding the Scottish accent was a key limitation in terms of these interactions. The project helped him overcome this limitation and develop a new sense of belonging in his community. He was also able to develop further his knowledge of nutritious food, drawing on the knowledge of the other project participants, RBGE staff and facebook groups. This is a good example of the application of the sociocultural theory of learning where the participant becomes gradually a member of this community which shares an interest in nutritious food.

The main aim of this paper was to discuss the importance of learning theory in science education in the context of botanic gardens. Understanding and, more importantly, applying learning theory in our work is not an easy task. This is made even harder by the fact that organisations like botanic gardens are complex institutions, not least because of the wider network of collaborations they are part of. These are not issues that practitioners alone can begin to address. Instead, they can build on existing or form new collaborations with academic researchers who study learning in informal learning environments. Such collaborations can benefit both researchers and practitioners as they can advance both learning theory and practice at the same time.

BRIGHT THINGS - GREAT RESOURCES

MUSEUM LEARNING: THEORY AND RESEARCH AS TOOLS FOR ENHANCING PRACTICE.

ROUTLEDGE, 2017. BY JILL HOHENSTEIN AND THEANO MOUSSOURI

Theano Moussouri has recently co-authored a book which supports museum and botanic garden educators to apply learning theories in their practice. This book provides a useful window for cultural organisation practitioners into both learning theory and research.

Botanic gardens, as with other cultural organisations, are increasingly being asked to demonstrate not only their cultural but also their educational and social significance; understanding how visitors learn becomes ever more important to government and potential funders. This book helps the reader make sense of multiple learning theories in the context of cultural organisations. A great read and an opportunity to reflect on what it means to learn in a botanic garden setting. The book represents an important practical resource for botanic garden educators. I have read the book through and then dipped into it again when I have been thinking about building a new programme. If you are seeking to build skills in your education team then reading a chapter here and there as a group would be a worthwhile exercise. Each chapter combines theory, research and a practical case study. A good team building exercise. A great way to keep up to date.

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Review by Sharon Willoughby, Head of Interpretation, Royal Botanic Gardens, Kew.

Author: Leonie Biggenden

‘SEEDS SOCIAL’: CONKERS, CO-CREATION AND CONSTRUCTIVISM

A few years back we launched a new NHM venture: Volunteer Co-creation. Over eight months, eleven Learning Volunteers created “Adaptations: Seeds”, a botany-related specimen handling activity and were involved from inception through to delivery. For the first time volunteers were given a major stake in designing, trialling and training a new informal learning activity. This included deciding activity ideas and visitor outcomes, sourcing specimens, producing background notes, piloting and training peers. Utilising sociocultural learning theories of development, this article documents how the volunteers collaborated towards a common cultural goal and how they co-constructed new knowledge by building on each other's contributions.

The Natural History Museum’s Learning Volunteer Programme invited volunteers to participate in a co-creation project developing a new activity to be delivered in the museum galleries and grounds. Broad aims were that it would be a high quality and object-rich learning experience to enthuse the public about the natural world and that the volunteers themselves were to come up with the activity itself and more specific outcomes. This article is a personal testimony written by one of the eleven Learning Volunteers who took part in the process. This individual is now a Learning Volunteer Engagement Manager and has therefore had the opportunity to view the process from both sides.

↑ *The finer points of Seeds ©Oomar Dhuru*

“I love constructive brainstorming, everyone was there because they thought they’d play a part in it”

SOWING THE SEEDS: ORIGINS

Informal learning activities for Learning Volunteers to deliver in the galleries have traditionally been created by Learning Volunteer Engagement Managers. In this form of development the manager was responsible for generating the idea, obtaining relevant specimens, formulating visitor outcomes, penning background notes and delivering training. All with a view to producing an engaging activity which visitors enjoy taking part in and volunteers like delivering. With this development method Learning Volunteers were not formally involved in the process until the activity trial stage. This is where their comments and suggestions were canvassed and acted on. Taking cues from other museums who had successfully piloted co-curation or dual-development, it was decided that a process whereby Learning Volunteers co-created an activity would give them a greater sense of ownership of their programme. Predicted benefits in utilising this method were that Learning Volunteers could bring their unique skills and experiences while gaining an insight into the activity development process.

THEORETICALLY SPEAKING: CONSTRUCTIVISM AND CO-CREATION, COFFEE AND CROISSANTS

Social constructivism is a theory suggesting that learning is a fundamentally social activity. Learning Volunteers have formed social bonds with those who volunteer with them on the same day and learn from each other at daily debrief sessions. This made an activity development style which was based on a sociocultural approach a very appropriate and familiar format. In the case of this example of co-creation, Dai Lee the Learning Volunteer Engagement Manager was the person who steered the process in the right direction. He provided guidance to the Learning Volunteers almost as if he were taking on the role of a teacher. As Saul McLeod notes, in Vygotsky's terms Dai was the 'more knowledgeable other' who could scaffold our learning. He was a presence to ensure that the co-creators all worked together and that we contributed to a challenging and at the same time achievable task. The team attended once a week and plenty of time during the day was devoted to discussion and reflection, often over a coffee and croissant! This made for most effective collaborative peer learning. The team worked together to find and create meaning within the activity. Ideas were shared and suggestions from team members improved them. As volunteers from across the week formed the co-creation team new social bonds were formed: "I hadn't known them before and I became friends with them" said one of the volunteers.

↑ *Seeds Selection Box: old familiars and 'Wow, What's That?' ©Oomar Dhuru*

↑ *Seeds: A closer look ©Oomar Dhuru*

"I feel so privileged to be part of the team which for the first time ever has given volunteers a major stake in designing, trialling and training of a new activity"

↑ *Dispersal Discussions: Peer Learning Visitors ©Oomar Dhuru*

↑ *Dispersal Discussions: Devil's Claw ©Oomar Dhuru*

GROWING SEEDS: MOTIVATION

Barohny Eun writes: "The sociocultural theory of development, founded on the works of Lev Vygotsky, espouses the view that social interaction among two or more people is the greatest motivating force in human development." How exactly is this evidenced in the co-creation process? Once the Learning Volunteers had decided their topic was going to be seeds we set out to share our botanical knowledge and experience with each other in order that we could come to a joint decision as to the focus of the activity. Amongst our team we had a professional herbarium technician, some keen gardeners, some volunteers who felt that botany was under-represented in terms of the learning activities which we offer, an artist, a teacher who was used to plants being in the National Curriculum, some students who were dab-hands at doing research and a volunteer who just had one window box and felt even that was a challenge (me!). This mixture of skills and enthusiasms served to motivate the team in lively idea-pooling sessions.

BRANCHING OUT: NEW KNOWLEDGE

Eun outlines: "By collaborating toward a common cultural goal, people co-construct new knowledge by building on each participant's contribution. Based on the main tenets of sociocultural theory… eight interrelated principles for instruction are presented, namely, that it should be: mediated; discursive; collaborative; responsive; contextualized; activity-oriented; developmental; and integrated." Looking at this assertion our mediator was Dai Lee. The discursive element was at the heart of the process as volunteers not only discussed ideas but recorded, circulated, reflected on, and updated them. The collaborative nature was enshrined from the beginning as we all honed and enhanced our ideas, notes and training texts. Activity choice was responsive to Learning Volunteer perception that there were not enough botany specimens for Museum visitors to freely handle. It was contextualised by our studying mission statements, strategies, curricula and exhibition timetables to select an activity which was most relevant. It was most certainly activity-oriented as the co-creators came up with the idea of adaptations of seeds to different modes of dispersal which visitors could test by throwing, blowing and sticking seeds.

"The camaraderie from volunteers who would not normally meet as they volunteer on different days of the week has built links across the NHM Learning Volunteer community"

"It was a terrifically good learning process on how to be constructive and listen to other people's ideas."

↑ *Dispersal Discussions: Wind, Water, Fire, Animal ©Oomar Dhuru*

"We as a committee all ran it together... I found it very interesting to be part of it... I feel inevitable joint pride at what we created"

The public can also look for evidence of fire or get a feel for a form which would be suitable for a water-borne journey. The developmental nature of the process was frameworked by Dai who used his position as 'more knowledgeable other' in terms of development of Museum-based learning activities to timetable the weekly sessions in a logical and scaffolded sequence. Finally, in terms of integration, co-creators got all Learning Volunteers involved in the project by surveying them before deciding on the final activity, calling on them to provide seeds for the activity, by training them to press plants on herbarium sheets and make capsules for the seeds and integrating the seeds activity into the suite of other object-based informal learning experiences which volunteers offer the public in Museum galleries and grounds.

NEW SHOOTS

It has been a few years since the Learning Volunteers co-created the seeds activity. For future steps it would be good to look at connectivism where humans, social relations and actions are combined with digital technologies. This would address the acknowledged problem of consistency of attendance of 11 volunteers across the 3 month span of the project. Technology could now be used for more meaningful digital as well as face-to-face connections. The digital aspect could also be used as part of the activity itself, not to replace specimen-handling but to enhance it. With the best will in the world we cannot set fire to plants in the Museum or have exploding seeds all over the public but technology can show visitors this. As mentioned, Learning Volunteers have daily debrief sessions in which the Learning Volunteer Engagement Manager encourages them to reflect on their practice and share 'tips and tricks'. In asking volunteers for their feedback now that the activity has been running for some time, in the week that this article was written it was reported that a visitor said: "Seeds are more interesting than my wife, but don't tell her that!" What could be greater proof that the sociocultural theory underpinning co-creation has produced a successful learning activity?

↑ *Dispersal Discussions: Wind, Water, Fire, Animal ©Oomar Dhuru*

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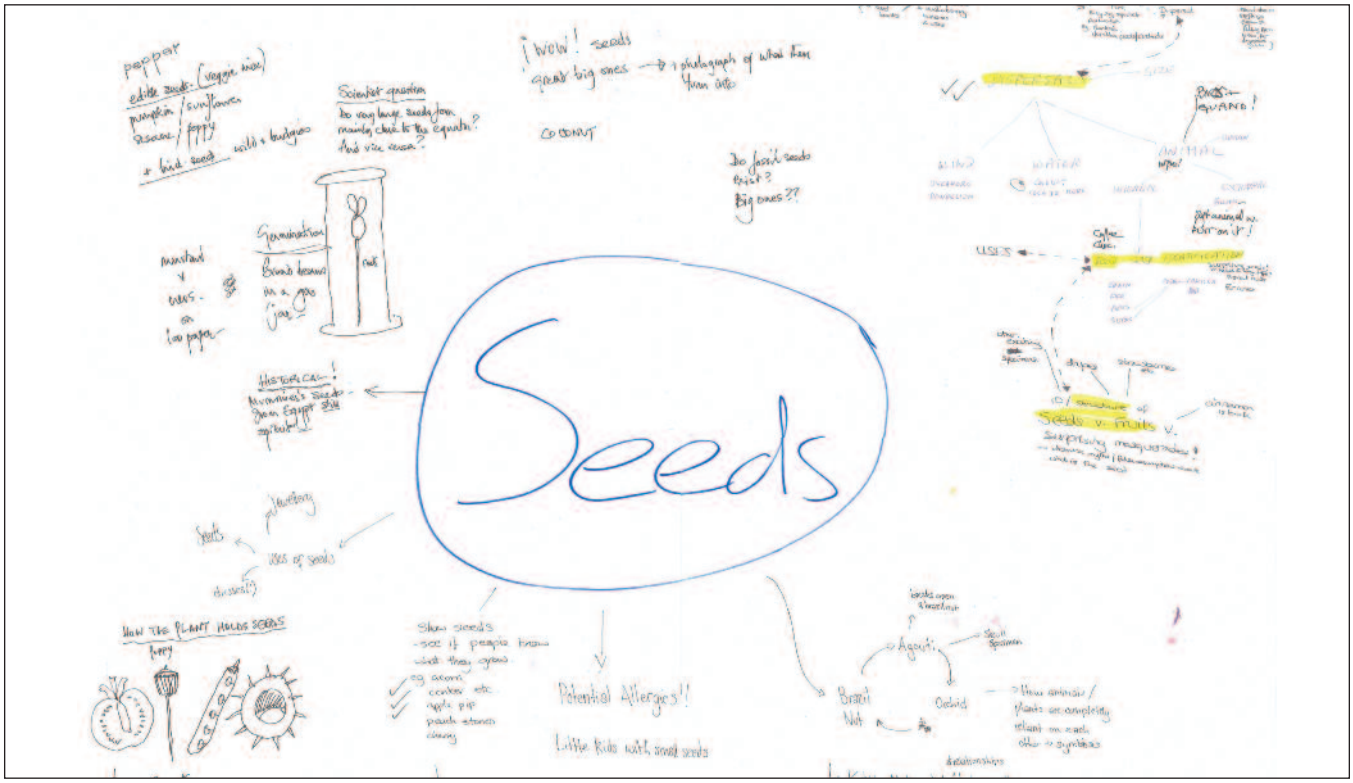

↑ *Ideas Exchange: Initial Seeds Discussion ©Dai Lee*

Authors: Kai Ma, Guanhua Ming

↑ *The students made compost according to their own methods ©Guanhua Ming*

A CLIMATE CHANGE EDUCATIONAL ACTIVITY: COMPOSTING KITCHEN WASTE ON A BALCONY

Composting Kitchen Waste on a Balcony is an educational activity designed by Beijing Teaching Botanical Garden to engage school students with climate change. By encouraging students and their families to adopt a simple environmentally minded action – composting on their balcony - the activity aims to make students aware of their role in climate change, and what they can do to mitigate it. We combined the *task actuation* teaching method, *self-regulated learning* strategy and *cooperative learning* approach to assist the students to master new skills and complete the task successfully. We also found that the process enhanced skills related to learning in general.

BACKGROUND

Beijing Teaching Botanical Garden was established in 1957 and is part of the Beijing Municipal Education Commission. It is the only botanic garden devoted to children's natural and environmental education in China. In 2016, the faculty began to focus on climate change and launched a project on designing educational activities for students. The purpose of this project was to increase students' awareness of climate change and the strategies that can support resilience to it. The aim was to achieve this by developing activities that were scientifically rigorous both in terms of content and teaching methods, that would also enhance their skills related to learning in general. *Composting Kitchen Waste on a Balcony* is one such example.

Kitchen waste is produced at each stage of the food supply chain and in an astounding volume. Compared with more common approaches to dealing with kitchen waste, e.g. landfill and incineration, which can cause soil pollution and energy over-consumption, composting is much more sustainable and environmentally friendly, and can help recycle and reuse nutrients from soil. The Composting Kitchen Waste on a Balcony activity aimed to encourage sustainable behaviours, starting with composting.

BRIEF INTRODUCTION TO THE ACTIVITY

This activity was first carried out on an autumn weekend in 2017 when fallen leaves could easily be collected. The participants were recruited via WeChat. Grade 3-5 students were eligible to attend and a maximum of 22 were assigned to each two-hour session. The goal of composting provided the context for students to learn about the environmental impact caused by kitchen waste, as well as the significance of composting for sustainability. This occurred via self-regulated and co-operative learning. The students mastered the composting method and were all able to complete the task successfully.

TEACHING AND LEARNING STRATEGY

1. Using the *task actuation* teaching method to initiate the students
The *task actuation* method is based on the constructive learning theory. By being guided through a task, learners can obtain knowledge, skills and improve their problem solving abilities (Qijun Wu, Meng Liu, 2015; Hongxue Yang, 2006). At the beginning of our activity, the teachers set up a scenario and clarify what the task will involve. They are encouraged to think deeply about the problem and to devise a method themselves. This method not only motivates students to learn but also helps them to recollect their own previously existing knowledge and experience of the subject and connect it to new.

↑ *Every student in the group had to specialize and focus on one aspect of the composting task, e.g. student A was responsible for collecting leaves, student B was responsible for cutting them ©Guanhua Ming*

The task actuation teaching method is based on the constructive learning theory. By being guided through a task, learners can obtain knowledge, skills and problem solving abilities
Qijun Wu, Meng Liu, 2015; Hongxue Yang, 2006

↑ *In this activity, learning material included worksheets, PowerPoint presentations and a toolbox ©Guanhua Ming*

← *Instead of showing the information directly to the students, the teachers provided learning material to them, and let the students discover the useful information by themselves ©Guanhua Ming*

← *Fallen leaves were useful material for composting ©Guanhua Ming*

↑ *All groups were able to complete the task successfully ©Guanhua Ming*

2. Application of self-regulated learning
Before completing the task, the students needed some basic information and to understand the steps in composting. In this activity, the teachers didn't provide this to students directly. Instead, they gave them different kinds of learning materials (PowerPoint presentations, worksheets and a toolbox) and let the students discover the useful information by themselves through reading, analysis, comparison and discussion. If there was confusion or misunderstanding, the teachers would explain. Self-regulated learning strategies can assist students to develop their learning potential and promote their ability to understand as well as their independence. (Weiguo Pang, 2001).

3. Application of *cooperative learning*
Once they had all the information, the students were ready to act. They were encouraged to form a group (3-4 people in each group) to complete the task together. After group learning and discussion, each group made an action plan. Every student in the group had to specialize and focus on one aspect of the composting task. They then completed the task together. Cooperative learning can help students to complete the task efficiently in a limited time, increase their sense of cooperation and team spirit and enhance their communication skills (Wensen Yu, 2004).

FINDINGS

1) The *task actuation* teaching method is very helpful in mobilising students' initiative and enthusiasm for learning.
2) Abundant learning materials such as worksheets and toolboxes support students to be capable of self-learning.
3) Choosing environmental-friendly materials and reusable tools complements the theme of climate change mitigation and can help to achieve better outcomes.

CHALLENGES

1) The students usually come from different schools and communities and have different learning capabilities, which can prove a challenge. Teachers need to be very well prepared and give clear instructions.
2) Affective observation is very important because the success of each step relies on the understanding of the proceeding. Therefore, if one part doesn't go well it will affect the overall success of the session. Teachers must be observant to ensure any issues are dealt with.

The self-regulated learning strategy can help students to develop their learning potential and promote their ability to understand the topic.
Weiguo Pang, 2001

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INTEGRATING A NATIONAL TEST: INDUSTRY DRIVEN EXPERIENTIAL LEARNING IN A BOTANICAL GARDEN

Credentials delivered by an academic institution should not be stand-alone qualifications but should form part of a package responsive to industry needs. Through experiential learning in the botanical gardens, retail nursery and garden centre, Fanshawe students achieve real experience vital for the budget lines of the program they are enrolled in. With access to over 5,000 species of plants and gardens curated at the highest level, and credentials such as the national Certified Horticulture Technician program, Fanshawe graduates are recognized as 'value-added employees'

← *Senior students pruning in the Canadian Rose Garden at the A. M. Cuddy Gardens ©Michael Pascoe*

Experiential learning has a long-rooted history in civilization and the techniques used can be traced back to an ancient Chinese proverb cited in Hersey *et al.* (2001, p. 36.): 'Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand.'

Ontario, with over 14 million people or 40 per cent of the population of Canada (Government of Canada, 2017) is the most densely populated province in the country and thus educational programs serving this community can be very competitive. Within the province there are 16 provincially accredited colleges and universities offering science-based programs with a focus on the environment, horticulture and landscaping, broken down into four categories: certificates 10, apprenticeships 4, diplomas 12 (diplomas are 2–3 years in length) and degrees 4 (Green Careers Canada, 2018).

Fanshawe College has a core group of horticulture and landscaping qualifications based in the school of design, including one apprenticeship, two diplomas and a degree; the institution has over thirty years' experience of delivering land-based sciences and is viewed as a preeminent provider of quality education.

↑ *Second-year students installing winter poly on the cold frames in the retail nursery ©Michael Pascoe*

Industry stakeholders, through program reviews at Fanshawe, have continually focused on experiential learning in landscape maintenance and construction to fuel the economic contribution of the horticulture industry in Canada, which amounts to $14,480,000,000 (Canadian Horticulture Alliance, 2009). Between 2002 and 2007 horticultural services such as landscape construction and maintenance generated the highest job growth, rising from 27,722 to 48,332 people directly employed in the service sector of the industry (Canadian Horticulture Alliance, 2009).

Fanshawe College is seen as a leader in horticultural education with its two-year diploma in horticulture now fifteen years old, continually wait-listed and accepting students from across the country and internationally. The executive director of Landscape Ontario (Tony DiGiovanni, 2018) says, 'The Fanshawe Program is a model of collaboration between the school system and the profession. They achieve the practical competencies that are so difficult to gain in a traditional classroom.'

There is a strong focus on experiential learning at Fanshawe especially in the senior year of the program. Students in year one typically spend 20 per cent of their time on experiential learning, but on moving into the second year this increases to 80 per cent. The gardens of Fanshawe College and the A. M. Cuddy Garden provide the classroom, as senior students play an integral role in their operation and development. All garden maintenance, renovation and development work is undertaken by the students, including weekend duties both in the gardens and associated retail nursery and greenhouses. This experience in maintaining a public facility and interacting with the consumer prepares students for the variability of their chosen profession through doing, feeling, watching and thinking (Clark *et al.*, 2010). Fanshawe reinforces Kolb's style (see Fig. 1) through its supervised and unsupervised practical programs, practical tests, journals, blog writing, and garden and greenhouse observation activities, such as pest and crop monitoring; all activities that would be performed 'on the job'.

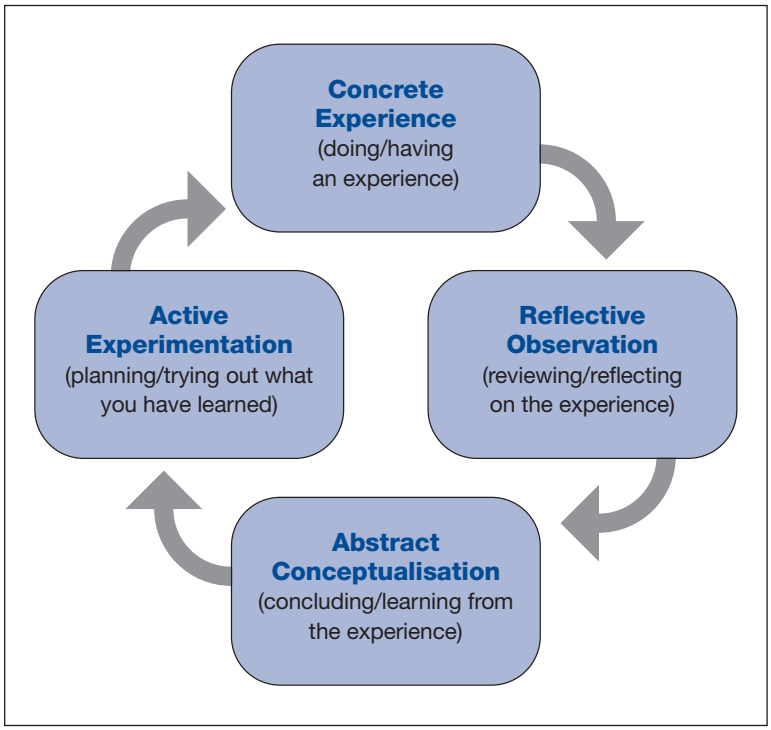

Figure 1. Kolb's learning style touches the four bases as outlined, and must be followed in sequence but the learner may start at any point in the circle (McLeod, 2017).

↑ Annual volunteer day with the Thames Talbot Land Trust, removing invasive species ©Michael Pascoe

Experiential learning has a long-rooted history in civilization and can be traced back to an ancient Chinese proverb … "Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand."

↑ Hortfest games, breaking down the walls between new and senior (red shirts) students. A day of games related to horticulture and the gardens ©Michael Pascoe

To achieve the true competency that the profession requires in Canada requires a two-fold approach. There is the experiential learning that is curriculum directed … in North America though there is a second critical factor: certification.

← Second-year students practising their arboriculture skills in the A. M. Cuddy Gardens ©Michael Pascoe

RESPONDING TO INDUSTRY

To achieve the true competency that the profession requires in Canada however, requires a two-fold approach. There is the experiential learning that is curriculum directed which has evolved through faculty specialization and industry-panelled program reviews. But in North America there is a second critical factor that determines competency: the Canadian Nursery Landscape Association certification program (CLT) ensures alignment of all practitioners with industry standards and best practices regardless of their formal education or industry experience. The program has seven individual certifications: retail, hardscape, turf, ornamental, interiors, landscape design, and manager, plus one level of company certification (Canadian Nursery Landscape Association, 2017).

With an existing reputation for producing sound graduates why should Fanshawe consider adding certification to the educational mix? The simple answer is that we must be responsive to the needs of industry: Fanshawe produces a 'product', the graduate, and if that individual does not meet the benchmark of the landscape profession we are failing to deliver. The question from both faculty and students was what made us think so? Fanshawe's graduates were getting jobs and the program was practically based, ensuring a fluid transition from school to career, or so it seemed. Faculty and students were keen to point out that no other academic institution in North America was considering certification, feeling the graduating credential was sufficient. So we were delivering on our mission—but were we sure?

Fanshawe needed to test the value of certification so I volunteered to take two of the certifications at the Landscape Ontario test site in Milton: Ornamental Maintenance and Turf, material that we covered in the two years of the diploma. A pass on each station or written test is 70 per cent. As it turned out, I did not achieve this on two stations and one test, showing I lacked what was considered the basic level of competency for our profession. I went back months later to retest and achieved the national designation in both. We considered the training provided to our students the best in the province if not Canada, yet the pass rate for Fanshawe students is 30 per cent on a first attempt and so, though above the industry average of 10 per cent, quite low.

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With this point proven to both the faculty team and student body we began the process of integrating the Ornamental Maintenance test into our curriculum. Ornamental Maintenance certification is a 3-hour written test divided into 4 modules and 7 practical stations. Usually such tests are delivered over two days, the written part in the evening and the practical test stations the next day; but Fanshawe decided to break the test down to fit into pertinent courses. Thus the integrated test is split over two semesters of the second year program, to ensure students have the practical skills required to feel confident. In the autumn they take plant identification, irrigation repair and head adjustment, and irrigation program set-up and tree planting; in January the written tests; and in April backpack blower, pruning and chainsaw.

NATIONAL STANDARD

The score that students receive on each module or practical station becomes part of their term mark in a related course—so 70 per cent on the practical Tree Planting is weighted as 10 per cent of their mark in the Landscape Maintenance (MTNC 1013). Anxiety is reduced since the industry test is part of their diploma, so students are not being evaluated twice. Since industry judges do all the testing students readily accept the results—they realize that it is not a Fanshawe-administered test but a North American-wide standard.

This is even more important since there is now a continuing culture of expectation and anticipation in the program from year to year, as first-year students anxiously observe seniors going through the process. Students are much more attentive in their pursuit of the credential and those who do not pass all the stations return to retest either at Fanshawe or one of the other provincial test sites.

Fanshawe students thus have the potential of graduating with several credentials besides their diploma, making them 'value-added' employees. In addition to potentially earning their CLT they may also graduate with the provincial pesticide licence and chainsaw certificate, and as Tony DiGiovanni (2018) stresses, 'from an institution perspective, they become much more relevant to the profession that provides a future for their students.'

↑ *Students taking the CLT test -Tree Planting in the Cuddy Gardens ©Michael Pascoe*

↑ *Senior students welcoming juniors to the annual Hortfest event at the A. M. Cuddy Gardens ©Michael Pascoe*

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↑ *First- and second-year students at the end of Hortfest ©Michael Pascoe*

Science HUNTERS Lancaster Environment Centre | Lancaster University

Authors: Laura Hobbs, Carly Stevens and Jackie Hartley

ENVIRONMENTAL EDUCATION AND ENGAGEMENT USING A CONSTRUCTION PLAY COMPUTER GAME

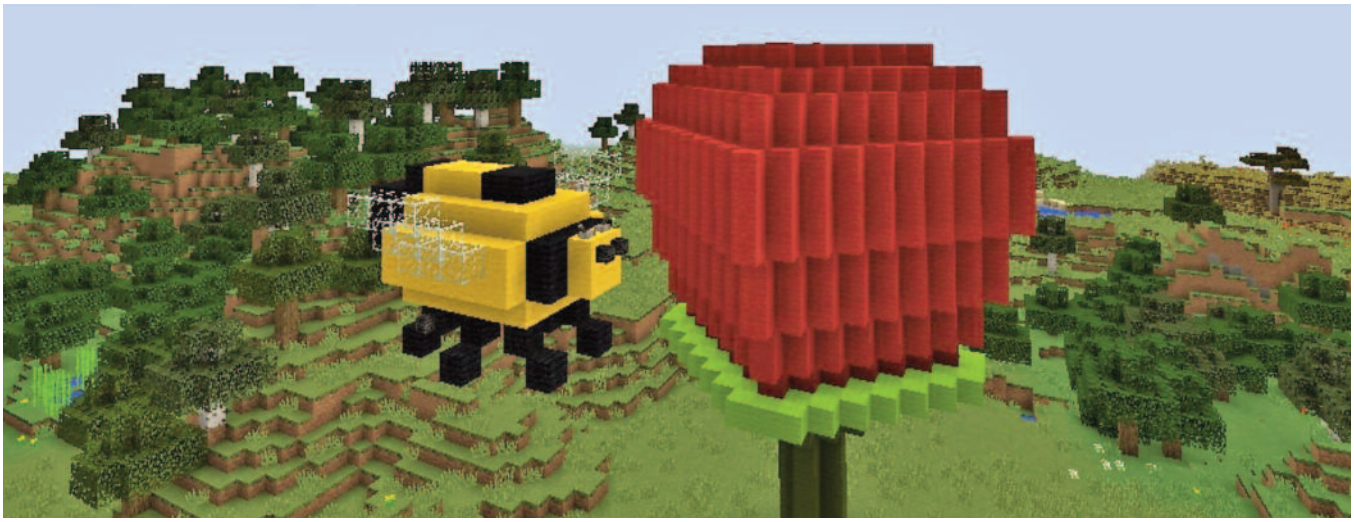
Science Hunters is a university outreach project which engages children of all ages with learning about science and the environment using the popular computer game, Minecraft. A learner-centred constructivist approach using anchored instruction and constructionism and an immersive experience in the Minecraft virtual world all allow children to direct and consolidate their learning. As they learn, they gain a sense of expertise and ownership and an appreciation that science, ecology and botanical topics are 'for them'.

THE SCIENCE HUNTERS OUTREACH PROJECT

Science Hunters is an outreach project, based at Lancaster Environment Centre (LEC) and initiated in 2014, which engages children with learning about environmental science. A key tool is the computer game Minecraft, a "game about placing blocks and going on adventures" (Mojang and Microsoft, 2018). Players can move freely around its virtual world, placing and breaking a wide range of blocks which have a variety of properties and can be used in a range of physical and ecological settings. Ecologically representative biomes and systems can be modified by the players, enabling them to interact with and alter the environment (Nebel *et al*., 2016). For example, it is possible to prepare ground, sow and grow seeds, and modify the features of the surrounding environment, for example by adding a water supply.

↑ *Minecraft offers opportunities for collaboration and peer support, seen here as children at The Park Primary School in Bristol design and build a plant growth environment together ©Science Hunters, Lancaster University*

Children can find and maintain interest in and understanding of scientific topics, and feel a sense of ownership and that science is 'for them'



For Science Hunters we use an educational version of the game developed specifically for classroom use, operating it in a mode which allows players unlimited access to the building blocks. Aside from the features mentioned above, Minecraft is a highly effective platform for engaging children with scientific topics because of its popularity and ability to capture their interest: it has been described as one of the most widely used and important games of the current generation (Lane and Yi, 2017).

DELIVERY AND AIMS

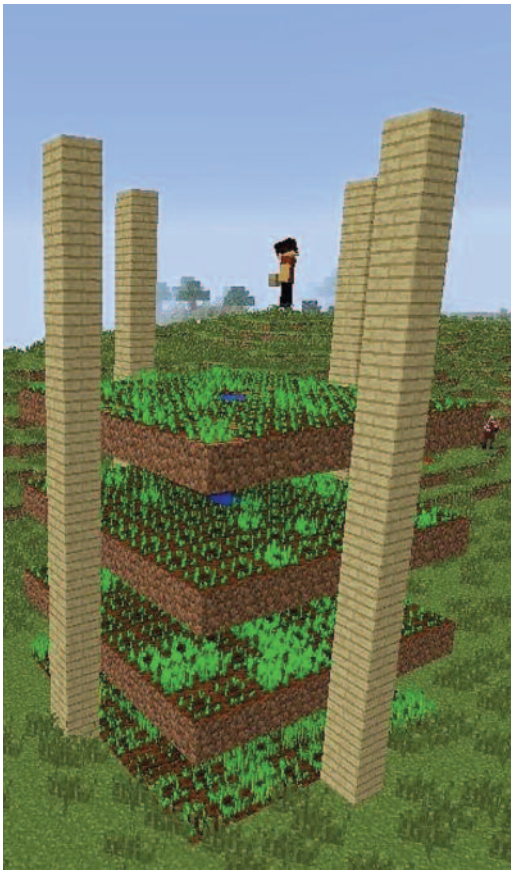
The Science Hunters project has a strong 'widening participation' focus, reaching children who may face barriers to accessing higher education such as low family income, special educational needs and disabilities (SEND) or being in care (Office for Fair Access, 2017). It was set up with funding from the British Ecological Society and now receives the majority of its funding from Lancaster University. Sessions are designed to both raise aspirations and inspire an interest in science, presenting a different experience to traditional school science lessons. Project activities include visits to primary, secondary and specialist schools, public events such as festivals, and a fortnightly on-campus Minecraft Club for children with autism spectrum disorder (ASD). Minecraft Club is run in association with the National Autistic Society. Children of all ages and abilities are included, with the project team adapting delivery to suit the needs of the group involved.

PEDAGOGICAL APPROACH

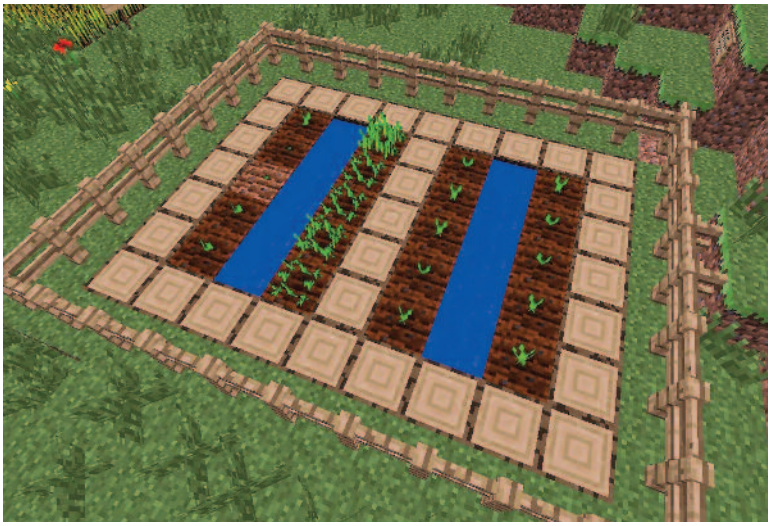
All Science Hunters delivery follows a *learner-centred constructivist* approach (Brooks and Brooks, 2001; Rovai, 2004). This means that the students direct their own learning and problem solving through use of Minecraft, with a clear emphasis on constructing understanding and meaning from the information they've been given. The approach was chosen to ensure that children can find and maintain interest in and understanding of scientific topics, and feel a sense of ownership and that science is 'for them'.

Making use of *anchored instruction* (The Cognition & Technology Group at Vanderbilt, Bransford et al., 1990), staff briefly introduce a scientific topic, with a practical hands-on demonstration. Students can refer back to this introduction and it provides a shared learning experience. *Applying constructionism* theory (Papert and Harel, 1991), topic-related Minecraft building challenges are then set as a way of deepening and consolidating learning. Minecraft worlds are physically and ecologically representative of reality, so these challenges situate the topic in a 'real-world' situation.

↑ *A bee approaching a flower to pollinate it, built in the virtual world of Minecraft. Children learn to infer that insects act as pollinators in Minecraft, as flowers reproduce ©Science Hunters, Lancaster University*



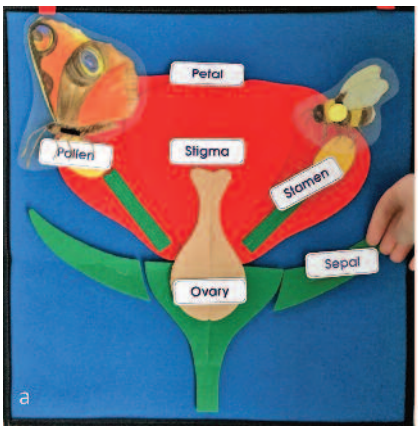
↑ *A 'space-saving farm' designed and built in Minecraft after learning about the challenge of food security ©Science Hunters, Lancaster University*



During the construction phase, children are encouraged to use their imagination and creativity, building on existing knowledge, exploring key concepts of the topic and deepening their understanding. Students usually work in pairs; Minecraft presents valuable opportunities for development of and benefit from peer collaboration and mentoring skills (Kervin *et al*., 2015), while interaction and discussion with peers and staff further develops understanding of the topic. Whilst the session topic provides a framework for construction in the virtual world, activity within the game is directed by the children playing. In practice, this means that the session leader sets a building task or challenge related to the session topic, which solves a real-world problem or demonstrates a real-world process, and it is then up to the children how they address this within the game. This means not only can children test and explore concepts in a way that is not possible in reality, it also allows them to choose the aspects of the topic which most engage them. Their input to the session direction is encouraged, to enhance the sense of student ownership and expertise.

USING MINECRAFT TO ENGAGE CHILDREN WITH BOTANICAL TOPICS

Drawing on research experience at LEC, areas of environmental science covered include a range of botanical topics, such as flower structure, pollination, germination, farming and food security. Topics can be interlinked and one can be used to enhance another. For example once the process of insect pollination is understood, it can be used to infer the presence of insects in the virtual world of Minecraft even though they are not seen (because flowers spread in Minecraft). The virtual world of Minecraft reflects real-world processes; for example, to grow crops, crop seeds must be provided with correctly prepared soil and adequate light. Growth rates then respond to sources of water and fertilizer.



← *Hands-on activities initiate exploration of a topic, which is then extended by child-directed building in Minecraft, for example by assembling a tactile flower cross-section (a) followed building a representative flower in Minecraft (b), consolidating the learning. ©Science Hunters, Lancaster University*

Feedback indicates that use of Minecraft in this way captures children's interest, engages them with the topic and facilitates and consolidates the learning gained through instruction.

← *Players can modify the Minecraft environment, applying scientific knowledge. For example, plant growth rates respond to presence of water, which has been applied in the image above ©Science Hunters, Lancaster University*

↑ *©Science Hunters, Lancaster University*

Engaging with such interactions in Minecraft and having the opportunity to handle relevant samples, also raises students' awareness of and interest in topics not usually covered within their formal education except where they pursue related subjects at a higher level.

Information is given and engagement with the topic promoted using the pedagogical approach described above. The structure of the food security session, for example, is broadly as follows:

- The topic of food security is introduced by the session leader, finding out what the students think it means, and leading them to better understanding by means of targeted questions and exploration and expansion of their own knowledge;
- Hands-on samples of foods found in Minecraft are used to support and elaborate on the topic, demonstrating the space needed to produce food and providing an opportunity for children to see food sources in unprocessed states (for example, carrots with uncut leaves, sugar cane, cocoa beans and wheat seeds). This links the real-world topic to the Minecraft world;
- The challenge of healthily feeding a growing population with ever dwindling space available for food production is thus raised. Students are set the task of designing a space-saving farm that could be used to resolve this difficulty in future.

Beyond this, it is up to the children how they approach the task and what form and function their farms take. Learning can be further reinforced over time by leaving them with an activity, such as growing seeds in a transparent bag which allows them to witness germination, and then plant development in a small space, such as on a windowsill.

IMPACT

Feedback indicates that use of Minecraft in this way captures children's interest, engages them with the topic and facilitates and consolidates the learning gained through instruction. Children report high levels of enjoyment and engagement with learning, teachers recognize that students are immersed in topics and retain what they've learnt as a result, and parents appreciate the social-communication skills developed as a result of collaborative play in an environment of which children feel they have ownership and expertise.

← Hands-on practical scientific demonstrations and activities provide an anchor underpinning constructive, learner-centred play in Minecraft ©Steve Pendrill/ Lancaster University

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AT PLAY WITH SCALE & SPIRITS

Three of the most commonly used educational approaches are constructivist learning, active learning and personal agency. At beautiful Selby Gardens, each of the three methods was put to use in engaging and informing guests during the Fall 2017 exhibition, *The Orchid Show: Earth, Air, Fire, Water*. In addition to a dynamic display of living plants in the tropical conservatory, the Selby Museum of Botany & the Arts' vibrant art and horticultural exhibition program explored the ties between nature and the artistic world, adding to the visitor experience and providing another layer of active learning.

Originally the home of William and Marie Selby, Marie Selby Botanical Gardens is, today, a coastal oasis showcasing a living collection of rare and beautiful tropical plants. Opened in 1975, the garden is also a respected leader in the study and conservation of plants, particularly epiphytes—plants adapted to live in the tree tops, including orchids, bromeliads, and ferns.

Gardens, in general, are great places to design engaging visitor experiences that effectively employ learning theory. In a garden, individuals and groups generally set their own agenda and pace on visits, free to choose whether to read wall text or labels, to take an audio or guided tour, and to chart their own path. By and large, gardens *invite* learning rather than demand it, which is why they are places of informal, public learning.

↑ *Glass vases for creating the largest pickled plant specimens ever made ©Jeannie Perales*

We challenged our team to display these important scientific tools in the museum in engaging and unique ways to expand the visitor learning experience

↑ *Museum of Botany & the Arts Spirit Specimen Display within The Orchid Show, 2017 ©Darren Erickson*

Three of the most commonly used approaches are *constructivist learning, active learning* and *personal agency*. Constructivism builds upon a learner's previous knowledge. Active learning is about the ways in which people *engage* with an experience. Personal agency, addresses the ways in which visitors *take charge* of their own experiences. In general, applying these theories leads to the activation of learning, which helps people acquire information at a deeper level and enhances retention.

It is well-proven that people like to have some degree of *personal agency*, some range of choice about how they engage in a learning experience or activity. Offering layers of information like tours, wall text, brochures, lectures, classes and demonstrations are typical ways in which garden educators engage guests to help shape their visits. Evocative display techniques and interpretive approaches such as prompting visitors with questions rather than feeding them information are additional ways to engage and encourage curiosity.

LAYERED LEARNING

At Selby Gardens, each of the three approaches outlined above was put to use during the Fall 2017 exhibition, *The Orchid Show: Earth, Air, Fire, Water*. As well as the dynamic horticultural display in the tropical conservatory, the garden's Museum of Botany & the Arts provided another layer of active learning with a rotating art and horticultural exhibition program to explore connections between nature and the artistic world. The beauty and breadth of the gardens is complemented by that of the bibliographic and preserved scientific collections. While highly regarded among the scientific community, in particular, our pressed and pickled plant specimens are typically archived far away from the meandering paths our guests travel. For this exhibition, we challenged our team to display these important scientific tools in the museum in engaging and unique ways, to expand the visitor learning experience.

Increased accessibility to works in the collection expands the possibilities for intimate encounters with exhibits in their full intricacy

By and large, gardens invite learning rather than demand it

To create an intriguing display, we enlarged photographs of the smallest orchids and pickled the largest

We selected some of the most intriguing preserved specimens and displayed them alongside our bibliographic collection for guests to discover. In comparison to living collections, these preserves can look shriveled and even grotesque, so we designed with learning in mind. To create an intriguing display, we enlarged photographs of the smallest orchids and pickled the largest—in doing so, we encountered some surprising challenges that only emerged because of experimental display and interpretive techniques employing informal learning theory.

Through exhibition design and display we considered how the viewer/visitor processes information and absorbs knowledge. By experimenting with scale we invited them to pause and consider the objects more closely. For instance, we have a collection of micro-orchids amassed by Drs Carl Luer and Toscano deBrito, the world's leading botanists in the study of *pleurothallids*. Research associate Dr Wade Collier photographs these delicate flowers using advanced technology.

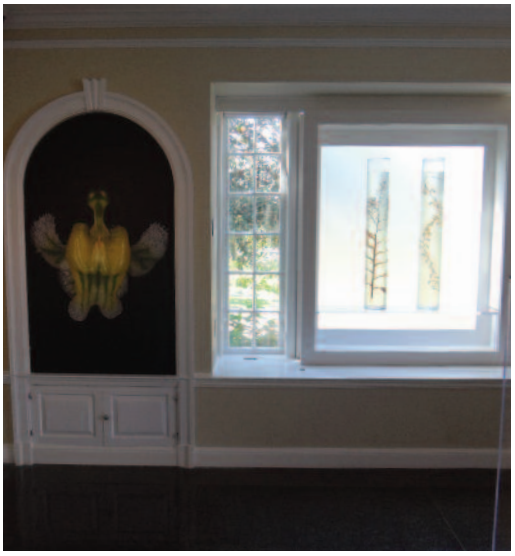
Contrasting displays

As their name suggests, micro-orchids have tiny flowers, with details best viewed under magnification. The museum display featured photos and spirit specimens of the same micro-orchids, presented side by side for comparison. The photos taken by Dr Collier were produced using a technique called focus stacking, in which multiple shots are taken at different focal distances and combined to form a single image with a greater depth of field than is achievable through traditional methods. We blew up the high resolution images of these delicate flowers to roughly 1.2 x 1.8 m in size. Glass vials of the preserved flowers were lit and displayed alongside the photographs, accompanied by a hand-held magnifying lens so as to encourage guests to take a closer look.

Nearby, a backlit window display of what may be the largest pickled plant specimens ever made were placed, intended as an exercise in contrast. We preserved the flowering spikes of the *Coelogyne pulverula* orchid in 1.2 m tall glass vases. Selby Gardens' spirit collection comprises approximately 28,000 preserved plants, mostly orchids. The benefit of preserving plants in this way is to enable the study of their most delicate parts, such as flowers, for accurate measurement and for clear observation of three-dimensional form. The collection is second in size only to that of the Royal Botanic Gardens, Kew. In short, we consider ourselves to be experts in the pickling of plants.

Staff figured it would be simple to create really large specimens for display. However, going from 4–8 oz vials to 5 gallons of liquid proved to be quite a challenge. Spirit specimens are composed of 70 per cent denatured alcohol mixed with 30 per cent water, topped off with a splash of glycerine to keep the petals supple. We typically use distilled water, but due to Hurricane Irma the state's bottled water supply was virtually non-existent. We set up an experiment with controls involving reverse osmosis, spring, and tap water. In small quantities we could achieve the desired clarity but when we made them large—up to 5 gallons—they were clouded. We thought perhaps the alcohol had been stored in rusty containers or that the glycerine played a larger role than we'd realized. After going to at least half a dozen stores and waiting for shipments, we obtained distilled water which at last did the trick and produced a clear liquid in which the plants could be properly viewed.

During the run of this annual exhibition, we have an opportunity to showcase the collections to some 25,000 visitors. Up until three years ago, we hadn't shared them with more than a couple of hundred people in a public setting. By simply exhibiting them we are able to offer access to and increase awareness of these valuable research collections, while improved accessibility to works in the collection creates possibilities for intimate encounters with the various exhibits in all their intricacy.



↑ *Museum of Botany & the Arts Micro and Macro Spirit Specimen Display within The Orchid Show, 2017 ©Darren Erickson*

The collection is second in size only to that of the Royal Botanic Gardens, Kew

↑ *Glass vases for creating the largest pickled plant specimens ever made ©Darren Erickson*

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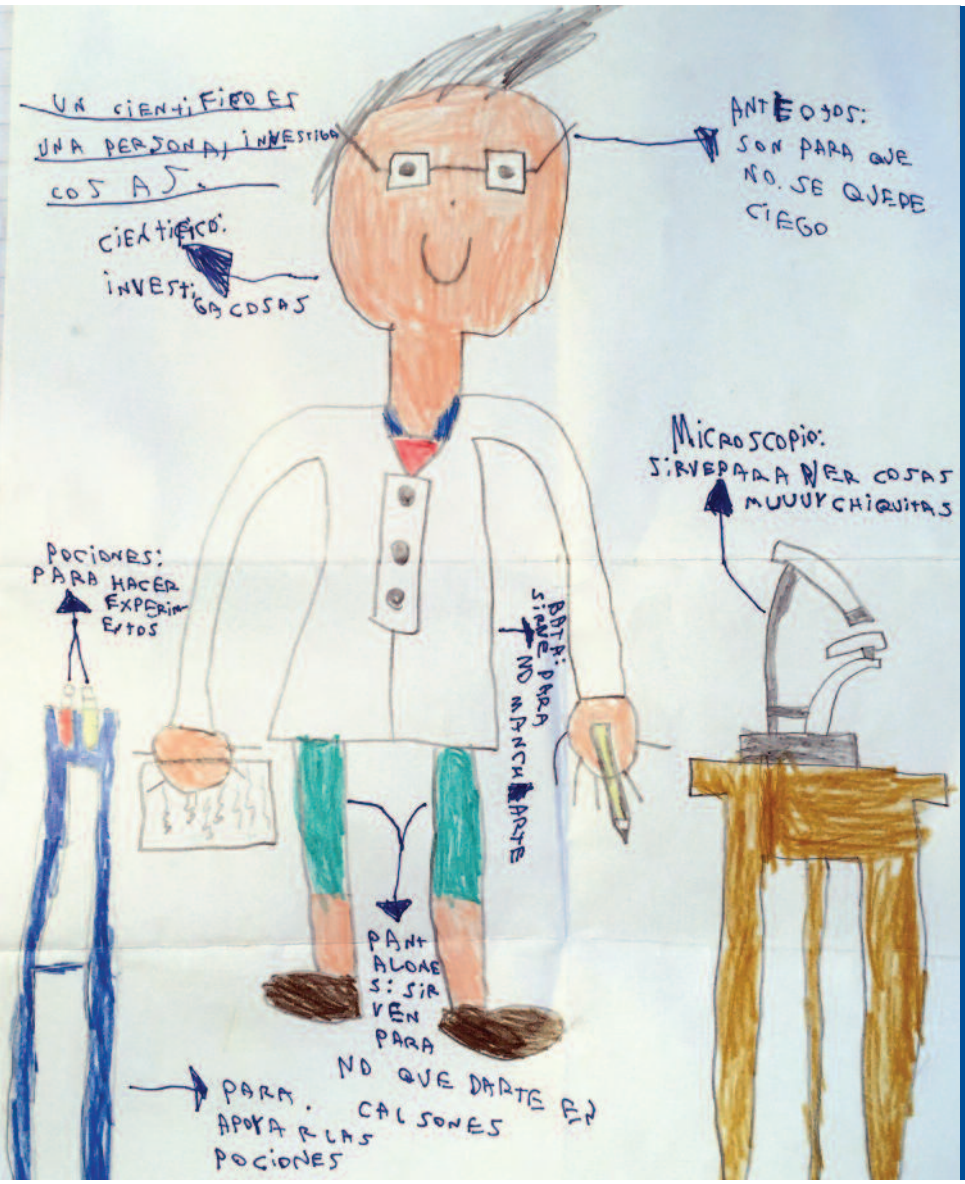
ECOLOGY IN THE GARDEN

What does it take to be a scientist? Far apart from the general misconception that a scientist is a solitary, laboratory dwelling creature with glasses and white coat, being a scientist means being passionate, creative and curious.

Knowing that kids are naturally inclined to science and that enjoyment is a fundamental part of meaningful learning, we used scientific skills and environmental education principles to develop the education programme "Ecology in the garden". 10 -12 year old students not only learn about ecology but also use tools that scientist use, face the same challenges and draw their own conclusions. Because science is much more fun when you make it yourself!



↑ *A 10 years old's drawing on what a scientist looks like*

Curiosity is a common quality that most children and scientist share. Discovering and understanding the world around us can be a great adventure. Unfortunately, children often have a misconception of what it takes to be a scientist and what science is. Usually they describe scientists as bright old men, working in a laboratory, wearing white coats and glasses who were geniuses at school. This leads to the belief that science is very hard and complicated and that they are not smart enough to become a scientist themselves.

Understanding the concepts related to science, incorporating its procedures and affective aspects (Kemp, 2002) contributes to the development of students' ability to creatively use appropriate evidence-based scientific knowledge and skills. According to constructivism, meaningful learning is a result of building on personal experiences and relating new facts and knowledge to what is already known. First-hand experiences of what it is like to work like a scientist can help shift misconceptions and eventually encourage young students to pursue a career in science. For this, it is important to include key aspects of science such as its empiric nature, methodology, abstract thinking, social components and counterintuitive ideas when planning new activities (Gellon, *et al*., 2005)

↑ *Exercising the ability to recognise simple and compound leaves. One of the activities to do before the workshop*

← *Discovering that "grass" is actually a group of very different species.*

ECOLOGY IN THE GARDEN

In this workshop, students from 10 to 12 years old come to the garden and learn about concepts in ecology such as species, population, community and biodiversity; using strategies and tools that ecologists use.

They have the opportunity to learn how to use three tools: a dichotomous key for eight plant species, a quadrant survey of vegetation and a survey of plant – animal interactions in the Butterfly Garden.

Teachers are given a set of activities developed by the garden´s education team to do with their students in the classroom before and after they visit.

BEFORE THE WORKSHOP

Teachers prepare students for the visit. Using an activity sheet they observe leaf characteristics such as shape, margin, vein patterns and petiole, they recognise simple and compound leaves, and exercise the vocabulary that will be used in the workshop. Afterwards they e-mail us the result of their work.

WORKSHOP AT THE BOTANICAL GARDEN

Divided into groups of five, they become scientists for a day while exploring the garden with one of the educators who shows them how to use scientific tools and helps them acquire new knowledge using inquiry based learning. Questions take the students from one activity of the workshop to the next.

What's the name of this plant? How can you find it out?
This question starts a debate, using the students' ideas, they realise that tools and methodologies are needed to study the vegetal world and that plant external characteristics are important for identifying them.

Next a key for 8 plants is introduced to the children. In the process of finding out the plant's name, they exercise observation, recognise leaf structures, use botanical terminology and a scientific tool. A discussion follows where students come to the conclusion that consensus had to be achieved by the scientific community to create the current classification system and that science is a social construction.

Finally, the educator invites students to express their ideas about what a species is and together reach a definition.

Is there only one species of grass?
After a first glance of a herbaceous community students take a moment and share their hypothesis about what constitutes a grassland, the number of species they can find and its composition.

Meaningful learning is a result of building on personal experiences and relating new facts and knowledge to what is already known.

↑ *Keying out trees. Students use a dichotomous key and a glossary to find the names of 8 plants.*

Students come to the garden and learn ecology concepts such as species, population, community and biodiversity; using strategies and tools that ecologists use.

↑ *Exercising the ability to recognise simple and compound leaves. One of the activities to do before the workshop*

The educator proposes the use of a scientific tool: a quadrant survey. Each group puts an empty frame on the grass and counts the amount of vegetal species present. Leaf shape is used to determinate each species. Students are asked to draw each species and assign it a relative abundance in a qualitative scale.

After sharing the results, they compare them to their previous hypothesis and ideas. Now, discussion is evidence based. Students realise that the number of species is not enough to characterize a community, their abundance has to be considered as well. Each group gets different results so, what constitutes a representative sample? Methodologies are necessary to obtain accurate results. Students then differentiate the concepts of species, population and community.

Why are there so many bugs here? What are they doing?
Students visit The Butterfly Garden and wonder, why are so many bugs there? Are they there for a particular reason? What are they doing?

Observation is a great skill to answer questions. The educator introduces an animal-plant interaction chart where students register their observations for 15 minutes. During the activity the educator helps them notice the difference between what they see and what they assume. Surrounded by butterflies, flowers, bees and hummingbirds students exercise observation and using a chart, learn to differentiate observations and inferences and to communicate results.

Afterwards children take a moment to discuss how plants sustain animal life and how all interactions are important in an ecosystem.

What does it take to be a scientist?
The workshop ends in the Native Plant Garden. There, students discuss what they have learnt. Questions guide them to shape their definition of the terms ecology and biodiversity. The educator introduces the concept of native plants and mediates a debate about their role in the ecosystem and their inclusion in the urban landscape. Students express what it felt like to work like a scientist and share their new ideas on what a scientist is and what it takes to become one.

AFTER THE WORKSHOP

Teachers can find instructions to make a herbarium and a key to common urban trees at the Botanical Garden website.

CONCLUSION

The inclusion of scientific tools allows student to acquire new skills and widen their knowledge. During the workshop, they exercise their capacity for observation, questioning, critical thinking and arguing and develop a self-driven attitude towards scientific learning. The inquiry based approach provides an opportunity to think and put into words old and new ideas and concepts.

This workshop focuses on botany and ecology concepts, and was developed placing the students at the centre of the educational process, understanding that according to the constructivism theory the learner constructs knowledge actively rather than passively. The result is a moment of connection with nature. Students are actively involved in the learning process, challenging old ideas and assigning new meanings. They find that curiosity, critical and methodical thinking and creativity are essential aspects of scientific work, while discovering amazing things about plant life.

Discovering and understanding the world around us can be a great adventure

↑ *Exercising observation, surrounded by butterflies, flowers, bees and hummingbirds*

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AN APPRENTICESHIP APPROACH TO TEACHING SCIENCE IN BOTANIC GARDENS

Participation in research apprenticeship programmes that engage students in working with expert mentors in authentic contexts can encourage young people to pursue science learning and scientific careers. There is no doubt that teaching science using an apprenticeship approach in informal settings, such as botanic gardens, is a challenging task. In a research botanic garden in China, we developed and implemented a three-day science programme, which incorporated the four key aspects of effective apprenticeship-related programmes for secondary students based on the existing literature.

← *The word cloud regarding students' written descriptions of changes due to TREP participation*

There has been an increasing global concern regarding an obvious decline in children's interest in science and science careers as they progress from primary to secondary school (DeWitt, Archer & Osborne, 2014; Shi & Zhao, 2017). Science education models for young students have still been dominated by classroom-based approaches. However, the effectiveness of this traditional model has been challenged. Educational interventions, particularly those designed based on learning theories that can actually provoke interest in science need to be identified.

Recently, research apprenticeships wherein students working with scientists on authentic scientific research, have become increasingly popular, particularly in informal settings. Apprenticeship approaches are largely informed by sociocultural perspectives and situated learning theory which assumes that learning occurs as students participate in the authentic Communities of Practice (Sadler *et al*., 2010). Given this framework, when students have the opportunity to participate in authentic science projects within authentic contexts such as a field-based setting or a research laboratory, they can understand how the science is conducted and develop a sense of belonging and confidence in themselves. This process is likely to promote their career aspirations, understanding of scientific content, and confidence in 'doing' science (Burgin, McConnell & Flowers, 2014; Sadler *et al*., 2010).

↑ *Participant students walking through a real rainforest*

↑ *Participant students visiting several living plant collections at night*

As one of the most popular informal settings, botanic gardens are recognized as a place "holding documented collections of living plants for the purpose of scientific research, conservation, display and education" (Wyse Jackson, 1999) and are thus qualified as suitable sites for teaching and learning science and for education on environmental issues (Sellmann & Bogner, 2012). There is no doubt that botanic gardens are suitable sites to teach science using apprentice approaches, yet there is currently little guidance on how to go about doing this.

Drawing on the existing literature, we developed and implemented a three-day apprenticeship-related programme, called the Tropical Rainforest Exploration Programme (TREP) in Xishuangbanna Tropical Botanical Garden (XTBG), Chinese Academy of Sciences. The TREP was first created in 2008, however it was enhanced, based on theory, in 2014. Below we present the details of the programme and the results of its evaluation.

A DETAILED PICTURE OF THE TREP

The TREP is a three-day (34-hour) intensive scientific experience for secondary school students. Programme applicants have primarily been recruited from schools in Beijing, Kunming and Xian. We recruited scientists and senior graduates from the garden to act as mentors. The mentors were requested to provide a brief introduction about their research projects and relevant information for participating students prior to their arrival.

The TREP, aimed to motivate students to carry out group work with mentors in an authentic context and was designed to include four key aspects: (1) student interest, (2) authentic science experiences in authentic real-world contexts, (3) multiple and maintained mentoring interactions with scientists, (4) peer collaboration and group discussion.

DAY 1

1. Welcome and introduction to the TREP programme;
2. Introduction to scientific research projects:
- Mentors gave brief presentations on the projects and possible topics for investigation with the students
- Students chose projects and topics of interest and were grouped accordingly (four to five students per group)
- Mentors and students decided how they would observe relevant phenomenon during field trips
3. Students were shown the research equipment in the central laboratory in the botanical garden;
4. Students were exposed to a research environment by walking through a real rainforest, visiting living collections (some at night).

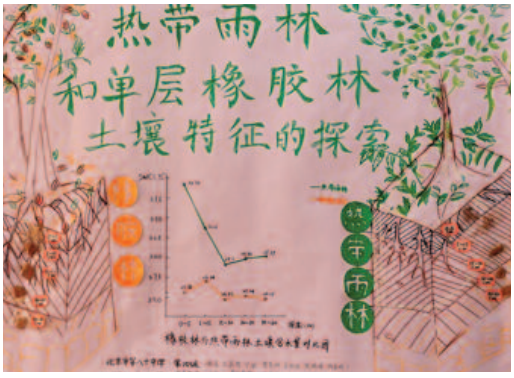
DAY 2

1. Students conducted mentor-led research through group collaboration (including hypotheses, field and laboratory experiments, data analysis, preparation of presentations) and discussion (e.g. connecting their project results to their real world):
- Mentors introduced the students to the natural environment, sharing background information of the research project; highlighting the relevance of their work to the students' lives and explaining the history behind research questions and hypotheses. This inspires the students to ask questions about the design of their subsequent experiments
- Students worked in groups to carry out their experiments
- Students worked in groups, with guidance from their mentors, to analyse their data
2. Students attended a lecture on becoming a scientist to provide them with relevant role models and ideas about possible careers.

↑ *Students working on their laboratory experiments with their mentor*

↑ *Students working on their field experiments with their mentor*

↑ *Students in each group defending their projects to a broad audience*



↑ *Hand-drawn poster from participant students in one group*

DAY 3

1. Final group work on posters and presentations:
- Students shared personal reflections on their projects and discussed the results under the guidance of the mentors (e.g., the limitations of projects, the relevance of the results to their lives)
- Students prepared presentations and drew posters
2. Group presentations in a lecture hall:
- Each group presented their findings with PowerPoints and hand-drawn posters, and defended their projects to a broad audience.

PROGRAMME EVALUATION

In order to examine the efficacy of the TREP, participants (N = 319) were asked to write a brief description of any changes they had perceived in themselves as a result of the programme. The term 'change' was purposely not defined for participant students, allowing them to interpret it in any manner they chose. A content analysis of students' written descriptions was then conducted according to the procedure outlined by Weber (1990).

This suggested that the students had observed seven types of changes. Specifically, as a result of the TREP experience, students were more likely to mention gains in increased knowledge about biology and scientific research (N = 197, 62%), research skills (N = 78, 24%), and science confidence or general self-confidence (N = 86, 27%). Additionally, some students mentioned promotion of positive attitudes to biology and scientific research (N = 48, 15%), greater interest in biology/science and scientific research (N = 57, 18%), and development of relationships with other science students and scientists (N = 35, 11%). Finally, 34% of students (N = 109) focused on the impact of the programme on their future plans, such as pursuing a career as a biologist/scientist (N =37), learning biology /science or applying what they acquired to their biology/science subjects (N = 32), participating in science-related activities (N =27) and protecting wildlife or specific species (N =25) in future.

PRACTICAL IMPLICATIONS

In general, the detailed picture of the TREP and some results about programme evaluation that we have been provided herein emphasize that apprentice approaches, which support students to work in groups with mentors in an authentic context, are effective learning environments within botanic gardens. Delivering and evaluating this could help to inform our understanding of how we might move forward in relevant programme design aiming at promoting students' interest in science and science careers. There may be some constraints for some botanic gardens, such as inexperience or access to research space or. An effective way to combat this is to establish collaborations with local colleges or scientific research institutions that have the capability to provide authentic science practice opportunities and science mentors for students.

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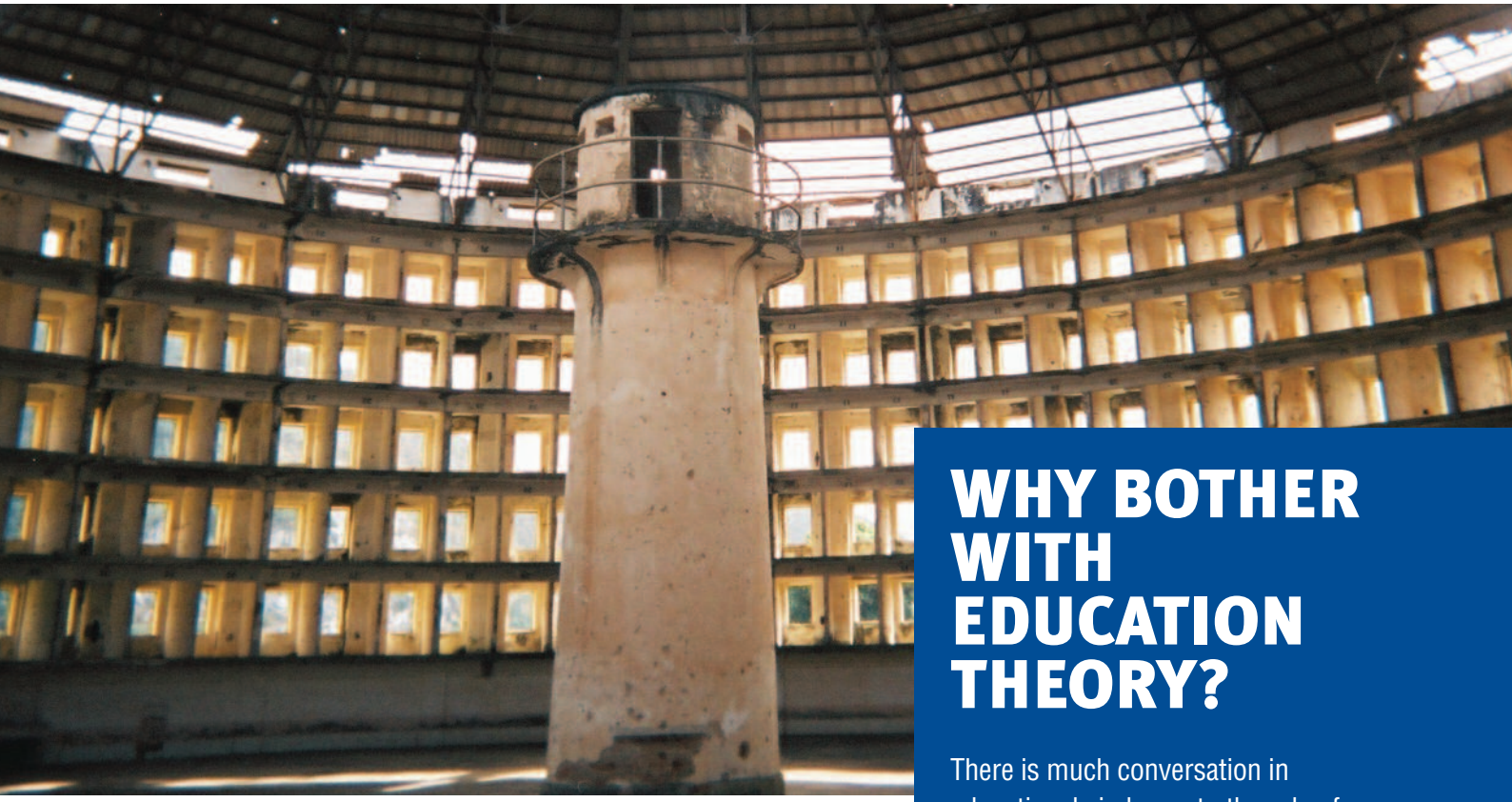

WHY BOTHER WITH EDUCATION THEORY?

There is much conversation in educational circles as to the role of learning theories. Rather than discuss learning theories, I examine theory and theorists in our practice as educators. I explore some of the 'pushes and pulls' which encourage, or indeed discourage, the use of educational theory. I argue that currently - due to the performative context which schools, colleges, museums and botanic gardens increasingly inhabit - there have never been more pressures on 'quick wins' to evidence impact. This is a context which positions educational theory ever more at the periphery of practice - a position which I maintain is at the detriment of both botanic garden educators' practice, as well as our ability to support the learners who visit our settings.

↑ *A Panopticon Prison Design in Cuba ©Friman*

WHY BOTHER WITH EDUCATION THEORY?

Anne O'Grady (2016), suggests that having a view on educational theories helps us to understand learners as partners rather than as recipients. In this article, I consider education theory in terms of 'why' learners learn - as opposed to increasingly 'performative' (Lyotard, 1979) concerns regarding the technique and pedagogy of 'how' learners learn. I argue that educational theory is not separate to educational practice, but integral to it. As such, an informed understanding of educational theory empowers us as educators as it informs our own philosophical position in relation to what education, and learning, means for both our learners and ourselves.

O'Grady (2016) tells us, that educational theory in contemporary pedagogy appears 'somewhat redundant'. I would not paint such a grim picture as certain contexts - undergraduate Education Studies degrees, Initial Teacher Education courses and Masters and Doctoral programmes - all stress the importance of theory. However, in preparation for this article I spoke to friends who are educators in schools, colleges, gardens and museums. All reported that educational theory was absent from their day-to-day work. As one friend (Shelly, a teacher in a Further Education College) told me "who has time for theory?!".

Nonetheless, having a working understanding of education theory informs one's philosophical position as an educator - for example, do you view learners as recipients or co-constructors of understanding? The tension then between what we do in practice, and the theory which (should) underpin and inform our practice, is increasingly stark. Engaging with the work of significant theorists in contemporary social and education theory, encourages us to think analytically about theoretical questions. This process also, crucially, leads to an understanding of the role, purpose and contribution of educational theory on and for our practice.

MICHEL FOUCAULT

Some of the key theorists influencing my practice have been Jean François Lyotard and Michel Foucault (both of whom of course argue against theory!). Mobilising the work of such theorists empowers us to critically consider contemporary education across a range of learning environments. Of course, central to engaging with theories in education is defending or rejecting their usefulness - central to the role of theory is that it leads us to critique theory itself.

As a case in point I have previously mentioned the work of Michel Foucault (1977). Foucault examined vast areas of society, but here I will briefly discuss his work on the Panopticon. For Foucault, neo-liberal demands to evidence 'best practice', and to successfully meet ever increasing targets, is mediated by the omnipresence of the inspector. Foucault employs the Panopticon prison design as a metaphor for how we, as educators, are increasingly regulated through inspection and external requirements to demonstrate impact.

The Panopticon design consisted of a central inspection tower surrounded by backlit 'cells'. The power of the Panopticon is that those under surveillance are never aware as to if the inspector is watching them or not.

Therefore, those being watched constantly regulate their actions to reflect that required by the watcher. Foucault then adds a little more complexity by stressing that the watcher also regulates her behaviour.

So, what does Foucault offer the botanic educator? I would argue, that if we are able to consider the wide pressures we face as educators - such as performance targets like impact or visitor numbers - we are able to have an informed understanding of what we do and why we do it. Foucault, argues that understanding power enables us to be empowered. Education theory like that of Foucault, supports us in understanding our core values as educationalists and as to what botanic garden education offers our public.

THEORY AND REALITY

In conclusion, I return to my friend Shelly. In our increasingly hectic and performance driven working lives, the time to engage in 'luxuries' such as education theory are ever more rare. Of course, this is what theorist such as Foucault argue. Modern society is designed for us to conform to power structures that keep the elite elite and the rest, well, not. Engaging with theorists who explore contemporary education analytically offers the opportunity to consider the role, purpose and contribution of what we do as botanic garden educators. To do so however takes time and perseverance.

As part of the university system, I would of course advocate what postgraduate study in education can offer. Part Time MA courses are able to support us to have the physical and emotional space to think deeply about what we do - space away from the pressures of the 'day-job'. However, postgraduate study is not the only way to develop a working understanding of how education theory, research and writing fit together. For example, Pat Thomson's blog 'patter' https://patthomson.net/ explores how education theory, research and practice fit - or do not fit - together. Being able to locate, contextualise and understand botanic garden education through theory is not easy – which of course is what makes it worthwhile. A theoretically informed ability to critically analyse our educational practice is key to our own development as an educational professional. The question then appears not to be 'if', but 'how'.

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PIONEERS IN PUBLIC ENGAGEMENT
U.S. BOTANIC GARDEN VOLUNTEER: TODD BRETHAUER

↑ *Todd Brethauer discusses* Amorphophallus konjac *with a visitor to the USBG Production Facility ©United States Botanic Garden*

Our volunteer Todd Brethauer always exceeds expectations in creating unique and valuable education experiences for our visitors to the United Stated Botanic Garden. He uses the plant collection to inspire excitement and interest in the natural world.

Todd develops high-level, seasonal plant science lectures and presents them throughout the year. Recent presentations include several orchid lectures offered in tandem with our orchid exhibition and an upcoming series on food plants from our kitchen garden. Todd's lectures are well-attended and receive rave reviews – for interesting content and quality of presentation style. Attendees know Todd by his ability to provide an interesting, nuanced take on complicated subjects often viewed as dry or dull.

Todd also excels in informal, walk-up interpretive experiences for visitors of all ages. He focuses on charismatic plants such as orchids, spices, and carnivorous plants. These brief experiences serve as a launch pad for further exploration of the many ways plants are critical to our lives. Todd enjoys educating the public about *Amorphophallus* spp., and he plays an important interpretive role for the thousands of visitors when we have a corpse flower (*Amorphophallus titanum*) bloom at the garden.

Todd began his academic career studying chemical engineering at the University of Illinois at Urbana-Campaign. He then transitioned to a focus on agriculture, earning a master's in plant pathology through studying the biochemistry of biological specificity in the interaction between nitrogen-fixing bacteria and soybeans. He was commissioned through the U.S. Navy's Naval Officer Candidate School and served for 22 years in submarines and aircraft carriers and onshore. Retiring as a Commander, he then served as science advisor to a government research and development program for 12 years, assessing and focusing the development of promising emerging technologies. Todd's agriculture and plant pathology background blend with his career as a Navy officer and government science advisor to inform his public programs in a fascinating way.

Todd's work at the garden demonstrates the value of allowing volunteer passions and experiences to propel programmatic opportunities. We provide support and resources, and Todd creates wonderful programs. We look forward to offering many exciting experiences with Todd in the future!

RESOURCES

A Brief Introduction to Learning Theories

Are you new to all of this? This short article offers a brief overview of some of the main paradigms and theories in education theory including behaviourism, cognitivist theory, humanism and learner-centred approach.

https://stories.linways.in/a-brief-introduction-to-learning-theories-4077b8fcd481

Learning Theories

This website covers everything from semiotics to systems thinking, providing a brief and easy to understand summary as well as suggested reading to give you a short introduction of all of the most important and well-respected learning theories.

https://www.learning-theories.com/

Museum Lectures: Learning Theories

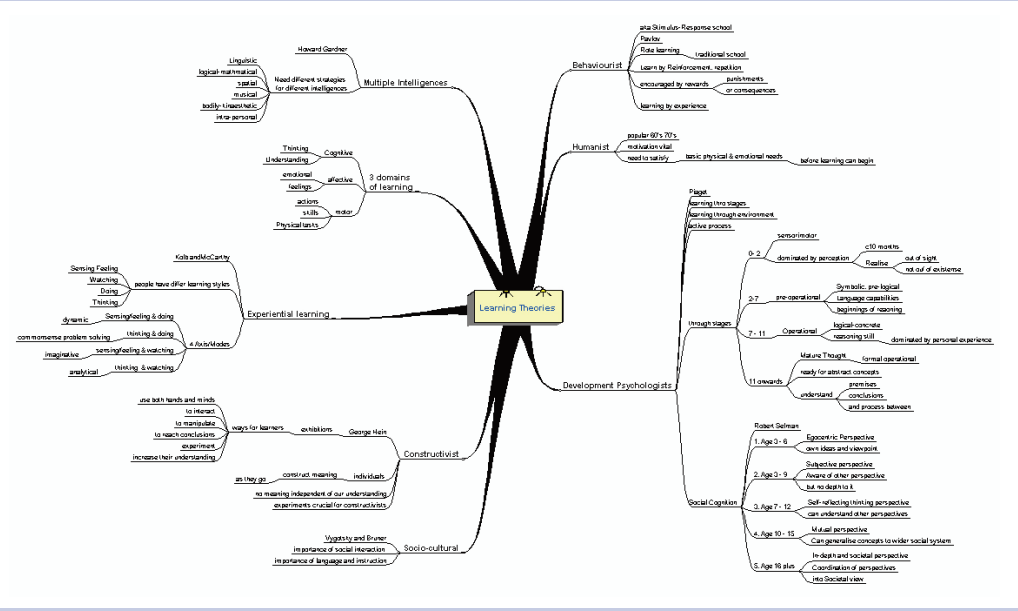
Learning theories are not self-contained ideas. Understanding the relationship between them can help to understand the important features of each as well as help to choose complementary approaches when designing education activities. This infographic works as a family tree of learning theories to help illustrate the evolution of each.

http://www.chr.org.uk/Museums/education2.htm

Constructivism Learning Theory

Constructivism and related ideas is an important paradigm in education theory. This article offers a historical summary of this school of thought as well as important considerations for offering education that is grounded in the constructivist way of thinking.

https://museumplanner.org/constructivism-learning-theory/



Mindmap by Kevin Flude for University of Worcester Museums Module

Teaching Science in Out-of-School Settings

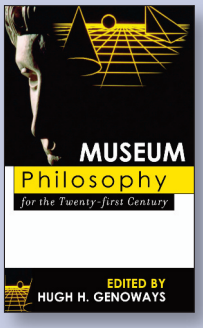
Are you looking to enhance your school audiences' engagement with science? This book examines pedagogy in science education in botanic gardens as well as considering which teaching behaviours can best support learning

Junqing Zhai (2015)
Springer, Singapore

New Museum Theory and Practice: An Introduction

Learning from best practice within our own and the wider museum sector is an essential part of growing as a botanic garden educator. This collection of essays provides examples of how theory and practice influence each other from a range of museums around the world.

Janet Marstein (2005)
John Wiley & Sons



Rowman & Littlefield, all rights reserved

Museum Philosophy for the 21st Century

The idea of what a museum is and should be and how it can be these things is ever changing. This book looks at the changing field of museum philosophy to offer theoretical and practical advice.

It also includes ideas about Communities of Practice which can be a powerful approach when considering botanic garden education, particularly when trying to encourage community participation.

Hugh Genoways (2006)
Rowman and Littlefield,
all rights reserved

Informal Learning

Educational research and theory can often be biased towards the classroom. Although an important space for learning, this is not always relevant to botanic gardens with their various spaces and audiences. This paper summarises informal learning from a historical and theoretical perspective.

http://shirleybriceheath.net/pdfs2016/informal-learning.pdf

As We See It: Improving learning in the museum

Considering how and why visitors learn what they do in a particular site and exploiting this can help to improve the educational offer. This paper offers a case study of how one museum carried out research to look at the way in which their displays encourage and inhibit learning.

http://www.leeds.ac.uk/educol/documents/00003271.htm

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Frank Vassen

The 10th International Congress on Education in Botanic Gardens

will take place on 9th - 14th September 2018 at the University of Warsaw Botanic Garden.

The theme of the Congress is Bringing nature to the city. *Celebrating the 200th anniversary of the University of Warsaw Botanic Garden* and we invite you all to join us for what we hope will be an exciting and interesting event.

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http://www.garden.uw.edu.pl/congress2018

And don't forget to sign up for our fabulous Post-Congress sightseeing tour to the National Parks of Poland. The tour will visit three National Parks, including Białowieża National Park - the oldest national park in Poland and one of the first to be established in Europe.

The tour will take place from 14th - 16th September and is great value for money with prices starting at 203 Euro for travel, accommodation and meals. You can join the tour by choosing the appropriate option during registration or contact:
congress2018@biol.uw.edu.pl

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