

# INITIATING INQUIRY BASED SCIENCE EDUCATION IN OUTDOOR LEARNING SITES: ISSUES AND CHALLENGES

*Suzanne Kapelari, University of Innsbruck; Elaine Regan, King's College London; Costa Bonomi, Natural History Museum Trento; Justin Dillon, King's College London; Julia Willison, Botanic Garden Conservation International; Asimina Vergou, Botanic Garden Conservation International; Hartwig Schepker, Botanika, Bremen; Doris Elster University Bremen*



## **Abstract:**

*The EU FP7 INQUIRE Project is supporting the development of science literacy in Europe by developing and offering one-year practically based IBSE teacher training course at 14 Botanic Gardens and Natural History Museums in 11 European countries. Botanic Gardens act as catalysts, training and supporting teachers and educators to develop their proficiency in IBSE and become reflective practitioners. The training locations, the practical nature of the course, the support offered and the subject content which is biodiversity loss and climate change, encourages teachers and educators to enrol in INQUIRE courses and try out IBSE in their everyday teaching. To ensure excellence, theoretical rigour and project progression, INQUIRE applies a reflective practitioners approach on all levels, the course level, the consortium level as well as the management board level.*

**Key words:** Inquiry Based Learning, Learning Outside the Classroom, Reflective Practice, Botanic Gardens, IBSE Teacher Training.

## **1. Theoretical Background**

Current science education reform initiatives require fundamental changes in how science is taught as well as in how teachers are supported to engage in alternative ways of science teaching (Osborne & Dillon, 2008; NRC, 2000a). One of the currently favored strategies in improving science teaching and learning in Europe and North America is to incorporate inquiry based science education (IBSE) into the everyday K12 science curriculum (Lená, 2009; Rocard et al., 2007; LOCM, 2006; NRC, 2000b). To accomplish this, teachers need opportunities to participate in a variety of professional development experiences that foster an understanding of science and inquiry based science teaching. However experience has shown that experts from outside the classroom who provide a one size fits set of solutions often fail to distinguish between different styles and different needs teachers have or may not address the real problems of classroom life (Hattie, 2009; Liebermann, 2000). However there is a growing awareness of alternative ways of facilitating teachers' professional development (Bakkenes et al., 2010).

In addition research has shown that learning that includes activities based outside the classroom is highly motivating, not only for children but also for teachers. The UK Governments education manifesto 'Learning outside the Classroom' was launched to emphasis this key issue (Dillon, 2007; Dillon et al., 2006) and Europe has already recognized the potential of Learning Outside the Classroom (LOtC) venues to support the implementation of IBSE methods on a large scale (Rocard et al., 2007; LOCM 2006; NRC 2000a).

### *1.1. Learning Out of Classroom Doors*

Research is increasingly clear that learning outside the classroom (LOtC) is associated with several positive outcomes such as more engagement in learning and higher levels of academic achievement (Dillon 2007; Richinson et al., 2004). In addition, research suggests that structured fieldtrips that include planning the trip jointly with teachers, students and venue staff, incorporate per-visit instructions and make use of organized post-visit reflections are considered to maximize the opportunities to learn (Cox Petersen et al., 2003; Kapelari & Bromley 2009). However education programmes developed and applied at botanic gardens are mainly based on practical approaches to teaching and learning. In addition botanic gardens as well as other LOtC venues may not focus on evaluating their programs in great detail. Action research or science education research based on theory and evidence is not commonly established in these settings. Phillips et al.'s (2007) survey with 475 LOtC sites in the United States of America concludes that they do have a great potential to support K 12 science education including professional development of teachers. However the survey uncovered some patterns around LOtC venues and their support for schools and named a lack of outcome measures as one of them (Philips et al., 2007).

### *1.2. Botanic Gardens Learning*

Botanic gardens are some of Europe's most inspirational cultural, scientific and learning institutions. They contain amazingly diverse collections of plants and plant artefacts and hold extensive botanical, ethno-botanical and horticultural knowledge and skills. Most European gardens are situated in urban areas and this makes them accessible to large numbers of people. With more people living in cities, botanic gardens offer some of the only outdoor learning sites for children to gain first-hand experiences in IBSE.

### *1.3. Professional Development*

When we think about teacher training the main goal is that teacher's professional learning supports changes in teachers practice and in their students learning. However, research has shown that teachers' professional development is likely to change teachers' learning but this learning has less effect on teachers' actual behavior and even less influence on students' learning (Hattie, 2009). Engaging in professional development does not necessary promote effective professional learning. The quality of the learning experience is most influential. Wade (1985) named four types of instructions found to be most effective on teachers' knowledge and behavior. Observation on actual classroom methods and classroom practice is one of those. In addition Timperley and colleagues (2007) reviewed 97 studies and isolated 84 characteristics in successful teacher training activities from which 7 seem to be particularly important:

- learning opportunities for teachers occur over an extended period.
- external experts are involved.
- teachers are engaged sufficiently during the learning process to deepen their knowledge
- extend teachers skills in ways that improve student outcomes.
- professional development has to challenge teachers 'prevailing discourse and conceptions about learning
- challenging teachers how to teach particular curricula more effectively
- involvement of a professional community of practice is necessary to engage teachers to talk about teaching.

#### *1.4. Communities of Learners*

Hofman and Dijkstra (2010) presented in their study that teacher networks can be an alternative and even more successful way for the professional development of teachers in the long run. These networks provide the space for learners to discuss and exchange knowledge as well as make use of the social capital individual members provide. Wenger and colleagues (2002) pointed out that in a community of practice social learning occurs as soon as people who have a common interest in some subject or problem collaborate over an extended period of time to share ideas, find solutions and build innovation. Shulman and Shulman (2004) note that there is an ongoing interaction between an individual professional and the community and that this leads to a shared knowledge of the team which finally offers members the opportunity to confirm, interconnect and develop their professional knowledge. Kelly (2011) highlights how important it is to have experts in the field when it comes to establish communities of learners because these people support the group to speed up their learning process.

In INQUIRE communities of learners are established on different levels. The common goals are to improve learning and teaching skills, to share responsibility for the professional growth and development of colleagues and to partake in professionally guided discourse about one's teaching and learning. The discourse and the different views of practitioners and education researchers serve to enhance the process of reflection about their classroom and botanic garden experiences and to expand their horizons, understandings and capabilities.

#### *1.5. Reflective Practice*

Reflective practice is expected to support practitioners in establishing a research relationship to their own practice (acting in the classroom and at the botanic garden) and to empower them to act as 'reflective practitioner' (Schön, 1983). Practitioner research is increasingly advocated as a self-reflection tool that can promote the development of teachers and researchers (Morris & Parker, 2003; Reid & Dillon, 2004). In INQUIRE, teachers, botanic garden educators and botanic gardens as institutions are encouraged to engage in reflective practice. By undertaking their own classroom/botanic garden-based as well as training course based practitioner research, practitioners can more easily reflect on the reality and the effectiveness of learning outcomes.

### *2. The INQUIRE - Project*

#### *2.1. Inquiry based teacher training for a sustainable future*

INQUIRE is a three year project focusing on inquiry based science education and involving 17 partners in 11 European countries. The project is funded by the European Union under the 7th Framework Programme Science and Society. Partners are named on the last page. Fourteen botanic gardens are involved in the project and are individually developing a one-year IBSE teacher training course, with support from Botanic Gardens Conservation International and two universities – King's College London, UK and the University of Bremen, Germany.

#### *2.2. The INQUIRE Website*

The INQUIRE website ([www.inquirebotany.org](http://www.inquirebotany.org)) supports the project through disseminating information and resources and promoting dialogue between Partners and teachers. The INQUIRE partners act as catalysts, training and supporting increasing numbers of teachers and educators to develop their proficiency in IBSE and become reflective practitioners. In addition we want to motivate other LOtC venues

to follow the path and develop and implement IBSE teacher training course at their institution by providing insight into the learning processes which is currently taking place in the INQUIRE consortium. An **INQUIRE Course Manual** will be published - to support teachers and educators participating in INQUIRE course successfully - and an **INQUIRE Train the Trainers Course Manual** will be published - to motivate LOtC venues to snowball the INQUIRE approach to IBSE professional development.

### *2.3. Inquiry Based Learning (IBSE) in the INQUIRE Project*

Inquiry based science education (IBSE) in INQUIRE is done in a unique learning environment created by a school and botanic garden partnership. It builds on a range of knowledge and resources provided by this collaboration. IBSE is applied in the INQUIRE project based on the notion that natural science isn't just about following fixed and unalterable operating plans which have to be completed one predefined step after another. It's actually a creative but still understandable and reproducible process of gaining information. The main principle of IBSE in INQUIRE is to promote a model of the learner as autonomous and independently thinking - someone capable of dealing successfully with many aspects of science. Therefore learners should be provided with free space for organising their learning processes individually. They do also need to be taught some science content by teachers - they cannot simply invent scientific knowledge without any basis level of scientific knowledge.

INQUIRE aims to support teachers and botanic educators and in the long run to help pupils to understand the various and creative scientific approaches which represent the foundation of scientific learning by enabling them to experience these approaches first-hand. Through using IBSE approaches, teachers, botanic garden educator and their commissioned students should develop the ability to critically examine what they are told by people or read online, in newspapers or even in education research journals. They should also examine their own ideas critically and ensure that, as much as possible, they are evidence-based. INQUIRE aims to enable practitioners to adapt the "circle of inquiry based education" flexibly and competently to their own and the needs of their students. Practitioners at all levels should be enabled to question their approaches self-reflexively, as well as to analyse the efficiency of their "inquiry-based teaching".

### *2.4. Biodiversity and Climate Change*

The content of the courses is focusing on biodiversity loss and climate change. Biodiversity, the variety of life on earth, provides us with food, clothing, shelter, medicines, fuel, even the air we breathe. Healthy ecosystems are essential for supporting natural processes and services such as air quality, climate, water purification, pollination, and the prevention of erosion. Yet, despite our reliance on biodiversity, plants and animals are increasingly under threat which is recognised, in the scientific world, to be the major global issues of the 21st Century. The International Council for Science Education (ICSU, 2002) identified the need to generate capacity to apply science and technology as important for achieving sustainable development. IBSE has an important role to play in this as it emphasises curiosity and observations followed by problem solving and experimentation. Through the use of critical thinking and reflection, IBSE enables students to make meaning out of gathered evidence. The subject content of the INQUIRE training course will focus on biodiversity conservation and climate change as a means of engaging young people in this critical discourse and equipping them for personal and collective decision making.

## 2.5. The INQUIRE Model:

Although we have a quite well developed theory-based understanding of what might work best in teachers professional development we are aware that teachers and teachers trainers can never be sure that a curriculum designed in great detail is going to work such as an engineer will expect a bridge to work as soon as it is built according to his plans. Any curriculum will require some self-conscious analysis (Winter, 1998). In our particular case self-consciousness is required not only on teacher trainers, teachers and educators development but also on the students learning. In INQUIRE the term learner is therefore not restricted to children learning in a LOTC venue– school learning environment but to teachers learning in a CPD training course and a group of botanic garden educators learning in a European project consortium. INQUIRE has established an inquiry and reflective practice based approach on three levels.

1. The INQUIRE Quality Management level
2. The INQUIRE Consortium Partner level
3. The INQUIRE Course Participants level

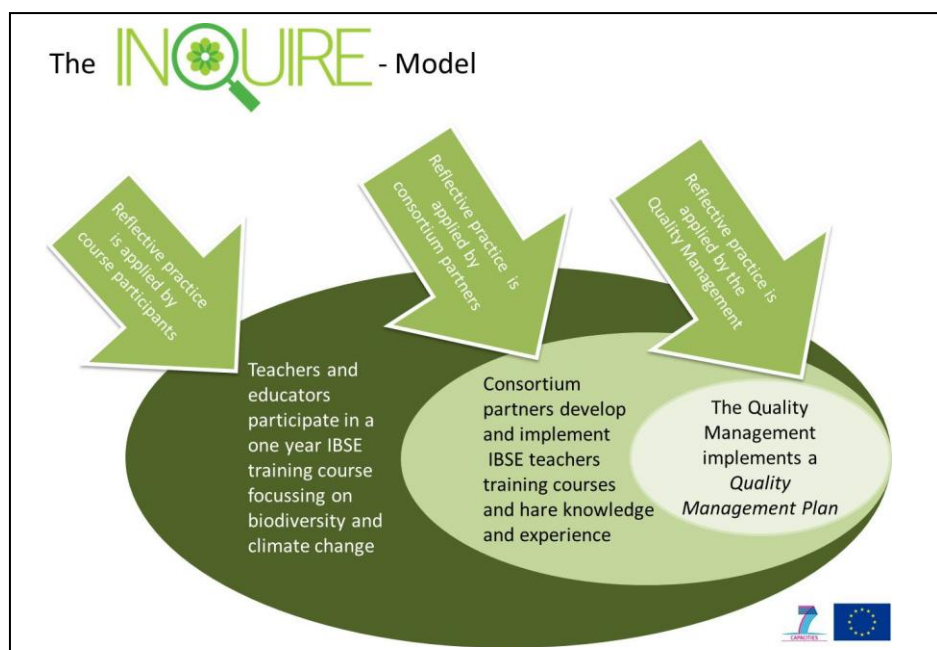


Fig. 1. The INQUIRE Model

### 2.4.1. Designing and implementing the INQUIRE courses in 11 European Countries:

Natural science isn't just about following fixed and unalterable operating plans which have to be completed one predefined step after another. With IBSE it is just the same. There is not just one way of doing it. Although IBSE is a teaching approach to find favor with education policies and European funding schemes it is still not well defined and meanings associated with inquiry are manifold (Minner et al., 2010). As with science education research INQUIRE partners associate various meanings when asked to define the multifaceted educational approach to IBSE. Many variations on the theme were mentioned, from

constructivism, as a theory of knowledge, to problem-solving as a mental process as well as project-based learning or learner centered teaching as an approach to classroom activities are used to paraphrase IBSE at the beginning of the INQUIRE joint venture.

It is one of the INQUIRE goals to visualize what ideas and concepts partner-organizations had when it comes to facilitating IBSE in school - botanic garden partnerships at the beginning of the project and how they develop this view while the INQUIRE project continues. It was never an INQUIRE goal to find the one single IBSE approach that works best in all participating botanic gardens but to support partners to find out whether the chosen approach is successful in helping teachers and students to meet IBSE learning goals. Our goal is to accomplish an understanding what happens when a particular IBSE program is applied in class and at the botanic garden INQUIRE course participating teachers and educators are asked to look closely and find evidence for whether they have reached their goals or not. Each participant may have his or her individual questions to inquire and they share their knowledge gained not only with their colleagues in the course but have the opportunity to share experience with teachers all over Europe via the Inquire website and during the final INQUIRE conference held at Kew gardens June 9<sup>th</sup> and 10<sup>th</sup> 2013.

#### *2.4.2. Creating a community of Practice in the INQUIRE consortium*

The INQUIRE consortium is a collaborative working group of botanic garden staff and science education researchers. We build a community of learners (Lave & Wenger, 1998; Borko, 2004; Brown & Duguid, 1998) and make progress by exchanging ideas and resources, building on everyone's work. Our common goal is to improve IBSE learning and teaching skills. In INQUIRE consortium meeting learners come together to fulfill both individual and group goals. We focus on sharing experiences, appraising good practices and creating new forms of knowledge in dynamic social structures which require cultivating for emergence and growth (Wenger, McDermott & Snyder, 2002; Zellermeier & Munthe, 2007). Consortium meetings and intense consortium discussions are central to INQUIRE partners building on their own understanding of IBSE. Partners discuss observations based on evidence collected during their own reflective process while evaluating the outcomes of their courses. Consortium meetings therefore are most valuable for members to reflect and construct their own understanding of IBSE taking their own sociocultural context into consideration.

### *3. A short Insight into Elected INQUIRE Training Courses*

Although each individual partner's course design would be worth mentioning in this paper, we had to select five partners to be presented here. These partners are the Royal Botanic Gardens Kew, UK; University Moscow Botanic Gardens; The Natural History Museum Trento, Italy; a training course facilitated by two Partners located in Bremen, Germany - the Green Science Center botanika Ges.m.b.H and the Institute of Biology Education at the University of Bremen; and University Botanic Gardens in Innsbruck, Austria.

At the **Royal Botanic Gardens at Kew** both Educators and Teachers have demonstrated a great interest and appetite for finding out more about IBSE pedagogical delivery and are excited about the concept of climate change, biodiversity and sustainability. Secondary Science and Geography teachers are keen and interested. The 60 hours training is a challenge for them due to their heavy teaching work load and/or their reluctance of school management to release them from their teaching duties. In practice teachers require at least a six months notice to gain permission and arrange to attend such an in-depth course. A course requirement - to bring a school group to Kew - means recruitment of course participants needs to be local to our site. Educators have been prepared to travel long distances and are not restricted to bringing a school for an

onsite IBSE visit to Kew as they will undertake this session in their own organisation. Challenges for educators were frequent evening sessions initially proposed in our programme. There is certainly an appetite for this type of course for educators as reflected in their response to attend and the waiting list to join the course.

The learning programme across Kew sites has appreciated the power of engagement and learning using IBSE pedagogy. All Educators on the course have been keen to trial IBSE activities immediately with their school visits and have been excited to share the results. Educators on the course and on the waiting list are keen to start up their own teacher training courses at their own site, which will increase the reach of IBSE and embed the practise nationwide. The most influential outcome has been to demonstrate an IBSE activity and the criteria checklist to England and Wales curriculum and assessment organisations. The potential of disseminating IBSE practise through the national curriculum via the UK assessment bodies is an exciting development.

The 1 year course for teachers and educators course at **University Moscow Botanic Gardens** is a 72-hour program, certified by University Moscow. The course contains 36 hours of workshops and lectures in the Botanic Garden, 10 hours of activities in the Botanic Garden, 26 hours of self-study and on-line communication with teachers to share experiences and a Final Assignment. The aspects of the course that worked well have been:

- The INQUIRE website, which we are actively using to publish lesson and presentation resources. (After each session all the information is placed on the website.)
- As the course participants have been given access to all the different language sections of the website, we suggested that they ask their language teacher colleagues to use materials they had selected as translation tasks for pupils
- One very important factor is the relaxed atmosphere in our classes, giving the teachers the opportunity to discuss issues and share experiences

Using the formative assessment methods we have identified a number of issues during the course and made adjustments in response to the feedback. The teachers wanted more hands-on activities and we increased the number of practical sessions and combined topics and activities from three different modules in each session. There have been some difficulties involving Garden colleagues, as the new teaching approach has to be explained to them. To overcome this we are working together to revise our lesson plans and materials. Our teachers don't have much experience of reflective practice, so there have been some difficulties with this aspect of the course. We are trying to include elements of reflective practice in each class and to get the teachers involved in discussing the technique and assessment criteria and compiling tests to help them make progress.

**The Natural History Museum Trento, Italy** course runs from October to May in 4 parts: Theoretical, Case studies of IBSE, Creative workshop, Testing and reporting. The course is well subscribed with 30 participants (16 Educators, 14 Teachers) and there has been regular participation and engagement within the sessions. The main challenges experienced have related to estimations of participants' prior subject knowledge, their computer literacy and late submissions of course work by participants. Our response has been to begin each session with an outline of the background theoretical information - to address subject knowledge; to promote the use of IT, web 2.0 and to send regular reminders to participants when deadlines and submissions are approaching.

The goals of the course in **Bremen, Germany** are:

- Promotion of subject knowledge about biodiversity and climate change in the school context
- Testing, discussing and reflecting methods of inquiry-based science education (IBSE)
- Focusing on inquiry-based learning outside the classroom
- Networking and cooperation in Learning Communities of teachers and garden educators
- Lesson plan development and curricular embedding.

The main challenges experiences and solutions trialled include that the course promotion did not reach enough teachers. We now aim at earlier distribution of course information and promotion by the participants of the current course. The participation of the 'Round tables' and the activity on the project website between the teacher training meetings are low and we now offer individual training in using the website and more time to discuss the development of common lessons. The course is time consuming, longer than most training for teachers. We aim to offer better support of the teachers by their IBSE lesson planning. The course is held during the winter so we need to draw attention to the possibilities of the botanical garden during winter.

What works well in the **University Botanic Gardens in Innsbruck, Austria** has been the IBSE theoretical background, teacher's individual IBSE concepts, support argumentation, the introduction in the method of Concept Map, and hands on IBSE. The main challenges have been: understanding the Nature of Science, developing confidence in IBSE and Reflective Practice. The key lessons learned from participants' feedback have been: more flexibility in the course structure, fewer and clearer IBSE questions, more time to do the tasks, more attention creating comfortable working environment in the botanical garden and to have central contact person at hand who functions as a crystallization point for the learning community.

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