Quality Management Report



INQUIRE Inquiry-Based Teacher Training for a Sustainable Future





INQUIRE Quality Management Report

Dr Elaine Regan and Professor Justin Dillon

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The following institutions are Partners in the INQUIRE project:

- University of Innsbruck, Austria
- Royal Botanic Gardens, Kew, UK
- King's College London, UK
- Museo delle Scienze, Trento, Italy
- University of Sofia, Bulgaria
- Agencia Estatal Consejo Superior de Investigaciones Cientificas, Spain
- University of Bremen, Germany
- Jardin Botanique de la Ville de Bordeaux, France
- National Botanic Garden of Belgium
- Schulbiologisches Zentrum, Hannover, Germany
- Natural History Museum Botanical Garden, Norway
- Coimbra Botanic Garden, Portugal
- Moscow State University Botanical Garden, Russia
- University of Lisbon, Portugal
- Botanischer Garten, Rhododendron Park, Botanika, Bremen, Germany
- Botanic Gardens Conservation International, UK
- Universidad de Alcala, Spain





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For more information about INQUIRE visit: www.inquirebotany.org







Students' inquiry activity at UBG, Bulgaria

1. Executive Summary

Botanic gardens and Natural History Museums represent a significant educational resource, often acting as major providers of a diverse range of formal and informal education programmes for people of all ages and levels (frequently with links to national curriculum). INQUIRE is a three year project focusing on Inquiry-Based Science Education (IBSE) involving 17 Partners in 11 European countries¹, aimed at reinvigorating IBSE in the formal and Learning Outside the Classroom (LOtC) educational contexts in Europe. Fifteen teacher IBSE training courses were developed, piloted and run in 14 botanic gardens and natural history museums, and in one University, representing educational programs at the intersection between formal and informal learning environments. Botanic Gardens Conservation International (BGCI), the University of Innsbruck (LFU) and King's College London (KCL), UK offered support during this process. The role of the university Partner², King's College London, has been to support, monitor, document, and collate the implementation and outcomes of the INQUIRE project, in particular to support Partners with reflective practice and evaluation.

The contents of this report are based on a qualitative evaluation strategy carried out by King's College London. The study centres on the examination of the INQUIRE Partners design, implementation and delivery of their IBSE teacher training courses. The data sources include semi-structured interviews with Partners, Partner portfolios of evidence and artefacts such as proposed and amended course design posters, lesson plans, course plans, outdoor IBSE activities, fieldnotes from support visits and

2. The responsibilities of the university Partners (King's College London and University of Bremen) changed in January 2012. King's College London took over sole responsibility for Work Package 7 – see The Grant agreement p64.

^{1.} All Partners are listed at the end of the executive summary.



Partner meetings, and contributions to project deliverables. All the findings are illustrated with specific examples and quotes from individual Partner projects including references to the academic literature. The aim of this report is to present the Quality Management Team (KCL) findings from the data and experiences gathered by INQUIRE's seventeen³ Partners.

The findings and conclusions fall into the following key areas of interest in the project: the collaborative development of science teaching in Europe; the status of learning outside of the classroom; the influence on the formal and informal sector; and the ability of botanic gardens to support LOtC.

Reporting conventions

In the text of this report, the following conventions are used:

Partners refer to the members of the INQUIRE project consortium (see next page for the complete list of Partners). There are 3 German Partners, (Uni-HB, BGRHB and SBZH); there are 2 Portuguese Partners (FCTUC and UL); and 2 Spanish Partners who have worked collaboratively on their courses (CSIC and UAH).

Participants refer to the teachers and educators enrolled on the INQUIRE courses in each country. Management board (MB) refers to the consortium members dedicated to ensuring the smooth operations of the project and the achievement of INQUIRE objectives. MB members are listed overleaf. [KEW, R1] indicates a quote taken from a Round 1 interview with UK Partner, Kew gardens in the pilot year of the course.

[FCTUC POE, 2012] indicates an extract or summary from the Portfolio of Evidence produced by the Portuguese Partner in Coimbra.

[BGRHB, Artefact] indicates an extract or summary from an artefact produced by the German Partner from Botanika Bremen.

[Name, Conference abstracts] refers to the contribution (poster, paper, workshop) from an individual Partner, teacher or educator that participated in the Final INQUIRE conference in Kew Gardens, July 2013

[Deliverable 4.2] refers to evidence drawn from Deliverable 4.2: Train the Trainers (TTC) Manual IBSE indicates Inquiry-Based Science Education

LOtC refers to Learning Outside the Classroom

PD refers to Professional Development

3. All Partners contributed to meetings, tasks and deliverables and these are utilised as artefacts/data.



List of Partners

Management Board:

- 1. UNIVERSITAET INNSBRUCK (LFU) Austria
- 2. BOTANIC GARDENS CONSERVATION INTERNATIONAL (BGCI) United Kingdom
- 3. KING'S COLLEGE LONDON (KCL) United Kingdom
- 4. MUSEO TRIDENTINO DI SCIENZE NATURALI (MTSN/MUSE) Italy
- 5. ROYAL BOTANIC GARDENS KEW (KEW) United Kingdom

Consortium Partners:

6. AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES

- CIENTIFICAS (CSIC) Spain
- 7. UNIVERSITAET BREMEN (Uni-HB) Germany
- 8. SOFIISKI UNIVERSITET SVETI KLIMENT OHRIDSKI (UBG) Bulgaria
- 9. NATIONALE PLANTENTUIN VAN BELGIE (NBGB) Belgium
- 10. LANDESHAUPTSTADT HANNOVER (SBZH) Germany
- 11. VILLE DE BORDEAUX (BORDEAUX) France
- 12. FACULDADE CIENCIAS E TECNOLOGIA DA UNIVERSIDADE DE
- COIMBRA (FCTUC) Portugal
- 13. M V LOMONOSOV MOSCOW STATE UNIVERSITY (MSU) Russian Federation
- 14. UNIVERSITETET I OSLO (NHM) Norway
- 15. BOTANIKA GMBH (BGRHB) Germany
- 16. UNIVERSIDAD DE ALCALA (UAH) Spain
- 17. UNIVERSIDADE DE LISBOA (UL) Portugal

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2. Background

Botanic gardens have traditionally had a role in research, teaching, and public education and currently have a mandate to educate students and the public, at all levels, about the Global Strategy for Plant Conservation (GSPC) particularly in light of 'the demands posed by climate change' (Schulman and Lehvävirta 2011 p.218). Climate change and biodiversity loss are major threats to achieving the Millennium Development Goals. Ensuring a more sustainable future will require a range of responses, including for instance, greater support for natural solutions and expansion of the world's protected areas (Lopoukhine et al 2012). Thus, biodiversity loss and climate change are two of the major challenges facing society in the 21st century. Schulman and Lehvävirta (2011) report that 'we are facing an unprecedented plant diversity crises' and furthermore 'climate change seems to rapidly have become recognised as the primary threat to many plants' (p.217). If society is to address these challenges in the future, young people will need to be literate and environmentally aware so as to participate in public debate as politically mature citizens. Botanic gardens and natural history museums represent a significant educational resource often acting as major providers of a diverse range of formal and informal education programmes for people of all ages and levels (frequently with curricular links).

Stemming from Europe Needs More Scientists (EC, 2004) and Education NOW: A renewed Pedagogy for the Future of Europe (EC, 2007) recent innovations in science education in and out of school have focused on IBSE which has been shown to support students' interest in science as well as the development of critical thinking skills. Furthermore, there is mounting evidence that LOtC can stimulate students' motivation in learning more about the world around us as well as supporting them to develop a wide range of skills. This is particularly important in a time of reported decreasing connectedness with nature (Louv, 2005; Bragg et al, 2013). It was against this background that the INQUIRE project developed.

INQUIRE is a three year project focusing on IBSE involving 17 Partners in 11 European countries⁴, aimed at reinvigorating IBSE in the formal and LOtC educational contexts in Europe. The overall aim of the INQUIRE project is the widespread uptake of inquiry-based teaching and learning across Europe. Fifteen Partners have developed, implemented and evaluated one-year IBSE teacher-training course, with support from Botanic Gardens Conservation International, University of Innsbruck and King's College London, UK.

The original grant agreement states (p.64) that The Quality Management Team is responsible for ensuring that the project meets the INQUIRE objectives and that resources are used effectively. The Quality Managers (KCL, Uni-HB) will facilitate a clear systematic approach for achieving goals. The responsibilities for the work package 7: quality management was altered from the original grant agreement in January 2012 with sole responsibility for the work allocated to King's College London. In this report, all references to the Quality Management Team refer to King's College London only.

^{4.} All Partners are listed at the end of the executive summary





An IBSE activity on the growth of plants at NBGB, Belgium

INQUIRE had 11 objectives (Part B of the Grant Agreement, p.4):

- 1. To introduce IBSE in formal and informal settings on a large scale
- 2. To snowball best practice pedagogical approaches through practitioner training
- **3.** To establish a key network of educators, teachers, teacher trainers and researchers for the revival of IBSE
- 4. To offer front-line support to teachers and informal educators to practice IBSE

5. To use IBSE to engage young people in a scientific discourse about biodiversity conservation and climate change

- 6. To bridge the gap between educational researchers and practitioners
- **7.** To support the development of European wide standards for evaluating formal and informal education programmes
- 8. To make the case for inquiry and context based learning
- 9. To examine the implementation of curriculum based innovations
- 10. To stimulate and motivate science learning from the earliest stage
- 11. To increase the self-confidence in girls to study science

The role of the university Partner, King's College London, as the Quality Management Team (QMT), has been to support, monitor, document and collate the implementation and outcomes of the INQUIRE project and ensure that the project delivers its objectives (Grant agreement Part B, p. 64). In this report we focus on the multi-site pan-European evaluation of INQUIRE teacher-training courses combining IBSE and LOtC in biodiversity and climate change. All the findings are illustrated with specific examples and quotes from individual Partner projects including references to the academic literature, where appropriate.



2.1 IBSE in INQUIRE

IBSE is probably most frequently defined as an approach to teaching science which engages students in the same sorts of activities, practices, and thinking processes that scientists use in their work (i.e. in their pursuit of scientific inquiry). The NRC sum up the benefits of inquiry-based approaches to teaching and learning science as follows:

When engaging in inquiry students...identify assumptions, use critical and logical thinking, and consider alternative explanations. In this way students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills. (NRC, 1996, p. 2)

In order to recognise when inquiry is taking place, the NRC put forward five 'features', which they suggest are essential for identifying scientific inquiry (NRC, 2000, p. 25), an Inquiry Science Indicator Checklist was developed by the KEW team based on these features for use in the project (a copy is located in the appendices). These are:

1. Learners are engaged by scientifically oriented questions.

2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.

3. Learners formulate explanations from evidence to address scientifically oriented questions.

4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.

5. Learners communicate and justify their proposed explanations.

INQUIRE recognised that inquiry-based teaching and learning is complex and that specialist aspects such as argumentation skills or disciplinary differences need to be taken into account. Therefore, INQUIRE specified learning environments in which the following learning can be applied:

- learning is problem-based and involves questioning and hypothesis generation;
- learning is based on modelling and experimentation;
- there is cooperation between learners working in groups;
- there is cumulative learning resulting from curriculum and standards;
- there is space to learn from mistakes;
- diversity, including gender, disability, ethnicity and socio-economic background is recognised;
- there are self-regulated learning sequences where student autonomy is emphasised;
- the central consideration in the design of activities is student interest and motivation.

2.2 Aims of this report

The purpose of INQUIRE is to achieve a high degree of course quality with all participants, addressing formal requirements in an effective, timely and responsible manner. The Quality Management Plan set out the quality assurance procedures for the INQUIRE project (see Deliverable 7.1). Consequently, the Quality Management Team was responsible for ensuring that the project met the INQUIRE objectives and that resources were used effectively.



In acting as quality managers and evaluators of the INQUIRE project, the role of the academic Partner (King's College London) was to support and advise each Partner on their course design and evaluation, and to document the varied practices with which each Partner engaged with in the design, implementation and evaluation of their teacher-training courses. KCL visited each participating Partner in their own garden once during the project duration to discuss local circumstances. Each Partner project was conducted following general INQUIRE principles but was informed by their own local contexts. Consequently, no direct comparison or 'score of success' is applied within this report. A pan-European, cross comparison of the courses using common dimensions of analysis was possible, employing a qualitative case study approach.

Evidence of the influence on professional development (PD) was collected on four levels during the implementation of the INQUIRE courses:

- Community of practice;
- Reflective practice;
- Inquiry-based Science Education (IBSE);
- Informal and formal education contexts.

These have been embedded into the presentation of findings outlined in 3.8.

This report addresses the following aims:

To present a set of findings on the nature, practice and outcomes of the INQUIRE Partner courses and activities

To present a set of findings on the nature, practice and outcomes of the INQUIRE project

To summarise the areas of success emerging from the design, implementation and evaluation of the IBSE teacher-training courses

To discuss these findings in relation to our experience in the field of science education and the research literature.



Students investigate seeds from fruit at NHM, Norway



3. Methodology

The findings presented in this report emerged from the analysis of fifteen INQUIRE teacher-trainer courses. The fifteen INQUIRE teacher-training courses were developed and implemented in a variety of contexts (national, local and political). Consequently, our research data consists of a participant observer perspective on a range of data sources. The data includes semi-structured interviews, portfolios of evidence, and artefacts such as proposed and amended course design posters, course plans, lesson plans outdoor IBSE activities, fieldnotes from support visits and Partner meetings and contributions to project deliverables. The nature of each data collection technique is outlined in this section, (see Table 1).

The analytical approach is based on a qualitative evaluation strategy carried out by King's College London and draws on frameworks such as Miles and Huberman (1995); Guskey, 2000; Hatton and Smith (1995). The study centres on the examination of the INQUIRE Partner's design, implementation and delivery of their IBSE teacher training courses using our experience in the field of science education and existing research literature. In implementing the quality management plan we offered support, advice and suggestions to each Partner about the best ways to develop their courses, activities and evaluation strategies. In addition, in conjunction with other members of the Management Board of the project, we helped in the identification and resolution of key issues, encouraged collaboration and sharing between Partners in order to strengthen the INQUIRE consortium.

3.1 Interviews

The interview protocols and the overarching framework for the Quality Management Plan was discussed and agreed within the MB, in advance. Semi-structured interviews were conducted with each Partner (n=14) during the implementation stage of the pilot courses to explore reflective practice and evaluation strategies. These were intended to be both evaluative and formative in nature, highlighting through questioning a need for an evaluative approach to the design and implementation of the INQUIRE course.

This set of short interviews (approx. 40 minutes) was conducted during the 3rd Partner Meeting in Spain, February/March 2012. A second semi-structured interview following the final INQUIRE course explored similar themes in addition to exploring the influence of participation in the INQUIRE project on Partners and their institutions. All Partners (n=14) contributed with either face-to-face interviews (n=10), Skype interviews (n=2) or email responses to interview questions (n=2). These final longer interviews (approx. 60 minutes) took place at the final INQUIRE conference and at the final Partner Meeting in Trento, Italy October 2013. In most cases, the interviews involved contributions from several members of each Partner's team, for instance three members from MTSN/MUSE, NBGB, CSIC/UAH, KEW or two members from LFU, SBZH, NHM, and UL. Quotes from these interviews are not attributed to any individual but to the Partner group.



Table 1: Description of data sources

Data Source		Description	Purpose		
Interviews	Semi-structured interviews	Interviews exploring reflective practice, evaluation and progress with PIC course implementation	Semi-structured interviews after pilot inquire course as a formative discussion about feedback and evaluation		
	Semi-structured interviews	Interviews exploring reflective practice, evaluation, issues with final course implementation, and personal gains from taking part in the project	Semi-structured interviews after final inquire course as a discussion of the course evaluation and outcomes from the project		
Artefacts	Materials from Partner meetings	Posters outlining plans for course structure, evaluation, lesson and session plans	To assess how Partners have modified their materials to develop IBSE lessons in LOtC setting, in response to support and evaluation		
	Other artefacts from project planning and reflection	Additional artefacts such as documents prepared as part of project tasks and deliverables	Provide insights into the reflective cycle processes, the development of a shared understanding of IBSE, the contribution to the community of practice and the professional learning		
Portfolios of Evidence	Evidences are collections of artefacts that show Partners' work and participants' learning	Provide a written commentary that explain the role of the artefacts and the evidence of course evaluation	Provides insights into critical reflection, professional learning and influences of the course		
Fieldnotes	Fieldnotes from support visits, Partner meetings and INQUIRE conference	Descriptions of events	Provide additional data to explore the design, implementation and evaluation of the INQUIRE courses		
Project Deliverables	Submitted deliverables to the EU as part of the project	Monitoring the implementation of the INQUIRE project	Provide additional data to explore the design, implementation and evaluation of the INQUIRE courses		





IBSE activities at Cambridge University Botanic Garden

3.2 Artefacts

Partners completed various project tasks and produced many artefacts during the INQUIRE project in preparation for the Partner meetings. Examples include posters outlining the intended structure of their INQUIRE course and their anticipated strategies for evaluation, course plans and lesson plans for review by the consortium members and resources for use within the course. These artefacts provide insights into the reflective cycle processes of the Partners while designing the INQUIRE courses, the development of a shared understanding of IBSE in botanic gardens, the contribution to the community of practice and the professional learning and development of all members of the consortium. Many project deliverables produced during the INQUIRE project generate data and examples relevant to the research questions. For instance, Deliverable 2.2 summarises how IBSE was defined in the INQUIRE course in the first year of the project while deliverables 4.4 and 4.5 collate data from all Partners in relation to feedback from their course participants.

3.3 Portfolios of evidence

The INQUIRE courses employ an "evidence-based" approach to support collaborative inquiries of teachers and botanic garden educators. Evidences are collections of artefacts in a particular science learning domain that show Partners' work and participants' learning, combined with written commentaries that explain the role of the artefacts within the learning context (Harrison et al. 2008). As such, Partners compiled and submitted portfolios of evidence to illustrate their reflective practice and course evaluation. The brief one-page summary of outline guidelines is located in the appendix.

Each botanic garden Partner compiled a portfolio of evidence (n=14) complete with artefacts (written and visual material) following the completion of the pilot and final phase of the INQUIRE course which we analyse for insights into critical reflection, professional learning and influences of the course.



The emphasis in portfolio development was on two different levels:
on the process of the portfolio construction (formative approach);
and on the portfolio as a product (summative approach).
The process of collecting, explaining and justifying the evidence resources support professional development and reflection.

3.4 Fieldnotes

The support visits from KCL represent personalised support for Partners and an opportunity for participatory reflection. During the visits the QMT had the opportunity to collect data about the Pilot INQUIRE Courses (PIC) and discuss their development in the early stages. This provided support for Partners in terms of IBSE, reflection, evaluation and action research and chance to voice any areas of concern or anxiety about development, delivery and evaluation of the PIC. In the course of conducting these visits we offered advice and suggestions to Partners about the best ways to develop their activities, plan their evaluation processes, assist with the resolution of issues with the project delivery and shared the experiences of other INQUIRE Partners in order to prompt consideration of alternatives and to strengthen the wider INQUIRE network.

Field notes in the form of visit summaries and reflective accounts are the main source of data.

3.5 Structure of the findings

In this report we present a synthesis of the outcomes from the INQUIRE project in order to demonstrate the nature, practice and outcomes of both the INQUIRE project and the INQUIRE Partner courses and activities. Seventeen Partners established a community of practice to share ideas and resources to design, implement and evaluate one-year, practically based IBSE teacher training courses. 15 botanic garden and natural history museum Partners launched courses in 14 different locations (two Spanish Partners chose to work collaboratively in this endeavour). The synthesis includes data drawn from all sources, and where appropriate we include quotes from raw data, but given that English was not the first language of the majority of our Partners, comments have been summarised rather than quoted verbatim in some cases. The findings are complemented with specific examples from Partners, including references to the academic literature where relevant.

We present the findings that summarise the areas of success emerging from the design, implementation and evaluation of the IBSE teacher-training courses around 4 main areas of interest:

- Contribution of INQUIRE project to the development of science teaching;
- 2. The status of learning outside of the classroom;
- 3. Influences on the formal and informal sectors;
- 4. Botanic gardens and natural history museums' ability to support LOtC.

In the final section we provide a set of recommendations for science educators interested in building effective teacher-training programmes in LOtC contexts and to inform policy.



4. Findings from the INQUIRE project

4.1 Contribution of the INQUIRE course to development of science teaching

A central research question explored in this report is 'how does participation in the INQUIRE course contribute to development of science teaching?' The contribution has been evidenced by several indicators from the interviews, portfolios of evidence, fieldnotes and artefacts. These include participants' views of the course, evidence of changing practices of teachers and educators as a result of their participation in the course (including collegial and institutional change), evidence of participant learning, and or change in beliefs/attitudes towards IBSE and LOtC, the influence on their students, and lastly, the identification of barriers to implementing teacher training in LOtC sites and strategies to overcome them.

FINDING: The course material produced across the partnership is a high standard

Overall, the quality of the course material produced across the partnership is a high standard with regard to IBSE in LOtC and offers a variety of sources of learning materials for the development of science teaching [Deliverable 4.1, 4.2, 5.1]. Consequently, feedback from participants on the INQUIRE project has been predominantly positive and strong indications of changing practice have been noted across Europe.

4.1.1 Participants' views of the INQUIRE courses

FINDING: Participants' views of the INQUIRE course are predominantly positive

During the second year of the project (2011-2012), fourteen INQUIRE Partners developed thirteen pilot INQUIRE Courses (PICs) and during the third year (2012-2013) fifteen Partners developed fourteen INQUIRE courses in eleven countries (Two Spanish Partners ran one course, two courses were run in Portugal, and three in Germany). All Partners reported predominantly positive feedback (*'very enthusiastic', 'genuinely positive', 'they were very happy', 'committed'*) from both educator and teacher participants.

"It's really positive, very enthusiastic, just take body language, they are practically skipping out at the end of each day, they are excited, interested, engaged, suggestive, you know, wanting to be part of it all." [Kew, R1]

Many participants expressed strong demands for more time outside and more time to adapt and trial the lesson plans provided by the courses. The INQUIRE approach involved using previously available resources, where possible⁵, that participants could trial both in the gardens while participating in the INQUIRE course and subsequently with their own students – they could adapt approaches or materials where necessary. This proved to be very highly regarded; participants liked to go home with something



practical that they could use and enjoyed trialling, discussing and adapting them for practice.

'The teachers were very happy to be learning by doing, actually performing all the lesson plans and learning that way.' [NHM, R2].

"The last module was very exciting because we handed out some non-IBSE lessons and asked both garden educators and teachers to put the concept of IBSE on this topic. ... It was very constructive. They even wanted to spend more time outside of the module, yeah, the training course, to complete this IBSE module they were creating, so it was a very positive experience and the feedback was also very positive, that they even want to spend more time to create an IBSE module." [BGRHB, R1]

"There's someone who's very, very enthusiastic, she wants to do these IBSE things for everything, from every lesson." [NBGB, R1]

FINDING: The topic biodiversity and climate change addressed by the course was popular

Participants were drawn to the course to gather resources and ideas and to spend time learning in the gardens. Partners report that participants were pleased to see the topic biodiversity and climate change addressed by the course [Deliverable 4.4 p.9]. Although participants generally welcomed the topic area, because it addressed a gap in their contemporary science knowledge, it raised further issues within some Partners' courses. The expectations from participants in NBGB included that the course would be focused on this topic and not necessarily on the IBSE approach, while Italian teachers in the pilot course had difficulty accepting the science of extinction and the concept of local extinction [MTSN/MUSE, Fieldnotes Oct 2011]. In CSIC/UAH, however, the advice of the advisory board and education authorities prevented them from advertising the course using the term 'climate change'.

FINDING: Educators and teachers held different perspectives of the INQUIRE course

Differences in perspectives arose in some instances between teachers and educators and also between primary and secondary teachers. Garden educators in LFU, for example, saw 'the real chance to be different from the school day, to bring a new perspective into different topics...the garden educators, they really wanted to set up INQUIRE activities' [LFU, R1]. They were keen to develop their practice and learn how to implement a new pedagogical strategy. Teachers, on the other hand, often came to courses expecting to find information and resources. While working together on the practical activities in the gardens it became clear for many Partners that the applicability of the lesson plans and resources differed, depending on the age of the students being taught and the training of the teachers. Courses with both primary and secondary teachers were sometimes challenging.

"Teachers really wanted to have just information, 'you have to do this', but the method was not so important for them, but the educators maybe wanted to learn new ways to do things". [CSIC/UAH, R1]

"The educators had more misunderstandings because teachers have a pedagogical background,

^{5.} During the INQUIRE project the consortium recognised that resources for IBSE in LOtC settings were in short supply. The project adapted in response to this need; Partners subsequently devised, trialled and submitted new resources for peer review and development within the community of practice. Following an evaluation of these resources a new manual of activities was produced by the consortium and which will increase the wider influence of the project through its dissemination.



but educators, usually they don't have it so much. They have experience, they have a degree in Science, they have the skills, but not a theoretical background about what is constructivism or evaluation?" [CSIC/UAH, R2]

FINDING: The practical activities were successful in increasing IBSE knowledge and skills

For almost all participants on the INQUIRE courses, the most interesting elements were the practical activities because they could use them either immediately in their practice or find inspiration to develop new ideas for their lessons. This aspect of the INQUIRE courses strengthened their IBSE skills and knowledge. Invariably, the most common feedback comment from both the INQUIRE course participants, and the project Partners was a request for more practical activities and lesson plans. Consequently, although the original plan for the project was to use pre-existing resources, Partners have dedicated time to devise new IBSE activities for use in their educational programmes and INQUIRE courses.

"Our activities in the garden were huge sources of knowledge for us. We learned a lot about botany; either with the trainer or placing ourselves in the role of the students during the development of the activities, or in friendly discussion with the other trainees". [Educator from FCTUC, Deliverable 4.4 p.7]

"IBSE activities were a new area for me but one that I found engaging and interesting. This technique makes for a very interactive and engaging learning environment in the classroom". [Educator from KEW, Deliverable 4.5]

Comprehensive feedback from all project Partners relating to what went well on the pilot and final INQUIRE course and how it could be improved was collated by our Italian Partner. The categories and comments relating to reflective practice, sharing of knowledge and practice, IBSE activities, biodiversity and climate change content, the effects on children and aspects relating to the delivery of the courses are defined in greater detail in Deliverables 4.4 and 4.5.

4.1.2 Participant learning

FINDING: Partners require additional support to determine whether or not their learning outcomes have been achieved in their PD courses

In many cases during the Pilot INQUIRE course Partners struggled to articulate with evidence what their participants had learned as a result of being on the course. A strong feature of the first round of interviews with Partners was a realisation that they needed to move beyond recollections and perspectives of what was happening on their courses and the need to draw on evidence to support their claims. These early interviews were devised with this formative purpose in mind: to focus Partners' attention on an evidence-based approach to their evaluations. Partners often described their views of participant learning in terms of their intended learning outcomes for the courses, and in particular *'more ideas how to maybe, do IBSE activities in class…how to reorganise their lesson plans'* [UBG, R1] or *'how to formulate an open research question, to run an inquiry-based exercise, learning activity'* [LFU, R1].



The intended learning outcomes of all Partners' courses are detailed in Deliverable 4.2, the *Train The Trainer Manual*.

"I think if they can learn that it's all about putting questions when you see something, when you have observed something and that is a great way to make young people learn something. I hope that that will be the outcome, but I'm not able to measure it so much". [NBGB, R1] "They have seen another way of teaching and they learned that it's nice to get to create such a kind of lesson plan that is totally in another way that they usually use in their lessons. I think they've seen that their students are, they're successful themselves, and to see that the students learnt a lot and have been more engaged than before." [Bremen Botankia, R2]

"They learned that it's important to have background knowledge, to be open-minded... that the most important thing they learned is a special attitude, another attitude... They told us, that was the result of the course in their opinion". [LFU, R2]

FINDING: Educators demonstrated increased use of evaluation tools in their assessment of participants' learning, in some cases underpinned by a clear theoretical framework

Although during some interviews Partners responded with comments such as '*I hope they learned a lot of things ...*', the data from their portfolios in many cases showed an increased use of evaluation tools strategies that provided evidence of learning. Participants' learning was evidenced from observations made of teachers/educators completing their IBSE lessons either during visits to the botanic gardens or within their own classrooms, analysis of lesson plans or other teacher work submitted during the course, including concept maps and portfolios of evidence. Some Partners (LFU, BGRHB, and Uni-HB) applied a strong theoretical approach to their evaluation of participants' learning, such as Social Network Analysis, Concerns Based Adoption Model and Pedagogical Content Knowledge.

"We evaluated the participants' professional growth regarding their Pedagogical Content Knowledge (subject knowledge about biodiversity, biodiversity loss and climate change), their methodological knowledge (IBSE methods), their knowledge about assessment (portfolios, concept maps, concept cartoons, questionnaires, world cafes, interviews..), self-evaluation, curriculum, self-efficiency, knowledge about pupils' interests and pre-concepts". [Uni-HB, R2]

FINDING: Participation in INQUIRE courses increase knowledge and practice of IBSE and reflective practice techniques

In most cases, INQUIRE course participants have reported an improvement in their knowledge and practice of reflective practice techniques, a wealth of different teaching and assessment techniques, and IBSE activities, evidenced in Partners' evaluations (interviews, questionnaires, evaluation sheets or world café workshops).

"Reflective practice is useful. I try to check after each activity, whether or not it had the expected result. If it hadn't, I try to find out what way I can change the questioning, the subject, or the support I give to children" [Educator from NBGB, Deliverable 4.4 p.7]

"The practical sessions gave me a feel for the differences between INQUIRE activities and ordinary excursions, and it's really great!" [Teacher from MSU, Deliverable 4.4 p.7]



"I got to know that IBSE doesn't need to involve 'hands-on' activities, but there has to be an inspiring and stirring task like a 'minds-on' activity". [Student teacher from Uni-HB, Deliverable 4.5]

Generally, the areas of learning evidenced through various evaluation strategies include learning about IBSE as a method, the theoretical components, reflective practice techniques and 'contemporary plant conservation issues such as restoration of regional endangered species, invasive plants and the impact of climate on plants, and Garden-based research work with students' [MSU, R2]. For many teachers and educators the experiences on the INQUIRE courses extended to speaking at conferences, such as the final INQUIRE conference, writing articles about their experience of making lesson more exciting using garden resources and through the inclusion of debates, concept maps and concept cartoons.

"I think they learned the method, to apply the method and they learned about our modules, how to teach biodiversity from the global view and from the local view and we gave them also expert knowledge about climate change and climate". [SBZH, R2]

FINDING: INQUIRE courses addressed some of the common misconceptions about IBSE

Partners across the project spent time during their courses addressing some of the common misconceptions of IBSE and barriers to using the approach in teaching and learning while developing participants' understanding of the method. In terms of participants' learning this manifested as a realisation that they could incorporate aspects into some, rather than all, of their lessons, and that it did not have to involve extended projects with their students. '*Small examples*' included using concept maps, concept cartoons, focusing on developing an inquiry question.

"I would say that there are two aspects about their learning. I think the most important might be that they feel that they have to give children the time to think about a question, they don't have to come to answers or solutions or whatever to help them quickly because they wouldn't find it, it wouldn't be helpful, a kind of quietness in waiting and seeing what comes from the children, what questions do they have, what do they understand."[NBGB, R2]

"Well, I want to think that they have changed a little bit their minds, to know from traditional teaching methods for the new ones, the INQUIRE methods and maybe now they have an idea that, well, they don't have to use it for the whole programme, well, they can use it for some topics and it is alright".[CSIC/UAH, R1]

"I think they have learned because I felt, when I know that at the very beginning they have misunderstood what IBSE is, because they thought, oh and you make some kinds of activity, it's inquiry, when you make any question, it's inquiry, but no, inquiry-based learning has special characteristics and not everything's inquiry and this is something that I think they have learned...we could see that through the lesson plans". [CSIC/UAH, R2]

FINDING: Participation in INQUIRE courses led to increased engagement with outdoor learning environments

Many participants across Europe had never visited a botanic garden before attending the courses. For many, participant-centred learning involved overcoming a fear of inquiry, a fear of outdoor learning and



a realisation that 'there are a lot of resources in the botanic gardens that they didn't know before' [CSIC/UAH, R2]. Through the INQUIRE courses, participants learned to be comfortable with the botanic garden as an outside space for learning and to develop their own investigations using gardens and outdoor spaces [UL and FCTUC, R2]. The result was many more teachers wanted 'to come to a botanic garden' and recognised that they 'could do inquiry-based work here' [KEW, R1] and overall, 'to change their way of working' [BORDEAUX, R2]. For educators in particular, 'the opportunity to learn more about teachers' [CSIC/UAH, R2] was the result and consequently, for all, learning how to collaborate with multiple stakeholders: between teachers, educators, trainers, scientists and experts.

4.1.3 Changing science teaching practices

FINDING: Science teaching practices changes for course participants and also within course providers' institutions

Changes to science teaching practices were observable in many Partner institutions and within the participants' practices in their schools and in gardens. The excitement and enthusiasm for the INQUIRE courses outlined in the opening section (4.1.1) resulted in a snowballing effect for participants. Teachers and educators returned to their work environments and shared the information and activities with their colleagues and proceeded to implement the lesson plans and activities with their students. An educator on the UK course returned to her garden to speak with her director about making their programme more inquiry-based, resulting in a change to the entire family summer programme [KEW, R1]. Most of the botanic garden Partners in the INQUIRE project remark *'we changed our practice, but it's changed the botanic gardens'* [UBG, R2]. The change in science teaching practices reported by Partners includes altering existing lesson plans for their school groups to make them more open and IBSE focused, which was found to be very useful for their day-to-day work. Many Partners also devised new lesson plans that focused specifically on both an inquiry-based approach and biodiversity/climate change topics.

"Yeah, we changed, I mean, not at every lesson, but some lessons are different than two years ago, so we always, if we create something new, we mostly now do it like INQUIRE."[BGRHB, R2] "It has changed a lot for our garden. We have employed two people first, [laughter], one of the things is we develop new workshops and things for schools, with this IBSE background. We're not meaning that every activity has to be a pure IBSE activity in future, but whenever it is possible, trying to put these things in and think about it in that way and so from the institution, that's changed a lot, yeah." [NBGB, R1]

Through a combination of garden visit observations, teacher lesson plans, portfolios and discussions with participants, many Partners provided strong evidence of changing science teaching practices in their participants. During a reunion organised by the NBGB Partner, teachers from the PIC course shared their experiences of embedding the lessons learned during the course in their daily classroom practice, while a LOtC educator claimed that every activity he develops was now based on IBSE [NBGB, R2].



"Ideas for new lessons, techniques, and question setting very often arise during discussions with teachers and this has resulted in an atmosphere of joint creativity. The teachers quickly picked up the IBSE concept and are now proactively promoting it themselves at various teacher conferences". [MSU, R2]

Several INQUIRE courses were structured around demonstrating IBSE activities and lesson plans, in fact encouraging, participants to try the activities, modify the activities and create their own IBSE activities for use in gardens or outdoors spaces. This proved to be a valuable design in terms of encouraging changes to science teaching practices of the course participants, in most cases.

"[Participants] were supposed to do an IBSE activity with the children and report it to us [in a portfolio], but some of them, their activities were very good, very INQUIRE and so on, but some of them, not at all". [CSIC/UAH, R1]

FINDING: Participation in the professional development led to institution-wide changes to education provision and practice

In many of the Partner courses, their own garden educators or museum educators attended the course and in some instances continued to contribute to them in subsequent years. The result of this approach to the professional development of educators in the gardens and museums was institution-wide changes to the education provision and teaching practices employed by the botanic gardens. *"we have noticed that they have changed a little bit their way to do things and also they want to change the activities and the lesson plans we use and so on to implement more the inquiry*

based learning, so they are more aware of this methodology". [CSIC/UAH, R2]

Changes in approaches to science teaching practices were also evident within the academic Partners in the project. Uni-HB devised an INQUIRE course for student teachers and report that these changes have been incorporated into the regular teacher education curriculum at the University. IBSE approaches (open, guided and structured) and assessment techniques now operate in the *"Modul 4 - 180 hours – 6CP 'Research and Methods in Biology Education"* [Uni-HB, R2].

FINDING: Teachers' attitudes towards and confidence using IBSE was increased as a result of INQUIRE courses

Changing teaching practices is often a slow process, beginning with a shift in beliefs and attitudes. Barbara Scapellato, an Italian teacher trainer, presented her work at the INQUIRE conference. In her poster, entitled Taking IBSE approach into Italian secondary school: the challenge of innovation, she explores the effects of in-service IBSE teacher training on teachers' confidence regarding IBSE teaching and their views of the impact of IBSE learning on the students. Her preliminary findings show an increase in teachers' confidence using IBSE and increasing perceptions that using an IBSE approach improves the quality of their teaching [INQUIRE conference abstracts].

Observation of classroom practices was often limited and Partners relied on teacher self-reports



regarding any changes to the latter's teaching practices. Some Partners, through their pre- and postquestionnaires and in their analysis of lesson plans submitted by participants, have reported a change in teachers' attitudes towards their teaching, resulting in teachers designing their lesson in a more reflective way [LFU, R1].

"In their attitude, in their practice, their way of formulating questions, instead of giving answers and they even didn't know how much the botanic gardens and the institutions can help them, using resources to accomplish their programmes" [FCTUC, R1]

The final INQUIRE conference provided an opportunity for several participants from each Partner country to present their work. Inessa Voynova from the Moscow course documented her changing practice as a reflective account entitled *'From Reflection to Research'*. She lists some of the projects she has run in 2013 highlighting her changing practice and dedication to inquiry, learning outside of the classroom and learning in informal environments [INQUIRE conference abstracts]. Svetlana Buldygina also from MSU provides strong testimony of her changing science teaching practices. She illustrates her understanding of IBSE, her commitment to the development of her teaching and her plans for further work.

"Since attending the INQUIRE course I have expanded the range of lesson topics, made broader use of reflective practice by the students themselves and organized my teaching around scientific research... Due to a lack of specialized equipment I have devoted much of my lessons to debating, gathering and evaluating facts, planning experiments and constructing hypotheses. I have begun suggesting that students conduct independent research as part of their homework, including tasks such as observation, planning experiments, problem analysis, preparation of questions for debate and creative work (such as writing scenarios, stories, crosswords and presentations)". [Svetlana Buldygina, INQUIRE conference abstracts].

In addition to acknowledging a teacher's prior experiences, it is important to consider how teachers' beliefs about their practice and ability will shape their expectations and desires to learn. Beliefs often influence behaviour (Pajares, 1992) and pedagogical practices are informed by beliefs. Science teachers' beliefs include: how children learn and should be taught (Calderhead, 1996), their epistemology of science (Tobin, 1998; Sutton 1996) and their notion of science content (Mulhall and Gunstone, 2008).

FINDING: Participation in the INQUIRE course led to increased levels of LOtC

The enthusiasm for inquiry-based approaches instilled within the INQUIRE courses also led to increased levels of science learning outside. In NHM, UL and MSU, for example, teachers have become more interested in the garden as an educational space, developing both resources and activities such as insect hotels. Some of these examples were presented at the final INQUIRE conference at Kew Gardens in July 2013. Diana Koleva, a teacher from Bulgaria, explored 'A Green Laboratory in School Yard' to create accessible environment where the children work as scientists. Her goals included the development of critical thinking, self-confidence and the integration of disadvantaged



young people and children with special educational needs into the outdoor learning environment [INQUIRE conference abstracts].

"Garden educators have become more active in developing Garden resources and creating new resources for LOtC (creating new teaching aids and expanding the Garden's exhibitions). Many of the resources are being converted into electronic form to provide free access to them." [MSU, R2]

"The teacher asked the school if they could use the garden, if the teachers and the students could use it to plant, to have some agricultural plants, some fruits or some vegetables. They sent us some photographs". [UL, R2]

The timing of the project also coincided with the publication of a revised edition in line with the new Russian education standards of Alla Andreeva's nature studies textbook for 5th grade students. As a result, she incorporated many IBSE ideas in the book which made it more up-do-date and offers enormous potential impact on teaching science in Russia.

4.1.4 Student learning outcomes

FINDING: Students' interest and engagement with science in botanic gardens was increased using IBSE activities

Partners reported on student learning outcomes in a number or ways, drawing on observations from the garden and classroom based lessons that their participants led, and on teacher reports of student outcomes from discussions and teacher portfolios. The majority of the influences were noted in terms of affective outcomes, for example, increasing students' interest. The outdoor landscape and environmental features have an impact upon how students learn, behave, develop personally, and gain a respect for the environment (Lieberman & Hoody, 1998; Sobol, 2004; Tanner, 2000; Titman, 1994). In addition to helping children develop intellectually, children's relationships to the outdoors help their physical, emotional, social, and spiritual development (Johnson, 2000).

"I saw some normally passive students becoming actively involved in the research work in the garden. It was a complete surprise and I began to see them through different eyes". [Teacher from MSU, Deliverable 4.4 p.10]

Other student learning outcomes centred on the development of scientific process skills such as observation, critical thinking, asking questions, and developing hypotheses, and social abilities such as listening and debating. Some Partners, such as NHM, adopted principally inquiry-based assessment strategies such as the KWL worksheet (What I Know, What I Want to Know, What I learned) which documented the knowledge that students gained from the inquiry approaches. Several participants note that they felt that IBSE was suitable for a range of student ability, including students with special needs.



FINDING: Students show increased understanding of issues of biodiversity and climate change Several posters and paper presentations at the final INQUIRE conference highlighted participants' explorations of student learning outcomes. Svetlana Soboleva from MSU presented her work at the INQUIRE final conference. She has integrated IBSE approaches in science with foreign languages using the project website (inquirebotany.org). She documents students' increased understanding of global issues such as biodiversity conservation and climate change through translation of articles from the website, which form topics for discussion in biology lessons [INQUIRE conference abstracts].

Fernanda Filipe, a Portuguese teacher, presented a paper at the conference showcasing a research project entitled *'Processionary caterpillars in January ...?'* designed by his students to answer their own research question: "Why are caterpillars already processing in January?" Although the presentation focused on the affective outcomes for students, Fernanda illustrates how his students engaged in scientific process while gaining an understanding of climate change issues [INQUIRE conference abstracts]. Portuguese educator Catarina Loureiro's presentation of her IBSE project work *Climate change: good or bad?* has a greater focus on students' cognitive learning outcomes. Through an exploration in the garden students showed a better understanding of the tree's role in an ecosystem, comprehending that trees need carbon dioxide, water and soil to survive, also serving as support and shelter for soil, plants and animals. Moreover students debated possible scenarios, proposing solutions to minimise climate change effects and naturally the answer to the question-problem emerged: climate change can be considered both good and bad [INQUIRE conference abstracts].

FINDING: Students require support with making connections and terminology during IBSE activities

Similarly, Petra Bucher-Spielmann from LFU explored scientific terminology during an IBSE activity with 10-13 year olds in a poster entitled '*Acquirement of scientific terms and vocabulary in IBSE (inquiry-based science education)*'. This study revealed that teenagers try to paraphrase items and processes when they lack the correct terminology. Petra suggests strategies for increasing scientific vocabulary acquisition during IBSE activities in botanic gardens [INQUIRE conference abstracts].

Elisabeth Carli from LFU explored whether children are able to link the IBSE activities performed in the garden with the overall scientific question being explored. Using video observations and photographs, children's notes on their hypotheses she found that children were able to link activities with each other, but unable to link the activities to the all-encompassing scientific question. The paper shows that it is important to confront the children with a problem, maybe create a dilemma, so that finding a satisfactory answer to this all-encompassing scientific question remains their main focus. While focusing on achieving student learning outcomes, this research shows that children have to know at any given time "what" they are doing and most notably "why" they are doing it [INQUIRE conference abstracts].



4.1.5 Difficulties with providing professional development in botanic gardens

FINDING: Fostering IBSE teacher-training provision in botanic gardens involves overcoming many barriers and challenges

Although the participant's reactions have been predominantly positive, the implementation of the courses was not without challenges and barriers. In some cases teachers believed that they were already using an inquiry-based approach and proved argumentative in the early days of the courses. *"I don't know what you want from me, I'm already doing it! … I'm setting up an investigation', many teachers think, they're doing already IBSE, because they are doing the active investigations in their practice"* [SBZH, R1].

Although many schools in Germany are aware that they need to include inquiry-based approaches in their teaching, many teachers exhibit common misconception about what IBSE is. In France, teachers had no IBSE knowledge from teacher training or professional development courses, *'if you want to be a teacher, you go in a classroom and you learn by seeing'* [BORDEAUX, R1].

Further challenges resulted from participants' responses to the types of activities and modes of communication within the courses. Involvement in discursive approaches, collaborative round tables and online activity were often problematic. The duration of the INQUIRE program, 60 hours of professional development across an academic year, was atypical of courses offered in some countries, leading to lower levels of engagement with collaborative and evaluation activities.

"I think the only challenge has really been recruitment of teachers... I think the other challenge, if I might say, is because of our seasonality and trying to run 60 hours that is an approachable way that teachers could be let out of school for individual days and you can't ask for three days in one week in England, that just doesn't work usually, teachers don't like to come out on a Saturday ... maintaining that long term contact and making sure there's a continuity is a challenge and that's why we did the homework assignment pieces, why we've maintained the emailed contact, so it is a challenge to maintain that kind of good contact and continuity".[KEW, R1]

As a result, in the initial stages many participants' expectations of the course were the acquisition of resources, or a 'recipe' for inquiry. Teachers and educators often struggled with the process of developing their own activities for use in their classroom, addressed through providing stimulating examples to trial and adapt during the course programmes.

FINDING: Fostering IBSE in new contexts is challenging in the absence of relevant literature in many languages

For some Partners such as UBG, MSU, Portugal and MTSN/MUSE, IBSE was a new approach that had yet to make an appearance in both language and literature, which left Partners with a challenge to provide resources and reading materials and a heavy translation burden.



"I'm trying to provide this kind of information to teachers and to explain them the different information techniques good for them to use in practice". [UBG, R1]

Lastly, due to the large catchment area of many of the courses (for example CSIC/UAH, Portugal, BORDEAUX), teachers and educators were not able to visit the garden easily with their students.

Barriers and strategies

Recruitment of participants

FINDING: The recruitment of teachers and educators into the course was a problem for a significant number of the project Partners.

The lesson learned for many Partners was the need to disseminate details about the INQUIRE courses through a combination of existing teacher and educators networks, education ministries, and other teacher-training establishments. Bureaucratic mechanisms and political unrest in many countries added an additional access barrier to potential recruits. In some Partner countries the course was accredited by their establishments, which provided additional incentive to participate and complete the courses.

"A large turnover of heads in the area slowed the recruitment process – two schools that had agreed to take part never showed up at the sessions. On a more positive note, the local authority provides funding for 2 days cover: getting out of school is an issue." [NHM, Fieldnotes February 2012]

Online participation

FINDING: Engaging participants with new forms of communication and engagement is challenging

In many cases, as with UBG, MSU and with the Italian Partners, participants were 'happy to participate in this kind of course, but unfortunately, they're not so happy to do online activities' [UBG, R1]. In response to this challenge, Partners adapted the course design to include additional meetings and personalised phone support. Following these changes, participants demonstrated that they were pleased to meet and discuss the work, including difficulties they had in their practice, usually in response to local contexts and political issues. In the Italian case, the result in terms of workload to the team was an additional 6 days per participant which was spent giving very individual and personalised phone support [MTSN/MUSE, R2].

Local educational and political contexts

FINDING: Educational and political contexts significantly influence educators' ability to connect with potential participants

In some contexts, participants 'were quite engaged to argue that all this kind of IBSE approach is not appropriate for the Bulgarian system' [UBG, R2] since the curriculum was heavy with terminology and concepts. Similarly, lack of subject knowledge around botany featured significantly in Partners' reports of their courses (e.g UBG, NHM, LFU). Through a combination of discussion about the process, a focus



on content knowledge in the courses, and use of practical activities in the botanic gardens participants were able to see the opportunities to teach children using IBSE in botanic gardens. These strategies focused on building self-confidence and *'confidence that inquiry-based learning is a good way'* [LFU, R1]. In contexts such as Austria and Norway, although taking children outside was common, inquiry-based science approaches was not.

The political situation in Spain was a contributing factor to ongoing recruitment problems for the CSIC and UAH Partners, and a concern to Portuguese Partners in terms of the sustainability of the INQUIRE courses in light of their crisis. Additionally in Spain, the use of terminology such as 'climate change' was unacceptable to ministerial authorities. MSU also reported issues with teacher inertia and lack of incentive due to heavy workloads.

"The general feeling of teachers would be something that, you know, stopped them to go, 'cause some of them tell us that, 'we didn't feel like in the mood of going to a course, it's like saying no to the Government', you know ...because they have to teach more hours than before, so they don't have so much free time to go with the students outside school" [CSIC/UAH, R2]

Strategies adopted in many countries such as MSU, UK, MTSN/MUSE and UBG included the organisation of course times to suit the teachers, providing additional and personalised motivation and support, and providing funding for teacher training (including supply cover while teachers attending the courses). A particularly unique arrangement exists in SBZH where a plant delivery service operates to facilitate engagement with scientific inquiry with plants in schools.

"And what I think is very positive, they [teachers] get a plant delivery and they can pick it up for schools. They don't have to come to visit us, because for many schools, it's a problem to come very often and so they have the chance to take the delivery into their schools and work with their children in the schools. There are certain topics to investigate with IBSE techniques, like photosynthesis, plants transpirations..."

Barriers to LOtC

FINDING: Barriers to outdoor learning persist across European contexts

Rickinson et al. (2004) summarised five key barriers to outdoor learning: concern about health and safety of young people; teacher confidence and expertise in teaching and learning outdoors; the demands of the school curricula; shortages of time, resources and support; and wider changes such as limiting timetables. Ofsted (2008) acknowledged additional barriers such as the view of learning outside the classroom as an 'extra' or special treat and student behaviour. A frequently cited challenge for Partners arose from a mismatch between participants' desires to take their students outside for lessons and trips and educational systems and policies which prevented it. A further issue, often cited in the literature on LOtC, was the curricular, bureaucratic and financial pressure associated with taking children outside of the classroom. In Portugal, for instance, many teachers *'are only allowed to leave school with their students once a year'* [UL, R2]. Partners such as the UK, UBG, BGRHB, and BOR-DEAUX initiated conversations 'with Education Ministry', extended free entry to all students in



participating schools and provided free transport and insurance in efforts to overcome such issues. "Last year, we had a teacher that could not implement her lesson plan at school because the school didn't want her to" [UL, R2]

4.2 The status of learning outside of the classroom (LOtC)

A second research question explored in this evaluation report is 'how does the INQUIRE project affect the status of learning outside the classroom?'. The status of LOtC was explored through an examination of interviews, portfolios of evidence, and artefacts for perspectives from the teachers, the educators and the institutions. Key indicators of the changing status of LOtC include any changes to the nature and number of visits to the botanic gardens by teachers, increased use of IBSE by educators, and increases in the level of knowledge and skills (beliefs and practices) with regard to working in botanic gardens and outdoor spaces.

4.2.1 Use of the botanic gardens

FINDING: INQUIRE exposed teachers to the potential of botanic gardens as places of learning As outlined earlier, many participants learned of the potential of botanic gardens as learning spaces, including the resources and expertise available within them. The significance of botanic gardens as centres of scientific excellence and teacher-training locations of LOtC and IBSE activities, were frequently cited as learning outcomes from participants in feedback questionnaires, interviews and discussions. As a result of the INQUIRE project the status and role of botanic gardens was broadened in the eyes of the teachers, viewed now as *'privileged spaces for learning'* [Teacher from FCTUC, Deliverable 4.5]. Educators working in LOtC sites also broadened their understanding of the potential offered by botanic gardens for inquiry-based science which manifest in their newly acquired desire to improve field-based activities using their gardens and green spaces.

"The garden is the ideal place for studying the world's plant diversity. I've seen enormous opportunities here for conducting interesting interactive lessons using the INQUIRE technique with students from biology and geography classes, and I'm definitely going to include lessons in the botanic garden in my lesson plans for all years in our school". [Educator in MSU, Deliverable 4.4 p.10]

The scientific relevance of the garden was noted by many teachers and educators both in terms of scientific knowledge and as a place to see and do real science. For many teachers and educators the value of the garden as a scientific location was grounded in the opportunities it afforded for gaining scientific knowledge, completing independent work through inquiry, gaining expertise from the staff (content and pedagogical), and gaining a better understanding of sustainability and the interrelations in nature.

"I believe working with living organisms [in the garden] is more effective than working with books and pictures, especially for younger children" [Teacher from Uni-HB, Deliverable 4.5]



"Being able to stand before the objects of study, the living beings themselves, their habitats and ecosystems, but also the botanic garden is a place where we can address concepts of various disciplines, including physics and chemistry, geology and soils, and other areas such as visual education, math, history and English, for example" [Educator from FCTUC, Deliverable 4.5]

In addition to broadening their understanding of botanic gardens as educational resources, almost all Partners had reports from participants' evaluations of how much they enjoyed their courses outside in the botanic garden and the visits they conducted with their students. The participants on the INQUIRE courses enjoyed 'behind the scenes' tours of seed banks, herbariums, and science laboratories, which made the whole experience more real and authentic. For many teachers and educators, a visit to the garden was seen as 'essential' in teaching and learning about biodiversity and climate change and an engaging, fun experience for teachers and students alike.

"I liked the lessons in the Botanic Garden and the visit of an out-of-school place of learning very much" [Teacher from BGRHB, Deliverable 4.5]

"They [the students] got to actualise and concretise theoretical matters in a good way. To experience plants, which they usually only view in photos and film, gives a whole impression in terms of smell, sounds and sight" [Teacher from NHM, Deliverable 4.5]

For many of the botanic garden Partners in the INQUIRE project, school trips to the garden form a major component of their educational provision, particularly LFU and SBZH. In many cases, no observable difference in the number of visits from teachers and students resulted because visits that would normally have been booked through their education office were instead filled through the INQUIRE course requirement that participants bring a class group to the garden to complete an IBSE activity. Provision within the botanic gardens is often associated with either an entry fee to the garden and/or a fee for school programme offered. This fee was waived for all INQUIRE course participants while bringing a school group to the garden to trail their IBSE activity. Popularity and enthusiasm for the IBSE visits and activities was so great with participants in that Partners (BGRHB, KEW) extended the entry fee waiver to the garden to all school groups of the participating teachers, many visiting multiple times with several class groups. LFU in the project operates a Green School where the educators run the school programs. In this case, the volume of visits did increase significantly; however these were Green School educator run activities (often with the assistance of the course participants) rather than participant planned and led sessions. LFU saw an increase in the popularity of their offer, with many teachers returning for more than 3 visits with school groups.

FINDING: Access to the botanic garden by schools and teachers was increased

BGRHB had unprecedented volumes of interest and visits from their participants, with many teachers visiting on numerous occasions throughout the duration of the PIC course. Partners such as UBG, MTSN/MUSE and CSIC/UAH, did however widen their network of teachers and schools booking a visit to the garden, though not always as extensively as they would have liked. In the Spanish case, their PIC course was run at a National Level, with many participants located more than 300 miles from their



gardens. In these cases, participants were encouraged to complete a lesson outside in a context that was local to them. Where teachers were local, many visited either the CSIC or UAH garden during the PIC and the following year. Partners such as NHM, FCTUC, MSU set a visit to their garden as a compulsory requirement of their INQUIRE courses, undertaking systematic observations of the process when teachers visited, resulting in an increase in their volume of teacher led school visits. As outlined earlier, bureaucratic restrictions have prevented some teachers from conducting any lessons outside or visiting the botanic garden. This was highlighted in the Lisbon case where a number of teachers were denied permission to visit the garden or indeed conduct an inquiry lesson plan in their own school [UL, R1 + R2].

4.2.2 Knowledge and skill development – beliefs and practices

FINDING: IBSE knowledge and skills were improved following participation in the INQUIRE courses

Teacher beliefs are known to impact on their teaching practices, sometimes guiding the pedagogical practices (Fang, 1996), and how and what they believe can have a 'tremendous impact' (Taylor and Calderelli, 2004). All Partners report an increase in the level of knowledge and skills, and in some cases beliefs and practices about both inquiry-based teaching and LOtC, with regard to working in botanic gardens. The INQUIRE course provided participants with opportunities to learn about IBSE and new assessment techniques and gain deeper theoretical insights into the methodology and current scientific debates. The course also afforded participants experiences of conducting lessons with students in the botanic gardens and outdoor spaces, while also learning about the gardens' scientific and educational offers. Most successful elements of the courses include the INQUIRE programme structure and design, the teaching and learning strategies employed within it and the practical activities.

Practical activities

FINDING: Practical IBSE activities are effective in improving engagement with IBSE

For the majority of Partners, their beliefs about the most successful aspects of the course centred on the practical activities, more than the theoretical lessons included in the programme. The practical activities included examples of scientific inquiry where participants were engaged in role play, concept mapping their own learning, utilising concept cartoons in discussion group exercises around biodiversity and climate change topics and exploring IBSE questioning approaches.

"The hands-on activities (IBSE questioning) ... Yeah, we had a good discussion and there were very different outcomes of the different groups ... so it made a good discussion, but after that activity, we had the hands on thing and so there, everything came together, theory, the questioning and so, yeah." [NBGB, R1]

"The climate game with the ice melting, that is a very good example I think to show what is IBSE... it became clear what IBSE was when I did that experiment... I think with many teachers it opened the eyes as well ... Well, it makes clear that IBSE is not only a hands-on activity, but that it's really an activity where children have to think or develop an experiment by themselves...



I also think that with this activity it is possible to show things in a relatively short time. You don't need the time of letting plants grow or [inaudible 0:04:41] or whatever, it's just 20 minutes and you have gone all through the programme of IBSE". [NBGB, R2]

The INQUIRE course structure

FINDING: Combining theory and practical activities is effective in increasing knowledge and skills of IBSE

Although a barrier to recruitment and participation in some cases, the longitudinal nature of engagement with the course was cited as one of the more successful aspects of the INQUIRE course in terms of increasing participants' skills and knowledge to conduct IBSE in botanic gardens and LOtC environments (e.g UBG, UL). The research literature on teacher professional development recognises that professional learning takes time (Darling-Hammond and Richardson, 2009; Joyce & Showers, 1988; Loucks-Horsley, Hewson, Love & Stiles, 1998; Yoon, Duncan, Lee, Scarloss, and Shapley 2007). Blank et al (2008) found that among the PD programmes that appeared to have demonstrated positive impacts on student outcomes, it was common for the teachers to have been engaged in over 50 hours or more of professional development. The continued support offered by this structure, the sharing of experiences and group activities were all thought to contribute to knowledge and skill development. The combination of theoretical approaches to the methodology (including assessment techniques such as concept maps) with practical outdoor activities that demonstrated the approach was thought to be particularly effective [FCTUC, R1, BORDEAUX, R1]. Based on assessments of participants work during the course at FCTUC and SBZH, it became apparent that successful application of the approaches and changing teaching practice was underpinned by a clear theoretical framework. The reinforcement of the methods in practical sessions resulted from 'going through the inquiry cycle' [SBZH, R2].

"Altogether, the whole package, from this emerges an attitude, not a new but a deeper attitude, not a deeper, a special attitude, which changes all the workshops, we never say, in former times we have a guided tour, then we had some aspects of IBSE or hands on and now most aspects are minds on and yes, it's open minded, it's a special kind of attitude we have taught the children, so they are free in thinking and yes, it's difficult to understand..." [LFU R2]

"It was the specialist's intervention... This lecturer was fantastic... he helped us to know more about the theoretical aspect, the practical aspect and he did understand really well the problems that the teachers can find in their progress in understanding the IBSE". [BORDEAUX, R1]

For many Partners, a wide variety of teaching and learning strategies were used to introduce inquirybased teaching to their participants, while also modelling approaches to learning outdoors in the garden. Examples include trialling and discussing sample lessons plans and assessment techniques, devising inquiry-based questions and activities for use in botanic gardens and adapting/designing lesson plans. Bell and Gilbert (1994, 1996) have argued that professional development is predicated on the need for teachers themselves to recognise a problem and desire to see it fixed. For many teachers, the 'problem' that required a fix was routed in their abilities to work outside with children using IBSE.



"Even writing their own lesson plans, because that's when you realise if they have understood the meaning of IBSE." [CSIC/UAH, R2]

"One point are the small groups, because in small groups, they are developing their first steps into INQUIRE activities and the other point are the concept maps, because later on, they can see the changes", [LFU, R1]

4.2.3 Models and practice of IBSE

FINDING: INQUIRE Partners illustrate a range of interpretations of IBSE

The INQUIRE project recognized from early conceptualisation that inquiry-based teaching and learning is complex and that specialist aspects such as argumentation skills or disciplinary differences need to be taken into account. As previously outlined, a range of learning environments were promoted within the consortium (see section 2.1). Consequently, much of the work within the project, including posters, workshops and paper presentations at the final INQUIRE conference, demonstrated that there is no single recipe for applying IBSE but rather a variety of IBSE approaches that work in both school and LOtC sites.

Examination of artefacts and project deliverables show that a range of interpretations of IBSE exist within the project, a finding also identified by the external evaluator [Deliverable 8.1] as ranging from relatively novice to 'expert'. To develop a shared understanding how IBSE should be defined in the INQUIRE project Partners explained their personal understanding at the Inaugural Meeting in Brussels, January, 20th, 2011. Partners largely interpreted IBSE as understanding natural concepts and mechanism and as a new practice in teaching and learning, where students are more autonomous actors working independently, asking questions, posing hypotheses and gather data using hands-on activities [Deliverable 2.2].

FINDING: Partners levels of understanding and practice of IBSE increased as a result of participation in the project

The nature and design of the INQUIRE project focused on the support and development of IBSE practice, reflective practice and evidence based approaches to designing teacher-training programmes. Levels of understanding of all of these dimensions have increased from early articulations of IBSE lessons, evaluation plans and course design, evidenced in lesson plan reviews at Partner meetings, portfolios of evidence and interviews. As articulated in the previous sections, exposure to IBSE in each country varied, with some Partners balancing the challenge of designing inquiry-based courses in environments where the terminology in their language did not yet exist. These educational and cultural differences across Europe account for some of the variation in levels of both experience and understanding of IBSE approaches.

Evidence from lesson plans, course descriptions and Partner meetings demonstrates that many Partners approach to IBSE involved:



- finding the answer to a particular question of a scientific nature;
- learning something about underlying scientific concepts;
- finding out how to go about answering scientific questions;
- developing skills and competencies in using scientific tools and techniques.

FINDING: Partners models of IBSE centre on collaborative learning and hypothesis-driven inquiry

The most common articulations of their understanding centred on language such as questioning and hypothesis generation, experiments or hands-on activities, cooperation and learning in groups, learning from mistakes, student choice and motivation and engaging interest of students. Use of these terms is not surprising given their representation with the INQUIRE project annex, and early articulations of the approach. Partners have been continually encouraged to explore and describe their understanding of IBSE within the tasks in Partner meetings and contributions to project deliverables. A clear articulation of this understanding has often proved challenging, with some Partners slower to communicate their understanding or using a less developed vocabulary. Evidence suggests that Partners' approach to IBSE focuses on peer and collaborative inquiry learning and hypothesis-driven inquiry and to a lesser extent multiple forms of representation or modelling approaches. Most Partners refer to the NRC definition or key features. The pedagogical features of these approaches include an initial orientation, hypothesising, designing, discussing, interpreting, investigating and reflecting.

FINDINGS: Partners produced a significant amount of high quality IBSE activities for use in LOtC

Most Partners demonstrate the following key features of inquiry when discussing and presenting their Best IBSE Outdoor Activity (applying a modified version of Forbes inquiry rubric for lesson plans):

- 1. Lesson engages students in scientifically-oriented questions
- 2. Lesson engages students in gathering, organising, and analysing data
- 3. Lesson engages students in formulating explanations for evidence to address scientifically-oriented questions
- 4. Lesson engages students in evaluating their explanations in light of alternative explanations
- 5. Lesson engages students in communicating and justifying their explanations.

The SBZH team presented a simple demonstration that they use to begin a session with students; the benefit being it is a short pre-starter activity. The purpose of the activity was to focus on observation skills and hypothesis generation with the intention of encouraging students to then engage with scientifically-oriented questions.

"We think this is a very good experiment to learn to build hypothesis and it's so easy that they can, afterwards they can try to find an experiment to check out which reason it might be". [SBZH, Best Outdoor IBSE Activity session, Trento 2013]

The rationale for adopting these models of IBSE in their activities with course participants focuses on



effective strategies for understanding the IBSE approach. In their example, the Spanish team reflect on the role of fruits and seeds in dispersal mechanisms in which they model an open, guided and structured approach to the topic, before exploring participants' responses to the 3 different activities. The approach that focuses on an inquiry question and showcases the five features above proved very effective in promoting the inquiry approach.

"We make them discuss some questions [after the activity], these questions are for example, what are the advantages or disadvantages of IBSE and if they think that IBSE is more significant to their learning. The most important thing is that at this point is when participants realise what IBSE really means, after seeing the different approaches together and after the discussion" [CSIC/UAH, Best Outdoor IBSE Activity session, Trento 2013]

The range of activities showcased in this 'Best Outdoor IBSE Activity' session highlights also the commitment to producing IBSE resources and activities for teaching biodiversity and climate change topics.

4.3 The influence of INQUIRE on the formal and informal sector

Our third research question in the evaluation framework asks '*what is the influence of the INQUIRE project on the formal and informal sector?*' The influences include an exploration of participant and institutional perspectives on involvement in a community of practice, adoption of reflective and evaluative practices and feedback from course participants. Findings have been drawn from interviews, portfolios of evidence, artefacts, fieldnotes and project deliverables.

FINDING: Partners have developed positive relationships that bridge the formal and informal context

The intention of many courses in the project was to disseminate IBSE as a pedagogical practice by linking formal and informal education to teach biodiversity and climate change. Central to this was the use of botanic gardens as a LOtC institution to promote students' engagement with science. Many Partners report positively about their relationships and extending networks with teachers, schools, education departments and other stakeholders in both the formal and informal sector. The UL team reported on the effectiveness of their course for development the knowledge and skills necessary for teachers to apply the approach in their own practice, raising student interest in science as a result. The influence of the course on the formal and informal sector stems from their reported success with bridging teachers and the botanic garden. In a paper entitled 'How can LOtC provide a change in teaching methodology to promote students' engagement in natural sciences?' Maria Amélia Martins-Loução explains how the course affected the relationship between teachers, schools, botanic gardens and natural history museums.

"Teachers learned how to use the Botanic Garden, how to interact with educators and scientists as a way of contact with real natural contexts and to engage students in the creation of scientifically oriented questions, emphasizing the importance in linking formal and non-formal education.



Also, the challenge of using a LOtC as the BG-NHMNS to discuss in situ like researchers, do make them feel important, keen in learning and able to motivate their families in their school programmes. As a whole we can say that Lisbon Botanic Garden presents itself as a good bridge on the promotion of formal and non-formal education institutions". [INQUIRE conference abstracts]

FINDING: Participation in the INQUIRE project raised the status of education and resulted in changes to educational provision and practice within botanic gardens

For several Partners (MSU, FCTUC, Uni-HB) the result of providing INQUIRE courses over two years has been the nature of the relationships that developed, and the sustained changes that resulted. Several Partners have reported plans to continue the courses on a permanent basis, a lasting legacy of collaboration between botanic gardens/natural history museums, universities and schools. *"As the University is expanding its work with schools, it is interested in continuing the INQUIRE course on a permanent basis and in introducing innovative educational techniques. We are therefore currently working not only to certify the pilot course, but to offer a certified INQUIRE course on a permanent basis. We are delighted that the BGCI has agreed to issue INQUIRE certificates to teachers who successfully complete the INQUIRE course, thereby raising the course's status". [MSU, R2]*

Partners such as UL and MSU, in cooperation with their respective universities, have extended their outreach programs such as Science Festivals and Open Days to incorporate inquiry-based offers.

"We have begun incorporating IBSE activities for school-pupils in MSU's regular Science Festivals. These are amongst the most popular and well-attended events in the city (attracting pupils from around Moscow and other towns). As part of the 2011, 2012 and 2013 festivals, for example, the Garden organized open lessons entitled "What kind of tree is this?" and "How scientists study plants". In 2012 and 2013, in addition to repeating these lessons, we set up an INQUIRE stand in the main festival venue. This was visited by several thousand pupils and teachers, all of whom had the chance to work with our microscopes. The stand was a big hit with the festival organisers: we have been invited to expand it and run more lessons during this year's festival, so we are aiming to get more garden staff involved as well as some of the teachers who have completed the INQUIRE course." [MSU, R2]

Extensive dissemination of inquiry-based education activities at ministerial and botanic conferences and meetings has taken place to connect with botanic garden specialists who have also expressed an interest in learning more about the IBSE methodology. Some Partners have shown a high commitment to this and plan to continue by offering further Train the Trainers courses, both nationally and internationally within Europe. Teachers, students and educators have come to understand the huge potential of botanic gardens for developing education, and many Partners expressed beliefs that providing educational programmes for schools (pupils and teachers) should be one of the botanic garden's core activities.



4.3.1 Communities of practice

FINDING: The INQUIRE project was successful in fostering an active Community of Practice A major challenge to integrating new approaches into practice is that it involves a complex process of acquiring and converting both explicit and tacit knowledge into teaching and learning activities. Research has shown that fostering the development of Communities of Practice (CoP) in CPD courses has a positive impact on teachers' learning outcomes and on their ability to integrate newly-gained knowledge into their everyday teaching (Wenger et al, 2002). With this in mind the INQUIRE project sought to contribute to the professional development of educators in the consortium by providing opportunities for sharing knowledge and experience, opportunities for communication and a developing sense of belonging to a network and support for interaction and collaboration (Wenger et al, 2002). Partners attributed high value to their involvement in the INQUIRE project for providing opportunities for reflection on the nature of inquiry-based learning, the value of learning outside the classroom, and the teaching of issues related to biodiversity and climate change. Ultimately, most Partners valued the experience in terms of their personal professional development and the resulting improvements and changes that abounded within their institutions.

"Well, I was so pleased to find our international Partners in the project. We had to go through the same process of learning, I think we all learned a lot and not being alone in this case was really helpful to me and so my personal development was really... I'm still thinking about how we can make this work in a technical way is to transpose the idea of the community of practice to the people here in Belgium that surrounds us, being involved with Biology education with the botanic garden". [NBGB, R2]

Feeling part of a COP manifested on many levels for Partners, and was particularly strong in terms of the collaborative working with other Partners, thought to be *'fundamental to giving us the resource and the tools'* [KEW, R2]. Talking about issues, planning and preparing for their course and the meetings may not have happened without the structure of the project. The effect was a strong desire and commitment to develop further COP within their own courses, institutions and wider networks. Many Partners openly criticised their own involvement in the COP, stating that they should have made more efforts to communicate, share and work with Partners outside of the project meetings and deliverables. *"No one was preventing us to do more interaction of IBSE because that was not compulsory, it*

was not actually a deliverable in itself, it was an opportunity that maybe we didn't fully exploit or fully use". [MTSN/MUSE, R2]

The 'emotional journey' reflections at the final Partner meeting in Trento highlighted each Partners' highs and lows, successes and challenges during the project. This was a particularly poignant and emotional session where the depth and strength of connections between Partners was evident. All key features of COP, including the challenges to participation, were illustrated both in the visual displayed among the bamboo and in Partners explanations and commentaries [Fieldnotes, Final INQUIRE Partner meeting].



Sharing knowledge and experience

Many Partners have reflected on the beginning of the project and their lack of understanding of IBSE and how over time, through engaging in the various INQUIRE project tasks, meetings, activities and online communications, they have developed as practitioners of IBSE. This time represented a period of partnership and joint creativity, without competition, judgement or rivalry where everyone participated on equal terms and learned from each other. The process is summarised in the quote below.

"At the beginning of the project I didn't understand IBSE, but eventually, somewhere after the half-way mark, having worked as a team with the Partners and participated in the discussions and workshops, it became clear. This was largely thanks to the active engagement between the Partners, our discussions and joint preparation of materials. ... Each participant had their own interesting experiences to share and I felt that the others were also interested in my work and ideas. Together we gradually formed an information community, and I felt I was part of this." [MSU, R2]

The levels of commitment to the COP continued past the completion of most Partners INQUIRE courses as part of the project. Many Partners felt strong connections within the consortium and engagement with the network of educators, and a strong desire to find ways to continue to work together.

"I think [the benefits have been] feeling closer to people, like teachers, working maybe, closer. And even with the Partners, like we're doing things 'til the last day, like today, we are reviewing each other's lessons plans, they keep learning, so we are always reflecting, individually and with different groups". [CSIC/UAH, R2]

Communication and a sense of belonging

The sense of belonging to a COP within the INQUIRE consortium was strong for almost all Partners, attributed mainly to the participation in the Partner meetings where knowledge and experiences were shared, and educators and trainers availed of opportunities to explore how different botanic gardens and natural history museums operated. A small number of exceptions to this were evident in the second round of evaluation interviews, with members of teams feeling isolated from the consortium due to the level of participation that had been afforded to them during the project. The high level of turnover of staff at BGRHB, for example, contributed to feelings of isolation and loss of a sense of belonging to a COP. Owing to operational conditions within this garden, the role of staff/INQUIRE members with regard to contributions to Partner meetings, evaluation requirements within the garden, and communication with other Partners was lower than in other gardens. This was the only example in the consortium where the educators did not express strong feelings of regret that the project was coming to an end. While discussing feelings of involvement in the INQUIRE COP and establishing a shared understanding of IBSE the following comments were made:

"Well, for my part, I mean, it was [name staff member] part the last year, so I was always in the background. I used it [IBSE] in the practice at the garden, but I wasn't much involved on the INQUIRE website and everything and actually I didn't have the time to read everything. I thought, okay, [staff member] is doing it and if there is a problem, [laughs], I'm going to help, but yeah."



A lesser degree of isolation was felt by one member of the LFU team, where despite feeling that great personal gains had been achieved through involvement in the INQUIRE project, it was attributed to the work completed internally in their garden and not as a result of contact, cooperation and a sense of belonging to the INQUIRE COP. In this case, also due to the separation of work roles and responsibility regarding evaluation and participation in the Partner meetings the educator felt she had no contact with the rest of the consortium, but also expressed no real desire for it.

Many Partners also demonstrated that their INQUIRE courses had instilled a sense of belonging to a COP. Despite some initial teething problems with engaging participants with group communication many courses ended with successful 'reunion' and celebration events and in many cases, participants from the PIC course contributed in a variety of ways to the final INQUIRE courses, dissemination events and of course, the final INQUIRE conference at Kew gardens.

"We had a kind of reunion [for] teachers at the second course, we invited the first year people as well and some of them were talking about they still did it differently as before". [NBGB, R2]

Several Partners incorporated the features of COP into their INQUIRE course design, and in particular, recognised complexity of integrating new approaches into practice. Partners offered continuous support to their participants, in many cases over and above the amount of time typically and reasonably expected of course providers (UBG, MTSN/MUSE, BGRHB, KEW, NBGB). In addition to the contact time embedded within course programmes, Partners in some countries included informal round table discussions between teachers and educators, café style get-togethers and world café sessions to foster feelings of feeling to a network while exploring, learning and sharing ideas and practices about IBSE in LOtC settings.

Success with this level of support varied, even across the PIC and final courses, with some teachers and educators unwilling to dedicate the time to extensive communication. Many Partners continued to stress in their courses that 'when you share things, there's so much you can see from each other and learn from each other' [NBGB, R1].

"I think one of the most important things is that we offer them a continuous support ... the teachers won't continue this course by themselves without our support or without co operation, so we need to continue communication between garden educators and teachers and there has to be one team who somehow establish this communication and continue it, because the teachers and also the garden educators won't continue it by themselves. Talking is one of the most important things to continue this course. We offer these round tables in between these teacher training modules and it's a possibility to visit the botanical garden and just to have a chat with other colleagues or garden educators". [BGRHB, R1]

"If I might make a comment here, a nasty one, I believe our teachers in Italy are spoilt, because they would need an amount of tutoring that I think is not...Yeah, I think that's unacceptable in any other European country... She said at least six working days for each participant." [MTSN/MUSE, R2]



Support for interaction and collaboration

Networks flourish with good communication and personal relationships. The INQUIRE project provided much support and structure to foster a community of learners in the project through dedicated support visits, Partner meetings, the project website, and an online collaborative tool (Glasscubes). The support offered by the academic Partners was also acknowledged both in meetings and in the interview data and thought to have a lot of impact within the COP. Many Partners, despite initial barriers with regard to training, benefitted greatly from the project website and the use of Glasscubes to exchange lesson plans and experience, explore literature and seek advice. Partners felt comfortable within the network to request help, advice and ideas: *'I think we could ask everybody, 'oh, I need this, can you send me your concept maps'* [SBZH, R2]. The timely nature of the communication within these offerings was a frequently cited reason for the success of the support.

I feel that during those meetings we have had, I've been very much inspired to do things later on by myself and I feel that it has been very easy to write mails and communicate, especially with Asimina ... she's always answering quite quickly and then I feel that, 'ah', she always has some ideas, so maybe she could, well, suggest something and so on. I haven't been good at all with the other countries, except for the French ones and the Spanish one, yeah, with two countries, but it has been very easy to contact the persons after seeing them and I should never have dared to contact". [NHM, R2]

The website has been very useful and using different sort of forms of electronic communication with our own course members, as well as meeting them regularly, has built that up and it's also led, certainly for me personally, to do a lot more research and reading and looking for and if you like, feeling, when I see good practice, I feel more confident that what I'm looking at is worth pursuing. We've done a lot more work to develop this through the whole practice and process that we've gone through with the INQUIRE course than ever would have happened if it hadn't been run like that. [KEW, R2]

The concept of COP was explored within individual Partner courses, such as in LFU, where Jakob Egg and Grüne Schule applied social interaction analysis in a paper entitled *'Professional Learning Communities/Communities of Practice implementing Inquiry Based Science Education (IBSE) in- and outside the classroom*'. They found that responsibility, self-initiative and cooperation of the individual participants was strengthened in their group of participants [INQUIRE conference abstracts].

4.3.2 Use of educational (and other) research

FINDING: Academic support led to an improvement with engagement with educational research The King's College team, in their role as academic and quality management support, developed guidelines on how to structure and run reflective practice/practitioner-based research while implementing IBSE – The Practitioner Manual. The management board team also produced a series of research informed manuals (PIC, Final INQUIRE course, and Train the Trainers manuals) for use by Partners. Despite an articulated need for literature to support their courses, many Partners expressed



that time taken to read this material (outside of completing the translation exercise) was a major constraint. Often, Partners preferred to seek advice and resources directly from the management board through email requests. This often stemmed from the additional time to translate the material and references provided. Furthermore, some Partners reported limited use of the course manuals by their own participants, preferring to engage with more activity based materials.

"It managed to link me with new papers and new theoretical and practical work, so for me, it was very nice to know and I feel very much supported by the manual also, I think the manual, it's very, very good, although the trainees use it in a small part of their time. They say they didn't get the time to use the manual, oh my God, [laughs], some of them, some used, some didn't use'. [FCTUC, R2]

During the support visits conducted by the KCL team, many Partners sought advice about accessing literature across a range of topics. These included keeping up to date with theoretical aspects of inquiry [Fieldnotes, NBGB; Fieldnotes, CSIC/UAH], examples of the ways in which informal learning environments engage with evaluation [Fieldnotes, UL], strategies for implementing reflective practice and communities of practice [Fieldnotes, UBG; Fieldnotes, LFU], and practical examples of evaluation tools such as observation grids [Fieldnotes, NHM], and approaches to analysing visual/audio data [Fieldnotes, SBZH]. Use of much of this material is event in Partners' portfolios of evidence. The KCL team are involved in a translational project that produces short practice-based articles and summaries of research findings.

To help informal educators, teachers and participants of the courses learn about new approaches in both formal and informal contexts, the QMT introduced Partners in a lecture and workshop to the online repository called Relating Research to Practice (http://relatingresearchtopractice.org/), as well as during the support visits. In several of these instances of increased engagement with theory, Partner teams included doctoral researchers associated with the projects. In these cases, theoretically informed evaluation designs were applied (LFU, BGRHB/Uni-HB).

"A characteristic of our teacher training courses is the encouragement and support of the participants in establishing "Communities of Practice" (CoPs). We wanted to evaluate how teachers and LOtC-educators, participating in IBSE-focused continual professional development, define their individual role in a CoP, and how understanding the social interaction helps the trainer to support the development of a CoP". [LFU, R2]

A disadvantage of these more theoretically informed approaches (LFU, BGRHB) was a separation of roles of responsibility for reflective and evaluative practice which limited other educators engagement with evaluation of educational programmes.



4.3.3 Use of evaluation tools

FINDING: Participating in the INQUIRE project led to increased engagement with evaluation The fifteen INQUIRE Partners adopted a diverse range of evaluation techniques and data collection strategies. Many of these were actively promoted within the project, as a toolbox of techniques to choose from, however the level of adoption was quite remarkable. The complete range of methods employed by Partners, evidenced in self-report interviews and their portfolios of evidence, can be seen in the table below. What is clear from the data presented is that all Partners drew on a range of

Technique																
	Interviews	Questionnaires	Photos	Film	Diaries	Portfolios	Observations	Concept maps	Concept Cartoon	Lesson plans	Activities notes	Teacher work	Online forums	Inquire cafe	Discussion	World cafe
KEW	•	•	•	•			•			•		•			•	
LFU	•	•				•		•		•	•		•	•	•	
MTSN/ MUSE	•							•		•	•		•		•	
CSIC/UAH		•				•		•		•	•	•			•	
SBZH		•	•	•						•					•	
Uni-HB	•	•			•	•			•	•					•	
BGRHB	•	•					•	•		•			•		•	
FCTUC		•				•			•	•		•			•	
UL		•	•	•		•	•			•					•	
MSU	•	•	•	•		•				•		•				
NBGB	•	•	•	•		•	•			•		•			•	
NHM	•	•	•				•		•	•		•			•	
UBG		•	•		•		•			•	•	•			•	
BORDEAUX		•						•		•		•				

Table 2: Range of evaluation techniques employed by INQUIRE Partners



evidence to support the claims they made in respect of participants' learning, development of IBSE approaches and the success of their courses. Each Partner has included up to nine different techniques to monitor participant learning and evaluate their courses. All Partners utilised the pre-course open questionnaire, devised to determine participant's expectations and pre-existing knowledge, beliefs and experience with IBSE and LOtC. The analysis of these questionnaires highlights Partners' acknowledgement that teachers, like learners, do not arrive at a training session as empty slates (Fullan and Hargreaves, 1992) but have their own experiences, insights and interests.

A range of evaluation techniques were found to be useful by the INQUIRE Partners, evidenced from the 4th Partner Meeting, Portugal October 2012 *Open space workshop on evaluation methods*. Partners were actively supported in their efforts to embed evaluation in their programmes, which was recognised and appreciated by many Partners.

"I think we received very good information and examples about the different techniques and not only participating in the INQUIRE meetings, but for example, having the opportunity to read the literature which is provided to all the participants and presentations" [UBG, R1]

Partners mainly utilised these techniques to reflect on the nature, practice and outcomes of each session of their courses and to determine the areas of success. As a result of engaging in the process Partners made changes to the design and activities of their courses to improve the quality of the provision.

4.3.4 Reflective practice

Finding: Partners have systematically monitored, evaluated and revised their practices using reflective practice

Over the past twenty years increasing attention has been paid to reflection and reflective practice as a goal in many professions, and in particular for teachers and educators. Learning to become a reflective practitioner involves making connections between theory and practice, specifically developing the ability to think consciously about what you are doing and analysing what you have done and how you have learnt. Evidence drawn from interviews, support visits, Partner meetings and portfolios of evidence demonstrate Partners developing technical efficiency in relation to IBSE. Partners have systematically monitored, evaluated and revised their practices using the variety of data collection techniques outlined in the previous section. Through doing this, all Partners have collaborated, shared and discussed with colleagues, both at work and within the course, their learning and professional development.

This is in keeping with research highlighting the potential of portfolios of evidence for development of reflective practice (Rogers, 2002). Several one-to-one sessions at Partner meetings, support visits, by phone and email were provided to Partners by KCL following a workshop on portfolios of evidence. Partners were provided with a handbook on how to prepare portfolios of evidence and engage in critical reflection as part of the ongoing support provided by KCL.



All Partners compiled portfolios of evidence for each INQUIRE course, following the INQUIRE portfolio model. This involved a semi-structured approach to provide a broad format for contents to allow practitioners to shape the portfolio to better reflect their own circumstances and practice. Participants were asked to reflect critically on their own development in IBSE and LOtC throughout the INQUIRE course. Partners submitted a range of portfolios types, including a chronological/sequential approach (NHM, UBG, FCTUC, SBZH), an evaluation/case study perspective (CSIC/UAH, LFU, Uni-HB, BGRHB, KEW) and also focusing on knowledge and learning through the analysis of developing a new IBSE lesson (NBGB, UL, BORDEAUX, MTSN/MUSE, NHM, MSU). In some of these cases (KEW, SBZH) Partners choose to focus on a research question to answer, such as *'Has the Kew INQUIRE course structure and delivery developed participants' IBSE learning journey?* [KEW POE 2012].

"This portfolio presents chronologically my expectations of the Course at each separate stage/session, compared with the achieved results by sessions and summarized. It also includes personal assessment of my work based on self-analyses and feedback from the participants". [UBG POE 2012]

The portfolios were analysed for evidence of the level of reflective writing, use of evaluation and connecting judgements with evidence and contribution to professional development and learning. In this report, we focus largely on the use of evaluation and contribution to professional development. In the MTSN/MUSE portfolio the team summarise their evidence to support their accomplishments and the judgements provided were linked to a well annotated index of artefacts.

"PRE-COURSE AND POST-COURSE EVALUATION QUESTIONNAIRES. The comparison between the initial and final questionnaires allowed us to understand if the participants' expectations about the Inquire course had been fulfilled or not. This gave us the opportunity to realise if the participants' ambitions had been satisfied, both personally and professionally, for instance, referring to the applying of IBSE methodology in several fields, to the comprehension of concepts and examples treated during the course and so on". [MTSN/MUSE POE 2012]

When analysed for levels of reflection in the writing Hatton and Smith's (1995) approach was used. The four levels outlined in this approach are: descriptive writing, descriptive reflection, dialogic and critical reflection. There was a predominance of descriptive reflection within the portfolios, describing what had been done, prepared, planned and adapted together with feelings of success or failure of the courses or approaches within the courses based on both personal judgements and data gathered. However, despite the presence of descriptive reflection in many parts of Partners' portfolios, there is also evidence of developing professional competencies with regard to evaluation, where Partners link their judgements to evidence they have analysed. The range of evaluation strategies employed and the sheer volume of data collected to evaluate their courses is worth noting. The main concern with many portfolios was the Partner's ability to link their inferences or judgements to the evidence or artefacts presented, and not with the quality of the evidence.



Similarly to Borko et al (1997), Partners present a favourable image through their portfolios. "In June, in the last day of the Course, the 20 projects were presented by the trainees. All the projects were well constructed and supported, used the IBSE methodology and had a good acceptation by the students. One of the weaknesses was the lack of time to explore and discuss all the interesting projects presented...Through the results of the 20 applied and collected questionnaires concerning the course internal evaluation, at the end of the last course' session, we could conclude that, in a general view, the course was well succeeded. The trainees evaluated very positively this course classifying it as Very Good, and 65% (13) of the trainees evaluate it with the highest level of the responses range1, 5 - Excellent, 25% (5) with the level 4 -Very Good and 10% (2) with the level 3 – Good". [FCTUC POE 2012] "We think the Pilot Course has surpassed our expectations. One of the reasons for this success

is the very high level of professionalism and commitment amongst the course participants, their creative potential and openness to new approaches and knowledge". [MSU POE 2012]

Some Partners also prepared more dialogic approaches to reflection, where the portfolios represented a form of discourse with themselves together with explanations and reasons for their actions. These Partners' professional and personal background may account for the choice to engage with a dialogic reflection, which is often avoided due to a lack of possible training in writing at higher reflective levels. In the chronological approach taken in the UBG portfolio, Ljuba illustrates the purpose of her session, findings based on observations, reflections, and discussion, and a reflective action based on what she learned. The extract below focuses on the first day with the PIC group and shows the structure of the reflections and also shows a good integration of the artefacts in the critical commentary.

"Module 1 Theoretical concepts of IBSE approach

Session 1: Introduction and discussion

Learning outcomes: Making group feel comfortable

Sharing previous pedagogical experience

Assessment, Evaluation and Reflection: Observation, notes, reflection

The beginning of a training metaphorically resembles a first date. The important thing is the impression the participants invariably get, as it is important for them to feel an atmosphere in which they can share and appreciate what they are actually to acquire from the training to implement in their practice.

The weather that day was unusually cold for the season (snow in October), yet the atmosphere in the hall was cosy due to the way the working tables were arranged (for group work) – the fortuitously placed heaters, and the arranged colourful compositions that all made the teachers feel on a par with each other. This part of the training was visibly intended for us to get acquainted with one another by each one introducing themselves to the group and sharing their motivation briefly.

In this session I planned to get an idea of the teaching methods (Attachment 1: picture 1) that were most often used by the participants. The expressions of the teachers showed me this exercise was overwhelming and/or embarrassing therefore I allowed time for us to talk. They said



they found it difficult to choose the 6 most often used methods as it all depended to a high degree on the topic they taught, and often also on the time they had at their disposal (in the next training this section will be modified). The sharing of experience continued with 'Learning in the open - where and were we last?' (pictures 2,3). The discussion revealed that more than three quarters of the listed classes in the open took place during weekends or holydays – extracurricular and they were never carried out in a botanic garden. Quite often the very classes (rather entertaining, and not intended at studying) were conducted by so called 'animators' from companies that offered excursions". [UBG POE 2012]

In the UL portfolio of evidence from their PIC course [UL POE 2012] the critical commentary discusses their course development, accreditation, engagement of participants and the Partners' own use of evaluation methods and tools. They provide many sources of 'good' evidence that clearly shows their learning and development. The intention of their portfolio was to summarise evidence to support the teachers and educators development of inquiry in the botanic garden activities. In the example below, they used photographs to document teacher engagement, but do not explain why this piece of evidence is important, how it illustrates teacher engagement or how it relates to a professional standard, accomplishment or competency.

"It was very clear to us that the INQUIRE course was a very positive experience for teachers and educators, concerning different levels of analyses. There was a great engagement of all participants in experiencing IBSE, even from those teachers that were not at all familiarised with the method at the beginning of the course (artefact: teachers and educators engagement)". [UL POE 2002]

4.4 Botanic gardens' ability to support learning outside the classroom

Our final research question in this evaluation report centres on the ability of botanic gardens to support LOtC: we ask 'what is the influence of the INQUIRE project on ability to support learning outside the classroom?' The ability to support LOtC draws on evidence from interviews, portfolios of evidence, artefacts, project deliverables and fieldnotes. Key indicators include changes at institutional, national, regional and international level, the effectiveness of the evaluation techniques, changes to the education course and programmes in Partners' botanic gardens and the development of knowledge and skills as an IBSE practitioner. These are evidenced in instances of involvement in and fostering of wider networks, accounts of developing training courses in LOtC, indicators of professional development and examples of sustainability of the INQUIRE courses.



4.4.1 Instances of involvement in, fostering of, wider networks

FINDING: Partners demonstrated wider engagement with national and international education networks

All of the Partners commented that they had been involved in a range of dissemination activities during the INQUIRE project, many of which had resulted in involvement in and fostering of wider networks for sharing ideas and insights from INQUIRE. For many Partners this originated with the formation of the National Advisory Groups, and developed further from there, culminating in strong promotion, networking and dissemination activity. The Train The Trainers programme run by all Partners resulted in a significant increase in networking with Partners' countries. The Spanish team is one example of an INQUIRE course run at the National and Regional level, promoting the INQUIRE model of teacher training beyond their immediate location. Through determination at the stage of recruitment to their course, they have connected with education ministries and other teacher training institutions. Dissemination of their work at International conferences has resulted in newly formed collaborations with partners in Mexico, added to the potential sustainability of the INQUIRE courses, and their ability to support LOtC in the longer term. For other Partners, the widening of networks began within their own institutions and has resulted in collaborations with the wider university (NHM, UL, MTSN/MUSE) or with universities in other cities (FCTUC, MTSN/MUSE).

"Our Train the Trainer Course for botanic garden educators was great and there were botanic garden educators ... From all over Germany, we have a network, a botanic garden network and they meet three or four times a year and there was just one course only for INQUIRE in Bremen and they come from all over Germany and two participants from Switzerland were there as well." [SBZH, R2]

The team at Uni-HB have fostered a new collaboration with "Zoo am Meer" in Bremerhaven to continue to promote subject knowledge in the field of biodiversity and climate change while fostering competencies in IBSE. In a paper entitled *'Linking inquiry-based learning and animal observation - innovative methods of zoo pedagogy at the "Zoo am Meer" in Bremerhaven'*, the team describe an IBSE in-service training program for primary teachers conducted at the zoo school [INQUIRE conference abstracts].

4.4.2 Designing, delivering and evaluating programmes in botanic gardens

FINDING: Partners successfully designed, implemented and evaluated IBSE teacher-training programmes

The INQUIRE project focused on the design, delivery and evaluation of IBSE teacher-training programmes in botanic gardens and natural history museums. Multiple sources of data indicate the differing aspects of planning and delivering successful teacher training on IBSE (artefacts, deliverables, interviews, portfolios). At the INQUIRE conference in Kew Gardens the project celebrated the project's



successes, reflected on its challenges and brought together researchers and professionals from schools and LOtC centres to discuss the current status and future of IBSE in Europe- 124 delegates from 14 countries. The response from participants was predominantly positive, articulated in the quote below.

"Really it all became very clear when we were at Kew, I think that was really kind of, yeah, a very amazing experience and I'm not the only one who would think about it like that because all the participants that joined us, they want to meet each other again and they want to go on with something that started at that moment [NBGB, R2]

As outlined previously, one of the challenges for the providers of teacher professional development is disseminating information effectively and attracting the interest of potential trainees. In response to this challenge, in a World café session delegates of the conference brainstormed the best methods to promote the INQUIRE courses. This was a very active and engaging session [Fieldnotes, INQUIRE conference] and showcased the Partners' experience and capabilities with respect to supporting LOtC and inquiry-based courses in botanic gardens. Key strategies included the importance of getting the support of policy makers and education authorities to promote the INQUIRE course e.g. by using their communication channels to disseminate information to teachers and educators and obtain funding. Promotion of the course through face-to-face contacts and social media are both important actions for advertising a training course.

Partners highlighted that the provision of outdoor activities and IBSE should not be regarded as an initiative undertaken by individuals in isolation, but through collaborations with schools, educators, thereby bridging the formal and informal. The INQUIRE project has demonstrated how it is possible to build these collaborations through a consortium of botanic gardens, natural history museums and universities. Botanic gardens and museums have also been proven to be excellent locations for training in IBSE because of their plant collections and their outdoor spaces and because of their expertise in plant science.

The Partners' ability to support IBSE in LOtC contexts is further supported by evidence from the Train The Trainers Manual. Through a series of tasks for Partners, a synthesis of advice for other LOtC providers was devised to disseminate their evidence-based recommendations. The evidence drawn upon derives from their experiences of running the pilot INQUIRE courses, underpinned by reflective practice and evaluation. All Partners contributed to guidelines on getting started, course structure and organisation, partnerships with other organisations, course content, teacher and educators recruitment, and collaboration and communication – see Table 3 for complete checklist. A full description of these guidelines is located in Deliverable 4.2, the *Train the Trainer Manual.* This piece of evidence documents the Partners experience and ability to design effective educational programmes in botanic gardens and natural history museums.



Table 3: Checklist for setting up and managing an INQUIRE training course

Activity	Yes/No						
Getting started							
Have you put together a team to set up and manage the INQUIRE course?							
Have you established or linked to an existing National Advisory Group (NAG)?							
Course structure and organisation							
Have you developed the course programme and lesson plans?							
Is the course content linked to the school curriculum?							
Do the dates for the INQUIRE course fit with the school calendar?							
Is the course accredited?							
Are health and safety processes in place and have you informed your course participants about them?							
Have you decided on the evaluation methods for the INQUIRE course?							
Partnerships with other organisations							
Have you established partnerships with: LOtC networks? Schools?							
Course Content							
Is your course content balanced between theoretical and practical sessions?							
Have you included talks in your course by: Climate change scientists? IBSE educational researchers?							
Have you included activities on developing IBSE lesson plans?							
Have you ensured that reflective practice is encouraged during the course?							
Have you included discussion time for teachers and educators to gain a common understanding of IBSE?							
Have you included discussion time on how open or structured a IBSE lesson can be?							
Have you set up assignments for participants to complete after each onsite training day?							
Teacher and educator recruitment							
Have you decided on the target audience for your course?							
Have you decided on the different strategies for recruiting teachers and educators?							
Collaboration and communication							
Have you encouraged teachers to form a Community of Inquiry?							
Have you set up an on-line communication channel for Partners?							



4.4.3 Indicators of professional development

FINDING: Partners developed their professional knowledge and practice as a result of the INQUIRE project

For many Partners, knowledge and experience of inquiry-based approaches was limited at the beginning of the project. Although all Partners were engaged in running education programmes through their gardens and museums, few had engaged in much IBSE within these offerings. Through involvement in the INQUIRE project, Partners commented that they had developed their understanding and practice of the approach and how to apply it to their own teaching. The result for most Partners was the revision of previous lesson plans and activities and the trialling of resources developed by other Partners in the project. An important role in this regard was played by the management board and the academic Partners who provided advice, support and direction on both practical and research based approaches to their work. As a result of the time allocated to development and reflection within the tasks set and project meetings, Partners were afforded ample opportunities that enabled reflection on and evaluation of their professional practice. This area needs further attention within individual gardens and museums when the project terminates to ensure that adequate allocation of time and resources are deployed to allow Partners to continue to evaluate and reflect and provide insights on which future work can be based.

When asked what they had personally gained from being part of the INQUIRE project, a common response was 'we learned a lot' [UL, R2]. Project Partners listed, and described, gains in terms of knowledge, experience, skills, relationships, ideas and the views and perspectives of other botanic gardens. For most, the levels of communication and sharing would be sorely missed and the most common response to what they would miss the most was the Partners and the Partner meetings because of the dynamic nature of the group and how much learning resulted from them.

"When it ends, what I would miss? the meetings. It was a great group, very active and very interested in the method and very interested in developing something and for me, it was very interesting to have the meetings in different countries to see how they work and how they practice inquiry and to know there are colleagues, you can ask them something [SBZH, R2] I feel better and I learn better when I see people and they talk to me with examples, with things like this, it is my personal thinking, but I think it is what I will miss the most here [BORDEAUX, R2]

The professional development discussed by Partners centred on the variety of experiences within the project, the broadening of views that prevented a more insular perspective. Viewing the strength, constraints and opportunities of various Partners was viewed as being extremely beneficial to their professional practice. Most Partners expressed their intentions to continue to make good use of the lessons learned in the current practice and to further develop their educational programmes in the future.

"What I gained from being part of the project is the friendship and the community of practice from the other national Partners, as well as internally here in the botanic garden, when we were able



to recruit new staff and we became a team. Before, I had to do all these things by myself. Now, we can have botanic discussions and reflective practice and it's another way of organising my work and organising things that we develop for the garden".[NBGB R2]

4.4.4 Examples of sustainability of inquire courses

Finding: Partners are committed to the continuation of INQUIRE courses and practices within their organisations

As outlined previously, many Partners have shown considerable institutional change as a result of participation in the INQUIRE project. During the final Partner meeting the issue of longer term sustainability of the INQUIRE courses was discussed, with several Partners presenting specific and detailed plans for work in this area [Minutes 5th Partner Meeting, Trento]. All Partners will continue to promote and discuss the INQUIRE project through their Facebook pages,Twitter feeds, communication channels and the INQUIRE website (inquirebotnay.org).

In addition to embedding IBSE activities in the day-to-day running of educational programmes, Partners have been working on new ventures to maintain the momentum built up during the project. The INQUIRE courses will continue to run in FCTUC, UL, NBGB, SBZH, Uni-HB and KEW in their existing structure. In some cases this has been aided by the accreditation process employed in setting up the original INQUIRE courses, which is beneficial to the recruitment process. Moreover, many Partners have plans, in various stages of completion, for extensions to the current INQUIRE offer. These include offering short day courses (BGRHB) and modified formats (KEW, NBGB, SBZH) that specifically target groups such as primary school teachers, informal science educators or teacher trainers.

"In 2013 – 2014 our target group is primary school teachers...for this course [primary teachers] we charge a fee (E100), make a personalised course manual with tips and examples that correspond with the Flemish situation and curriculum... We can conclude that having teacher trainers and students in the courses is a very important way of ensuring the sustainability". [NBGB]

Future work on INQUIRE courses involves new collaborations resulting from dissemination and networking activity during the INQUIRE project. In England, for example, Kew will launch a similar annual INQUIRE PD in Spring/Summer 2014 in partnership with the Royal Botanic Gardens, Edinburgh for teachers in Scotland. The collaboration has explored how best to adapt content and activities and how to support a community of practice between participants across the two sites. Similarly, newly formed collaborations have been formed between Uni-HB and "Zoo am Meer" where INQUIRE courses will continue to be offered to primary teachers.

Uni-HB was the first Partner to initiate an INQUIRE course into the teacher-training offer in the university. This Partner will continue this work with trainee teachers and education students in postgraduate programmes, in collaboration with a range of schools and informal learning sites. Other



Partners that have begun to build relationships between formal and informal learning sites are UL and FCTUC.

"Moreover, the INQUIRE COIMBRA course could be integrated with a proper design in the first curricular year of the Coimbra University, on the Biology and other connected Natural Sciences superior courses, linked to a curricular discipline of conservation, botany or science education, in this last case directly addressed to the training of future teachers". [FCTUC]

The final area where Partners will address issues of sustainability relate to strategies targeting both visitor engagement and future recruitment of participants to courses. In an effort to raise awareness of the botanic garden and Natural History Museum in Norway, NHM are planning a 'Get to know the Museum' evening to address the persistent issue of teacher engagement with informal learning sites. "Many participants in the previous courses reported that they knew little about the Botanic garden prior to the course. Therefore we are planning to have a "get to know the museum" evening where we present what we can offer. Hopefully this will get more teachers to utilise the opportunities in our Botanic garden and recruit participants for next year's course" [NHM]

In the Belgian context, building on substantial institutional changes to the education team as a result of participation in the INQUIRE project, the team are proposing changes to general visitor engagement. Through the use of research questions that may be answered during the visit to the garden, along with additional materials, they aim to promote an experience more akin to IBSE.

"We want to go one step further and offer all our visitors some research questions on different locations in our Garden. We will start this in the Glass Houses, providing cards with research questions that visitors can try to answer while visiting one certain part of the Glass House. They will be stimulated to find the answer by observing, talking to our gardeners or reading information panels. At the end of their visit, they will be invited to buy a booklet that contains more information concerning the research questions. All these actions will be made visible by using the INQUIRE banner and the INQUIRE symbol on different locations and documents". [NBGB]

The clearest message from all Partners was one of commitment [Fieldnotes, Trento meeting]. The end of the project was in sight but no Partner expressed any sense of stopping the work that had begun with the project. This section portrayed some of the examples that Partners are exploring in efforts to continue what they started, in partnership, in 2010.



5. Summary of Findings

5.1 Contribution of the INQUIRE course to development of science teaching

The INQUIRE course has contributed to the development of science teaching, evidenced in the range and quality of the course material prepared, resulting in predominantly positive feedback from course participants with strong indications of changing practice noted across Europe. This has largely been a result of the use of practical activities within the gardens that allowed teachers and educators to trial IBSE in LOtC settings and in their own classrooms. These strategies on the course were most successful in increasing IBSE knowledge and skills because they could be used immediately or act as sources of inspiration for adaptation.

Several INQUIRE courses were structured around demonstrating IBSE activities and lesson plans, in fact encouraging, participants to try the activities, modify the activities and create their own IBSE activities for use in gardens or outdoors spaces. This proved to be a valuable process resulting in increases in positive attitudes towards IBSE, confidence using IBSE and changes to teachers' teaching practices. The enthusiasm for inquiry-based approaches instilled within the INQUIRE courses also led to increased levels of science learning outside, with many examples described or presented in both portfolios and at the INQUIRE conference. Participation in the professional development also led to institution-wide changes to education provision and practice and increased professional development of educators in the gardens and museums.

Similarly, choosing a content area such as biodiversity and climate change was opportune as it addressed a knowledge gap for many participants. While running the courses, differences were noted between various course participants that has implications for future course design. For instance, it may be necessary in some instances to design separate courses for teachers and educators or for primary and secondary school teachers owing to differing needs. In terms of Guskey's model of professional development, this accounts for level 1 impact: that is, participants were satisfied with the course and reactions to it were positive.

Participation in INQUIRE courses led to increased engagement with outdoor learning environments, since many teachers had never before visited a botanic garden. As a result of the courses, they learned to be comfortable with the botanic garden as an outside space for learning and to develop their own investigations using gardens and outdoor spaces. Because the courses addressed some of the common misconceptions about IBSE, such as 'doing hands-on science is the same as inquiry' or 'you needs lots of time to do IBSE' or 'you can't assess inquiry', the course participants themselves felt that their knowledge and practice increased. In addition to theoretical pedagogical and subject knowledge gains (biodiversity and climate change), confidence in using IBSE and reflective practice techniques



also increased. However, the INQUIRE Partners, despite showing increased use of evaluation tools in their assessment of participants' learning, continue to require additional support to determine whether or not their learning outcomes have been achieved in their courses in order to improve their ability articulate with evidence. Partners often described their views of participant learning in terms of their intended learning outcomes for the courses rather that what participants' actually did learn. Furthermore, in the portfolios, many Partners struggled to link their judgments to artefacts that provided evidence for the judgment. In terms of Guskey's model of professional development, this accounts for level 2 impact: that is, the teachers and educators learned new knowledge and skills.

Changes to science teaching practices were observable in many Partner institutions and within the participants' practices in their schools and gardens, such as altering existing lesson plans for their school groups to make them more open and IBSE focused, or devising new lesson plans that focused specifically on both an inquiry-based approach and biodiversity/climate change topics. The botanic gardens as organisations also demonstrated significant changes in terms of staffing, provision for public engagement as well as educational programmes and their whole educational offer. In terms of Guskey's model of professional development, this accounts for level 3 impact: that is, support was offered by both botanic gardens and schools for participants. The result here was organisational change in botanic gardens and changes in teaching practices for teachers in schools. It also demonstrates level 4 impacts because both teachers and educators implemented their new knowledge and skills in the classroom and garden contexts.

For students, interest and engagement with science in botanic gardens was increased using IBSE activities through the development of scientific process skills such as observation, critical thinking, asking questions, and developing hypotheses, and social abilities such as listening and debating. Students also showed increased understanding of issues of biodiversity and climate change. In terms of increasing student learning outcomes from IBSE activities in outdoor spaces, practitioners should realise that students require support with making connections and using terminology during IBSE activities. The level of evidence for student learning outcomes, or Guskey's level 5 impacts, is not as strong as the previous levels, however, instances of effect on affective as well as cognitive outcomes have been offered by the teachers' and educators' own reflective practice or practitioner research on the implementation of IBSE with their class.

Although the project can report very positively in terms of participant's views and learning from the courses and student learning outcomes as a result, providing teacher-training courses in botanic gardens was not without its difficulties. Fostering IBSE teacher-training provision in botanic gardens involves overcoming many barriers and challenges including the recruitment of participants, engaging in online participation, local educational and political contexts and bureaucracy, the absence of relevant IBSE literature in some languages and the persistence, in European contexts, of known barriers to outdoor learning.



5.2 The status of learning outside of the classroom (LOtC)

The status and role of botanic gardens was broadened in the eyes of the teachers, viewed now as *'privileged spaces for learning'* as a result of the INQUIRE project. The significance of botanic gardens as learning spaces, centres of scientific excellence and teacher-training, locations for LOtC and IBSE activities was recognised by the course participants. Enjoyment of the garden as a learning space was also noted, resulting in increased school bookings and visits to the gardens by teachers with their classes. In many cases this was generated from more positive attitudes and from the practical activities that developed the knowledge and skills required to conduct IBSE in botanic gardens. A successful strategy was the combination of theory and practical sessions. Similarly to the previous section, this is indicative of Guskey's level 1 and 2 impacts.

Partners' models of IBSE in practice were centred on collaborative learning and hypothesis-driven inquiry and illustrated a range of interpretations of IBSE. Through participation in the INQUIRE project however, the levels of understanding and practice of IBSE increased and Partners produced a significant amount of high quality IBSE activities for use in LOtC. Many of these resources actively target some of the common known misconceptions of IBSE and facilitate easy access into the pedagogical strategy from short starter type to longer running activities. Although this was not the original intention of INQUIRE, the project responded to an identified need for IBSE resources for use in outdoor contexts. As a result of the project demonstrates a wider influence through the dissemination of a new Activities Manual derived from Partners' work. This is particularly relevant at a time of increasing concern for young people's disconnection with nature, not just at European level, but globally (Louve, 2006; Bragg et al. 2013).

5.3 The influence of INQUIRE on the formal and informal sector

The INQUIRE project has had numerous significant influences on both the formal and informal sector. In developing the courses Partners have developed positive relationships which bridge the formal and informal divide. Many Partners report positively about their relationships and extending networks with teachers, schools, education departments and other stakeholders in both the formal and informal sector. As a result, the use of botanic gardens as a LOtC institution to promote students' engagement with science has been highlighted in both formal and informal settings. The successful implementation of the courses has meant an increase in the status of education within individual gardens as well as teachers and schools now having broader views of the educational potential of botanic gardens as learning sites. Consequently, changes to educational provision and practice within botanic gardens were evident in many participating European countries. Several Partners have reported plans to continue the courses on a permanent basis, a lasting legacy of collaboration between botanic gardens are gardens/natural history museums, universities and schools. Partners also have extended their outreach programmes such as Science Festivals and Open Days to incorporate inquiry-based offers and



instigated change to the broader public engagement offer with many Partners expressing beliefs that providing educational programmes for schools (pupils and teachers) should be one of the botanic garden's core activities. In terms of Guskey's model of professional development, this is indicative of level 3 impact.

The INQUIRE project was successful in fostering an active COP that Partners attribute high value to. Partners felt that their involvement in the INQUIRE project provided opportunities for reflection on the nature of inquiry-based learning, the value of learning outside the classroom, and the teaching of issues related to biodiversity and climate change that would not have occurred ordinarily. Ultimately, most Partners valued the experience in terms of their personal professional development and the resulting improvements and changes that abounded within their institutions.

Sharing knowledge and experience combined with communicating and a sense of belonging was a strong feature of the project. The INQUIRE project provided much support and structure to foster a community of learners in the project through dedicated support visits, Partner meetings, the project website, and an online collaborative tool (Glasscubes). As a result of the academic support, an improvement in engagement with educational research was observed. Despite an articulated need for literature to support their courses, many Partners expressed that time taken to read this material (outside of completing the translation exercise) was a major constraint. Engaging with literature and relating research to practice remains a challenge for many Partners.

A strong feature of involvement within the INQUIRE project was the influence on usage of and attitude towards evaluation. The fifteen INQUIRE Partners adopted a diverse range of evaluation techniques and data collection strategies representing increased engagement with evaluation. Many of these were actively promoted within the project, as a toolbox of techniques to choose from, however the level of adoption was quite remarkable. Partners mainly utilised these techniques to reflect on the nature, practice and outcomes of each session of their courses and to determine the areas of success. As a result of engaging in the process Partners made changes to the design and activities of their courses to improve the quality of the provision. Partners have systematically monitored, evaluated and revised their practices using reflective practice.

5.4 Botanic gardens' ability to support learning outside the classroom

The INQUIRE project focused on the design, delivery and evaluation of IBSE teacher-training programs in botanic gardens and natural history museums, a successful venture evidenced throughout this report. Despite encountering many challenges along the way, the INQUIRE project has demonstrated how it is possible to build collaborations between formal and informal contexts through a consortium of botanic gardens, natural history museums and universities. For many Partners, knowledge and experience of inquiry-based approaches was limited at the beginning of the project. Although all Partners were



IBSE activity in the classroom, part of the INQUIRE course at NBGB, Belgium



involved in running education programmes through their gardens and museums, few had engaged in much IBSE activity within these offerings. Through involvement in the INQUIRE project Partners commented that they had developed their understanding and practice of the approach and how to apply it to their own teaching. The result for most Partners was the revision of previous lesson plans and activities and the trialling of resources developed by other Partners in the project. More significant has been the stimulation of institutional change, as previously outlined. An important role in this regard was played by the management board and the academic Partners who provided advice, support and direction on both practical and research based approaches to their work. As a result of the time allocated to development and reflection within the tasks set and project meetings, Partners were afforded ample opportunities that enabled reflection on and evaluation of their professional practice. The professional development of educators was positively affected through involvement in the courses. This is an area that needs further attention within individual gardens and museums when the project terminates to ensure that adequate allocation of time and resources are deployed to allow Partners to continue to evaluate and reflect, and provide insights on which future work can be based.

The Partner's ability to support IBSE in LOtC contexts is supported by evidence from the *Train The Trainers Manual*. Through a series of tasks set to Partners, a synthesis of advice for other LOtC providers was devised to disseminate their evidence-based recommendations. The evidence drawn upon derives from their experiences of running the pilot INQUIRE courses, underpinned by reflective practice and evaluation. All Partners contributed to guidelines on getting started, course structure and organisation, partnerships with other organisations, course content, teacher and educator recruitment, and collaboration and communication. This piece of evidence documents the Partners' experience and ability to design effective educational programmes in botanic gardens and Natural History Museums.

In addition to the persistence with embedding IBSE activities into the day-to-day running of educational programmes, Partners have been working on new ventures to maintain the momentum generated during the project. This section clearly shows impacts at level 4 and 4 (Guskey, 2000).



6. Concluding remarks

It has long been acknowledged that botanic gardens and museums constitute unique resources for supporting learning. While many botanic gardens and museums have worked with schools, they have traditionally focused on fieldtrips, often providing resources pre and post visit. Given their expertise and physical situation, botanic gardens and museums may be considered well-equipped and well-placed to provide professional development programmes for teachers and educators. They bring specialist science content knowledge; access to unique resources/environments; and experienced staff.

It has been argued that many traditionally employed forms of professional development, such as one-shot in-service workshops, are *'woefully inadequate'* at meeting their aims of transforming practice (Borko, 2004; Darling-Hammond et al, 2009; Lumpe, 2007). Programmes which include a lengthy package of PD sessions (30+ hours); follow-up workshops; or the provision of materials to be used in school with students or colleagues, have been found to be more effective in enabling sustained change. INQUIRE courses were informed by what we know about effective professional development. Consequently, a number of features were evident (Desimone, 2009) such as a focus on active learning during the professional development experiences, alignment to teachers' needs, occurrence over a long duration, collective participation by teachers and educators in their professional learning, and a focus on the content to be learned by students. As such, the courses provided opportunities for participants to examine their own practice, developed solutions to known barriers to engagement with IBSE and learning outside of the classroom and provided extensive support both in the course sessions and in an on-going nature in participants' own educational settings.

The INQUIRE courses were developed in different national contexts using a broadly defined common framework (60 hours of professional development focusing on climate change and biodiversity using IBSE in LOtC). General findings emerge from a comparison of all programmes relating to the contribution to the development of science teaching, the status of LOtC, the influences on formal and informal contexts and the ability of botanic gardens and museums to support LOtC. The findings show that the courses were reviewed positively by the participants, who learned both theoretical and practical aspects of implementing IBSE in LOtC contexts. A greater appreciation of botanic gardens as a learning resource was also noted. From a review of the evidence, there are strong indications of good quality course provision across the project, illustrated in the structure and nature of the design of the programmes and in the outcomes from participants.

As a result of participating in the INQUIRE project significant professional development outcomes resulted. **The key factors for success of the INQUIRE project are:**

- The courses are designed on the research evidence for effective professional development
- The courses build on established expertise of the botanic gardens and natural history museums
- The project is based on a sound, yet developing, understanding of the theoretical aspects of the underpinning pedagogy





Students' inquiry outdoors at NBGB, Belgium

The Partners extended the professional development to their own informal science educators
 The project benefits from evaluation and pedagogical support from academic Partners and a competent management board structure.

The INQUIRE project had two central goals, to invigorate IBSE in Europe leading to the widespread uptake. Through an examination of Partners' and participants' responses to the INQUIRE course, ample evidence has been provided that indicates a new energy and enthusiasm for IBSE, and take-up of the approach both within gardens and museums and with teachers and schools has been significant. Over 500⁶ teachers and educators participated in the INQUIRE courses during the lifetime of the project, in 14 different European countries, representing an impressive potential reach in terms of student learning.

The project articulated 11 objectives set out in the Description of Work taking a number of learning environments into consideration during the courses. These have largely been achieved within the timeframe of the project. While the project has achieved the majority of its objectives, **three areas for improvement** have been identified:

1. The development of European wide standard or evaluating formal and informal education programmes

2. Increase self-confidence in girls to study science

3. Address issues of diversity, including gender, disability, ethnic and socio-economic background

6. At the time of writing, the final number of course participants was being computed



No specific work programmes addressed the identification of or adherence to standards for evaluation formal and informal education programs. Through persistent support offered by the academic Partners in the project, a more systematic approach to evaluation was undertaken. However, the since each programme was a function of its own local context a direct comparison through the use of standard measures of success was not applied. Cross-case comparative analysis of the project outcomes have been conducted qualitatively and Partners decided, with support, on the most appropriate methods by which to evaluate their programmes. Allocation of time and resources, local contexts, constraints and opportunities were the deciding factors for each Partner.

Partners' main aims and objectives, in relation to their teacher-training course, were were to focus on the IBSE method and LOtC. Programmes did not explicitly address issues of self-confidence in girls, or questions of diversity or social justice. It is important to consider gender and diversity difference when designing, implementing and evaluating educational programmes because this may offer insights into techniques that may actively enable ALL students, regardless of gender, disability or socio-economic background, to engage with science in gardens and museums. This is an area that is important to address in the current climate of declining interest in the sciences, particularly among girls and disadvantaged groups. The opportunities for facilitating engagement with science for these audiences is an area for future work and may impact significantly on garden and museum visitor demographics. The INQUIRE project offers a significant contribution to education provision across Europe, through the introduction and fostering of IBSE, in both formal and informal settings, on a large scale. This approach offered numerous opportunities for the successful cascading of best practice IBSE and LOtC pedagogical approaches in both the courses that were offered and as a result of extensive networking and dissemination. The INQUIRE courses constituted significant front-line support to teachers and informal educators interested in engaging with IBSE in their practice, and represents the bridging of the gap between informal science educations, formal science educators and educational researchers. Consequently, a key network of educators, teachers, teacher trainer, researchers and key educational and political stakeholders was established and considerable revival activity and discourse was achieved within each country. The net result of this three-year project is strong evidence for successful implementation of curriculum based innovations, ultimately making a strong case for IBSE in LOtC settings. The project provides concrete examples of what IBSE looks like in practice in LOtC settings.



Teacher training in IBSE at LFU, Austria



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INQUIRE Partners sharing IBSE activities at Obergugl, Austria



Appendices

Appendix 1: Evaluation interviews INQUIRE Partners – Round 1

Thank you for agreeing to talk to me about the INQUIRE course. We are trying to find out about the influence of the INQUIRE course on science teaching in schools and gardens and whether it has affects the status of learning outside the classroom in both the formal and informal sector.

We would like to audio-record the interviews with your permission. The data will be used by the Quality Management Team for INQUIRE project evaluation purposes and treated confidentially. Any questions before we start?

Questions

1. What types of feedback do you collect?

- Vhat are teachers' and educators' views of the INQUIRE course?
- Is this across the board or are there educators/teachers who feel differently?
- Vhat do you do with the feedback?

In your view how effective are the evaluation techniques utilised in INQUIRE in assisting you to gauge the appropriateness, effectiveness and impact of the INQUIRE course for your participants?
 What do you think your participants have learned as a result of being on the course?

▼ What additional support, if any, is required for participants? How will you monitor/ manage, etc?

4. Did the experiences on the INQUIRE course impact of participants' classroom practice?

▼ How? Try new skills, changed practice? Evidence for this?

Are you aware of any impact of the course on pupils that your participants (both teachers and educators) teach? How do you know there has been impact (i.e. what evidence, measures and so on?) Examples, for instance, on pupil attainment, attitudes, behaviour, motivations, ways of working – observations of student groups in the garden?

5. Which aspects of the INQUIRE course have been most successful in increasing the skills and knowledge needed to work with IBSE in botanic gardens or outdoor spaces?

6. How have the experiences on the INQUIRE course impacted on participants' immediate colleagues in their schools or gardens? (Has there been any impact on the practice of participants' colleagues? In terms of their teaching, what they now do, attitudes, their pupils etc, what evidence, measures do you have?)

7. In what way has the INQUIRE course affected LOtC?

▼ More visits from teachers, increased IBSE use by educators, teachers/educators using IBSE activities on school grounds, Reflecting on your own way of teaching?...

▼ Has the planning and delivering the INQUIRE course had any impact on how you conduct education in your garden?

8. What were the main challenges/barriers you encountered in developing a teacher training course on IBSE? What strategies did you develop to overcome these?



Appendix 2: INQUIRE Partner interviews – Round 2

Thank you for agreeing to talk to me about the INQUIRE course. We are trying to find out about the impact of the INQUIRE course on science teaching in schools and gardens and whether it has an impact on the status of learning outside the classroom in both the formal and informal sector. We would like to audio-record the interviews with your premission. The data will be used by the Quality Management Team for INQUIRE project evaluation purposes and treated confidentially. Any questions before we start?

Questions

1. Which aspects of the INQUIRE course have been most successful in increasing participants' skills and knowledge needed to work with IBSE in botanic gardens or outdoor spaces?

- 2. What types of feedback do you collect about the course? How is it used and by whom?.
- 3. What were the main barriers you encountered in providing professional development?
 - What do you think are the main reasons for resistance to CPD?
 - How might these and any other barriers be overcome?
- 4. What do you think your participants learned as a result of being on the course?
 - How did you monitor/manage their learning, etc?

5. Do you think that the participants' experiences on the INQUIRE course changed their classroom practice?

In what ways? Try new skills, changed practice? Evidence for this?

6. Do you think that there been any impact of taking part in the courses on the participants' colleagues? What evidence, measures do you have?.

7. Are you aware of any impact of the course on pupils that your participants teach?

If so how do you know there has been impact (i.e. what evidence, measures and so on?)

8. Do you think that participation in the INQUIRE course has increased the number of visits from teachers? Or increased IBSE use by garden educators? Any other impacts?

9. What has been the impact of the INQUIRE course on your institution/education team?

- Evidence for this?
- Local impact, regional impact, national impact or international?

10. In your view, how effective are the evaluation techniques utilised in INQUIRE in assisting you to guage the appropriateness, effectiveness and impact of the INQUIRE course for your participants?11. What are you doing now in your teaching (delivery of CPD) differently than you did before as a result of running the INQUIRE course?

- Vhy have you changed these things and not others?
- What impact have these changes had on your participants?

▼ What evidence do you have that the changes have been a success (e.g. in terms of participants' learning, adoption of IBSE)?

▼ What about your colleagues? Have they introduced any changes as a result of the course or ideas and materials from it? How do you know about the effects of any changes?



12. To what extent do you feel that your personal involvement in the project has allowed you to feel part of a Community of Practice?

▼ What have you personally gained from being part of the INQUIRE team? What will you miss most?

13. Do you think that you have developed your knowledge of IBSE and your skills as a practitioner of IBSE?



'CO2 in the world: production and absorbtion' activity at NBGB, Belgium



Appendix 3: How should I structure the Portfolio of Evidence?

The portfolio should demonstrate that participants understand how to critically evaluate, analyse and reflect on their learning to enhance their personal and professional development. The following outline provides a general guideline for the portfolio. The process of reflection is central to the portfolio as a practitioner must review, evaluate and most importantly, make sense of their own experiences and professional practice. Each portfolio should contain (In English):

How to structure the Portfolio of Evidence?

Cover page: Name of INQUIRE Partner, City, Country, Date
 List of key competencies or learning outcomes (max 1 page): This should be cross-referenced to evidence

A brief introduction (Max. 1 page): introduce yourself and the context in which you work. In this section you should be clear about what you have done and the approach you are taking in your portfolio: are you presenting a piece of action research – a trial of an IBSE activity and your conclusion from the study; are you summarising evidence to support your accomplishments within the INQUIRE course; are you presenting an indexed critical reflection on your professional learning in one area of the INQUIRE course (concept cartoons, concept maps, IBSE questioning, leading inquiry outside in botanic gardens? A critical reflective commentary on your learning within the INQUIRE course (max. 4-6 pages): A reflective commentary is an analysis of the practitioner's own work, the synthesis of the practitioner's personal inquiry and learning during the course. The reflective commentary ensures that practitioners have a voice in saying how the portfolio is to be read, and it helps us know how to read the evidence with their intentions in mind. This may take the form of a professional autobiography (for instance, a timeline within INQUIRE project or an examination of critical events, people, feelings, etc). See notes below on critically reflective commentaries

An index to the artefacts with brief justification for inclusion (max 2 pages):
 Conclusions (max 2 pages): A brief summary of the key themes, conclusions and next steps

■ Appendix – the evidence (no limit): the appendix should include all artefacts/items that are referenced in the critical commentary. This can take the form of printed material, photographs or an electronic version (CD/DVD/Memory stick, link to online content – be aware of the ethical issues of making your evidence 'public' such as online. This can be in your own language.



Appendix 4: Inquiry Science Indicator Checklist

An example: Feedback for Students

Table 4: Inquiry Science Indicator Checklist

For (student's name):							
This student	Often	Sometimes	Seldom	Never			
1. Asks testable questions							
2. Plans appropriate tests to answer questions							
3. Defines a hypothesis							
4. Gathers data in an organised and logical manner							
5. Searches for additional information related to investigation							
6. Exhibits an understanding of variables in an experiment							
7. Exhibits understanding and use of a control							
8. Translates observations into usable data							
9. Discusses ongoing investigations with others							
10. Compares data with others doing similar investigations							
11. Asks new questions based on new data							
12. Creates or modifies models							
13. Engages in self-directed investigations							
14. Makes entries in a journal/research book.							
15. Makes connections between different investigations							
16. Expresses interest in replicating the investigations of others							



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