

The INQUIRE Project



Inquiry based teacher training for a sustainable future

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Project Abstract (GA: FP7 SiS 266616)

The science education community agrees that pedagogical practices based on IBSE methods are more effective, but the reality is different. For various reasons, this type of teaching is hardly being practiced in European classrooms. INQUIRE counteracts this by developing and offering a one-year practical IBSE teacher training course that will reach out to hundreds of teachers, and in turn thousands of children, in 11 European countries. The course is offered at 14 Botanic Gardens and Natural History Museums - some of Europe's most inspirational cultural and learning institutions. These places act as catalysts by training and supporting teachers and educators to develop their proficiency in IBSE and become reflective practitioners. Most of the partner institutions have experience in delivering IBSE. To ensure excellence, theoretical rigour and project progression, two highly regarded science education research institutions participate: King's College UK (informal learning; practitioner's research) and University of Bremen BRD (research into teacher education). The training locations, the practical nature of the course, the support offered and the subject content encourages teachers and educators to enrol in INQUIRE courses and try out IBSE in their everyday teaching. Biodiversity loss and climate change are the major global issues of the 21st century and many teachers are looking for innovative ways to tackle these subjects. INQUIRE training supports teachers to do just that and introduce them to institutions where children can carry out 'real' investigations and see science in action. INQUIRE training courses are promoted through national systems that support professional development for teachers as well as informal education training networks. The website encourages the uptake of IBSE. It promotes dialogue between partners and teachers, showcase best practice published on other EU websites and highlight the results of practitioner research in IBSE.



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Project Overview

List of Partner Institutions

Management Board

1. UNIVERSITAET INNSBRUCK (LFU) Austria (Coordinator)
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



Some facts

The INQUIRE project united 17 partners from 11 countries.

9 Partners were Universities, 7 Partners non University Educational Institutions, 1 Partner was a NGO Global Networking Institution. 14 Partners run a Botanic Garden.

All botanic gardens are located in more or less big cities and some of them look back on a very long history such as the Botanic Garden in Innsbruck (about 200 years) Botanic Garden Madrid (250 years) Kew Gardens (250 years).

Some of them are rather new, such as the National Botanic Garden in Meise/Belgium (about 30 years) or the University of Alcalá Botanic Garden in Spain (10 years).

At the beginning of the project all partners had already been running educational programmes for many years, but some of these gardens were more experienced in facilitating Inquiry Based Science Education (IBSE) programmes than others. At the start of the project hardly any botanic garden partner was experienced in evaluating educational programmes.

Botanic Garden educators who participated in INQUIRE predominately have an educational background in science, only a few hold an educational degree.

INQUIRE Quality Management

The findings presented in this case study are based on the INQUIRE Quality Management Report (QMR¹). This Report was done by Kings College, Elaine Regan and Justin Dillon, supported by all members of the management board. Research data consists of a range of data sources from a participant-observer perspective. 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, field notes from support visits and partner meetings and contributions to project deliverables. This led to a multifaceted approach to evaluating INQUIRE project outcomes. The full QMR 2013, including the description of the methodology applied, is available on the INQUIRE website: www.inquirebotany.org

¹ For simplicity purposes the Inquire Quality Management Report (Regan/Dillon 2013) will be quoted as QMR 2013 throughout this paper.



National Botanic Gardens Belgium

The Background of the INQUIRE Project²:

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 Lehvavirta 2011:218). 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 Lehvavirta (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*' (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 debates as politically mature citizens. Botanic gardens and Natural History Museums represent significant educational resources, often acting as major

² QMR 2013:8ff

providers of a diverse range of formal and informal educational 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 Inquiry-Based Science Education (IBSE) which has been shown to support students' interest in science as well as the development of critical thinking skills. Furthermore, there is growing evidence that *Learning Outside the Classroom* (LOtC) can stimulate students' motivation to learn 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 was a three year project focusing on inquiry based science education (IBSE) and 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. In addition INQUIRE aimed for supporting Botanic Gardens to value reflective practice as a tool to evaluate and improve their educational programmes as well as to share knowledge and experience not only within the consortium but with the science education research community.

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 self-confidence in girls to study science

In this report we focus on the multi-site pan-European evaluation of INQUIRE teachertraining courses combining IBSE and LOtC in biodiversity and climate change.

IBSE in INQUIRE³

IBSE is probably most frequently defined as an approach to teaching science which engages students in the same kind of activities, practices, and thinking processes that scientists use in their work.

As mentioned above, partners were more or less experienced in running inquiry based programmes on site. Thus in order to recognize when inquiry is taking place, an Inquiry Science Indicator Checklist was developed based on the 5 NRC 'features' (NRC, 2000, p. 25).

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.

The INQUIRE learning environments are characterised by:

- 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

³ QMR 2013:10

- diversity, including gender, disability, ethnicity and socio-economic background is recognized
- there are self-regulated learning sequences where student autonomy is emphasized
- the central consideration in the design of activities is student interest

Reflective Practice in INQUIRE⁴

Teachers and botanic garden educators participating in INQUIRE teacher training courses were encouraged to engage in reflective practice. By undertaking their own classroom or garden based practitioners research, practitioners can more easily reflect on the reality and effectiveness of learning outcomes. Andrew Morris and Philip Barker (2003) stated that there has been considerable discussion concerning the impact of education research on policy and practice. This has included the importance of an interactive model of education research which is linked to both practice and development, the need to develop research capacity amongst all contributors and beneficiaries of education research, and the importance of two-way communication strategies that link research to practice and vice versa. The use of practitioner research is increasingly advocated as a self-reflective tool that can promote the development of teachers and science educators. Dillon et al. (2002) reported on an innovative project that demonstrated how teachers and academic researchers could work together on action research projects chosen by the teachers themselves. Engaging formal and informal practitioners in their own IBSE research helps them to adapt research outcomes more easily. Presenting the practitioners point of view to the education research community and key decision makers in formal education supports discussions on a more practical scale. Researchers, as well as curriculum planners, are able to see which support is most effective for teachers; teachers become accustomed to research terminology, as well as the researchers being able to adopt a language that is understandable by teachers. This helps the communication process all round.

⁴ GRANT AGREEMENT, PART B. page 13

The LFU Case Study

As the Botanic Garden at Innsbruck University was a “typical” partner in the INQUIRE project and the QMR findings are based on a well-defined data set we refer to this data whenever this was observed on the local level. Whenever findings of the report are cited literally – this is highlighted via *italic letters* and the page it appears in the QMR.

University Innsbruck Botanic Garden

The Educational Department at the University Botanic Gardens holds two 50% part time posts (master level). Both employees hold a degree in botany.

In addition, the department is supported by six freelance educators running educational programmes on a regular basis. Most of them hold a Master’s degree; some hold Bachelor degrees in botany or ecology. None have a teacher’s degree.

Head of the department was Suzanne Kapelari, the coordinator of the INQUIRE project. She holds a doctorate in biology, Master’s degree in biology teaching and a Master of Arts in education.

Via the INQUIRE project it was possible to employ a PhD. student 70% (Master of Biology Teaching) to do developmental work, design, run and evaluate teacher training programmes and fulfil other tasks foreseen by the contract. In addition, an additional person (Master of Biology and currently studying to become a biology/chemistry teacher) was employed for 20h/week to do the INQUIRE project manager. When the INQUIRE project ended these two co-workers had to leave the team. In addition Suzanne Kapelari left University of Innsbruck to work at the University of Vienna, as head of the Austrian Education Competence Centre Biology.

Analysis of Outcomes

Inquiry Based Learning at Botanic Gardens

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 (QMR 2013:64).

The INQUIRE courses at LFU 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 future 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 portfolios (QMR 2013:64).*

Participation in the professional development also led to institutional-wide changes to education provision and practice and increased professional development of educators in the garden.

Similarly, choosing the content area "Pollination" was opportune as it addressed a knowledge gap for many participants.

Participation in INQUIRE courses led to increased engagement with outdoor learning environments, *since many participating 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 (QMR 2013: 64).*

Because the courses addressed some of the common misconceptions about IBSE, such as 'doing hands-on science is the same as inquiry' or 'you need 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, confidence in using IBSE and reflective practice techniques also increased (QMR 2013:64-65).

Reflective Practice

Botanic Garden educators at LFU, despite showing increased use of evaluation tools in their assessment of participants' learning, will 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 to articulate with evidence. As many other partners' educators often described their views of participant learning in terms of their intended learning outcomes for the courses rather than what participants' actually did learn. However, in the portfolios, it was obvious that LFU educators link their judgments to artefacts that provided evidence for the judgment (QMR 2013:53f).

As with many INQUIRE partners, changes to science teaching practices were observable at LFU and within the educators' practices in the 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 educational programmes and their whole educational offer (QMR 2013:65).

The result here was organisational change in botanic gardens and changes in teaching practices for teachers in schools.

The INQUIRE project was successful in fostering an active Community of Practice that partners in the project attribute high value to. Educators at LFU 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, they 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 with engagement with educational research was observed.

A strong feature of involvement within the INQUIRE project was the influence on usage of and attitude towards evaluation. LFU educators 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. LFU applied, social Network analysis, Analysis of Concept maps, interviews and questionnaires 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 LFU made changes to the design and activities of their courses to improve the quality of the provision. (QMR 2013:67)

Students

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 pollination. 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 (QMR 2013:65).



University Botanic Garden Innsbruck

Obstacles

While running the courses, differences were noted between various course participants that had 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 (QMR 2013:53).

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 (QMR 2013:66).

Botanic Gardens are unique Learning environments in Europe.

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 learning outside of the classroom 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.

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 production, peer review and testing of a range of new resources throughout the project lifecycle 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) (QMR 2013:66-67).

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/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 expressed beliefs that providing educational programmes for schools (pupils and teachers) should be one of the botanic garden's core activities (QMR 2013:67).

Botanic Gardens' Ability to Support Learning Outside the Classroom

The INQUIRE project focused on the design, delivery and evaluation of IBSE teacher-training programmes 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 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. 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 LOfC 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 LOfC 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. This piece of evidence documents the partners experience and ability to design effective educational programmes in botanic gardens and Natural History Museums.



National Botanic Gardens Belgium

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 (QMR 2013:68-69).



Royal Botanic Gardens Kew

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