

### 3. Part B – Putting Theory into Practice

Cultural psychology design based research (Bell, 2004) is applied to learn more about how international educational reform based projects need to be structured and implemented in order to become successful in implementing change in educational practice, at schools, as well as at Learning Outside the Classroom institutions.

As learning occurs most naturally and meaningfully when embedded in a sociocultural, activity related context, I will explain the INQUIRE project idea, design and framework and how collaborative knowledge creation processes have been supported among a group of Botanic Gardens, Natural History Museums and Science Education research institutions participating in the international EU 7<sup>th</sup> framework Science and Society project - INQUIRE: Inquiry based teacher training for a sustainable future (2010–2013).

The activity theory and the expansive learning model is applied to explore the collaborative knowledge creation process of one activity system, the Spanish INQUIRE partner, in detail. By analysing knowledge artefacts (e.g. understanding IBSE) and objects (e.g. lesson plans, training course design etc.) I try to learn more about how collaborative knowledge creation occurs and can be supported. In addition I will look at whether and how this new knowledge contributes to the transformation of practices in respect to a partner's socio-cultural context. According to Yrjö Engeström's theory, I value both the improvement on the scale of what is currently assumed to be good practice in IBSE teaching as well as the horizontal movement in terms of exchanging and hybridising different cultural contexts, concepts and attitudes; I also try to understand the totality of their work and practices.

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**How to cite this book chapter:**

Kapelari, S. 2015. Putting Theory into Practice. In: Kapelari, S *Garden Learning: A Study on European Botanic Gardens' Collaborative Learning Processes*, Pp. 101–155. London: Ubiquity Press. DOI: <http://dx.doi.org/10.5334/bas.c>. License: CC-BY 4.0.

I conclude that the European commission's 7<sup>th</sup> Framework Program designers were wise to focus on 'Inquiry Based Science Education'. Not because some researchers claim IBSE is the most successful approach, but because it is still such a vague concept that requires teachers, educators, teacher trainers, researchers, curriculum planners and policy makers to 'move across boundaries' (Engeström & Sannino, 2010), and to find information and tools wherever they happen to be available.

Thus IBSE has a great potential to trigger 'expansive learning' processes amongst stakeholders all over Europe. However, experience has shown that some EU programmes, as well as project designers and evaluators, are too pre-occupied with what they value as success. The focus is put on a monological stance or on measurable facts, such as timely delivery of reports and deliverables, progress towards the objectives of the project, whether and how project beneficiaries proceed in producing high numbers of educational materials published on websites or high numbers of contacts established with stakeholders. All this is independent of the quality of these contacts.

As a result of number crunching, we are left with little understanding of how educational practises change in relation to IBSE reform interventions at the organisational level or in schools and LOtC organisations. We know very little about what knowledge turns into organisational memory and whether it is implemented sustainably in future practice.

### 3.1 The INQUIRE Project

'Improving science education was and is an issue in educational policy in many European countries and worldwide for a couple of years already. High quality science teaching applied by those engaging in science education, formal and informal settings alike, is essential for effective student learning' (Osborne & Dillon, 2008).

The project 'INQUIRE: Inquiry based teacher training for a sustainable future' (EU Nr. 266616) was one of several initiatives funded by the European 7th Framework programme (2007–2013) Science and Society. I was the applicant and the coordinator of this three year project, running between 2010–2013, and which joined 17 partners from 11 European countries and had an allocated budget of 2,3 Million €.

INQUIRE was the follow up to the Project, PLASCIGARDENS- Plant Science Gardens: Plant Science Education for Primary Schools in European Botanic Gardens (SAS6-CT-2005–20577) which was mainly dedicated to developing an 'inquiry based, multilingual, multicultural plant science education tool about plant diversity' ([www.planscape.net](http://www.planscape.net)).

I coordinated this project from 2005 to 2007 and ran it together with partners from Bulgaria, Italy and the UK. All three of these partners joined me again in

the INQUIRE project. The first project already put an emphasis on developing teacher training offers at botanic gardens for promoting collaboration between botanic gardens and their local teachers and schools.

### 3.1.1 *The INQUIRE Idea*

Project abstract (Project Proposal handed in At the European Commission Research Directorate in 2010):

*The science education community agrees that pedagogical practices based on IBSE methods are more effective. But the reality on the ground is different. For various reasons, this type of teaching is not practiced in most European classrooms. INQUIRE counteract this by developing and offering a one-year practically based 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 run through 14 Botanic Gardens and Natural History Museums - some of Europe's most inspirational cultural and learning institutions. These places act as catalysts, 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. 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 (Kapelari et al., 2010).*

### 3.1.2 *The INQUIRE Framework*

Educational reforms efforts around the world are seeking to provide opportunities for pre and in service teachers to enhance their professional knowledge, skills and attitudes (s.p. 99ff) to develop new and more effective instructional practices. However many institutions that provide opportunities for teachers and students to learn about science outside the classroom often do not engage in bigger educational reform efforts (Phillips et al., 2007) and in service training programs for LOTC educators are rare. The INQUIRE project therefore asked Botanic Gardens and Natural History Museums to engage in designing and implementing inquiry based training offers for teachers and

LOtC educators and thus contribute to improving science education in their country.

Traditional professional teacher development schemes have come under criticism for their inability to promote teacher learning in ways that impact on outcomes for the diversity of students in the classrooms (Timperley et al., 2007). Criticism is directed to in-service training that follows approaches based on an external view of what knowledge and skills teacher need to be equipped with - a separation from the teacher's daily work or a setting that focuses on an individualistic development practices. These settings do not take into account what we already know about how adults and teachers learn (s.p. 106ff). Taking this into consideration, the INQUIRE approach to professional learning and development relies on collaborative knowledge creation processes to support consortium partners as well as their course participants in developing an understanding of IBSE that is fruitful in their particular socio cultural setting. The INQUIRE learning environment is based on Engeströms 'Expansive Learning Theory' (s.p. 34ff) thus expanding Vygotsky's constructivist approach of 'socio-cultural learning' (p. 31) and Lave and Wenger's ideas of 'situated learning in communities of practice' (p. 23ff) and assumes that a collaborative knowledge creation approach to learning has a great potential to support individual as well as organisational development.

### 3.1.3 *The INQUIRE Network*

As mentioned earlier, the Rocard Report (2007) suggests that 'Teachers are key players in the renewal of science education. Among others, being part of a network allows them to improve the quality of their teaching and supports their motivation' (p. 14). The use of network structures is becoming popular, in business and education alike, not only as a source of knowledge and to improve the effectiveness of organisations but as a source of innovation and transformation. Learning in collaborative networks is a special mode of knowledge production and values knowledge that is embedded in social structures within and between individuals and organisations. The INQUIRE network therefore is recognised as a collaborative network which is characterised by connecting all 4 levels of action.

- Level 1: the individual science teacher acting in the classroom / the individual science educator facilitating learning outside the classroom
- Level 2: the group of science teachers or science educators working in a particular school or in the education department in particular LOtC organisation
- Level 3: the collective of educational organisations (schools and LOtC organisations) actively engaged in science education in a particular country
- Level 4: the collective of formal education providers and LOtC organisations acting on an international level (Level 4).

A horizontal movement of information between organisations, as well as a vertical movement between all four levels of action, is accomplished by individuals acting on all 4 of these levels simultaneously – as botanic garden educators responsible for running school programs, as INQUIRE training course designers, as course teacher and as representative of their particular institution in the INQUIRE consortium. Knowledge created by teachers and educators participating in INQUIRE training courses is introduced through monitoring tools that the course trainers apply to evaluate their course and through assignments participants have to hand in to fulfil course requirements. Thus knowledge transfer and learning is not considered to be a one way road but interplay between these levels. It is assumed that it leads to the formation of new levels of learning located in the partnership. Van Aalst (2003) argues that, in terms of its efficiency, the quality of the network structure is important. As a consequence the INQUIRE project planning and the follow up implementation exhibit the following thoughts:

- Producers (Botanic Gardens, Natural History Museums offering training courses) and customers (schools, teachers, other LOTC organisations interested in running INQUIRE courses etc.) were linked via a national advisory board which consisted of teachers, members of the national school system, LOTC organisations etc. This was established to increase the degree of partner's integration on the national level.
- Links between partners in the consortium were assumed to be interactive and all partners expected gains from being involved in this network.
- The network enjoyed a degree of self-management which included different leaders for different aspects (visible in the INQUIRE management board)
- The INQUIRE consortium partners shared the common purpose of developing a deeper understanding of IBSE in a school - botanic garden learning environment and establishing teacher training courses which reflect this understanding and their organisational development (object).
- A sense of belonging, cohesion and reinforcement of values was created and maintained throughout the project via a sequence of meetings which were perfectly organised by the Management Board and the local host partner.
- Networks often come and go. The INQUIRE project came to an end after three years, however partners prepared the ground for new networks in a variety of partner combinations and with additional LOTC organisations.

### 3.1.4 *The INQUIRE Design*

The INQUIRE project design aspired to create a collaborative expansive learning environment (Engeström, 2001) that put the following characteristics into practice:

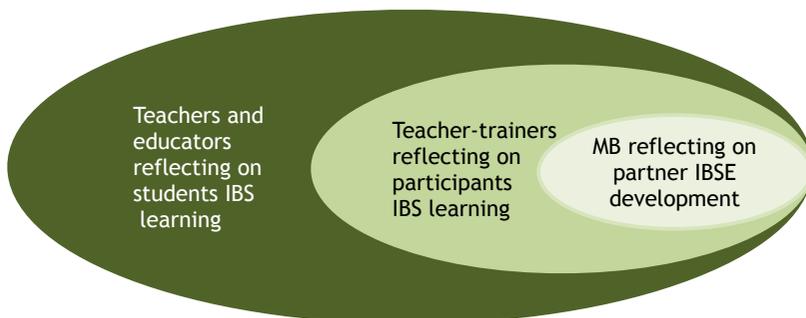
*Circles of learning actions. . .*

INQUIRE efforts are founded upon the idea that humans of any age learn more effectively through ‘personal inquiry experience with others’ than through didactic teaching and telling. Multiple expansive learning cycles (s. p. 35) were integrated into the INQUIRE project design from the start in order to develop a new and specific understanding of inquiry based science teaching at botanic gardens. The project management never advanced a monological view of the ‘one and only best practice model of inquiry based science teaching’ but repeatedly asked consortium partners to question their understanding of inquiry based science teaching, to develop lesson plans and model new solutions, examine them in practice and reflect on them not only in their own organisational context but to consolidate their understanding in dialogue with other consortium partners (s. p. 113).

Practitioner’s inquiry is increasingly advocated as a self-reflection tool that can promote the development of teachers and researchers alike (Taber, 2007; Reid & Dillon, 2004) and this approach was applied to scaffold reflection throughout the process.

Partners present their findings in ‘Portfolios of Evidence’ which were introduced as a tool to

- promote reflective practice
- shared knowledge and experience with colleagues
- to encourage cooperation
- offer a bottom-up voluntary process that is owned by the partner and was not used for evaluation purposes
- support partners by enabling conditions (Klenowski, 2002,)



**Figure 7:** Reflection took place on 3 levels: course participants, botanic gardens and the Management Board were engaged in reflective practice.

Teachers and educators participating in the INQUIRE training courses were asked to investigate their own teaching and learning and hand in assignments that illustrate their learning process. Partner institutions did the same. The consortium as a whole applied a range of 16 different evaluation tools to monitor their practice (Regan & Dillon, 2013).

To value this process, a pilot and a second INQUIRE teacher training course was planned and implemented to provide the opportunity for partners to adapt their training course design in the light of experience, reflection and feedback from network partners and to see whether their new understanding proves successful. Partners were asked to hand in portfolios of evidence after each training course was finished. Portfolios of evidence were applied

[. . .] to consider the complex multifaceted nature of teaching by providing the opportunity to reflect critically on their practice, to engage in professional dialogue with colleagues and to collaborate and develop understanding and ideas on teaching and learning (Klenowski, 2002, pp. 24–25).

*. . . informed design based research*

‘The design researcher proceeds through a series of highly aligned cycles of design, data gathering and analysis, using each implementation as an opportunity to inform and reformulate subsequent design principles. Through a parallel and retrospective process of reflection upon the design itself, the study of its implementation, its critical features and its formative outcomes, the researcher builds on the initial hypotheses and design principles. This reflective process occurs in real time and when done well it allows the researcher to provide fundamental understanding and to build a more coherent and robust theory based in actual practice’ (Kelly & Sloane, 2003, p. 32)

Portfolios of evidence and other artefacts and objects (e.g. Lesson plans) handed in by partners after the first and after the second course were analysed. Interviews with partners were conducted in the middle as well as at the end of the project (s.p. 172). An ‘Interims Evaluation Report’ as well as a ‘Final External Evaluation Report’ Allun Morgan (2013) was commissioned to collect additional data and provide an external perspective on the work done in course of the project. All interims findings were used to adapt and improve the project design while the project was in progress.

*Value multifaceted knowledge*

The INQUIRE network design was chosen to value the innovative potential of a heterogeneous group. Multifaceted knowledge, experience and creativity was

contributed through scientists, education researchers, botanic garden educators, teachers, horticulturalist and others who joined in and constituted this multicultural group. Building on the 'Model of Knowledge Creation' (Nonaka & Takeuchi, 1995), INQUIRE explicitly valued both stages of knowledge which are the 'tacit' and the 'explicit'. Explicit knowledge is easy to articulate and to express formally in clear terms whereas tacit knowledge is embedded in individual experience, involves personal beliefs, perspectives and values. The basic source of information in the INQUIRE model is tacit knowledge, which needs to be explicated in order to be transformed into knowledge that is useful at the level of the group and the whole project. A creative knowledge development processes is an ascending process of learning from the individual level to the group and organizational level and finally between organizations. The INQUIRE project management team aimed to activate all four levels of knowledge development.

The dynamics in INQUIRE can be explained by an interaction between tacit and explicit knowledge about IBSE available in the consortium and research and practice base literature made accessible by consortium partners. The consortium started by sharing tacit knowledge about IBSE by presenting IBSE activities during consortium meetings as well as articulating each individual's understanding of IBSE at that moment in time. Nonaka and Takeuchi (1995) termed this first phase *socialization* (planned and took place in project Work Package (WP1). It is followed by the second phase called *externalization* in which INQUIRE partners conceptualized tacit knowledge by means of presenting activities and developing a deliverable presenting a concept of IBSE in INQUIRE (planned and took place in project WP 2).

Explicit knowledge about IBSE was continuously discussed in a series of consortium meetings, where partners presented lesson plans and activities and questioned each other's teaching and learning approaches. This third phase is called the *combination* phase and asked partners to share explicit knowledge (planned and took place in project WP 2-4). INQUIRE finally reached the fourth and final phase which is called *internalization* (planned and took place in project WP5) which asked INQUIRE partners to absorb explicit knowledge gained in the project so that it becomes tacit again and is sustainably implemented through the partner's philosophy of IBSE teaching and learning. This organisational knowledge becomes visible in the final training course design and lesson plans which partners published on the INQUIRE website.

### *Collaborative learning in a community*

The knowledge community that it was hoped would emerge in the INQUIRE consortium was an 'Advance Community of Practice', because it values expansive learning processes and not the system defined by Lave and Wenger's early understanding of situated learning which was seen as a predominantly vertical

movement from the stage of incompetence to competence. The major goal in INQUIRE was to nurture the development of an international collaborative network described as a ‘Community of Inquiry’.

The 14 Botanic Garden partners (see list of partners on p. 161) were selected because these Gardens feature an educational department with at least one employee. Consortium participants were expected to have a common interest in improving science education programmes (object) and in collaborating over an extended period of time to share ideas, find solutions and build innovation. Consortium meetings as well as an online platform provided the space for collaborative action.

Shulman and Shulman (2004) noted that an ongoing interaction between an individual professional and the community leads to a shared knowledge of the team/organisation which finally offers members the opportunity to confirm, interconnect and develop their professional knowledge. Thus the project management was responsible for setting tasks and timelines to nurture this ongoing reflection and knowledge sharing processes.

#### *Provide additional source of information*

VanDriel (2011) and Van Aalst (2003) highlight the importance of including experts in the field when it comes to maintaining networks/communities of learners because these people help the group to speed up their learning process. Experts were therefore asked to inform the INQUIRE community in two areas of knowledge development:

- Scientific background knowledge about ‘biodiversity loss and climate change’.
- Science Education Research based knowledge about IBSE, Reflective Practice, Teachers Professional Development and Assessment.

The discourse and the different views of practitioners and researchers served to enhance the process of reflection and to expand the horizon, understanding and capabilities of both agents.

#### *Appreciating science education research knowledge*

Timperley, Wilson, Barrar, and Fung (2007) published a list of characteristic professional development activities which should be included in any professional development offer so that it becomes more successful in supporting teacher development (s.p. 106ff). The original INQUIRE teacher and educator training course design asked partner institutions to integrate these characteristics. However, as the expansive learning process took place in many different countries, these characteristics were discussed and trialled, with the result that on some occasions the final courses design turned out to be slightly different.

### 3.1.5 *IBST in INQUIRE*

The shared understanding of IBST in INQUIRE is valued as an expansive learning process and based on knowledge provided by science education research as well as on practice based knowledge provided by partners and other IBSE related educational project. The focus is put on student learning outcomes, not on a particular model of IBST. It is based on the notion that natural science is not all about following fixed and unalterable operating plans, which have to be completed one predefined step after another. It's actually a creative, but still understandable and reproducible, process of gaining information. The main principle of IBST in INQUIRE is to promote a model of the learner as autonomous and independently thinking - someone capable of dealing successfully with many aspects of science. Therefore, learners should be provided with free space for organising their learning processes individually. They also need to be taught some science content by teachers - they cannot simply invent scientific knowledge without any basic level of scientific knowledge. INQUIRE aims to support teachers and botanic educators and, in the long run, help pupils to understand the various and creative scientific approaches which represent the foundation of scientific learning, by enabling them to experience these approaches first-hand. Using IBSE approaches, teachers, botanic garden educators and their participating students should develop the ability to critically examine what they are told by people or read in on-line publications, newspapers or even in education research journals. They should also be able to examine their own ideas critically and ensure that, as much as possible, they are evidence-based (Kapelari et al., 2011). Thus INQUIRE aims to enable practitioners to adapt the abstract 'circle of inquiry based teaching' (see p. 58ff) innovatively, flexibly and competently to their own and to the needs of their students. Practitioners at all levels should be enabled to question their approaches self-reflexively, as well as to analyse the efficiency of their teaching approach while focusing on students learning outcomes.

#### 3.1.5 *The INQUIRE Proposal*

I was primarily responsible for the development production of the INQUIRE project proposal. This was the 'road map' that the project consortium followed throughout the whole duration of the project without any major adaptation. The proposal was handed in to the EU in January 2010 and was positively evaluated by two external evaluators.

I was primarily responsible for negotiating the Grant Agreement with representatives of the European Commission between June and September 2010. The writing process, as well as the negotiation process, was supported by Julia Willison and Gail Bromley, for the most part in terms of fruitful discussion and editing of the English script .

The following INQUIRE partners were asked to contribute to the proposal by providing written sections appropriate to their expertise and therefore hold authorship of particular paragraphs.

Julia Willison: ‘Supporting education for a sustainable Europe’ (Proposal, p. 101)

Prof. Doris Elster: ‘Assessing INQUIRE course development’ (Proposal, p. 19–20)

In the end, the theoretical background provided by Prof. Doris Elster did not fully match my understanding of good practice in professional development, which has been described in great detail in this work already. The Framework for evaluating teachers professional development suggested by Prof. Elster did not meet the approval of the INQUIRE Management Board, so the evaluation strategy was changed and is described in detail in ‘The Quality Management Report’ (Regan & Dillon, 2013), which mirrors my understanding of collaborative knowledge creation in the light of activity theory. Nonetheless, at that stage of the proposal development I was grateful for these contributions.

Prof. Justin Dillon: ‘Stimulating and motivating science learning from an earliest stage’ (Proposal, p. 15–16)

The following pages have been taken from the proposal to give an insight how the basic principle of the INQUIRE Framework was put into practice.

[...]

B.1. Concept and objectives, quality and effectiveness of the support mechanisms and associated work plan

B.1.1. Concept and objectives

*‘We cannot solve our problems with the same thinking we used when we created them.’*

*Albert Einstein*

The overall objective of the INQUIRE project is the widespread uptake of inquiry-based teaching and learning in science education across Europe. With this in mind, the overwhelming goals of the INQUIRE project are the following:

### The Goal

INQUIRE aims to reinvigorate inquiry-based science education (IBSE) in the Formal and the Learning Outside the Classroom (LOtC) educational systems throughout Europe. INQUIRE envisages to promote the professional development of teachers by implementing effective teacher training interventions using the expertise in inquiry-based learning and teaching of a consortium of 17 partners in 11 countries.

The consortium will develop and is planning to implement a rolling one-year training course for practitioners in inquiry-based learning methods, research methodology and assessment techniques. Through training, ongoing mentor-

Summary Table	Work packages addressing this issue
INQUIRE will link informal and formal education systems as well as the science education research community through assembling an interdisciplinary project team	WP2 Levelling
INQUIRE will develop a shared understanding of inquiry based learning in formal and informal educational institutions on a European scale	WP2 Levelling
INQUIRE will develop a rolling one-year training course for practitioners in inquiry-based learning (INQUIRE course manual) Addressing pupils age 9–14 years	WP3 INQUIRE course development
INQUIRE will promote already existing best practise models (PLASCIGARDEN, SINUS Transfer, POLLEN, S-TEAM, FIBO-NACCI) throughout the project in both the formal and informal education system	WP3 INQUIRE course development WP6 Dissemination
INQUIRE will develop a course whose subject content will highlight the major global issues of the 21 <sup>st</sup> Century: biodiversity loss and climate change	WP3 INQUIRE course development
INQUIRE will promote learning in and outside the classroom	WP3 INQUIRE course development
INQUIRE will promote its course through the various national systems that support continual professional development for teachers	WP4 Implementation
INQUIRE envisages to implement pilot courses at a local level throughout 11 European countries	WP4 Implementation
INQUIRE will ensure that formative assessment encourages the course design to be adapted to the needs of individual countries	WP7 Quality Management
INQUIRE will create an interactive website and regularly published electronic newsletters to support a practitioners network	WP6 Dissemination
INQUIRE will train teachers and informal educators to carry out their own practitioners research	WP4 Implementation
INQUIRE will encourage teachers and educators to participate in website activities through establishing a teacher recognition scheme	WP3 INQUIRE course development
INQUIRE will run a final Conference to disseminate the project outcomes on a European wide scale	WP6 Dissemination
INQUIRE will support other informal learning institutions seeking to gain experience in the area of inquiry based science education techniques and run the INQUIRE Train the Trainer Course.	WP4 Implementation
INQUIRE outcomes will be promoted through a range of networks including the EU central information provider for dissemination of best practice	WP6 Dissemination

**Table 3:** Summary table of project objectives.

ing and promotion of best practice, INQUIRE will try to firmly embed this pedagogy within the educational systems of 11 European countries.

The subject content of the course will focus on the major global issues of the 21<sup>st</sup> Century: biodiversity loss and climate change and will build on already published teaching resources (PLASCIGARDEN, POLLEN, SINUS Transfer, S-Team, Biology in Context, etc.) as well as on newly created resources.

Plants are the basis for all life on earth and it is critical for a sustainable future that students and teachers understand the fundamental importance of plants to our lives. IBSE allows learners to critically explore inter-connections between subjects, which is an important tool in the development of fully informed citizens that play an active role in democracy.

Botanic gardens and science education researchers, with their practical as well as theoretical expert knowledge in this field, will mainly facilitate the course development and implementation.

LOtC institutions are known to increase learners' motivation to continue with their studies about science. Research into LOtC demonstrates clearly that learners develop their knowledge and skills in ways that add value to their everyday experience in the classroom. Research also shows that some experiences have a particularly positive impact on long-term memory. Out-of-class learning reinforces the link between the affective and cognitive domains and this provides a bridge to higher order learning.

#### The road to success

LOtC institutions are attractive learning sites for children and adults alike. Engaging LOtC institutions in offering teacher training courses in IBSE techniques will be an effective way to motivate teachers to implement IBSE in their classrooms. In addition LOtC institutions house experts working in scientific fields that can offer specialised knowledge to teachers - helping them to increase their effectiveness in IBSE. Seventeen partners are involved in this project. They will organise advisory groups in 11 European countries, comprising teachers, teacher trainers, botanic garden educators, representatives of regional or national school boards and science education researchers (optional). All LOtC learning sites are well equipped and experienced in the practical side of developing and conducting IBSE teaching programmes.

All partners will feed into the development of the INQUIRE teacher training course. The education researchers will ensure the theoretical underpinning of the course while other partners will add their expertise and perspectives. In addition the quality and effectiveness of the support mechanism will rely on researchers excellence to support partners and participating teachers in reflecting on their own doing as well as provide formative assessment while work is in progress. The aim is to develop a training course that is inspiring, meets practitioners as well as school authorities needs and is theory and evidence based. Through collaboration with stakeholders at local levels (Advisory Groups), cul-

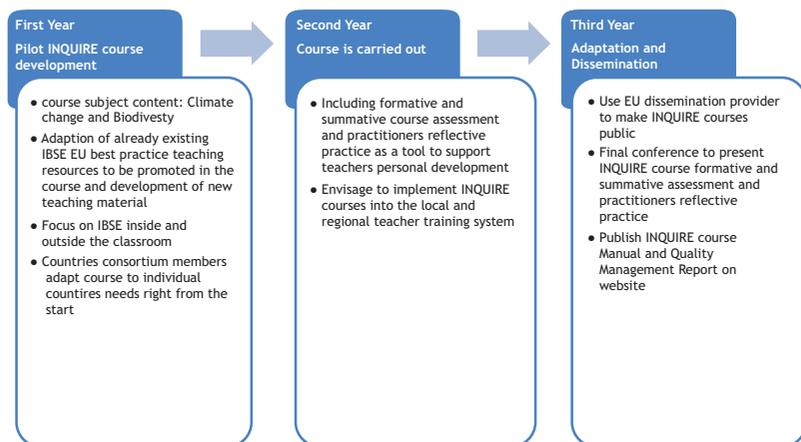
tural differences and needs can be incorporated and fed into the overall design of the course which will be finalised at IBSE Expert Consortium level. LOTC institutions will deliver the pilot course in their countries and use their various networks to invite teachers and educators from other LOTC institutions (Natural History Museums, Science Centres, Zoos and other Botanic Gardens) to participate in these courses. The goal is to help these institutions to develop their knowledge and skills in this area in order to deliver INQUIRE courses themselves and snowball IBSE expertise in formal and non-formal learning environments throughout Europe.

Teachers will be incentivised to participate in the INQUIRE courses through a range of benefits – these will include:

- free professional development
- joining a pan-European network of teachers with an opportunity to communicate with teachers in other European countries
- an opportunity to develop good contact with a prestigious LOTC site.
- an opportunity to showcase good teaching practice and influence practice in their own country and abroad
- an opportunity to participate in the final conference
- free entrance to LOTC sites
- free passes for their classes to visit LOTC sites

### B.1.2. Quality and effectiveness of the support mechanisms and associated work plan

**The first year** of the project will involve developing the pilot course, a teaching manual and an interactive website. Discussions will be held about teaching methodologies, course structure and promotion and how this course can be



**Figure 8:** Project progress.

adapted to different country conditions, taking into consideration cultural differences in educational systems and working practices (WP1 Levelling). The course will be promoted through the various national systems that support continual professional development for teachers. One of the main objectives of the course is also to link informal and non-formal education systems through encouraging educators working in a range of LOtC institutions to participate in the project. The draft course manual will be adapted to the needs of different European countries as well as to the needs of various formal and LOC institutions (WP2). The interactive website (WP6) will encourage dialogue between partners and teachers and showcase best practice methods published on other EU websites, eg. POLLEN, SINUS Transfer, FIBONACCI and S-TEAM. INQUIRE will promote these practices throughout the project in both the formal and LOtC education system in 11 countries. A training workshop will be held for all partners to develop a shared understanding of inquiry-based learning and how it can be used effectively to teach environmental education and sustainable development.

**The second year** of the project will see the launch of the pilot INQUIRE course in 11 European countries. The course, run by the project partners, will consist of three two-day modules - one run in each teaching term (autumn, spring and summer) for teachers and LOtC educators from other institutions. The first workshop will focus on training in inquiry-based learning and methods, the second workshop will concentrate on reflective practice methodology and the third workshop will be dedicated to teachers' developments and reflective practice outcomes. During the workshops, the teaching manual will be discussed and refined and formative evaluation will be used to sharpen the course content. In between workshops, teachers will be encouraged to bring their students to visit the LOtC site and experience IBSE. Educators from other LOtC sites who have attended the INQUIRE course will be encouraged to develop their own network of teachers, teacher trainers and educational researchers to deliver INQUIRE courses the following year. These sites will be responsible for all costs associated with developing their own networks and running INQUIRE courses.

Following the second Module, participating teachers will be encouraged to engage in reflective practice to look on their own process of change and gather data how IBSE works in their classroom. INQUIRE will support teachers through the website and publish regular electronic newsletters. The challenge of encouraging teachers to participate in the website will be addressed by establishing a teacher recognition scheme to participate in the final European conference. During the year, botanic gardens will also provide an open informal space for teachers to meet and discuss their experiences gained through the project. They will be invited to post new methods and ideas on the website to share with their colleagues involved in the project. INQUIRE will facilitate this sharing through translations.

**The third year** of the project will see partners run the course again to consolidate and embed it within the botanic gardens and education systems. At this stage other LOtC institutions are invited to run courses. LOtC institutions are invited to participate in free “Train the Trainer courses” run by partner LOtCs to obtain an insight into the INQUIRE course design. If they are interested in running courses on their own costs themselves, partner organisations will support them by for example, providing already prepared teaching resources. They will not provide funding. The INQUIRE course manual will be finalised, edited and published on-line. It will also be promoted throughout the 11 regional networks. Increasing numbers of teachers are invited to bring their students to visit LOtC sites and experience IBSE. Partners will support practitioners’ reflective practice through continuing to provide a forum for teachers to meet and discuss practice and INQUIRE will continue to publish regular e-newsletters and encourage shared dialogue through the website. Towards the end of the project a European practitioners’ (teachers, science educators, researchers) conference will be held to showcase inquiry-based learning in Europe. Through the teacher recognition scheme 14 teachers will be invited to attend the conference.

#### Quality counts

**Formative evaluation** focusing on the process of the course development will be carried out during the project life cycle. Additionally an **external evaluator** will carry out a summative as well as formative evaluation on the meta-level to assess the outcomes of the project. He will not carry our research himself but will rely on data provided by project partners.

The external evaluator is brought in at the start of the project and will participate in two consortium meetings (one in the first year and one in the second year). During the third year he will attend the final conference and will hand in two external reports one in month 24 and one by the end of the project (month 36).

[...]

#### B.1.2.12.2. Timing of work packages and their components

The central goal of the project is to develop an INQUIRE course design, addressing primary and secondary school teacher’s needs, that is flexible enough to work in different European education systems. Pilot INQUIRE course will run in each of the 11 participating countries. While one course will run in most of the participating countries two will run in Portugal, Spain and Germany (all in all 14 Pilot Courses) in the second project year. Alongside the pilot course a formative and summative evaluation is conducted and supported by partners KCL and UniHB which will help to improve the course design while work is in progress. The third year will see running the Final INQUIRE course in 11 participating countries (all in all 14 Final Courses) It is planned to develop this final course version into a standard available course offered by participating botanic gardens in cooperation with their local teacher training institutions within times to come. The project is structured within nine work

Work package (WP)	WP- Number	WP-Leader	Duration
Set up Project	WP 1	BGCI	Month 1–4
Levelling	WP 2	LFU	Month 2–5
INQUIRE course development	WP 3	UniHB	Month 4–12
Implementation	WP 4	MTSN	Month 10–36
Sum up	WP 5	KEW	Month 32–36
Dissemination	WP 6	BGCI	Month 1–36
Quality Management	WP 7	KCL	Month 1–36
Project Management	WP 8	LFU	Month 1–36
Ethical Issues	WP 9	UniHB	Month 1–36

**Table 4:** Work package summary.

packages with four in consecutive phases. Each phase is characterized by one work package. Four work packages span the whole project duration. An external evaluation is planned.

The project structure is kept as simple as possible. A number of partners will be allocated the same workload to make supervising and monitoring the project progress accomplishable. This will also make it easier for the Management Board to identify delays in the sense that partners will operate more or less independently and so delays will be limited to a particular partner.

The inaugural meeting (month 2) and the first Consortium Meeting will be crucial to establishing detailed timescales and management structures. In the inaugural meeting participants will agree on a detailed project schedule, deadlines for submitting work, discuss draft versions of “Project Planning, Dissemination Plan, and the Quality Management Plan” Partners will discuss and agree on the procedures that need to be taken should a partner not meet the required standards and deadlines. The modalities of money transfer will be discussed and agreed upon, keeping various risks in mind. Each partner will provide a Letters of Intent from a regional Teacher Training Institutions demonstrating their commitment to support the implementation of the INQUIRE teacher training course in their country. (See work package description).

**Consortium Meetings:** Consortium Meetings will enable work to be supervised and deadlines checked regularly. In total there will be 5 Consortium Meetings in three Years (a 6<sup>th</sup> is optional) and each meeting will last 2 days (2 nights including arrival and departure). Partners will be invited to host one of the 5 meetings. Two people will represent LFU and BGCI while all other partners will be represented by one person. In case partners send more than one person to meetings they will explain why.

The partner responsible for **Quality Management** will support the project at the Consortium level. This partner will ensure the smooth progression of the project and support partners to achieve high quality standards agreed upon.

**Management Board Meetings** will generally be held one day before Consortiums Meetings except the first one which is held in month 1 to prepare the Inaugural Meeting. This meeting will be held between partners BGCI, KCL, LFU and UniHB. It is planned as a video conference and the External Evaluator might be invited. Therefore Work package Leaders will not attend this meeting. All other Management Board Meetings will include all management board members. The Management Board will be dedicated to preparing Consortium Meetings and to support Botanic Gardens achieving the INQUIRE objectives. A final meeting at the end of the project is optional.

[. . .]

*Work package 1 (WP1): Project Set Up*

*Month 1–4*

Work package 1 will be initiated with a Management Board meeting that will prepare for the Inaugural Meeting (Kick off Meeting) in Brussels. This will be attended by at a minimum of 5 people (LFU, BGCI, KCL, UniHB and the External Evaluator) and is planned to be organized as a video conference. This Management Board will prepare detailed timescales and management structures to facilitate the progress of the project. “Project Planning”, “Dissemination Plan”, “Quality Management Manual” will be drafted and sent to partners before the inaugural meeting.

The Inaugural Meeting will gather the whole consortium for the first time. This will involve 19 people – 2 people each from LFU and BGCI and 1 person from each of the other partners. In case partners send more than one person they will explain why.

The consortium will work and agree on a detailed project schedule guided by the Management Board and agree deadlines and quality standards for handing in work carried out during the project.

A list of criteria for selecting existing IBSE teaching material to be used in the pilot INQUIRE course will be discussed, agreed on and finalized by the end of month 4.

Consortium members will discuss the draft of the “Dissemination Plan” and will add local and international activities run on their behalf. Project Management Board will finalize this work by the end of month 4.

The Quality Management team will discuss ideas with the consortium partners relating to the Quality Management Plan (see WP 7). Participants’ ideas and individual, local and regional circumstances will be considered and a final version of the Quality Management Plan will be added to the Consortium Agreement.

Each Partner will identify and invite relevant members to participate in their Advisory Group. Each partner will document their members for inclusion on

the INQUIRE website. A document detailing their Advisory Group constitutions will be produced,

[...]

*Work package 2 (WP2): Levelling*

*Month 2–5*

Partners will constitute and manage their Advisory Groups (AG). Each partner will decide whether they reimburse travelling costs for their members of the AG.

The installation of **Advisory Groups** supporting INQUIRE activities voluntarily has proven to be successful in the PLASCIGARDEN project already and will be documented in 11 EU-partner countries. Via experts knowledge gathered in group discussions partner institutions will plan for opportunities to localize official training activities to the national curriculum as well as legal and structural conditions in each participating country. Partners will collect information, e.g. curriculum requirements, criteria and requirements for INQUIRE course implementation and discuss these with their AG's. AG's will decide which existing teaching resources (PLANTSCLAFE; SINUS TRANSFER; POLLEN; S-TEAM; FIBONACCI, BGCI, local material etc) are relevant and will fit within the INQUIRE training programme based on the criteria identified in WP1.

Partners will call on their 'national knowledge' to discuss national needs for developing the pilot INQUIRE course. National differences will be discussed and strategies developed to meet the needs of each country when it comes to offering the courses via the local teacher training systems.

The First Consortium Meeting in month 5 will focus mainly on developing a shared understanding of inquiry based science education for developing the pilot INQUIRE course (PIC), including teaching techniques and methods. The discussions will be underpinned by a theoretical basis.

Action minutes of the first consortium meeting will summarize the shared understanding established (Document summarising how IBSE is defined in INQUIRE course).

In addition a "Strategy Plan" will be formulated for implementing the course within each local teacher training system and will be sent to the Management Board by each participating partner. The Management Board will examine each strategy plan and will produce a final INQUIRE Course Implementation Plan (CIP) that takes into account national differences by the end of month 5. The **INQUIRE Course Implementation Plan** will summarize potential links to school curricula and national requirements across 11 countries and will be published

[...]

*Work package 3 (WP3): INQUIRE Course Development*

*Month 4–12*

By participating in the Advisory Group (AG) all stakeholders (formal and informal educators, teachers, school authorities, etc) are invited to bring their

knowledge and skills when it comes to developing the ‘pilot INQUIRE course’ (PIC) at a regional level. They will work on a voluntary basis and will meet twice a year. In between they will be informed about project progress via the INQUIRE newsletter.

The INQUIRE teacher training course will bring together teachers from the school sector (formal education) with educators from site-based education centres (informal education). Teachers participating in the courses should develop an understanding of how to facilitate inquiry based science education in their classrooms as well as outside at botanic gardens and natural history museums. These experiences are envisaged to deepen and enrich children’s understanding of science.

Participation in the INQUIRE teacher training course is envisaged to support teachers to make the most of using IBSE materials with their students. IBSE often requires technical resources and living organisms. Teachers will be encouraged to use their school gardens as well as site based education centres that usually offer far more in terms of natural resources as well as specialist equipment. By bringing the formal and informal sectors together, teachers are envisaged to benefit from the amazing resources that site-based education centres have to offer. Pupils will also have the opportunity to see real conservation in action and this will facilitate their understanding of the need to address biodiversity conservation and climate change. INQUIRE envisages that a visit to a botanic garden or natural history museum will no longer be just a nice day out but an integrated part of pupils and teachers science curriculum in 11 European countries.

Because inquire based teaching methods often require a considerable amount of technical resources and living organisms we hope that teachers learn to use LOtC learning environments to enrich their pupils science learning environment by integrating LOtC attractions and expert knowledge to go for Inquiry based learning. The main goals the INQUIRE course will aim for are:

- to support teacher with scientific knowledge to teach biodiversity and climate change in IBSE classes as well as at LOtC learning site
- to encourage teachers to develop a proficiency in facilitating IBSE learning (how to work with experiments, facilitate group discussions, support students to develop higher order thinking skills)
- to support students and teachers to understand basic concepts of selected climate change and biodiversity issues
- to encourage teachers own development while reflecting on their own teaching and evaluating ISBE learning outcomes

Informal educators will provide profound background knowledge as well as methodological experience when it comes to structure and scaffold IBSE learning process in class as well as at LOtC institutions. Learning in a formal as

well as an informal learning environment will support not only pupils but also teachers to give IBSE a go. These LOtC learning sites provide a unique setting and learning resources that a formal school environment simply cannot provide. Teachers will be introduced to teaching concepts that rely on the school as well as on the informal learning environment and will learn to extract the best from both.

Ideas and materials will be gathered at the national level and partners will document and bring them to the consortium meetings (month 5 and 10). The aim is to ensure that cultural differences and needs can be incorporated within the overall course design or can be met through individual adaptations right from the beginning.

The first year of the project will involve developing the pilot INQUIRE course modules and publish a draft **Pilot INQUIRE Course (PIC) Manual**.

Discussions will be held about teaching methodologies, course structure and promotion and how this course can be adapted to different country conditions taking into consideration cultural differences in educational systems and working practices. A **Strategy Plan for PIC Promotion** in each country and on an international level will be discussed and agreed upon.

Relevant existing teaching material will be identified according to the criteria published in Month 4 and adapted where necessary to the subject content (climate change and biodiversity) and translated into INQUIRE project languages.

The PIC manual will be adapted to various needs in various European countries and for various formal and LOtC institutions. The goal is to finally develop an overall European INQUIRE course design that is flexible enough to work in different European education systems.

During the second consortium meeting partners (month 10) partners will learn how they can contribute to the formative and summative assessment carried out alongside PIC implementation (facilitated by Uni Bremen), how reflective practice can be carried out by PIC participants (facilitated by KCL) and how LOtC institutions can support PIC participants development.

The Management Board will present the draft selection criteria for the teacher recognition scheme and the consortium members will discuss and finalise the criteria.

A ‘Train the Trainer’ Course (TTC) manual will be developed to support partner organisations preparing to run the PIC in their institutions.

TTC’s will be held in each partner institution to ensure high quality standards when it comes to facilitating the pilot INQUIRE course.

[...]

*Work package 4 (WP4): Implementation*

*Month 10–36*

The PIC will be carried out by each participating LOtC in every participating country from Month 10 – Month 24. In total 14 courses (one course in most of

the partner countries, two in Spain, Germany and Portugal) are envisaged to be carried out. This one year training course will oversee a manageable work load that could be easily integrated within a full time teaching schedule. The course will be held during holidays/ over weekends/or during working hours depending on participating countries customs. It is structured in three modules (each 2–3 days =20h; 60h for the whole course). In between these modules teachers will be encouraged to work in class and try out what they have learned during course modules.

It is envisaged that at least 15 primary and low secondary teachers (all in all approximately 210 primary and lower secondary teachers) and at least 5 informal educators (all in all ca 70 informal educators) will participate in each course.

Formative and summative assessment, focussing on professional development of participating teachers will be carried out for selected courses (at least 11 courses in 11 different countries). Outcomes that lead to changes will be incorporated into the course design.

The final INQUIRE Course (IC) design will be established based on formative assessment results.

From month 24 – month 36 educators from other botanic gardens, natural history museums or science centres will be invited by LOTCs to participate in the free TTC's to develop their own knowledge and skills to run future INQUIRE courses at their own institutions (open 'Train the Trainer' courses). These sites will be responsible for all costs associated with running INQUIRE courses. The third consortium meeting will be held in month 15.

The final version will be offered to teachers as INQUIRE course in year three

From Month 24 – Month 36 indicatively 14 INQUIRE courses (IC) will be organised again.

It is envisaged that at about 15 primary/secondary teachers (all in all approximately 210 teachers) and about 5 informal educators (all in all ca 70 informal educators) will participate in each course.

It is envisaged that the INQUIRE course will develop into a standard available course offered by participating botanic gardens in cooperation with their local teacher training institutions within times to come.

[. . .]

*Work package 5 (WP5): Sum up*

*Month 32–36*

The final outcomes of the project are summarised. Teachers will get support in preparing posters for the Final Conference. The Quality Management report will be completed. All project outcomes are summarised and material will be collected for final project reports.

The INQUIRE course manual will be revised and will be published on the website in 10 European languages

An optional final consortium meeting is planned to the close of the project and will provide opportunities to discuss and plan further cooperation's between partners.

[...]

*Work package 6 (WP6) Dissemination*

*Month 1–36*

The INQUIRE course will be promoted through the various national systems that support continual professional development for teachers. One of the main objectives of the course is to link informal and non formal education systems, by encouraging educators working in LOtC institutions to participate in the project. INQUIRE will focus attention on supporting IBSE in 11 European countries, bridging the gap between researcher, practitioners and key decision makers as well as setting up a European wide network of IBSE practitioners to support and encourage each other to put adequate teaching and learning techniques into practice.

Successful dissemination of the outcomes is of particular importance. A Dissemination Officer working at BGCI will be dedicated to fulfilling these requirements. A dissemination strategy will be prepared by the end of month 4 including all potential opportunities for disseminating INQUIRE ideas and findings.

The INQUIRE website will be set up during the course of the project and will be translated into 10 European languages. It will be updated on a regular basis and enable practitioners to interact with each other and to exchange knowledge and experiences gained while participating in the INQUIRE pilot courses. The Dissemination Officer will maintain the English area of the website and partners will update their own language areas in collaboration with the Dissemination Officer. The website will contain a range of materials including downloadable resources, links to relevant websites, training videos, images and news items. The final course manual will also be uploaded onto the website in month 36.

E-newsletters will also be sent out regularly to inform subscribers (botanic garden educators, teachers and school authorities) about new developments happening in the project and announce any materials that may be of relevance. E-newsletters will be written by the Dissemination Officer with input from partners, then be translated by partners and distributed throughout the 11 countries.

Information leaflets promoting the INQUIRE pilot courses will be prepared and translated and sent out by the end of month 10 to recruit teachers onto the courses. Scientific papers, abstracts, posters and oral presentations will be submitted at national and international meetings and conferences. Both the scientific community and the public media will be kept informed on a regular basis about developments with the INQUIRE project via press releases.

**The Final Conference:** We envisage that the target audiences for the final conference will be teachers, informal educators and members of the science education research community. It is indicative that INQUIRE teachers and informal educators will present their reflective practice data collected during the pilot INQUIRE courses and their knowledge gained through the formative and summative evaluation of the course. In addition teachers, informal science educators and researchers working in other EU IBSE projects will be invited to share preliminary and final results. All in all 100–150 delegates are expected to participate.

**Community building on the international level** will be supported through presenting papers and posters at international conferences throughout the whole project duration such as BGCI's International Congress on Education in Botanic Gardens (Mexico 2012), American Public Gardens Association Annual Conference (Philadelphia, 2011), ECSITE conference Warsaw, Poland May 2011, European Association of Zoos and Acquaria (Innsbruck, 2011), European Science Education Research Association (ESERA, Lyon, France, 2011), etc. The INQUIRE website will also be promoted to networks of LoTC institutions worldwide (eg. botanic gardens (BGCI, BGEN), zoos (WAZA, EAZA), wetland centres (WLI), Field Study Centres (FSC), RSPB sites, natural history museums, science centres (ECSITE), environmental education networks (eg. Australian Association of Environmental Education (AAEE), Environmental Education Association of Southern Africa (EEASA)).

Project partners will make their training sessions available to potential associate partners (or 'friends of INQUIRE') who may send a representative (at their own cost) to training sessions (open and free Train the Trainer courses). This will support LoTC community building on a national and international basis.

**Support project management** when it comes to prepare deliverables and documents for publication

[...]

*Work package 7 (WP7) Quality Management*

*Month 1–36*

This work package is dedicated to creating a supportive structure for practitioners' development. The Quality Management Team (KCL and UniHB) = QMT will work in tandem with all partners to ensure that every team will produce high quality outputs with respect to running and evaluating pilot course progression.

UNI Bremen is responsible for supervising summative and formative assessment of Pilot INQUIRE participant's professional development (month 10–24). KCL will oversee reflective practice done by participating teachers and educators. LoTC Partners inform teachers and educators about how work is shared between these two partner institutions.

Participating teachers are supported to reflect on their own classroom teaching and learning and all activities developed and used are supposed to meet the defined and agreed standards. For teachers reflective practice, INQUIRE will draw on research in investigative science, argumentation, attitudes to science, interest and motivation, use of external partners and facilities (e.g. botanic gardens, science centres).

For summative and formative course evaluation, INQUIRE will draw on research in teacher collaboration, pedagogical content knowledge, teacher beliefs about science, teacher beliefs about integration of out-of-school facilities, video-based reflection on classroom practice.

The QMT, after discussing and designing the **Quality Management Plan** within the first four months, will be responsible for overseeing the INQUIRE course activities carried out in all 11 participating countries. The QMT will support practitioners to analyse, summarize and present outcomes. Outcomes will be evaluated to meet the expected high standards. The Quality Management Plan will be adapted to emerging needs in month 18. Best practice models, recommendations and ideas will be included in a detailed Quality Management Report by the end of month 36. The report will be uploaded to the INQUIRE web site in month 36. The QMT will develop a draft document that will be discussed during the Inaugural Meeting.

[...]

*Work package 8 (WP8) Project Management*

*Month 1–36*

INQUIRE's Management Board is responsible for ensuring smooth project progress. It will support the project at the consortium level. A meeting schedule will be set up and updated according to participants' needs. A management handbook (website domain to share documents, minutes, agreements etc) will be installed. 5 Management board meetings will be held to plan and prepare consortium meetings. It is planned to hold the first meeting as video conference. Project periodical reports will be prepared in months 18 and 36.

[...]

*Work package 9: Ethical issues*

*Month 1–36*

Based on the EU recommendations addressed in the Ethical Review Report (date 16.09.2010) the INQUIRE consortium will establish an additionally work package "Ethical Issues" including two dimensions:

1. Ethical issues in relation to plants
2. Ethical issues regarding children protection, safety and data protection

[...]

### 3.1.6 *INQUIRE Outcomes*

The following INQUIRE ‘Publishable Report’ (Kapelari et al., 2013) gives a short overview about what the project has finally achieved.

#### *Summary*

The EU FP7 INQUIRE Project was developed and implemented to support science literacy in Europe through teacher training courses, focussing on the integration of Inquiry Based Science Education (IBSE) into informal and formal education programmes. Courses were developed and offered in 14 sites across 11 European countries with a cohort of over 570 participants that included both teachers in the formal education system and also education officers in informal education sites (Botanic Gardens, Natural History Museums etc).

Botanic gardens and similar LOtC sites are inspirational sites that can provide training for teachers and educators on critical issues such as conservation of our natural resources, sustainability and threats to our future, such as climate change. Integrating these themes into activities using IBSE pedagogy provides an exciting and stimulating programme which encourages teachers and informal educators to develop their proficiency in IBSE and to become reflective practitioners as well as raising awareness of these issues.

#### *Introduction*

Current science education reform initiatives require fundamental changes in how science is taught and in how teachers are supported to engage in alternative ways of science teaching. One current approach is the incorporation of inquiry based science education (IBSE) into the everyday school science curriculum. To help make this change happen, teachers need opportunities to participate in a variety of professional development experiences that foster an understanding of science and inquiry based science teaching. Research has also shown that learning that includes activities based outside the classroom is highly motivating, not only for children but also for teachers. The UK Government’s education manifesto ‘Learning outside the Classroom’ was launched to emphasis this key issue and Europe has already recognized the potential of Learning Outside the Classroom (LOtC) venues to support the implementation of IBSE methods on a large scale. With more people living in cities, botanic gardens, which provide excellent opportunities for education in major cities worldwide, offer some of the only outdoor learning sites for children to gain first-hand experiences of IBSE.

#### *The INQUIRE project and its objectives and achievements*

The Inquire project was set up to foster the development and implementation of IBSE in both formal and informal education systems by developing, testing

and implementing IBSE training courses in 11 European countries. One of the key aspects of this project was the provision of a 'long-term' training course (60 hours +) over a prolonged period and a course where there was a real emphasis on reflective practice being developed by both course participants and Consortium Partners. This is a change from short, sharp training sessions that often are the objectives of projects and which, although they may result in high numbers of participants, unfortunately do not actually effect real behavioural and attitudinal change in those participating. Inquire course participants and partners were a smaller cohort but were offered a more intense and in depth training and were encouraged to develop an action research approach, which has been evidenced in both the Quality Management Report and the external evaluation. There has also been a good community of practice developed. All of these outcomes are likely to result in real sustainability of the project aims and objectives going forward and for long-term and profitable collaborative work in the future across the range of participating EU organisations.

The content of the INQUIRE training courses focused on various aspects of biodiversity loss and climate change, drawing on the expertise and inspirational settings for the courses in Botanic Gardens and natural history centres across Europe. The courses were piloted by partners early on in the project and post evaluation of the pilot course, a second course was run. The project partners used reflective practice and evaluation processes to analyse good practice, effectiveness and impact of the courses both with their course participants, through the consortium partnership meetings and through support sessions provided by the Quality Management team and Management Board. The courses were refined and improved through this process, resulting in enhanced courses with more polished delivery and good impact. Throughout the Inquire training courses, teachers and botanic garden educators had also been encouraged to learn with, and from, each other and to develop a shared understanding of how IBSE can be facilitated in class and in botanic gardens and natural history museums. Sustainability was key to the project and this was attained through the community of practice and through the running of 'Train the Trainer' courses to cascade knowledge and experiences gained through the project to other LOtC institutions. There was also excellent dissemination of outcomes and practices through a range of media and at conferences, workshops, seminars and promotional events both nationally and internationally.

#### *INQUIRE courses developed and implemented in 11 EU countries*

Two sets of Inquire courses were run over the project period. The pilot courses ran between September 2011 and July 2012 and the second set, building on the initial course content and processes, ran between the autumn of 2012 and the summer of 2013. Using the reflective practice developed throughout the project and supported by partnership interaction and exchange of best practice,

partners were able to refine and enhance their courses for the second period. Overall the courses reached a total of 576 participants; 250 in the pilot courses and 326 in the second set of courses. Course participants included educators in LOtC sites, primary, secondary and student teachers, education authority officers and other staff from LOtC sites. The outcomes and impacts from these courses were explored in the Final Quality Management Plan and the Final External Evaluation Report which draw on the 'Portfolios of Evidence' (PofE) and case studies submitted by partners following the two sets of courses. These partner PofE, in turn, draw on the findings and reflections from participants on individual courses as well as partner course tutor's/ organiser's reflective practice. A sea change in both practice and attitude can be seen in these findings.

#### *A Quality Management Plan has been implemented and supported*

The Quality Management Plan was developed and agreed in the initial period of the project. The plan outlined how evidence for project outcomes would be collected through surveys, on-line questionnaires, case studies submitted by partners during partner meetings, interviews, observation and Portfolios of Evidence. This plan was implemented and augmented as necessary over the project period. Regular support was provided throughout the project period by both the QM team and the full Management Board including provision of partner visits, support telephone calls, on-line via Glasscubes and through the Inquire website and regular newsletters. The Final QM Report, published in month 36 (Deliverable D7.2) provides an analysis of participants and Partner feedback. This was very positive and was further demonstrated by the innovative and stimulating workshops and presentations from partner and course participants at the final INQUIRE conference, held at Kew Gardens, London UK on July 9<sup>th</sup> and 10<sup>th</sup> 2013 and attended by 124 participants from 13 countries. The Final External Evaluation report, submitted in the final month 36 (November 2013) additionally demonstrated very positive outcomes for the project.

#### *Development of a Community of Practice between Partners*

The Consortium Partners quickly developed and maintained an excellent Community of Practice during the three years of the project. The success of this was in part due to the very good support from the QM team and full Management Board. Communication was a strong focus for the project team and was very well managed by BGCI. This was built on regularly through the 5 partner meetings, Train the Trainers course and final conference held during the project period. Many good friendships were established and the opportunities to share best practice face to face, discuss common problems and successes was valued very highly by all partners. Partners are still communicating regularly post project and are

actively seeking new inter-European joint project / programme collaborations for the future.

*Impact through establishment of National Advisory Groups (NAG)*

The National Advisory Groups (NAG) were established in the early project months and continued to meet and support partners within their countries throughout the project period. Most partners had 2 meetings per year; a few had just one often due to availability of the AG members. Advice included how to integrate the courses into the national teacher training mechanisms, how best to promote courses, on the structure and content of courses and where to find appropriate resources and other support. The NAGs were established with experts in the field of formal and informal science education and were influential in encouraging regional take up and curriculum input through their contact as well as effective at adding value to the partner course delivery and evaluation by sharing their broad expertise with partners.

*Snowballing the INQUIRE idea: Train the Trainers and Dissemination*

Besides the partner Train the Trainers course run in Obergurgl, where 57 educators were trained in IBSE delivery and processes, the 15 Train the Trainers courses delivered through the project engaged over 285 participants, snowballing the project aims and objectives further. Participants were from a range of professional backgrounds and included not only educators from botanic gardens, science centres, natural history museums, zoos and environmental NGO's but also secondary teachers, primary school teachers, teacher trainers and representatives of Educational authorities.

The dissemination of the Inquire aims and objectives was managed through a variety of media across the project period. Besides the many and varied written texts, either published in printed format or on-line, partners attended and offered dissemination activities at 56 International conferences / events and 135 national conferences /events. The Inquire co-ordinator participated in several other IBSE linked EU project meetings and events as well as joining ProConet and was therefore able to ensure cross project dissemination. The conference, organised by BGCI and KEW and held at Kew on 9–10<sup>th</sup> July 2013 also attracted 124 delegates from 13 countries disseminating best practice and project outcomes more widely. Four other EU funded projects (PATHWAY, Natural Europe, GreeNET and S-TEAM.) were also represented at the conference- broadening the experience of all project partners and opening up new avenues for collaboration in the future. The published Train the Trainers and Inquire course manuals and activity booklet will additionally support this process.

**The following Partners worked on the INQUIRE project:**



**Figure 9:** Project countries.

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

## Inquire courses

**Aim:** Help reinvigorate IBSE in the formal and the Learning Outside the Classroom (LOtC) educational systems throughout Europe through teacher training courses.

**Activities:** Run by botanic gardens and Natural History Museums in 11 countries, INQUIRE training courses demonstrate to teachers and educators how IBSE can inspire students in science and engage them with issues of biodiversity and climate change. Courses comprise minimum 60 hours of training with a combination of full day sessions and self study. They promote the integration of learning in and outside of the school classroom.

**Achieved:** 28 Pilot and final INQUIRE courses run in the period 2011–2013. The courses took place in 11 countries across Europe engaging in total: 576 teachers, educators and other professionals and reaching more than 16,000 students who experience IBSE in their school and in LOtC. The INQUIRE course manual has been published in 10 languages.

## Quality Management

**Aim:** Ensure implementation of high quality INQUIRE courses by establishing evaluation processes.

**Activities:** Determine and conduct summative and formative evaluation, train Partners to use evaluation tools, support visits to Partners, encourage reflective practice, collect Portfolios of evidence and improve quality of courses.

**Achieved:** Pre- and Post- course questionnaires designed for summative evaluation of courses, used by all Partners. Partners trained to use formative evaluation methods- interviews, concept maps, reflective journals, observations and compiled portfolios of evidence. Quality Management Plan developed. KCL conducted support visits to 14 Partners. The Quality Management team and the Management Board supported Partners through personal contacts, on –line communications via Glasscubes and through workshops during the 4<sup>th</sup> Partner meeting in Lisbon, October 2012. The Final Quality Management Report (Deliverable D7.2) provides an analysis of participants and Partners feedback which was very positive.

## Consortium meetings

**Aim:** Bring Partners together to ensure work is delivered on time and to high standards and develop a Community of practice amongst the consortium.

**Activities:** Discuss deliverables, discuss INQUIRE course structure and evaluation, provide training on evaluation, reflect on running the courses, exchange good practice on IBSE, peer review lesson plans and modules, discuss communication in the project, training on evaluation and website, prepare for INQUIRE conference.

**Achieved:** An Inaugural meeting, five Consortium meetings and a Train the trainers meeting held. Between 30 and 40 people attended each meeting which resulted in preparing the deliverables on time, developing, running and improving the Pilot and Final INQUIRE courses, establishing project evaluation methods, developing Partners' reflective practice and creating a collaborative atmosphere within consortium. 12 Management Board meetings held to plan and prepare Consortium meetings.

## Advisory groups

**Aim:** Support running and promotion of INQUIRE courses.

**Activities:** advise on development and delivery of INQUIRE courses, recommend resources, advise on dissemination of project and course participants' recruitment, comment on implementation and effectiveness of project outcomes, advise on accreditation of the course.

**Achieved:** A National Advisory group has been established in each country. 122 members in total (Education authorities representatives, teacher trainers, science education researchers, teachers, educators, head teachers, representatives of other LOTC institutions and networks). 49 meetings held in total by the 11 Advisory groups. The meetings were organized to support major developments i.e. establishing, revising and running the INQUIRE course, preparing for the INQUIRE conference and ensuring the courses sustainability.

## Dissemination

**Aim:** Achieve public awareness about project goals.

**Activities:** develop and run INQUIRE website, distribute newsletters, present work of the INQUIRE project in conferences, produce dissemination resources, distribute press releases, organise INQUIRE conference.

**Achieved:** INQUIRE website [www.inquirebotany.org](http://www.inquirebotany.org) live since September 2011 in 10 languages. Monthly e-newsletters have been sent to 1000 subscribers. Partners have presented INQUIRE project in 56 International and 135 National conferences and events. The INQUIRE conference was held at Kew, London on 9–10<sup>th</sup> July 2013 and attracted 124 delegates from 13 countries, stimulating discussion and reflections on IBSE. An INQUIRE leaflet has been produced in 10 languages and an INQUIRE film subtitled in 10 languages.

## Snowballing

**Aim:** Encourage further implementation of IBSE in 11 European countries of the project.

**Activities:** meetings and training seminars for LOTC staff and teacher trainers to inspire them to run INQUIRE courses. Advisory groups promote IBSE through networks.

**Achieved:** The Partner Advisory groups included 16 representatives of education authorities, 8 teacher trainers, and 16 staff from LOTC institutions. All promoted IBSE through their positions. In order to encourage further implementation of IBSE, Partners have been running Train the Trainers courses. Some of these were day seminars while others were run in a similar structure to the INQUIRE course. 15 Train the Trainers courses have been run by 15 Partners. These were attended by 289 participants mainly educators from botanic gardens, science centres, and other LOTC sites.

### 3.2 The INQUIRE Case Study

*The following chapter is an extensively elaborated version of the chapter “Collaborative Pedagogical Content Knowledge Creation in Heterogeneous Learning Communities”(p. 127–145), published by Kapelari (2015).*

#### 3.2.1 Rational

‘Learning outside the classroom is about raising achievement through an organised, powerful approach to learning in which direct experience is of prime importance. This is not only about **what** we learn but importantly **how** and **where** we learn.’ (LOTCEM, 2007)

Becoming and remaining a place that offers high quality learning experiences outside the classroom requires professional educators and educational program designers to continuously improve their knowledge, skills and attitudes (s.p. 99ff) toward teaching and learning in their particular context. However, if learning is valued as a situated process in a social context, the individual learner cannot be the only centre of attention. In the INQUIRE context the educational department, and even the whole Botanic Garden in which this learning takes place, has to be recognised as an entity for learning if changes in practice are expected to be implemented sustainably. It is assumed that if the members of a particular educational department develop their understanding of IBSE collaboratively over time, collective understanding and experience evolves and becomes organisational knowledge. Declarative knowledge and procedural knowledge such as skills and routines are then shared in the particular community and become organisational memory.

In addition, one has to recognise that no organisation is an autonomous island floating in an infinite space. All educational institutions - schools, LOTC sites, universities etc. are building blocks embedded in a socio-cultural setting that enables or inhibits development that governs actions, divides labour and creates the community in which action and learning takes place (s.p. 31ff). Thus educational reform efforts, such as those supported by the EU 7<sup>th</sup> Framework Science and Society can never be assessed as a simple input - output system. Sustainable change is the result of sophisticated information processing taking place in a complex network of social interactions.

Focusing on individual teacher or educator learning as the only unit of analysis may fail to recognise the socio-cultural setting in which these individuals act. It ignores the fact that:

‘most organisations[schools and botanic gardens included] have shared assumptions that protect the status quo, preclude people from challenging others, troublesome or difficult qualities and characteristics, and

provide silent assent to those attributions; hence, very little learning is possible' (Kim, 2004, p. 35).

As a logical consequence, the unit of analysis in the following case study is the activity system named the 'Spanish partner' (s.p. 29ff).

Activity theory and expansive learning (s.p. 31ff) is applied as a framework to interpret the significant steps of transformation that occurred during the three year project duration. Traditionally, we would expect that learning is manifested as change in the subject, in the behaviour and cognition of the learner. In this respect, this case study challenges the traditional view of learning as an isolated activity in which an individual acquires knowledge from a de-contextualized body of knowledge (s.p. 17ff).

Expansive learning is manifested primarily as changes in the object of the activity system (Engeström, 2001, Paavola et al., 2004). The objects in this case are IBSE lesson plans and the design of the teacher training course. Object artefacts, such as portfolios, as well as knowledge artefacts, such as partner interviews, are at the centre of attention when interpreting organisational sense making and societal transformations. As such, this more pluralistic and multi-levelled interactional approach offers conceptual tools to achieve a more nuanced picture of the significance of IBSE use in botanic gardens educational practises. In exploring the potential role of 'expansive learning' as a framework for extending botanic gardens perception and knowledge of IBST and reflective practice, the purpose of this case study was to address the following questions:

- How does the expansive learning environment contribute to partners understanding of Inquiry Based Science Teaching?
- Do partner organisations feel competent to implement this pedagogy into their educational programmes?
- Do partners develop an awareness of the role reflective practice and assessment plays in good science teaching?

### 3.2.2 Methodology

#### *Case Study*

I chose to conduct this case study because a vivid and full description of a single case is most valuable at this stage of my understanding of Botanic Garden learning and in order that I could understand organisational development from a partner's point of view. Gerring (2004) suggests that a case study is an in depth study of a single unit where the scholar's aim is to elucidate features of a larger class of similar phenomena. Thus it is a particular way of defining cases, not a way of analysing cases or modelling causal relations. The term 'case study' might be used in various ways. However, in the context of my work, I define

my case study accordingly as ‘an intensive study of a single unit for the purpose of understanding a larger class of similar units’ (Gerring, 2004, p. 342). and I went for his? Type I occupation which is defined as ‘case studies [that] examine variation in a single unit over time, thus preserving the primary unit of analysis’ (Gerring, 2004, p. 343).

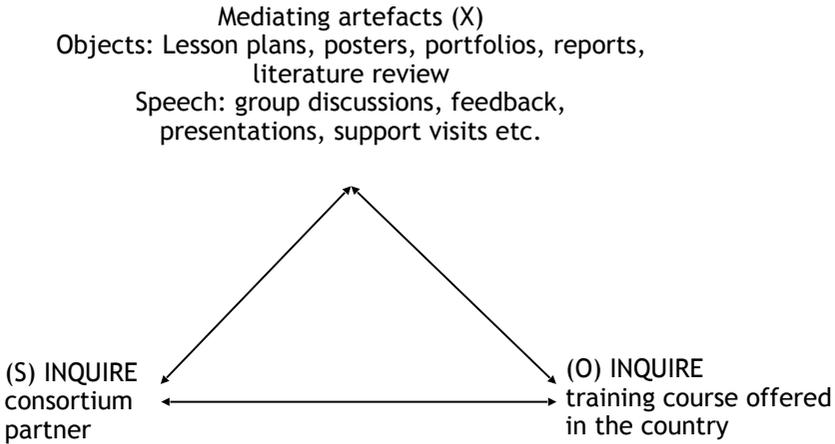
This case study is dedicated to the process of the development of two Spanish Botanic Gardens who decided to work as a single activity system called ‘Spanish Partner’. However, in the INQUIRE consortium case study, outcomes cannot be interpreted as being detached from findings reported by the External Evaluator Dr. Alun Morgan, Exeter University UK (External Evaluation Report) and the Quality Management Team - Dr. Elaine Regan and Prof. Justin Dillon, Kings College London, London, UK (Quality Management Report). Both reports can be downloaded from the website: [www.inquiryebotany.com/resources](http://www.inquiryebotany.com/resources). These reports illustrate project outcomes at the whole consortium level and thus inform this particular research case study about the context in which it is situated.

### *Framework for Analysis*

Wertsch (1991, p. 3) cites Dewey, who assumed that the discipline would not be able to deal with the many phenomena it sought to examine if it continued to focus exclusively on the individual organism. Psychology would have to come to term with how individuals are culturally, historically and institutionally situated before it could understand many aspects of mental functioning. Cultural Historical Activity Theory and expansive learning (s.p. 31ff) is applied as a framework to interpret the significant steps of transformation occurring during the three year project duration. Engeströms (2001) dynamic model of an activity system is used to explain the interactions between a subject (and groups of subjects), object, mediating artefacts, rule, communities, and division of labour. In this study, the primary focus is on the top triangle of the activity system (s.p. 31ff). The research methods of artefact analysis and interviews are applied.

‘Artefacts become data through the questions posed about them and the meanings assigned to them by the researcher. There is no one right way to analyse artefacts. A wide range of disciplines informs the analysis of artifacts, including anthropology, archaeology, art history, history, human geography, ethnography, and sociology. In the process of analysis, we are asking the data to tell us something. An artifact has a story to tell about the person who made it, how it was used, who used it, and the beliefs and values associated with it.’ (Norum, 2008, p. 1)

The production process in any activity system involves a subject, an object/various objects and mediating tools (artefacts) that are used in



**Figure 10:** Mediating activity in INQUIRE.

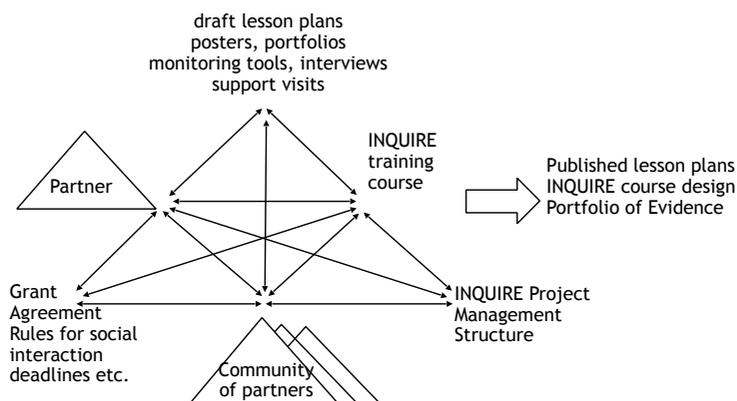
the activity. These may be concrete ones such as written lesson plans or operations mediated via talks and conversation captured via interviews. INQUIRE consortium partner activities were oriented to the object; the implementation of an inquiry based teacher and botanic garden educator training course. The science content addressed in these courses was related to biodiversity and climate change and enabled learners to experience an inquiry based science learning environment created in the class as well as at the botanic garden.

The process of creating the object was facilitated via an expansive learning process (s.p. 35ff). It is assumed that with the production of the course, the consortium partner develops new knowledge about the activity (developing an inquiry based course design, its components (e.g. IBSE activities), its assumptions (= good teaching practice) and contradictions (= student learning outcomes). Partners are expected to consciously understand the characteristic of their knowledge gaining process because their own learning cannot be separated from the activity.

### *The INQUIRE consortium*

Any consortium partner is a member of at least two community systems – their particular Botanic Garden institution and the INQUIRE consortium. Both communities are influential not only to the object but the subjects own development.

As a consortium partner, the Spanish partner, as with other partners, had to follow rules set up in the grant agreement or which were developed during the project, such as how and when to fulfil tasks. The division of labour was defined



**Figure 11:** The INQUIRE project activity system.

according to roles various partner play e.g. as botanic garden partner, science education research institution, project management or project coordinator. Partners took over different roles simultaneously e.g. course designer, critical friend, host etc. For example, the Spanish group was responsible for hosting one consortium meeting in March 2012.

The community of partners plays an important role in choosing tasks which lead to meditating artefacts, giving feedback and are therefore most influential in enabling and preventing learning processes. The INQUIRE management board was responsible for designing and cultivating a collaborative expansive learning environment for consortium partners. As collaborative knowledge creation processes are dynamic, much effort was put in cultivating a space for people to connect, to communicate in a given context, to share information, stories or personal experience and knowledge in ways that built on understanding and insight. Scaffolded social interaction was applied to enable dialogue, capture and diffuse existing knowledge, introduce collaborative processes, generate new knowledge and help people organize around purposeful actions that deliver tangible results (Cambridge et al., 2005). The INQUIRE project lasted for three years. Five consortium meetings, a train the trainer course and a final conference were organised to provide space for face to face contact among consortium members. Consortium meetings lasted for at least two full days. In between these face to face contact periods, partners were asked to produce object artefacts to share their knowledge and experience in poster presentations, lesson plan discussion or workshops for the following meeting. An online platform, Glasscubes (<http://www.glasscubes.com/>), was introduced to organize collaboration and enhance communication among partners in between direct contact sessions.

### *Rational for choosing the ‘Spanish Partner’*

The basic notion guiding this study is the view that individual persons who have feelings, values, needs, and purposes for acting are members of social groups and organisations, which directly or indirectly set the general condition for day to day learning processes (s.p. 31ff). Even if a single member of a social unit has the potential to fulfil an extraordinary development in this unique INQUIRE setting, this will remain a single facet of an organisational learning process and may or may not result in changing existing practices.

Thus the focus of my study is on the organisational level, the INQUIRE partner as a social unit, which will act as the sum of its components (s.p. 31ff).

The Spanish Partner was chosen for this in-depth study for three reasons:

- these two Spanish organisations decided to establish one activity system at the national level.
- This activity system merges a Botanic Garden with a very long history of c.260 years (which is representative for one set of partner institutions in the INQUIRE project) and another institution with a relative short history of about 12 years (which is typical of some other INQUIRE partners).
- The history of both educational departments is closely linked and these institutions have already shared a very close partnership for many years, which was maintained during and post the INQUIRE project. This close relationship was the reason why two Spanish gardens were invited to join the INQUIRE consortium; most other countries participating in the project had only one Garden invited.

### *Data Collection*

Data collection was distributed over a period of three years (2011–2013). A multifaceted approach was used to gather different types of artefacts, which were then used to describe different perspectives or for cross checks. Individual data sources have particular strengths and weaknesses. For example, interviews provide subtle and personal feelings but statements may consciously or unconsciously be tailored to the interviewers’ expectations. Artefacts give insight into what people put into practice, but may miss information about the reason for doing it in a particular way. To balance detachment and involvement and to inhibit tendencies to over identify with particular interpretations, I considered other colleagues work which focused on evaluating the consortium as a whole from an ‘External Evaluators’ and the Quality Management Team’s’ perspective.

In reference to Cultural Historical Activity Theory (s.p. 31ff) and principles of knowledge creation approaches to learning, I considered the following combination of data relevant to understanding the dynamics present in the INQUIRE setting. In this respect interviews are considered knowledge artefacts while posters or lesson plans etc. are considered to be object artefacts/outcomes.

<b>Data Source</b>	<b>Data unit</b>	<b>Description</b>	<b>Purpose</b>
Semi structure Interviews	Interviews 1 (I1/2011)	Interview: exploring reflective practice, evaluation and progress with Pilot Inquire course implementation Conducted by E. Regan	Semi structured interview after pilot INQUIRE course as a formative discussion about feedback and evaluation
	Interview 2 (I2/2013)	Interview: exploring reflective practice, evaluation, issues with final course implementation personal gains Conducted by E. Regan	Semi-structured interview after the final INQUIRE course as a discussion of the course evaluation and outcomes from project
	Interview 3 (I3/2013)	Individuals/staff educational background, history of education department Conducted by S. Kapelari	Exploring division of labour, rules and community within the activity system
Mediated Artefacts produced by partners (Botanic Gardens)	Lesson Plans (LPy1/1,2) (LPy2/1) (LPy3/1–5)	Lesson plans were developed by partners on a regular basis to share the current understanding of 'good IBS teaching' Year 1: 2 lesson plans Year 2: 1 lesson plan Year 3: 5 lesson plans published on the INQUIRE website	Lesson Plans provide insight into how partners put their understanding of IBST into practice
	Posters (P)	Posters were presented at partner meetings to share partner understanding of a good INQUIRE course design, course evaluation and how these was developed (4 Posters)	Provide insight into the socio-cultural context in which the INQUIRE course was implemented as well as into partners understanding of useful assessment and evaluation strategies
	Presentation at INQUIRE Conference (PIC)	Posters and/or Papers presented at the Final INQUIRE conference July 2013 1 workshop	Show what partners consider important for presentation to a wider public

(Continued)

Data Source	Data unit	Description	Purpose
	Portfolio of Evidence (P 1/2)	Evidences are collections of artefacts partners consider give insight into their learning. A written commentary explains why these artefacts were chosen. Portfolio 1 was handed in after the INQUIRE pilot course Portfolio 2 was handed in after the Second INQUIRE course A detailed Case Study was part of the P2	Provide insight into partner ability to carry out critical reflection; their professional learning and experience gained in practice.
	Reports and Deliverables (R/D)	Partners contribute to the final Project report via handing reports on -Progress towards the Project objectives - Working with their national Advisory Board -Plans for Implementing the INQUIRE training course in the future	Provide insight into partners learning progress, competence development and future perspective
Consortium based findings produced by others	Final External Evaluation Report	Author: Dr. Alun Morgan, Exeter University UK <a href="http://www.inquirebotany.org">www.inquirebotany.org</a>	Provide the opportunity to reflect on outcomes in the context of the whole consortium
	Quality Management Report	Authors: Dr. Elaine Regan and Prof. Justin Dillon, Kings College London, London, UK <a href="http://www.inquirebotany.org">www.inquirebotany.org</a>	Provide the opportunity to reflect on outcomes in the context of the whole consortium

**Table 5:** Data source.

### *Data analysis*

The analytic tools used were selected so as not to create additional work for the INQUIRE Partner organizations; however they served as a reference for participating partners on the project outcomes as they developed their processes during the project

### Interview transcripts

The interview protocols and the overarching framework for the Quality Management Plan was discussed and agreed within the management board in advance of starting the project proper. Due to my role as the project coordinator it was important not to conduct interviews myself. However partners were informed about the fact that all members of the INQUIRE Management Board would have access to data collected. The first semi-structured group interview was done by Dr. Elaine Regan during the implementation stage of the pilot courses to explore reflective practice and evaluation strategies (Interview 1). This short interview (approx. 40 minutes) was conducted during the 3rd Partner Meeting in Spain, February/March 2012. For the Spanish partner 2 people participated in the interview.

Post the second INQUIRE course, a second semi-structured group interview (Interview 2) explored similar themes as well as exploring the influence of participation in the INQUIRE project on partners and their institutions. These final longer interviews (approx. 60 minutes) took place at the final Partner Meeting in Trento, Italy October 2013. All four members of the Spanish group participated. The interview was conducted by Dr. Elaine Regan. In addition, I held a semi-structured interview (Interview 3) with the Spanish partner to explore additional themes such as the cultural-historical background, the division of work and particular rules applicable for the Spanish partner. Interview 3 took place at the Partner Meeting in Trento, Italy October 2013 and was transcribed by myself. Interviews 1 and 2 were transcribed by a third person. I finally analysed all three transcripts myself. Quotes from these interviews are not attributed to any individual but to the partner group. Interview transcripts were analysed following the content analysis approach suggested by Mayring (2008).

### Posters, reports and deliverables, conference contributions

Whenever applicable, the same coding scheme used for analysing interview transcripts was applied to text based artefacts. Partners completed various project tasks and produced many artefacts during the INQUIRE project in preparation for the partner meetings (2011–2013), the conference (2013) and the train the trainer course in Oberurgl (2011). Examples include posters outlining the intended structure of their INQUIRE course (Poster 1: Course Design) and their anticipated strategies for evaluation (Poster 2: Evaluation), lesson plans (Lesson Plans: 1,2, . . .), course plans for review by the consortium members (Lesson Plan Review: 1,2, . . .) and the Conference workshop (CW1)

### Lesson plans:

A rubric for analyzing lesson plan development was developed based on the BSCS (Biology Science Curriculum Study) 5E Instructional Model. This model was chosen as a reference for analyzing expansive knowledge creation because

it provides more flexibility in valuing hybridizations of exiting knowledge and relies on a foundation of contemporary research on student learning, particularly in science (Bybee et al., 2006).

#### Portfolio of Evidence

Partners were asked to select material they considered appropriate for providing evidence of the effectiveness of their INQUIRE course, as well as artefacts that they considered important to their own work. In addition, they needed to highlight evidence that course participants handed in. All partners were asked to write a one page review on why and how they selected these particular items and why they considered them representative for their organizational development. Portfolios were accomplished following the completion of the Pilot INQUIRE Course (Portfolio 1, 2012) and the Second INQUIRE course (Portfolio 2, 2013). While the first one was compulsory the latter was optional. Portfolios have been uploaded on the project website to share with consortium partners as well as with the MB. The Spanish partner handed in two portfolios. For analysing the portfolios I went for a holistic approach, focusing on the overall quality of the work with attention to how the individual piece of work contributes to the whole. It was more important for me to see what partners did, rather than comparing entries with prior expectation that may not necessarily align with partner performance. Whenever applicable the same coding schemes as for analysing interview transcripts or lesson plans were used.

### 3.2.3 Case Study Findings

Question: Do you think this type of activity helps to improve your learning?

*‘Si, porque vivimos una experiencia propia’* = Yes, because we live our own experience

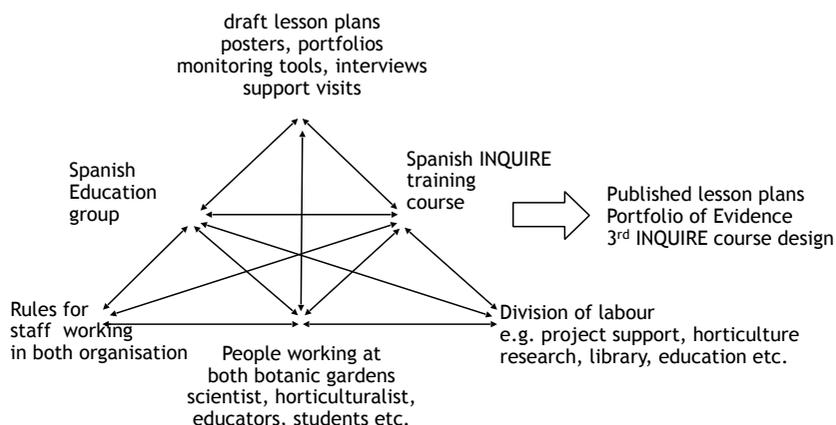
A teacher’s response (Case study, p22).

Who are the subjects of learning, how are they defined and located?

The ‘Spanish Partner’ is a group of people employed at two different Botanic Gardens but forming a discrete activity system in the INQUIRE consortium

#### *Real Jardín Botánico Juan Carlos I, Alcalá*

*The Garden:* Real Jardín Botánico Juan Carlos I belongs to the University of Alcalá, in Alcalá de Henares, Madrid. The garden was founded in 1991 and the education department was established in 1995. The Garden covers about 26 Hectares and is located in the campus area of the University. Plant conservation and education are considered to be the main priorities. Apart from hosting the biggest collection of cacti in Spain, other living plant collections such as



**Figure 12:** The Spanish partner activity system.

the collection of roses, tropical plants, conifers, Spanish trees, regional flora, *Cycadales* and garden plants add to about the c.8000 taxa which contribute to the plant conservation strategy the garden applies. A ‘seed bank’ (about 10.000 accessions) and related research and horticultural practices have been developed in the garden over the last couple of years.

*Education department:* The educational department includes has two full time positions. The ‘INQUIRE representative (IRA), Alcalá is head of the ‘Educational Program in the Real Jardín Botánico Juan Carlos I’ and has been responsible for designing and developing the Educational Program since 1995. She holds a degree in botany and did additional training to become a secondary school teacher; she spent 2 years teaching secondary and high school students (16–18 years). IRA worked as a Teacher of ‘Botany for Horticulturalists’, a course at Madrid Botanic Gardens, for about 5 years before she and a group of colleagues were asked to establish the new garden in Alcalá. Another biologist, a specialist in geology, holds the position of ‘Coordinator of the Educators’. He has been working in the program since 1999 but has no pedagogical background. The ‘group of educators’ includes about 4–10 students from Alcalá University; all of them are studying biology or environmental sciences and they work as ‘freelance’ contracts. The University employs them and they currently stay for 3–4 months, although in former times they stayed for about 1–3 years. As soon as they have finished their studies they now have to leave. One person was exclusively employed via INQUIRE funding to support IRA in fulfilling project related tasks.

*Educational Program:* Running for more than 15 years, the educational program is one of the oldest and most developed ones offered by botanical gardens in Spain. It provides a huge number of activities (more than 60) involving local and regional participants. The educational program is supported by

the University of Alcalá. Educational staff members also participate in national and international outreach activities such as offering courses, contributing to congresses, publishing in journals, etc. The team has contributed to the creation of the new botanical gardens in Malabo (Equatorial Guinea) and at the University of León (Nicaragua).

Alcala botanic garden offers educational activities to different target groups, of all age groups, in a formal as well as an informal setting (eg. kindergarden -, primary – secondary and high school classes, students with special needs, the elderly, groups of adults with special interests in a particular subject and the general public). Most of these activities are designed and carried out by the garden staff themselves, but some are developed and conducted in collaboration with other institutions or groups of interest. The educational program has been linked to the formal school system since its inception and an official convention with the local school authority (Regional Training and Innovation Centre for Teachers) has existed since 1998. The garden engages with local schools in international projects such as the “Key to Nature” project and in local and regional activities like “The Week of Science”, “Science Fair”, “Plant Fair”, etc. Aside from this, the educational department maintains a close collaboration with the educational department of the Spanish botanical garden society.

#### *Real Jardín Botánico de Madrid*

*The Garden:* The Garden, founded in 1755, belongs to the National Research Council (Consejo Superior de Investigaciones Científicas), the largest research institution in Spain. It is declared a ‘Major Scientific Facility’ due to its important historical collections (herbaria, library and archives). Within this mission, the Garden focuses on scientific research in plants and fungi, exhibition and conservation of the living plants collections, conservation of historical and scientific collections (e.g. herbarium, library and archives) and the development of plant-based educational programmes.

In 1755, Fernando I ordered the building of the Royal Botanical Garden of Madrid, which was first settled in the outskirts of the city, close to the Manzanares River. In 1774, Carlos III decided to move the Garden to its current location at the Paseo del Prado, where it was opened in 1781. Sabatini (Architect to the King) and Juan de Villanueva (architect who designed the Prado Museum and the Astronomical observatory) were in charge of this project. At that time, the garden was designed as three terraces and the plants were ordered according to Linnaean system of plants for the first time. The iron fence, several greenhouses and the vine arbors were also built at that time and still exist today.

From the very first days, teaching of botany took place in the garden, expeditions were supported, large collections of drawings were ordered and the herbaria began to grow.

Since 1939, the garden has been under the ownership of the Spanish National Research Council (CSIC) and in 1942 it was declared an 'Artistic Garden'. In 1974, after decades of hardship and neglect, the garden was closed to the public for restoration work and it reopened in 1981. The Garden holds a huge Library (32,000 books, 2,075 periodicals, 27,000 brochures or off-prints, 3,000 titles on microfiche, 2600 maps and 60 CD-ROMs). Its collections contain historical materials of incalculable value from the 17th and 18th century as well as electronic resources and online databases, with access to the most recent publications in botany and horticulture.

The *Historical Archive* contains the textual and graphical documents produced by the institution between the 18th century and the present day. It also keeps the botany-related documents produced by Spanish scientific expeditions in the 18th and 19th centuries. It comprises approximately 20,000 documents and over 10,000 botanical drawings.

The Herbarium is the largest in Spain and one of the most representative ones in Europe. It houses over a million specimens organized accordingly to standardized classification systems. The herbarium's collections are still growing thanks to the research work of the RJB's scientists, as well as donations, acquisitions and exchanges of specimens with other herbaria.

The Living Plants collection comprises 5.500 species which are exhibited on the three main terraces:

- *Terraza de los Cuadros* – collections of ornamental plants, medicinal, aromatic, endemics and orchard specimens gathered around a small fountain. All are planted in box-edged plots.
- *Terraza de las Escuelas Botánicas* – a taxonomic collection of plants, ordered phylogenetically and set within plots in and around 12 small fountains.
- *Terraza del Plano de la Flor* – a diverse collection of trees and shrubs, in the romantic English style as designed in the mid-nineteenth century. It contains the Villanueva Pavilion, built in 1781 as a greenhouse, and a pond with a bust of Carl Linnaeus.

*Research* focuses on the diversity of plants and fungi at the species level, how this diversity has come about, and how it can be conserved, as well as on biodiversity at the ecosystem level, particularly in the case of aquatic ecosystems in the Mediterranean region and the tropics.

#### *Educational department*

The education team was established in 2002 and nowadays belongs to the Scientific Culture Department of the Garden along with media, (including on-line materials and social networks) and external relationship sections. In total, the department employs 5 people and some external collaborators.

The INQUIRE representative, Madrid (IRM) holds a degree in Botany and did a one year training course in education to become a teacher. She has been responsible for the educational department at Madrid Botanic Garden since the beginning and is Head of Education now.

15–20 educators are hired on a day to day basis to deliver educational activities, some of whom have been working with the garden for many years. The garden offers in-house training for these educators once or twice a year with attendance on a voluntary basis.

Educators usually hold a degree in, or are still studying, biology or similar sciences and have either training or previous experience in education or dealing with groups. One person was exclusively employed via INQUIRE funding to support IRA in fulfilling project related tasks.

*Educational Program:* During the week the main target groups addressed via educational activities are school classes. Workshops and visits for the general public and families are carried out on weekends. The Garden also participates in several regional, national or international events such as Science Week, Science Fair and Fascination of Plants Day. The department additionally is involved in several national and European projects, such as INQUIRE (7th Frame Program).

### *Division of work*

In the course of the INQUIRE project the Spanish Partner employed one person at each of the two botanic gardens. Both employees have a science, not an educational, background and they were mainly responsible for developing the lesson plans and producing all required artefacts which have been produced during the INQUIRE project. According to their statements, the four members of this partner group felt responsible for the content and quality of each single artefact that was handed in. Thus their work is the product of a joint venture and cannot be assigned to any individual in particular. According to them, they spent much time discussing and reflecting on their work and running the training courses jointly. These 4 members met on a regular basis and divided the work amongst themselves, according to each person's particular strengths. IRA and IRM see themselves as being responsible for the final quality checks of all the project work conducted.

These four members of the Spanish team attended the INQUIRE meetings as well the 'Train the Trainer Course' in Obergurgl and the Final Conference at Kew Gardens apart from the INQUIRE employee (Madrid), who went on maternity leave in December 2012 (end of 2<sup>nd</sup> Year) and was replaced by another employee who attended the Final Conference at Kew Gardens. No other members of the educational departments from either garden attended an INQUIRE meeting. According to IRA and IRM, these other staff have been informed about progress, lessons learned and outcomes on a regular basis.

Project administrative issues have been discussed with support staff at Alcalá and Madrid University. Due to economic reasons, both INQUIRE employees left their respective organizations after the money ran out at the end of the project.

*Why do they learn? Why do they make the effort?*

According to Lave and Wenger (1991), the motivation to learn emerges from participating in a community that values collaborative practices and aims to improve these practices in order to produce something useful. These two Spanish Gardens were selected for participating in the INQUIRE consortium because both of them have an educational department with more than one person employed. One Spanish Garden was additionally partner in two unsuccessful attempts to get a proposal accepted by a funding agency and has repeatedly shown commitment to join the collaborative INQUIRE group. They initiated the invitation for the other Spanish garden to join the project. This same Spanish partner repeatedly showed their interest in improving science education programs (object) and in collaborating with the other garden over an extended period of time. The gardens shared ideas, found solutions and built innovation. However due to the economic crisis, the Spanish activity system faces a funding crisis and the raising of funds for education activities is now of extreme urgency. IBSE has been a good ‘buzz word’ when it comes to raising money for educational reform activities. In addition participating in an international Botanic Garden education project was highly valued in the organisation.

‘I think they [botanic garden as a whole] value a lot to participate in an European project of this framework, it’s a great point for the garden, but also for the whole institution (I272013p19)

*What do they learn? How do they learn? What are the outcomes of learning?*

The inquire model of professional development asks participants at either level, the national INQUIRE course or the international INQUIRE consortium, to experience at first-hand what will be later applied. While planning, designing and trialling their INQUIRE courses, partners engaged in their own inquiry and learned to assess and reflect on their own, as well as their course participants’ learning outcomes.

‘... it is just that with the second course we make not only more activities but activities we have done were more reflective. I mean we could explain better the steps in inquiry based learning education and we make it different [...] from other methodologies, so this kind of reflection, while we are making activities, were an improvement from the first course’ (Int2, p. 2).

## Partners understanding of IBSE:

‘... at the beginning, I didn’t know anything about IBSE, I’d just seen a few activities in our botanic garden, they were very practical, but not exactly IBSE, so for me, it was a new topic, so I’ve developed a whole knowledge, not whole knowledge but from zero to more advanced’ (Int2, p. 31).

Reflective cycles applied to developing IBST ‘Lesson Plans’ supported the Spanish team to change their understanding of the role of the educator as being the person ‘in charge of the knowledge’ and responsible for ‘*explaining the contributions of biodiversity to human beings and to the environment*’ (LP1a,2011) or ‘*explaining what real scientists do at seed banks*’(LP1a; 2011).

In 2011, LP1a was presented at the Train the Trainers Meeting in Obergurgl. The team was paired with another consortium partner to discuss strengths and weaknesses of their lesson outline. In 2013 the revised lesson plan (LP3a) was published.

The initial lesson plan suggested that teachers perform two experiments to show students that CO<sub>2</sub> is a heavy gas and that plants take up CO<sub>2</sub> and produce oxygen.

The final lesson plan asks students to think about how they can use the first experiment to ‘*design another experiment that proves plants absorb CO<sub>2</sub>*’.

Both lesson plans are strong for engaging students, asking them to access prior knowledge and to expose their prior perceptions. Both provide students with opportunities to actively explore scientific concepts. The revised lesson plan is obviously stronger in helping students to use prior knowledge to generate new ideas and provides opportunities to demonstrate conceptual understanding and process skills (*Explanation*) as well as asking them to apply their understanding of concepts by conducting additional activities (*Elaboration*).

Feedback given to an assignment that a teacher handed in during the course was put into the partner portfolio of evidence that was handed in after the Pilot INQUIRE course (PE1). It gives a good insight into what the team considered best IBSE practice in Spain in 2012:

‘We had the idea that your lesson plan was good but now that I’ve read it carefully it seems just excellent. It brings together many of the most important aspects of inquiry based learning for example it is entirely focused on student, the teacher has the role of being a facilitator which promotes a high degree of student involvement to unleash their creativity and confidence in their approach. It promotes the active pursuit of information from different source and media it places great emphasis on communications skills of students, the feedback between them is an important part of the activity I also find very good the final evaluation report: how you selected the criteria to evaluate each aspect of the activity and how you have developed a method to quantify with tables that offer.

Anyway in my opinion is a great example of good activity IBSE, congratulations.' (PE1, p. 5)

Spanish partners were given a similar opportunity to share lesson plans and get feedback from other partners 3 times in the course of the project duration. Lesson plan analysis shows that the Spanish group developed their understanding of good IBSE teaching in terms of 'Instructions- Scaffolding', 'Quality of Questions', 'Number of alternative approaches to solve a problem' and 'Emphasising a systematic scientific approach'.

Early lesson plans (LP1's, LP2) frequently used directives such as '*Look at the map and think*' or '*Experiment: Place the covered jar with the plant inside under the lamp . . .*'.

Closed questions such as '*In your opinion which of the following species should not exist?*' or '*How many energy sources do you know*' were asked more frequently.

While activities did identify skills and asked learners to use prior knowledge they rarely offered alternative ways of doing a task.

*'Divide the class into groups of 4 students. Deliver them the material. Each group should cut the pieces of the puzzle and the foam. Students should stick the pieces of the puzzle and the foam. Try to solve the puzzle'* (LP1c)

Early lessons plans did not expect students to formulate a hypothesis, design experiments or assess their understanding. However teachers were motivated to assess students learning via observation of and oral communication with students.

All 5 LP3s (LP3a-e) handed in at the end of the project demonstrate obvious clear change in the role the students are expected to play in the knowledge gaining process. Students are required to become more responsible for their own learning and frequently design their own experiments to prove their hypothesis:

*'How could you prove it? Encourage them to use the material you provide in order to design their own scenario and check how water acts on different types of soil'* (LP3d).

Learners are asked to explain their knowledge right from the start and formulate hypotheses. For example, LP3b, asks students to explain '*How do plants move?*' and to come up with various explanations (hypotheses).

While offering more freedom for students to shape their own learning processes all LP3s put more emphasis on the systematic scientific approach which is commonly used in IBST, e.g. LP3c starts with a *brainstorming/question-Phase*, followed by formulating *hypothesis*, conducting *experiments* and finally *communicating* and *discussing results*.

The training course includes an activity which asks participants to discuss advantages and disadvantages of IBSE when implemented in class and at the botanic gardens.

According to the worksheet responses, partners considered that the advantages of IBSE were:

‘... that it works on previous experiences, is motivating, asks for active participation of the student, includes both trial and error, promotes creativity and cooperation, is in contact with reality. Learning is meaningful and very visual.’

Disadvantages included: preparation time is needed, allies are needed, it is more difficult to control, teacher training is necessary, (teaching) materials necessary and it is difficult for us as teachers because we did not experience inquiry-based learning ourselves’ (PE2).

In course of the INQUIRE project the Spanish team became aware that IBSE needs to find a balance between an open/unstructured and a closed/very structured approach and mentioned teachers recognising this in course of the training programme.

‘The beliefs of the teachers have changed a lot from the beginning of the course. For example, the most significant discovery was that most of them thought that IBSE was chaotic and disorganized at the beginning, but their answers completely changed when they were asked the same question at the end of the course’ (PE2Case Study p10)

#### *Appreciating reflective practice:*

From artefact analysis, we can see that the Spanish team describe, in their portfolio of evidence, outcomes that emerge spontaneously from reflective practice.

‘The impressions of the Spanish team are that through gaining experience in organizing the courses, in the last course we have felt much more confident and prepared than in the first one. Attending the Inquire meetings and getting feedback from other partners was also crucial to increasing the “Inquire skills” (PE2p4).

Gaining experience and reflecting on outcomes led the Spanish team to put more emphasis on particular learning phases.

‘The balance between theory and practical activities was basically maintained, but in the second and third course the practical activities had much more space for teacher’s comments and were continually compared to the IBSE learning cycle so that every step of the activities would fit on it (PE2p3)

Finding a balance between structure and freedom in IBST is necessary to support certain groups of students in specific learning environments to achieve particular learning goals. This requires practitioners to constantly observe and evaluate what happens in the classroom or outside in the botanic garden. This is tedious task however and may not be appreciated by all practitioners alike.

The team used the nickname '*pieces of evil*' when referring to the portfolios of evidence materials they had to collect over the course of the project. Nevertheless, although only one portfolio was compulsory, they handed in a very detailed second one following the second course and valued this exercise as helpful to their own learning.

'Just I said before that although the portfolio and the case study was a bit tricky but it's good method or it made us reflect on our practice and even the interview because it is not the same writing about it and explaining to someone else about your and it makes us think also as a group' (Int2p32)

Their course assessment included a written case study/portfolio, which had to be handed in at the end of the course and the team noted that there was a reluctance amongst their INQUIRE course participants to evaluate their teaching efficiency.

'It is interesting to remark that, although they could only get a certificate through delivering the assignment, most of them didn't (they were extremely busy, in the final exams period); they argued they had taken the course for the learning itself rather than the certification. This was pretty encouraging for us' (PE2p8).

The Spanish team, however, values their reflective practice and sees sharing their findings with the learning community as important for their own benefit.

'Moreover, we took into account the suggestions and ideas from the National and Regional Education Authorities, the Advisory Group and other INQUIRE Partners. These improvements consisted on improved lesson plans and conferences given by experts and invited teachers' (PE2CaseStudyp10).

Partners appreciated new ideas introduced not only by consortium partners or advisory group members but by teachers. This knowledge was valued and as soon it was shared at meetings and via lesson plan publications became INQUIRE consortium knowledge.

'I remember that during the final discussion, this was a big issue - the evaluation methods- and they [teachers] even suggest new methods and

they were helping each other with very quick methods and they were very inspiring, for us too' (Int2p12).

After three years, the Spanish partner feels confident and competent about running IBST teacher training courses successfully.

'Throughout the whole reflection, we are positive we can conclude that there has been a clear improvement in the practice of the courses from the first one' (PE2p11).

### *The INQUIRE Community of Inquiry*

INQUIRE consortium meetings were important for partners and an assumption was that being able to interact face to face with other partners will be sorely missed now the project is finished. Some ideas and approaches shared by partners during these contact sessions were ignored; however, several were copied or adapted for partners' own purposes. The idea of investigating different types of honey, which was finally published as the Spanish lesson plan: 'Do we know what we eat?', was presented by another partner during an earlier stage of the project and was adopted by the Spanish team as a starting point for developing their own approach to plant diversity. In contrast, an experiment introduced by the Spanish group to visualise CO<sub>2</sub> gas qualities was used in IBSE activities developed by others.

The Spanish team valued the opportunity to visit each other institutions and observe others doing their work.

'Ideas, not only about the inquiry based learning but visiting each other in our gardens and institutions gives us the opportunity to see how [...] said before, how other people work in a botanic garden, maybe they have very different ways to do things but still we have always something to learn.' (I2/2013p30)

They take advantage from participating in the INQUIRE learning community.

'The INQUIRE courses have definitely been very positive for both institutions as they have helped to grow the teaching role of Botanic Gardens. They also served as a link to connect formal and non-formal education. In addition, we have learnt a lot from our collaboration between both Botanic Gardens and between other INQUIRE Partners' (PE2CaseStudyp12).

Organisational learning has taken place, was recognised by partners as such and mentioned explicitly

'The staffs of the Botanic Gardens have gained a lot of experience and we will try to continue running these courses in the future because we

have raised and improved our contact and understanding with teachers. It has been also positive not only to the education team but to the rest of the staff who have been involved in the development of the courses, meetings, dissemination plan, conferences, etc.' (PE2Case Study p12).

Knowledge is now embedded in educational programmes/ lesson plans and routines and attests to partner's growth.

'because [writing lesson plans] it's hard work, I mean, we have lesson plans for everything we make, so we have [over talking] I mean, it's something we have to do from now on (Int2p28).

This knowledge enables partners to use these resources accordingly as well as to improve their education programmes in the future. Nevertheless partners realize that there is still room for improvement. Learning and sharing knowledge needs to continue in the future.

'yeah, for me as well. I think like we've spent three years learning, learning, learning and practising a bit and we will need at least another three years, put in practice a lot, a lot, a lot and then getting back to, so [I don't feel to be already] an expert [in IBST] really' (Int2p31).

#### *Partners and their socio-cultural context*

Implementing an inquiry based science teaching approach sustainably within a well-established botanic garden education department cannot only be met by training individual educators to adopt new skills and knowledge. This is particularly true if these staff are solely employed on a limited contract funded by the EU or other sponsor. It cannot be ignored that Spain has been, and still is, facing a severe economic recession since 2010 (the year the INUQIRE project started). Budget cuts of 20% led to an increase of working hours for teachers for the same payment. In primary schools, the number of students per class increased from 25 to 30, and in secondary education from 30 to 36. For 'non-obligatory' secondary education for students aged 16–18, classrooms were filled with up to 46 students. Teachers and Tutors went on major strikes in May 2012 as well as in October 2013 in response to these cuts.

For Spanish teachers it became more and more difficult to engage in any educational reform.

'Likewise, they [teachers] think that the scarce time and the large number of students is a difficulty. On the other hand, they believe that this methodology is very positive because it helps the students to understand the content of Science and it is more engaging.' (PE2Case Study p. 10)

The funding crisis was ably demonstrated by the issues around recruitment for the second Spanish INQUIRE course.

‘. . . so the general feeling of the 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’ (Int2p9).

In addition local and regional authorities were having problems. Consequently these had an impact on partners work.

‘We realised that being enthusiastic and able to express the objectives of the project was crucial to the “Ministry of Education” to include the course in their programme. In fact, they were enthusiastic too. So they offered us to include our pilot course in their summer programme, so our second target was achieved too, which was getting promotion of the course by a national teacher training institution [EVIDENCE 3]. These meetings took place in the Ministry of Education’s facilities and in both BGs. As it was a national course, teachers came from all over Spain so the Ministry of Education provided them with accommodation and meals. This fact was appreciated by the teachers ending with a list of more than 100 [EVIDENCE 4]. The conditions they asked for were not very demanding and adapted well to our course. . . . In order to do the second INQUIRE course, we have contacted/plan to contact them but the main problem is that they have removed all the summer teacher training courses. This is mostly caused by the economic cuts that the Ministry of Education is experiencing by the Government. Likewise, this institution has been replaced by the “*Centro Nacional de Innovación e Investigación Educativa*”, “Ministry of Education, Culture and Sports” and some employees have changed. In summary, future collaborations with this institution are uncertain’(P1, p. 4–5).

So it became more difficult to recruit teachers for the second INQUIRE course in 2013.

We launched [the call for teachers] twice for the course for primary and twice for secondary level but, unfortunately, we did not have the same success in recruiting teachers as during the IFIE’s course since at the end of the call we did not have enough teachers so we could not run the course [EVIDENCE 10, 11, 12 and 13]. This was due to some social and political facts.

Nevertheless, the Spanish team eventually managed to run three courses and argue:

‘We also found that delivering the courses independently from the Ministry of Education has given us more freedom in order to design the structure, number of speakers and so on; in the first course we were more tided up’ (PE2p3).

All the courses proved very successful in the end and the Spanish team provided good evidence for sustainable organisational development. The economic situation however is unfortunately accountable for the Spanish INQUIRE employees having to leave the organisation when the project finished at the end of November 2013.