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# Report on IBSE Teacher Education and Assessment programme - Stage 1

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# D4.2 Report on IBSE Teacher Education and Assessment programme - Stage 1

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Project name: Strategies for the Assessment of Inquiry Learning in Science (SAILS)
Project number: 289085
Start date: 01/01/2012
Duration: 48 months
Lead partner for this deliverable: Kristianstad University Sweden (HKR) and Malmö University (MaH)
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The research leading to these results has received funding from the European Union's Seventh Framework Programme for research technological development and demonstration under grant agreement no 289085

# Contents

# 1. Introduction

A key objective for the SAILS project is to engage teachers in teaching and assessing through inquiry practices, with the resultant aim that teachers will be confident and competent, not only to teach science through inquiry methodologies but also to assess skills developed though inquiry in their classrooms. To this end, a series of Teacher Education Programmes (TEPs) have been developed and implemented within the SAILS project. The roll out of the SAILS TEP in inquiry and assessment is planned over three stages, with three successive cohorts of teachers. These stages are shown in Figure 1.

The focus for the first round of TEP, with Teacher Cohort 1 (STAGE 0 TEPs) was on introducing teachers to IBSE, helping teachers implement inquiry-based activities in the classroom and addressing key issues such as classroom management strategies, problem-solving, handling investigations, etc. This cohort consisted of teachers from each country that had varying experiences in IBSE and the STAGE 0 TEPs were primarily based on existing IBSE materials and teacher education programmes selected from those already developed from IBSE projects funded under the Sixth and Seventh Framework Programmes such as PARSEL (2005), PRIMAS (2010) and ESTABLISH (2010) or from the resources already available in each country. The STAGE 0 TEPs have been reported under SAILS Deliverable Report on IBSE Teacher Education (D4.1). The shared experience of running STAGE 0 TEPs have informed the further development of STAGE 1 TEPs.

The second round of TEPs (STAGE 1 TEPs) aims to incorporate assessment into the inquiry programme. The Teacher Cohort 2 began their teacher education programmes in IBSE programmes that now include some of these assessment frameworks/instruments within the IBSE teaching and learning materials. Additionally, teachers from Teacher Cohort 1 are also invited back to the STAGE 1 TEPs to address how assessment can be carried out in an inquiry classroom. This report focusses on STAGE 1 TEPs and reports on their implementation across 10 countries. The implementation of the STAGE 1 TEPS has informed the development of the STAGE 2 TEPS that will be implemented with the Teacher Cohort 3. The final round of TEPs (STAGE 2 TEPs) aims to integrate assessment strategies within the inquiry TEPs. This will form the SAILS report on IBSE Teacher Education and Assessment programme, STAGE 2 (D4.3), which will describe implementation, resources used and evaluations and impact of the TEPs on the teachers.

Following an extensive review of the literature on the assessment of inquiry skills (as presented in D2.1: Report on the strategy for the assessment of skills and competencies suitable for IBSE) and the development of SAILS draft units that have been trialled by experienced inquiry teachers across the partner countries, SAILS partners have culturally adapted these and other resources for use in SAILS STAGE 1 TEPs. Scope was given to allow partners to concentrate on particular areas of inquiry and its assessment so that their TEP addressed their teachers' needs. STAGE 1 TEPs have incorporated assessment materials developed in WP2: Assessment in IBSE and trialled by experienced IBSE teachers in WP3: Pilot and Evaluation (D3.2: Report from evaluation of implementation with pilot teachers). The final materials used in the TEP have incorporated recommendations arising from the evaluation of SAILS assessment frameworks and instruments.

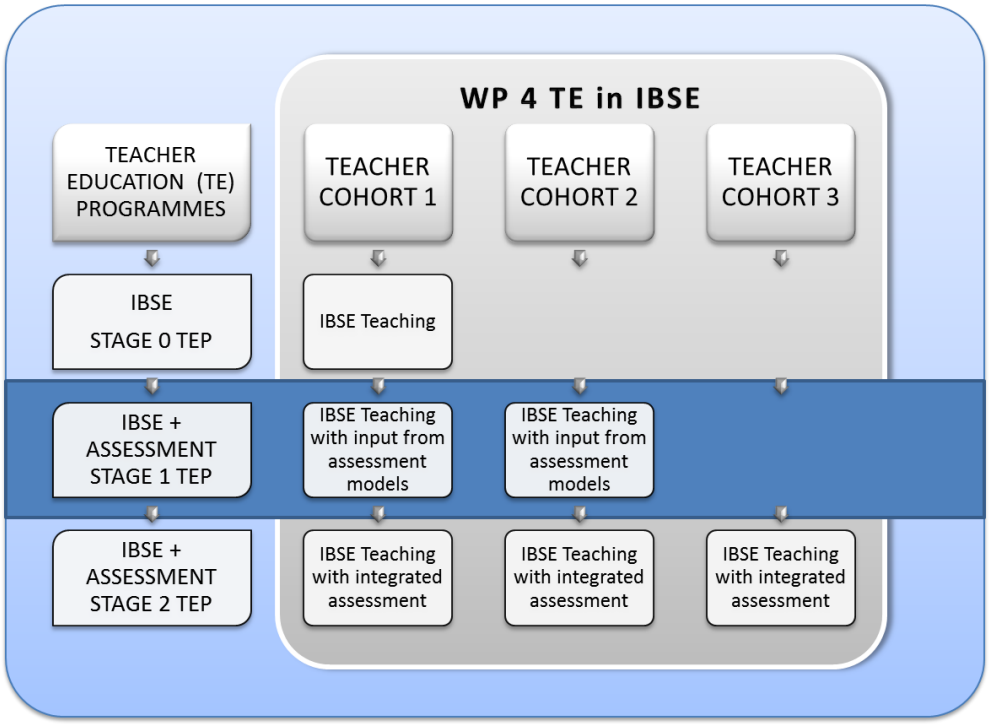


Figure 1. Structure of SAILS TEP over the course of the project

This document reports on the implementation of STAGE 1 TEP Programmes across the partner countries, highlights good practice and provides recommendations for the STAGE 2 TEPs and its evaluation.

Section 2 of this report provides an overview of the participating teachers, their experience with inquiry, the subjects taught and types of schools they work in. Details of the range of TEP formats employed by the partners are given. Section 3 describes the aims for each of the TEPs that have been carried out in SAILS countries and how partners have incorporated assessment tools and instruments within their TEPs for in-service and pre-service teachers. It also presents an overview of the main barriers teachers face in each country in implementing an inquiry approach and using non-traditional assessment strategies. This section draws together conclusions from the analysis of the STAGE 1 TEPs. Section 4 focusses on the implications from the analysis in Section 3 for the STAGE 2 TEPS and provides a structure for SAILS STAGE 2 TEPs which will provide an integrated inquiry and assessment programme. This section will also provide activities and strategies to include within the TEPs to help teachers address and become of aware of possible gender biases in their assessment of students.

Finally, Appendix A describes and references effective inquiry and assessment resources for TEPs that have been developed and/or used by the partners within their TEPs while Appendices B and C provide more detailed information on the TEPs run by SAILS partners. This material has been put in the Appendix, rather than in the main document, to aid the reader to get an overall sense of the development of the TEPs. The detail provided by each country on their TEP programmes is informative and provides the detail that is not given within the report itself. The reader is recommended to read the Appendices as it will provide useful information for other training providers in developing TEPs.

# 2. Overview of SAILS STAGE 1 TEPs

SAILS STAGE 1 TEPs have taken place during the 2013 school year (September 2013 – June 2014) in ten of the partner countries. These TEPs were attended by Teacher Cohort 2 (see Figure 1), who were teachers who had not previously attended SAILS TEPs, and also by a number of teachers from Teacher Cohort 1, who had previously attended STAGE 0 TEPs. In some countries, the STAGE 1 TEP programmes brought together these two teacher cohorts, while in others, separate workshops were held for returning teachers from Teacher Cohort 1.

Table 1 provides an overall summary of the in-service STAGE 1 TEPs, showing the number of teachers attending as well as the number of returning teachers. It also shows the teaching discipline and level of the teachers and their prior experience in IBSE (as a group). The format of the STAGE 1 TEP programme is also outlined. From Table 1, a total of 413 in-service teachers have participated in STAGE 1 TEPs of which approximately 21% were teachers returning after completion of STAGE 0 TEPs. The teachers were mainly involved in teaching the science disciplines of biology, chemistry, and physics, but also the additional subjects of geology, geography and mathematics. Teachers from both lower and upper secondary schools attended. However, STAGE 1 TEPs were not implemented in two countries during this project period. In Denmark, TEPs were not possible due to teacher-conflict and new school reform at national level. This issue has now been resolved and STAGE 2 TEPs will be implemented in Denmark in the next project period. In Belgium, the partner's expertise is in ICT and therefore discussions with local teacher educators have taken place to form national partnerships to organise STAGE 2 SAILS TEPs in Belgium.

The in-service teachers taking part in the STAGE 1 TEP had a range of experience with inquiry. Teachers in Greece, Poland, Slovakia, Turkey and the UK had very little experience with inquiry before the TEP, while teachers in Hungary, Sweden, Ireland and Portugal had some experience with inquiry. Teachers attending the TEPs in Germany were a mixture of beginners and experienced teachers in IBSE. As seen in the following sections of this report, this range of experience with inquiry resulted in variation in the content and activities within the TEPs across the SAILS countries.

The STAGE 1 TEPs for in-service teachers consisted of a number of workshops; however, the format of the workshops varied between countries to suit the needs of the teachers. In some countries, the workshops were provided as one-day – or half a day – sessions with some time between sessions in order to allow teachers to implement what they have learned in the TEP within their own teaching and then to share their experience and challenges. In other countries, the sessions were concentrated in a one to five day continuous series of workshop, often between semesters, in order to attract teachers from around the country. Teachers were encouraged to do some work such as developing their own inquiry and assessment materials in between or after the TEP and/or to implement particular aspects of the TEP within their own teaching.

| *Country* | *C1*[1] | *C2*[2] | *C1+C2* | *Subject*[3] | *School level*[4] | *Experience with IBSE*[5] | *Format* | *Hours per session* | *Total hours*[6] |
|---|---|---|---|---|---|---|---|---|---|
| Germany | 13 | 19 | 32 | P, S | L, U | BE, VE | 0.5 day and/or 1.5 day sessions | 3-4.5<br>12 | 4.5-19.5 |
| Greece | | 50 | 50 | P, C, B, GE, M | L | BE | 0.5 day | 4 | 4 |
| Hungary | | 26 | 26 | P, C | L, U | SE | 1 day | 10 | 10 |
| Ireland | 5 | 36 | 41 | P, C, B, M | L, U | SE | 2-days summer school and 2 –hour follow up session in autumn | 5, 2 | 12 |
| Poland | 18 | 75 | 93 | C, B | L, U | BE | 3-days winter school or<br>2-days workshop | 7<br>4.5 | 21<br>9 |
| Portugal | 11 | 8 | 19 | P, C, B, G | L, U | SE | 5 sessions | 3 | 15 |
| Slovakia | | 33 | 33 | P, C, B | L, U | BE | 4 × 1 days | 6 | 24 |
| Sweden (HKR) | 24 | 2 | 26 | P, C, B | L | VE | 3 sessions | 5 | 15 |
| Sweden (MAH) | 17 | 20 | 37 | P, C, B | L | SE | 3 sessions | 4 | 12 |
| Turkey | | 40 | 40 | P, C, S | L | BE | 2-day summer school | 5 | 10 |
| United Kingdom | | 16 | 16 | P, C, B, S | L, U | BE | 5 sessions over the school year | 4 | 20 |
| **TOTAL** | **88** | **325** | **413** | | | | | | |

**Table 1: Overview of SAILS STAGE 1 TEPs for in-service teachers.**

[1]C1 the number of teachers attending SAILS STAGE 1 TEP who also attended SAILS STAGE 0 TEP.

[2]C2 the number of new teachers attending STAGE 1 TEP. C1+C2 is the total number of teachers attending SAILS STAGE 1 TEP.

[3]P Physics, C Chemistry, B Biology, M Mathematics, S Science, G Geology, GE Geography.

[4]School level represents the level of secondary education that the teachers are involved with, L lower secondary and U, upper secondary.

[5]The TEP trainers gave their impression of (or determined) the experience level in IBSE of their teachers attending the TEP as Beginners (BE), some experience (SE) and very experienced (VE).

[6]The number of hours stated is face-to-face time only and does not include any independent work done by teachers as part of their training such as time spent developing their own inquiry and assessment resources, implementing aspects of the training programme within their own teaching and communicating off-line with the training providers.

Table 2 describes the SAILS STAGE 1 TEPs for pre-service teachers. In total, 591 pre-service teachers attended SAILS STAGE 1 TEPs. Pre-service teachers were mainly beginners in terms of experience with IBSE. The pre-service teachers were groups involved in teacher education for one subject or were groups where different science disciplines were represented. The TEP workshops for pre-service teachers were in the majority of cases provided as a part of courses in subject didactics/methodologies. The total number of workshop hours were significantly smaller for pre-service teachers: ranging from 3 to 21 hours (median 12 hours) as compared to 5 to 28 hours (median 15 hours) for in-service teachers. However, pre-service STAGE 1 TEPs were not implemented in four countries during this project period. In Denmark, pre-service teacher training is done at college rather than university level, so SDU do not have access to pre-service teachers. For STAGE 2 TEPs, SDU will run pre-service workshops in collaboration with University College Lillebaelt and University College Sealand and plan to engage with up to 80 pre-service teachers. In IEUL, partners wished to concentrate on the in-service TEP so that they could finalise content and materials on this programme before rolling this out with the pre-service teachers in their STAGE 2 TEPs. In Belgium, the partner's expertise is in ICT without access to pre-service teachers.

| *Country* | *Number of teachers* | *Subject*[1] | *School level*[2] | *Experience with IBSE*[3] | *Workshop format* | *Hours/ session* | *Total number of hours*[4] |
|---|---|---|---|---|---|---|---|
| Germany | 49 | P | L, U | BE | 2 seminars (group 1)<br>14 seminars (group 2)) | 1.5 | 3 (group 1)<br>21 (group 2) |
| Greece | 150 | P, C, B | U | | 2 sessions | 2-2.5 | 4.5 |
| Hungary | 24 | B | L, U | BE | 26 seminars | 2 | 52 |
| Ireland | 53 | P, C, B | L, U | SE | Lab sessions and/or seminars | 2-3 hour | 12-24 (depending on cohort) |
| Poland | 118 | | | | 6 workshops | 2-3 | 15 |
| Slovakia | 9 | B | L, U | SE | 9 seminars | 2 | 18 |
| Sweden (HKR) | 7 | S | L | BE | 2 seminars | 3 | 6 |
| Sweden (MAH) | 61 | P, C, B | L | BE | 2 seminars | 3 | 6 |
| Turkey | 120 | | | | 10 seminars | 2 | 20 |
| **TOTAL** | **591** | | | | | | |

**Table 2: Overview of SAILS STAGE 1 TEP for pre-service teachers**

[1] P Physics, C Chemistry, B Biology, M Mathematics, S Science, G Geology, GE Geography .

[2]School level represents the level of secondary education that the teachers will be teaching at, L lower secondary and U, upper secondary.

[3]The TEP trainers gave their impression of (or determined) the experience level in IBSE of their pre-service teachers when they were attending the SAILS workshops as Beginners (BE), some experience (SE) and very experienced (VE).

[4]The number of hours stated is face-to-face time only and does not include any independent work done by pre-service teachers as part of their training such as time spent on background material or developing their own inquiry and assessment resources.

# 3. SAILS STAGE 1 Teacher Education Programmes

## 3.1 AIM AND PHILOSOPHY OF SAILS STAGE 1 TEACHER EDUCATION PROGRAMME

The objective of STAGE 1 of the SAILS teacher education programmes (TEPs) has been to include the assessment of inquiry skills as part of teacher workshops and to provide teachers with the opportunity to realise assessment opportunities and develop their understanding of the modes/types of assessment that can be used in the classroom. As teachers in each country have different prior experiences of inquiry and assessment, each partner has been given the scope to develop and implement workshops that best meet the professional-development needs of their cohorts of teachers. Each partner organised their TEP to address the local/national curricula and assessment frameworks and were encouraged to integrate assessment, using the SAILS materials, in their own manner. Therefore the aims of the TEPs in different countries have varied somewhat – but all had the general aim of equipping teachers with knowledge and skills to implement IBSE in the classroom and raising the awareness and use of different assessment strategies that can assess inquiry in the classroom.

### 3.1.1 STAGE 1 in-service TEPs

The aims and philosophy for STAGE 1 in-service TEPs are compiled in Table 3 below, which indicates several common aims across the programmes. A central aim of all TEPs was to introduce teachers to a range of assessment strategies that they could use in their own classroom to assess inquiry skills and to provide teachers with opportunities to develop their own resources. In addition, teachers were encouraged to implement inquiry and strategies for assessing inquiry skills within their own teaching practices. In countries, where teachers are beginners with using inquiry, a key aim of the TEP was to enhance teachers' awareness of IBSE and how it differs from more traditional teaching methodologies.

| | **Aim and Philosophy of In-service TEP** |
|---|---|
| Germany | Provide possibilities for teachers to work on their own IBSE ideas or to adapt existing materials to their individual teaching situations. Show examples of formative and summative assessment to make teachers more confident in the use of assessment strategies in their own teaching. |
| Greece | Contribute to science teachers' preparation, not only to be able to teach through inquiry-based science methods but also to make them more confident in their assessment of IBSE. |
| Hungary | To familiarize teachers with IBSE methods, to develop their competencies in formative assessment, and the role of assessment technology in the development of inquiry skills. |
| Ireland | Provide teachers with the opportunity to experience/realise assessment opportunities in a particular inquiry activity. Develop their own lesson sequences |

| | |
|---|---|
| | for inquiry and illustrate assessment opportunities and criteria for assessment of different inquiry skills. Consider the role of classroom dialogue in the assessment process. |
| Poland | To familiarize teachers with the idea of constructivism and the IBSE methodology, including basic assessment strategies. |
| Portugal | Discuss different assessment perspectives (diagnostic, formative and summative) with teachers. Share experiences focussing on the assessment of inquiry tasks. Develop an assessment instrument in iterative cycles of feedback and revision. Share and discuss difficulties experienced when developing or assessing inquiry tasks. |
| Slovakia | To provide teachers with an opportunity to develop their understanding and experiences of IBSE and elements of IBSE assessment. Support teachers in developing and implementing inquiry lessons with elements of assessment in their own classroom and reflecting on these practices. |
| Sweden | Support teachers in developing assessment items and rubrics for particular inquiry skills, which are emphasized in the latest curriculum reform in Sweden, but are not generally a part of "traditional" science teaching. These inquiry skills are, for example, to search for scientific information and formulate arguments in controversial issues. Focal areas included in the workshops were scientific reasoning and argumentation, Socio-Scientific Issues (SSI) and "Nature of Science" (NOS), which were integrated with the construction of assessment items and rubrics. |
| Turkey | Understand the concept of IBSE and assessment. Carry out some sample IBSE activities in groups. Practice sample IBSE activities and use different types of assessment strategies within these activities. Share experience with peers. Put these ideas into their classroom practice. |
| United Kingdom | Develop strategies for assessing a range of inquiry skills. Strengthen collaborative learning strategies in the classroom. Develop strategies for assessing 21st Century Skills. |

**Table 3: Aims and Philosophy of SAILS STAGE 1 In-service TEP in each beneficiary country.**

### 3.1.2 STAGE 1 Pre-service TEPs

The nature and structure of pre-service teacher preparation programmes is different across the partner countries. In some cases, participants are taking science education courses concurrently with science discipline courses to lead to a science teaching qualification at BSc or MSc levels (e.g. Germany, Ireland, Poland, Slovakia, Turkey). In other situations, participants were science graduates undertaking a postgraduate teacher training programme to gain qualification as a secondary school teacher (e.g. Greece and Ireland). In the case of Sweden, participants were future teachers for both primary and secondary level.

In contrast to in-service TEPs and due to the prior experience of pre-service teachers in the classroom, the aims of pre-service TEPs were concentrated on introducing students to IBSE methodologies, as outlined in Table 4.

| | **Aim and Philosophy of pre-service TEP** |
|---|---|
| Germany | Give the students an insight into the IBSE approach. Students gain conceptual knowledge about inquiry learning and assessment and become familiar with different European Inquiry Projects. Students are provided with opportunities to trial inquiry based teaching units and assessment strategies. |
| Greece | Contribute to pre-service teachers' preparation, not only to be able to teach through inquiry-based science methods but also to make them more confident in their assessment of IBSE. |
| Hungary | Introducing IBSE methods for the students on the methodology courses for biology pre-service teachers. |
| Ireland | The aim of the pre-service workshops is to prepare and empower students to teach science in a second level setting. It aims to give students an introduction to a range of teaching and learning strategies including Inquiry Based Science Education (IBSE). For the undergraduate teaching, students also learn chemistry and physics as well as gaining experience of inquiry approaches. |
| Poland | Introducing IBSE methodology and linking to the new science curriculum that is currently being implemented in Poland. Discussing the feasibility for implementing IBSE in the Polish school system. Students have to design their own proposals for lessons in inquiry-based science. |
| Slovakia | To acquire basic knowledge of IBSE and elements of IBSE assessment and to compare this to traditional methods. To experience activities in a laboratory. Implementation and development of IBSE activities. |
| Sweden | The overall aim of this series of workshops was to introduce IBSE as a way to teach science, as well as to assist the students in trying alternative modes of assessment. The students designed inquiry tasks and assessment instruments, which were trialled during their practicum and then discussed with peers. |
| Turkey | Introduction of IBSE and formative assessment, assessment of IBSE skills, Practicing sample IBSE activities and using different types of assessment strategies within these activities<br>Carry out some sample IBSE activities in groups<br>Practice how to integrate assessment into IBSE activities. |
| United Kingdom | Introduction of IBSE. IBSE and Assessment Opportunities.<br>AKSIS and graphing and analysis skills.<br>Inquiry in botanical gardens.<br>Personal, learning and Thinking Skills.<br>Cognitive Acceleration through Science Education |

**Table 4: Aims and Philosophy of SAILS STAGE 1 Pre-service TEPs in each beneficiary country.**

## 3.2 Integration of Assessment in Stage 1 in-service TEPs

A description of the STAGE 0 SAILS TEPs for both in-service teachers has been presented in SAILS Deliverable 4.1: Report on IBSE Teacher Education. The first stage of SAILS TEPs focused on introducing IBSE and increasing teachers use of inquiry in the classroom in the participating countries. The focus of SAILS STAGE 1 in-service TEPs has been to integrate assessment strategies into these existing programmes or to develop new programmes suitable for this purpose in each participating country. The national programmes and workshops developed are discussed in this section and these narratives provide details of the approach adopted for including assessment content and practices in each TEP as well as information on the resources used. In particular, details of how the teachers were introduced to assessment strategies, modes and types of assessment are outlined along with details of the opportunities given to teachers to discuss and develop criteria for assessing inquiry skills. In addition to describing the TEP assessment content and practices, the background of the participants and the outcomes of evaluations with the TEP participants is discussed. The resources and support materials used in these TEPs are collated and listed in Appendix A, while a more detailed account of the programme participants and the structure and content of each programme is described in Appendix B.

### 3.2.1 Germany

The participants were experienced physics and science teachers from different schools, school types, and geographic regions. Over half of the group had attended a STAGE 0 TEP. A combination of different workshop formats was offered: a half-day workshop and 1.5 days workshop.

The initial half-day workshop served as a kick-off meeting with the cohort of teachers and began with all of the teachers carrying out an initial inquiry task using their own experimental setup. A literature review about different views on the topic of IBSE (e.g. Bell, 2007) was presented and the transition towards more open inquiry (Fradd et al., 2001) was discussed. A review of the basic methods to assess students' inquiry skills was presented to the group. The teachers were introduced to different formative assessment tools like the rubric system in the UV-Radiation SAILS Unit. In the practical part of the workshop, the teachers rotated around different stations with materials and experiments, e.g. the PIKO-Unit "Crashtests" (Bell, 2010), and the teachers were facilitated to re-enact the inquiry task from the students perspective.

The 1.5 day workshop focused on the presentation of SAILS Units and implementation of formative-assessment tools in schools. Therefore formative assessment tools, like short written students' answers and self- and peer-assessment tools, were discussed. Additional assessment methods, like the use of "student flashcards", "traffic light cups" or the assessment rubrics from the SAILS Units were also discussed and trialled during the workshop. The use of "flashcards" is for example a possibility for students to display their answer to a multiple choice question. The teacher can then easily estimate the different answers and gets quick feedback about students' conceptions. The assessment tool "Traffic light cups" enables teachers to get quick and easily accessible feedback during students' practical work. The approach gives students the opportunity to indicate their need for help during practical work and facilitates selective assistance by the teacher. Different coloured cups (red, yellow, green) are used as a sign to indicate students' needs in a process and allows for

immediate feedback to the teacher. This approach attracted the interest of many teachers and after the workshops about 2000 coloured cups were sent by the SAILS teacher group in Germany that wanted to trial the method in their schools.

The main part of the workshop focused on the design and improvement of SAILS Units for the use by the teachers in the implementation of formative assessment (for more details see Appendix B.1) in the classroom. The teachers from this cohort implemented these units in their own classrooms and shared their experiences at a follow up half-day workshop and several of these teachers presented at the SAILS conference in Dublin, June 2014.

The post-workshop evaluations obtained from the participants were very positive and the teachers particularly thought that the workshop were well organised and that the content of the workshops was interesting.

### 3.2.2 Greece

In-service science teachers with varying degrees of teaching experience at lower and upper secondary level participating in the Greek TEPs. A particular focus of the Greek TEP programme was to introduce participants to the concept of learning design and learning scenarios.

During the first session, participants are introduced to modern assessment techniques such as Rubrics, Self-Assessment, Peer Assessment, Quizzes and Concept Maps. Then, the participants took part in a hands-on activity from a SAILS unit (Acids, Bases and Salts). During this exemplary scenario, the teachers were asked to discuss what kinds of assessment were needed and what kinds of instruments could support the underlying assessment in relation to each of the phases in the scenario. During the reflective discussion session, teachers were asked to agree which assessment instruments should be used. After the workshop, participants (collaboratively or individually) were asked to design their own learning scenario, incorporating modern assessment techniques.

### 3.2.3 Hungary

Participants were in-service science (physics, chemistry) teachers from both lower and upper secondary levels. The teachers were introduced to the concept of learning science and developing scientific thinking as well as been provided with a theoretical background and the characteristics of inquiry-based learning.

SAILS units were used as a core part of the programme to facilitate teachers in developing methods and opportunities for the assessment of inquiry skills in class. The units provided a detailed description for the teachers, highlighting which skills each unit was supposed to help students develop and how those skills can be assessed during the lesson. In particular two SAILS units that have been developed by the Hungarian team were focussed on: The speed of chemical reactions and how big is a drop of water? A discussion on how these units can be piloted in the classroom was carried out with the cohort of teachers. In particular, the TEP focussed on in the recognition and assesssment of the inquiry skills Formulating hypothesis, Planning measurement, Drawing conclusions and Groupwork.

### 3.2.4 Ireland

In general participants had some experience of using IBSE in their teaching and all were actively involved in teaching science at lower and upper secondary level and voluntarily participated in this SAILS summer school.

The teachers experienced assessment by working in pairs, carrying out an investigation (from the SAILS unit Reaction Rates) and experienced an on-the-fly assessment by workshop facilitators. This was followed by a discussion on participants' experiences and opportunities for inquiry and its assessment in the classroom. Classroom dialogue was addressed by teachers working in small groups discussing three vignettes and discussed in relation to how it can used as a mode of assessment. Teachers were asked to select topics for developing inquiry-based lessons with integrated assessment and these were developed during the workshop. The teachers working in small groups presented and shared the activities and assessment they had developed and received feedback from their peers and the workshop facilitators.

### 3.2.5 Poland

The participants were teachers from various regions of Poland, teaching in lower and upper secondary schools. The teachers participated in the workshop voluntarily. For most participants this was their first encounter with the IBSE.

The programme was presented in two parts; the first part was focussed on the basics of IBSE and the second part on the assessment of IBSE. Teachers were given the opportunity to carry out and discuss open- and guided- inquiry activities. The basic strategies and tools for assessing IBSE were presented in the format of a lecture with follow on discussions. The teachers were then given the opportunity to assess their own lab work, using self- and peer-assessment. In the final part of the programme they were facilitated to develop their own assessment tools and strategies for activities of their own choice.

### 3.2.6 Portugal

Teachers participating were from lower and upper secondary levels. According to a questionnaire 10 percent have solid knowledge about IBSE and regularly use IBSE in class; 80 percent have some or limited experience of teaching IBSE.

The key focus for this TEP was on assessment and during the sessions teacher discussed different assessment perspectives, diagnostic, formative and summative. SAILS pilot teachers were invited to share their experience on piloting inquiry tasks and producing assessment tools. The first four workshop sessions were provided in a seminar format with invited contributors, four science educators, who shared their experience and knowledge in IBSE and assessment. In the first session, the assessment criteria for the self-regulation of learning were discussed. The second session addressed the role of formative assessment in inquiry learning, while the last two sessions focussed on what and how to assess. In the final session, teachers, working in pairs, were given the opportunity to make their own proposals for assessment and present and analyse these with their peers. Teachers were encouraged to continue to work individually or in small groups to further develop assessment instruments through the Community of Practice (CoP).

### 3.2.7 Slovakia

Participants came from lower and upper secondary schools. Most teachers did not have any experience with IBSE, but were very enthusiastic about it and attended the workshop voluntarily.

The programme was presented over four workshops and focussed on the basics of IBSE, the use of ICT and embedding the assessment of IBSE in the classroom Teachers were given the opportunity to carry out and discuss open- and guided- inquiry activities. The main topics in relation to assessment were how and what to assess and an introduction to formative and summative assessment tools. The teachers engaged in a discussion on the use of formative and summative assessment tools in the classroom. The teachers were asked to implement an inquiry activity in their classrooms and to include the use of assessment tools. At the end of the programme, teachers developed a plan for teaching a science topic in their classroom that included IBSE activities as well as elements of assessment.

### 3.2.8 Sweden

Participants were the same teachers who participated in Cohort 1, which means that they were familiar with IBSE and also had some experience of assessing IBSE. According to a questionnaire, the teachers describe themselves as having medium to long experience with assessing IBSE.

Specific content in relation to assessment of IBSE was how to assess inquiry skills through Socio-Scientific Issues (SSI) and the construction of adequate assessment items and rubrics. The teachers trialled assessment items and brought samples of student performance which were presented and discussed with their peers during the next workshop. Social moderation practices were carried out where teachers discussed, explained and compared their assessment judgements of student work. The whole group discussed the accuracy of assessing student performance and how to improve the assessment items and rubrics used. A whole group discussion on the constraints and obstacles to assessing inquiry skills was held and proposals for how to address these were given.

### 3.2.9 Turkey

Participants were grades 6-8 science teachers and some of these teachers had attended a STAGE 0 SAILS TEP.

The workshops mainly focused on IBSE activities and strategies for assessment of IBSE. Some teachers (who participated in previous SAILS workshops) shared their experiences and challenges while implementing IBSE activities in their classrooms. The workshops focused on the following skills: Asking questions, determining variables, formulating hypothesis, designing and conducting an experiment, recording data, evaluating data and writing a report and communicating their results to others. We also discussed how to implement assessment in a way that it would support learning.

Teachers were requested to try out some of the discussed activities in their classrooms. Reflections on the implemented activities in the classroom will be the focus of the coming workshops with the same cohort teachers. Teachers were also requested to develop IBSE activities and get feedback from their colleagues.

### 3.2.10 UK

Participants were all secondary science teachers who teach science to lower-secondary school (age 11-14) and then either biology, chemistry, physics or science in upper-secondary school (age 14-18).

The TEP was delivered over 5 sessions and between sessions teachers were encouraged to trial different activities in their classrooms and share these experiences with their peers. Initially the teachers were provided with hands-on experience of inquiry using the first three developed SAILS Units – Food labels, Rates of Reaction and Speed. A group discussion on the different purposes of formative and summative assessment and the role of feedback and opportunities for feedback in inquiry activities was held. Teachers then worked in small groups to carry out two Quick & Simple Inquiry activities with each group member adopting different roles, e.g. one teacher elected to be the assessor and made notes on how s/he could assess the students. Teachers discussed each of the different inquiries, how they might be assessed and also what was the age expected competence for each inquiry. The use of rubrics and how they may be used by a teacher for describing learning progression or in peer assessment to help learners understand how to make assessment judgements was considered. The group discussed what they considered 21st Century skills to be and reviewed various descriptors for personal learning and thinking skills. The group were asked to devise or redesign inquiry activities to enable students to develop and strengthen these 21st century skills as well as including elements of teamwork/dialogue in these activities. In the final TEP session, SAILS Cohort 1 and Cohort 2 teachers were combined in mixed groups to discuss their experiences of inquiry and assessment in classroom practice. They were individually required to write a case study about their experience of working on the project and how they now changed their views of teaching and learning through inquiry and the assessment of inquiry skills. Teachers were involved in peer assessment of one another's case studies and suggested improvements**.**

## 3.3 Integration of Assessment in STAGE 1 pre-service TEPs

A description of the STAGE 0 TEPs for both pre-service teachers has been presented in SAILS Deliverable 4.1. This section discusses how assessment has been integrated into existing pre-service undergraduate or postgraduate programmes as part of the SAILS STAGE 1 pre-service TEPs. In particular details of how the teachers were introduced to assessment strategies, modes and types of assessment are outlined along with details of the opportunities given to teachers to discuss and develop criteria for assessing inquiry skills. In additional to describing the TEP assessment content and practices, the background of the participants and the outcomes of evaluations with the TEP participants is discussed. The resources and support materials used in these TEP are collated and listed in Appendix A, while a more detailed account of the programme participants and the structure and content of each programme is described in Appendix C

### 3.3.1 Germany

Science student-teachers at Leibniz Universität Hannover are obliged to take courses in science education beside the scientific disciplines (e.g. physics) at university. In the context of their teacher training special modules concerning IBSE approaches were provided for bachelor and master students.

The undergraduate students workshops had the aim to give students an insight into the IBSE approach and two 1.5 hours workshops were given as part of a course. Therefore, the students got a literature overview (e.g. Höttecke 2010, Fradd et al. 2010) and trialled a simple inquiry task ("How many drops of water that can be placed on a 5-Cent coin", see Examples in 6.1). Formative assessment methods in inquiry learning were introduced in the seminar and linked with former seminar contents (formative assessment in general, and selected examples like the "traffic light cups").

The complete course for graduate students (21 hours) pursued the aim to gain a comprehensive overview of the IBSE-approach and in addition to the bachelor seminar the students had to develop and to present their own short inquiry based teaching sequence. Other EU-Projects concerning IBSE like ASSIST-ME or PRIMAS and also formative assessment methods during IBSE-approaches (e.g. "flashcards", "traffic light cups", SAILS rubrics, etc.) were discussed in detail. The perspective of an invited In-service teacher was given at the end of the seminar. Based on her experience of teaching inquiry and using assessment strategies in regular school situations she worked with students on specific inquiry units. The evaluations were very positive and the students claimed that the lectures promoted their interest in the topic.

### 3.3.2 Greece

The pre-service teachers took part in a two-days training workshop after a call for participation addressed to participants of the course called "Educational Assessment" of the ASPAITE School of Pedagogical & Technological Education (150 pre-service teachers attended the workshop). This course is part of a 1-year program of pedagogical education for prospective teachers, which leads to a "Certificate of Pedagogical and Teaching Competence".

Participants take part in a hands-on IBSE Learning Scenario. The added value of this learning scenario based on the inquiry based activities, is the modern assessment techniques and the exploitation of new technology (electronic laboratory – Labdisc). The exemplary Learning Scenario, SAILS unit Acids, Bases & Salts was completed. The facilitator led a discussion about positives and negatives of IBL Scenarios implementation and on how participants might put their learning design ideas into practice at their school. The pre-service teachers produced their own inquiry learning scenarios which incorporated various modern techniques for assessing students' performance in all phases of these scenarios and have uploaded their scenarios to the SAILS CoP. Finally, the facilitator emphasised the importance of actual enactment in order to complete participants' learning.

### 3.3.3. Hungary

Participants were prospective teachers in biology taking an introductory didactical course. It was a discipline specific didactical course provided by a university-staff member.

When learning about the history of biology, the students get an insight into the epistemology of – and the characteristic ways of thinking in – biology, as well as the connections to other sciences interrelated with biology. The students can see the connection between science-technology-society and acquire the skills of critical analysis and interpretation of sources. Knowing the history of biology helps the students to explore their own misconceptions, to develop their scientific thinking, to respect the work of science and scientists, to understand the close relationship of the sciences, as well as the relationship between biological and social problems, and to increase their interest in

biology during teaching. During this course, the SAILS approach to inquiry and assessment was introduced to the students and they were given an opportunity to discuss some of the units developed by the in-service Hungarian teachers.

### 3.3.4 Ireland

The SAILS TEP was included in education modules for students involved in undergraduate programmes leading to a BSc Science Education or a BSc Physical Education with Biology and postgraduate students studying for a Professional Masters in Education. Therefore, the content and focus of the training for each student cohort varies in order to meet the programme requirements.

Assessment is introduced into pre-service workshops through discussions focusing on determining the criteria for assessment for particular inquiry activities. Assessment for learning strategies are introduced and students discuss these approaches and watch videos of practical classes to discuss what can and how learning elements can be assessed.

### 3.3.5 Poland

The SAILS TEP was included in didactic courses for chemistry and biology students, which are obligatory for all students. During three introductory lectures the pre-service teachers gained knowledge about IBSE basics, as well as the advantages and possibilities of implementing IBSE in Polish schools. Also, basic strategies and tools for assessing IBSE were presented, using the SAILS units as exemplars. The lectures were followed by workshops where students worked in small groups. One of the tasks was the design of an inquiry-based lesson, including assessment of chosen skills.

### 3.3.6 Slovakia

Participants were students in their second year of their masters programme in biology education. The workshop included basic knowledge of IBSE in comparison with traditional teaching methods, elements of IBSE assessment and formative and summative assessment tools (dialogue, questioning, self-, and peer-assessment). The SAILS units were introduced as exemplars. The students also had to development their own IBSE activity with assessment tools, which were presented to the other students. This final presentation was completed by all students.

### 3.3.7 Sweden

The workshop was included in a regular course on science and science teaching in the teacher-education programme. In this workshop, students received a lecture on the assessment of IBSE and then trialled inquiry items during their practicum. Their trials were followed by group discussion on merits and restraints of assessing inquiry skills in school.

### 3.3.8 Turkey

The pre-service teachers participating in the TEP were undergraduate students who were to become elementary school teachers or middle school science teachers. All of the pre-service teachers are supposed to teach science when they graduate. They had little or no experience with inquiry based science education or various assessment methods prior to their university education. In the TEP, students do inquiry based activities to learn about inquiry and after they become familiar with inquiry, they are asked to develop inquiry based activities themselves.

### 3.3.9 UK

The pre-service teachers were all science graduates undertaking a one year postgraduate course that would enable them to teach in lower and upper secondary school. They had a limited experience of inquiry mainly focused on control and manipulation of variables and where the teacher controlled much of the investigation by selecting the inquiry question and method. While most had experienced Assessment for Learning strategies in their own schooling, they had little idea about how to use evidence in a formative manner. However, this improved as they began to plan more assessment opportunities into the inquiry activities. Several reported that they did some inquiry lessons during their teaching practice.

## 3.4 Evaluations of STAGE 1 TEPs

The overall aim of SAILS teacher education programmes (TEP) is to prepare teachers to teach through IBSE and to be confident and competent with assessing their students' learning. The teachers should be familiar with different assessment strategies so that they may evaluate a number of key skills and competencies that are developed in the classroom.

As can be seen in the descriptions presented above, there is considerable variation in the content and focus of the in-service TEPs provided (Section 3.2). This is also due to the difference in teachers' experience with inquiry and non-traditional assessment tools. In some countries, TEPs start with an introduction to inquiry and then lead onto the different types of inquiry and experiencing an inquiry activity as a learner. In other countries (e.g., Portugal and Sweden), teachers were in general familiar with inquiry practices, so the workshops focus on the assessment of inquiry skills from the beginning. Common content areas are evident, which include basic strategies and different tools for assessing IBSE (such as scoring rubrics), design and improvement of IBSE units for the teachers' own teaching, and the implementation of formative assessment (including peer- and self-assessment). Each TEP organiser was responsible for the evaluation of their own TEP programmes and these have mostly been carried out using post workshop feedback forms. Plans for each country's evaluation were presented and discussed at general assembly meetings during this period. According to these evaluations, participating in-service teachers were generally very positive, both in terms of how the workshops were organised and in terms of content. Participants claimed that they found the content relevant for their practice and they valued collaborating with other teachers.

The descriptions for pre-service TEPs (Section 3.3 and Appendix C) show that these were mainly incorporated into courses in subject didactics. Similar to the in-service teacher evaluations, pre-service teachers were also very positive about the workshops and many claimed that the workshops promoted their interest in IBSE and assessment. However, a number of pre-service teachers raised concerns about implementing IBSE in their classrooms, and this indicates that the focus of these teachers was more on content knowledge rather than on the assessment of skills.

In the final stage of SAILS TEPs, final evaluation of the impact of teachers, both in-service and pre-service, participating in the STAGE 2 TEPs will be carried out and will address the following aspects:

1. The overall effect on the teachers as a result of the IBSEA (Inquiry Based Science Education and Assessment) TEP.
2. The overall effect on the teachers' attitudes to assessment as a result of the IBSEA TEP.
3. The main constraints the teachers experienced.

However, during the implementation of STAGE 0 and STAGE 1 TEPs, a pilot questionnaire was developed and trialled with cohorts of teachers attending TEPs in several countries. The final report on the evaluation of the impact of SAILS TEPS on teachers (WP4) will include details of the piloting of this evaluation instrument. Follow up interviews were also carried out with some of the teachers that completed this questionnaire to determine the accuracy with which teachers interpreted and responded to each question. The accurate interpretation of each question is an essential part of determining the validity and reliability of the final evaluation instrument and addressing any difficulty that teachers have with understanding terminology such as scientific literacy and reducing any translation issues that may arise from translating this instrument into 12 different languages.

The final questionnaires been developed for use as a pre- and post TEP instrument and to collect data on the following five aspects:

A. Background information – This section was included to obtain some identifying information about the participants including gender, years teaching, subject information and student information. As we would like to determine whether or not the teachers are experienced with IBSE, we asked them to self-rate in one of four categories, as below. This was done to enable analysis of later responses to determine if any differences are related to the experience level or knowledge of IBSE.

1. I have no/ hardly any knowledge of IBSE
2. I have some knowledge about it but no practical experience with IBSE in class
3. I have some/ limited experience with IBSE in class
4. I have good knowledge and regular use of IBSE in class

B. Understanding of Inquiry and assessment – As the TEPs are aimed at increasing teachers' confidence and competence at assessing through inquiry, this section includes questions about the teachers' understanding of inquiry and the role of the teacher and the student in an inquiry classroom. Teachers are asked to indicate their understanding of the nature of assessment in an inquiry classroom and how a teacher can highlight the strengths and weaknesses of a particular student's work.

C. Inquiry and frequency of inquiry and assessment in practice – This section was developed to allow us to determine how, if at all, the teachers were currently including elements of inquiry in their classroom and if they assess inquiry skills. A list of possible inquiry activities that students may do was presented and teachers indicated if each were included in their inquiry and assessment practices.

D. Feedback – Assessment is not just about summative goals, so to include an assessment for learning aspect to the instrument a section on teachers' feedback practices was included. This

section aimed to determine the forms of feedback that teachers provide their students with, and also what records teachers keep of this feedback.

E. Challenges – The post-evaluation instrument requested teachers to identify the major constraints that teachers face when implementing assessment strategies. The instrument provides a list of different challenges, and asks the respondents to rank their top four challenges listed here. An "other, please describe" option was also provided for any teachers who may have additional concerns.

## 3.5 KEY BARRIERS IN IBSE ORIENTED ASSESSMENT

In each of the workshops, teachers identified what they perceived to be the major constraints in implementing IBSE oriented assessment practices in their classrooms. In Table 5 below these constraints as collated and identified by the project beneficiaries are presented for each of the countries. The main constraints identified by the teachers and educators across different partnering countries were:

1. Lack of time to develop and implement IBSE assessment,
2. High content requirements in national curriculum,
3. External tests are not focused on assessing inquiry skills,
4. Lack of familiarity with formative assessment tools for IBSE.

The consideration of these identified barriers is important in the planning of STAGE 2 TEPs and how the national programmes will incorporate discussions and activities to address these constraints.

| | *Germany* | *Greece* | *Hungary* | *Ireland* | *Poland* | *Portugal* | *Slovakia* | *Sweden* | *Turkey* | *United Kingdom* |
|---|---|---|---|---|---|---|---|---|---|---|
| Time to develop assessment tools | X | | X | | X | X | X | X | X | X |
| Knowledge on formative assessment | X | | X | | X | X | | X | | |
| National Assessment (i.e. inquiry not assessed) | | X | X | X | | X | X | | X | X |
| Teacher confidence in assessment | | | X | X | X | X | | X | | X |
| Curriculum | | | X | | X | X | X | X | | X |
| Validity of alternative assessment strategies | X | | | X | | | | | | |
| Lack of resources | | X | X | | X | | | | X | |
| Concern with suitability for weaker students | | | | | X | | | X | | |
| Students acceptance of alternative assessment strategies | | | | | X | | | X | | |
| School management acceptance | | | X | | X | | | | | |
| Knowledge of IBSE | | | | | | | X | | | X |
| Classroom management issues | | | | | | | | | X | |

**Table 5: Key barriers in IBSE oriented assessment as identified in each beneficiary country.**

## 3.6 Overview of Stage 1 TEPs

STAGE 1 in-service and pre-service TEPs have been implemented across ten European countries and the content of these programmes have varied due to the background of the participants: for some it was their first encounter with IBSE while others where quite familiar with IBSE and also had some experience assessing inquiry skills. However some core components have been highlighted.

First, the introduction and the description of IBSE was addressed. In most programmes teachers had "hands on" experience of different inquiry activities and discussed the different types of inquiry, e.g. open and guided and skills of inquiry, e.g. formulating hypothesis, planning investigations, discussion with peers. The basic strategies and tools for assessing IBSE was common to most SAILS workshops, as was the introduction of different assessment instruments for both summative and formative use. Basically, the assessment content focussed in the workshops can be summarized as the Why (i.e., formative – summative), What (i.e., content knowledge and different inquiry skills), and How (i.e., different assessment instruments, such as scoring rubrics) of assessment. In several cases a review of current literature on assessment strategies was presented.

Second, in the workshops, support was given for teachers to trial inquiry activities that incorporated assessment items and to implement these activities in their classroom. In some cases teachers had the experience of being formatively assessed while they carried out inquiry activities. This support was partly provided by their peers attending the same workshop. In this way, teachers developed their knowledge and awareness of assessment opportunities and were involved in small and whole group reflective discussions on these activities.

Third, a primary focus was to provide possibilities for teachers to design their own IBSE material and assessment instruments or to adapt existing materials to their own circumstances. The support for designing their own material was also partly provided by the peers attending the workshop. In a number of workshops the development was done in iterative cycles of feedback and revisions, either in face-to-face presentations and discussions or through the national CoP.

The main constraints identified by the SAILS partners across the different partnering countries were identified as:

- Lack of time to develop and implement IBSE assessment,
- High content requirements in national curriculum,
- External tests are not focused on assessing inquiry skills,
- Lack of familiarity with formative assessment tools for IBSE.

A key aspect for the success of these TEPS was the use of appropriate inquiry and assessment tools and materials. The use of the SAILS units provided opportunities for teachers to experience inquiry and assessment as a learner and provided the teachers with exemplars to trial in their own classrooms. The development of more good quality resources for IBSE and assessment tools has been facilitated both during and after the TEPs and the continued use of the SAILS national and International CoP provides an invaluable platform for this endeavour.

Despite the great variation in the STAGE 1 TEPs in the participating countries and in particular the resources used, the evaluations from the teachers are unanimous in that the content and structure of the workshops are relevant and supportive. It is therefore of paramount importance that the experiences from these STAGE 1 TEPs are incorporated into the preparation of the final TEPs of the SAILS project. However, these evaluations have mostly provided limited or general feedback and the use of a more robust evaluation instrument will be necessary to capture feedback from all STAGE 2 participants as essential measure of this project.

The collection of SAILS STAGE 1 TEP reports do serve the purpose of highlighting good practice that should be included in the preparation of the final stage of SAILS TEPs. The importance of providing participants with first-hand experience of inquiry learning is particularly emphasised. The programmes should also include the following essential aspects and support teachers in:

- Identifying assessment opportunities in relation to inquiry activities.
- Preparing and implementing IBSE units and assessment of inquiry skills in schools.
- Reflecting on the use of IBSE units and assessment of inquiry skills in schools.
- Designing own IBSE tasks and assessment instruments.
- Reflecting on the use of own IBSE tasks and assessment instruments.
- Considering possible gender bias.

# 4. Implications for SAILS STAGE 2 Teacher Education Programmes

The previous section has highlighted and evaluated the SAILS STAGE 1 TEPs that have been implemented across the 10 countries. These TEPs were developed to not only introduce teachers to inquiry practices but also introduces them to a number of different aspects of assessment of inquiry activities.

The SAILS STAGE 2 TEP aims to integrate education about inquiry practices with the assessment of these practices; i.e. teachers are introduced to inquiry and its assessment within the TEP. Inquiry methodologies are used to develop not only students' content knowledge, but also skills that student develop through engaging in inquiry practices such as planning investigations, argumentation, problem solving and therefore the assessment of these skills is essential to ensure student development.

From the evaluation of SAILS STAGE 1 TEPs, it is clear that a flexible TEP programme is required for a number of reasons; SAILS TEPs need to:

1. Accommodate the diverse range of teachers participating in such programmes- based on both subject specialism, prior experience with IBSE and assessment;
2. Take account of the time available for in-service teachers to attend such programmes;
3. Take account of the structure of the programmes (summer schools/winter school vs. series of workshops over time vs. one day programmes);
4. Fit in with pre-service teacher modules;
5. Suit all countries with different modes of work, cultural differences and curricula constraints.

From analysis of SAILS STAGE 1 TEPs, it is clear from the evaluations that the content and structure of the workshops were relevant and supportive. Therefore, it is important that the experiences from the STAGE 1 TEPs are incorporated into the STAGE 2 TEPs. Therefore, a common approach has been developed that identifies what are the core elements of all SAILS TEPs on IBSE and Assessment. The length of time that is devoted to each element is variable and will be decided by the teacher educator to suit the needs of the teachers attending.

Each TEP should adopt approaches and discussions to address the constraints identified by the teachers and educators across different partnering countries (Table 5), e.g. lack of time to develop and implement IBSE assessment; high content requirements in national curriculum; external tests are not focused on assessing inquiry skills; lack of familiarity with formative assessment tools for IBSE.

How to address teachers' unconscious gender biases in carrying out inquiry and its assessment and identifying gender awareness in the inquiry classroom should be included. TEPs should provide teachers with activities that are useful to increase their awareness of possible gender prejudices and some suggested activities are discussed in section 4.2.

The importance of teachers sharing their experiences and resources with their peers, through face to face discussions and online through the national and international CoP should be emphasised. The benefits of peer discussion and working collaboratively are an integral aspect of IBSE and should be embodied in the approaches adopted in all TEPs.

The three core elements of all SAILS STAGE 2 TEPS have been identified as (shown in Figure 2):

1. Experiencing inquiry and assessment
2. Trialling IBSE and assessment in the classroom
3. Developing IBSE and assessment resources

Each of these Core elements are discussed in Section 4.1 and examples of good practice as described in STAGE 1 TEPs are highlighted. In the implementation of national TEPS additional elements may be added, as appropriate to the length of the programme and the experience level of the teachers. In particular, SAILS TEPs may provide participants with additional support for:

- Facilitating and assessing group work
- Developing assessment criteria and/or learning progression
- Facilitating and assessing student argumentation
- Providing students with productive feedback
- Using ICT in assessment.

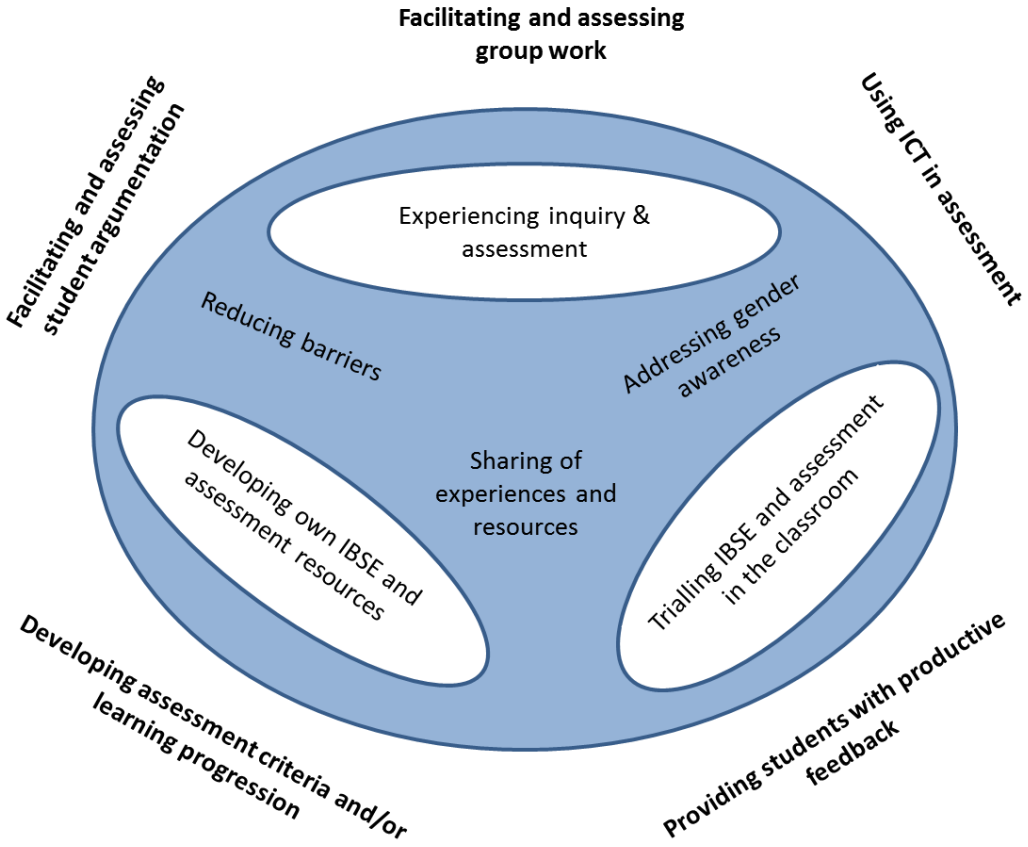


**Figure 2 Core Elements in SAILS STAGE 2 TEP**

## 4.1 Core Elements of SAILS STAGE 2 TEPs

### 4.1.1 Core Element 1: Experiencing Inquiry and Assessment

Within Core Element 1, teachers are introduced to the:

- The goals and framework of the SAILS project
- The What?, Why?, and How? of Inquiry Based Science Education (IBSE)
- The Why?, What?, and How? of assessment of inquiry skills.

The content can be introduced in the workshops in many different ways and each partner will decide on the methodologies that they can use that are most suitable for their teachers.

The main outcomes from this workshop are that:

- Teachers are familiar with the overall aims and objectives of the SAILS project (particularly that it involves 14 partners from 12 countries working collaboratively to produce resources for teachers use in the classroom; also that it is informing policy makers in each country as to the value of IBSE and its assessment in the classroom).
- Teachers through experience of IBSE activities, will recognise the value of IBSE as a teaching methodology and be motivated to try IBSE in their classrooms
- Teachers will recognise opportunities for and the value of different assessment strategies and how they can be implemented.

Introducing the SAILS project can be achieved through short presentations on SAILS, available on the project website.

Introducing teachers to IBSE may be achieved by e.g.

- Allowing teachers to carry out a number of IBSE activities (e.g. open inquiry, guided inquiry) and then reflecting in group discussion on the nature of the learning that occurred during these activities and particularly on the different inquiry activities in different inquiries
- Supporting information e.g. through lectures/seminars or background material.

Particular activities could be:

- Investigating capacity of baby diapers/nappies?
- How many drops of water can be placed on a 5c coin?
- Many introductory activities from SAILS units.

Teachers are encouraged to join the Community of Practice to share their resources and experiences. Also teachers will complete the PART A Evaluation Tool at the beginning of the first workshop, and PART B at the end of the series of workshops, after they have had an opportunity to trial and implement IBSE and assessment in their classroom.

Introducing teachers to the Assessment of IBSE may be achieved in a number of ways:

- Following the IBSE activity above, a discussion of the learning that occurred can then be followed by a discussion of assessment of that learning
- A variety of assessment tools (such as short written students' work, self- and peer assessment, assessment rubrics) may be introduced, discussed and trialled in relation to the activity used

- Introduced through lectures and seminars – outlining formative and summative assessment of different inquiry skills and different modes of assessment

Particular activities could be:

- The workshop providers giving "assessment feedback" to the groups of teachers during/after they have carried out an inquiry activity
- Teachers peer assess the work of their groups
- Highlight the main inquiry skill developed within an activity and develop an assessment rubric to describe levels of the skill.

*Examples of good practice For Core Element 1:*

In Poland, participants are guided into IBSE through a series of lectures and seminars. These lectures and seminars introduce for instance constructivist learning, characterization of inquiry activities according to students' independence and degree of teacher guidance, and IBSE materials available to teachers. The participants are also surveyed with an IBSE self-assessment tool designed within the Fibonacci project. After the lectures and seminars, participants take part in a hands-on seminar, where simple experiments (for instance investigating the capacity of baby diapers and the physical properties of polystyrene cups) are planned and carried out according to the methodology of IBSE.

In Germany, participants performed a hands-on activity, investigating how many drops of water that can be placed on a 5-Cent coin. They also studied example units from the SAILS project, such as the speed activity, the electricity unit, and the UV-radiation beads. In the second session, formative assessment tools (like short written students' answers, self- and peer-assessment, and assessment rubrics) were introduced, discussed, and trialled during the workshops.

In Sweden, participants were introduced to assessment through lectures and seminars. The central content was formative and summative assessment (Why?), assessment of different inquiry skills (What?), and different modes of assessment, such as performance, written, and oral assessment (How?). An important resource in Sweden is the nationally developed formative assessment material for primary science education called "DiNO", which includes assessment rubrics for both investigations and argumentation in science.

### 4.1.2 Core Element 2: Trialling IBSE and assessment in the classroom

As part of the SAILS STAGE 2 TEP, the teachers should have an opportunity to trial some of the activities that they have engaged in in Core Element 1 or the SAILS units or adapt their own lessons to inquiry. It is by seeing how their own students conduct such activities, that allows teachers to see at first hand the effect of inquiry on their students. Additionally, teachers should be encouraged to trial different assessment formats with their students, particularly those that involve assessment during the inquiry activity.

Following trialling/implementing in the classroom, the teachers need to be given an opportunity during Core Element 2 to reflect on the implementation in the classroom and discuss this with others at the follow-up workshop, in particular:

- Preparing and implementing IBSE units and assessment of inquiry skills in schools.
- Reflecting on the use of IBSE units and assessment of inquiry skills in schools.

Reflection should focus on:

- The student learning during the IBSE activity
- The inquiry skills developed during the activity
- The assessment strategy used by the teacher
- How decisions were made to arrive at the assessment
- The feedback given to the student

Teachers should be encouraged to bring evidence of their students' learning to form the basis of discussions at the workshop. If these are not available, then examples from the SAILS units can be used as the basis for discussion.

Discussions should include the following and include strategies to address the difficulties:

- Skills addressed in inquiry activity
- Difficulties with implementation to overcome (e.g. group work, time, etc.)
- Forms of assessment and their relevance or applicability for different groups of students
- Preparing students for different focus of assessment
- Where to now?-following on assessment episode

If particular examples have not been addressed during the workshop, particular examples should be highlighted, e.g. student dialogue, student presentations, student arguments, etc.

*Examples of good practice for Core Element 2:*
In Greece, participants take part in an exemplary IBSE Learning Scenario. The facilitators then lead a discussion about the pros and cons of implementation and on how participants might put their ideas into practice at their own schools.
In Sweden, reflection on the use of IBSE units and assessment of inquiry skills in schools is facilitated through peer group discussion. Therefore, every session start with small-group discussions among the participants.

### 4.1.3 Core Element 3: Developing IBSE and assessment Resources

Teachers will then adapt and develop their own resources for use in their classrooms. With the support of their peer group and teacher educators, teachers (individually or in small groups) will decide on a topic area and develop their own inquiry resource or assessment strategy for use in their classroom.

These materials/resources will then be made available to the other teachers through the CoP. In this way, teachers are supported in not only implementing new strategies for teaching and assessment, but also to develop and adapt other resources to suit their needs.

- Designing own IBSE tasks and assessment instruments.
- Reflecting on the use of own IBSE tasks and assessment instruments.

*Examples of good practice for Core Element 3*

In Slovakia, participants are introduced to examples of both guided and open inquiry activities. Participants are given assignments where they are supposed to: (a) design an interactive demonstration activity; (b) design an activity at guided discovery/inquiry level, (c) plan for a lesson based on IBSE principles, and (d) implement an inquiry activity in the classroom, including assessment tools.

In Portugal, participants select an inquiry task and which inquiry skills to assess. The construction of an assessment tool is then done in an iterative process, where participants share their work on the national CoP and receive feedback. Participants present, analyse, and discuss their assessment instruments. They are also prompted to hand in an individual written reflection and share the final version of their assessment tool on the national CoP.

### 4.1.4 Gender in the Inquiry classroom

While effort has been made throughout the workshops, to ensure that the material presented to teachers is gender neutral, teachers will be made aware of the possibility of unconscious gender bias issues that may arise in assessment. Particular exercises as outlined below in Section 4.2 can be adapted to fit in with Core Elements 1 to 3.

*Examples of good practice for highlighting gender*

In the UK, in order to support teachers in thinking about the role of relationships and teamwork in an IBSE classroom, the teacher discussed gender stereotypes and were asked to observe the interactions of a group (with mix of males and females) involved in a problem solving construction activity, noting who spoke and how the activity was progressed or slowed down by the group interactions. They looked at male and female involvement in the dialogue and activity and discussed what this suggested to them about how groups work in an inquiry situation and factors they needed to consider when planning and implementing inquiry. This created a wide discussion about how learners work in groups, the importance of teamwork and dialogue in the classroom and the responsibilities of teachers to monitor and consider how s/he might encourage particular ways of working rather than others.

## 4.2 Activities to Highlight Gender Issues

When inquiries are being done in the classroom, it is possible that gender issues can be a factor. Here are some of the ways that teachers can take account of gender.

There are some principles that can be followed:

a. Expand the definition of inquiry
b. Make gender issues explicit to the teachers and to pupils.
c. Analyse what went on during the social aspects of inquiry.
d. Give space for people/pupils to say how they feel.
e. Ensure assessments of inquiry make explicit gender interactions.

**(a) Definition of inquiry**

Inquiry is commonly defined as being a process that achieves knowledge through observation, experiment, data collection, analysis and conclusion. However, such definitions, to various degrees, hide the extent to which social and emotional processes and interactions are essential to inquiry. These processes would include discussion at conferences, feeling elated or frustrated, dialogue with colleagues, emotional commitment to ideas, determination to beat other scientists, and being creative. If there is a focus on only the 'objective' and non-emotional side of scientific inquiry a gender bias is introduced. To overcome this, teachers can make explicit to pupils how important social and emotional processes are. Teachers, therefore, need to assess these aspects.

**(b) Making gender/power issues explicit**

The first stage is to make gender issues explicit with teachers within TEP. For example, during teacher TEP meetings there can be an observer. The observer makes notes on how often men and women make contributions, and any other important facts - such as were there interruptions. After a while the teachers can be asked what the ratios of contributions were. The ratio does not matter, what is important is whether or not they were aware of the interactions. It is common for teachers to report and overemphasise the male contributions, and for their contributions to be valued more highly.

Similarly, the teachers in TEP can be put into male-male, female-female, and female-male groups and the teachers asked to discuss how each felt. These discussions can help make social and emotional interactions explicit and so improve them.

The purpose of looking at the interactions during the teacher-meetings is to ensure that they are aware and will ensure that pupil interactions are addressed and seen as important in the classroom during inquiry (and other times). At the same time, pupils can be made aware that inquiry involves communication and interactions between people.

NOTE, it is more difficult to tackle gender issues in single-sex groupings. This makes it more important that it is done. One key aspect is to realise that power relations are an underlying current in all situations, and what one is trying to achieve is to enable people to deal with/confront the power imbalances, and this applies in single as well as mixed gender groupings.

*Student interactions*

There are a variety of ways that students can be made aware of their interactions in addition to those mentioned above. Sometimes providing students with tally sheets that allow them to record who spoke in a given situation or how long they spoke for, provides opportunity for the group to reflect on how conversations went during the inquiry. If a pupil is made aware that they don't contribute much or that they prevent others speaking, then they are more likely to think about changing that behaviour. A series of sheets were available that allowed students to comment on a range of factors such as how much they learnt, were able to explain ideas, how they could improve their discussions and how they resolved arguments.

The advantage of the using tally sheets, or other written methods, is that it gives space for students to say what they felt went on, if the students helped each other, if they listened, and how they could improve their interactions. Gender biases in these interactions should surface and be made visible.

Other aspects could also be raised. For example, do the boys tend to do experiments while the girls make notes? (In single-sex groupings, do some pupils tend to take on certain roles?).

### (c) Explicit assessment of gender/power issues

One way to draw attention to gender issues is to make sure that they are evident in the assessment of inquiry. Many assessment rubrics or criteria sheets could include social aspects.

It is probably preferable to use the non-hierarchical 'Learning Landscapes' assessment sheets for factors such as teamwork, peer assessment, argumentation, critical thinking and communication (See Figure 3). This is because such abilities take a long time to develop and if a student was consistently given a low assessment it would hamper their chances of development.

Figure 3. Example of part of a teamwork Learning Landscape assessment sheet

Group names: _____Date:_____
Group assessment: how the group on average manage their teamwork.
Ring those achieved. Add any that have been missed out. Say if filled out by pupils or teacher,

| | | | |
|---|---|---|---|
| Listening positively | Resolve ideas | Work towards a common goal | Be friendly |
| Be supportive | Share tasks | Allocate tasks | Collaborate |
| Empathise | Work with boys/girls/different groups | Contribute to discussions without dominating | Peacemaker |
| Work under pressure | Manage emotions | Use resources and equipment without taking over | Democratic leader |

**Figure 3. Example of part of a teamwork Learning Landscape assessment sheet.**

This *teamwork* sheet can be used for a group or an individual. However, it is **essential** that assessment is not made a site for anxiety or students will feel apprehensive about their interactions and so can become stilted with others. Overall, students should enjoy doing inquiries. If they feel the

weight of assessment such that they do not, perhaps we have to reflect on our assessment procedures.

**Pupils' understanding of inquiry**

Pupils should realise that socially interactive elements are an integral part of inquiry.

One way to find out if a balance has been achieved is to ask pupils a question such as 'What is inquiry?'. If their reply is confined to the elements such as questioning, data collection, analysis and write-up, and does not include the social and emotional elements, it would be one indication that the balance has not been achieved.

# Appendix A: Resources used in Stage 1 TEPs

| | |
|---|---|
| Germany | Bell, T., (2007) Entdeckendes und forschendes Lernen, In: Mikelskis-Seifert, Physik Methodik, p.70-81, Berlin: Cornlesen Scriptor<br>Bell, T. (2010), Physik im Kontext – Konzepte, Ideen, Materialien für effizienten Physikunterricht, p. 61-64, Velber: Friedrich Verlag<br>COMPASS: Desertec and Dangerous cold, http://www.compass-project.eu/<br>Fradd et al. (2001) Promoting Science Literacy with English Language Learners Through Instructional Materials Development: A Case Study, Bilingual Research Journal (4) 25, p. 417-439.<br>Höttecke, D. (2010). Forschend-entdeckender Unterricht. Unterricht Physik, Nr. 119, 21. Jg., p. 4-12<br>PRIMAS – The candle experiment, http://www.primas-project.eu/<br>SAILS Units: Speed Activity, Electricity-Unit and UV-Radiation-Unit<br>Student response system Socrative, www.socrative.com |
| Greece | Electronic laboratory – Labdisc<br>Templates for Learning Scenarios |
| Hungary | SAILS units from website<br>PRIMAS units from website, http://www.primas-project.eu/zoeken/search.do<br>Special issue of the journal "Iskolakultúra" [in Hungarian] on inquiry-based learning<br>Csapó Benő (2004): Tudás és iskola. (Tanulmánygyűjtemény) Műszaki Kiadó, Budapest.<br>Fradd, S.H., Lee, O., Sutman, F.X., & Saxton, M.K. (2001). Promoting science literacy with English language learners through instructional materials development: A case study. Billingual Research Journal, 25 (4), 417-439.<br>Wenning, C. J. (2007). Assessing inquiry skills as a component of scientific literacy. Journal of Physics Teacher Education Online, 4(2), 21-24. |
| Ireland | SAILS Units: Activity Sequence for Reaction Rates<br>Sails definition of inquiry skills and competencies.<br>In-service teacher questionnaires – A and B<br>Classroom Dialogue – 3 scenarios as produced by Paul Black/KCL<br>Exploratorium of Inquiry) INSTITUTE FOR INQUIRY: www. exploratorium.edu<br>ESTABLISH units (e.g. Exploring Holes, Light), http://www.establish-fp7.eu/<br>Teaching Science, http://tools4teachingscience.org<br>Youtube, https://www.youtube.com/watch?v=2WJVHtF8GwI<br>Learning Skills for Science – Activity Book and Teachers Guide – Science Enhancement Programme, Weizmann Institute of Science & Nuffield Curriculum Centre<br>McComas, W.F. (2010, Fall). Educating science critics, connoisseurs and creators: What gifted students should know about how science functions. Gifted Education Communicator, 41(3), 14-17. |
| Poland | ESTABLISH project materials, http://www.establish-fp7.eu/<br>SAILS Units<br>Volvox project protocols, http://www.eurovolvox.org/<br>Sample final exam forms from lower and upper secondary schools in Poland.<br>Literature comprising samples of questions that may serve a base for inquiry based lessons (e.g. "New Scientist" series – M. O'Hare (ed.), "How to Fossilise Your Hamster", "Why Don't Penguins' Feet Freeze"). |
| Portugal | SAILS definition of inquiry competencies |

| | |
|---|---|
| | SAILS rubrics<br>SAILS units<br>Portuguese SAILS Case Studies<br>Diverse bibliographical references (national and international authors) |
| Slovakia | SAILS units<br>ESTABLISH teachers and students materials, http://www.establish-fp7.eu/ |
| Sweden | <u>Swedish books on IBSE and assessment:</u><br>”Att bedöma förmågan att genomföra systematiska undersökningar i kemi” [Assessing inquiry skills in chemistry] – by A. Jönsson<br>”Scientific Literacy” – teori och praktik, by E. Lundqvist, R. Säljö & L. Östman (Eds.)<br>”Samhällsfrågor i det naturvetenskapliga klassrummet” [Socio-Scientific Issues in the science classroom] – by M. Ekborg, M. Ideland, B. Lindahl, C. Malmberg, C. Ottander & M. Rosberg<br><br><u>International books and articles:</u><br>“It’s Debatable! Using Socio-Scientific Issues to Develop Scientific Literacy” – by D. L. Zeidler & S. Hahn<br>“Don’t be nervous, don’t be flustered, don’t be scared. Be prepared” – by D. Hodson in Canadian Journal of Science, Mathematics and Technology Education<br>“Science Education for Citizenship. Teaching Socio-Scientific Issues” – by M. Ratcliffe & M. Grace |
| Turkey | SAILS Units: Electricity, Speed : http://sails-project.eu/<br>FIBONACCI Project materials: Fish, Moon and Earth Phases http://www.fibonacci-project.eu<br>“Teaching Science as Inquiry” Book: Coin Drop http://www.amazon.com/Teaching-Science-Inquiry-MyEducationLab-Edition/dp/0138143749<br>Egg Drop: http://college.cengage.com/education/pbl/project/project3.html<br>Electric motor: http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/9780873552677.16<br>Exploratorium website: Institute of Inquiry: http://www.exploratorium.edu/ifi/<br>“Investigating Matter through Inquiry” American Chemical Society.: http://www.inquiryinaction.org/ |
| United Kingdom | SAILS Units<br>Perspectives on Education: Inquiry based science education (Wellcome trust 2011)<br>PRIMAS units from website, http://www.primas-project.eu/<br>It’s not Fair – or is it? (Millgate House publishing)<br>Cognitive Acceleration through Science Education project<br>Practical Action project (see www.practicalaction.org/floatingagrdenschallenge)<br>Engaging Education: Developing Emotional Literacy, Equity and Coeducation, published Open University Press, 2005 |

# Appendix B: SAILS Stage 1 in-service TEPs

## B.1 GERMANY

**Background of the in-service teachers participating**

The SAILS In-service teachers of Germany which took part at the workshops of 2nd cohort are experienced physics and science teachers from different schools, school types, and regions in Lower-Saxony.

**Aim / philosophy of TEP**

A specific aim of SAILS Germany is to provide possibilities for teachers to work on their own IBSE ideas or to adapt existing materials to their individual teaching situations. Therefore we provide two different kinds of workshops: Half day workshops in the Leibniz University of Hannover and 1.5 days workshops which enable intensive work in groups on several topics.

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | Total number of teachers: 32<br>Cohort 1 teachers:<br>9 teachers (12hours)<br>4 teachers (15 hours)<br>Σ 13 teachers (12-15 hours)<br>Cohort 2 teachers:<br>13 teachers (4.5 hours)<br>5 teachers (16.5 hours)<br>1 teacher (19.5 hours)<br>Σ 19 teachers (4.5 -19.5 hours) |
| Subjects represented | physics and science (plus a second subject) |
| Educational levels represented | several years of teaching experience at lower and upper secondary school level |
| Programme format | half day or 1.5 day workshops |
| Number of workshops | three half day and two 1.5 day workshops |
| Number of hours/workshop | half day: 3 or 4.5 hours; 1.5 day: 12 h |
| Total number of hours | 4.5 -19.5 hours |

**Structure and content of in-service programme**

| | |
|---|---|
| Workshops 1 Cohort 2<br>(half day Kick-off meeting) | The structure of the kick-off meetings for cohort 2 were based on previous kick-off meetings for cohort 1 (see also D4.1).<br>Information about the aims of SAILS, the project implementation and project organization were given.<br>In the first activity, the teacher dealt with one example unit for inquiry learning: the water-drop-experiment. This unit can be found in Höttecke (2010). This activity starts with the research question |

| | |
|---|---|
| | "How many water drops can be placed on a 5-Cent coin?". The teachers designed the experiment themselves and used a number of experimental setups. Afterwards the whole group discussed at length various issues ranging from the elements of inquiry learning in this unit to links between inquiry and the curriculum.<br>A literature review about different views of inquiry based science teaching and formative assessment tools was given. The second literature review focused mainly on basic methods to assess students' feedback on their inquiry skills (e.g. experimental skills).<br>Additionally a summary of the range of IBSE units in Europe was given.<br>In a practical part of the workshop, the teachers rotated around different stations with materials and experiments. They studied sample units from the SAILS Project (Speed Activity; Electricity-Unit; UV-Radiation Unit, rubrics for formative assessment) and from inquiry based learning projects such as COMPASS, PRIMAS or the former national project Physics in Context (piko).<br>At the end of the workshop, the next Exchange-meeting was announced and an introduction to the Community of Practice (CoP) was given. |
| Workshop 2<br>(1.5 days exchange meeting) | The workshops ran in February and March 2014 for one and a half day each. In comparison to the workshops of cohort 1 (2013), these focused on teaching materials (e.g. SAILS Units) and on the implementation of formative assessment tools in school situations. Formative assessment tools such as short written students' answers or self- or peer-assessment tools were discussed. Additionally assessment methods such as the use of "student flashcards", student response systems like the internet platform Socrative or the assessment rubrics from the SAILS Units were showed and trialled during the workshop.<br>The workshops started with teachers' reports on their experience with implementing inquiry units or formative assessment tools in the own teaching since the kick-off meeting. The main part of the workshop covered teachers working on improving and adapting IBSE Units for their own teaching and the implementation of formative assessment. These activities were divided into three periods distributed over the whole workshop.<br>During the last part of the meeting, the next steps in the SAILS project (materials, literature for the units, time schedule, etc.) was agreed upon and teachers were asked to complete a short evaluation. Some materials will be used in the teaching during the summer term. Therefore a follow-up meeting (half-day) will be offered after the summer break, i.e. in September / October 2014. |

| | |
|---|---|
| Workshop 3<br>(follow-up, half day exchange meeting) | A subgroup of cohort 2 and cohort 1 teachers worked on developing presentations on their implantation of inquiry and the assessment of inquiry skills for participation at the SAILS teachers' conference. Products: 8 posters and 2 oral presentation |

## B.2 GREECE

**Background of the in-service teachers participating**

18 Greek in-service science teachers (physicists, chemists, biologists, geologists) with several years of teaching experience at lower & upper secondary level.

**Aim / philosophy of TEP**

The main objective of the seminar was to contribute on science teachers' preparation, not only to be able to teach through inquiry-based science methods but also to make them more confident in their assessment of IBSE. In addition, this TEP focussed on specific aspects, including:

- Development of IBSE scenarios
- Enhancement of IBSE scenarios with assessment strategies
- Implementation of IBSE scenarios
- Establishment of Greek Community of Practice

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 18 |
| Subjects represented | Phy/che/bi |
| Educational levels represented | Lower & upper secondary school |
| Programme format | 1 day workshop |
| Number of workshops | 1 |
| Number of hours/workshop | 5 |
| Total number of hours | 5 |

**Structure and content of in-service programme**

Session 1

| | |
|---|---|
| Introduction | Introduction to SAILS<br>New approaches to teaching science, inquiry based learning –IBL philosophy and IBL learning models. |
| Learning Design | Participants were introduced to Learning Design through a Learning Scenario Analysis. They learn about basic elements of learning scenarios such as Title, Learning Problem, Course Info, Learning |

| | |
|---|---|
| | Objectives, Learning Approach, Characteristics of Learners, Needs of Learner, Participating Roles, Material & technical infrastructure, Presentation of Scenario, Assessment of students performance, Resources. |
| Assessment | Participants are introduced to modern assessment techniques such as Rubrics, Self-Assessment, Peer Assessment, Quizzes and Concept Maps. |

Session 2

| | |
|---|---|
| IBSE Hands on Experience | Participants take part in a hands-on IBSE Learning Scenario. The added value of this learning scenario based on the inquiry based activities, the modern assessment techniques and the exploitation of new technology (electronic laboratory – Labdisc). We use the exemplary Learning Scenario "Acids, Bases & Salts" for the «Acids, Bases & Salts» lecture in the sixth grade of lower secondary school.<br>Facilitators lead a discussion about positives and negatives of IBL Scenarios implementation and on how participants might put their learning design ideas into practice at their school. |

Session 3

| | |
|---|---|
| Independent learning | Participants develop their own IBL Scenario either collaboratively or individually which incorporates modern assessment techniques based on the template of Learning Scenarios. Their Learning Scenario should include all the necessary material/resources. |

## B.3 HUNGARY

**Background of the in-service teachers participating**

The teachers participating in the TEP were interested in innovative education, including inquiry-based teaching and relevant strategies of assessment. However, they had little experience in inquiry-based teaching.

**Aim / philosophy of your TEP**

The aim of the TEP was to get the participating teachers acquainted with IBSE and the different (primarily formative) assessment opportunities, as well as the role such teaching and assessment may play in the development of students' skills.

During the TEP, some SAILS units were introduced. The units included a detailed description for the teachers, highlighting which skills each unit was supposed to help students develop and how those skills can be assessed during the lesson. Recent Hungarian science education puts great emphasis on this, but there are only a few concrete examples.

Many teachers think that developing inquiry skills is separate from learning content knowledge and the teachers cannot link skills development with the subject content. However, the SAILS units are tasks that can be embedded into the curricula and via the elaboration of these, the conscious development of skills is feasible.

The development of IBSE skills is characterized by much more group work, but many Hungarian teachers believe that group work is only useful during science lessons when the students are carrying out an experiment together (based on given instructions). However, it can be used in other situations as well, for example during the formulation of problems and hypotheses, planning experiments, bringing questions together to explain phenomena, etc.

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 26 (9 male, 15 female) |
| Subjects represented | Physics, Chemistry |
| Educational levels represented | Lower (3) and upper secondary school (23) |
| Programme format | 1 day workshop 13th Sept 2014 |
| Number of workshops | 1 |
| Number of hours/workshop | 10 |
| Total number of hours | 10 |

**Structure and content of in-service programme**

| | |
|---|---|
| 1 | Learning science, developing scientific thinking. |
| 2 | Introduction of SAILS project. |
| 3 | Theoretical background and characteristics of inquiry-based learning. |
| 4 | Developmental opportunities of inquiry skills in class. |
| 5 | Methods and opportunities for the assessment of inquiry skills in class. |
| 6 | Structure of units developed within the SAILS project. |
| 7 | Introduction of two Hungarian units. The speed of chemical reactions and How big is a drop of water? Presentation and discussion of their piloting . The skills to be developed were: Formulating hypothesis, Planning measurement, Drawing conclusions, Groupwork. |
| 8 | The promotion of teachers piloting units. |
| 9 | Enrolling participants on the Hungarian COP. |

## B.4 IRELAND

**Background of the in-service teachers participating**

36 teachers participated, 13 male and 26 female. Most of the teachers taught Junior Certificate Science, and there was an even spread among physics, chemistry, biology, and mathematics as subjects they taught. The median answers in survey questions suggested that a typical participant would have some experience using IBSE in teaching. The content of Stage 1 Inservice TEPs are described for 2-day summer schools completed in 2013 and 2014.

**Aim / philosophy of your TEP**

Teachers develop their own lesson sequence for an inquiry and illustrate assessment opportunities and criteria for assessment for several assessment elements. This TEP was focussed so that:

- Teachers actively participate in inquiry based lessons.
- Teachers explore ways to help students generate investigable questions.
- Teachers engage in ways to identify and enhance inquiry in their own teaching practice.
- Teachers discuss classroom dialogue.

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 36 |
| Subjects represented | Lower secondary science, Chemistry, Physics, Biology, Maths |
| Educational levels represented | Lower and upper secondary school |
| Programme format | 2-day Summer school, 6th & 7th June 2013<br>2-day Summer school, 19th and 20th June 2014<br>2 hour follow up meeting 24th October 2014 |
| Number of workshops | 1 |
| Number of hours/workshop | 11 |
| Total number of hours | 11 |

**Structure and content of in-service programme June 2013**

Day 1:

| | |
|---|---|
| Activity 1 | Registration, welcome, introduction & overview of workshop<br>Experiencing assessment: working in pairs, teachers carry out an investigation on reaction rates and experience on-the-fly assessment by workshop providers. responses. |
| Activity 2 | Discussions on experiencing assessment: participants' experiences, and opportunites for the classroom. Focus on preparation of back-pocket questions, assessing the quality of student responses, and how to build on these |
| Activity 3 | Classroom dialogue: working in small groups teachers discuss three vignettes and discuss the degree of inquiry and the types of assessment. |
| Activity 4 | Selection of topics for developing inquiry-based lessons with built-in assessment, and formation of groups of three or four participants. |

Day 2:

| | |
|---|---|
| Activity 1 | Participants work on integrating appropriate assessments with inquiry based lessons. Facilitators rotate among groups. |
| Activity 2 | Feedback, presentations, and sharing of activities and assessments developed. |
| Activity 3 | Registeration for Ireland's CoP |

**Structure and content of in-service programme June 2014**

Day 1:

| | |
|---|---|
| Activity 1 | Registration, welcome, introduction & overview of workshop<br>Identifying and enhancing inquiry : working in pairs, teachers participated in three forms of inquiry – from open to guided. The task involved designing a spinning top that can spin for at least 10 seconds. In pairs teachers designed their spinning tops out of everyday materials and then tested their designs. Teachers then evaluated the effectiveness of their spinning tops. Teachers did this either in an open investigation (no guidance given), or in a semi guided manner (with limited guidance) or followed a guided worksheet (guided). Discussions followed as to the variation in the tasks and the merits to student learning of each format. This activity was adapted from the Exploratorium of Inquiry. |
| Activity 2 | Generation of questions that could be answered through investigation. Using ice balloons, teachers in groups generated as many questions as they could; these questions were then discussed to determine which questions were good questions to investigate and which ones were not suitable for laboratory work. This activity was adapted from the Exploritorium of Inquiry. |
| Activity 3 | A short activity involving evidence of chemical reaction was used to show how worksheets could be adapted to open up inquiry activities, even if the students were expected to follow a recipie type of instruction. |
| Activity 4 | Using the SAILS Reaction Rates unit, teachers carried out the investigation on the rates of reaction. Teachers were 'assessed' during this group activity. A detailed discussion followed, identifying opportunities for assessment and developing criteria for the assessment. |

Day two:

| | |
|---|---|
| Activity 1 | Classroom dialogue: working in small groups teachers discuss three vignettes of teacher/student dialogue. Opportunities for inquiry and its assessment were discussed. |
| Activity 2 | Using the SAILS unit 'Up There how is it? teachers , in groups, devised questions they would ask astromanuts on the spaceship and also to disscuss how the astronauts carried out day to day tasks such as showering , making a cup of coffee , sleeping etc. Discussion followed as to how this unit could be used in class and how different aspects could be assessed. |
| Activity 3 | Feedback by the group on the workshops. |
| Activity 4 | 1. Set up Ireland's CoP. |

## B.5 POLAND

**Background of the in-service teachers participating**

The participants were teachers from various regions of Poland, teaching in lower and upper secondary schools. They participated in the training voluntarily. Most of the participants were women (90%). The age of participants varied from 26 to 60 years old. For most participants, this was their first encounter with the IBSE.

**Aim / philosophy of TEP**

The aim of the training was to familiarize teachers with the idea of constructivism and the methodology of IBSE including basic assessment strategies. Polish teachers are used to traditional teaching methods and treat science lessons only as preparation of students for a final subject exam. Nevertheless, according to new Polish curriculum the school should also equip students with skills that enable them to apply what they have learned in practice and to participate fully in cultural, social and professional life. So, the important part of the training was to show teachers that Inquiry based methods, can not only equip students with the subject knowledge, but also with the necessary cross-curricular skills.
The workshop was divided into two "courses". The first course (A), was a winter school which took place on 20-23 February 2013 at the Jagiellonian University in Poland. Forty one biology and physics in-service teachers from different school types and regions in Poland participated. This event was combined with training for chemistry teachers organized by the ESTABLISH project. The training focused on the basics of IBSE. The second part (B) was in April 2014, which focused on assessment in IBSE.

**Participants and Programme Format**

| Number of participants | Course A | Course B | |
|---|---|---|---|
| | 60 | 33 | |
| | | Old teachers from cohort 1 (bio/phy) 18 | New teachers 15 (che) |
| Subjects represented | bi/phy/che | bio/phy/che | |
| Educational levels represented | lower & upper secondary school | lower & upper secondary school | |
| Course format | winter school (completed 20-23.02.2013) | workshops 2014 11-12.04.2014 | |
| Number of workshops | 1 | 1 | |
| Number of hours/workshop | 28x45min | 12x45min | |
| Total number of hours | 21 | 9 | |

**Structure and content of in-service programme**

| Area | Type/title of classes | Aim |
|---|---|---|
| **Introduction to IBSE** | Lecture - The teacher as an architect of the student's knowledge | Presentation of methodological foundations and evidence showing the effectiveness of constructivist teaching models. |
| | Seminar - IBSE and the project method in the Polish curriculum. | Discussion on the benefits of using project-based learning and the possibility to include IBSE in project group work. |
| | Seminar - 'Better to ask the way than to go astray' | Seminar focused on finding interesting subject areas and formulation of research questions, followed by a discussion on how to carry out literature reviews in school. |
| | Seminar - Types of activities within IBSE | Characterization of inquiry activities according to the students' independence and degree of teacher guidance. |
| | Seminar - available materials in the field of IBSE. | Presentation materials available to teachers in the field of IBSE, which may be used in school practice. Presented projects: ESTABLISH, PROFILES, PARSEL, Scientix, Fibonacci, Volvox, etc.. |
| | Survey – are your lessons Inquiry based? | Self-assessment tool for science teachers who try to use IBSE (designed within Fibonacci project) |
| **Experiencing IBSE** | Hands-on seminar - Simple experiments planned and carried out according to the methodology of the IBSE | Realisation of simple experiments beyond the school laboratory.<br>Examples of investigations:<br>a) Capacity of baby diapers<br>b) Physical properties of polystyrene cups (foamed vs. non-foamed polystyrene)<br>c) Solubility of sugar in water<br>d) Amount of Vitamin C in juices |
| | Laboratory part 1 | Lab based on guided inquiry activities - teachers independently perform experiments. |
| | Laboratory part 2 | Lab focused on open inquiry and SAILS units - teachers can experience open inquiry, only general subject and lab resources are delivered. During lab, data logging devices are introduced. |
| **Assessment of the IBSE** | Lecture – assessment in IBSE | Introduction to IBSE assessment:<br>• Review of IBSE skills that can be assessed.<br>• Purpose of the assessment (summative vs. formative)<br>• Examples of actual formative assessment tasks at national exams (complex multiple-choice questions - Lawson type, open/problem questions). |

| | | |
|---|---|---|
| | | • Why formative assessment is important?<br>• Methods of evidence collection (teacher observations, peer assessment, reports, ICT evolvement, etc.)<br>•Rubrics – how to use rubrics, analytic vs. holistic rubrics, how to construct rubrics. |
| | Seminar - assessment in IBSE | During the seminar, each subject group work separately. The first task for teachers is to choose one 'SAILS' experiment they made during 'Laboratory part 2', and create assessment tools for it (teachers work in pairs and each pair works with a different experiment, assessment suggestions included in units are not provided). Teachers are asked to pick three skills they consider suitable for assessment during the experiment, choose methods for collecting evidence for each skill, and then construct an assessment tool.<br>When the task is ready, assessment materials included in units are presented to teachers. Teachers compare their proposals with units' suggestions, modify and supplement their assessment tools. Finally each group presents the developed assessment strategy. |

## B.6 PORTUGAL

**Background of in-service teachers participating**

The teachers are from lower and upper secondary levels. Mostly they teach biology/geology and natural sciences, 4 teachers are from chemistry and physics. Regarding the teachers' IBSE background, 10% have good knowledge and regularly use IBSE in class and 80% have some/limited experience with IBSE in class.
Assessment is usually carried out in a diagnostic, formative and summative way. Particularly in upper secondary teacher's deal with student's national exams and that determine their action during the last grade. Students and teachers are particularly focused on it.

**Aim / philosophy of TEP**

The main focus of the Portuguese TEP was on the assessment of and for learning. The title of the programme was What, How and Why to assess? A proposal for the development of assessment strategies applied to Inquiry tasks in the Science classroom.

During the training course, teachers:

- Discussed different assessment perspectives (diagnostic, formative, summative)
- Shared experiences focused on the assessment of inquiry tasks
- Shared experiences of difficulties either in the development or in the assessment of inquiry tasks

The Community of Practice is used to promote teachers' online interaction and to share all the resources produced in the workshop.

The teacher education programme involves face-to-face sessions, collaborative work under the CoP and individual peer work. In face-to-face sessions teachers had the opportunity to analyse and discuss handouts and explore and construct frameworks for assessing inquiry tasks, as well as analyzing, reflecting and sharing the experiences in the classroom in a collaborative and professional setting. Teachers had then been encouraged to discuss and share work and experiences in the online Community of Practice for Portuguese teachers.

We cooperated with 5 external science educators, who have shared their experience and work developed in IBSE and assessment.

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 19 |
| Subjects represented | Natural Sciences – Physics and Chemistry-Biology and Geology |
| Educational levels represented | Lower and upper secondary |
| Programme format | 32 hours training course, with face-to-face and distance sessions supported by the CoP |
| Number of workshops | 5 face-to-face sessions |
| Number of hours/workshop | 3 hours |
| Total number of hours | 15 hours face-to-face and 17 hours distance and individual work = 32 hours |

**Structure and content of TEP**

| | |
|---|---|
| **Session 1** | Assessment of and for Learning – a departure point: some practical examples (Pilot Teacher Collaboration)<br>Invited: Ines Bruno- Assessment criteria for the development of self-regulation of learning |
| **Teacher assignments** | Joining the CoP |
| **Session 2** | Invited: Paula Serra-Inquiry and Formative Assessment: new challenges for science education |
| **Teacher assignments** | Selection of an inquiry task and inquiry competencies (one or two) to assess<br>Construction of an assessment tool – 1st version<br>Sharing assessment tool on the CoP<br>Feedback was given to all proposals |

| | |
|---|---|
| **Session 3** | Invited: Isabel Martins – Scientific literacy: what and how to assess |
| **Teacher assignments** | Construction of an assessment tool – 2nd version<br>Sharing updated assessment tool on CoP |
| **Session 4** | Invited: Raquel Barata-IBSE in the Botanical Gardens: Challenges and opportunities |
| **Teacher assignments** | Construction of an assessment tool – 3rd version<br>Sharing updated assessment tool on CoP<br>Feedback was given to all proposals |
| **Session 5** | Assessment of and for learning-Presentation, analysis and discussion of assessment instruments |

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|---|---|
| **Teacher assignments** | Final assessment instrument and individual written reflections<br>Sharing updated assessment tool on CoP |

## B.7 SLOVAKIA

**Background of the in-service teachers participating**

Physics, chemistry and biology teachers came from lower and upper secondary schools. Most teachers did not have any experience with IBSE; on the other hand they were very enthusiastic and applied for the course voluntarily. Most teachers were women and the average age about 40 years with about 15 years of teaching experience.

**Aim / philosophy of TEP**

This course was a preparatory course for the teachers´ thesis. Teachers´ thesis belong to a system of in-service teacher education scheme in Slovakia that is based on accredited courses and two teachers´ thesis (1st, 2nd). This course was a preparatory course for the 2nd thesis. The main topic was IBSE and elements of IBSE assessment. At the end of the course teachers were supposed to develop a plan for their thesis that should have been based on implementation of IBSE activities with elements of assessment. The course consisted of present and distant part. Present part: 4 meetings per 6 hours and distant part: 36 hours. Present part – lectures + labwork. Distant part was aimed at studying different resources and assignments. E-learning Moodle platform.

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 33 (18+12+3) |
| Subjects represented | Physics, chemistry, biology |
| Educational levels represented | Lower and upper secondary school |
| Programme format | Four one day meetings |
| Number of workshops | 4 |
| Number of hours/workshop | 4*6 (present) + 36 (distant) |
| Total number of hours | 60 |

**Structure and content of in-service programme**

| | |
|---|---|
| Module 1 | Current problems of science education, interactive methods, active learning<br>Introduction to IBSE, short examples of activities<br>Analysis of selected activities from ESTABLISH project<br>Hierarchy of IBSE activities<br>Interactive demonstration/ discussion<br>Home assignment: design an interactive demonstration activity |
| Module 2 | Examples of guided discovery and guided inquiry activities<br>Activities at this inquiry level in a laboratory<br>Industrial content knowledge<br>Home assignment: design an activity at guided discovery or guided inquiry level |
| Module 3 | Examples of bounded and open inquiry activities,<br>Activities at this inquiry level in a laboratory<br>Role of ICT in IBSE<br>Home assignment: design a lesson plan for a lesson based on IBSE principles |
| Module 4 | Assessment of IBSE<br>Formative and summative assessment tools<br>Discussion on the use of formative and summative assessment tools in the current classroom<br>Home assignment: implementation of inquiry activity in the classroom with assessment tools, feedback on the implementation, questionnaire |
| Final defence | Developing a project of the teachers´ thesis connected with IBSE and its assessment. |

## B.8 SWEDEN

**Background of the in-service teachers participating**

These were the same teachers who participated in cohort 1, which means that they were familiar with IBSE and also had some experience of assessing IBSE. According to the questionnaire, the teachers describe themselves as having medium to long experience with assessing IBSE.

**Aim / philosophy of TEP:**

The overall aim of this series of workshops was a to aid teachers in developing assessment items and rubrics for certain inquiry skills, which are emphasized in the latest curriculum reform in Sweden, but are not generally a part of “traditional” science teaching. These inquiry skills are, for instance, to search for scientific information and formulate argument in controversial issues. Focal areas included in the workshops were scientific reasoning and argumentation, Socio-Scientific Issues (SSI) and “Nature of Science” (NOS), which were integrated with the construction of assessment items and rubrics.

Our workshops typically have a balance between input from educational research (i.e. lectures) and collegial learning through group discussions.

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 63 (HKR: 26; MAH: 37) |
| Subjects represented | biology, physics and chemistry |
| Educational levels represented | lower secondary |
| Programme format | Half-day workshops on three different dates |
| Number of workshops | 3 |
| Number of hours/workshop | HKR: 5; MAH: 4 |
| Total number of hours | HKR: 15; MAH: 12 |

**Structure and content of in-service programme**

| | |
|---|---|
| ***Session 1*** | Inquiry skills in the science curriculum<br>Assessing inquiry skills through SSI<br>Construction of assessment items and rubrics<br>Home work: Try out an assessment item and bring samples of student performance |
| ***Session 2*** | Presentations and group discussions about teachers' experiences with the assessment items<br>Moderation of student performance samples<br>Whole-group discussion about constraints and obstacles to assessing inquiry skills (and possible ways to overcome them) |
| ***Session 3*** | Group discussions about how to improve the assessment items and rubrics used<br>Seminar on how to teach "Nature of Science" |

## B.9 TURKEY

**Background of the in-service teachers participating**

A 2-day summer school on inquiry-based science teaching (IBST) and assessment was held in Ankara on 10-11 September 2014. Participants of the workshops were Grades 6-8 science teachers. The workshops mainly focused on IBST activities and strategies for assessment of IBST. Some teachers who participated in previous SAILS workshops shared their experiences and challenges while implementing IBST activities in their classrooms.

**Aim / philosophy of TEP**

- Understand the notion of IBSE and assessment
- Carry out in groups some sample IBSE activities
- Practicing of sample IBSE activities and using different types of assessment strategies within these activities
- Share experience with peers (One of the Cohort 1 teachers shared her experience about IBSE practice with Cohort 2 teachers and she carried out an activity with the participants)
- Be able to put these ideas into their classroom practice

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 40 |
| Subjects represented | Lower secondary science, chemistry, physics |
| Educational levels represented | Lower |
| Programme format | 2-day summer school, 10-11 September 2014 |
| Number of workshops | 1 (A 2-day summer school) |
| Number of hours/workshop | 10 /1 |
| Total number of hours | 10 |

**Structure and content of in-service programme**

| | |
|---|---|
| A 2-day summer school on inquiry-based science teaching (IBST) and assessment | Introduction of SAILS project to teachers.<br>Introduction of Inquiry Based Science Education (IBSE) and formative assessment to teachers.<br>Assessment in IBSE was discussed with teachers. |
| | We have focused on following issues on seven activities that were carried out by teachers in groups: Asking questions, determining variables, formulating hypothesis, designing and conducting an experiment, recording data, evaluating data and writing a report and communicating their results to others. We also discussed how to implement assessment in a way that it would support learning. |
| | Teachers were requested to try out some of the discussed activities in their classrooms. Reflections on the implemented activities in the classroom will be the focus of the coming workshops with the same cohort teachers. |
| | Teachers were requested to develop IBSE activities and get feedback from their colleagues. |

## B.10 United Kingdom

**Aim / philosophy of TEP**

Develop strategies for assessing a range of inquiry skills. Strengthen collaborative learning strategies in the classroom. Develop strategies for assessing 21st Century Skills.

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 16 |
| Educational levels represented | Upper and lower secondary |
| Programme format | 5 sessions over the school year |
| Number of workshops | 5 |
| Number of hours/workshop | 4 |
| Total number of hours | 20 |

**Structure and content of in-service programme**

Session 1 – What is Inquiry?

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| **Introduction (30 mins)** | We explained the project aims and got teachers to chat, in pairs, about their expectations and hopes for the project. The teachers then introduced each other. Teachers were given opportunity to ask questions about the project. Most related to practical considerations (e.g. what our expectations of them was, whether there would be much work to do between sessions) |
| **Activity 1: Definitions or Inquiry (30 mins)** | Teachers were asked when they applied for the PD course to explain what they believed inquiry was and how they used inquiry type activities in their current teaching. In this session they shared their definitions in groups of 3-4 and reached a consensus in each group as to what they believed IBSE was and its benefits to learners. This prompted a whole group discussion and sharing of what IBSE they currently did.<br>In the main, as we expected, most teachers did 3-4 fair test type inquiries and assessed the lab write-ups of these in the same way as was demanded by our examination boards for GCSE (our national exam for 16 year old in which teacher assessment forms 10% of the final mark). This assessment involves a very rigid set of criteria for the skills of planning, observing/data collection, analysis and evaluation which only fits a narrow set of fair test type inquiry activities.<br>We then looked at the Wellcome Inquiry document (http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtvm055190.pdf) and discussed the 5 reasons they claimed were constraints for IBSE and whether these were applicable to their contexts. We then looked at the Teacher's Report from the Wellcome document and discussed in groups whether his thinking on IBSE was similar to or different from the teacher's thinking. Constraints raised were time, restrictions of the curriculum, student expectations and parental expectations. |
| **Activity 2: Which Skills are involved in Inquiry? (60 mins)** | We looked at the current state of practical work and inquiry in UK classrooms. We then looked at the list of inquiry skills that the PRIMAS project worked on and discussed whether we agreed with their list or not. We then looked at the IBSE activities that teachers already did and decided which inquiry skills were being developed in each activity. Teachers noted that the range of skills the students were using was limited to planning, tabulating data, graph drawing and critiquing and that it was mainly the teacher that was closing down the inquiry.<br>We looked at the primary book - It's not Fair – or is it? (Millgate House publishing) which has 5 categories of inquiry activities for 4-6yrs, 7-9 and 9-11 year olds. There are 5 categories of inquiry in the book – Observation over time, Pattern seeking, Research, Identifying and classification and Fair Testing. In groups, the teachers were provided with the teaching materials for 9-11 year olds but with the inquiry category name removed. Teachers were asked to categorise these and consider whether similar IBSE activities might be possible in lower secondary classes. We also looked at some activities from the Cognitive Acceleration through Science Education project to consider whether scientific reasoning might be considered an IBSE activity. We also looked at an activity from Practical Action project (see www.practicalaction.org/floatingagrdenschallenge and decided if this was an |

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| | IBSE activity. Teachers then had to work in groups to list which inquiry skills could be developed (and assessed) in these activities. We looked at whether any of the Primas skills were extra to or missing from the Primas list. |
| **Activity 3: Trying Out Inquiry activities (90 mins)** | We split the group into Biology, Chemistry and Physics teachers and tried out the first three developed SAILS Units – Food labels, Rates of Reaction and Speed. Teachers had to do the inquiries and think about<br>- How could they make them as open as possible?<br>- Which questions they might ask during the inquiry to find out student thinking/understanding?<br>- Which inquiry skills might be assessed during the inquiry or from artefacts (lab write-up, posters, etc.)<br>Each teacher group reported back their findings. |
| **Activity 4: Action Planning (30 mins)** | Teachers then planned which of the inquiries they felt they could try before next session. |

Session 2 – Exploring IBSE

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| **Activity 1: Sharing experiences for trying inquiries in their classrooms (60 mins)** | Teachers report on their experiences. They reported that:<br>a) They were surprised how well students responded to planning inquiry in the physics and chemistry inquiry when they had apparatus to select and try out rather than planning on paper and then ordering equipment. They reported a greater range of approaches to the inquiry<br>b) The Biology teachers reported how the food labels activity enabled them to see the various misconceptions students had about balanced diet and what food types common foods contained. They also noted that students found the mathematical concept of ratios difficult to handle at first.<br>c) Teachers felt they got a different view of what students could do, could partly do and couldn't do from assessing during the inquiry rather than waiting to assess their lab write-up. They were surprised how competent students were when left to get on with the inquiry and most did not require teacher intervention and support. |
| **Activity 2: The SAILS Assessment Model (30 mins)** | Presentation of Sails Assessment Model and reasons for it<br>Discussion of idea and how it may work in schools.<br>Focus on different purposes of formative and summative assessment<br>Role of feedback and opportunities for feedback in inquiry activities |
| **Activity 3: Quick & Simple Inquiry (approx. 90mins)** | Teachers tried 2 of the SAILS project Quick & Simple Inquiry activities. These activities were selected because it was thought the focus could be on process skills needed for inquiry and so teachers used to inquiry might try these as 'one-off' activities. They were also designed to be completed in a one hour lesson therefore not causing time constraints that teachers had been worried about. We stopped and discussed which skills could be developed through each of the inquiry activities.<br>We reorganised the teachers into groups of 3-4. One teacher elected to be the assessor. The other 2-3 teachers did a third activity from the Quick & Simple |

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| | Inquiries. The Assessor teacher made notes on how s/he could assess the students. We then discussed for each of the 4 activities. Which skills were easy and which difficult to assess ad what our expectations would be for different age groups doing the inquiry. So teachers tuned in to age expected performance for each inquiry. We the considered what would be a "working towards" performance for each skill in each inquiry and an "exceeding performance" for each skill. |
| **Activity 4: Action Planning (30 mins)** | Teachers then planned which of the inquiries they felt they could try before next session. |

Session 3 – How might we approach assessment?

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| **Activity 1: Teachers share experiences (60 mins)** | The teachers discussed how successful or not they had found the Simple & Quick Inquiry activities. They reported:<br>- The Cooked Food inquiry presented various health & safety issues they hadn't envisaged. One teacher actually used this aspect as an inquiry skill to assess and this prompted a discussion as to whether 'able to work safely' was or wasn't an inquiry skill.<br>- The Floating Orange inquiry was considered to be very good at getting learners to raise inquiry questions. Teachers found it difficult not to intervene particularly if the question was likely to result in no relationship being shown. There was a big discussion about the importance of realising this is a likely result from an inquiry and how you conveyed that 'no relationship' was as important as finding a relationship.<br>- In the Cookie Mining inquiry, the discussion about focused on allowing students to make mistakes and the value of learning from mistakes.<br>- Teachers revisited the ideas behind formative assessment and progression. Some wanted to assign levels to the development (as they do with our National Curriculum assessment) while other preferred to just assess within the context and possibilities of that specific inquiry.<br>- The teachers discussed the complexity of different inquiries and felt that there was so much more opportunity for differentiation by outcome with the Quick & Simple inquiries we had developed.<br>- One teacher explained how he had done the Cooked Food inquiry first with 11 year olds and he was able to assess their competency at measuring a range of different factors and their safe working practices. With a group of 14 year olds, some students were still focused on selecting how to measure and observe change while others hypothesised that cooking the spaghetti changed the starch. So, they used potassium iodide to test uncooked and cooked spaghetti for starch. When they found that both gave a positive result for starch, they moved their ideas to testing for sugars and they found that sugars were formed more quickly with cooked than uncooked starch. This resulted in a discussion about whether starch can breakdown to glucose without enzymes being present, with students researching about enzyme activity in their textbook. This led to a discussion about whether what they |

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| | were witnessing was a chemical reaction or a physical reaction – is cooking simply putting the starch in a situation where it can breakdown into starch or is the cooking chemically changing and breaking down starch. Most students felt it was the former but they were not fully confident about their findings. The teacher reported that he had begun to get worried at first that these students were exploring ideas that maybe directed them away from the main science curriculum but he decided, on reflection, that their discussions and actions were probably the best science they had done all year. He was particularly impressed with their better use of language in trying to articulate their ideas rather than simply give statements. |
| **Activity 2: Assessing Inquiry Skills (30 mins)** | We listed the various inquiry skills that had been assessed in the 7 inquiries attempted so far and discussed age expected competence for each within each inquiry. We looked at progression and discussed how we might represent this. Some teachers liked the idea of a rubric. We discussed whether such a rubric could possibly be general or inquiry specific. We also discussed whether the rubric should be at 3 levels or whether 4 or 5 would be preferable/achievable. Teachers agreed to try one of the inquiries they had yet to try and to be more explicit in how they reached their judgements. Several teachers wanted to move to peer assessment situations and wanted a rubric to help learners understand how to make assessment judgements. |
| **Activity 3: Thinking about Relationships and Teamwork (90mins)** | Teachers were introduced to ideas from Engaging Education (Matthews, 2005). This work was intended to help teachers focus on the unconscious bias to gender that could occur in science inquiry classrooms. Gender stereotypes were discussed.<br>The teachers then did an activity were they observed the interactions of a group involved in a problem solving construction activity, noting who spoke and how the activity was progressed or slowed down by the group interactions. They looked at male and female involvement in the dialogue and activity and discussed whet this suggested to them about how groups work in an inquiry situation and factors they needed to consider when planning and implementing inquiry. This created a wide discussion about how learners work in groups, the importance of teamwork and dialogue in the classroom and the responsibilities of teachers to monitor and consider how s/he might encourage particular ways of working rather than others. The discussion was especially interesting because we did have teachers from girl', boys' and mixed schools with some teachers who had worked in at least two of these settings. Ethnicity was also discussed as one school had a large input of Hong Kong and Eastern European students in recent years, while other teachers taught in quite diverse communities and some in very monoculture communities. |
| **Activity 4: Action Planning (30 mins)** | Teachers then planned which of the inquiries they felt they could try before next session. |

Session 4 - Strengthening inquiry through collaborative work

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| **Activity 1:** | The teachers discussed how successful or not they had found the Simple & Quick |

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| **Teachers share experiences (90 mins)** | Inquiry activities and the inquiry activities they were now developing .They also reported on how they had tried out ideas relating to teamwork and dialogue in the classroom.<br>- Most teachers were becoming more confident in implementing more inquiry in the classroom<br>- They were able to describe several incidents in the classroom which convinced them that they were ensuring better opportunities for individuals within groups to participate fully in the inquiry:<br><br>One school had already got learners to start assessing group work by having an observer for each group and creating opportunity for discussion between the observer and the group as to each of their perceptions on how the teamwork had played out. They believed it as affecting their student's attitude to learning and especially moving the students away from an exam focus, which had been prevalent previously.<br>- There were concerns for some teachers that they were unable to observe all students directly during an inquiry and so they felt they had detailed assessment data on some students and not others.<br>- The group decided to think about assessment in terms of direct observation/discussion and indirect by artefacts such as lab reports, posters and presentations..<br>- New inquiries had been developed – How do you make the biggest ink splot?, Digestion, Corrosion and Fruit Batteries.<br>- Some teachers had introduced the ideas more broadly and had colleagues back in school trying these. One school did a whole staff presentation which included the staff doing the Cookie Mining Inquiry |
| **Activity 2: Assessing 21st Century skills (60 mins)** | We discussed what we considered 21st Century skills to be and reflected on the teamwork /Dialogue session from the previous month. We looked through various descriptors for Personal Learning and Thinking Skills *see[i] and selected the one we felt most fitted with science. We then set about devising or redesigning inquiry activities to enable students to develop ad strengthen these. We looked at a range of descriptors for each learning behaviour and considered which we were likely to see within a specific inquiry activity. There was some discussion as to whether you should note good or 'working towards' behaviour as well as behaviour observed. |
| **Activity 3: Case Studies (30 mins)** | We outlined why and how the case studies for specific inquiries should be written up. Teachers selected which inquiry they intended to write a case study on. |
| **Activity 4: Action Planning (30 mins)** | Teachers then planned which of the inquiries they felt they could try before next session. |

Session 5 - Sharing Practice

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| **Activity 1:** | In this session we combined cohort 1 and cohort 2 teachers. They began by |

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| **Teachers share experiences (90 mins)** | discussing their different experiences of the project in mixed groups. They were then asked to individually write a piece about their experience of working on the project and how they now viewed teaching and learning through inquiry<br>The teachers then discussed how successful or not they had found the Inquiry activities and writing the case studies. They reported:<br>- They were beginning to build up a picture for some inquiry skills of how students performed these and what progress had been made.<br>- There was still a big emphasis on fair testing though all teachers said they had extended the range of their inquiry activities, particularly with 'observation over time' type activities.<br>- Inquiries were more student centred and teachers were starting to be able to hold back intervention in the early stages<br>- More inquiry activities were being done and these were sometimes broader than lab based inquiries (e.g. does exercise improve memory?)<br>- Group work, teamwork and dialogue had all improved<br>- Teachers and students) more accepting of broad range of artefacts resulting from inquiry. Photos of different stages of an inquiry becoming quite popular. |
| **Activity 2: Case Studies (75 mins)** | Teachers peer assessed one another's case studies and suggested improvements**.**<br>We also looked through 12 of the inquiry units developed by SAILS partners and they decided which they might try in their classrooms and write case studies on. |
| **Activity 3: Dissemination (45 mins)** | General discussion about project dissemination and use of CoP.<br>One of the teachers explained how he had done two workshops at ASE regional meetings and we discussed which other meetings we might present at.<br>The 5 teachers going to the Dublin SMEC conference planned what they thought should go their posters.<br>We had been approached to write a secondary school version of Its not fair – or is it? And so we discussed possible inclusions of inquiries and how it should be different from the primary book. |
| **Activity 4: ASSISTME (30 mins)** | We explained about the ASSISTME project and links with SAILS. We asked teachers to consider whether they wanted to join ASSISTME and also if they could recruit maths colleagues to the project. |
| **Activity 5: Action Planning (30 mins)** | Teachers then planned which of the inquiries they felt they could try before the end of the year. |

# Appendix C: SAILS Stage 1 pre-service TEPs

## C.1 GERMANY

**Background of the pre-service teachers participating**

Science student-teachers at *Leibniz Universität Hannover* are obliged to take courses in science education beside the scientific disciplines (e.g. physics) at university. In the context of their teacher training, special modules concerning IBSE approaches were provided for bachelor and master students. All students received a first contact to the IBSE-approach in a basic lecture at the beginning of their university studies.

**Overall aim / philosophy of the TEP**

The aim of the pre-service teacher workshops of cohort 2 was to gain an insight for undergraduate (bachelor students) and graduate students (master students) into the IBSE approach. The workshops gave a literature overview and provided opportunities to trail inquiry based teaching units.

**Participants and Programme Format**

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|---|---|
| Number of participants | Total number of students:49<br>41 undergraduate students (3 hours) and<br>8 graduate students (21 hours) |
| Subjects represented | physics (plus a second subject) |
| Educational levels represented | undergraduate and graduate students |
| Programme format | Undergraduate students: 2 Seminars as part of a course<br>Graduate students: A complete course |
| Number of workshops | 2 |
| Number of hours/workshop | Undergraduate students: 2 seminars (1.5 h each);<br>Graduate Students: A complete course (21 hours, 14 x 1.5 hours) |
| Total number of hours | 3-21 hours |

**Structure and content of pre-service programme**

| | |
|---|---|
| Pre service teacher workshop – undergraduate students | The undergraduate students workshops had the aim to give students an insight into the IBSE approach and two 1.5 hours lasting workshops as part of a course were given. Therefore the students got a literature overview (e.g. Höttecke 2010, Fradd et al. 2010) and trailed a simple inquiry task from ("How many drops of water that can be placed on a 5-Cent coin", see Examples in 6.1). Formative assessment methods in inquiry learning were introduced in the seminar and linked with former seminar contents (formative assessment in general and selected examples like the "traffic light cups"). |
| Pre service teacher workshop | The complete course for graduate students (21 hours) pursued the aim to gain a comprehensive overview of the IBSE-approach and in addition to the |

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|---|---|
| - Graduate students | bachelor seminar the students had to develop and to present their own short inquiry based teaching sequence. Other EU-Projects concerning IBSE like ASSIST-ME or PRIMAS and also formative assessment methods during IBSE-approaches were discussed in detail. The perspective of an invited In-service teacher was given at the end of the seminar. Based on her experience of teaching inquiry and using assessment strategies in regular school situations she worked with students on specific inquiry units. |

## C.2 GREECE

**Background of the pre-service teachers participating**

This cohort of pre-service teachers was 150 postgraduate students from the School of Pedagogical & Technological Education, which provides a one year teacher training program for upper secondary school teachers.

**Overall aim/philosophy of the TEP**

The main objective of the workshop was to contribute to pre-service teachers' preparation, not only to be able to teach through inquiry-based science methods but also to make them more confident in their assessment of IBSE. In addition this TEP focussed on specific aspects, including:

- Theory of IBSE
- Theory about assessment techniques
- Development of IBSE scenarios
- Enhancement of IBSE scenarios with assessment strategies
- Establishment of Greek Community of Practice

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 150 |
| Subjects represented | Phy/che/bi |
| Educational levels represented | Upper secondary school |
| Programme format | 2 days' workshop |
| Number of workshops | 1 |
| Number of hours/workshop | 2h 30min & 2h |
| Total number of hours | 4h 30 min |

**Structure and content of pre-service programme**

Session 1

| | |
|---|---|
| Introduction | Introduction to the aim and structure of the workshop<br>Introduction to SAILS |
| Inquiry Based Learning in Science | Facilitator present new approaches to teaching science, inquiry based learning –IBL philosophy and IBL learning models. |

| | |
|---|---|
| Learning Scenario Analysis. | Participants are introduced to Learning Design through a Learning Scenario Analysis. They learn about basic elements of learning scenarios such as (Title, Learning Problem, Course Info, Learning Objectives, Learning Approach, Characteristics of Learners, Needs of Learner, Participating Roles, Material & technical infrastructure, Presentation of Scenario, Assessment of students performance, Resources). |
| Modern Techniques of Assessing the Performance of Students | Participants are introduced to modern assessment techniques such as Rubrics, Self-Assessment, Peer Assessment, Quizzes and Concept Maps. |

Session 2

| | |
|---|---|
| IBSE Hands on Experience | Participants take part in a hands-on IBSE Learning Scenario. The added value of this learning scenario based on the inquiry based activities, the modern assessment techniques and the exploitation of new technology (electronic laboratory – Labdisc). We use the exemplary Learning Scenario "Acids, Bases & Salts" for the «Acids, Bases & Salts» lecture in the sixth grade of lower secondary school. |
| Discussion | Facilitator led a discussion about positives and negatives of IBL Scenarios implementation and on how participants might put their learning design ideas into practice at their school. |

| | |
|---|---|
| Wrap-up | Facilitator wrap-up the workshop with some parting reflections, thanking pre-services teachers for their collaboration. Also the collaborative homework exercise is introduced here. The pre-service teachers have produced their own inquiry learning scenarios which incorporated various modern techniques for assessing students' performance during in all phases of these scenarios and have uploaded their scenarios in the SAILS CoP.<br><br>Finally, facilitator emphasise the importance of actual enactment in order to complete participants' learning. |

Independent work

| | |
|---|---|
| Homework | Participants author collaboratively (worked in groups) their IBL Scenario which incorporates modern assessment techniques based on the template of Learning Scenarios. Their Learning Scenario should include all the necessary material/resources. |

## C.3 HUNGARY

**Background of the pre-service teachers participating**

The course took place during the first semester of the teacher education for biology students. In this phase of teacher education, no distinction is made between students aiming for elementary and secondary levels. This was the first time they encountered the methodology of biology teaching.

**Overall aim / philosophy of the TEP**

The aim of the course was to help the students acquire a scientific way of thinking by reviewing the logic of biology and models of cognition. In this way they will be able to acquaint their future students with scientific methods and models of cognition and to support the development of their students' inquiry skills and thinking during teaching.

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 10+14 |
| Subjects represented | Biology |
| Educational levels represented | Postgraduate - MSc |
| Programme format | Teacher education (undergraduate students) |
| Number of workshops | 13+13 |
| Number of hours/workshop | 2+2 |
| Total number of hours | 26+26 |

**Structure and content of pre-service programme**

When learning about the history of biology, the students get an insight into the epistemology of – and the characteristic ways of thinking in – biology, as well as the connections to other sciences interrelated with biology. The students can see the connection between science-technology-society and acquire the skills of critical analysis and interpretation of sources. Knowing the history of biology helps the students to explore their own misconceptions, to develop their scientific thinking, to respect the work of science and scientists, to understand the close relationship of the sciences, as well as the relationship between biological and social problems, and to increase their interest in biology during teaching.

During the sessions the students learn the history (i.e. the steps of the events and the ways of thinking) of the most important biological discoveries. The students gather examples of the role of analogies, coincidences, mistakes and intuitions from the scientific discoveries in biology and they are encouraged to identify parallels between the history of biological science and false ideas and misbeliefs in biology.

## C.4 IRELAND

**Background of the pre-service teachers participating**

DCU provides a number of courses for teacher training. There are two undergraduate degrees - Science Education which qualifies students to teach two subjects between Mathematics, Chemistry and Physics and Physical Education with Biology which qualifies students to teach Biology and Physical Education. All students study basic courses in physics, chemistry and biology so that they can teach lower secondary science which covers topics across physics, chemistry and biology. There is also a postgraduate teacher training programme for students (Professional Masters in Education) who have already completed an undergraduate degree.

The cohort 2 groups include second year Science Education students, second year Physical Education and Biology students and a mix of first and second year postgraduate students. The second year students had been introduced to inquiry during the first year of their studies.

**Overall aim / philosophy of the TEP**

The aim of the pre-service training is to prepare and empower students to teach science in a second level setting. It aims to give students an introduction to a range of teaching and learning strategies including Inquiry Based Science Education (IBSE). For the undergraduate teaching, students also learn chemistry and physics as well as gaining experience of inquiry approaches.

**Participants and Programme Format**

| | Group A | Group B | Group C |
|---|---|---|---|
| Number of participants | 32 | 13 | 8 (5 x 1st years, 3 x 2nd years) |
| Subjects represented | Chemistry | Physics | Physics, Chemistry and Biology |
| Educational levels represented | undergraduate 2nd year pre-service teachers | undergraduate 2nd year pre-service teachers | Postgraduate professional masters in education |
| Programme format | 3 hour lab sessions | 3 hour lab sessions | Lecture / Workshop / Microteaching Analysis |
| Number of workshops | 4 | 5 | 10 |
| Number of hours/workshop | 3 | 3 | 2 and 3 hour timeslots over a 10 week period |
| Total number of hours | 12 | 15 | 24 |

**Structure and content of pre-service programme**

Teacher training took place following adaptation of existing modules for pre-service students. Therefore, the content and focus of the training for each group varies in order to meet the module requirements.

**Group A: Chemistry laboratory sessions with undergraduate students studying for a BSc in Physical Education with Biology**

Pre-service teachers carried out inquiry activities within a chemistry context that can be used at lower secondary level. The skills focused on were developing hypothesis, planning and conduction investigations and working collaboratively. Students had to develop criteria for assessing these skills.

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| Workshop 1 | Students are given instruments to carry out and experiment and asked to develop additional experiments to check the hypothesis |
| Workshop 2 | Planning investigations: Students are given a question and realise that they need to perform a number of trials before they can fully develop an actual plan for the investigation |
| Workshop 3 | Given a question to investigate, students plan and carry out an investigation and submit a written report |
| Workshop 4 | Students analyse reports and take part in small group discussions of assessment criteria to develop criteria for final assessment. |

**Group B: Physics laboratory sessions with undergraduate students studying for a BSc in Science Education**

Pre-service teachers carried out and critiqued IBSE activities within a physics context that can be used at lower secondary level. Each week focused on a different aspect of inquiry, with formative on-the-fly assessment always built in: contrasting open and guided inquiry, reducing scaffolding, developing diagrammatic representations, turning a cookbook experiment into an inquiry activity, and exploring a concept before discovering the name.

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| Workshop 1 | Focus on open v guided inquiry. Using reflection of light in a plane mirror as a vehicle, the pre-service teachers are given an open inquiry activity in which they discover that the angle of incidence and angle of reflection are equal, followed by a guided version. They then critique the overall approach and (in the guided version) the sequencing of the questions and the purpose of each individual question. |
| Workshop 2 | Big Idea framework: students are shown video footage with fragments of a 9-class sequence where lower secondary students develop their ideas on pressure. They pay particular attention to inquiry activities, classroom dialogue and what the teacher does. |
| Workshop 3 | The pre-service teachers are given a set of two tutorials focusing on representations. In the first tutorial, they develop their own representation of forces to understand what needs to be represented along the ideas of Hubber, Tytler and Haslam (2010); in the second, the normative representation is adopted and used to develop students' conceptual understanding of balanced forces and weight. The activities largely consist of questions based around thought experiments. |
| Workshop 4 | Pre-service teachers were given a guide inquiry activity exploring how a spring behaves when masses are attached, and contrast it with a well-known cookbook experiment (verifying Hooke's Law). Thus they see that and how a cookbook |

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| | experiment can be turned into an IBSE activity. Homework questions designed as formative assessment are presented and discussed. |
| Workshop 5 | The topic of electrical conduction acts as a vehicle for introducing these notion of introducing a concept before a name and testing a hypothesis. Acting as students, the pre-service teachers test different materials in a circuit to see how these affect the brightness of a bulb then design an investigation to test the hypothesis that copper is a better conductor than nichrome wire. |

**Group C**: **Combination of Lectures, Workshops and Microteaching Analysis with postgraduate students undertaking a Professional Masters in Education**

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|---|---|
| Activity 1 | Planning: Pre-service teachers are given an overview of the module. The session includes discussions on the nature of science and why we teach science. A number of open questions are used to frame the discussion such as: Why do you teach science? What is your measure of being a successful science teacher? What do you want your students to be able to do? The outcomes of these discussions are explored in terms on their influence on teacher planning and decisions on how and what we teach. Students are assigned a reading for reflection on session. |
| Activity 2 | Planning and Practical Classes: The session explores the purpose of using practices, introduction to various laboratory methods (inquiry, expository, etc.). Pre-service teachers are given a practical class to plan in groups. The activity chosen is 'How do you measure the volume of an irregular shape? This is chosen as it's quite a simple experiment and thus allows pre-service teachers to focus on the instructional approaches that can be used with this task. Their proposed plans are peer critiqued in terms of the anticipated learning, and skills developed through the various instruction approaches suggested. |
| Activity 3 | Introduction to Assessment and Differentiation (1): In this class pre-service teachers reflect on their experiences of assessment discuss their perspective on the purpose of assessment. They watch a video introducing Formative Assessment and complete an Exploratorium task which they read vignettes of class and determine they if assessment and what type of assessment takes place. The class concludes with a discussion on the formative assessment cycle and a comparison with summative assessment. |
| Activity 4 | Introduction to Inquiry: Pre-service teachers are given an introduction to inquiry through modified Exploratorium activities. They explore the inquiry continuum and examine how various stages on the continuum are instructed i.e. using challenges, teacher led, student led etc. They also examine process skills such as observing, questioning, hypothesising etc. (Appendix A) |
| Activity 5 | Assessment and Modelling in Inquiry: In this session pre-service teachers examine an inquiry physics class on pressure. They review a video of the class and complete some of the class activities. Through this they are introduced to the approach of inquiry modelling (students' representations of the processes of phenomena) and explore how the approach can be used to evaluate students' conceptual understanding. |

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| Activity 6 | Microteaching and Inquiry: This session is divided into two parts. In part A, pre-service teachers review videos of practical classes and critique them based on instructional approaches. In part B, PSTs complete and critique a paper-based inquiry activity on forces to demonstrate that inquiry does not always need to include practical activities. This session is important as very often Inquiry is only considered as a minds-on activity. |
| Activity 7 | Microteaching and Assessment: This session involves more in depth discussion of assessment for learning strategies. Pre-service teachers discuss these approaches and watch videos of practical classes to discuss what can and how learning elements can be assessed. In future sessions I intend that pre-service teachers would develop rubrics and identify evidence of learning from the video examples. |
| Activity 8 | Classroom Discourse: In the session students explore discourse in the classroom and examine how it can be used to elicit student ideas and thus evaluate student learning and hence inform teaching instruction. They evaluate a transcript of classroom dialogue and a number of video examples and discuss how they can encourage more student scientific discourse in their practice. They examine and identify questioning techniques such as probing, pressing, re-voicing, peer to peer talk etc. These examples are adapted from University of Washington - http://tools4teachingscience.org |
| Activity 9 | Scientific Literacy 1 (Data representation): Pre-service teachers examine activities developed to show various ways of engaging students in data representation and interpretation using tables and graphs. This session is run as a model based workshop where pre-service teachers complete classroom tasks and then reflect on the experience and nature of understanding and skills required to complete the task. They furthermore reflect on the instruction approach. |
| Activity 10 | Scientific Literacy 2 (Using Media in the class): Pre-service teachers are introduced to various approaches to develop student's scientific literacy through using a variety of media sources. The complete tasks using video and newspaper scientific articles that seek to enhance literacy skills. This session is run as a model based workshop where pre-service teachers complete classroom tasks and then reflect on the experience and nature of understanding and skills required to complete the task. They furthermore reflect on the instruction approach. |

## C.5 POLAND

**Background of the pre-service teachers participating**

Chemistry and biology students who want to become qualified to teach chemistry or biology must complete subject didactics course. The IBSE training is included into didactic courses and is obligatory for all students.

**Overall aim / philosophy of the TEP**

During the course a mixed approach of theoretical framework and practical IBSE workshops was introduced. Students learned about the basis of IBSE methodology and searched for traces of IBSE in a new science curriculum currently being implemented in Poland. Throughout the whole course, a

discussion was triggered about feasibility for implementing IBSE in the reality of the Polish school system. To complete the course the students have to design their own proposals of one hour lessons in inquiry-based science. Students participated in the training are ready-to-implement IBSE in school practice in agreement with new science curriculum.

The IBSE training for the biology students was included in the biology didactics course at final year. At the start of the training students are practically and theoretically prepared for the use of activating methods and different type of assessment. They have already completed lectures, exercises and two-months practice in schools. Before the training each biology student prepared and conducted more than 40 biology lessons.
The IBSE training for chemistry students was also included in chemistry didactics course. The main difference is that idea and methodology of IBSE are included into program from beginning of the course.

**Participants and Programme Format**

| | Group A | Group B | Group C |
|---|---|---|---|
| Number of participants | 41 (training completed) | 26 (ongoing training) | 51 (ongoing training) |
| Subjects represented | biology | biology | chemistry |
| Educational levels represented | lower & upper secondary school | lower & upper secondary school | lower & upper secondary school |
| Programme format | Included in subject didactics course | Included in subject didactics course | Included in subject didactics course |
| Number of workshops | 6 for each group | 6 for each group | 6 for each group |
| Number of hours/workshop | 3x4h<br>3x3h | 3x2h<br>3x3h | 3x2h<br>3x3h |
| Total number of hours | 15 h | 15h | 15h |

**Structure and content of pre-service programme**

During the three introductory lectures the pre-service teachers gained knowledge on the IBSE basics, the advantages of its implementation in school programme and possibilities of its implementation in Polish schools. One of the aims was to convince them, that there is already an open space for implementation of inquiry-based methods within the new curriculum. Next the pre-service teachers got acquainted with engaging questions, i.e. such problems that induce pupils to ask questions on their own that can be answered experimentally. Finally basic strategies and tools for assessment IBSE are presented.

The lectures are followed by workshops. Students work in small groups (2-3 students), they complete given tasks and present results to other participants.

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|---|---|
| Workshop 1 | Adaptation of the inquiry circle.<br>Asking questions focused on various types of IBSE<br>Research on IBSE available resources. |
| Workshop 2 | Hands-on inquiry laboratory classes |
| Workshop 3 | Design of inquiry based lesson including assessment of chosen skills.<br>Summary |

## C.6 SLOVAKIA

**Background of the pre-service teachers participating**

Participants are students of 2nd year of their master study who have selected the optional subject "Active learning in biology education". They had some basic knowledge in IBSE that they gained during the compulsory subject of the 1st year of their master study aimed at general problems of science education. They had some teaching experience gained within 7 weeks of teaching at lower and upper secondary school. Within pre-service teaching they hardly see IBSE approach in the classroom since there are traditional methods used even by teachers who guide students during their teaching.

**Overall aim / philosophy of the TEP**

The overall aim of this series of workshops was to enhance the basic knowledge of IBSE in comparison with traditional methods, elements of IBSE assessment. Introduce and discuss activities in a laboratory, implementation and development of IBSE activities.

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 9 |
| Subjects represented | Biology |
| Educational levels represented | lower & upper secondary school |
| Programme format | seminars |
| Number of workshops | 9 |
| Number of hours/workshop | 2 |
| Total number of hours | 18 |

**Structure and content of pre-service programme**

| | |
|---|---|
| 1.<br>/4 hours | Introduction to IBSE, assessment of IBSE, formative and summative assessment tools. |
| 2.<br>/ 8 hours | IBSE activities in the laboratory, discussion on implementation and assessment of inquiry skills |
| 3.<br>/ 4 hours | Detailed description of assessment tools (Dialogue, questioning, self assessment, peer assessment tools). |

| | |
|---|---|
| | Home assignment: Development of IBSE activity with assessment tools |
| 4.<br>/ 2 hours | Presentation of designed IBSE activities involving assessment tools |

## C.7 SWEDEN

**Background of the pre-service teachers participating**

Participating pre-service teachers were students reading integrated science early in their teacher education. The students are to become teachers in primary and lower secondary school.

**Aim / philosophy of TEP**

The overall aim of this series of workshops was to introduce IBSE as a way to teach science, as well as to assist the students in trying alternative modes of assessment. The students designed inquiry tasks and assessment instruments, which were trialled during their practicum and then discussed with peers.

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 68 (HKR: 7; MAH: 61) |
| Subjects represented | biology, physics, chemistry, general science |
| Educational levels represented | primary, lower secondary |
| Programme format | 2x3 hour sessions as part of course |
| Number of workshops | 2 |
| Number of hours/workshop | 3 |
| Total number of hours | 6 |

**Structure and content of pre-service programme**

| | |
|---|---|
| ***Session 1*** | What is IBSE?<br>Inquiry skills in the science curriculum<br>Assessing inquiry skills<br>Construction of assessment items and rubrics |
| ***Session 2*** | Group discussions about students' experiences with the assessment items<br>Whole-group discussion about constraints and obstacles to assessing inquiry skills (and possible ways to overcome them) |

## C.8 TURKEY

**Describe the background of the pre-service teachers participating**

The pre-service teachers participated in our TEP programs were undergraduate students who were training to become elementary school teachers or middle school science teachers. All of the pre-service teachers supposed to teach science when they graduate and become teachers. They had little or no experience with inquiry based science education or various assessment methods prior to their university education. We recently, thanks to projects like SAILS, increased the amount of Inquiry Based Science Education (IBSE) in our methods courses. In our TEP programs we offer science teaching methods courses in which students do inquiry based activities to learn about inquiry and after they become familiar with inquiry, they are asked to develop inquiry based activities themselves.

**Describe your overall aim / philosophy of your TEP**

- Introduction of Inquiry Based Science Education (IBSE) and formative assessment to pre-service teachers, assessment of IBSE skills,
- practicing of sample IBSE activities and using different types of assessment strategies within these activities
- Carry out in groups some sample IBSE activities
- Practice how to integrate assessment into IBSE activities

**Participants and Programme Format**

| | |
|---|---|
| Number of participants | 120 |
| Subjects represented | Lower |
| Educational levels represented | Lower |
| Programme format | 10 two-hours sessions |
| Number of workshops | 10 |
| Number of hours/workshop | 2 / 10 |
| Total number of hours | 20 |

**Structure and content of pre-service programme**

| | |
|---|---|
| Week 1: | Doing the “corn seeds” activity for introduction to inquiry. After the activity, the subjects of “questions appropriate for investigation, steps of inquiry, hypothesis forming, determining variables, planning an experiment, changing questions into questions that can be investigated” were discussed. |
| Week 2: | “Drop on coins” inquiry activity was done. The variables in the activity were presented to students and they determined an inquiry question based on the variables that they have chosen. Based on the question they determined, students performed an inquiry to answer their questions in groups. |
| Week 3: | Activity reports from previous week were discussed. Weak points and suggestions for improvement were given to students. Then “heat-temperature” activity was discussed with students. After determining variables, students formed their inquiry |

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| | questions and planned an investigation for next week. |
| Week 4: | Activity reports from previous week were discussed. Weak points and suggestions for improvement were given to students. Students performed their inquiry about the "heat-temperature" activity. They followed the steps of forming a hypothesis, performing an experiment, collecting data, analysing and interpreting data and answering their inquiry question. They sent their activity reports online. The "magnet" activity for next week was discussed. They determined their inquiry questions based on the variables they determined. |
| Week 5: | Activity reports from previous week were discussed. Weak points and suggestions for improvement were given to students. Students performed their inquiry about the "magnets" activity. They followed the steps of forming a hypothesis, performing an experiment, collecting data, analysing and interpreting data and answering their inquiry question. They sent their activity reports online. The "pendulum" activity for next week was discussed. They determined their inquiry questions based on the variables they determined. |
| Week 6: | Activity reports from previous week were discussed. Weak points and suggestions for improvement were given to students. Students performed their inquiry about the "pendulum" activity. They followed the steps of forming a hypothesis, performing an experiment, collecting data, analysing and interpreting data and answering their inquiry question. They sent their activity reports online. The "spinning tops" activity for next week was discussed. They determined their inquiry questions based on the variables they determined. |
| Week 7: | Students were given a subject from the science curriculum and asked to prepare an inquiry based activity based on the subject. Possible activities were discussed. |
| Week 8: | Students performed the activities that they developed in groups and all students gave feedback for the activity. |
| Week 9: | Students performed the activities that they developed in groups and all students gave feedback for the activity. |
| Week 10: | Students performed the activities that they developed in groups and all students gave feedback for the activity. |