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Report on IBSE Teacher Education and Assessment programme, STAGE 2

SAILS
Strategies for Assessment of Inquiry Learning in Science

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D4.3 Report on IBSE Teacher Education and Assessment programme, STAGE 2

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1. Introduction

A key objective for the SAILS project has been 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 TEPs in inquiry and assessment was delivered over three stages, with three successive cohorts of teachers. These stages are shown in Figure 1.1.

The focus for the first round of TEPs, 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) aimed to incorporate assessment into the inquiry programme. The Teacher Cohort 2 began their TEPs in IBSE programmes that now included some of these assessment frameworks/instruments within the IBSE teaching and learning materials. Additionally, teachers from Teacher Cohort 1 were also invited back to the STAGE 1 TEPs to address how assessment can be carried out in an inquiry classroom. The SAILS Deliverable Report D4.2 focussed on STAGE 1 TEPs and reported on the implementation across 10 countries. The implementation of the STAGE 1 TEPs informed the development of the STAGE 2 TEPs that were implemented with the Teacher Cohort 3. The final round of TEPs (STAGE 2 TEPs) aimed to integrate assessment strategies within the inquiry TEPs. This forms the current SAILS report on IBSE Teacher Education and Assessment programme, STAGE 2, which will describe the implementation 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 2 TEPs. Scope has been given to allow partners to concentrate on particular areas of inquiry and its assessment, so that their TEPs could address their teachers' needs. STAGE 2 TEPs have incorporated assessment materials developed in WP2 (Assessment in IBSE) and trialled by experienced IBSE teachers in WP3 (Pilot and Evaluation; see D3.2, Report from evaluation of implementation with pilot teachers). The final materials used in the TEPs have incorporated recommendations arising from the evaluation of SAILS assessment frameworks and instruments.

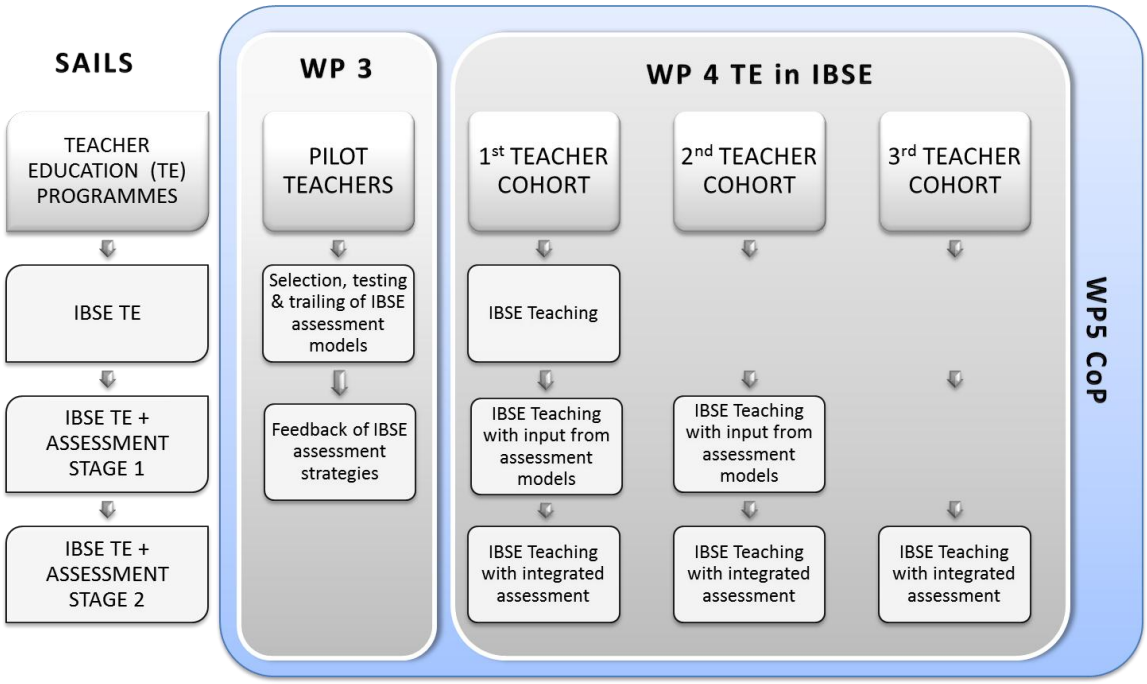


Figure 1.1 Structure of SAILS TEP over the course of the project

This report focuses on the implementation of SAILS STAGE 2 TEP Programmes across the partner countries, highlights good practice and presents the impact of the TEPs on the teachers.

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 TEPs formats employed by the partners is presented and an overview of the main barriers teachers face in each country in implementing an inquiry approach and using non-traditional assessment strategies is given. Section 3 gives examples of how the "Core elements" of the TEPs have been implemented for in-service and pre-service teachers across the 12 participating countries. The impact of the TEPs on the teachers, both presrervice and inservice on the basis of analysing responses to pre- and post-TEP questionnaires is presented in Section 4 while Section 5 presents a summary of the impact from the perspective of the SAILS partners. Finally, Section 6 presents the conclusions and implications for supporting teachers developing confidence and competences in inquiry and assessment practices.

2. SAILS STAGE 2 TEPs

2.1 Overview of SAILS STAGE 2 TEPs

SAILS STAGE 2 TEPs have taken place during the final 15 months of the project (September 2014 – December 2015) in the twelve partner countries. These TEPs were attended by TEACHER COHORT 3 (see Figure 1.1), who were teachers who had not previously attended SAILS TEPs, as well as teachers from the first and second cohorts.

Table 2.1 provides an overall summary of the in-service STAGE 2 TEPs, showing the number of teachers attending as cohort 3. 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 2 TEP programme is also outlined. From Table 2.1, a total of 697 in-service teachers have participated in STAGE 2 TEPs. The teachers were mainly involved in teaching the science disciplines of biology, chemistry, and physics, but also the additional subjects of general science, technology and mathematics. Teachers from both lower and upper secondary schools attended.

The in-service teachers taking part in the STAGE 2 TEPs had a range of experience with inquiry. For instance, teachers in Greece, Hungary and Poland had very little experience with inquiry before the TEPs, while teachers in Sweden mostly had some experience with inquiry. Teachers attending the TEPs in for example Belgium and United Kingdom were a mixture of some and very 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 2 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-day sessions with some time in between in order to allow teachers to implement what they have learned in the workshops within their own teaching and then to share their experience and challenges. In other countries, the sessions were concentrated in winter schools or summer conferences, 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 workshops and/or to implement particular aspects of the TEPs within their own teaching.

Table 2.2 describes the SAILS STAGE 2 TEPs for pre-service teachers. In total, 499 pre-service teachers attended SAILS STAGE 2 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, due to the fact that not all countries offered workshops for pre-service teachers in this cohort.

Table 2.1: Overview of SAILS STAGE 2 TEPs for in-service teachers

Country	***Number of teachers***	***Subject[1]***	***School level[2]***	***Experience with IBSE[3]***	***Format***	***Hours per session***	***Total hours[4]***
Belgium	77	P, C, B, S	L, U	SE-VE	Part-day workshops	3.5	10.5
Denmark	64	P, C, B, S, T	L, U	BE-VE	Part-day workshops	3	12
Germany	55	P, S	L, U	BE-VE	Whole-day workshops	2-8	2-27
Greece	27	P, C, B, M	L, U	BE	Part-day workshop	5	5
Hungary	34	P, B, C	L, U	BE	Part-day workshops	5	15
Ireland	49	P, B, C	L, U	BE-VE	2 day summer school	11	11
Poland	68	P, B, C	L, U	BE	Winter school/summer conference	25/10	35
Portugal	34	P, B, C	L, U	BE-SE	Part-day workshops	4	24
Slovakia	30	P, B, C	L, U	BE-SE	Whole-day workshops	8	40
Sweden (HKR)	12	P, B, C	L	BE-SE	Part-day workshops	5	20
Sweden (MAH)	10	P, C, B, S	L	SE	Part-day workshops	4	16
Turkey	206	P, B, C, S	L	SE	2 day summer school	10	20
United Kingdom	31	P, C, B, S	L, U	SE-VE	Part-day workshops	3	12
TOTAL	**697**						**222.5-247.5**

[1]P Physics, C Chemistry, B Biology, M Mathematics, S Science, T Technology

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

[3]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)

[4]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 2.2: Overview of SAILS STAGE 2 TEP for 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]***
Denmark	64	P, C, B, S, T	L	BE	Part-day workshops	4	8
Germany	55	P	L, U	BE	Seminars and workshops	1.5-2	2-21
Greece	65	P, C, B, M	U	BE	2 day workshop	2/2.5	4.5
Hungary	38	P, C, B	L, U	BE	Whole-day workshops	6-8	30
Ireland	24	P, C, B	L, U	BE	Part-day workshops	3	30
	13					2	10
Poland	79	C, B	L, U	BE	Part-day workshops	2-5	10-15
Portugal	9	B-G, P-C	L, U	SE	Part-day workshops	3	42
Slovakia	31	P, C, B, M, I	-	BE	Part-day workshops/seminars	2/12	8/24
Sweden (MAH)	31	S	U	BE	Part-day workshops	2	6
Turkey	40	C	L	BE	Part-day workshops	2	10
United Kingdom	60	P, B, C, P with M	L, U	BE	Part-day workshops	3	15
TOTAL	**499**						**145.5-199.5**

[1]P Physics, C Chemistry, B Biology, M Mathematics, S Science, I Informatics, G Geology

[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

2.2 KEY BARRIERS IN IBSE ORIENTED ASSESSMENT

In each of the national TEPS, teachers identified what they perceived to be the major constraints in implementing IBSE oriented assessment practices in their classrooms. In Table 2.3 below these constraints as collated and identified by the project beneficiareis 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. Traditional approaches to teaching and learning in science.

The consideration of these identified barriers were important in the planning of STAGE 2 TEPs and how the national programmes incoroprated discusssions of activities to address these constraints.

Table 2.3: Key barriers in IBSE oriented assessment as identified in each beneficiary country.

	BE	***DK***	***DE***	***GR***	***HU***	***IE***	***PL***	***PT***	***SK***	***SE***	***TR***	***GB***
Perceived lack of competence		X										
National assessments							X	X	X	X	X	X
Traditional approach to teaching/assessing	X			X	X	X			X	X		X
Curriculum requirements			X	X			X	X	X			X
Time required to develop assessment	X	X	X	X			X	X		X	X	X
Time required to implement assessment	X	X	X	X			X	X		X	X	X
Lack of equipment							X					
Large classes											X	

3. SAILS STAGE 2 Teacher Education Programmes

3.1 Aim of SAILS STAGE 2 teacher education programmes

The objective of previous SAILS TEPs (i.e. STAGE 1) was 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 was given the scope to develop and implement workshops that best meet the professional-development needs of their cohorts of teachers. Each partner organised their TEPs 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 TEPs in different countries 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.

The SAILS STAGE 2 TEP aimed to integrate education about inquiry practices with the assessment of these practices; i.e. teachers were introduced to inquiry and its assessment within the TEPs. Inquiry methodologies explored in the TEPs were those that are used to develop not only students' content knowledge, but also skills that students 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 was 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 was clear from the evaluations that the content and structure of the workshops were relevant and supportive. Therefore, it was important that the experiences from the STAGE 1 TEPs were incorporated into the STAGE 2 TEPs. Therefore, a common approach was developed that identified the core elements of all SAILS TEPs on IBSE and Assessment. The length of time that was devoted to each element varied and was decided by the teacher educator to suit the needs of the teachers attending.

The three core elements of the SAILS STAGE 2 TEPs are shown in Figure 3.1 and outlined below.

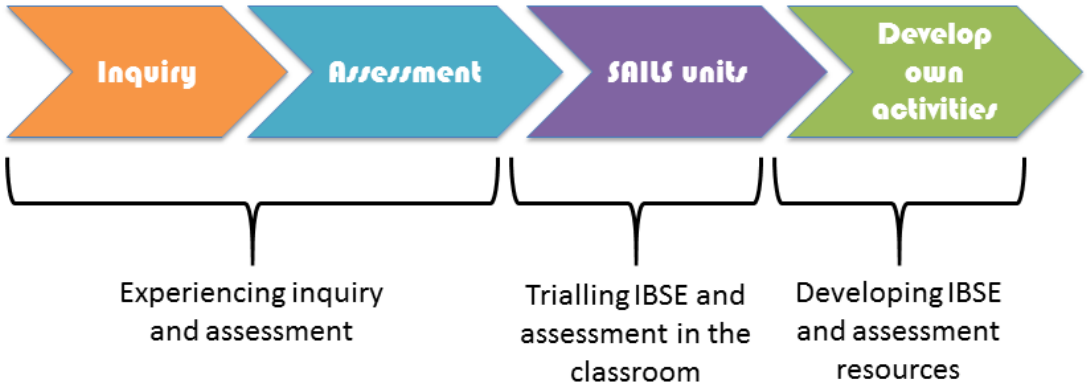


Figure 3.1 The Core Elements of SAILS STAGE 2 TEPs

3.2 Core Elements of SAILS STAGE 2 teacher education programmes

3.2.1 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 What?, Why?, 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 are that:

- Teachers become 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 with IBSE activities, recognise the value of IBSE as a teaching methodology and become motivated to try IBSE in their classrooms.
- Teachers 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 (for instance):

- 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 experienced
- Supporting information, e.g. through lectures/seminars or background material.

Particular activities could be:

- Investigating the capacity of baby diapers/nappies
- Investigating how many drops of water that can be placed on a 5c coin
- Using introductory activities from SAILS units.

Teachers were encouraged to join the Community of Practice (CoP) to share their resources and experiences. Teachers also completed 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:

- Completing an IBSE activity (such as those listed above), followed by a discussion of the learning that occurred and the assessment of that learning
- A variety of assessment tools (such as short written student work, self- and peer assessment, assessment rubrics) may be introduced, discussed and trialled in relation to the activity used
- 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 assessing the work of their groups
- Highlighting the main inquiry skill developed within an activity and developing an assessment rubric to describe levels of the skill.

3.2.2 Core Element 2: Trialling IBSE and assessment in the classroom

As part of the SAILS STAGE 2 TEP, the teachers were given opportunity to trial some of the activities that they engaged with in Core Element 1, to trial 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 were 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 focused 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 were encouraged to bring evidence of their students' learning to form the basis of discussions at the workshop. If these were not available, then examples from the SAILS units were

used as the basis for discussion. Discussions included the following and included 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.

3.2.3 Core Element 3: Developing IBSE and assessment Resources

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

These materials/resources were 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.

3.3 Implementation of Core Elements in Stage 2 in-service TEPs

In this section an overview of the partners TEPs are described in relation to the three core elements.

3.3.1 Belgium

Element 1: Experiencing inquiry and assessment

Time was set aside at each workshop to discuss what inquiry and assessment meant in the broad sense and in the philosophy of SAILS, making use of a lot of examples, going through SAILS units and case studies together and watching videos with teachers conducting an activity followed with discussions to trigger teachers' understanding of these concepts. The first session was also meant to reduce barriers, the activities in the workshop were very open and focussed on discussions that were used to help the faciltators to learn what the teachers understood as inquiry and assessment and to understand their level of experience. The aim was also to let them understand that every experience was a valuable one, and SAILS was aiming to collaborate with the teachers and explore new practice together rather than directing them.

Element 2: Trialling IBSE and assessment in the classroom

In every workshop session teachers were encouraged by the facilitators to choose a unit/activity to try out in their classroom. During the second session (January 2015) time was set aside to work in groups and individually on units relevant for the teachers student group (subject/grade) and/or to adapt it accordingly (with help from the facilitators) for their specific situation.

Specifically barriers were tried to be reduced by linking the learning goals in the SAILS units to learning goals familiar to the teachers from their own curricula. To make this even more concrete and to be able to guide them better in between sessions, the teachers were asked to sign in on a schedule when and what unit they wanted to try out. Contact was kept with the teachers in between

the workshops (by e-mail, through the COP, face-to-face) to guide them when they had difficulties. Teachers were also encouraged to discuss with their colleagues and help each other as much as they could.

In the following workshops teachers were asked to reflect on their experiences. In the last session short presentations were given by teachers that trailed a unit in their classroom during the year. During these reflective discussions teachers also discussed the topic of gender awareness. For example it was discussed if it would be a good idea to divide students in mixed groups, and also to assign roles to students beforehand (note-taker/observer/chairmen), so that the tasks were not always done by the same students.

Some teachers had non-mixed groups when doing the inquiries (most of the times because the students were free to choose their group), in these cases they noticed clear differences in the way students would tackle a certain task. A teacher who tried out an open investigation in his classroom (on the way springs work) noticed that the boy groups immediately started to play and try out the material given, whereas groups with only girls would first sit down to write a plan and would then start to try out different things with the material, girls took less risks then the boys and so in the end the teacher noticed that the boys came up with more creative uses. On the other hand the girls were more considered and also provided better written reports on what they had done.

Element 3: Developing IBSE and assessment resources

The teachers were assisted to adapt the existing SAILS units to fit their specific needs. Some teachers developed their own assessment strategies (e.g. example Global Warming case study: a mix of assessment by the teacher, peer- and self-assessment, translation and implantation of the Floating Oranges unit, adaptation of the Up there, how is it unit for a one hour lesson). Teachers were encouraged to share their resources on the COP, and did so in the discussion and folder section. We saw that this was encouraging for other teachers. In the third session (May 2015) six teachers shared their classroom experiences of their implementation of SAILS units with the group by giving a presentation, we felt that this was really encouraging for the other teachers to understand that trying out something did not mean it has to be perfect but was a learning experience in itself, sometimes a first step in changing the classroom practice. After this last SAILS workshop session all the presentations and extra materials from teachers were published on the Belgium COP, for teachers to take a look and get inspired from. As most of the teacher experiences were positive we felt that listening to these good practices also reduced the barrier for less-confident teachers to understand how they could try out inquiry and assessment of inquiry in their class.

3.3.2 Denmark

Element 1: Experiencing inquiry and assessment

In experiencing inquiry, the teachers have been introduced to different levels of inquiry, ranging from limited inquiry to open inquiry. There has been a special emphasis on distinguishing between inquiry as a means and inquiry as a goal. The distinction between different levels of inquiry provided a framework for the teachers for structuring their further work on setting goals and finding assessment strategies suitable for their goals.

During the workshops teachers discussed both ready-made and self-made materials according to the distinction in levels. The issue of gender was approached indirectly when talking about different types of students. Teachers were introduced to the following matrix for student behaviour.

		General attitude towards school	
		Disciplined	Open
Experimental attitude	Disciplined		
	Open		

The matrix was discussed with a focus on different student groups. In all workshops teachers had the experience that girls were more disciplined than boys and that there is a challenge in bringing girls towards a more open, experimental approach. In fact, in the examples brought up, students in the different categories were all male, except for the category of disciplined/disciplined.

In order to reduce barriers for practical implementation there were discussions about how fast you could move from one level of inquiry to another. There were also discussions about students doing the same task, but with different levels of inquiry. In the workshops there was time allocated for discussing teachers' draft lesson plans, which had not yet been trailed. This was intended as a collaborative refinement of lessons plans and a possibility for teaching working towards an inquiry approach. In this way teachers also shared their ideas with the group.

Element 2: Trialling IBSE and assessment in the classroom

The trialling of IBSE was carried out between workshop 2 and 3. This was done on the basis of the discussions mentioned above about the development of IBSE material. In workshop 3, the teachers' experiences were discussed and further improvement were made of their inquiry and assessment approaches.

Element 3: Developing IBSE and assessment resources

The core idea of the TEP workshop was for teachers to become able to develop their own material for inquiry and assessment. Therefore there has been a strong focus on teachers' own ideas and discussions on how to develop these ideas and put them into practice. In the overall structure of the TEP, there are two developmental stages were the teachers developed their first material for workshop 2 and then developed and trialed their second material for workshop 4.
In order for the teachers to be more focussed on assessment in the second stage, they were asked to use the SAILS case study template to describe their development.

3.3.3 Germany

Element 1: Experiencing inquiry and assessment

To reduce barriers, teachers were encouraged to trial several SAILS units and other materials during the workshops. They could also work on own units. This was true for formative assessment as well. Different methods, such as traffic-light cups, were not only introduced, but also regularly used at workshops. All working phases were reviewed and discussed with the teachers to provide enough space to share ideas. To support this, pictures, sheets and other helpful materials to share could be

uploaded by the teachers to the CoP. Gender aspects concerning IBSE were discussed on the basis of research results from UK SAILS partner Dr. Brian Matthews.

Element 2: Trialling IBSE and assessment in the classroom

Besides development of their own ideas mentioned above, the teachers were supported to trail IBSE units and assessment tools by using materials provided by LUH. The assembling of all materials required for a certain unit is a huge barrier for teachers, as well as financial barriers. To overcome these obstacles, complete sets of materials could be borrowed from LUH.

Element 3: Developing IBSE and assessment resources

To reduce barriers during the workshops, a simple sheet was developed by participants, which allowed for the transfer of IBSE ideas into a compact overview (i.e. a table with rows such as "Materials, student activities"). Teachers also mainly worked in groups – to ensure communication – on a certain unit. The CoP could also be used to share materials, so that teachers could enhance existing units.

3.3.4 Greece

Element 1: Experiencing inquiry and assessment

In our seminars, a facilitator presented new approaches to teaching science, inquiry based learning – IBL philosophy and IBL learning models. Participants are introduced to modern assessment techniques, such as Rubrics, Self-Assessment, Peer Assessment, Quizzes and Concept Maps, and they are shown ICT tools for implementing assessment in practice. Following this, participants took part in a hands-on IBSE Learning Scenario (Acids, Bases, Salts). In our seminars, there was always a session with hands-on experience in IBSE. What separated the cohort 3 seminars in relation to the previous seminars, was that the teachers used an integrated IBSE scenario (Acids, Bases, Salts) supplemented with assessment. Moreover, in the classroom, teachers working in groups were asked to select IBSE skills and suggest appropriate assessment instruments for an IBSE scenario. The scenario could be the IBSE scenario from the preceding session or the teachers could choose between two other scenarios (Rainbow, Ecosystems) that had been developed by the UPRC team. They could also suggest their own IBSE activity on a topic of their own choice. We decided to make this change in the TEP on the basis of the very positive feedback we had received from the previous seminars. In these seminars, all participants had noted how important the experiential part of the seminar had been. Furthermore, it was found that teachers – due to the difficulty to work with such scenarios in the classrooms and the time required to carry out such a scenario (after the seminar) – it was decided to allocate time for these activities within the seminars. Furthermore, all participants joined the CoP in order to share materials and resources from the seminar. In the future, we will use the finalized SAILS Units in the seminars to provide the teachers with more choices.

Element 2: Trialling IBSE and assessment in the classroom

Participants were encouraged to implement their own IBSE scenarios (with assessment) in their classrooms if possible. Unfortunately, however, this is difficult for teachers in Greece. Therefore we decided to enhance the experiential part of the seminars for the cohort 3 teachers. Participants were also encouraged to use the Greek CoP and other national platforms, such as Advanced Electronic Scenarios Operating Platform (http://aesop.iep.edu.gr) and Photodentro-GREEK NATIONAL

AGGREGATOR OF EDUCATIONAL CONTENT (http://photodentro.edu.gr/aggregator/?lang=en) to find, build and upload IBSE scenarios. Moreover, these national platforms have contests where prizes are awarded for the best and most innovative scenarios. As a consequence, these scenarios have more visibility and may motivate teachers to participate.

Element 3: Developing IBSE and assessment resources

During session 4 of the seminar, the participants, working in groups, developed assessment instruments for IBSE skills. These instruments could relate to the experiential scenario from the last session or they could relate to another IBSE script of their own choice. Participants were encouraged to use and download relevant material from the CoP or other national platforms.

3.3.5 Hungary

Element 1: Experiencing inquiry and assessment

Most of the participants were beginners in IBSE except for some teachers, who participated in other IBL projects (i.e. PRIMAS) previously. Summative assessment is frequently used in the classrooms, but formative assessment is used only in verbal form by the teachers, so they were beginners in the systematic and methodical use of formative assessment.

Element 2: Trialling IBSE and assessment in the classroom

Participants were encouraged to implement their own IBSE scenarios along with assessment in their classrooms. Trialling units and the assessment were key elements in the workshops, however, the strict curricula impeded the implementation of trialling the units in the classrooms. During trialling the IBSE units the teachers gathered experiences in IBSE, they realized the efficiency of IBSE and developed their skills in order to use IBSE in the classrooms.

Element 3: Developing IBSE and assessment resources

The application of the developed SAILS units and assessment tools had to be adapted to local and national curricula, and to the specific features of the group. The adaptation of the units was also a practice for the teachers in order to develop their own lesson plans for teaching science. The assessment tools developed for the units were good samples for the teachers in order to develop their own assessment strategies adapted for the students' characteristics.

3.3.6 Ireland

Element 1: Experiencing inquiry and assessment

In the Stage 2 TEP, teachers were introduced to the inquiry spectrum (guided/bounded/open) and to assessment using the SAILS Units. On the first morning, the teacher cohort was split into two halves where one half experienced Activities A and B of the SAILS *Speed* Unit, the other half the SAILS *Reaction rates* Unit. In each case, they spent approximately 30 minutes doing an open inquiry activity (four groups) from the unit. They then experienced a guided (2 groups) or bounded version (2 groups) of the same activities for approximately 20 minutes; in the final 30 minutes, one group that had done bounded version and one group that had done guided version came together and discussed all three versions.

After a short break, all groups came back together and a 10 minute whole-group discussion on what teaching by inquiry means was held. The teachers were then introduced to Wynne Harlen's

assessment framework which was followed by an exploratory discussion on how the inquiry skills they had experienced earlier could be assessed (40 minutes).

The teachers were then tasked with developing a short teaching activity based on their morning experience. They were asked to teach a group who had not done their activity i.e. a group who had completed the speed unit would teach a group who had done the reaction rates activity and vice versa. In executing this, each group had one participant teaching while the others observed what went on in the "class" - in terms of teacher activity, student activity, and assessment. A discussion of this experience was held based on observations and different perspectives of the experience i.e. teacher and student. Day 1 ended with teachers taking home case studies on *Speed* and *Reaction Rates* for evaluation.

Day 2 started with 15 minutes of a discussion of the case studies, after which the teachers were split into 9 groups. In three consecutive 10 minute sessions they experienced *Floating Oranges* which focuses on generating questions (in which we focussed on making questions investigable), *Woodlice* which focuses on developing hypotheses (in which we used a placemat technique), and activity 3 of *Light*, with a view to forming coherent arguments. These were discussed with the entire group.

The final 'experience of inquiry and assessment' element was implemented to give teachers an opportunity to explore the inquiry skill working collaboratively and gender considerations. In this activity a group of teachers completed a set-task while the remainder of the cohort observed the activty. The observations focused on partipant interaction, nature and amount of dialogue and assumed roles. A group discussion was then held to highlight the learning from the activity and how it may impact their future inquiry teaching.

Element 2: Trialling IBSE and assessment in the classroom

On completion of the TEP workshop, the teachers were asked to trial inquiry and assessment activities in their classrooms during September 2015 and to report back at the October meeting. The teachers were able to use SAILS units or use units they had developed individually or in groups as part of Element 3 (Day 2). The teachers shared these units on the SAILS CoP.

Element 3: Developing IBSE and assessment resources

During the afternoon session of Day 2 all of the teachers worked in groups on designing inquiry classes with integrated assessments. They were to asked to design a number of classes assessing 1 of 5 inquiry skills. They self-assembled in groups of 3-4 that decided to assess same skill. Each group picked a topic or topics that could be trialed as part of Element 3 during September 2015.

3.3.7 Poland

Element 1: Experiencing inquiry and assessment

Teachers took part in lectures, workshops and lab work. During lectures, teachers learned about the methodological foundations of inquiry-based methods, curriculum requirements of using IBSE elements and the possibilities to include IBSE in existing syllabuses. During the first day of training, teachers designed and carried out simple investigations beyond the scope of school laboratories. During lab work teachers worked in groups (3-4 persons/group) according to subject and educational level. Teachers experienced open and guided inquiry based on issues proposed in the SAILS units. Manuals for investigations were not provided, participants only received the general theme of the investigation and different lab materials. Participants were asked to formulate research questions, hypotheses, design the procedure, carry out the experiment and collect data. During the following workshops, the teachers practised their skills in analysing qualitative and quantitative data obtained during lab work, drawing conclusions and making evaluations. Additional time was used for discussions and exchange of experiences and resources.

Teachers were supposed to gain methodological knowledge about IBSE assessment during the lectures. Later, they applied this knowledge during workshops. Teachers worked in small groups and at the end of the training they were asked to reflect on the strategies for group formation (i.e. how can groups be formed, benefits and limitations of different strategies, gender issues, etc.).

Element 2: Trialling IBSE and assessment in the classroom

After the training, teachers were asked to apply SAILS units, as well as units designed by themselves, in schools. Volunteers created case studies on chosen topics. Teachers shared their results and experiences via the CoP and during a “Summary conference”.

Element 3: Developing IBSE and assessment resources

During workshops teachers developed their own units integrated with assessment tools and criteria. After the training they were asked to adapt resources to local conditions (such as educational level, student age, school equipment, syllabus, etc.), and share the results at the CoP.

3.3.8 Portugal

Element 1: Experiencing inquiry and assessment

Teachers were introduced to the SAILS project through the website. The CoP was presented to the whole group and they were encouraged to access it and to explore all the information available from the previous TEPs, such as theoretical documents about inquiry and assessment, inquiry approaches produced by teachers and the SAILS Units. To share experiences, the pilot teachers were invited to present the SAILS units that they have created and developed, as well to share their own difficulties and successes. We also promoted the analysis of some resources (assessment instruments) created by pre-service teachers. Moreover, we promoted the share of all the work produced during the TEP sessions, not only face to face (during the presentation/discussion moments), but also through the CoP. Gender awareness was discussed using science education international reports (e.g. ROSE, ROCARD). We also invited one particular pilot teacher to present her assessment instrument focused on gender issues, created during the implementation of the SAILS Unit Plant nutrition, based on Bryan Matthews work.

Element 2: Trialling IBSE and assessment in the classroom

Departing from the SAILS UNITS, teachers were encouraged to produce their own materials according to their particular school context. During all sessions, we reserve some time to discuss with teachers about their fears, expectations and constraints (curriculum, school organization, external exams, and teachers' assessment). During these moments, we promoted the interaction between all participants, trying to make them share their strategies to overcome the constraints. We intended them to be more confident by becoming aware that these processes are supported by international perspectives and science educators.

Element 3: Developing IBSE and assessment resources

The teachers created or adapted their own resources in groups. All the resources were shared on the CoP. Teachers were invited to reflect on several topics after the implementation on schools. They also presented and discussed the activity, and shared lesson plans, resources and experiences. There was a discussion about gender that tried to highlight some evidences about the possible gender differences detected during the activities implementation.

3.3.9 Slovakia

Element 1: Experiencing inquiry and assessment

Teachers participating in the training are presented examples of IBSE activities. Teachers conduct inquiry activities at different levels of inquiry in a role of a student. The activities are analysed and discussed from the point of their implementation in the classroom. There are exemplary inquiry activities enhanced with assessment tools. Based on the concrete example of assessment tools teachers develop assessment tools for selected inquiry activities. The corresponding home assignment requires adopting an existing activity that teachers conduct with their students into more inquiry activity and designing appropriate assessment tools. There is a number of inquiry activities aimed at different topics available for teachers.

Element 2: Trialling IBSE and assessment in the classroom

Teachers get first experience with inquiry and assessment in the role of a student. Following this, teachers participating in the course are strongly encouraged to trial inquiry activity in the classroom. They can implement either exemplary IBSE activity or an activity developed by teachers. They are expected also to get experience from the implementation of assessment tools. Their experience is then discussed within the face-to–face meetings. Teachers from the same school are encouraged to cooperate within their own school and they are offered help in sharing teaching materials and technical equipment.

Element 3: Developing IBSE and assessment resources

There is a number of inquiry activities available for teachers that have been developed within the ESTABLISH or SAILS projects. Within the course, there are new teaching materials developed by teachers. Also bachelor, master thesis of pre-service science teachers, and PhD thesis in didactics of science subjects aimed at IBSE and assessment are exchanged among teachers. All these materials are available through on-line Moodle platform for teachers to use in the classroom.

3.3.10 Sweden (HKR)

Element 1: Experiencing inquiry and assessment

Experience inquiry: The participants worked with the SAILS unit *UV Radiation*. First, they were given an article about UV radiation and they were encouraged to ask questions about UV radiation that could be answered through systematic investigations. Then, the participants were provided with a lot of equipment, such as UV beads, UV lamps, different sun lotions, etc., so that they could investigate some of their questions. We also "re-introduced" inquiry from a broader (NOS) perspective, when the teachers had become familiar with the more narrow (investigation and argumentation) interpretation of IBSE.

Experience assessment: Assessment of IBSE was introduced through a Swedish assessment material ("DiNO"), which is developed in relation to the Swedish national curriculum and includes both inquiry tasks and scoring rubrics as an aid for assessment. The teachers then trialled SAILS units in their classroom, in order to experience assessment of certain aspects of IBSE.

Element 2: Trialling IBSE and assessment in the classroom

The trialling of IBSE and assessment was completed in two steps. First, the teachers tried out single aspects of IBSE of their own choice in their classroom and then shared their experiences with colleagues. Second, the teachers chose and adapted SAILS units that they trialled in their classrooms. Again, afterwards they shared their experiences with colleagues.

Element 3: Developing IBSE and assessment resources

The teachers developed IBSE tasks and assessment instruments together in groups, which they then trialled in their classrooms. Afterwards they shared their experiences with colleagues. They also compared their assessment of student performance.

3.3.11 Sweden (MAH)

Element 1: Experiencing inquiry and assessment:

Sharing of experience and resources :The workshops started with narratives about own experience about IBSE and assessment.

Gender awareness: The teachers reported their experiences of IBSE. Many teachers thought boys were more self-confident in hands-on activities. The first workshop discussed how this can be challenged.

Element 2: Trialling IBSE and assessment in the classroom

Reducing barriers: A special focus on working in pairs or groups was empahsized.

Sharing of experiences and resources: A task was given to the teachers to either develop own material or evaluate some of the SAILS units. During the workshops, almost all teachers were interested in sharing own material and experiences. Especially different kind of rubrics were discussed and evaluated.

Element 3: Developing IBSE and assessment resources

Gender awareness: Some of the teachers reported how they had challenged gender issues. The positive and negative consequences of forming lab groups with one boy and one girl were

highlighted. A common view was that it was hard for the girls to get involved in the labs. Some teachers thought that this was a matter of how self-confident the students were and thereby a matter of personality and skill.

3.3.12 Turkey

Element 1: Experiencing inquiry and assessment

During the workshops the teachers were introduced to different activities ranging from guided to open inquiry. See below for some examples from these activities. The activities were carried out together with teachers by focusing on IBSE and a range of assessment procedures:

- SAILS Units "Electricity" and "Speed" (sails-project.eu/)
- FIBONACCI Project materials "Fish" and "Moon and Earth Phases" (www.fibonacci-project.eu)
- "Coin Drop" from the book "Teaching Science as Inquiry" (www.amazon.com/Teaching-Science-Inquiry-MyEducationLab-Edition/dp/0138143749)
- "Egg Drop" from college.cengage.com/education/pbl/project/project3.html
- Electric motor from learningcenter.nsta.org/product_detail.aspx?id=10.2505/9780873552677.16
- Design and build from www.engineer-project.eu/download/design-your-own-small-vacuum-cleaner/index.html

Element 2: Trialling IBSE and assessment in the classroom

Participants were asked to implement a SAILS unit or an activity from the workshop in their classrooms. They were asked to write a short report/case study on this implemantation and/or bring some data (students' notes, pictures from the implementation etc.) to the coming workshop. At the second workshop the main focus was on participating teachers' experiences and challenges while implementing IBST activities and a range of assessment procedures in their classrooms.

Element 3: Developing IBSE and assessment resources

Participants had experienced differenct inquiry activities and assessment procedures. They implemented SAILS units in their classrooms and developed some activities based on this framework. They have uploaded many examples of their activities into SAILS COP Turkey portal.

3.3.13 UK

Element 1: Experiencing inquiry and assessment

During the sessions the teachers were introduced to 12 inquiries. The 12 inquiries ranged from guided to open inquiries. There were examples of learning *through* inquiry – here questions are raised by the students or teacher that lead the activities; learning *about* inquiry – here activities are organised to develop specific skills and their role in science; Learning *through doing* an inquiry – here the main activity is an inquiry where students use a range of inquiry skills.

Formative assessment was stressed through a range of ways, including a focus on the evidence of student learning of inquiry skills. Teachers explored,

- How to use and develop rubrics
- How to use questioning that opened up an inquiry rather than close it down
- How to use Learning Landscapes
- The range of ways that evidence can be collected
- The importance of assessing both individuals and groups, and that this can be done over a period of time rather than trying to assess the whole class.
- Part of assessing group work is to consider how to form the groups (friendship, by ability, by gender) and the effect this has on collaborative working during inquries
- When students work in groups there are always power dynamics, and in particular, gender differences and interactions should be made considered and how to support good collaboration in the classroom

Element 2: Trialling IBSE and assessment in the classroom

The inquiries used in sessions were adapted by the teachers for their particular schools and classes. The teachers all did at least one inquiry in between the sessions. In all, over 120 inquiries were taught by the teachers where,

- A range of assessment procedures were used. The teachers used rubrics, learning landscapes, notes, photos, databases, place mats and peer reviews.
- Teamwork was assessed regularly, along with planning, drawing hypotheses, scientific reasoning, argumentation (not so much)
- Teachers did give feedback but the role of feedback for formative assessment was not clearly articulated by the teachers
- The teachers became more aware of gender issues and started to think about the way groups were formed, and to notice interactions more.
- A few teachers were noticing, recording (teacher and peer) and discussing gender interactions.

Element 3: Developing IBSE and assessment resources

The teachers developed and adapted the resources that we provided in the sessions. In addition they changed the way they taught aspects of the curriculum to incorporate inquiry; for example, rusty conditions, rock salt, investigating the properties of metals, un-wrapable parcel, dirty water, great nuclear debate. The teachers also developed their own rubrics and learning landscapes and databases for their classroom observations. recording evidence and making judgements. Again the role of feedback was not clear due to the way teachers reported what happened with their classes. The teachers engaged with and downloaded materials from the CoP.

3.4 Implementation of Core Elements in Stage 2 pre-service TEPs

3.4.1 Denmark

The structure of the pre-service TEPs in Denmark was very similar to the first half of the in-service TEPs.

Element 1: Experiencing inquiry and assessment

In experiencing inquiry and assessment approaches, the students were introduced to 6 different SAILS items translated into Danish. These items were discussed in relation to different ready-made lesson plans from the most common Danish textbooks. The material was used as inspiration for the teachers' development of own materials and also used as an example of how to implement IBSE and assessment in practice.

Element 2: Trialling IBSE and assessment in the classroom

Since the workshops were running outside the pre-service teachers' practicum there were no trailing of the material they had developed. Instead, all discussions of the materials were based on students' prior experiences from their practicum and from school.

Element 3: Developing IBSE and assessment resources

As part of the workshops, the students developed their own lesson plans with an IBSE approach and with assessment strategies. These lesson plans were the main content for discussions in workshop 2.

3.4.2 Germany

Element 1: Experiencing inquiry and assessment

In each workshop the students had the opportunity to trail SAILS Units or other IBSE examples. Different assessment methods (e.g. "traffic-light cups") were integrated into the workshop and reflected upon. To reduce barriers, protocols, case studies and materials from in-service teachers participating in SAILS TEPs were shown, trailed and discussed during the seminars. The students could see that IBSE ideas can be implemented into everyday physics lessons. Gender aspects concerning IBSE were discussed on the basis of research results from Brian Matthews.

Element 2: Trialling IBSE and assessment in the classroom

Classroom trials were generally not possible during student seminars, but a small group of students used SAILS Units as part of their bachelor or master theses.

Element3: Developing IBSE and assessment resources

Copies of IBSE Examples and assessment methods as well as basic literature were distributed to the students. In addition graduated students that participated at the seminar were invited to join the CoP and posted ideas or had opportunity to download other IBSE examples and units.

3.4.3 Greece

Element 1: Experiencing inquiry and assessment

The pre-service TEPs had a similar structure and content regarding inquiry and assessment as the in-service TEPs described in previous section. The main difference between the cohort 3 and cohort 2 workshops was that cohort 3 teachers used an integrated IBSE scenario (Acids, Bases, Salts) supplemented with assessment. Also, the participants, working in groups in the classroom, were asked to select IBSE skills and suggest appropriate assessment instruments for an IBSE scenario. Moreover, all participants joined the CoP in order to share materials and resources. In the next workshop we will use the finalized units from the SAILS project to give the participants more choices.

Element 2: Trialling IBSE and assessment in the classroom

Unfortunately, participants did not have the opportunity to implement scenarios in the classroom.

Element 3: Developing IBSE and assessment resources

During session 4 of the TEP, the participants, working in groups, develop assessment instruments for IBSE skills. These instruments could relate to the experiential scenario from the last session or they could relate to another IBSE script of their own choice. Participants were encouraged to use and download relevant material from the CoP or other national platforms.

3.4.4 Hungary

The participating teachers of our pre-service programs were from the University of Szeged, Faculty of Sciences, studying chemistry, biology and physics. The participants were beginners in IBSE, they had some knowledge about it, but the curriculum of the teacher training system does not focus on IBSE. So the pre-service teachers did not learn science with IBSE methods in their grammar school years, and they don't have university courses focusing on IBSE.

Element 1: Experiencing inquiry and assessment

The pre-service teachers are beginners regarding IBSE. They have studied assessment methods in theory, but it mostly focuses on summative assessment, some of them have limited experience in the classroom context, they are beginners in using formative assessment, too.

Element 2: Trialling IBSE and assessment in the classroom

The pre-service teachers had to make their own IBSE task plans regarding their main subject in order to fulfil the university course. The trainers made available their materials for the participants.

Element 3: Developing IBSE and assessment resources

On the one hand participants were the subjects of trialling units, and on the other hand they were observers of trialling units and assessment practice with upper secondary students. The trainers made continuous feedback about the units and the participants had the opportunity to study about IBSE methods in practice.

3.4.5 Ireland

In Ireland, two separate cohorts of students from Dublkin City University completed the pre-service teachers TEPs. Group A refers to undergraduate PSTs who were pursing a concurrent model of teacher education and group B referes to graduate PSTs who were pursing a consecutive model of teacher education.

Element 1: Experiencing inquiry and assessment

Group A

These TEPs were conducted during a laboratory module where, in all of the sessions pre-service teachers experienced inquiry teaching themselves and were required to reflect on the activity from an inquiry point of view. In the last three workshops, assessment of inquiry, with an emphasis on AfL, was added and pre-service teachers also engaged in reflection on these sessions. In all of the lab sessions students experienced inquiry teaching themselves and were required to reflect on the activity from an inquiry point of view. In the last three workshops, assessment of inquiry, with an emphasis on AfL, was added. The students carried out all eight activitities of the SAILS Unit "Light" as students and then assessed their peer's written work.

Group B

These pre-ervice teachers gained experience of inquiry and assessment through completion of activities during workshops that used some in-house and SAILS inquiry units (*Reaction Rates*). In workshop 2 and 3 they gained inquiry experiences where they looked at the spectrum of inquiry and explored the changing role of the teacher and student depending on the nature of the inquiry instruction. They furthermore engaged in discussions on the skills that were developed in the different inquiry activities. In workshops 4 and 5 the pre-service teachers gained direct experience of IBSE activites where assessment and inquiry where integrated. Following discussion of these experiences (based on SAILS units) the pre-service teachers were provided an opportunity to discuss and design additional assessments that could be used with the inquiry activity they experienced.

Element 2: Trialling IBSE and assessment in the classroom

The Group A pre-service teachers did not have an opportunity to trial IBSE activities in their classrooms. The Group B pre-service teachers did however as part of their coursework assignment. They were required to develop, implement and reflect on trialling of a developed teaching unit.

Element 3: Developing IBSE and assessment resources

Group A

In the workshops, student teachers designed inquiry-based activities with embedded assessment concerning the theme of Energy. They worked in small groups. Two experienced tutors were on hand for guidance.

Group B

This was primarily developed through the final workshop and through the assignment of the module. In the final workshop pre-service teachers worked in groups to develop a number of inquiry units which they shared and peer evaluated. In the assignment they had to individually develop an IBSE teaching unit which they had to trial in a classroom context.

3.4.6 Poland

Element 1: Experiencing inquiry and assessment

During training, students design and carry out simple investigations and experience open and guided inquiry basing on issues proposed in SAILS units. In all cases manuals for investigations are not provided, participants are given the general subject of investigation and various lab resources. Participants are asked to formulate research questions, develop hypotheses, design the procedure, carry out the experiment and collect data for each investigation. During subsequent workshops, students develop their abilities of analysing qualitative and quantitative data collected during the laboratory session and formulating conclusions and evaluations. Additional time is used for discussions and exchange of experience and resources.

Students also gain theoretical knowledge on IBSE assessment and apply it during workshops when they design and trial assessment tools.

Element 2: Trialling IBSE and assessment in the classroom

As part of didactic courses, students have the opportunity to conduct lessons in a school for a period of up to eight weeks. Implementation of IBSE lessons during school practice is not obligatory but students are encouraged to do it.

Element3: Developing IBSE and assessment resources

During workshops, students develop their own lessons integrated with assessment tools and criteria. They adapt existing resources to local conditions (students level, age, school equipment, syllabus etc.).

3.4.7 Portugal

Element 1: Experiencing inquiry and assessment

Students took part in a visit to an intertidal zone. They undertook research about organisms, environmental conditions, and geologic features that characterize the locality as well as search about the human activity at that local and its impacts. They worked in groups for the creation of several activities for exploring the intertidal zone, according to different perspectives: biological, geological, and social (relationship with fishermen). Students were introduced to some possibilities that inquiry provides and they worked based on their outdoors activities. From their experience they plan an inquiry activity that they could develop in schools.

Element 2: Trialling IBSE and assessment in the classroom

Students planned the lessons sequence, namely preparing the outdoor activity with the students, the visit and subsequent classes and also build the right tools to help students in their field exploration, ensuring compliance with the proposed objectives.

Element3: Developing IBSE and assessment resources

Pre-service teachers developed two inquiry tasks about sound and 2 inquiry tasks about materials. The tasks were developed based on Bybee 5 E's model. They were implemented in the classroom with students from lower and upper secondary. Students' answers were analysed and discussed.

Students shared with their colleagues their work and experiences. The proposals were discussed in the group.

3.4.8 Slovakia

Element 1: Experiencing inquiry and assessment

Within the key subject Methodology of Education in Physics (chemistry, Biology) there were two lectures dealing with IBSE and 2 seminars to experience IBSE.

Element 2: Trialling IBSE and assessment in the classroom

- Compulsory practice at schools – pre-service teachers trialled selected activities in the classroom
- Diploma thesis dealing with IBSE
- Participation of pre-service teachers at in-service teacher training.

Element 3: Developing IBSE and assessment resources

Microteaching within the seminars of the Methodology of Physics (chemistry, biology) education aimed at IBSE activities involving assessment tools.

3.4.9 Turkey

Element 1: Experiencing inquiry and assessment

During the course, students were introduced to different activities which ranged from guided to open inquiry. Groups of students were given, or chose, a topic from the analytical-chemistry curriculum and were then asked to prepare an inquiry-based activity on that topic. Students performed the activities in groups of 4-5 and all students gave feedback on the activity.

Element 2: Trialling IBSE and assessment in the classroom

N/A. Students performed their activities in groups of 4-5 and all students gave feedback on the activity

Element 3: Developing IBSE and assessment resources

Students are given the opportunity to design, implement, and write a short report on their IBSE activities with embedded assessment.

3.4.10 United Kingdom

Element 1: Experiencing inquiry and assessment approaches

Looked at and tried SAILS, CASE and AKSIS project activities

Element 2: Trialling IBSE and assessment approaches in the classroom

Worked out IBSE pedagogy on activities tried as learners

Discussed IBSE activities tried in school or observed

Element3: Developing IBSE and assessment resources

Looked at development of rubrics and Learning Landscapes

Discussed how pedagogy could allow assessment during process of inquiry

Element 4: Addressing Gender issues

Gender issues were raised during the TEP through:

a) Pre-service teachers being made aware of how gender impacts in the classroom through teacher interactions and the materials that teachers produce. The main element being in how gender issues are made explicit. For example, teachers ensuring that both male and female scientists are referred to and used as examples. Making such elements explicit is essential in single-sex schools and mixed sex schools.

b) How the whole school approaches gender. For example, tracking the progress of boys and girls

c) Teachers being made aware of the interactions between themselves and students, and how students interacted together.

d) A lecture on science and gender, and how the rationalist/realist version of science as being neutral and objective is very limited and drawing out how science is also a social process. The students have usually been taught that science is the process of planning, method, data collection etc., and this vision was challenged.

4. Impact of SAILS STAGE 2 Teacher Education Programmes

4.1 Evaluations of STAGE 2 TEPs

During most of the SAILS project, each TEP organiser has been responsibe for the evaluation of their own TEPs and this have mostly been carried using post workshop feedback forms. Plans for each country's evaluation were presented and disussed 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.

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 have been carried out and addresses the following aspects:

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

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. 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 item. The accurate interpretation of each item is an essential part of determining the validiaty and reliability of the final evaluation instrument and addressing any difficulties 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 lanuages.

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 assesses 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.

4.2 Teacher Profiles: In-Service

The effect of the Teacher Education Programme (TEP) on the in-service teachers was evaluated through questionnaires which teachers completed before (initial) and after the SAILS TEP programme (final). Specifically the questionnaires determined their understanding of inquiry, their use of inquiry practices in the classroom and their assessment of these practices. The main challenges faced by the teachers in assessing inquiry were also determined. The data presented in this section is only that from teachers who completed both initial and final questionnaires within the SAILS TEP cohort 3. In total 305 teachers from 12 countries completed both questionnaires. The sample is outlined in Table A in Appendix 1, with each country coded with a unique letter.

The data was analysed statistically and by multidimensional scaling analysis – a technique used to determine the similarities or dissimilarities between objects. Countries that have similar responses will appear close together on the MDS diagram, while those with averages that are quite different will be positioned further apart. An "ideal" point is also included which represents the most positive response

4.2.1 Teachers Attending TEP

In total 305 cohort 3 teachers who attended TEP STAGE 2 completed both questionnaires. Female teachers outnumbered the male teachers overall (29% Male, 71% Female), however, countries A and C had 50% or greater male teachers. Almost all of these teachers (94%) teach in mixed gender schools. The participants ranged in teaching experience from less than 5 years' experience, to more

than 20 years' experience (Figure 4.1). They also self-rated their experience with inquiry from (Figure 4.2):

- no / hardly any knowledge about IBSE (NE)
- some knowledge about IBSE but no practical experience with IBSE in class (BE)
- some/limited experience with IBSE in class (SE)
- good knowledge of and regularly use IBSE in class (VE).

Following the TEP programme, the teachers again self-rated their own experience with inquiry and the data shows that they now rated themselves as having more experience with inquiry (Figure 4.2). Following the TEP programme, the teachers rated themselves as having more experience with inquiry (Figure 4.2).

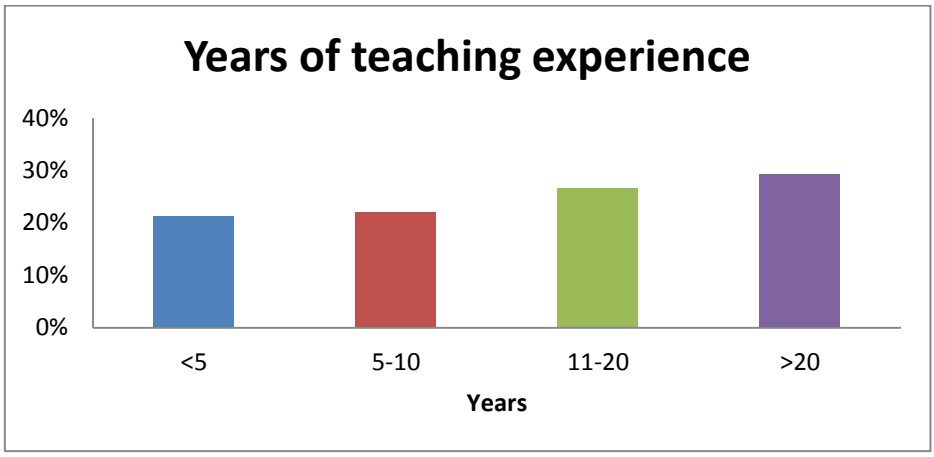


Figure 4.1 Years of teaching experience of the 305 teachers from across 12 countries

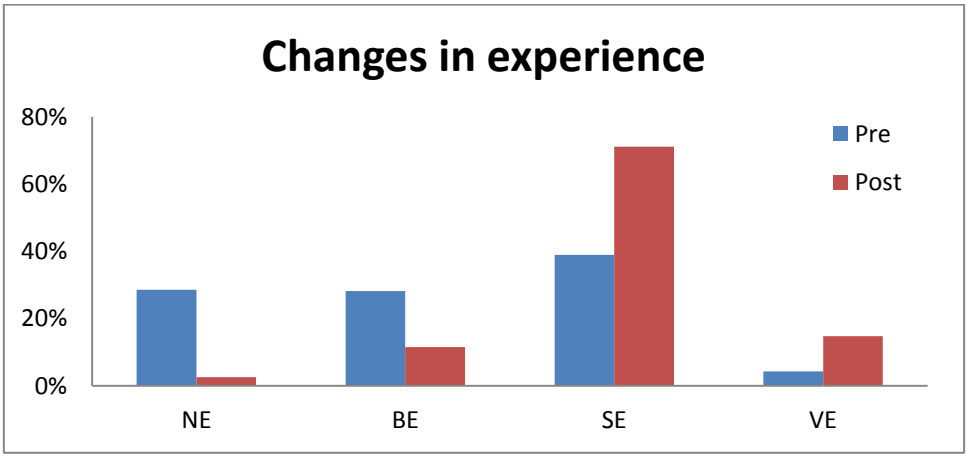


Figure 4.2 Experience with inquiry of the 305 teachers from across 12 countries, blue is initial ratings and red is final ratings after the TEP. Coding is no / hardly any knowledge about IBSE (NE), some knowledge about IBSE but no practical experience with IBSE in class (BE), some/limited experience with IBSE in class (SE), good knowledge of and regularly use IBSE in class (VE).

4.2.2 Understanding of Inquiry

Teachers' understanding of inquiry changed significantly following the TEP programme for all cohorts. Figure 4.3 shows the MDS cluster analysis initially and after the TEP programme, relative to a notional 'ideal' value that represents a comprehensive understanding of inquiry based science education and of the roles of teachers and students in the inquiry classroom.

While there are some differences noted between cohorts of teachers from different countries, their initial responses are reasonably clustered – the two more distant groups (E and G) and J have over 80% of their participants in the NE/BE group of teachers. Following TEP, all the cohorts are in one cluster, suggesting that the TEP programme was effective in all countries at increasing understanding of inquiry and the roles of teacher and students in the inquiry classroom. All of the country cohorts of teachers increased their understanding of inquiry with statistically significant increases for NE, BE and SE teachers (Figure 4.3, Table 4.1).

Table 4.1: Mean values for Understanding of Inquiry

Statement	NE mean	BE mean	SE mean	VE mean
I have a comprehensive understanding of inquiry-based science education	2.46→3.86	3.02→4.07	3.49→3.99	4.30→4.54
I have a comprehensive understanding of my role as a teacher in an inquiry classroom	2.91→4.02	3.04→4.09	3.60→4.09	4.20→4.38
I have a comprehensive understanding of the role of the students in an inquiry classroom	2.93→4.02	3.13→4.11	3.67→4.13	4.20→4.38

Numbers represent change in mean from initially to after TEP. (Mean values, based on 1 for strongly disagree, 2 disagree, 3 uncertain, 4 agree and 5 strongly agree).

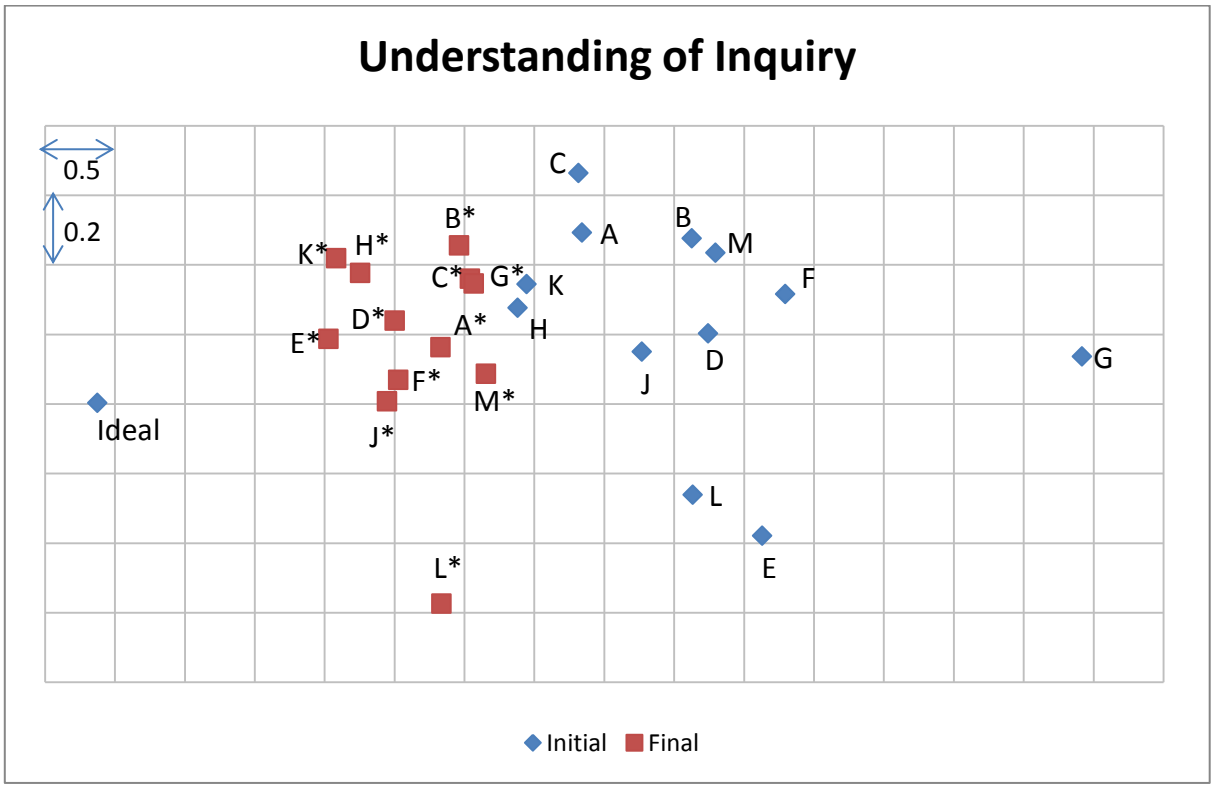
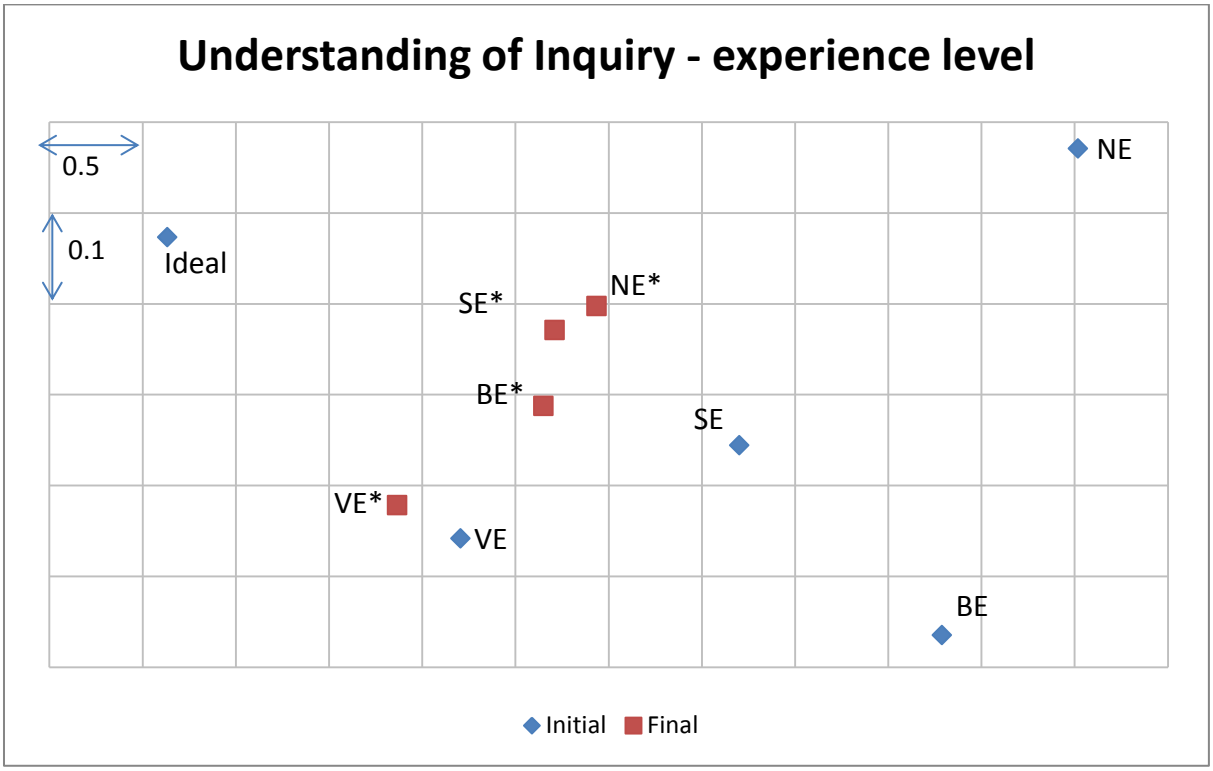


Figure 4.3 MDS of Change of understanding of Inquiry (* indicates responses from final questionnaire)

Looking at MDS analysis based on inquiry experience level of the teachers and also years of teaching experience, their understanding of inquiry has increased following the TEP programme (Figure 4.4a, 4.4b).



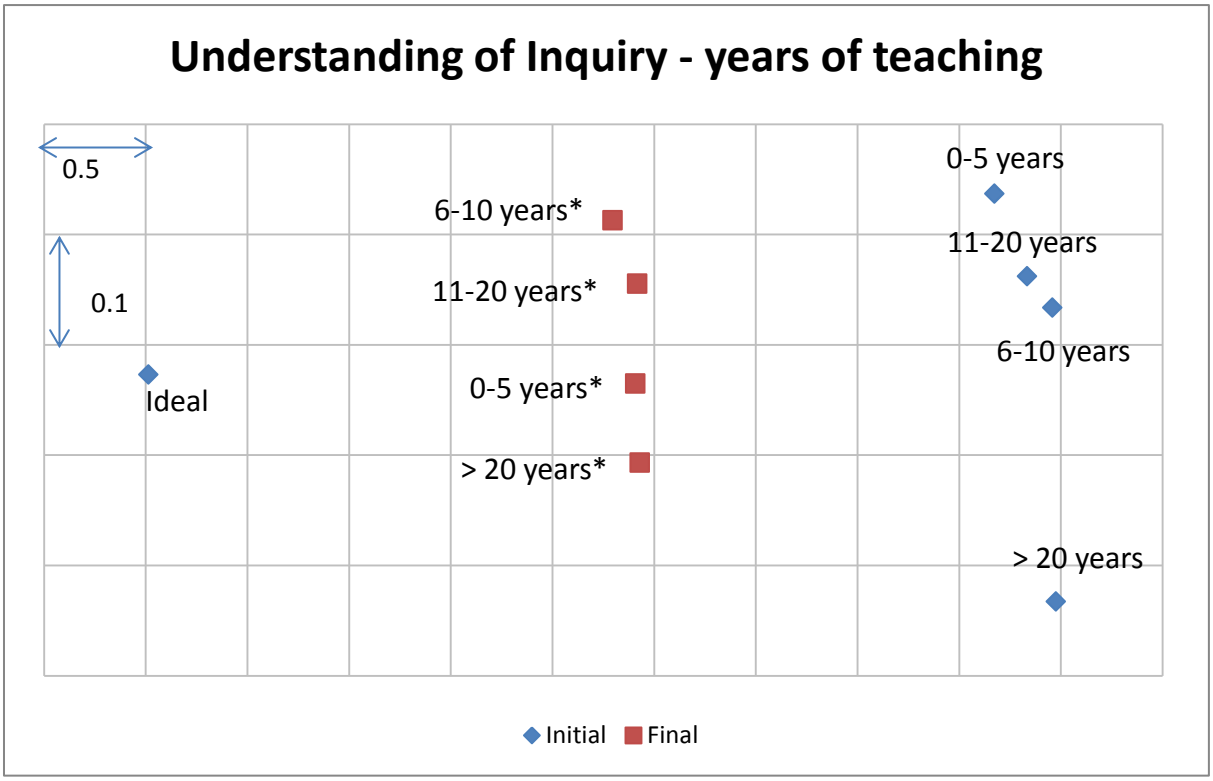


Figure 4.4a, b MDS of change of understanding of inquiry based on experience in inquiry teaching (4.4a) and years of teaching experience (4.4b).

There was a clear statistical correlation evident in the teachers self rating on the inquiry experience scale (NE to VE) and their responses to their understanding of inquiry – the more experience with inquiry, the greater level of understanding. Therefore it was considered valid to analyse the data on the basis of their experience level in inquiry.

4.2.3 Practice of Inquiry

In terms of inquiry practice, several practices were identified as being carried out more frequently by the overall group. Specifically, the following practices were carried out frequently by approximately 50% of the teachers, in that their students:

Table 4.2 Percentage of teachers who practice and are confident in assessing particular inquiry skills

Students ….	**Percentage of teachers who:**		
	practice this frequently	**confident in assessing (before TEP)**	**confident in assessing (after TEP)**
Analyse their own data	45	43	77
Justify their conclusions	47	50	74
Develop their own conclusions from investigations	50	52	76
Present their results and conclusions from investigations	52	53	84
Have opportunities to talk and listen to each other in the inquiry classroom	54	41	71
Have opportunities to develop empathy with their peers in the inquiry classroom	45	35	62
Respect and understand each other in the inquiry classroom	54	40	66

However, when teachers indicated their confidence in assessing these practices, the proportion of teachers overall were similar (Table 4.2). Following the TEP, the proportion of teachers who were confident in assessing these practices increased significantly. Generally, these practices were carried out less frequently by the NE, BE and SE groups of teachers compared to the VE group. However, the confidence for all of the teacher groups has increased, and significantly more for NE and BE groups.

The inquiry practices that were carried out least frequently are summarised in Table 4.3, also showing the proportion of teachers who are confident in its assessment. However, following TEP, the proportion of teachers who are confident in the assessment increase, particularly for those with less experience of inquiry practices (NE and BE groups).

Table 4.3 Percentage of teachers who practice and are confident in assessing particular inquiry skills

Students….	Percentage of teachers who:		
	practice this frequently	confident in assessing (before TEP)	confident in assessing (after TEP)
Formulating questions which can be answered by investigation	25	28	58
Refining questions that can be answered by investigations	31	31	57
Designing their own procedures for investigations	24	33	63
Conducting their own procedures for investigations	24	32	66
Critiquing the procedures that are used when they conduct investigations	27	27	57
Determining which data to collect in their investigations	20	31	63
Consider a variety of ways of interpreting evidence when making conclusions	28	37	61

Considering the range of practices carried out, it is clear that those that move the focus of control to the student were carried out frequently by less teachers (e.g. allowing students to design their own procedures or determining the data to collect). With the increase in confidence of the teachers to assess these practices, it is hoped then that the teachers will actually implement these practices more in their classrooms.

The SAILS project focussed on the development and assessment of four main inquiry skills: planning investigations, developing hypotheses, working collaboratively, and forming coherent arguments, in addition to the broader competencies of scientific reasoning and scientific literacy. While the questionnaire was initially developed in a more general way to determine practice in the classroom, following discussion, it was deemed possible to group particular questions. This grouping was also supported by MDS data reduction and was considered to be a reasonable approach to draw out specific trends in the data. Each of these skills is now discussed separately in the following sections, in terms of the teacher's practice and changes in confidence in assessment.

4.2.3.1 Planning Investigations

This inquiry skill was represented by four statements, determining if:

- Students formulate questions which can be answered by investigation
- Students design their own procedures for investigations.
- Students conduct their own procedures of an investigation
- When conducting an investigation, students determine which data to collect

Teachers indicated the extent to which they agreed with the statement that ' In my classroom, this practice almost always occurs'. Overall, less than 25% of the teachers indicated that they agreed or strongly agreed with these statements with about 45% disagreeing/strongly disagreeing. It is clear

that these inquiry practices are not occurring very frequently in classrooms, regardless of the inquiry experience of the teacher, except for the VE group (Table 4.4 shows mean of responses for each question, based on inquiry experience level of the teacher). Particularly evident was the lack of opportunity for students to determine which data to collect when conducting an investigation.

Table 4.4 Responses in terms of practice and Initial and Final confidence with assessing planning investigations - experience differences

		NE mean	**BE mean**	**SE mean**	**VE mean**
Students formulate questions which can be answered by investigation	P	2.77	2.79	2.86	3.65
	C	2.83→3.45	2.61→3.51	3.00→3.83	3.55→4.23
Students design their own procedures for investigations.	P	2.56	2.49	2.76	3.45
	C	2.76→3.73	2.63→3.69	3.13→3.73	3.90→4.38
Students conduct their own procedures of an investigation.	P	2.32	2.55	2.89	3.65
	C	2.80→3.76	2.61→3.75	3.06→3.79	3.80→4.38
When conducting an investigation, students determine which data to collect	P	2.39	2.35	2.78	3.50
	C	2.84→3.73	2.47→3.58	3.02→3.71	3.84→4.55

Top number in each box represents mean of practice statements (P). Bottom numbers represent change in mean of confidence from initially to after TEP (C). (Mean values, based on 1 for strongly disagree, 2 disagree, 3 uncertain, 4 agree and 5 strongly agree).

In terms of assessment, approximately half of the teachers stated that they assessed each of the practices of this skill as listed above. In terms of their confidence in assessing this practice, there was a direct correlation between the conducting of the practice and the assessment of the practice in that the more strong agreement that the practice occurred, the more confident the teacher was in its assessment (and vice versa). Furthermore, of the approximately 50% who stated that they assessed a particular practice, of those only approximately half were confident in assessing the practice. (The opposite was also the case in that of the 50% who did not assess the practice, half of those were not confident in its assessment). (Table 4.5)

Table 4.5 Confidence with assessing planning investigation practices that they do or do not assess

	Yes, I assess		**No, I do not assess**	
I am confident in assessing this practice:	Disagree/ Strongly Disagree	Agree/ Strongly Agree	Disagree/ strongly disagree	Agree/ Strongly agree
16. Students formulate questions which can be answered by investigation	15%	42%	50%	12%
18. Students design their own procedures for investigations.	15%	50%	50%	14%
20. Students conduct their own procedures of an investigation.	11%	52%	52%	14%
22. When conducting an investigation, students determine which data to collect	10%	48%	50%	16%

Remainder % uncertain

Following the TEP programme, teachers' confidence in assessing all of these practices increased (see MDS data analysis, Figure 4.5). All country cohorts moved significantly towards an 'ideal' response, with only small movement by country cohort C who were already within the final cluster initially.

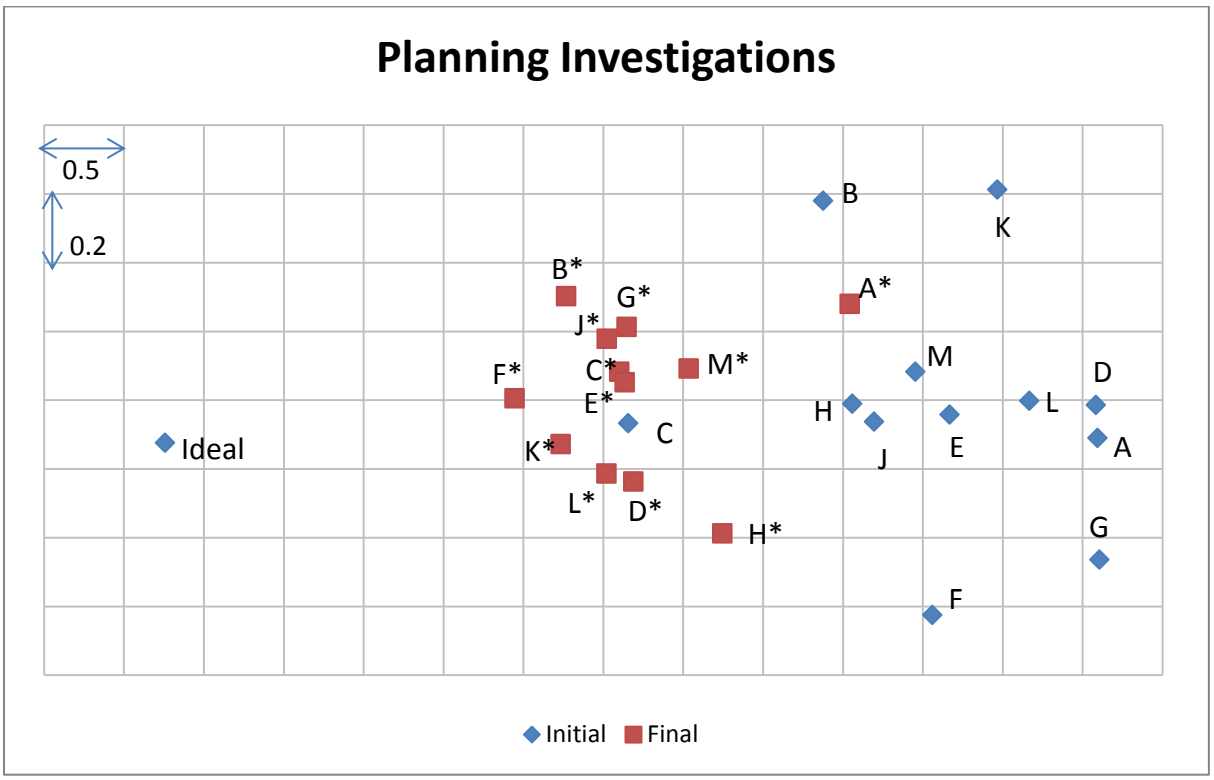


Figure 4.5 MDS of Change in Confidence – Planning Investigations

The change in confidence level was reflected for all teachers, regardless of their experience level with inquiry but was significantly larger for those with less experience i.e. NE, BE and SE cohorts (Table 4.4 - shows change in mean value initially and finally depending on experience level).

Following the TEP, all teachers were more confident in each of the elements of the inquiry practice of Planning investigations.

4.2.3.2 Developing Hypotheses

Developing hypotheses is an inquiry skill that requires students to develop questions that they can investigate and that then require time to refine those questions. Two statements were grouped under the skill of developing hypotheses: Students formulate questions which can be answered by investigation; Time is devoted to refining student questions so that they can be answered by investigations.

Before the TEP, only 25% of the teachers agreed that the students formulating questions occurred frequently in thir classroom, while 31% agreed that time was devoted to refining student questions. However, 55% of the teachers indicated that they assessed students on formulating questions, however, of that 55% only 42% of them were confident in their assessment of this practice.

Across all of the countries, there was a range of responses in terms of their confidence with assessing developing hypotheses (Figure 4.6). Following the TEP, the responses cluster together, and have all moved towards the notional 'ideal', implying that the confidence of the teachers in assessing these practices has increased.

Based on the experience level of the teachers in inquiry, the responses differ; the VE group conduct these practices significantly more frequently than any of the other groups (NE, BE and SE) and are

significantly more confident in doing so. Following TEP, all of the groups increased in confidence with statistically significant differences for NE, BE and SE groups (Table 4.6).

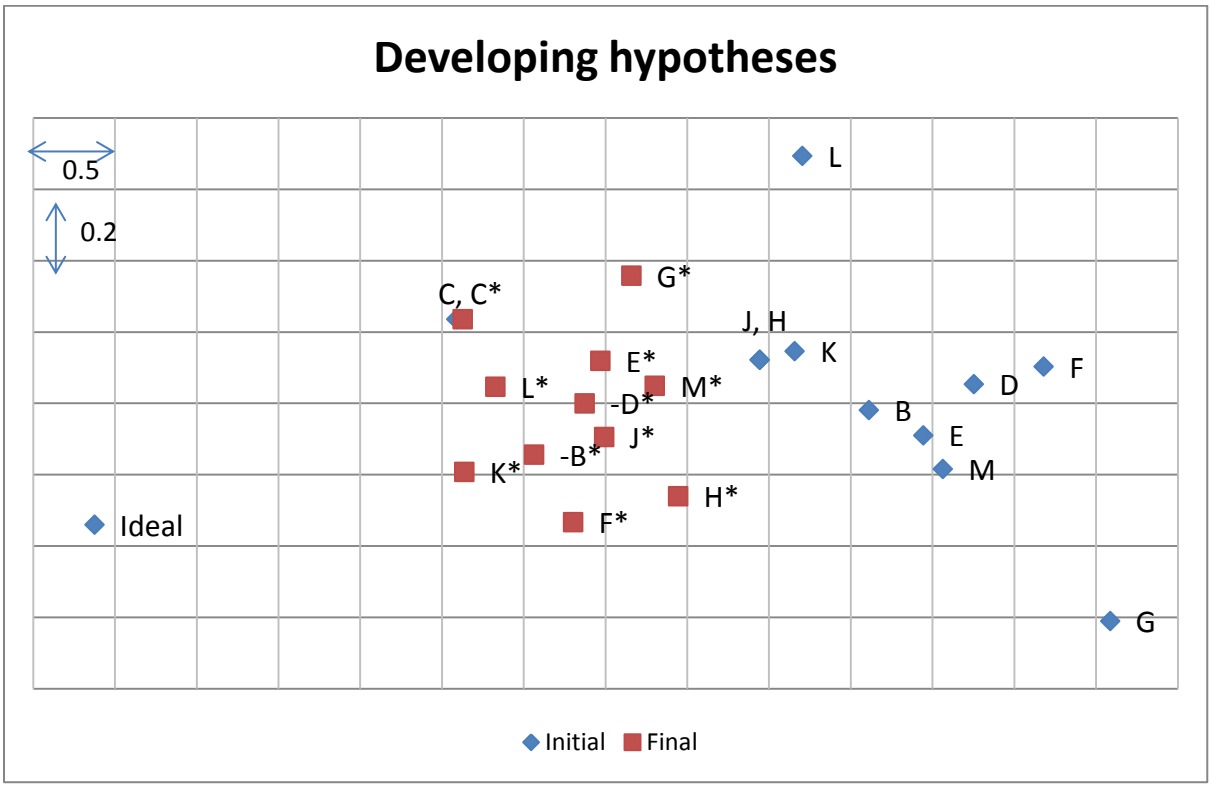


Figure 4.6 MDS of Change in Confidence – Developing Hypotheses

Table 4.6 Responses in terms of practice and Initial and Final confidence with assessing planning investigations - experience differences

		NE mean	BE mean	SE mean	VE mean
Students formulate questions which can be answered by investigation	P	2.77	2.79	2.86	3.65
	C	2.83→3.45	2.61→3.51	3.00→3.83	3.55→4.23
Time is devoted to refining student questions so that they can be answered by investigations.	P	2.89	2.67	2.84	3.83
	C	2.80→3.62	2.47→3.60	3.01→3.63	3.59→4.23

Top number in each box represents mean of practice statements. Bottom numbers represent change in mean of confidence from initially to after TEP. (Mean values, based on 1 for strongly disagree, 2 disagree, 3 uncertain, 4 agree and 5 strongly agree)

4.2.3.3 Working Collaboratively

Four statements were grouped to determine teachers' practices for working collaboratively, namely:

- Each student has a role as investigations are conducted
- Students have opportunities to talk and listen to each other, in the inquiry classroom
- Students have opportunities to develop empathy with peers, in the inquiry classroom
- Students have the opportunity to respect and understand each other in the inquiry classroom

Before TEP, 54% of the teachers indicated that the practices of students having opportunities to talk and listen to each other, and to respect and understand each other occurred frequently in their inquiry classroom (Table 4.7). Less than half of the teachers responded positively to students having opportunities to develop empathy with their peers (45%) and students having a role when conducting investigations (38%). Interestingly 56% of the teachers indicated they assessed student talk and listening, of which 61% were confident in the assessment. Again strong correlations were evident in those that conducted the practice frequently, indicated greater confidence in its assessment.

Comparing the confidence level of assessment of these practices between the cohorts from each country, (Figure 4.7), the MDS analysis shows a greater variation in responses. However, clearly confidence by all cohorts (except group C) increased and were closer to the notional ideal following the TEP programme. There is still a degree of spread of the points and this may reflect the variation in the TEP programmes across the countries with regard to this element.

Based on the teachers' level of experience with inquiry, again the more experienced the teacher is with inquiry, the more the practice occurs with statistically significant differences between the NE, BE and SE groups compared to the VE group (Table 4.7). Following the TEP, the NE, BE and SE groups all significantly increased their confidence with assessing working collaboratively. While there were changes in the mean values recorded for the VE group, these changes were not statistically significant.

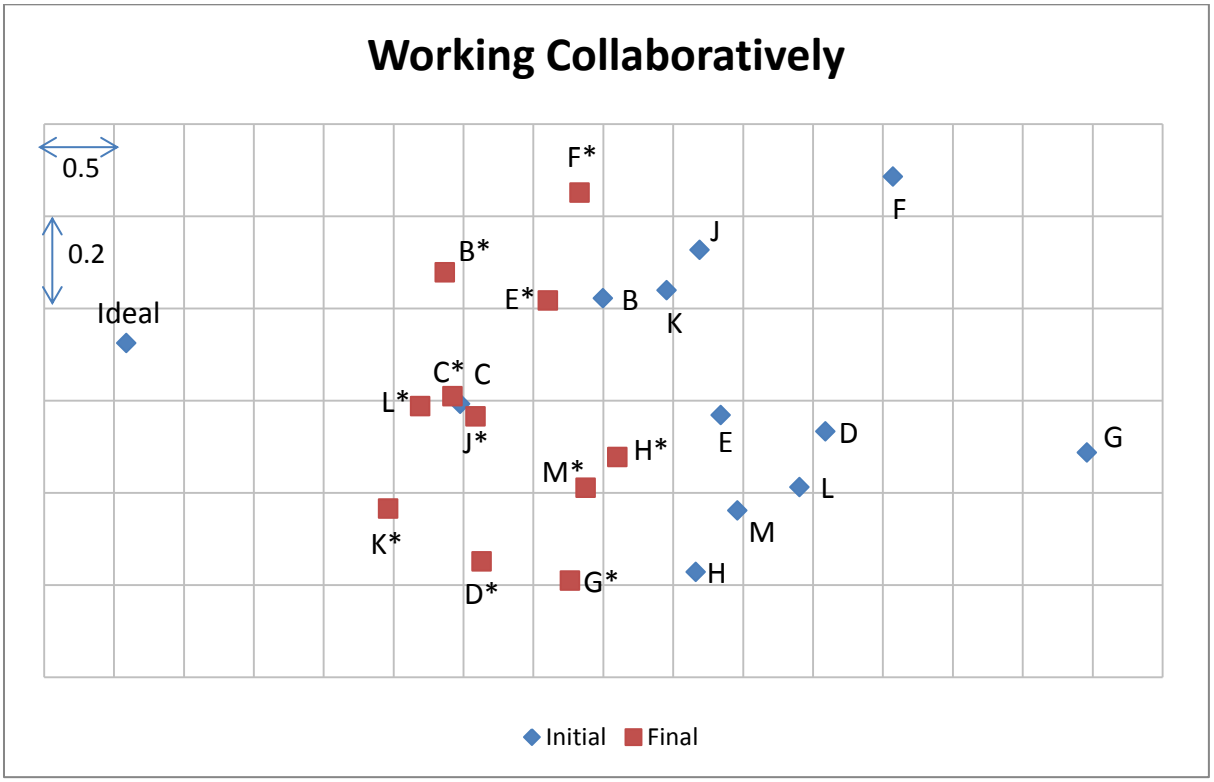


Figure 4.7 MDS of Change in Confidence – Working Collaboratively

Table 4.7 Responses in terms of practice and Initial and Final confidence with assessing planning investigations - experience differences

		NE mean	BE mean	SE mean	VE mean
Each student has a role as investigations are conducted	P	2.77	2.93	3.20	3.82
	C	2.97→3.75	2.80→3.75	3.18→3.75	3.63→4.46
Students have opportunities to talk and listen to each other, in the inquiry classroom	P	3.28	3.39	3.83	4.42
	C	3.05→3.99	2.83→3.90	3.38→3.86	4.00→4.69
Students have opportunities to develop empathy with peers, in the inquiry classroom	P	3.17	3.21	3.47	4.32
	C	2.97→3.74	2.62→3.60	3.14→3.72	3.61→4.23
Students have the opportunity to respect and understand each other in the inquiry classroom	P	3.24	3.47	3.78	4.37
	C	3.05→3.72	2.74→3.75	3.29→3.85	3.33→4.38

Top number in each box represents mean of practice statements. Bottom numbers represent change in mean of confidence from initially to after TEP. (Mean values, based on 1 for strongly disagree, 2 disagree, 3 uncertain, 4 agree and 5 strongly agree)

4.2.3.4 Forming Coherent Arguments

Grouping three statements can focus on the skill of forming coherent arguments, i.e.

- Students develop their own conclusions for investigations.
- Students consider a variety of ways of interpreting evidence when making conclusions.
- Students justify their conclusions.

While almost half of the teachers stated that students often develop their own conclusions (50%) and justify them (47%), only 28% of the teachers stated that students were often involved in considering different ways of interpreting the evidence. Even the VE teachers rated this practice as less frequently occurring than students developing their own conclusions. This suggests that within investigations, that if students develop their own conclusions but they are not encouraged to consider the arguments in different ways.

Students developing conclusions and justifying their conclusions was assessed by most teachers (71% and 73% respectively), however those who were confident was only about half (at 52% and 49% respectively). Again there was a significant correlation in that the more teachers indicated they conducted these practices, the more confident they rated themselves.

Generally, all country cohorts showed a similar degree of confidence in the assessment of these practices, except cohort G. (Figure 4.8). Following the TEP, there is a small shift towards the notional ideal for all cohorts, indicating an increase in confidence to assess these practices. Based on experience with inquiry, again the groups with less experience in inquiry (NE, BE and SE) all made significant increases in their confidence with assessing forming coherent arguments (Table 4.8).

Table 4.8 Responses in terms of practice and Initial and Final confidence with assessing planning investigations - experience differences

		NE mean	BE mean	SE mean	VE mean
Students develop their own conclusions for investigations	P	3.11	3.25	3.63	4.10
	C	3.23→3.89	3.27→3.95	3.57→4.05	4.20→4.62
Students consider a variety of ways of interpreting evidence when making conclusions.	P	2.66	2.70	2.99	3.55
	C	2.90→3.73	2.73→3.62	3.23→3.59	3.89→4.38
Students justify their conclusions	P	3.12	3.18	3.51	3.75
	C	3.23→3.92	3.21→4.10	3.45→3.95	3.90→4.69

Top number in each box represents mean of practice statements. Bottom numbers represent change in mean of confidence from initially to after TEP. (Mean values, based on 1 for strongly disagree, 2 disagree, 3 uncertain, 4 agree and 5 strongly agree)

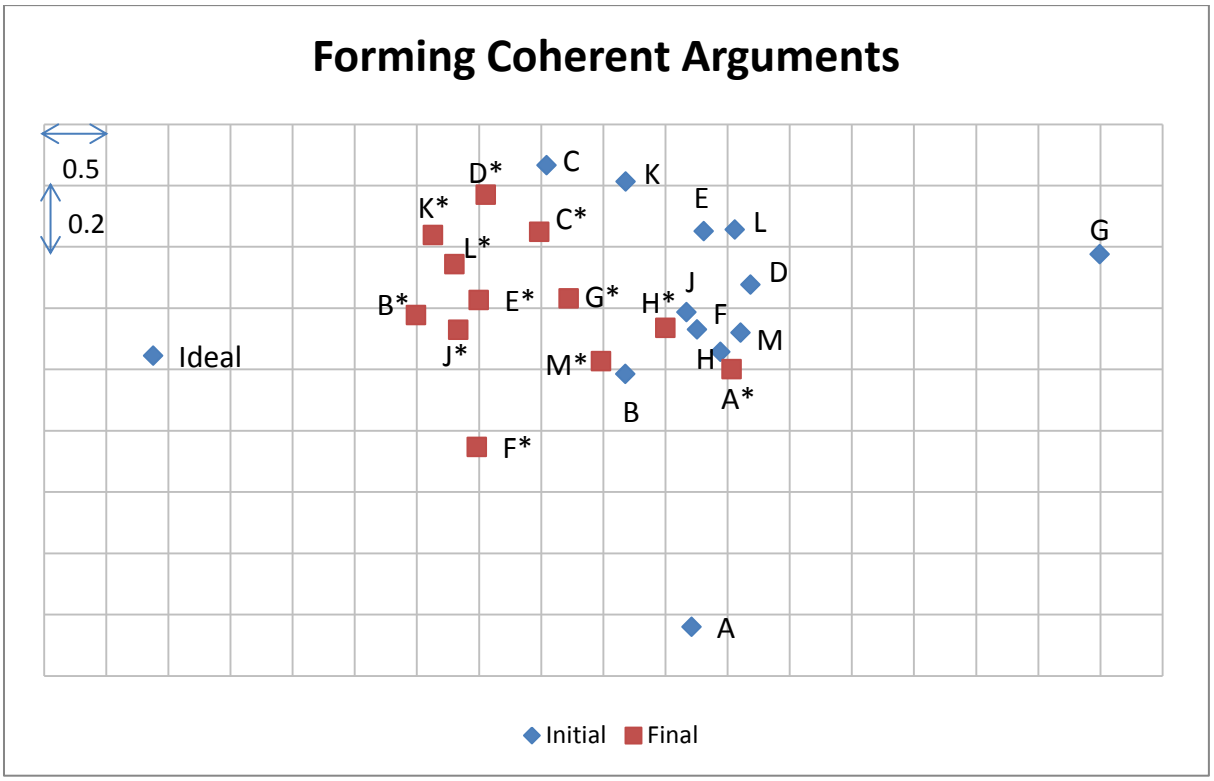


Figure 4.8 MDS of Change in Confidence – Forming Coherent Arguments

4.2.3.5 Scientific Reasoning

While scientific reasoning can be considered to be the underpinning of all of the questions asked, five statements were selected where reasoning was very evident. These statements were:

- When conducting an investigation, students understand why the data they are collecting is important
- Students analyse their own data.
- Students develop their own conclusions for investigations.
- Students consider a variety of ways of interpreting evidence when making conclusions.
- Students justify their conclusions.

Most of these questions have been discussed under forming coherent arguments; however it is interesting to group them under this heading for discussion. While nearly 50% of teachers stated that the students almost always analyse their own data (45%), less than this number stated that students understand why the data they are collecting is important (39%); also there was no difference between the responses from the teachers regardless of their experience with inquiry. However, these two practices are assessed by 66% and 58% of the teachers respectively, with approximately 43% of them confident in the assessment practice. Table 4.9 shows the means of the practice and confidence in assessing depending on the inquiry experience level of the teacher. Taking all of these statements collectively, the cluster analysis (Figure 4.9) shows that, following the TEP programme, all cohorts move towards the notional ideal, however, different cohorts cluster and are all equidistant from the ideal. Following the TEP, all the teachers have increased confidence in assessment of these inquiry practices.

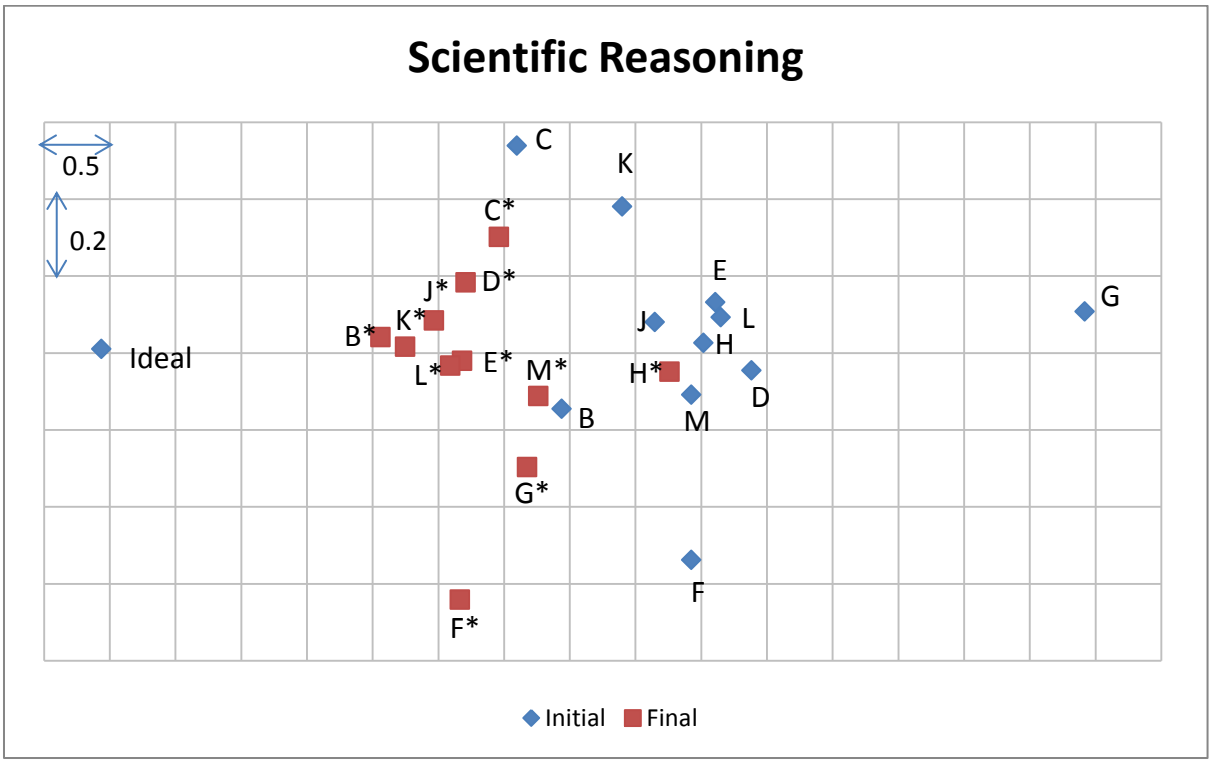


Figure 4.9 MDS of Change in Confidence – Scientific Reasoning

Table 4.9 Responses in terms of practice and Initial and Final confidence with assessing planning investigations - experience differences

		NE mean	BE mean	SE mean	VE mean
When conducting an investigation, students understand why the data they are collecting is important	P	3.08	3.05	3.33	3.55
	C	3.17→3.73	2.92→3.79	3.31→3.79	3.75→4.46
Students analyse their own data	P	3.16	3.29	3.59	3.95
	C	3.14→3.82	3.15→4.01	3.53→4.02	4.00→4.54
Students develop their own conclusions for investigations	P	3.11	3.25	3.63	4.10
	C	3.23→3.89	3.27→3.95	3.57→4.05	4.20→4.62
Students consider a variety of ways of interpreting evidence when making conclusions.	P	2.66	2.70	2.99	3.55
	C	2.90→3.73	2.73→3.62	3.23→3.59	3.89→4.38
Students justify their conclusions	P	3.12	3.18	3.51	3.75
	C	3.23→3.92	3.21→4.10	3.45→3.95	3.90→4.69

Top number in each box represents mean of practice statements. Bottom numbers represent change in mean of confidence from initially to after TEP. (Mean values, based on 1 for strongly disagree, 2 disagree, 3 uncertain, 4 agree and 5 strongly agree)

4.2.4 Assessment and Feedback Practices

4.2.4.1 Feedback Practices

A key aspect of assessment is the feedback from teachers that guides students and enhances their learning. The feedback practices of the teachers were determined at the beginning of the TEP programme (no follow-up data was collected from the teachers formally on feedback after the TEP). Table 4.10 shows the proportion of teachers (%) who used particular forms of feedback and Table 4.11 shows the mean value for each form of feedback depending on the inquiry experience of the teacher.

Table 4.10 Forms of Feedback provided by teachers to their students (% of teachers)

Forms of feedback	Almost never[1]	Seldom[2]	Some-times[3]	Often[4]	Almost always[5]	Mean
Writing grades on their written work	15.0	6.8	20.1	24.9	33.2	3.54
Writing comments on their written work	7.5	6.8	26.8	27.8	31.2	3.68
Writing questions on their written work	11.7	15.6	31.9	27.0	13.9	3.16
Writing comments, highlighting correct work and areas for further learning	11.4	14.8	29.2	30.7	13.9	3.21
Discussing examples of student work with the class	9.5	14.1	30.7	29.9	15.8	3.28
Discussing quality of inquiry with students	12.2	19.3	29.5	28.0	11.0	3.06
Negotiating next steps in learning	15.8	16.8	31.4	25.8	10.2	2.98

Table 4.11 Forms of Feedback - experience averages

Forms of feedback	NE mean	BE mean	SE mean	VE mean
Writing grades on their written work	3.68	3.49	3.59	2.78
Writing comments on their written work	3.34*’	3.73	3.87*	4.17’
Writing questions on their written work	2.88*	3.18	3.32*	3.39
Writing comments, highlighting correct work and areas for further learning	2.94*’	3.20	3.36*	3.78’
Discussing examples of student work with the class	3.14	3.24	3.37	3.94
Discussing quality of inquiry with students	2.87*	3.04’	3.13^	3.89*’^
Negotiating next steps in learning	2.82*	2.96’	3.03^	3.72*’^

*, ‘, ^ differences between these two values is statistically significant (values given as 1 almost never to 5 almost always)

The more experienced group in inquiry use comments on written work, highlighting correct work and areas for further learning, discuss examples of student work with the class and the quality of the inquiry more frequently than the other cohorts of teachers. The main feedback by the NE group are written grades.

As feedback is only one step of the learning, what happens as a result of the feedback is important. Table 4.12 shows data on what happens as a result of the feedback, based on the experience level of the inquiry experience level of the teacher. The significant differences between the experience levels are primarily between the NE participants and the SE and VE participants. Those teachers with more inquiry experience are using the feedback to provide further learning by the student.

Table 4.12 Following feedback based on experience level (mean responses based on experience level)

Following feedback,	NE mean	BE mean	SE mean	VE mean
I give students opportunities to respond to my feedback	3.53*’	3.72	3.94*	4.11’
Students use comments I give them to revise their inquiry activity	2.99*’	3.18	3.43*	3.65’
Students use feedback I give them to improve their inquiry skills	2.90*’	3.09	3.35*	3.53’

*, ‘, ^ differences between these two values is statistically significant (values given as 1 almost never to 5 almost always)

4.2.4.2 Additional Forms of assessment

Two aspects of assessment that are used frequently within an inquiry classroom are peer assessment and assessment of team-working skills. The teachers attending the TEP were asked how frequently they engaged in these assessment practices (Table 4.13). These forms of assessment are carried out more frequently by the teachers more experienced in inquiry.

Table 4.13 Additional forms of assessment

Additional Forms of assessment:	NE mean	BE mean	SE mean	VE mean
I organise time in class for students to peer assess	2.75*’	2.88^”	3.23*^	3.59’”
I assess the teamwork skills of individuals during group work	3.04	2.93	3.28	3.47

*, ‘, ^ differences between these values are statistically significant (values given as 1 almost never to 5 almost always)

4.2.4.3 Records kept by teachers

All of the teachers maintain records of student learning, with the most common record as grades with comments. The form of the record does not vary depending on inquiry experience level; however, this practice varies depending on the country cohort (see Table 4.14). This may reflect policy in particular countries or schools; also shows the reliance of grades as records of students work.

Table 4.14 Records kept by teachers based on country cohort (values given as % of that country cohort)

	Experience level				**Country Cohorts**										
	NE %	**BE %**	**SE %**	**VE %**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**	**K**	**L**	**M**
Grades only	18	26	27	11	62	14	9	7	57	53	6	26	0	27	11
Grades and comments	69	59	60	78	39	76	61	89	35	39	94	74	93	53	44
Comments only	7	11	10	6	0	4	18	4	9	0	0	0	7	12	27
No records	6	4	4	6	0	1	12	0	0	8	0	0	0	9	12

4.2.4.4 Challenges to changing assessment

The main challenges identified by the overall cohort are:

time required to develop assessment (21.3%)

curriculum requirements (19.7%),

preparation for national assessments (18.0%) and

lack of experience with alternative assessment practices (12.5%).

Other values are identified by less than 5% of the overall group. Figure 4.10 shows the challenges identified by the different groups of teachers based on their inquiry experience level. (Teachers identified their top 4 challenges and Figure 4.10 shows the % of teachers who identified particular changes, with the group normalised to 100). The challenges identified by the NE participants are quite varied. Their greatest challenge, with just under 50% of the NE participants including this in their top 4, is a lack of experience with alternative assessment practices. The top challenge identified by the BE, SE and VE teachers is time to develop assessments. The VE participants don’t see curriculum requirements and resistance from students or colleagues as much of a challenge. However, they do identify resistance from parents as more of a barrier than NE, BE, or SE participants.

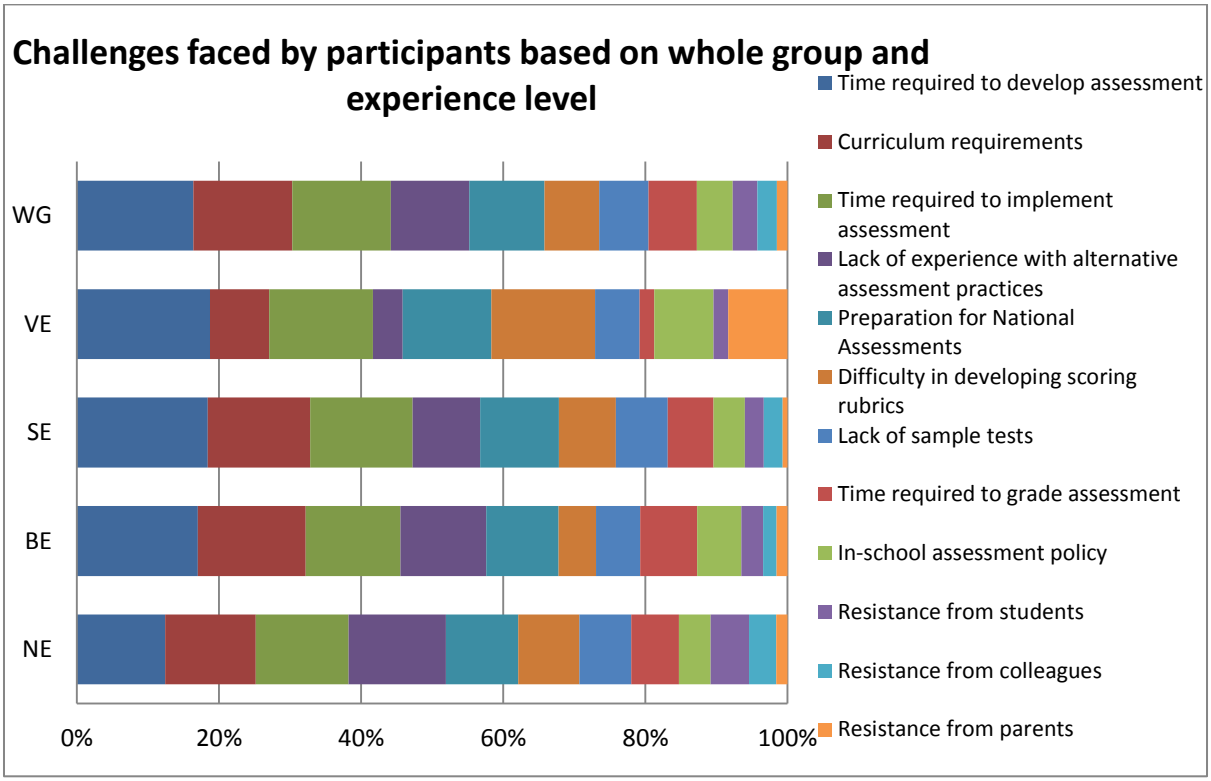


Figure 4.10 Challenges faced by teachers based on experience level (WG is whole group, VE, SE, BE and NE refer to inquiry experience level of the teachers)

4.2.5 Gender Effects

Of the 305 teachers who completed both questionnaires, 29% were male and 71% were female. The earlier discussions have highlighted differences between cohorts of teachers in terms of their prior experience of inquiry. Adding in an analysis of gender effects has divided the overall group onto six different groups as shown in Table 4.15.

Table 4.15 Numbers of teachers based on prior experience in inquiry and gender

Teacher prior experience with inquiry	NE	BE	SE+VE
Male	24	19	44
Female	62	66	86

Statistical tests were carried out on all the data comparing these six groups and very few differences were evident. In terms of practice of some inquiry elements, for those with no experience of inquiry (NE), female teachers statistically significantly stated that they more frequently carried out the following practices than the male group (means given for male and female groups)

- Students analyse their own data (Male mean 2.87, Female mean 3.34)
- Students develop their own conclusions for investigations (Male mean 2.91, Female mean 3.37)
- Students have the opportunity to respect and understand each other in the inquiry classroom (Male mean 2.90, Female mean 3.55)

Following the TEP, the female NE cohort were significantly more confident in assessing 'Students develop their own conclusions for investigations' (mean 4.00) than male NE cohort (mean 3.61).

For the BE group, following the teacher education programme, females were significantly more confident (mean 3.85) with assessing the practice "Students conduct their own procedures of an investigation" than males (mean 3.35).

Within the more experienced cohort (SE and VE), males significantly carried out the following practice more frequently than females:

- When conducting an investigation, students understand why the data they are collecting is important (Male mean 3.68, Female mean 3.22)

Males were also more confident in assessment of 'Students analyse their own data' (male mean 3.95, female mean 3.54). Following the TEP, female teachers significantly felt that the assessment of the following practices was more valuable than male teachers.

Table 4.16 Gender differences of SE&VE participants following the programmes

Statements	Significance	Male	Female
Students design their own procedures for investigations.	.046	3.74	4.10
Students conduct their own procedures of an investigation	.002	3.58	4.14
Students present their results and conclusions from an investigation.	.008	4.00	4.47
Students critique information from other sources, e.g. newspapers, web links, magazines	.025	3.70	4.17
Students have opportunities to talk and listen to each other, in the inquiry classroom.	.046	4.05	4.44
Students have opportunities to develop empathy with peers, in the inquiry classroom.	.036	3.77	4.17
Students have the opportunity to respect and understand each other in the inquiry classroom.	.017	3.95	4.41

It is difficult to determine if any of these differences form a pattern or are really only a random difference. One tentative conclusion that could be drawn is that of those experienced inquiry teachers, the female cohort value more discussion in the classroom than their male counterparts. However, further analysis should be conducted before there is real evidence for this statement.

4.2.6 Discussion of impact of TEPs on in-service teachers.

From the analysis presented, teachers from all country cohorts moved to having a greater understanding of inquiry and the roles of the teacher and students in an inquiry classroom following the SAILS teacher education programme. This occurred regardless of the prior experience level of the teachers in inquiry and of their number of years teaching experience.

In terms of inquiry practice, several practices were carried out more frequently by the overall group than others (Table 4.2), specifically, students analyse their own data, justify their conclusions, develop their own conclusions from investigations and present their results and conclusions from investigations. However, approximately half of the teachers or less indicated they were confident in assessing these practices. Following the TEP, the proportion of teachers who were confident in assessing these practices increased significantly. Generally, these practices were carried out less

frequently by the NE, BE and SE groups of teachers compared to the VE group. However, the confidence for all of these groups has increased, and significantly so for NE and BE groups.

The inquiry practices that were carried out least frequently (Table 4.3) were e.g. students formulating questions which can be answered by investigation, designing and conducting their own procedures for investigations, determining which data to collect in their investigations and considering a variety of ways of interpreting evidence when making conclusions.

Looking at the range of practices carried out, it is clear that those that move the focus of control to the student were carried out frequently by less teachers (e.g. allowing students to design their own procedures or determining the data to collect). With the increase in confidence of the teachers to assess these practices, it is hoped then that the teachers will actually implement these practices more in their classrooms.

Interestingly the nature of the feedback for learning given to students still concentrates on grades as the overall records are maintained as grades. In many countries, both grades and comments are maintained. Within the context of assessment of learning and assessment for learning, teachers may need further support in giving feedback to student in a format that can drive student learning forward.

Finally, several challenges need to be faced by teachers to develop their assessment strategies and these main be the major impediment to implementing alternative assessment procedures. Hence a key recommendation is that further TEP programmes are required to focus on development of assessment strategies e.g. within a school environment. The results presented, in this section based, on the teachers responses in the initial and final questionnaires have shown that the SAILS TEP programme has been successful in developing and deepening teachers understanding of inquiry and assessment practices.

4.3 Teacher Profile: Pre-Service

The SAILS TEP was implemented within pre-service teacher education programmes in a variety of ways that have been discussed earlier in this report. The effect of the SAILS (TEP) on these pre-service teachers (PST) was evaluated through questionnaires, completed before (initial) and after the SAILS TEP programme (final). Specifically the questionnaires determined their understanding of inquiry, their use of inquiry practices in the classroom (or whether they felt this practice was important) and their assessment of these practices. The data presented in this section is only that from those PST who completed both initial and final questionnaires within the SAILS TEP cohort 3. The sample is outlined in Table B in Appendix, with each country coded with a unique letter. The data was analysed statistically and by multidimensional scaling analysis as discussed in Section 4.2.

4.3.1 Pre-service SAILS teachers

The pre-service cohort of teachers are a very heterogeneous group, with many having little to no teaching experience and others having over 20 weeks of teaching experience (see Table B, Appendix). Only the group with teaching experience could complete questions about their practice in the classroom, and so the whole group has been divided in two with those PST with teaching

experience (PSTW) answering about their practice while the group of with no teaching experience (PSTWO) were questioned on whether they valued the inquiry practices in the classroom.

In total 175 PST completed both questionnaires, 91 PSTW and 84 PSTWO. Female teachers outnumbered the male teachers overall, however, countries L and M had 50% or greater male teachers. Each PST self-rated their experience with inquiry from (Figure 4.11):

- no / hardly any knowledge about IBSE (NE)
- some knowledge about IBSE but no practical experience with IBSE in class (BE)
- some/limited experience with IBSE in class (SE)
- good knowledge of and regularly use IBSE in class (VE).

Following the TEP programme, the teachers again self-rated their own experience with inquiry and the data shows that they now rated themselves as having more experience with inquiry (Figure 4.11). Note there were no PST with a good knowledge of inquiry initially but following TEP, several rated themselves as VE. In all subsequent analysis, the VE group are combined with the SE group.

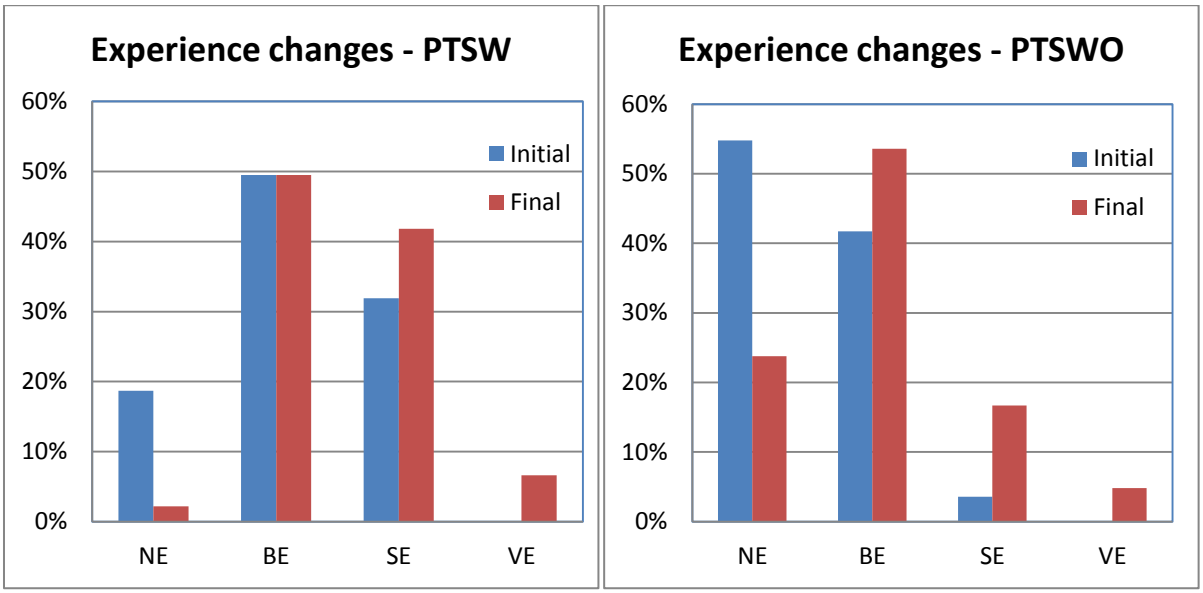


Figure 4.11 Change in PST self-rating of inquiry experience initially and finally after TEP programme for PSTW, with teaching experience PSTWO, without teaching experience.

4.3.2 Understanding of Inquiry

The PSTs understanding of inquiry all changed significantly towards a more comprehensive understanding following the TEP (see Figure 4.12, MDS analysis plot). This occurred for all the PST, both with and without teaching experience. The pattern of responses is very similar to the in-service cohort, in that following the TEP, all country cohorts form a cluster and are approximately equidistant from the notional ideal. Initially before the TEP, the PSTWO group are somewhat further from the ideal than the PSTW group.

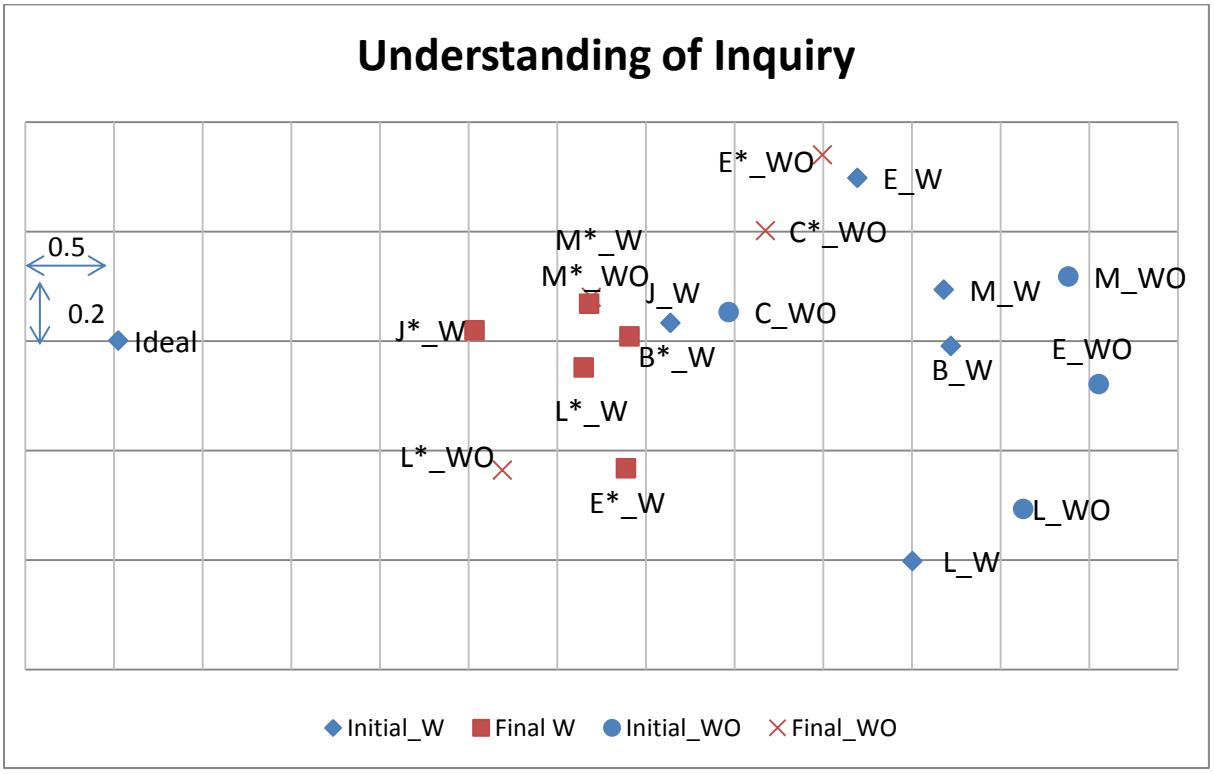


Figure 4.12 MDS of Change of understanding of Inquiry (* indicates responses from final questionnaire), W and WO teaching experience

As the PST self-rated in terms of experience, there were statistical differences between those who considered themselves to be NE, compared to BE and also SE. Within each level of experience, for both the PSTW and PSTWO groups, those NE, BE and SE all significantly increased (Table 4.17), showing that the SAILS TEP programme was effective for all PST, across all the countries, regardless of their experience with teaching or their prior knowledge of inquiry. Therefore the analysis for PST was carried out based on the teaching experience of the group and also their stated experience level with inquiry.

Table 4.17 Responses of pre-service teachers in terms of Understanding of inquiry

	PSTW			PSTWO	
Statement	NE mean	BE mean	SE mean	NE mean	BE mean
I have a comprehensive understanding of inquiry-based science education	2.59 → 3.71	3.24 → 3.87	3.41 → 3.90	2.64 → 3.52	2.74 → 3.49
I have a comprehensive understanding of my role as a teacher in an inquiry classroom	3.24 → 4.06	3.64 → 4.11	3.69 → 4.14	3.09 → 3.78	3.37 → 3.91
I have a comprehensive understanding of the role of the students in an inquiry classroom	3.00 → 4.18	3.69 → 4.16	3.72 → 4.17	3.14 → 3.78	3.60 → 3.94

Numbers represent change in mean from initially to after TEP. (Mean values, based on 1 for strongly disagree, 2 disagree, 3 uncertain, 4 agree and 5 strongly agree).

4.3.3 Practice of Inquiry

In terms of inquiry practice, the PSTW were asked if they carried out the particular practice frequently, while the PSTWO were asked if the particular inquiry practice was important in the classroom. Table 4.18 shows the % of teachers who practice and are confident in a particular inquiry skill. The table shows the main practices where the majority of the PSTs indicated agreement. Note the table is in two parts with both the PSTW and PSTWO groups noted.

Table 4.18 % of teachers who practice and are confident in assessing particular inquiry skills

Students ….	**% of PSTW teachers who:**			**% of PSTWO teachers who:**		
	practice this frequently	**confident in assessing (before TEP)**	**confident in assessing (after TEP)**	**This practice is important**	**confident in assessing (before TEP)**	**confident in assessing (after TEP)**
Analyse their own data	62	47	64	83	69	81
Justify their conclusions	63	54	78	87	76	82
Develop their own conclusions from investigations	70	52	76	96	74	81
Present their results and conclusions from investigations	63	51	79	94	76	81
Have opportunities to talk and listen to each other in the inquiry classroom	65	40	52	94	64	75
Have a role as investigations are conducted	62	42	65	86	64	74
Respect and understand each other in the inquiry classroom	68	45	46	85	66	63
Formulating questions which can be answered by investigation	41	31	52	87	38	58
Understand why the data they are collecting is important	54	31	63	86	61	80

Over 60% of the PSTW teachers state that they practice these elements of inquiry frequently in their classroom (except for the last two in the above table), practices such as students developing their own conclusions from investigations or students have opportunities to talk and listen to each other in the inquiry classroom. However, half (or less) of these teachers are confident in their assessment of these inquiry skills. Following the TEP, their confidence has increased, particularly for elements such as students justify their conclusions or present their results and conclusions from investigations.

Looking at the PSTWO group, approximately 90% of them are indicating that the practice of these elements of inquiry is important and they are much more confident in their assessment than the PSTW. Likewise, the proportion of teachers who are confident following the TEP also increases for the PSTWO group.

The practices of inquiry that were carried out least frequently are summarised in Table 4.19, which also shows the proportion of the teachers who are confident in its assessment, for both the PSTW and PSTWO groups. Following TEP, the proportion of teachers who are confident in the assessment increases. As in the previous table, a higher proportion of the PST who have not been out in classrooms, consider each element of the inquiry practice as important and are more confident in their assessment before the TEP than those who have had teaching experience.

Table 4.19 % of teachers who practice and are confident in assessing particular inquiry skills

Students ….	**% of PSTW teachers who:**			**% of PSTWO teachers who:**		
	practice this frequently	**confident in assessing (before TEP)**	**confident in assessing (after TEP)**	**This practice is important**	**confident in assessing (before TEP)**	**confident in assessing (after TEP)**
Formulating questions which can be answered by investigation	41	31	52	87	38	58
Refining questions that can be answered by investigations	43	23	39	73	42	62
Designing their own procedures for investigations	34	33	60	80	55	81
Conducting their own procedures for investigations	32	30	56	69	51	63
Critiquing the procedures that are used when they conduct investigations	32	29	45	69	54	62
Determining which data to collect in their investigations	30	23	54	54	57	73
Consider a variety of ways of interpreting evidence when making conclusions	36	30	52	79	58	68

Interestingly for the PSTW group, these elements of inquiry that are frequently carried out by the smaller proportion of teachers, are the same elements as noted in the previous section for in-service teachers (see Section 4.2.3).

As discussed earlier, the SAILS project focussed on the development and assessment of four main inquiry skills: planning investigations, developing hypotheses, working collaboratively, and forming coherent arguments, in addition to the broader competencies of scientific reasoning and scientific literacy. The data from grouping of the questions in the questionnaire are now discussed under these SAILS inquiry skills and competencies. The grouping of questions is as that given in Section 4.2.3 for In-service teachers. As each skill has already been discussed in Section 4.2.3, this section will highlight only significant differences with the PST teachers.

4.2.3.1 Planning Investigations

The PSTW group indicated the extent to which they agreed with the statement that 'In my classroom, this practice almost always occurs' for the following statements:

- Students formulate questions which can be answered by investigation
- Students design their own procedures for investigations.
- Students conduct their own procedures of an investigation
- When conducting an investigation, students determine which data to collect

Between 27 and 39% of the PSTW indicated that these practices occurred frequently, with the remainder either uncertain or disagreeing. There was no significant difference in their practice based on their experience level with inquiry. Mean value for these elements initially are given under practice in Table 4.20. In contrast, 56-88% of the PSTWO group indicated that these practices were important in the inquiry classroom, with no difference between experience level with inquiry.

In relation to assessment, approximately 45% of PSTW indicated that they assessed these practices (but only 34% indicate that they assess students determine what data to collect) and of those, only about 40% were confident in their assessment. The remaining 55% did not assess the practice and only about 15% of these were confident in the assessment of the practice. In contrast, approximately 85% of the PSTWO indicated that they would like to assess these elements in practice, with approximately 60 % of these confident in the assessment.

Following the TEP programme, teachers' confidence in assessing all of these practices increased (see Table 4.20). Only those changes indicated with ' were significantly statistically. Combing these results based on country cohorts, the MDS shows the trend in movement towards the ideal following the TEP. Figure 4.13). It is interesting to note that three cohorts moved away from the ideal – these were all PSTWO, who may have either become less confident or more realistic as the TEP progressed! As the content of the TEP programme for PST varied between countries and also the content had to fit in with the modular basis of some programmes, it is difficult to comment on any changes.

Table 4.20 Responses in terms of practice and Initial and Final confidence with assessing planning investigations - experience differences

Statement		PSTW			PSTWO	
		NE mean	BE mean	SE mean	NE mean	BE mean
Students formulate questions which can be answered by investigation	P	3.53	3.09	3.36	4.28	4.17
	C	2.76 → 3.41	2.84→ 3.61'	3.22 → 3.38	3.42→ 3.80'	3.12→ 3.66'
Students design their own procedures for investigations.	P	2.35	2.98	3.00	4.09	4.14
	C	2.44 → 3.29'	3.29 →3.04'	3.07 → 3.48	3.69→ 4.15'	3.49→ 4.09'
Students conduct their own procedures of an investigation.	P	2.29	2.73	3.00	3.93	3.94
	C	2.44 → 3.47'	2.78→ 3.55'	3.14 → 3.29	3.59 → 3.70	3.51 →3.83
When conducting an investigation, students determine which data to collect	P	2.41	2.89	2.86	3.37	3.83
	C	2.44 → 3.53'	2.67→ 3.68'	3.00 → 3.36	3.71→ 4.09'	3.49→ 3.94'

Top number in each box represents mean of practice statements (P). Bottom numbers represent change in mean of confidence from initially to after TEP (C). (Mean values, based on 1 for strongly disagree, 2 disagree, 3 uncertain, 4 agree and 5 strongly agree). 'statistically significant change.

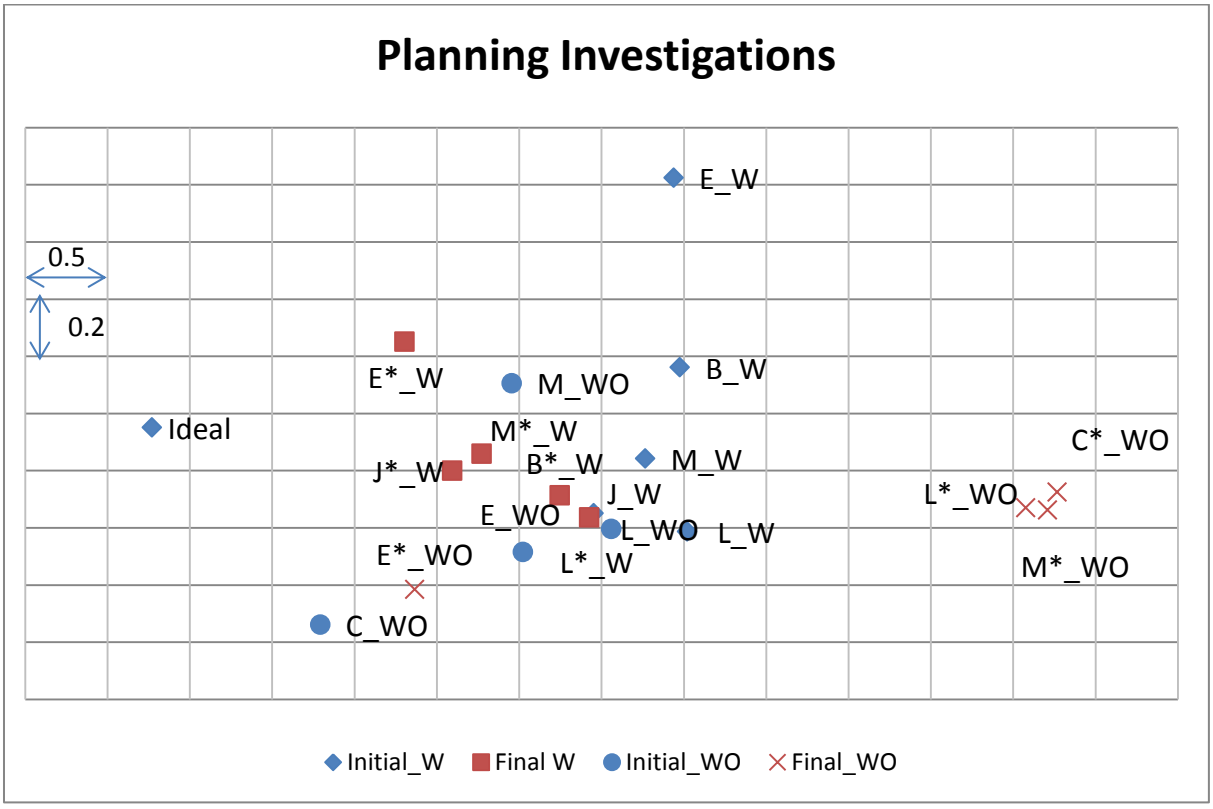


Figure 4.13 MDS of Change in Confidence – Planning Investigations

4.2.3.2 Developing Hypotheses

Two statements were grouped under the skill of developing hypotheses: Students formulate questions which can be answered by investigation; Time is devoted to refining student questions so that they can be answered by investigations. Before the TEP, 40% and 42% of the PSTW group indicated that these two practices respectively occurred frequently in their classtroom; in contrast to 89% and 47% of the PSTWO cohort.

In terms of confidence in assessing these elements, there was statistically significant differences initially based on experience level with the SE group of the PSTW cohort more confident in assessing the practice of refinning student questions. The NE group of the PSTWO cohort were more confident in this practice compared to the BE group. However, following the TEP, there was no differences noted for this practice.

4.2.3.3 Working Collaboratively

Four statements were grouped to determine teachers' practices for working collaboratively, namely:

- Each student has a role as investigations are conducted
- Students have opportunities to talk and listen to each other, in the inquiry classroom
- Students have opportunities to develop empathy with peers, in the inquiry classroom
- Students have the opportunity to respect and understand each other in the inquiry classroom

Before TEP, 60% of the PSTW cohort indicated that each student has a role when investigations are conducted, while 65% were involved in practices of students having opportunities to talk and listen to each other, and to respect and understand each other occurred frequently in their inquiry classroom (68%) (Table 4.21). However, developing empathy was practiced frequently by only half of the group. Their confidence in assessing these practices was less evident with e.g. only 40% of the teachers confident in assessing students talk and listening. Based on experience with inquiry, the SE cohort were significantly more confident than those with less experience. In contrast, over 85% of the PSTWO group valued each of these practices in the inquiry classroom and over 60% were confident in their assessment, with the NE group being significantly more confident than the BE group.

While some changes in confidence were determined, these changes were more on individual cohorts for particular practices. Cohorts J and M (with PSTW) showed significantly increased confidence for the assessment of 'each student has a role as investigations are conducted'.

Examining the experience level in inquiry of the different cohorts, there are some small changes that are statistically significant (see Table 4.21).

Table 4.21 Responses in terms of practice and Initial and Final confidence with assessing working collaboratively - experience differences

		PSTW			PSTWO	
		NE mean	BE mean	SE mean	NE mean	BE mean
Each student has a role as investigations are conducted	P	3.29 3.00	3.38	3.89	4.46	4.26
	C		2.91→3.66'	3.65	4.09	3.43→4.06'
Students have opportunities to talk and listen to each other, in the inquiry classroom	P	3.41	3.51	3.89	4.72	4.34
	C	3.18→3.88'	2.96	3.62	4.20	3.57
Students have opportunities to develop empathy with peers, in the inquiry classroom	P	3.06	3.36	3.71	4.54 4.07	3.74
	C	2.59	2.67	3.15		3.26
Students have the opportunity to respect and understand each other in the inquiry classroom	P	3.47	3.71	4.04	4.65	4.06
	C	2.94→3.47'	3.00	3.88	4.13→4.11'	3.40

Indicate significant changes' Only significant changes in the mean values are indicated. All other values are the initial means.

For both PSTW and PSTWO, the BE teachers' confidence in assessing student roles increased significantly following the TEP. The NE group of the PSTW cohort also increased their confidence in assessing student dialogue and respect within the classroom.

4.3.3.4 Forming Coherent Arguments

Most of the PSTW teachers stated that the students often develop their own conclusions (70%) and justify them (63%), only 37% of the teachers stated that students were often involved in considering different ways of interpreting the evidence. For the PSTWO group, the respective figures for those who felt these practices were important were 96%, 87% and 79%. As in other practices, the PSTWO were more in favour of these practices than the PSTW cohort. Interestingly, students considering different ways of interpreting evidence was the practice that was least occuring. There was no significant differences in the practice between the groups of teachers based on their experience level with inquiry (Table 4.22).

Students developing conclusions and justifying their conclusions was assessed by most PSTW teachers (69%), but of these, only half were confident in the assessment practice. The PSTWO group indicated (at 91%) that they would assess these practices, of which 75% were confident in their assessment. Experience with inquiry (for both PSTW and PSTWO) did not influence the level of confidence in assessment (Table 4.22).

Table 4.22 Responses in terms of practice and Initial and Final confidence with assessing forming coherent arguments - experience differences

		PSTW			PSTWO	
		NE mean	BE mean	SE mean	NE mean	BE mean
Students develop their own conclusions for investigations	P	3.88	3.60	4.04	4.54	4.54
	C	3.35	3.38→4.02'	3.89	4.04	3.94
Students consider a variety of ways of interpreting evidence when making conclusions.	P	2.82	2.98	3.46	4.24	4.09
	C	2.76→3.65'	2.69→3.59'	3.33	3.93	3.51
Students justify their conclusions	P	3.29	3.56	4.04	4.27	4.63
	C	3.06→3.76'	3.44→4.14'	3.85	4.00	4.03

Top number in each box represents mean of practice statements. Bottom numbers represent change in mean of confidence from initially to after TEP. (Mean values, based on 1 for strongly disagree, 2 disagree, 3 uncertain, 4 agree and 5 strongly agree) ' indicates significant changes. While small changes in mean confidence values were determined, only changes that were statistically significant have been included.

Following the TEP programme, and examining the mean values of country cohorts, there were small shifts evident in the MDS towards the notional ideal for all cohorts from PSTW and PSTWO; however, this shift was only significant for PSTW groups E and M (Figure 4.14).

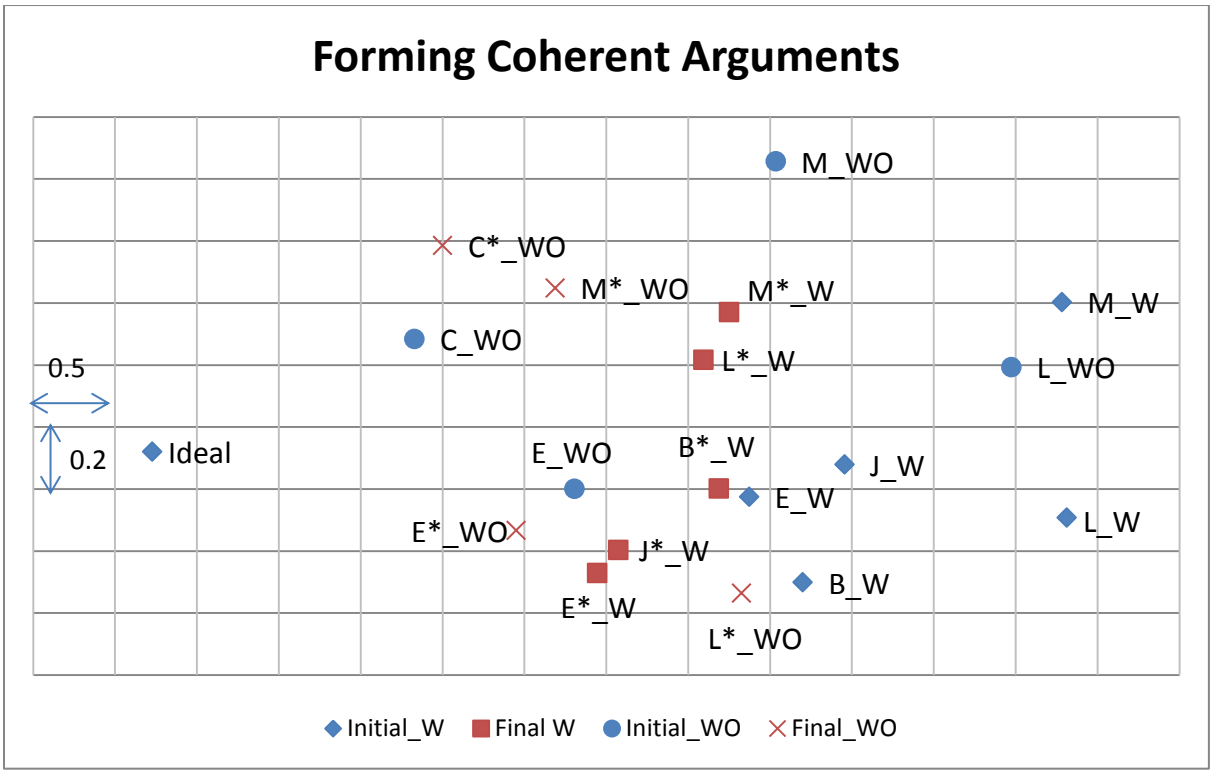


Figure 4.14 MDS of Change in Confidence – Forming Coherent Arguments

Based on their experience with inquiry, the NE and BE groups of PSTW showed significant increases in their confidence level following TEP programme; however, there was no significant change for the PSTWO group. THE PSTWO group were more confident initially anyway and the TEP programme did not change this level of confidence (Table 4.22).

4.3.3.5 Scientific Reasoning

Two further statements were added to the questions in section 4.3.3.4, to form the category of scientific reasoning: When conducting an investigation, students understand why the data they are collecting is important and Students analyse their own data.

While 68% of PSTW teachers stated that the students almost always analyse their own data, less than this number stated that students understand why the data they are collecting is important (54%); also there was no difference between the responses from the teachers regardless of their experience with inquiry. However, these two practices are assessed by 68% and 56% of the teachers respectively, with 58% and 47% confident in the assessment of these practices, respectively. In contrast, over 83% of the PSTWO valued these practices with 88% of them wanting to assess them, of which approximateley 70% were confident in their assessment. Table 7 shows the means of the two additional statements in terms of practice and confidence, based on the inquiry experience level.

Folloeing the TEP programme, the significant changes in confidence were evident in cohorts B, E and M for PSTW. Based on inquiry experience level, the confidence of the PSTW who were NE, BE and SE all increased significantly for the statement that students understand why the data they collect is important but only the SE cohort significantly increased their confidene in assessing students analyse their own data. There were no significant changes for the PSTWO group (Table 4.23).

Table 4.23 Responses in terms of practice and Initial and Final confidence with assessing 2 statements from scientific reasoning - experience differences

		PSTW			PSTWO	
		NE mean	**BE mean**	**SE mean**	**NE mean**	**BE mean**
When conducting an investigation, students understand why the data they are collecting is important	P	3.35	3.33	3.75	4.38	4.49
	C	2.94→3.76’	2.91→3.52’	3.30→3.93’	3.82	3.74
Students analyse their own data	P	3.65	3.40	3.89	4.04	4.34
	C	3.24	3.31	3.52→3.93’	3.82	3.97

Top number in each box represents mean of practice statements. Bottom numbers represent change in mean of confidence from initially to after TEP. (Mean values, based on 1 for strongly disagree, 2 disagree, 3 uncertain, 4 agree and 5 strongly agree) ‘ indicates significant changes. While small changes in mean confidence values were determined, only changes that were statistically significant have been included.

4.3.4 Attitudes to Assessment and Feedback

The PST were given a number of statements regarding feedback and asked to indicate their level of agreement with them. The level of agreement with each statement is given in Table 4.24 for PSTW and PSTWO teachers. The level of agreement between the PTSW and PTSWO is clear in that the level of agreement with each statement is very similar – particularly so re the benefit of feedback (because it helps students learn, is not a wasted effort, helps students to decide what to include and/or exclude in their work and helps them to evaluate their own work.

There is more uncertainty with regards to the process of feedback – e.g. that feedback is a two way process or that it happens interactively and immediately in the classroom while students are learning. There is also much uncertainty as to the use of peers as the best source of feedback. Timing of feedback was not really considered as an issue with a variation of opinions as to the usefulness of feedback after a week. Finally, the purpose of feedback to help student feel good about themselves was mainly disagreed by the PSTW cohort but the PSTWO cohort were in agreement.

Following the TEP, there were significant changes in answers to four statements – and these statements relate to inquiry practices. There was greater agreement by PSTW (mean 3.71 increased to 3.91) and PSTWO (mean increased from 3.66 to 3.88) to the statement 'Quality feedback happens interactively and immediately in the classroom while students are learning'. Feedback being a two-way process also had greater agreement by the PSTWO group only after TEP (mean from 3.87 to 4.08). Also agreement increased that peers were a source of feedback (for PSTW mean increased from 3.03 to 3.30, and for PSTWO, mean increased from 2.88 to 3.12). Agreement that feedback helps students decide what to include and/or exclude in their work had greater agreement by the PSTWO after TEP. These values suggest that the TEP programme increased students understanding of the nature and purpose of feedback within an inquiry classroom.

Table 4.24 % of PST that agreed with a number of statements

Feedback practices	**PSTW**				**PSTWO**			
	SD/D	**U**	**A/SA**	**Mean**	**SD/D**	**U**	**A/SA**	**Mean**
Giving students feedback is important because it helps them to learn	0	2	98	4.6	2	8	87	4.3
Time spent giving feedback is a wasted effort	96	3	1	1.5	86	12	0	1.7
Feedback helps students decide what to include and/or exclude in their work	1	15	84	4.2	5	16	77	4.0
Feedback is about helping students evaluate their own work	3	11	86	4.1	1	19	77	4.0
Feedback is a two-way process between the students and the teacher	4	13	83	4.0	1	29	68	3.9
Quality feedback happens interactively and immediately in the classroom while students are learning	6	29	66	3.7	6	31	61	3.7
The point of feedback is to make students feel good about themselves	42	33	25	2.8	12	37	48	3.4
Feedback that takes more than a week is useless	30	48	22	2.9	32	37	27	3.0
Peers are the best source of feedback	21	57	22	3.0	29	51	18	2.9

Values assigned to strongly disagee 1, to strongly agree 5.

When the PSTW and PSTWO cohorts are divided into their experience level with inquiry, the means of a number of the practices increased significantly. These are shown in Table 4.25. Only those practices that changed significantly are shown. It is clear that the NE group made the most significant changes.

Table 4.25 Mean values depending on PST experience level with inquiry

Feedback practices	**PSTW**			**PSTWO**	
	NE	**BE**	**SE**	**NE**	**BE**
Giving students feedback is important because it helps them to learn	4.82	4.56	4.69→4.48	4.09→4.33	4.51
Time spent giving feedback is a wasted effort	1.53	1.42	1.55	1.70	1.74
Feedback helps students decide what to include and/or exclude in their work	4.59	4.07	4.17	3.93→4.43	4.09
Feedback is about helping students evaluate their own work	4.35	4.09→4.36	3.97	4.00	4.00
Feedback is a two-way process between the students and the teacher	3.94	4.20	3.83	3.89→4.20	3.83
Quality feedback happens interactively and immediately in the classroom while students are learning	3.76	3.78→4.07	3.59	3.73	3.54
The point of feedback is to make students feel good about themselves	2.76	2.89	2.69	3.42	3.40
Feedback that takes more than a week is useless	2.71→3.29	2.84	3.14	2.95	3.14
Peers are the best source of feedback	2.88	3.07→3.41	3.07	2.89→3.28	2.83

4.3.5 Gender Differences

Considering the PSTW and the PSTWO cohorts as two separate cohorts, significance tests were conducted to determine if there were any differences that were due to gender. Now this anlaysis is not conclusive as the experience level with inquiry was not considered and the numbers in each category would then be too small for reliability.

For the PSTW cohort, there were a number of practices where significantly more of the female cohort conducted the practice than the male cohort, both initially and following the TEP. These are summarised in Table 4.25. There was no difference between the confidence of male and female PSTW in assessing inquiry. Many of the statements noted are linked together under scientific reasoning

Likewise within the PSTWO cohort, a greater proportion of the female cohort valued the particular inquiry practice more than the male cohort initially but were also more confident in its assessment both initially and following TEP. Specific practices are noted in Table 4.26. In addition to the practices noted for the PSTW group, the PSTWO group have also included the working collaboratively statements.

It should be noted that there may be other factors, such as experience level that may account for some differences; however, as the numbers of males in each category is small, no real conclusions can be drawn from this data – other than the trend shown.

Table 4.25: **PSTW** Mean of male and female response (only significant changes noted)

Statement – Practice - mean values	**Initially – before TEP**		**Finally – after TEP**	
	male	**female**	**male**	**female**
Each student has a role as investigations are conducted	3.0	3.8	3.4	3.9
When conducting an investigation, students understand why the data they are collecting is important	3.1	3.7		
Students analyse their own data	3.3	3.8		
Students develop their own conclusions for investigations	3.3	4.0		
Students consider a variety of ways of interpreting evidence when making conclusions.	2.8	3.3	2.8	3.4

Table 4.26: **PSTWO** Mean of male and female response (only significant changes noted)

Statement – mean values	**Initially – before TEP**		**Confidence in assessing Initially**	
	male	**female**	**male**	**female**
Each student has a role as investigations are conducted	3.7	4.5	3.0	4.0
When conducting an investigation, students understand why the data they are collecting is important	3.9	4.5	3.3	3.9
Students consider a variety of ways of interpreting evidence when making conclusions.	3.7	4.3	3.1	3.9
Students have opportunities to talk and listen to each other, in the inquiry classroom	4.0	4.7	3.1	4.1
Students have opportunities to develop empathy with peers, in the inquiry classroom	3.5	4.4	2.7	4.0
Students have the opportunity to respect and understand each other in the inquiry classroom	3.8	4.5	2.9	4.0

5. Impact Reports

5.1 BELGIUM

The Belgium TEP programme was not foreseen in the original project proposal; the Belgium partner ATIT, an SME organisation, was mainly responsible for dissemination in the SAILS project and unlike the other partners is not directly linked to a Teacher Training Institute. Nevertheless already early in the project teacher educators in Flanders showed a lot of interest in the SAILS project and we started discussing to see if an activity for Flemish teachers could also be organised. Teacher educators in Belgium had already taken part or collaborated in other European Projects around IBSE like SECURE and they were looking for good practice and materials to encourage teachers to reflect on their practice and in particular to hand them the tools to change their assessment methods. For them SAILS came at a good time to respond to their needs. In this way, SAILS provided an opportunity to take IBSE and assessment of inquiry skills to the next level in Flemish Schools.

The most logical approach was to organise workshops in Belgium in the last stage of the project in order to use the experience and materials from the other SAILS TEPs. The Belgium TEP did not therefore start with the other countries but joined in at the last stage (stage 2 in Year 3). In 2014-2015 three workshop sessions (October, January, May) were organised. SAILS partner Paul van Kampen from DCU (but originally from the Netherlands) helped to translate some of the Irish workshop elements into a Dutch-speaking version and also came over to lead the sessions in Belgium. From Belgium, Flanders we had three teacher trainers leading the workshops with him: Wim Peeters (Catholic Education Flanders), Mieke De Cock (KU Leuven) and Marc Beddegenoodts (GO! Onderwijs). When the call for the workshop in Belgium went out, there was a huge interest from teachers. More than 70 people showed interest and it meant that instead of proposing a half-day workshop we decided to organise two half days in order to be able to accommodate all participants.

In the Flemish curriculum for secondary education, inquiry skills are highlighted as important learning goals. During the SAILS project the learning goals have focussed even more on inquiry learning. Nevertheless in practice teachers still find it difficult to change their practice to give more space to inquiry practices and stimulate these skills amongst their students.

In Flanders every school has autonomy on the methods used for the assessment of these skills. The school inspection is responsible for evaluating if the learning goals have been reached. Although the inspection is not in the position to decide for schools what assessment methods should be used, in the last years they have been recommending schools to look more and more for “wider assessment opportunities” of skills & attitudes as well as assessment *for learning*. In some schools this has already been picked up by implementing rubrics for different topics in order to assess inquiry skills. Nevertheless apart from this first initiative in some Flemish schools, there have not been a wide range of tools available for teachers to use and meet these recommendations. The SAILS project confirmed the vision of the education inspection, that change in assessment methods is needed. The workshops organised in Belgium for the Flemish teachers gave the teacher trainers the opportunity to again put this topic higher up the agenda of teachers and school headmasters. Furthermore they offered teachers real practical tools to change their assessment practices and re-assured teachers that assessment can and should be an integral part of IBSE.

Teachers coming to the SAILS workshops were very interested in the topic of IBSE and assessment as they were already stimulated to change some of their assessment practices, but often did not know how to do this. The SAILS project and TEP in particular gave them:

- An opportunity to reflect on their own practice when it comes to IBSE and the assessment of inquiry skills as well as new tools to try out in their class
- A platform to discuss with peers and hear good practice from colleagues, but also share challenges and difficulties when trying to change their practice
- A framework to test out new activities and methods in the classroom and coaching to improve their practice

Furthermore, several teachers were given the opportunity to attend the SMEC-SAILS Conference in Dublin in 2014, which was very encouraging for them. It was a real eye-opener to meet other teachers working on the same topic, to find out about methods used in other countries as well as to become aware of the fact that everyone else is also struggling with this topic. The Flemish teachers were also given the opportunity for the first time to share and discuss their own work with an international audience.

Teachers taking part in the workshops started implementing activities proposed by SAILS (one teacher produced a case study on the implementation of the Global Warming unit, another reported on their implantation of Floating Oranges, while another adapted the Up there, how is it unit to fit into a one hour lesson), and tried out assessment methods in their classrooms. Although Belgium teachers are quite familiar with doing inquiry in their lessons, sometimes this is rather limited and sometimes can be very “guided”. Belgian teachers also developed their own inquiry lessons which they shared with the group. The SAILS examples helped them to test out new ways of teaching inquiry and showed them a variety of ways to assess inquiry skills. During the workshop sessions and when testing out activities in their class, teachers became aware of the fact that assessment is not only about giving marks and they could experience that there are many different ways to assess. Using observation, questioning students, peer-assessment – sometimes teachers can feel these are not legitimate ways to assess. SAILS confirmed to teachers, teacher trainers, headmasters and the education inspection that these assessment methods are valuable and necessary methods to use in class in order to develop students’ learning.

In Belgium the SAILS story does not stop when the project ends. First of all In February 2016 a last session will be organised in order to hand out and discuss the 19 inquiry & assessment units published by SAILS with teachers. During a working session teachers can look into the units and find useful activities and assessment methods to try out in their class and where necessary they will be guided to adapt the material to their specific context. The session will also be used as an opportunity for teachers that already used SAILS activities in their classrooms to present their work. We are confident this will inspire other teachers to start changing their practice as well.

Also after this last session it is planned to continue using the SAILS units in existing in-service teacher training sessions. In these sessions, units will be used to show good practices and as a starting point to reflect on own teaching practice. Further on in particular, pedagogical coach and teacher trainer Wim Peeters is also actively coaching schools that have started with special STEM classes in lower secondary grade. SAILS units can suit as an ideal starting point to develop project-based learning materials for the specific STEM programme which is at the moment still “inventing itself”. The SAILS

units provide an ideal opportunity to not only help to develop good project-based inquiry courses but also to integrate assessment methods inside these specific STEM courses.

5.2 DENMARK

The in-service teacher training program in SAILS in a Danish context was offered as 4 connected workshops each of three hours. The workshops were arranged so that the teachers had time to work individually or in small groups at their schools in-between the workshops. Each workshop started with a theoretical presentation of a theme related to inquiry and/or assessment. The first workshop was almost entirely theoretical with an introduction to both inquiry teaching and assessment of inquiry skills. The purpose of this was to introduce the teachers to the thoughts behind the doing. The following three workshops were a mixture of theoretical presentations and group work on the participants own inquiry lesson plans and assessment strategies. Theoretical themes for these workshops were analysis of practical work, motivation and engagement, and concepts maps and conceptual change.

The workshops were held locally at schools or municipalities where they could gather more than 10 participants. This meant that for all workshops there was more than one participant from every participating school. A response to the workshops from the teachers was that this was very beneficial for the work between the workshops. Teachers thereby had the opportunity to collaborate in the development of inquiry lesson plans and assessment strategies.

In all there was a positive response to the TEP. The opportunity to work on the development between the workshops was mentioned as particularly fruitful for the teachers' outcome in participating. Traditionally in-service teachers training in Denmark is structured as one or two days of intense introduction to the topic but without any follow up on the content. In this way the SAILS TEP was a new structure for in-service teacher training and it was said to be better than the traditionally approach.

An unexpected outcome of the TEP was that teachers found the theoretical presentations not useful. It seemed that the gap between the theory behind and the practical doing of inquiry and assessment was too big for the teachers to cope with. A result of this was that some teachers attended only the first workshop. This of course is an experience that we have noticed and during the workshops we tried to minimize this gap by introducing more practical examples of the theory behind. Still teachers seemed to find it not worth attending. So even though we had many teachers attending the workshops from a start we ended up with having considerable fewer participants for the following workshops.

Another issue in having the workshops structured as we did was in the adaptation to the new form. Many teachers attending the workshops did not work very much with inquiry and especially not with assessment in the periods between the workshops. This influenced the flow of the workshops in that teachers were supposed to give supervision and develop on each other's work. But since many teachers attended without having prepared any lesson plans or without experience in trialing these out it gave some dead points in the workshops to fill in.

A reason for teachers not preparing and trialling between the workshops seemed to be that they in their work structure had been assigned 12 hours of work for participating in the workshops but the school administration had not given any extra time for developing mew materials and assessment structures between the workshops. Teachers therefore felt a time pressure in that they had to

prepare their teaching and knowing that if they were to prepare an inquiry structure including assessment strategies it would take much more time than doing their usual preparation. Many teachers there chose to skip the inquiry and assessment development.

After the last workshop a survey was distributed to the participating teachers. In the below table there are some of the teachers responses to 4 questions on the workshops and the outcome.

Table 5.1: A summary of comments from teachers after ending the workshops

What was the best about the SAILS workshops in which you participated?	What was the worst about the SAILS workshops in which you participated?	What from the workshops can you use in your future practice?	What from the workshops can you not use in your future practice?
Nice atmosphere and inspiration for my daily teaching	I had a pressure in my daily work so did not experiment with the SAILS units to the degree that I would have wished for	Maybe a more systematic approach to my daily work	Don't know
Don't know	Too theoretical	The practical part	Theoretics
The lesson plans that we shared with each other.	Too little time for trialing lessons	Ideas and experiences from the other teachers	There was some that I cannot use sine it does not target my group of students
The new way of thinking teaching	Missing examples from practice	The way of thinking in letting the students learn through their own investigations	Nothing
Inspiration to teaching physics	It was placed too late. I was too tired to be totaly engaged	The new way of structuring experimental work and data collection	My teaching at the time did not fit the content of the workshops

As seen in table 5.1 there was quite diverse comments to the workshops. But even if the teachers had critics to the workshops they all got some kind of inspiration for their future work. In the Danish curriculum there have for many years been a focus on students doing inquiry but still the thoughts behind inquiry teaching and formative assessment seems to be new for a good deal of the teachers.

I would be hopeful that the participating teachers from the TEP workshops in the future will use their new inspiration not only for their own teaching but also for inspiring their colleagues to experiment with inquiry teaching and different assessment strategies. In a Danish context it seems that there has been sowed some seeds for this.

During the pre-service training, discussions were held about students' perception of their own skills for practicing IBSE and assessment of skills and competencies. In these discussions it became clear that the students' confidence in using IBSE as a didactical tool was not great. The students found it hard to grasp the different approaches to teaching and the role of the teacher in inquiry lessons as opposed to ordinary lessons. But it also became clear that most students had gained more confidence after attending the workshops. So the students left an impression of being uncertain, but willing to try IBSE.

5.3 GERMANY

In the teacher workshops organized by the SAILS-team at Leibniz Universität Hannover, the teachers tried out and adapted SAILS-units as well as they developed new units for their science lessons to foster inquiry learning and formative assessment. In total more than 30 new inquiry units/tasks were developed during the teacher workshops. Those units are all trialled in school and highly adapted to the curriculum in Lower Saxony.

Examples of inquiry tasks are:

- How high can the spring of a ballpoint pen jump?
- How does Google-Maps calculate the time of travel?
- How can we build a dynamometer?

For each of the inquiry tasks a small protocol sheet was written, where the resources, the main question and advises are recorded. The materials are all collected at the Germany CoP. One reason that prevents teachers from trying out those new developed and adapted (SAILS)-units, is the lack of required material and the effort to get it. For this reason, the SAILS-Team at LUH provides materials for many units to lend. The materials are stored in boxes per unit. Everything is on board and ready to use. Therefore, if a teacher remembers a (SAILS)-unit, that was part of a TEP he/she attended, he just gives the LUH a short call or an email – and the box with the complete experimental equipment is sent out directly to his/her school into the classroom. We, the LUH, provide boxes on the UV radiation unit, Hooke's law, free fall, pendulum experiments and many other inquiry units, which stem from original SAILS-units or where developed by our teachers.

Figure 5.1 Images of LUH TEP materials - Black Box, droplet experiment, various materials that are to lend to experiment and traffic light cups used for assessment.

One further highlight of the TEP was the introduction of so-called "mysterious boxes". These are mid-sized wooden boxes, with "something" inside. What is this something? That is the students' task to find out. They have the help of various "research methods" such as shaking, putting wires through a little hole, rolling tiny balls through the inside and scanning with magnets. Looking inside is strictly prohibited! By those activities, the students can reconstruct a research process (rather a model of it) and improve their image of scientific models. Another TEP-introduced experiment is the "droplet-experiment" with which lower-grade students seemingly try to answer the question, how many water drops can fit on a coin – and end up learning a lot about the research process as such and posing sharp research questions. The mysterious boxes and the droplet-experiment were tried out during the TEPs and of course they are also to lend at LUH – which happens on a regular basis.

Of course, the TEP did not just focus on the inquiry aspect of SAILS, but also strongly on the assessment aspect. Some teachers practiced formative assessment methods long before the TEPs, to some it was a completely new business. No matter to which of the mentioned groups teachers belonged, they were highly fascinated by the formative assessment method of the "Traffic light cups" we introduced to them in the TEPs. The red, yellow and green cups are used by the students as a signal to give instant feedback to their teacher – I am lost, I might need a hint, I do not need help. Beneath the feedback advantage, by the use of cups, the students are encouraged to rethink and categorise their current state of working progress. To simplify the use of the traffic light cups, we lend them to teachers to foster the formative assessment idea in their science lessons. For the moment, more than 1000 cups are among our teachers, who got to know this method at our TEPs.

One of the main barriers for the German TEP-Teachers concerning formative assessment was that they had no overview over different assessment methods and goals to insert formative assessment into everyday classroom activities. Therefore the SAILS-Team Germany provided beside the assessment-tools for the SAILS-Units a paper with a description of different assessment methods and goals. These different assessment methods are described in a document that gives a summary of recent practical classroom literature.

Zusammenstellung verschiedener formativer Assessmentmethoden:

<table>
<tr><td rowspan="2">Zeitpunkt der Auswertung/ Rückmeldung</td><td colspan="2">Lernprozessbezogene Rückmeldung</td><td>Rückmeldung zur Klassenorganisation</td></tr>
<tr><td>Reflexion über fachliche Inhalte / Reflexion über den Lernstand
z.B. physikalische Konzepte werden direkt abgefragt</td><td>Metakognitiv- Reflexion über den Lernprozess
SuS reflektieren über den Lernprozess (z.B. benennen Schwierigkeiten im Lernweg etc.)</td><td>Klassenorganisatorische Abläufe werden erhoben bzw. verändert.</td></tr>
<tr><td colspan="4">1. Mündliche Verfahren eines formativen Assessments mit unmittelbarer Auswertung / Rückmeldung</td></tr>
<tr><td>unmittelbar</td><td colspan="3">1.1 Veränderungen von Klassengesprächen im Sinne eines formativen Assessments

➢ Volleyball – not Ping-Pong! (Keeley, S.211) Mit Hilfe dieser Methode soll in unterrichtlichen Gesprächssituationen gezielt eine größere Anzahl an Schülermeinungen und -antworten zu einer Frage einbezogen werden, um der Lehrperson mehr Einblicke in die Vorstellungen und Fähigkeiten der SuS zu ermöglichen. Anstelle eines Gesprächsablaufs, in dem die Lehrperson jeweils auf eine Äußerung antwortet (Ping Pong), wird in dieser methodischen Vorgehensweise eine Reihe von Äußerungen der SuS eingefordert, in der sich die einzelnen Schülerinnen und Schüler aufeinander beziehen (Volleyball).

➢ No-Hands Questioning (Keeley, S. 140 oder Black et al. 2003) Nach einer Fragestellung der Lehrperson dürfen keine Handzeichen für eine Meldung gemacht werden, sondern die Lehrperson wählt nach etwas Bedenkzeit zufällig eine Schülerin oder einen Schüler aus. Die Methode soll dazu beitragen, dass auch Ideen und Lösungsvorschläge oder auch fehlerhafte Vorstellungen von SuS im Klassenraum aufgegriffen und diskutiert werden, die sich sonst weniger aktiv am Klassengeschehen beteiligt hätten.

➢ Think –Pair-Share Eine Fragestellung der Lehrperson wird in einer ersten Phase von jedem Schüler eigenständig bearbeitet. In einer zweiten Unterrichtsphase tauschen sich die SuS in Paaren über die Fragestellung aus. Erst in einer dritten Phase werden die Ideen im Klassenverband oder in Gruppen gesammelt. Ziel der Methode ist es SuS die Möglichkeit zu geben, über einen bestimmten Sachverhalt zuerst alleine nachzudenken, um eigene Ideen besser einbringen zu können, aber auch, um auf eigene Verständnisschwierigkeiten oder Wissenslücken aufmerksam zu werden. In der zweiten Phase können diese Ideen oder Verständnisschwierigkeiten erst einmal mit einem Mitschüler besprochen oder geklärt werden, bevor die Aufgabe dann im Plenum besprochen wird.

➢ Partner speaks (Keeley, S.147)
In Partnerarbeit wird eine Aufgabenstellung bearbeitet. Die Partner werden beauftragt sich jeweils besonders aufmerksam zuzuhören. Im Anschluss an die Arbeitsphase werden ausgewählte SuS aufgefordert, jeweils die Ideen des Partners zur Bearbeitung der Aufgabe wiederzugeben. Die Methode soll ein aufmerksames Zuhören und das Bewusst machen eigener Vorstellungen und Schwierigkeiten in einer Aufgabenstellung fördern, indem sich die SuS aktiv mit den Vorstellungen und Ansätzen des Partners auseinandersetzen.</td></tr>
</table>

Figure 5.2 Description of different formative assessment tools in a literature review.

For the final SAILS teachers' workshop in summer 2015, we set up an agenda, which was rich in variety. Unlike at the other workshops, we invited external speakers from Freiburg and Basel, who are prestigious nationwide and across the border in the field of assessment and inquiry learning. Those speakers provided examples of their work and gave much practical advice to the participating teachers. The topics covered the wide range from investigating the sinking of Titanic, via implementing assessment into case examples and connecting inquiry learning with smartphones. At the last of the two days of the workshop, we were supported by fellow SAILS colleague Gultekin Cakmaci, who gave insight into the connection between inquiry learning and technical education.

As a result of our TEP, we are able to meet many committed teachers and to build a network. Through the rich materials and units that were developed at the TEPs, the teachers are able to share their experience they made with other teachers. For this purpose, the German SAILS division will publish a special edition of a German teachers' journal, for which our teachers write articles. With this journal, we try to inspire the reading teachers to approach towards inquiry and formative assessment – this would not be possible, if our teachers had not developed so many ideas, units and materials during the TEP, which enable them to share them.

Arising from our preservice-TEP two master theses with a special focus on formative assessment in inquiry learning were written. The theses encompassed the implementations of SAILS-Units into the German school curriculum and were trialled at school.

Pre-service

Over the SAILS-project, IBSE and Assessment ideas, protocols, as well as experimental devices, were collected or bought by the SAILS-team in Germany. Students at the Leibniz Universität, Hannover, or of the "Studienseminaren", had the opportunity to borrow these materials. The frequent requests from students about using the materials (e.g. to present them at other university seminars or to test them in schools), is an indication of the interest to learn more, and to adapt ideas, about IBSE and assessment.

5.4 GREECE

In Greece, the URPC team tried to achieve two goals around the topics of inquiry science learning and new assessment methods through the TEPs:

- Raise awareness and Foster understanding
- Influence and change practice

By evaluating all the feedback from the TEPs, including feedback from both participants and facilitators, conclusions from the collected experience of the UPRC team can be summarized as follows:

- It is essential to provide hands-on experiences in the TEPs, both regarding IBSE and assessment.
- Teachers are looking for integrated scenarios with learning objects related to the national curriculum, in order to apply these scenarios in their classrooms.
- Everyone considers the classroom experience necessary, but in Greece an amendment of the national program is required to help implement IBSE scenarios in the classrooms.
- The use of technology (such as Labdiscs) in IBSE scenarios can motivate teachers and help them overcome the problems of inadequate or non-existent equipment for laboratories (as is the case for many Greek teachers).

The TEPs of this kind should be provided continuously, because they increase the confidence of teachers in teaching IBSE.

Apart from the positive feedback from the evaluation of the workshops and seminars that had been organized, they observed some very good results concerning the achievements of the above mentioned goals.

A. Prograduate programs at three universities addressed to in-service or prospective teachers have enriched related courses with the topic of “inquiry science learning and new assessment methods” and the SAILS material is being reused. More specifically, these new topics have been added into the curriculum of the postgraduate course “Instructional Design using New Technologies” offered at the MSc program on e-learning of the Department of Digital systems at Universty of Piraeus the curriculum of the postgraduate course module "Applied Pedagogy" offered by the MSc Program "Educational Technology and Development of Human Resources", organized by the University of Athens and the Piraeus University of Applied Science the course “Educational Evaluation” which is thought at the pedagogical training programme offered by ASPETE (School of Pedagogical and Technological Education)

B. Teachers from the private school "Saint Paul" (http://www.saintpaul-delasalle.gr/) participated to UPRC TEPs. These teachers, under the approval of the school principal, decided to apply inquiry based method and assessment methods in the teaching & learning practice. They did not just re-used SAILS but they enriched existing scenarios which they shared to the school teachers community. Three teacher from "Saint Paul" school were awarded with a prize by the Institute of Educational Policy, Greek Ministry of Education for those scenarios which have been uploaded in the Aesop Platform (http://aesop.iep.edu.gr/) as best practices.

C. The last UPRC TEP stage 2 program had been implemented as a one-day seminar. The audience was in-service teachers with different specialties (Phy / Math / Che / bio) and different levels of education (Lower and Upper Secondary Level). This time the whole set of SAILS Units were presented to teachers as exemplary IBSE scenarios. The teachers had graded high this activity and they asked the URPC team to re-use the SAILS material (case studies) along with the necessary equipment (due to the fact that resources are limited) in order to be capable to implement selected SAILS Case Studies at their classes.

5.5 HUNGARY

Photos were taken on the workshops and we required feed-backs from our teachers. The teachers uploaded their own IBSE plans and drafts to CoP Hungary. We had very positive feedback from the participants. We administered our own questionnaire to the pre-service teachers. According to our questionnaire, the pre-service teachers were satisfied with the teaching approach applied, with the IBSE experience and the structure of the workshop.

The key outcome of the TEP was that the participants committed themselves to the IBSE approach. Because of the barriers mentioned above, the teachers were beginners in IBSE, but the trainers’ instructions and the active sharing of knowledge during the workshops helped to break those barriers. The workshops provided good opportunity to deepen the interpretation of IBSE skills, to help each other in planning the IBSE tasks.

The key barriers of the IBSE-oriented assessment are the following: in Hungary, IBSE is not incorporated in the teaching practice. Regarding assessment we have national competence assessment only in mathematics and in reading comprehension along the lines of PISA. There is no national assessment regarding science, there is assessment data only from the students who choose

science in the maturation exam. The tasks of the maturation exam are not focused on IBSE tasks and skills, so there is a lack of IBSE-oriented national assessment in Hungary.

5.6 IRELAND

In-service teachers

It is clear that the nearly 100 teachers who participated in the SAILS TEPs benefitted from the SAILS approach to inquiry and assessment. The have actively engaged in workshop activities and discussions and have returned for subsequent workshops brimming with new ideas and enthusiasm for the SAILS approach. They have presented their experiences of trialling inquiry and assessment practices in the classroom, shared students artefacts and the judgements made by them on their student learning. Resources in the Community of Practice website show how they changed classes they had taught in essentially the same way for many years, to being more student-centred, more inquiry-based, and with a greater prominence for student discussion and less teacher-led dialogue. Some of these teachers and the science education researchers implementing the SAILS workshops have developed a dynamic working relationship in which resources and experiences are exchanged and discussed. These teachers have presented their inquiry and assessment practices at national science teacher's conferences, two have facilitated classroom recordings of their practices to be shared on the SAILS website and one Irish teacher has shared his experiences at the final SAILS conference in Brussels in November 2015. Three Irish teachers, three from Portugal and four from the UK came together in October 2015 to develop new draft SAILS units. These ten teachers have maintained communication and development of these units using a WhatsApp group and email communication. The three Portuguese teachers subsequently visited Dublin in December 2015 to further collaboration and contributed to the assessment practice in a lower secondary classroom doing one of the SAILS units.

However, the impact of SAILS TEPs goes beyond those that directly participated in the workshops. Many of the teachers that participated in SAILS TEPs have shared their experiences with colleagues in their schools whom had not attended SAILS workshops, and some even have designed classes together. One example of this is a mid-to-late career teacher who came to the SAILS workshops to look for ways to revive his teaching that he felt had become stale. He then spent the summer rethinking and redesigning science lessons for 12-15 year olds in his school. Less than a month into the next school year, he and a colleague had set up a Science club for students of that age group that meets weekly to do extracurricular science-related activities. Together with the woodwork teacher, he has facilitated students to construct a three-dimensional food pyramid out of wood and populate it themselves with food items from the supermarket. He had carried out all of this pre-work in advance of implementing the *Food labels* unit with his students and is strongly encouraging his colleagues to also adopt this unit in their teaching.

Following on from the SAILS TEPs in Ireland, the DCU team will facilitate its annual teachers Summer School on IBSE and assessment. This will be the cornerstone of ongoing engagement and communication with in-service teachers interested in IBSE and assessment of inquiry learning in science.

Pre-service Teachers

The SAILS project has had a big influence on pre-service science teacher education courses in Dublin City University. Firstly, the academics themselves now have a greater understanding of a broader range of inquiry goals and activities, and this has influenced their teaching of future teachers greatly. Not only are many SAILS units and activities now embedded in the modules these pre-service teachers take, many other activities are indirectly informed by this. Furthermore, some of the pre-service teachers have developed their Masters dissertations into studies on the implementation of inquiry and assessment.

Feedback was sought from both roups of pre-service students: Group A refers to undergraduate PSTs who were pursing a concurrent model of teacher education and Group B referes to graduate PSTs who were pursing a consecutive model of teacher education.

Group A: Feedback from student teachers on the *Speed* DU:

- "This week we felt that the activity was very engaging and really got us thinking about the concept of speed" (Group 6)
- "We also think that the first question is good as it is not spoon-feeding the students the method of how to do the investigations - instead, it is allowing the student to apply their knowledge and really think about what they think they should do" (Group 6)
- "One thing we would do with this question, however, is we would instruct the students to compare their answers in pairs once they have completed the planning and discuss any differences in their planning." (Group 6)
- [the experiment] "Encourages group work and discussion and debate" (Group 1)

Assessing teacher-student dialogue during the Classroom Dialogue activity:

- "We felt this was better than the first, as it concentrated more on student discussion rather than the teacher just talking. The teacher also did not dismiss any answers, they praised the effort and encouraged the student to try again." (Group 2)
- "We also like how the students aren't just recalling facts in this dialogue, instead they are saying what they thought about different things." (Group 6)
- "The teacher is doing the majority of the talking, the lesson could be improved if the students were encouraged to talk more." (Group 3)
- "The students are explaining their answers more as they are constantly using the word "because". The students are more eager to tell the class their answers, this is indicated in all of the class putting their hands up. This is a very inquiry based lesson." (Group 3)

Group B: Examples of pre-service teachers work and reflections are included here as evidence of the impact of the TEP. They show how pre-service teachers integrated the learning from the TEP when developing and implementing IBSEA units as part of their module assignment.

One pre-service teacher used student reflection journals to assess student learning. These included questions:

- What did you do in science today?
- What did you learn about today's topic?
- Write down any questions or comments you have on today's class

Another pre-service teacher develedop a a rubric that evaluated the design of an experiment poster to detect the Presence of Dissolved Substances in Water Sample.

Criteria	1	2	3	4
ORGANISATION	Clutter, no visible structure, all over the place	Hard to follow, missing parts, obviously needs refinement	All present but unclear, must reread for clarity	Defined sections, clear heading, flows well, finished product
CREATIVITY	No use of colour or diagrams Bland, no variation	Very little use of colours or pictures but enough to engage and hold attention	Some use of colours and diagrams Engaging but not stimulating	Aesthetically appealing use of colour, diagrams and text Interesting and engaging
SCIENCE CONTENT AND LITERACY	No analysis of science topic, no explanation, no specific science connection	Poor explanation, inaccurate science connection	Adequate explanation Science connection present but could be developed further	Experiment design fully and properly explained Specific science connections made Content is comprehensive and well supported

The same pre-service teacher asked students to complete a reflection on their progress in relation to the class learning outcomes. This helped the students identify what they had achieved and still needed to work on. Equally it provided the same information to the teacher that was used then to design the following lessons instructions:

Student Learning Outcomes Rubrics

At the end of this lesson I will be able to :	Red	Yellow	Green
List and Explain the different stages of the Water Cycle			
Explain that some dissolved compounds, including compound of calcium cause hardness in water			
Conduct an experiment to test water for water hardness			
List the advantages and disadvantages of Hard/Soft Water			
Explain that water hardness can be removed using an Ion Exchanger			

At the end of this lesson I will be able to :	Red	Yellow	Green
List and Explain the different stages of the Water Cycle			

Explain that some dissolved compounds, including compound of calcium cause hardness in water			
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List the advantages and disadvantages of Hard/Soft Water			
Explain that water hardness can be removed using an Ion Exchanger			

Pre-service teachers reflections on their implementation of IBSEA activities proved useful indicators of the impact of the TEP. Two examples of reflections are provided as evidence of this.

Example 1:

The key objectives of today's class were for the students to develop good observation skill and to develop a hypothesis and offer up explanations for their findings. I used a clip from Youtube called The Bell Jar experiment – Sound. I played the video in 3 parts, allowing sufficient time for each group to write down their observations. I handed out one sheet per group, as I found in the previous lesson with each student having their own activity sheet, they tended to work individually more than in a group. The students had to discuss who would take on different roles in the activity.

After each stage of the video, I circulated around the classroom and went to each group and sat with them. I asked the students could they offer up their observations for each stage. I asked if they could offer me a reason for their thinking, and did not push the students in the direction I wanted them to go until they saw the third stage of the video and to see if their opinions changed.

Throughout each stage I encouraged the students to write down everything they had observed, even if they think it may be irrelevant, but just to have all their sightings written down to help draw up a concise hypothesis. I went through each group's hypothesis on the board. I then asked each group "what does this tell us about sound?" and pressed them to explain to me what they think that meant. When a correct answer was offered I didn't agree straight away but asked the other groups what they thought. In the end we all agreed when the bell rings, it vibrates and this in turn causes the air particles to vibrate in a motion called a wave. Therefore the sound wave then travels to our ears and we can hear it.

Example 2:

1. Did the lesson work?

I felt this lesson worked very well because the students were able to see the different densities of objects first hand and in different situations. The students really enjoyed being able to work at different stations, and carrying out different fun experiments at each. This was the first time I have done this in my teaching, so I was nervous about how it would work but overall I was pleased about how the lesson worked out.

The students were amazed by how the experiments worked and their results. They did not expect most of the results to come out how they did. I know this from looking at their worksheets and through the discussion at the end of class.

2. Did the students learn what I had hoped they would learn?

I do believe the students learnt what I had hoped for them to learn, because at the end of class when we were discussion the results of each experiment they were able to tell me the objects/liquids had different densities. I did have to prompt them to talk about their masses and their volumes, and how they did/didn't change. An example was the tinfoil test, when scrunched up into a ball its mass didn't change but its volume did and that is why it sank. These experiments allowed the students to see how both mass and volume are important in the density of an object.

3. What strategies where effective?

The strategy I found most effective was they students working in groups to carry out their experiments. It made the students think for themselves instead of waiting for a teacher to tell you how to do things. They had instructions to follow which really helped them. They students working together also helped them understand density more, as they taught each other and helped one another understand what was happening in the experiment.

National Curriculum Change

At present, the Irish lower secondary Science curriculum (for 12-15 year olds) is being changed, to be more in line with the aims and goals of inquiry. Crucially, this includes changes to the terminal state examination and a number of nationwide in-service courses for all practicing science teachers, starting in autumn 2015.

Since one of the members of the Irish SAILS team is part of the development group, and others have attended SAILS workshops, SAILS has impacted on the thinking behind the proposed new syllabus. The ability to show concrete examples trialled in several European countries has helped the entire development group to an understanding of how inquiry may be applied and assessed in classroom teaching and in examinations.

About half of the people who will implement the nationwide in-service courses have attended the SAILS workshops. To what extent these have influenced their thinking is hard to assess objectively, but it is clear that their courses align well with the SAILS TEP. Thanks to SAILS their nationwide audience will comprise at least 100 teachers who are more receptive and more tuned in to the in-service program and are likely to advocate the changes than would otherwise have been the case

5.7 POLAND

In 2008, a new core curriculum was introduced in Poland. In its learning objectives and general requirements a number of inquiry-related skills were included: *students note down observations, draw conclusions, analyze the data, etc*. Thus the legislator indicated what skills students should possess, but no form of the objectives accomplishment process was imposed. The application of the Inquiry-Based Science Education method, although not mandatory, seems to be the natural choice. For that reason teachers are keen to take part in training, in which they can acquire theoretical knowledge and practical skills concerning the application of IBSE.

At the Jagiellonian University, a number of projects under the 7th EU Framework Programme have been implemented. The beginnings of the IBSE implementation and teacher training in that area are associated with the implementation of the Fibonacci project at the JU Faculty of Physics and the ESTABLISH project at the JU Faculty of Chemistry. As part of those projects, the first curricula for pre-service and in-service teachers in the field of IBSE have been developed. The implementation of the SAILS project allowed to further develop the previously created programmes and to supplement them with the elements of the assessment of students working with that method. Currently, the developed model of students' education in the field of IBSE is an integral element of didactic courses. Therefore, it may be concluded that the education of students in that area will be continued, even though the project has already been completed.

The training sessions for in-service teachers carried out as part of the SAILS project were attended by more than 200 teachers from across Poland, representing various levels and profiles of education. As a result, we managed not only to convey knowledge and skills in the field of IBSE, but also to create a community of people who are convinced of the high value of those methods and who want to use them in practice. An evaluation survey was used with the last cohort of in-service teachers. The participants had to describe what elements of the training were: unknown, new, interesting, boring, useful, and useless. In addition, they were asked to comment on training issues: syllabus, form of realization, instructors and technical issues. A basic analysis of this survey indicates that the IBSE methodology is new and interesting for teachers. As the most useful part of the training, participants have chosen laboratory classes and the integration of ICT with IBSE.
The fact is confirmed, for example, by the participation of over 70 teachers who have completed the training under the SAILS project in a national conference summarizing the project. During the conference, the teachers presented their achievements in the application of IBSE, materials developed, students' reactions, etc., which was met with great approval of other participants.

The idea of using IBSE will be further developed and promoted by the JU. Currently, we have proceeded to the implementation of other projects closely related to the method discussed:

The IRRESISTIBLE FP7 project including the use of IBSE in the context of RRI (Responsible Research and Innovation), nanotechnology and informal education.

Academic Center of Creativity, where the training of teachers in the field of IBSE is carried out.

In both of those projects, the teacher training components developed in the SAILS project are used. Moreover, both of them involve teachers who have participated in the SAILS project and previous projects as well. Thanks to the knowledge and experience they gained, they can now act as tutors and help their colleagues in applying IBSE.

5.8 PORTUGAL

SAILS project provide several teachers education programmes (TEPs) developed along three years. Those programmes suit the needs of the Portuguese teachers in content and as well as in format and agenda. Different kinds of workshops were provided to in-service and pre-service teachers.

Pre-service teachers have explored inquiry and assessment in two different moments across the years 2013 and 2014. The Lake and the Beach project allowed students to create didactic resources concerning an IBSE approach and its assessment. They turned out to feel more confident developing IBSE activities and inquiry competencies in the classroom. They state that the development of inquiry activities in the classroom allows them to promote creativity, curiosity, independence, and ability to investigate the surrounding environment. Pre-service teachers felt that the participation in these activities is valuable to students and that the promotion of their autonomy and the integrated exploration of different curriculum subjects have a positive impact in their learning progress.

In-service teachers had the opportunity to participate in three workshops. The three TEPs were accredited by the national agency, the scientific committee for teachers' continuous education. Portuguese TEPs completely fits the SAILS goals.

A set of workshops were carried out. The TEPs involve face-to-face sessions, collaborative work under the CoP and, individual and/or peer work. In 2013 the main focus was on inquiry and the introduction to the Community of Practice (CoP) with two training courses "School in the Vegetable Garden: Science curriculum development", and "Why is there so much talk about INQUIRY across Europe? A proposal to work with the science curriculum in the classroom"; in 2014 the main focus was on assessment and the CoP development with the training course "Assessment *to* and *for* Learning: What, How and Why to assess? - A proposal for the development of assessment strategies applied to Inquiry tasks in Sciences classroom"; in 2015 the focus was on integrated assessment and inquiry and the CoP as a plain resource for teachers with the final training workshop named "Inquiry tasks and Assessment".

The impact on Portuguese teachers was very positive. They demonstrated a full interest in SAILS TEPs with an active participation and engaging discussions. The workshops format allowed the exchange of experiences between teachers and collaborative work, which contributed to the promotion of a more critical and reflective action.

"The training held in face-to-face sessions and in parallel with the COP, highlighted several points, including sharing activities/training sessions focused on the development of inquiry tasks as well as the accomplishment of experiments whose core objective is the context of inquiry tasks and assessment. It is to mention that such exchange of experiences and materials between all participants through the CoP was quite enriching and positive enabling a broader view on the potential and constraints of implementing inquiry activities."

The group of Portuguese pilot teachers came mostly from the first TEP. Some of the teachers' proposals became part of Sails case studies. Sails project has also provided the opportunity for teachers to develop their work and to be recognised by the international partners and peers. They felt that their effort was recognised and their contribution turns to be more effective as the time was passing by. The first TEP has also provided knowledge and experience and those teachers were a fundamental element because they brought their previous experience in SAILS to the next TEPs. The activities have been discussed and applied previously in schools so that the teachers who attended

the new courses could hear from other teachers' experience. This was a very significant way to get together the academic research and teachers practice.

In an holistic way teachers felt that inquiry activities led students "*to experience and live unique moments of pleasure and discovery*" and that the workshops contributed effectively to transfer those practices to the classroom in order to encourage children's interest in science and research. Teachers developed curriculum management activities and frequently resorted to interdisciplinary subjects. They felt more motivated and somehow changed their teaching practices. Furthermore it was sustained by some teachers the progresses revealed on students' behaviour in the classroom, "*this methodology also helps fight indiscipline, apart from making the learning closer to everyday life*".

The proposed assessment was welcomed. The formative assessment was seen as a positive point lightened the negativity that often appears associated to assessment. Teachers adopted easily the assessment perspective proposed by SAILS project. The proposed framework "*helps the student to face the assessment for learning, so students can face the positive evaluation mode allowing them to set individual goals towards the improvement and development of their learning*". In addition, the feedback practices were recognised as an important part of the teachers work in the classroom "*feedback is essential for students to achieve the goals. Feedback helped/guided students to successively overcome the different stages of their work*."

It is relevant to mention that some of the teachers that attended the workshops were at the XVI National Meeting on Science Education and chosen deliberately to attend the SAILS conference and the SAILS workshop. A teacher wrote that "*I was glad when Chris Harrison says: "When teachers share their practice with others, they begin to understand their own practice better*". *That is the spirit behind the communities of practice, proposed and encouraged by SAILS Project*."

Another one said, "*The inquiry methodology promoted by SAILS is a foundation that should be the focus of the needed change in science education in Europe/Portugal*."

Finally a significant number of teachers came back to the Institute of Education in order to improve their professional development in education by participating in master and doctoral programmes.

Quotes from teachers' individual written reflections:

The assessment framework facilitates the student to face the assessment for learning, so the students can face the positive evaluation mode allowing them to set individual goals towards the improvement and development of their learning. In the construction of this instrument I had difficulty in the definition of the descriptors in an accessible language to the students. Follow the proposals in the training session using the performance levels Emerging, Developing, Consolidating and Extending converting the assessment framework in a learning progression scale. (Teacher A)

I emphasize the difference that I observed in the course of group working lessons: more productive and without conflict, compared to more expository classes. Students showed up clearly more motivated, autonomous and quiet, which usually (especially in classes taught in Friday at the last evening time) showed impatience, difficulty concentrating and even some indiscipline. Another aspect I noted was the cooperation between the different working groups, which arose spontaneously and often by students over irregular academic performance. (…) I observed that in general the students throughout the year revealed major difficulties with the scientific content and more formal assessment were the ones that showed the best performance in terms of development and involvement in the tasks required. (Teacher B)

Feedback is essential for students to achieve the goals. During the activity was through the feedback that helped/guided the most students to successively overcome the different stages of their work, and used, in many cases, little questions that students were responding after search; other times were the students who made the questions so as to draw their doubts that were emerging during the search moments. I consider that the application of inquiry tasks makes a difference in the final results, because students feel more involved and motivated. The use of this methodology also helps fight indiscipline, apart from making the learning more close to everyday life. (Teacher C)

The training held in face to face sessions and in parallel with the COP, potentiated several aspects, including sharing activities / formation sessions focused on the development of tasks centred on inquiry as well as the realization of experiments whose core objective is centrally in the inquiry tasks assessment context. It is to mention that such exchange of experiences and materials between all stakeholders through the CoP was quite enriching and positive enabling a broader view on the potential and constraints of implementing inquiry activities. (Teacher D)

5.9 SLOVAKIA

In-service Teachers

There is a systematic approach to teachers´ professional development in Slovakia. Firstly, there is a system of accredited courses that are offered by different institutions so that teachers can apply and participate. Depending on the type of the course it is finished by a presentation of the work resulting from the course goals and done by a participant in front of a 3-member board or a written work on a specific topic with regard to the course content. Secondly, teachers can develop a thesis (1st attestation about 30 pages, 2nd attestation around 50-70 pages) on a selected topic concerning science education that is submitted, reviewed and defended in front of a board. After successful course completion or defence teachers are awarded credits that count for their professional career development.

The accredited course on Innovative methods in Science Education has been developed at the Faculty of Science, Pavol Jozef Safarik University and offered to teachers. The content of the course was in correspondence with SAILS project goals. As a result, teachers were asked to develop a lesson plan on IBSE implemented with assessment tools. The lesson plan was presented at the final presentation in front of a 3-member board.

There were also a number of teachers who, as a result of the course, decided to follow with developing a thesis. The topics of the theses were connected with IBSE and assessment in several cases.

Examples of theses:

Chemistry: Formative assessment of inquiry activities, Inquiry activities in teaching of Chemical mixtures, Inquiry activities on Natural substances, From inquiry to project-based method, Inquiry activities on Detergents, Inquiry in teaching about Soap, Inquiry in teaching Acids, bases and salts.

Biology: Inquiry activities for upper secondary school “Body and water”, Enjoy to learn biology with inquiry, How do I know first aid? Student self-assessment before and after lessons.

Physics: Implementation of interactive methods in teaching physics in technical school, Inquiry activities aimed at development of selected inquiry skills at lower secondary level, Development of inquiry skills in physics education in upper secondary level, Modelling of physical phenomena in COACH system, Inquiry methods in teaching Optics

Pre-service teachers

In 2013 within a European City of Culture Project there was a Steel Park built in Kosice. It was a result of cooperation between U.S. Steel Košice and scientific institutions - Technical University in Košice, University P. J. Šafárik and Slovak Academy of Sciences. The exhibition offers to visitors the active playing with more than 50 exhibits demonstrating the story of steel, from the area of metallurgy, geology, physics, chemistry, safety, engineering, and other.

Within the Steel Park there was also an **inquiry science laboratory** designed. The aim of the inquiry lab is to provide space for students from secondary schools to come and participate at inquiry activities. There is a selection of activities offered for teachers to apply. The activities are usually enhanced by digital tools (measuring with sensors) and they are complemented by self-assessment tools. The activities have been adapted from already existing activities by pre-service physics teachers. The activities in the lab are led also by **pre-service teachers who have taken part in pre-service education on IBSE and assessment**. Up to now there were about 3000 upper secondary school students participating in different inquiry activities there. The teaching materials used in the lab are offered to teachers to use in their own classrooms.

Examples of inquiry activities: Can we measure the weight of air? (density of air), What is the refraction index of water? (using laser distance meter), How does bat measure distance? (walking according to graph in front of a ultrasonic position sensor), There was a crime (chemical analysis of samples in order to catch the murderer) , How do we breathe? (basic principles of breathing, model of lungs), Hydrogen-powered car.

Follow-up projects

As a result of experience gained within ESTABLISH and SAILS projects there are national projects running on IBSE or new projects are being prepared with relation to IBSE at secondary and also undergraduate level. The **national project VEMIV** (Faculty of Science as a coordinator) is aimed at research on efficiency of innovative methods in mathematics, physics and informatics. Within the project there are existing activities on IBSE adapted (developed within Establish, Sails and other projects) or developed and teacher training on IBSE is carried out. There are 6 upper secondary schools participating and cooperating with Faculty of Science involved in the project. After teacher training course aimed at development of teachers´ skills and abilities to use inquiry in the classroom teachers implement inquiry activities in their classrooms across three disciplines: physics, mathematics and informatics. During the experimental teaching the development of inquiry skills is monitored and evaluated. The project involves **physics teachers who already participated at teacher trainings in IBSE** and consequently they can help and cooperate with teachers from other subjects in order to implement IBSE strategies within all three subjects.

The **national project Innovation of content, forms and methodology of laboratory practices** in the study programs of Inorganic, organic, Analytical Chemistry and Biochemistry is aimed at students at undergraduate and graduate level. The project focuses on innovation of laboratory practices towards implementation of modern synthetic and analytic methods and inquiry-based learning.

There is a large **national project IT academy** being prepared. The goal of the project is to improve education in informatics and science and mathematics at secondary level through wide implementation of IBSE strategies enhanced by digital technologies. One of the project goals is to design an interdisciplinary subject aimed at inquiry science activities enhanced by digital technologies. The project will start in 2016 and will reach 60 lower secondary schools and 30 upper secondary schools and much more teachers in Slovakia.

5.10 SWEDEN (HKR)

In Sweden (HKR), we have collected evidence of: (a) Adaptations of existing SAILS units and (b) Teachers' own original inquiry activities (including samples of student work).

The following units have been transladed and adapted to Swedish conditions:

- Natural selection.
- Plant nutrition
- Up there – How is it?

Teachers have developed a number of own inquiry activities, some of which has been developed into SAILS units (marked with asterisk):

- Hearing protection in school
- Energy sources
- Sports nutrition*
- Global warming*
- Using scientific information about water

5.10 TURKEY

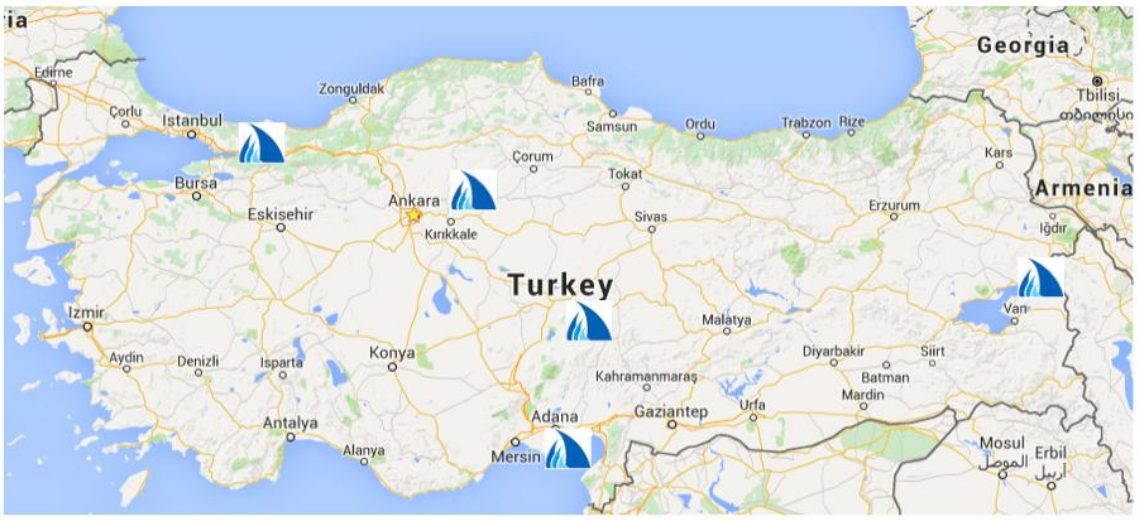
The main impact of the SAILS project in Turkey has been on in-service and pre-service teachers. More than 300 in-service teachers in 5 different cities have involved in SAILS workshops. Through 4 conferences in Turkey, SAILS resources were delivered to wider audiences. Two SAILS books were translated into Turkish and will be available in use for teachers in December 2015.

SAILS Teacher Workshops

In-service TEP

More than 300 in-service teachers in 5 different cities have involved in SAILS workshops. Two 2-day workshops on inquiry-based science teaching (IBST) and assessment were held in Ankara, Kocaeli, Van, Kayseri and Adana. Participants of the workshops were Grades 6-8 science teachers. The workshops mainly focused on IBST activities and strategies for assessment of IBST. Selected teachers who participated in previous SAILS workshops shared their experiences and challenges while implementing IBST activities in their classrooms. After the first workshop, teachers implemented SAILS units in their classrooms. After the implementation, second 2-day workshop was organized to get their experience on the implementation phase and modified our TEP program based on that. Based on teachers' reflective reports and responses, SAILS workshops have an important impact on

their classroom practices. By considering significant number of SAILS teachers, more than 30000 students have influenced by SAILS per year.



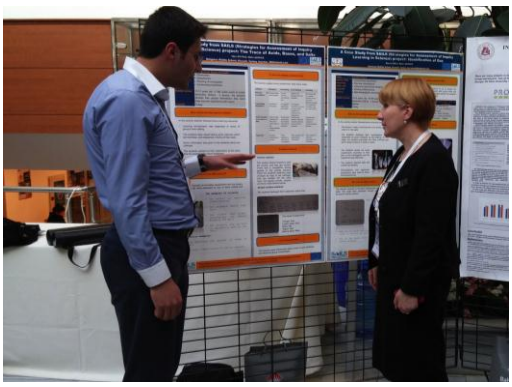
Pre-service TEP

More than 200 pre-service teachers have involved in SAILS workshops at Hacettepe University. The pre-service teachers participated in TEP programs were undergraduate students who were training to become elementary school or middle school science teachers. All of the pre-service teachers supposed to teach science when they graduate and become teachers. They had little experience with inquiry based science education or various assessment methods before participating in pre-service SAILS TEP.

Wider dissemination through conference presentation

SAILS Turkey team has presented papers in 4 conferences in Turkey:

- IOSTE Eurasia Regional Symposium 2013, Antalya. http://www.ioste2013.org
- III. National Chemistry Education Conference, Trabzon. http://oyegm.meb.gov.tr/www/3-ulusal-kimya-egitimi-kongresi/icerik/158
- IOSTE Eurasia Regional Symposium 2015, Istanbul. http://ioste2015.org



SAILS team member, Metin Sardag, presents his poster at IOSTE 2015 in Istanbul.

In September 2015, SAILS Teacher Conference (STEM teacher conference (SAILS - Strategies for Assessment of Inquiry Learning in Science) was organized in conjunction with "STEM & Makers Fest/Expo" in Ankara. Around 2000 participants from 3 years old have attended and engaged with IBSE activities. Around 700 teachers have participated in 26 workshops. Many EU-funded projects and national projects were presented in a workshop format. This event influenced over many stakeholders and researchers to re-orient their practical communication efforts around the cultivation of dialogue between STEM and the public. (Url: http://www.stemandmakers.com)

Some pictures from this event are presented here.

Invited speakers are answering questions from the audience. SAILS team members, Gokhan Kaya and Metin Sardag, run a SAILS workshop

Team of Feza Gursey Science Center running a science show. URL for the video: http://www.stemandmakers.com/portfolio/stem-makers-festexpo-turkiye-2015/.

5.11 UNITED KINGDOM

The main impact of the SAILS project has been on teachers through the TEP. About 50 practicing teachers have been involved in 28 schools. The schools were all secondary 11-16 year old students or 11-19 year old students and covered the full range of science subjects.

Strengths of the TEP

The teachers were fully engaged in the TEP sessions and reported that they learnt many aspects of inquiry and its assessment from SAILS. All teachers trialled inquiry activities that they had been introduced to on the TEP with their classes; some teachers shard the ideas with other teachers in their schools and a few developed their own inquiry activities.

A. In one inquiry that was developed the teacher shared with the students at the start of the lesson what the inquiry was about "investigating the effects of caffeine on reaction rates". She then explained they would choose how to go about this and as a team do the inquiry. She stated she was going to assess their 'group work' and planning. The teacher use a PMI sheet, where students write down a plusses, minuses and interesting points. This is formative assessment AFL because it shows the students taking a lead in their own learning. Using the PMI is a tool to get them actively involved in self assessment and identifying their next steps, then acting on these It also provides an opportunity to open up a dialogue between teacher and student and student and teacher. Sharing the learning intentions such as openly stating this is an inquiry lesson and we are focussing on the inquiry skills 'group work' and 'evaluating our plans' is another example of AFL in practice. Here are three samples of what was written:

- *P: This time everyone had equal work loads so everybody contributed equally*
- *M: I did not stay with or co-operate with my group as much as I usually would*
- *I:The drastic change in reaction rate time was very interesting as I have never before had coffee*

- *P: You achieve more if you work as a team.*
- *It is easier to work when you have a good plan*
- *M: Managing my time better, give ourselves a limited schedule for the lesson.*
- *I: What is it that caffeine does to your body?*

- *P: I think that structuring our plan was efficient as it meant we knew what to look for*
- *M: We didn't identify our variables so our results weren't accurate*
- *I: How does sugar affect our reaction times?*

B. An inquiry was adapted from an experiment on photosynthesis. The experiment is a common one in British schools and was changed to incorporate aspects of inquiry that included assessing the method and teamwork. See file WP4-KCL-ASE2015 for details.

C. An original inquiry was developed on the idea of a droplet of ink. The inquiry was to find out what affects the size of an ink splat when a droplet hit a surface. The type of surface, size of drop, height, temperature and constituent of the ink were all factors that could be investigated.

D. One school did a student survey to capture the students' perceptions of how learning in science had changed because of IBSE.

E. There was evidence of new strategies to promote collaboration and groupwork as a result of the IBSE activities. In one inquiry, the students were asked, in groups, to write down their method for finding the rates of reaction on an *Inquiry Sheet*. After a discussion in the next lesson they were asked to write down on the *Inquiry Sheet,* in a different colour, how they could improve their method. When the students had completed the investigations the groups had to send an envoy to the next group to both explain what they did in their experiment and the data collected, and to listen to how the other group had done their inquiry. Then the students evaluated how well they had explained the inquiry and the results to each other. An *Evaluation Record* was agreed and completed by the students.

One aspect that they worked on was finding ways of enabling students to be comfortable with open situations where they had some control over what they were doing. As one teacher put it; 'SAILS and inquiry learning really puts the student in the driving seat'. Some teachers reported that it had revitalised their teaching and commitment to it. Students and teachers understood that there was a learning journey where the students could value and develop their inquiry skills. The change in emphasis meant that students had to change their behaviour, but also the teachers, as one said 'I realised that I had been programmed to teach in a certain way and I had to change role', there was a change in mindset.

Questions were asked during inquiries that opened up the possibilities, rather than restricting what the students could do. The teachers were aware that, 'even your body language can close down an enthusiastic child's route forward'. Realisations such as this indicate the extent to which teachers were able to reflect on and develop their own practice.

Assessment procedures

Assessment techniques were introduced to the teachers, such as rubrics, place mats and learning landscapes, so that range of inquiry skills, including teamwork and collaboration, were assessed during the inquiry activity. The teachers became confident in using these techniques and assessing students and began to use this data to give feedback to students, so that they could improve what their skills further. Teachers realised that they could build up their assessment data over weeks or months with different groups of students being focused on in a lesson. One teacher said 'I will come back to reflect on the evidence [from observations and written work] to see progression'.

Teachers learnt much more about students and their misconceptions through listening to student-talk. The teachers also used probing questions to tap into student thinking, while at the same time ensuring their questions did not steer the learners away from the inquiry path they had decided to follow. The assessment of group-work led to a greater understanding of students; 'The lesson on gender was an eye-opener for me, as I had not thought about it, I started noticing more about gender gaps and I have gained more clarity about why a student is acting the way they do'. Another teacher said 'I am more into my students heads [because I listen to them]'. An understanding of peer assessment was developed and helped students reflect on their skills.

Several of the teachers helped in the dissemination of SAILs by taking lead roles in some of our workshops. One teacher also organised a professional development session for the whole school staff, where the teachers looked at how they might translate the inquiry ideas into other subject areas. This not only created interest in the Project but also guaranteed sustainability beyond the time frame of the project.

Student engagement

An important impact is shown by the way students responded to inquiry lessons. About 6000 students were involved with inquiry lessons and their response is key to realising the impact of SAILS. Teachers reported overwhelmingly that the students learnt well, enjoyed the activities and were involved in inquiry lessons. 'Students become more resilient and self-aware', 'They learnt a lot even though they were not used to inquiry, and they really enjoyed it'. In general the increased engagement of students in inquiry lessons, as compared to traditional lessons was noted. Students reported that they enjoyed the inquiry lessons more; 'Yeah, there're much better, you can do things and you don't have the teacher telling you what to do all the time', and 'I really enjoyed that, you can talk and it doesn't matter if you go wrong, you can think about it'. Teachers found they were often surprised how 'low attaining' students did inquiries well. The involvement and success of students who were seen as less able is important in raising the profile of science and it being seen positively.

Pre-service TEP

The TEP has also been integrated into the Postgraduate Certificate of Education (PGCE) and Schools Direct routes into pre-service teaching. This involves about 70 pre-service teachers per year, which means more than 200 have been involved since the start of the project. The TEP incorporates some of the activities from in-service teachers course, adapted for these less experienced teachers, and has 6 sessions, 3 delivered at King's College and 3 externally. The initial focus is on helping pre-service teachers conceptualise what inquiry is in science classrooms and challenges their often narrow 'fair test' approach, that is often used in schools. The aim is to educate pre-service teachers to learn to understand the principles of different forms of inquiry, different ways of assessing, and also to develop their own inquiry activities in the classroom. Aspects of inquiry are also encouraged within other workshop sessions on the PGCE course so that pre-service teachers come to accept this approach as the 'norm' and not an addition to their normal teaching. Pre-service teachers, over the last 3 years, have been very interested in the inquiry approach and while they have some concerns over classroom management in such an open situation in the learning context, many have reported how they have tried inquiry activities or parts of activities in their teaching.

Publications

A 60 page A4 TEP booklet, with resources has been produced to guide professional development providers through the process of running an effective teacher education programme. Differentiation has been included to meet the needs of in-training teachers, newly qualified teachers and more experienced in-service teachers. There is an accompanying A5 Teacher Inquiry Diary and a USB card - containing both publications, power-point slides, resource sheets and a vod-cast from one of the original project teachers. Together they provide everything that is necessary to replicate four three hour TEP sessions over a year.

These materials are being distributed through an open access Kings College University portal. Further dissemination to international and national science educators will be achieved through a series of workshops at the Association for Science Education (ASE) annual conference January 2016. Further dissemination will occur

through STEM Learning Centres in the UK, other universities and through clusters of schools throughout the year.

A three page A4 colour pamphlet has been created with two examples of 'stand alone' inquires, including guidance on managing the assessment process. These teaching ideas are being disseminated through the open access Kings College university portal and then through a range of science workshops at the ASE annual conference, their portal and regional teacher meetings throughout 2016.

We have had one paper published in Science Education International and an article on the project in Science Teacher Education. Three papers were presented in the ESERA 2016 conference in Helsinki. There have also been presentations at the *National Association for Research in Science teaching* (NARST) conference Several other papers on the project and how the teachers responded to the TEP are under construction.

Wider dissemination

There have been a range of presentation to educators at all levels. The *Association for Science Education* (ASE) has over 8000 members and runs international conferences, as well as eight regional ones. We have also presented to the Biology Education Research Group (BERG), Association of Science Tutors (ATSE), National Advisors and Inspectors in Science (NAIGs), Primary Science Trust (PSST) and the Education Group of ASE. There will be presentations, with SAILS teachers involved, at the 2016 Annual ASE conference sessions on the International Day and at the main conference. There have also been 6 Regional conference and 10 regional meetings in last 2 years and Professional Learning Conference for ASE in July 2015.

6. Conclusions

The SAILS IBSE Teacher Education and Assessment programme, Stage 2 has been presented in this report. Details have been given about how assessment frameworks and instruments were incorporated into the teacher education programmes in each of the partner countries. Furthermore, the overall effect on the teachers and their attitudes to assessment has been outlined, including both responses to SAILS teachers questionnaires and additional evidence as reported by the partners.

Taken together, the objectives of work package 4 have been successfully reached by implementing TEPs in IBSE with the 3rd cohort of teachers and follow-on programmes with 1st and 2nd cohorts of teachers. In all, over 2,500 teachers have attended the SAILS TEPs over the duration of this project.

By explicitly addressing the major constraints in implementing IBSE oriented assessment practices in classrooms, as perceived by the teachers, the SAILS project has also equipped the teachers with the power to actively engage in the transformation of these obstacles into manageable challenges. Not least in changing traditional approaches to teaching and assessing towards IBSE and formative-assessment practices in their own classrooms and schools.

The focus on assessment as an integral part of learning was a cornerstone of the SAILS Teacher Education Programmes. SAILS workshops have supported teachers in using assessment strategies to make judgments and give feedback to their students on how to improve their learning. An additional tenet of the teacher education programmes was that teachers should experience the inquiry and assessment practices themselves as learners. In this way the teachers can realise the skills involved in inquiry learning, how learners are more active in the learning process and how they can do science as well as learning about it. Teachers developed strategies for students to work collaboratively in their own classrooms, being particularly aware of cultural and gender issues.

As evidenced by the analysis of questionnaires completed by 305 in-service teachers (both initial and final) all participating teachers' understanding of inquiry changed significantly following the TEP. When teachers were asked to indicate the frequency with which they use a range of inquiry practices, 50% teachers reported that they frequently include seven of these inquiry practices (Analyse their own data, Justify their conclusions, Develop their own conclusions from investigations, Present their results and conclusions from investigations, Have opportunities to talk and listen to each other in the inquiry classroom, Have opportunities to develop empathy with their peers in the inquiry classroom, Respect and understand each other in the inquiry classroom) in their classroom. Prior to the workshops the proportion of teachers that were condifdent in assessing these practices varied from 35%-53%. Following the TEP, the proportion of teachers who were confident in assessing these practices increased significantly, varying from 62%-84%. A similar increase in confidence was seen with less frequently implemented inquiry practices. Considering the range of practices carried out, it is clear that those that move the focus of control to the student were carried out frequently by less teachers (e.g. allowing students to design their own procedures or determining the data to collect). Interestingly the nature of the feedback for learning given to students still concentrates on grades as the overall records are maintained as grades. In many countries, both grades and comments are maintained. Within the context of assessment of learning and assessment for learning, teachers may need further support in giving feedback to student in a format that can drive student learning forward.

The 175 pre-service teacher (PST) cohort that completed the initial and final questionnaires were a very heterogeneous group, with many having little to no teaching experience and others having over 20 weeks of teaching experience. Therefore the anaylsis of the impact on pre-service teachers was divided in two with those PST with teaching experience (PSTW) answering about their practice while the group of with no teaching experience (PSTWO) were questioned on whether they valued the inquiry practices in the classroom. All of these PSTs understanding of inquiry changed significantly towards a more comprehensive understanding following the TEP. Over 60% of the PSTW teachers state that they practice some elements of inquiry frequently in their classroom, practices such as students developing their own conclusions from investigations or students have opportunities to talk and listen to each other in the inquiry classroom. However, half (or less) of these teachers are confident in their assessment of these inquiry skills. Following the TEP, their confidence has increased, particularly for elements such as students justify their conclusions or present their results and conclusions from investigations.

The SAILS project focussed on the development and assessment of four main inquiry skills: planning investigations, developing hypotheses, working collaboratively, and forming coherent arguments, in addition to the broader competencies of scientific reasoning and scientific literacy. The data analysis presented for both in-service and pre-service teachers shows that following the TEPs, all teachers were more confident in the assessment of each of these four inquiry practices, as well as scientific reasoning.

In addition to the anysis of questionnaire date, other evidence of the impact on the Stage 2 TEPs has been provided by the partners, including adaptations of existing SAILS units, teachers' own original inquiry activities and evidence of students learning inquiry skills through formative assessment strategies. This evidence clearly shows how the SAILS project has supported teachers across Europe in adopting IBSE. It also shows how the SAILS project has prepared teachers to independently and confidently assess students' learning with a breadth of different strategies and instruments and has had even wider impacts.

The results presented in this report based on the teachers responses in the initial and final questionnaires have shown that the SAILS TEP programme has been successful in developing and deepening teachers understanding of inquiry and assessment practices.Through participating in SAILS TEPs, teachers have become familiar with a wide range of assessment materials and developed skills in producing their own instruments and items. Although the TEPs have been developed as appropriate for each country, both with regard to format and to content, they still had a common core to guarantee the quality and coherency of the SAILS TEPs across the participating twelve countries. However, several challenges need to be faced by teachers to develop their assessment strategies and these main be the major impediment to implementing alternative assessment procedures. Hence a key recommendation is that further TEP programmes are required to focus on development of assessment strategies e.g. within a school environment.

We believe that the excellent SAILS legacy website and vibrant Communities of Practice that been established in SAILS will enable effective sharing of project resources (e.g. Frameworks, Units, Case Studies) and support all science teachers in developing their inquiry and assessment practices.. We look forward to continuing to work with the many teachers whom have enhanced their inquiry and assessment practices through participation in SAILS TEPs and CoP.

APPENDIX

Table A Cohort 3 In-service teachers attending TEP STAGE 2 programme, data shown only for teachers that completed both pre-and post-questionnaire

Partner	Code	Number of teachers	Years of teaching experience %				Gender %		Type of school %			Experience level %			
			0-5	6-10	11-20	>20	M	F	All boys	All girls	Mixed	NE	BE	SE	VE
ATiT	**A**	16	18.8	31.3	31.3	12.5	50	50	0	0	93.8	0	25	68.8	6.3
DCU	**B**	18	22.2	11.1	33.3	33.3	27.8	72.2	22.2	22.2	55.6	0	11.8	47.1	41.2
HUT	**C**	49	24.5	26.5	34.7	12.2	57.1	42.9	0	2	98	40.8	20.4	28.6	6.1
IEUL	**D**	27	0	14.8	29.6	55.6	11.1	88.9	0	0	100	14.8	40.7	44.4	0
JU	**E**	41	7.3	17.1	24.4	51.2	14.6	85.4	0	0	100	65.9	17.1	17.1	0
KCL	**F**	19	52.6	36.8	10.5	0	26.3	73.7	21.1	5.3	73.7	10.5	15.8	73.7	0
LUH	**G**	7	28.6	14.3	42.9	14.3	42.9	57.1	0	0	100	42.9	42.9	14.3	0
MaH/HKR	**H**	15	0	26.7	46.7	20	33.3	66.7	0	0	100	6.7	20	53.3	13.3
UPJS	**J**	25	12	24	20	44	12	88	0	4	96	44	40	16	0
UPRC	**K**	27	63	22.2	14.8	0	29.6	70.4	3.7	0	96.3	7.4	51.9	40.7	0
US	**L**	34	17.6	8.8	20.6	52.9	14.7	85.3	2.9	0	97.1	32.4	20.6	41.2	5.9
SDU	**M**	27	18.5	33.3	25.9	22.2	29.6	66.7	0	0	100	19.2	23.1	53.8	3.8
Total		305	21.3	22	26.6	29.2	28.5	71.1	3.3	2.3	94.1	28.6	28.2	38.9	4.3

Table B Cohort 3 Pre-service teachers attending TEP STAGE 2 programme, data shown only for teachers that completed both pre-and post-questionnaire

Partner	Code	Number of teachers	Weeks teaching %				Gender %		Inquiry experience		
			0 weeks	≤5 weeks	6-19 weeks	≥20 weeks	M	F	NE	BE	SE
DCU	**B**	21	0	71	24	5	29	71	14	14	71
HUT	**C**	20	100	0	0	0	0	100	85	15	0
JU	**E**	9	0	100	0	0	11	89	44	33	22
		45	100	0	0	0	18	82	51	49	0
UPJS	**J**	31	0	100	0	0	23	77	0	81	19
US	**L**	7	0	100	0	0	57	43	14	86	0
		10	100	0	0	0	50	50	20	80	0
SDU	**M**	22	0	18	23	55	54	46	41	36	23
		9	100	0	0	0	33	67	44	56	0
Total PST		91	0	69	15	14	33	67	19	50	32
Total PSTWO		84	100	0	0	0	19	81	55	45	0