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Report from EAP on teacher education programme and CoP

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Authors: Bronwen Cowie, Debra McGregor, Odilla Finlayson, Eilish McLoughlin, Paul van Kampen and PSC
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Contact: info@sails-project.eu
Website: www.sails-project.eu

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Contents

1. Introduction

The SAILS project adopted a phased approach to the development and implementation of teacher education programmes (TEPs) over the lifetime of the project. The final TEPs (Stage 2) provided the final cohort of teachers ("3rd Teacher Cohort") to experience inquiry and assessment of inquiry skills and competences. The overall objectives of SAILS TEPs were that the teachers will not only have the skills and competences to be able to teach through IBSE, but also to include assessment of IBSE skills and competencies as part of their classroom practices.

An essential feature of all TEPs was that teachers were encouraged to share their experiences with other teachers, initially within their own cohort and then later within the wider group of IBSE practitioners within their own country. This approach facilitated the development of community of practitioners (CoPs) whom shared their experiences of implementing IBSE and supported each other in railing in the classroom. The sharing of teachers' experiences and practices of IBSE and assessment in their classrooms with other teachers is an extremely powerful tool for the wider dissemination and sustained impact of the SAILS project.

The SAILS Inquiry and assessment framework and instruments for IBSE skills have been an integral component of all TEPS. The SAILS team have collaborated with science teachers to produce a collection of 19 SAILS Inquiry and Assessment Units which showcase the benefits of adopting inquiry approaches in classroom practice, exemplify how assessment practices are embedded in inquiry lessons and illustrate the variety of assessment opportunities and processes available to science teachers. In addition over 100 case studies of trialling SAILS units in the classroom have been prepared by teachers in each of the twelve participating countries. These case studies show how evidence of student learning can be collected and evaluated using a variety of methods such as classroom dialogue, teacher observation, presentations, peer-assessment, self-assessment, student artefacts, and use of assessment rubrics. The SAILS Inquiry and assessment framework presents describes each of these inquiry skills and competencies and presents proven strategies for assessing them.

Two independent experts, Professor Debra McGregor and Professor Brownen Cowie were recruited as members of the SAILS External Advisory Panel (EAP) and were asked to review core aspects of the SAILS project

- SAILS Teacher Education Programmes and Community of Practice
- SAILS Inquiry and assessment framework and instruments for IBSE skills

A joint summary report from both EAP members on these interlinked aspects is presented in Section 2. A report on observations by Professor Debra McGregor from three TEPs is presented in Section 3. Professor Debra McGregor final report of on the features and outcomes of all SAILS TEPs across the 12 participating countries is presented in section 4. Professor Brownen Cowie feedback on the final report on the assessment framework and instruments for IBSE skills is presented in Section 5. Section 6 outlines the response of the SAILS Project Steering Committee (PSC) to the input and commentary of these two EAP members.

2. Summary report of EAP members

The SAILS project relates and connects directly to the current OECD agenda (OECD, 2015) that includes development of tools to assess abilities important for scientific innovation. This is achieved through the project focus on how to distinguish, nurture and assess key skills including developing coherent arguments, reasoning and scientific literacy and collaboration. The integrated approach of the SAILS activities to curriculum, learning and assessment is pioneering – because assessment is usually enacted as an afterthought to curriculum innovation.

The teacher educators in the 12 partner countries (of the project) have worked together to devise learning experiences that teachers could use to support students to generate their own inquiry questions. Alongside the SAILS units these two strands of development characterise some of the ways teachers can use innovative approaches to pique student interest and to generate evidence of their learning. Through the project the teacher educators have worked with clusters of local teachers to trial and verify the potential of the SAILS units and then extend them to new contexts.

The SAILS approach required teachers to trial, reflect on and reconceive both their own, and their students' assessment of the learning processes involved in inquiry learning. The multi-country case studies compare and contrast the development of teachers' understanding and awareness of the nature of science and science inquiry and how this might be made visible and valued within the classroom. Through trialling the SAILS inquiry units it has become apparent how control of learning can be relocated from the teacher to the student. Teachers were often surprised and then impressed with the imaginative and innovative suggestions that their students could make.

The case studies make an important contribution through the way they illustrate something of the dynamics of teacher assessment attention, which can usefully foreground individuals, groups or the class as a whole. They provide evidence that most aspects of the SAILS inquiry framework can be assessed in any one task but some units lend themselves more readily to particular inquiry skills. Clear outcomes for classroom implementation from the SAILS work include:

- teachers would be well advised to choose 2-3 skills to focus on, at most, within an inquiry
- the use of multiple sources of evidence to map student learning and progress can provide illuminating indications of progress
- the use of 'emerging', 'developing', 'consolidating' and 'extending' as indicators of progress proved helpful for students as well as teachers in 'assessing' progress in skill development

The implementation of the SAILS approach demonstrated the value of garnering evidence through activities such as student discussion and explanation, student-made videos, peer and self-assessment. Teacher use of a range of assessment strategies allowed students with different strengths to gauge and monitor their own progress. The SAILS strategies enabled students to become aware of the more elusive inquiry skills such as the nature of their contribution to collaborative endeavours. Teachers involved with project over three years (rather than just one) were able to revise familiar activities to enact the SAILS inquiry approach.

The compilation of examples from different teachers and countries to illustrate the SAILS units in action has highlighted that there are many ways to achieve and demonstrate the same aspect of the inquiry process and hence many different ways to assess student learning. The project programme, designed to develop multiple case studies from each SAILS unit is both distinctive and innovative. It communicates a clear message that teachers are expected to adapt the SAILS resources to suit their circumstances and their students. What is also clear from the programme outcomes is that the participating countries and teachers within them not only enhanced *and* enriched their understandings and practices, but that SAILS has generated real momentum and commitment toward inquiry learning amongst teachers and researchers. Just as importantly, it has drawn in and attracted the interest of additional teachers, professional development providers and policy makers outside the project.

By illustrating that current project teacher's practices range along a continuum, the SAILS work emphasises that teachers need time and support to develop and implement science inquiries, in which teaching and assessment become mutually supportive for student learning and the mastery of inquiry skills. Adjusting teaching and assessment into the more dynamic and iterative process that SAILS envisaged, can more effectively support inquiry learning. When teaching and assessment are enacted in this more responsive and integrated way classroom learning becomes revitalised and transformative.

Joint report by:
Professor Debra McGregor and Professor Brownen Cowie

3. EAP Report of observed TEPs – Debra McGregor

This report presents the observations of Professor Debra McGregor from three different TEPs observed during cohort three TEPs. Section 3.1 presents a report on each observation from three countries (Ireland, UK and Portugal) that were visited to directly observe the implementation of SAILS Cohort 3 TEPs. Section 3.2 presents a summary report from the observations and the range of practice in the TEPs, focused on:

- Sharing of experiences and resources
- Gender awareness
- Reducing barriers
- Element 1: Experiencing inquiry and assessment
- Element 2: Trialling IBSE and assessment in the classroom
- Element 3: Developing IBSE and assessment resources

Highlights from the TEPs observations are presented in Section 3.3 and suggestions for future consideration are discussed on Section 3.4 and concluding remarks in section 3.5.

3.1 SAILS Cohort 3 TEPS

Three SAILS TEP workshops were observed at various stages of the cohort three TEPs.

- Ireland (Dublin City University, Dublin): two consecutive (introductory) summer school days were observed. These were the first two days for the majority of the cohort of 25 and final two days for a small group of five teachers in a sequence of several workshops engaged with over a period of two years.
- Portugal (at the Instituto de Educação, Universidade de Lisboa): a whole Saturday TEP was observed. This was the final day in a series of in-service days for a group of 30 qualified teachers with a wide range of expertise (mostly upper secondary physics and chemistry teachers (of 15 – 18 year olds), but some taught slightly younger students aged 10 – 12 years).
- UK (at King's College, London): half day TEP for 23 qualified teachers was observed on Friday 1st May. This was the 3rd in a series of 4 half days.

3.1.1 SAILS TEP Ireland

30 teachers were involved in a two-day summer school experience. The teachers involved ranged from newly qualified to those who had been teaching for over 25 years (there appeared to be very enthusiastic support for a summer school that took place at the beginning of the school holidays). Five experienced teachers had been involved in SAILS for two years, this more experienced group were given differentiated tasks to engage in. Some of the time they joined the more 'novice' group to share their experiences and reflective expertise.

Day 1 of the summer school included:

1. Introduction to the SAILS project
2. Introduction to inquiry by eliciting from the participants what they think their students do in an inquiry classroom.
3. Engaging with practical activities (Vitamin C; Speed; Oil and Water) with differing levels of support (so that teachers contrast their experience of engaging with an open inquiry or a

prescriptive, more bounded, practical activity). For each of the practical activities, the teachers worked in smaller groups of three or four. The key questions that were considered by the participants were "How much control does the learner have over what happens?', "Do the learners or the teachers ask the questions?", "What does each approach contribute toward learning content?", In what way does the approach foster curiosity and other scientific attitudes?", "What skills are practised in each approach" and "Which skills are required for each approach?". Responding to these questions through well-structured worksheets, prepared by the Teacher Educators (TEs) resulted in teachers' in-depth reflective discussions of their views of the implications of their students experiencing open and more prescriptive or bounded activities.

4. Plenary discussion about inquiry and what it looks like in classrooms (informed by Linn, Davis and Bell, 2004).
5. Comparing ways to carry out the 'Speed' activity. Teachers were organised in small groups to devise ways that they could respond to "How long does it take you to walk 5 metres, walking slowly, then walking quickly?" This was a very useful way to engage teachers in reflecting about the variety of solutions students might produce and 'which' kinds of inquiry skills were possible to practice and assess in certain practical situations.
6. Reflective discussions about "What will you assess?" and "How could it be assessed?" were sometimes challenging for the teachers to immediately appreciate. Mediation from the TEs ensured that participants in the summer school appreciated the tension between learning 'content' and 'developing skills' in inquiry contexts.
7. Devising an inquiry and assessment tools. One of the most powerful activities enabling teachers to appreciate all the above teaching and learning issues discussed, was the one where groups of teachers rotated through different roles (as learner, teacher devising inquiry and assessment criteria and then as assessor using the assessment tools devised). The task guidelines for this were:
    - "What was assessed?
    - How was it assessed?
    - What was teacher reaction?
    - What was student action?
    - What evidence was collected?
    - What steps were taken based on assessment?
    - Did the assessment align with the goals [of the inquiry]?"

    This presented unique insights into the pragmatic challenges of designing, managing and assessing effective inquiries for secondary students.

    One interesting observation was that one group initially felt that 'washing up' and 'clearing away' was an appropriate [inquiry] skill to be assessed! This illustrates how teachers need support, not only to appreciate the fresh approaches to teaching through inquiry, but also to make the cultural shifts needed to recognise which skills are relevant in 'inquiry' and which might be appropriate in everyday practical situations.

    Other interesting discussion points from this session in the summer school, included "What is 'good enough' from the student perspective?"; "The need to be explicit with the students about 'what' is being assessed"; "Does it [the inquiry] need doing again if good quality data is not produced?"

8. Plenary reflections including 'unexpectedness'. This included the more 'expert' teachers listening and responding to each 'novice' group reporting back on their experiences and key 'learning' from the activities of the day. Some of the 'unexpectedness' included discussion about how students need to understand what 'variables' are; that effective working-together (group work) needs assessing; that it is invaluable to assign and 'swop' roles of individuals in groups; there is real value in the 'talk' that emerges between students; that there are a variety of different kinds of assessment approaches, not just 'observing'; that the ratio of teacher:student talk in inquiry situations should shift from 80:20 ratio to 20:80.
9. Homework provided for the participants was to read about Speed and Reaction Rates case studies from other countries (to consider: "What might be more or less useful for teachers beyond SAILS to use"; "Whether case studies are of interest to other teachers" and "How useful are these for other teachers".

Day 2 of the summer school included:

1. Reviewing in a collective discussion why it is worth bothering with inquiry. Harlen's inquiry cycle was reviewed and the nature of collaborative working to support inquiry emphasized.
2. Practical activities. These involved Floating Oranges; Woodlice and Light. Given resources to investigate each of the three different contexts, the groups of teachers were asked to consider what kinds of questions they might come-up with. Once the range of possible questions were listed, the teachers were then asked to consider, a. Which were good or poor questions?; b. Which questions were difficult or easy to investigate; c. How could difficult to investigate questions be modified to become investigable?; d. How can students be helped to devise good questions? e. How can hypotheses be developed from questions?
3. Discussions about dialogue and forming coherent arguments were particularly well developed through the Light activity.
4. What does collaborative work look like? A group of teachers were invited to work on an 'egg race' type of activity (making a straw and paper clip tower to hold a real egg). The remainder of the group watched (for the amount of talk from each person, the type of dialogue they entered into and any other particular kinds of interactions) as the task was undertaken by the group. Part-way through the activity the group members were assigned certain roles. The onlookers then watched for changes in verbal exchanges (and actions) between the participants as they reached the end of the task.
5. Reflective discussion after the role play regarding the activity, involved the participants themselves and focused on a range of issues and influences (within group-working) that can affect cognitive development.
6. The teachers then worked collectively to plan a series of lessons that they could try out back in school to develop (and assess) students' inquiry skills. The teachers are expected to implement the lessons in September and provide an evaluative review to the rest of the cohort at a follow-up day later that month or in October.

3.1.2 SAILS TEP Portugal

This was the final day in a series of in-service days for a group of 30 qualified teachers. Teachers who had been involved in the previous professional development days were organised to provide presentations on their use of the SAILS project materials (and IBSE approach to teaching) over the

past year. The group of 30 teachers was divided into seven smaller groups with various briefs to consider:

1. Teaching (and the teacher's role) in inquiry
    a. Elaborating on (the nature of, as well as) the ways inquiry 'scenarios' were developed;
    b. How (and what did teachers do) to organise/maintain continuous engagement of students working during the activities;
    c. Explaining how the relationship between inquiry skills (competencies) was developed/emphasized and assessed.
2. Learning within inquiry
    a. The student's role within inquiry
    b. The students difficulties during activities implemented during lessons
3. Assessment rubrics
    a. Elaborating on how the basic 'emerging'; 'developing', 'consolidating' and 'extending' competencies were incorporated into the various assessment 'tools' generated by teachers
    b. Student difficulties faced when implementing the use of assessment rubrics and feedback (student work to be used to illustrate)

The seven groups (of between 4 and 5 teachers) were constituted from different schools and/or different sections of the same school. Time was ring-fenced at the beginning of the day to discuss and prepare for the group presentations.

All the teachers had been encouraged to try out the SAILS Units and the group as a whole had formally trialled two to contribute to the international comparative case studies (of the ways different countries implemented particular inquiry activities).

As a non-native Portuguese speaker I could not understand all that was uttered, but because slides, illustrations, photos and even mini video clips were presented I could 'glean' some of the essence of discussion. The Portuguese TEs kindly organised a PhD student who was familiar with the SAILS project and could translate the presentations for me. For that invaluable explanatory assistance I would like to express many grateful thanks.

After each presentation the TEs engaged with the participants in reflecting on the key professional learning points. This was very impressive. It was highly professional, academically informed and pragmatically insightful.

Some of the key aspects that were particularly highlighted in the reflective discussions that unfolded throughout the day:

i. The challenge related to successfully engaging students in the inquiry process, i.e. how to design an intriguing and piquing activity at an appropriate level for the class (and individuals within it). Ensuing discussion related to choosing an apt subject focus and context (e.g. why do different birds have different gizzards? explored using photographic images; why do earthquakes happen in some places, but not others?). However, the real test was devising

scenarios for the students to generate their own questions, which is related to participation, motivation, interest and curiosity.

ii. What is relevant to focus on when 'assessing' inquiry skills (the presentation had focused on a group where the 'correct' answers were highlighted. The TEs led the discussion to emphasize how it was important to understand and assess process and development in achieving skills (e.g. the six identified for the SAILS project: planning investigations, developing hypotheses, debating with peers, forming coherent arguments, Scientific literacy and Scientific reasoning) and recognise that practice is needed to become a 'developing' scientists or even be 'consolidating' a skill (i.e. progress through the four stages of competency (Emergent; Developing; Consolidating; Extending) suggested by King's College London).

iii. To recognise that what is relevant (and obvious) to the teacher, may not be so for the student. This was particularly pertinent when considering assessment rubrics (and the associated criteria). The TEs encouraged the teachers to reflect on the shortcomings of only student written 'documents' as evidence of inquiry skills achieved.

iv. The ways the students worked together, that is co-operatively or collaboratively. Working with others (without disruption or 'smoothly') is not necessarily collaboration. The TEs discussed peer-peer assessment, as well as self-assessment, especially in the instance of a high achieving child, who thought he was only 'developing' as a team worker, because he realised he couldn't help his peers. The discussion involved reflections about how those students who are high-achievers, academically, but may not be good collaborators and vice versa.

v. The nature of scientific literacy and how that can be described precisely in assessment rubrics. This was done through various examples of rubrics being shared and explained to highlight what worked well and how.

vi. Reflective questionnaires that the students completed after their inquiry activities that provided the teachers with their self-assessments of their views of their personal development, their quality of work, the way they worked as a group, what others had done to contribute to their group outcome(s) and what they thought of the inquiry.

The TEs referred to the four skills highlighted in WP2 (planning investigations, developing hypotheses, working collaboratively, forming coherent arguments) and the additional two (scientific literacy and scientific reasoning) highlighted in WP3 were referred to throughout the discussions.

It was clearly evident that the Portugal CoP was very well used and the two Teacher Educators had obviously provided much conscientious, on-going support for the member teachers. There were research and professional 'papers' on IBSE and assessment, shared not only by the TEs, but also participants in the CoP. The CoP webspace was particularly well used pre (to provide the participants with an overview of the agenda for the day and other preparatory materials that may be useful to refer to) and post in-service provision.

3.1.3 SAILS TEP UK

23 teachers attended the third half day in a series of four half days. The teachers began the half-day session together and reviewed the theoretical ideas behind IBSE, 'What is inquiry?' and the

questions (as a teacher wishing to assess student progress) to consider whilst engaging in the inquiry activities.

The half-day was designed so that the teachers could work in six groups of five or six teachers. Each group rotated around the three SAILS units to consider how to develop enquiries within the following three units:

- Food Labels
- Rates of Reaction
- Speed

There were two resource tables (for each SAILS unit) that provided the teachers with a variety of equipment. This enabled the teachers to explore through handling (and manipulating) the materials how inquiries might be promoted within the three contexts. The kinds of materials that were provided, included: for food labels (a wide variety of different food labels; washing line with pegs; 'Fat'; 'Protein'; 'Carbohydrate' headings for the washing line; paper plates); for Rates of reaction (Effervescent vitamin C tablets; beakers; measuring cylinders, thermometers; timers; electronic scales); for Speed (timers; metre rules; tape).

At each station the groups of teachers were asked to consider for each unit:

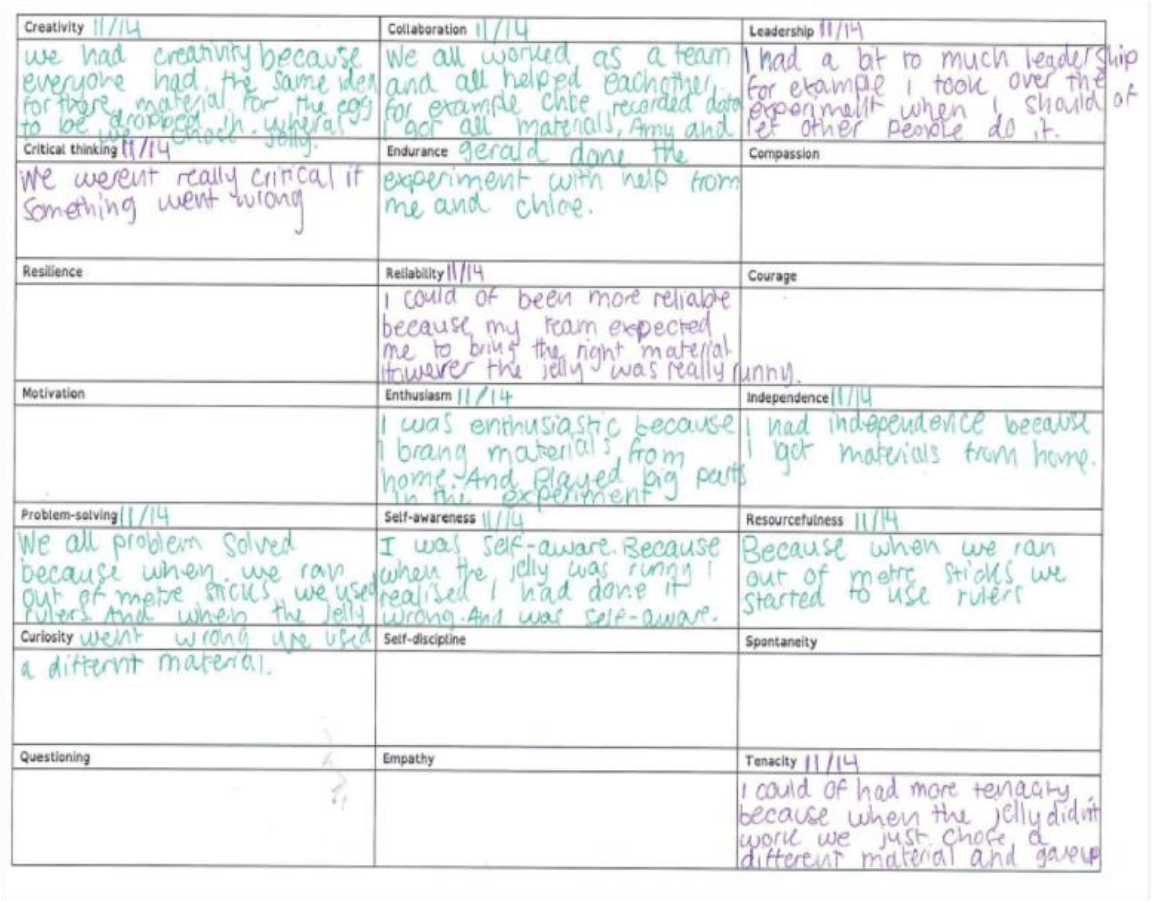
i. What are the benefits of developing the activity into an inquiry?
ii. How could they teach to help their students generate an inquiry?
iii. Which inquiry skills should be emphasized (foregrounded) within the inquiry?
iv. What kinds of 'evidence' of 'learning' elicited from the students could indicate progress?

During the practical activities the TEs conscientiously interacted with the teachers, questioning, discussing and sharing experience of using the SAILS unit resources. They modelled how the teachers themselves could promote more effective inquiry-focused discussion with their students. There were good examples of not 'giving away *correct* answers', but promoting thinking through questioning.

After the teacher groups had rotated around the activities, the TEs conducted useful discussions that focused on developing the six key skills (planning investigations, developing hypotheses, debating with peers, forming coherent arguments, scientific literacy and scientific reasoning). The plenary discussion also included consideration of gender issues and pedagogic ways that inquiry activities could be managed and organised for effective learning with and through each other.

The TEs explained and exemplified ways that male and female students behave differently whilst engaged in mixed group-working together. One example of this was illustrated by inviting a group of teachers to investigate what might be in some 'mystery boxes'. Other teachers watched with clear observational (blank) frameworks that they marked in various ways as the group interactions unfolded to draw their attention to different aspects of learners' actions and feelings when learning. The task to note what each member of the group did, uttered and appeared to 'feel' illustrated to the onlookers how social and emotional perspectives should be considered within processes of learning. The TEs offered useful insights after the activity and related the observations to published research findings.

The discussion then progressed to "What do teachers focus on when assessing students during experimentation activities?" and "What evidence do you need to inform your assessment judgements?". To illustrate this learning landscapes that students had completed to assess their own and others' progress, were provided for scrutiny. The examples below of different completed learning landscape sheets (see Fig. 1) were then considered to explore how this tool could be used and what it might helpfully suggest about inquiry learning.

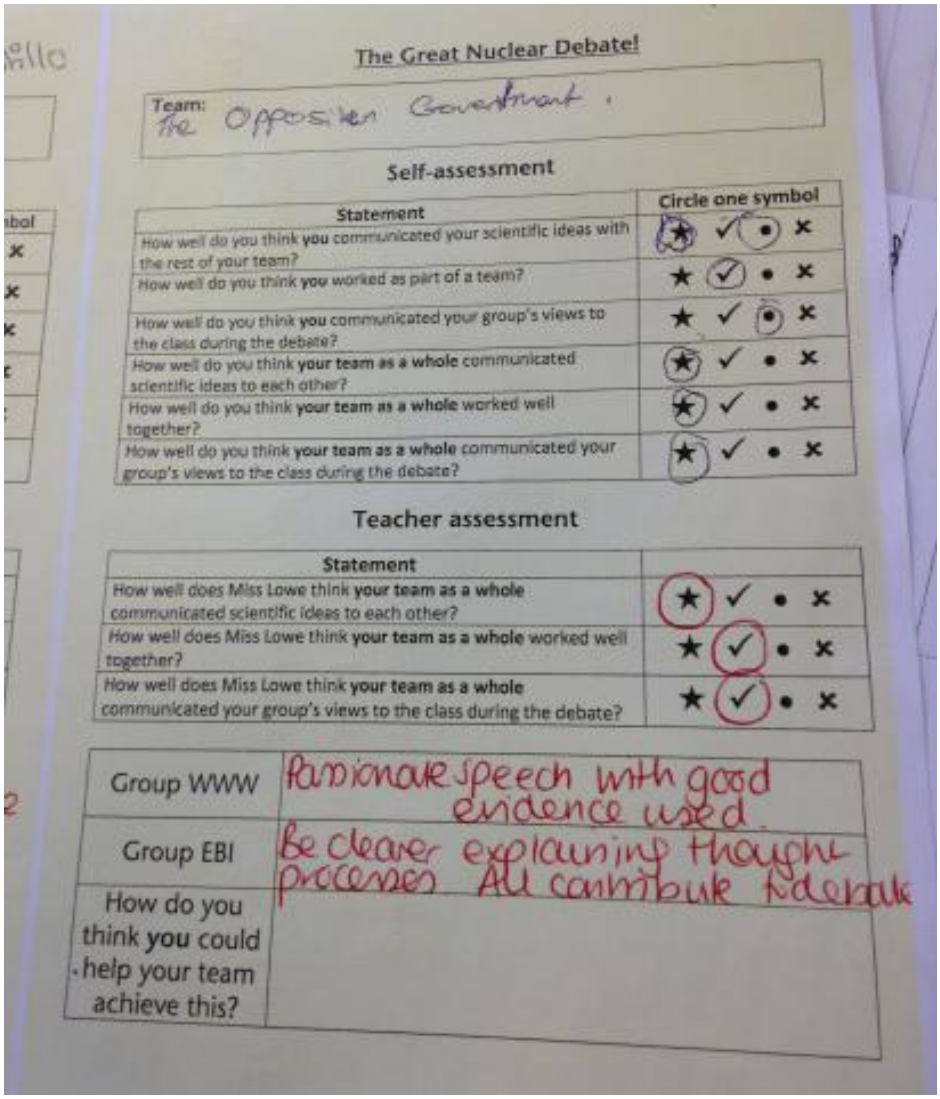


Creativity 11/14	Collaboration 11/14	Leadership 11/14
we had creativity because everyone had the same idea for there material for the egg to be dropped off the chair. whereas jelly.	We all worked as a team and all helped eachother, for example chloe recorded data I got all materials, Amy and gerald done the	I had a bit to much leadership for example I took over the experiment when I should of let other people do it.
Critical thinking 11/14	Endurance	Compassion
We weren't really critical if something went wrong	experiment with help from me and chloe.	
Resilience	Reliability 11/14	Courage
	I could of been more reliable because my team expected me to bring the right material however the jelly was really runny.	
Motivation	Enthusiasm 11/14	Independence 11/14
	I was enthusiastic because I brang materials from home. And played big parts in the experiment	I had independence because I got materials from home.
Problem-solving 11/14	Self-awareness 11/14	Resourcefulness 11/14
We all problem solved because when we ran out of metre sticks we used rulers And when the jelly went wrong we used a different material.	I was self-aware. Because when the jelly was runny I realised I had done it wrong. And was self-aware.	Because when we ran out of metre sticks we started to use rulers
Curiosity	Self-discipline	Spontaneity
Questioning	Empathy	Tenacity 11/14
		I could of had more tenacity because when the jelly didn't work we just chose a different material and gave up

Figure 1: Example of a learning landscape self-assessment sheet.

Further discussions (that connected research with practice) focused on the cycle of inquiry (Harlen's theoretical model), the nature of open and closed questions that can influence inquiries, different types of inquiries, conceptual development through inquiries and the ways students might respond to various inquiries.

Teachers also shared a variety of assessment tools they had devised and used with their own students in science classes (see Figure 2).



The Great Nuclear Debate!

Team: the Opposition Government.

Self-assessment

Statement	Circle one symbol
How well do you think **you** communicated your scientific ideas with the rest of your team?	★ ✓ • ×
How well do you think **you** worked as part of a team?	★ ✓ • ×
How well do you think **you** communicated your group's views to the class during the debate?	★ ✓ • ×
How well do you think **your team as a whole** communicated scientific ideas to each other?	★ ✓ • ×
How well do you think **your team as a whole** worked well together?	★ ✓ • ×
How well do you think **your team as a whole** communicated your group's views to the class during the debate?	★ ✓ • ×

Teacher assessment

Statement	
How well does Miss Lowe think **your team as a whole** communicated scientific ideas to each other?	★ ✓ • ×
How well does Miss Lowe think **your team as a whole** worked well together?	★ ✓ • ×
How well does Miss Lowe think **your team as a whole** communicated your group's views to the class during the debate?	★ ✓ • ×

Group WWW	Passionate speech with good evidence used.
Group EBI	Be clearer explaining thought processes. All contribute tolerate
How do you think **you** could help your team achieve this?	

Figure 2: An example of an assessment framework devised within a CoP and used by a teacher.

The reflections of the sessions were brought to a close with the PMI useful technique from de Bono.

The use of the CoP (and the resources available on it) was discussed and many of the teachers had used it, but often found it time consuming to locate what they were searching for. The King's CoP was a well-organized site with many useful materials and resources for the teachers involved in the project.

A really useful aspect of the plenary was discussion about the informal support (or coaching) that King's offered through classroom visits. The teachers could identify what they wished to have help with and the TEs would specifically support that area of work (questioning; use of the learning landscapes tool; interviewing students about their views of difficulties and benefits of inquiry; liaising with head teachers for in-school support, etc.).

3.2 More generalised observations: The range of practice in the TEPs

Amongst the three observations, the following key elements (gender awareness; reducing barriers; sharing of experience and resources we well as elements 1,2,3 agreed to be included in the cohort 3 TEPs) were tackled in a range of ways:

Sharing of experiences and resources

Reflections on experiences were shared in various ways, from collective discussions, to verbal reports and more formal presentations with visual (even video) illustrations. The focus of reflections varied from 'How well did the students raise their own inquiry questions'? to 'Who was most engaged with inquiry' and 'Why' to 'Which resources did not work well?' and 'Why'.

There were reflections that focused on different aspects of inquiry and assessment practice:

- Using inquiries in general classrooms (and secondary laboratories);
- Trialling similar and different activities with a clear reflective framework (i.e. specific questions to discuss and share) in in-service sessions;
- Reflections from trialling (personally devised and provided) activities in different roles, as a student and as a peer (student assessor) and a teacher assessor in school (and in in-service sessions) with students;
- What does research say about inquiry and assessment
- How do (different countries) implement the inquiry activities and assessment tools as illustrated through the case studies?

Gender awareness

This was generally discussed as part of an introductory discussion within an in-service session or after activities (usually practical experiences) when considering how students would respond to particular inquiry contexts.

There were also 'specific', almost staged activities whereby a group of teachers (with and without specific roles, e.g. time manager, results recorder, etc.) were observed by other participants within the TEP.

Piquing professional development activities (building straw towers or hypothesizing about the contents of mystery boxes) were used to demonstrate how students might interact differently. This was to help teachers recognise how social and emotional interactions can influence learning through inquiry.

Reducing barriers

This has been approached in a number of ways through discussing, trialling and demonstrating the different ways that diverse groups (mix of ability, gender etc.) would tackle the same inquiry. Reflective discussions about experiences of solutions to identical problems, showing they can be solved in contrasting ways illustrates practically to teachers how they might encourage or mediate their students' inquiry issues.

Implementing assessment in a wide variety of ways that has been experienced, discussed, demonstrated and reflected upon during in-service sessions serves to highlight to teachers how they could develop their practice (to boost recognition of wider achievement of 'skills' in inquiry activities).

Element 1: Experiencing inquiry and assessment:

The range of ways this has been done extends from teachers' direct experience within in-service sessions to observing other teachers enacting or practicing something, reviewing the outcomes of students' work or watching videos of students engaged in projects.

Where research evidence or research studies were used to justify the IBSE approach, effective assessment and inquiry learning it was consolidatory and offered validation of the approaches taken in project.

Element 2: Trialling IBSE and assessment in the classroom:

This has been generally carried out after teachers have experienced the SAILS units, the teachers become familiar with them and then trial them with their students (often one or two classes). They [the teachers] become familiar with the features of inquiry activities and are able to then apply IBSE principles to develop in-school original exploratory activities.
Teachers have begun to recognise how questioning, observing and other techniques may provide evidence of development, not just student's written work.

Assessing collaborative working-together has become much more prominent in teachers' assessment repertoire across all the in-service sessions. Some teachers have trialled one or two (or many of) the SAILS units (and assessment rubrics and other Afl suggestions) through downloading them from the CoP and then have exchanged comments on experience with fellow CoP members. The IBSE and assessment approaches devised through SAILS were being used in schools specifically to stretch the more able (and boys).

Element 3: Developing IBSE and assessment resources:

Many of the teachers involved in SAILS training sessions had created in various forms their own 'inquiries' using everyday materials and situations (e.g. cookies, biscuits, cakes, making hot drinks) and additional original contexts beyond the SAILS units e.g. the water cycle, cells, etc.).

Teachers had also generated a wide variety of assessment strategies and tools, often different kinds of rubrics, not only in in-service sessions, but in collaboration with their science departments back in school. Assessment rubrics and learning landscapes had helped teachers think about ways to measure 'skills' development (rather than content).

Several schools were applying the approach to older students (up to 18 years old). There were schools that reported recognition of the way that the inquiry approach helps develop thinking. One school had even applied the inquiry approach to their engineering club in school.

3.3 Highlights of TEP observations

A. Organising teacher (peer) presentations that reflects on different aspects of inquiry teaching, learning and assessment offers rich material for discussion about:
   - The nature of inquiry materials used
   - The range of ways the inquiry 'opportunities' are introduced/developed (by teachers)
   - The collaborative opportunities that emerge for learners to learn together (through group work)
   - Consideration of gender (and ability) influences on inquiry learning processes (and outcomes)

B. Sharing findings, when reflectively asking the students to assess their learning through the inquiry involvement (including their personal and others' contributions to collaboratively working-together) provided real insights into learners experiences, e.g. "Because they helped me to understand the meaning of the 'things' that I don't understand" and "I like it because I lived beside the factory and I don't know what is going on there".

C. Rotating through roles as teacher and/or student, as well as devising an inquiry and its 'appropriate' associated skill(s) assessments. This approach can emphasize challenging aspects of inquiry-teaching, including making clear for students the success criteria in an inquiry as well as highlighting for teachers what are 'relevant' and 'fitting' skills to assess for an inquiry.

D. The use of the collaborative envelope approach to collect group views. This is done using an A4 sheet divided into quarters, using diagonal lines from corner to corner, with a circle in centre. Each of the four members of the group write their answers in the corners and as they do so they have to justify their perspective. The circle in the centre of paper is completed after each has shared their views and agree what is the group consensus.

E. Utilising role-play effectively in various ways, e.g. teachers as students given a 'unique' inquiry to engage with to illustrate the kind of dialogue, decision-making and assessment opportunities that could arise in particular inquiry situations.

F. Offering teachers the opportunity to apply for specialist equipment to resource the inquiry activities that have been tried out during the in-service training days.

G. Organising in-service training at appropriate times when more significant numbers of teachers can participate, e.g. the beginning of a school holiday period when 'cover' costs are zero and there is no disruption to school classrooms and students' learning.

H. Promoting rich and meaningful dialogue through teachers actively (trialling) and then thoughtfully reflecting on ways that practical activities are presented influences their students' development (open or bounded). Framing focused professional discussion that includes:
   - varied pedagogical enactments
   - influence of resources
   - nature of mediation
   - range of student responses

- inquiry assessment opportunities
    - illustrations and instances of the six inquiry skills (scientific reasoning; scientific literacy; developing hypotheses; working collaboratively; forming coherent arguments; planning investigations)

Using the SAILS framework (see Figure 3) as an initial focus to expand discussion centred on assessment tools or strategies that work well.

Competence	**Includes such skill areas as:**
a) Planning investigations	Raising questions Conducting investigations Identifying variables Designing Classification Deciding on resources
b) Developing Hypotheses	Defining question to test Formulating hypotheses Making comparisons Formulating research questions
c) Working collaboratively	Team work Engagement with peers Offering ideas Challenging with respect Actively listening to others Turn taking Communication Peer assessment
d) Forming coherent arguments	Verbally: Analysed, supported evidence, drew conclusions
e) Scientific literacy	Understanding how things relate to real world context Communicating in creative & clear ways.
f) Scientific reasoning	Addressing problem through logic and use of evidence Making conclusions Data entry Observation skills Reasoning

Figure 3: The key SAILS inquiry skills.

I. Providing (other country) case study reports related to the practical activities trialled to consider and contrast with personal experience(s).

J. Teacher educator visits into schools to observe assessment of inquiry in practice. This was carried out to good effect. One teacher reported that having a TE coach them and talk to the children to explain what collaborative working meant was very helpful. Providing a way of assessing being collaborative had introduced something that this particular school's students knew nothing about.

3.4 Suggestions for future consideration

Should there be more clarifying discussion, within the in-service programmes, regarding the nature of variables, e.g. in an investigation being able to make a distinction between the independent and dependent variable; recognising categoric, discrete and continuous and discontinuous variables; acknowledging 'controlled' and 'manipulated' variables? Being able to identify and discuss variables in this way could have resulted in more precise discussions about the design of practical inquiries. A more targeted approach on this within in-service may have augmented the scientific literacy and reasoning skills that inquiry aims to support.

Does there need to be more debate and deliberation with teachers within in-service sessions about the differences and commonalities between the 'scientific method' and 'inquiry'? There appears to be, from conversations with teachers, some persisting confusion about these concepts. This, again, would support the development of scientific literacy.

How are students' reflections on their inquiry experiences to be used? Is it to inform inquiry teaching (design of tasks and materials) or is it to formatively assess progress of individuals (i.e. the task(s) and assessment(s) developed will be adopted as part of the school curriculum and measure of academic or personal development) or is it to critically appraise what constitutes a good inquiry activity and an effective assessment approach (and inform curriculum development and assessment policy and practice)? Should it be more explicit in in-service sessions about the 'ways' that formative assessment of inquiry skills can help teachers develop their practice?

How is the successful 'embedding' of inquiry skills to be judged? Teachers may use new ideas because they are 'fresh' and innovative and develop renewed interest for them and their students. However, can this be maintained, especially in light of the acknowledgement of the 'need' for inquiry skills (Crawford 2014; Roberts & Bybee 2014). How can the project sustain a high profile (legacy) after December 2015? Should examples of Schemes of Work or other teaching plan documents be shared through the CoPs?

Consider the range of AfL strategies [Wiliam's (2012) 53 formative assessment tools] within the assessment of the SAILS units to evaluate which could offer particularly effective ways of assessing certain skills. Review the effectiveness of the tools for assessment of inquiry skills, perhaps some kind of matrix or star system could be developed? This should also include the relative benefits and constraints of self, peer and teacher assessment of collaboration and other inquiry skills.

Key: AfL Strategies

1. Best examples discussion
2. Daily sign-in
3. Choose-swap-choose
4. Coloured cups
5. Error classification
6. Exit pass
7. Exit pass placements
8. Extended wait-time
9. Find the errors and fix them
10. Generating test items
11. Group based end of topic questions
12. Group based test prep
13. Hinge point questions
14. Homework help board
15. Hot seat questioning
16. If you don't know, what would you say?
17. If you don't know, I'll come back to you.
18. I-you-we checklist
19. Learning logs
20. Learning portfolios
21. Match the comments to the essay
22. Mini white boards
23. No hands up except to ask a question
24. Page protectors
25. Plus-minus equals grading
26. Popsicle sticks
27. Preflight checklist
28. Question shells
29. Ranking exemplars
30. Real-time test
31. Red/green disks
32. Reporter at random
33. Statements rather than questions
34. Student reporter
35. Think-pair-share
36. Three best samples discussion
37. Three-fourths of the way through a unit test
38. Traffic lights
39. WALT and WILF
40. What did we learn today
41. What not to write
42. Writing frames
43. ABCD cards
44. ABCD corner
45. A or nothing
46. Ask the audience
47. Go 50-50
48. Phone a friend
49. Pose-pause-pounce-bounce
50. Best accent competition
51. Best composite paper
52. If you've learnt it help someone else who hasn't
53. Two stars and a wish

Consider whether and in what form 'coaching' might be a useful supplement to the in-service training, take to ensure, i. teachers are correctly implementing the assessment of IBSE and ii. helping to sustain and extend change within schools.
Supporting and coaching for development within whole science departments (rather than two teacher out-of-school) should consolidate and broaden the impact of the SAILS project.

Further consideration of the ways that research indicates 'gender' and 'collaboration' influences learning science in practical situations (Scantlebury 2014; Treagust & Tsui 2014).

How can teachers' professional learning (alongside changed beliefs, understandings and practices) about inquiry and assessment be most effectively judged? Is just 'watching' and 'asking about their views' through surveys sufficient?

Consider some 'performed' recorded video clips that also offer transcripts (as well as resource material) of the dialogue that teachers could reflectively discuss:

- at different stages of the inquiry process to demonstrate each of the six skills (planning investigations, developing hypothesis, working collaboratively, forming coherent arguments, scientific literacy and scientific reasoning) to be assessed
- offer a range of different assessment instruments that could be applied to scrutinise the video clips
- provide some teacher and student example assessments of the 'same' experiences of inquiry to highlight the contrast in perspectives

3.5 Conclusions

There is a range of varied and excellent practice(s) within the TEPs observed. Teachers who participate in SAILS in-service experiences appear to be appreciating and understanding how inquiry skills teaching and assessment differ to their 'usual' classroom practices (driven by policy and examination agendas).

The effective professional learning appears to be consistently underpinned by good quality resources and effective questioning frameworks.

There are a range of different 'assessment' tools that have been developed through the SAILS project, and indeed, teachers have even devised a wide variety of their own ways of measuring students accruing inquiry competences (outlined in Figure 2). It would be helpful to consider how to augment this to provide teachers with a 'quick' guide suggesting which assessment tools would work to evaluate particular inquiry skills.

To maintain the legacy of the SAILS project, it would be helpful for teachers to be able to access (on-line post project) exemplary assessment tools (for self, peers and teachers) for each of the six (key) inquiry competences. Alongside this it might also be helpful to review (and rate) in some systematic way the efficacy of the range of different strategies that Wiliam (2012) and others (Osborne 2014; Black & Atkin 2014) suggest support teachers' formative assessment of inquiry skills.

4. Final EAP report - Debra McGregor

4.1 Overview of TEPs

The TEP element of the FP7 SAILS project achieved its aims, that is, all the partner institutions provided high quality teacher education experiences that integrated inquiry materials and assessment instruments for use in classrooms across Europe. The project enabled science teachers in secondary schools to distinguish, nurture and assess key skills including developing coherent arguments, reasoning and scientific literacy and collaboration.

The pioneering approach of the SAILS units to integrate curriculum, learning and assessment has resulted in a timely educational innovation. The teacher educators in the 12 partner countries (of the project) worked together to devise learning experiences that teachers could provide to support students generating their own inquiry questions. Many of the SAILS units characterise some of the ways teachers can use innovative approaches to pique student interest and to generate evidence of their learning. As part of the trialling aspect of the TEP, the project teacher educators have worked with clusters of local teachers to explore and verify the potential (and success) of the SAILS units and even extend them to fresh contexts. The teacher educators set-up SAILS experiences for classroom teachers to trial, reflect on and reconceive both their own, and their students' assessment of the learning processes involved in inquiry learning. The multi-country case studies compare and contrast the development of teachers' understanding and awareness of the nature of science and science inquiry and how this might be made visible and valued within the classroom. Through trialling the SAILS inquiry units it has become apparent how the control (and excitement) of learning can be relocated from the teacher to the student. Teachers in the project were often surprised and then impressed with the imaginative and innovative suggestions that their students could make. The case studies provide rich examples of the ways that teachers can utilise the SAILS approach. They provide a variety of illustrations about how the inquiry activities can be assessed. Experience has shown that some units better lend themselves more readily to development (and assessment of) particular inquiry skills.

Clear outcomes for classroom implementation from the work within the TEPs includes:

- teachers would be well advised to choose 2---3 skills to focus on, at most, within an inquiry
- the use of multiple sources of evidence to map student learning and progress can provide illuminating indications of progress
- the use of 'emerging', 'developing', 'consolidating' and 'extending' as indicators of progress proved helpful for students as well as teachers in 'assessing' progress in skill development
- that students are likely to succeed in a full investigation if they have previously practiced and honed a range of inquiry skills

Teachers' active experiences within TEPs, have shown that in implementing the SAILs approach, they have become much more aware of the value of garnering evidence through activities such as student discussion and explanation, student---made videos, peer and self-assessment. Sharing practice within the TEPs, has elicited the variety of ways teachers' implement assessment strategies to enable students of differing abilities to gauge and monitor their own progress. Presenting to each other, how the inherent use of formative assessment in the participating secondary classrooms has better enabled teachers to inform assessment practice that makes obvious how students become aware of the more elusive inquiry skills such as the nature of individual contribution to collaborative endeavours. Teachers involved with TEPs in the project over three years (rather than just one) have been able to revise familiar activities to enact the SAILS inquiry approach across the science disciplines.

The compilation of TEP practice from different countries has enriched science teacher education programmes. In communicating how different programmes can achieve development in pedagogy, it has become clear that the SAILS activities offer ways to enhance and enrich understanding about teaching and learning science. By illustrating that current project teachers' practices range along a continuum, the SAILS work emphasises that teachers need time and support to develop and implement science inquiries. It also demonstrates how teaching and assessment become mutually supportive for student learning and the mastery of inquiry skills. Adjusting teaching and assessment into the more dynamic and iterative process that SAILS envisaged (through guided reflection and review with teachers), the nature and content of effective TEPs has been extended. What has become abundantly clear is that when teaching and assessment are enacted in such a responsive and integrated way classroom learning becomes revitalised and transformative.

4.2 Key features of TEPS

A. Introduction to IBSE

The ways that IBSE was 'introduced' for participant teachers ranged from a lecture (about IBSE) to a carefully constructed discussion about the nature of inquiry (that drew on prior reading of either case studies, journal articles or other appropriate literature) or even teachers reflecting on the experience of themselves being formatively assessed in different ways and subsequently considering how the contrasting approaches could be appropriate for their learners was illuminatory for participants. Many countries followed the Slovakian practice, that most conscientiously prepared participants for the TEPs by having them critically read and review papers in advance of the workshops. This was an extremely effective way to have teachers engage quickly and thoughtful with the often overlooked nuances of setting up good quality inquiry experiences for students.

B. Active hands-on (and minds-on) workshop experiences

All the TEP workshops provided some aspect of "hands-on" experience. The minimum experience

involved trialling some activities in situ, in the participant teacher's school. Good workshops provided 'Open' and 'Guided' inquiry experiences (as well as prescriptive practical activity) to enable experiential contrasts to be contemplated. Activities were varied and ranged from all participants carrying out the same activity and then collectively reflecting on it to workshop attendees rotating around a range of different inquiry activities (that often included SAILS units). The more effective TEPs enabled a cadre of teachers to regularly meet and collaboratively share their developing understanding and practices. Outstanding activities involved teachers rotating through different roles related to inquiry and assessment (e.g.: designing an inquiry; conducting an inquiry; writing an assessment for an inquiry; implementing someone else's assessment tool etc.). The most successful TEPs included those where teachers had devised (and shared) their own original inquiries they created for their own students.

C. Interactive reflective or plenary discussions

Useful discussion, included in the workshops, designed to share teacher views of 'hands---on' and 'minds---on' experiences ranged from reflecting immediately after a practical experience to collective discussions that were structured around teachers having devised inquiries within a topic, as well as the embedded formative assessment tools. Focused discussion about the trialling and evaluation of these enabled less experienced teachers to appreciate how features or characteristics of inquiries were related to the benefits and pitfalls for students. Gender and group---work were often 'key' features for reflective discussion after participants had engaged in 'role---play' to explore or investigate. A particularly good example of this was the 'mystery boxes' inquiry where male and female teachers were invited to (collaborate and) explicitly share how they might 'work---out' what (varied) contents were in sealed containers.

D. Introducing assessment of inquiry skills

Practice within TEPs varied to help teachers 'see' how to implement a wide variety of assessment (both formative and summative) strategies. Sometimes these were demonstrated; read about in case studies; experienced through workshop activities; disseminated through collective presentations illustrated with students work, self---assessed artefacts or even student---made videos. The chance to also reflect on task vignettes or transcripts of dialogue or talk in an inquiry situation to consider 'evidence' of inquiry skill development is an additional dimension of teacher education that can be very informative to help shape effective practice. The ways that different written, verbal and visual tools could be applied in contrasting assessment situations contributed towards effective professional development discussions. Offering Masters level Accreditation to enact an Action Research project (focused on inquiry and assessment) appeared to be a great motivation for some partners in the project. Finally, teachers devising inquiries within a topic, designing (formative and summative) assessment tools, trying them out, evaluating and reporting on the success (or not) of their learners through an extended dissertation.

E. Community of practice

These have become rich archives of good quality materials, inquiry resources, reflections on experience, exemplary assessment tools, pragmatic know---how to share with would---be SAILS teachers and much else besides. The legacy website offers a wealth of support for teachers who are keen and enthusiastic to learn more about SAILS (inquiry and formative assessment).

F. Evaluation of TEPs

Well run TEPs evaluated their impact on teacher's knowledge and practice (through the collective questionnaire). This meant that not only were their understandings and current practice sought at the beginning of the project, but they were (re)assessed at the end of the programme. In addition to this, some TEPs gathered on---going evidence of impact, involving :

- Participant (teacher) reaction;
- Participant (teacher) learning;
- Organisational support and change (how had schools/science departments changed as a result of involvement in SAILS);
- Participant use of new knowledge and skills (development of practice);
- Pupil (student performance of inquiries as well as the ways they self and peer assessed etc.) learning outcomes.

4.3 Conclusions

The TEPs within the SAILS project affected much change in understanding and practice (of over 2,500 teachers) throughout 12 partner countries. The teachers involved developed not only their appreciation and enactment of inquiry, but also how the component skills might be (best developed and) assessed. The TEPs provided the support (and mediation) to enable teachers to manage and organise effective (and affective) inquiry learning experiences. Both the students and the teachers became more expert in different forms (teacher, self and peer) of formative assessment of inquiry skills.

5. Final EAP report - Bronwen Cowie

Thank you for the opportunity to provide feedback on the SAILS report "Final report on the assessment framework and instruments for IBSE skills"(D2.4) and to take part in discussion of the framework at the project general assembly meeting in Dublin (October 2015). In this report I offer comments on the framework as outlined in a draft that I received before the Dublin meeting and on the version of the report that was tabled and discussed at the Dublin meeting. I have not read the final version of the framework report but, based on the depth of the discussion at Dublin, I am confident that the framework will contribute to conduct and assessment of inquiry learning of science across the EU community. The project design, through the dual focus on articulating a clear and shared framework and the production of case studies that illustrate aspects of the framework in action in different country contexts meets with recommendations from research that when the goal is to influence action and support self-assessment it is important to exemplify criteria. I consider I have been privileged to be part of the project.

5.1 Comments on framework report

The purpose of the report is articulated through its title, which clearly signals its focus is on assessment frameworks and instruments. The structuring of the report is consistent with this agenda and current understandings of the need to consider curriculum, pedagogy and assessment as the three key and interacting messages systems that impact schooling (Bernstein, 1971). An essential starting point in any assessment process is to decide what we wish to assess with this decision closely linked to what we wish to value and what we want students to learn. Deciding what activities could provide evidence of the different learning outcomes we are interested in is another important step. These aspects and their interaction are recognised through the structuring of the framework document and the text included in the different sections. In my view this approach will be of assistance to teacher readers and professional development providers/ teacher educators who use the document as a basis for professional development programmes.

What is to be assessed?

The SAILS project has identified four main aspects as central to the inquiry learning in science and as competencies that students could and should develop:

- content knowledge – concepts, facts
- inquiry skills:
  - planning an investigation
  - developing hypotheses
  - working collaboratively
  - forming coherent arguments
- reasoning ability
  - inductive, deductive, combinatorial, probabilistic
- scientific literacy
  - capacity to use knowledge in different contexts

The Dublin discussion usefully analysed and further elaborated how these might play out within the classroom.

Assessment in the context of SAILS

I read the intention of this section as being to provide an elaboration of the assessment process as it links to inquiry. In assisting to reframe thinking about assessment it foregrounds the formative role assessment can, and needs to have, for students to be able to monitor and manage their progress through the inquiry cycle and for teachers to be able to offer guidance that does not take the thinking away from students (Harlen, 2013). That teachers, students themselves and students with peers need to be involved in assessment as part of inquiry is a clear focus. Further attention could be given to the unit of analysis for teacher data collection and feedback – when is it appropriate to focus on the individual, the group and the whole class. This would assist teacher decision making around matters such as if/when they have enough data to know whether to intervene with the whole class and what kind of intervention is likely to be the most appropriate.

This section emphasises the need for teachers to be able to use a range of tools and techniques to generate information on student learning and to provide feedback on their progress – written, oral, observation, and demonstration. It is a real strength that the cases illustrate variations in these practices in action. I consider that the tables in Sections 3 and 4, that summarise which of these approaches are foregrounded and feature more strongly in the different cases will be of use to teachers/ teacher educators who are interesting in asking: What could/does this form of data generation look like?

There is evidence from the report that project members have made considerable use of rubrics. Different levels or degrees of understanding/ competency for the different inquiry skills are unpacked in different ways in the different examples. For example, the examples in the report involve 3/4/5/6 levels for judgement and the basis for judgement ranges from more quantitative criteria such as number of items, ideas, variables, to more qualitative judgement criteria such as coherence, completeness, clarity, link to/use of evidence and reasoning, and includes some examples where the basis for judgement reads as more affective as in the sense of making a judgement about what 'seems' or 'feels' to be. Robust discussion was had on the relative merits of different numbers of levels, the potential positive and negative influence of different labels for levels, and the different bases for judgement. This matter is something the assessment community is grappling with, all the more so at this time when countries are looking to define standards and or learning progression for use in monitoring student/ teacher achievement and progress. The report makes a contribution in drawing this issue to the attention of readers.

The report authors would be advised to provide more evidence and examples of feedback and formative action as this is the aspect of the formative assessment cycle most teachers find challenging and many appear to omit.

What are the principles that underpin SAILS assessment focus and approach?

As part of the Dublin meeting there was a robust discussion about what principles provided the ground for assessment in SAILS. The following ideas emerged from this discussion:

- Careful thinking to develop a broad consensus about the 'what' of inquiry – this is defined and detailed;
- An overall formative agenda

- A deliberate expansion, in-line with current thinking about formative assessment, about what counts as evidence;
- A re-visioning of the teacher role to that of someone who stands back and guides rather than directs students through the inquiry learning process.

For me these translated into the following principles and values:

- Teacher assessment is a dynamic responsive multifaceted cyclic process that takes place multiple timeframes
- Teacher assessment practice is shaped by the local context (country, school and classroom) – teachers need to be able to adjust their practice to the local context.
- Most units can be used to help students to learn any and all of the aspects of inquiry detailed in the SAILS framework and hence they can provide evidence of most of the learning outcomes that SAILS is interested in.
- Teachers need to access and use a range of evidence to ground and inform their decisions
- Teachers would be advised to focus their assessment and student self-assessment on only 2 or 3 aspects of inquiry in any one lesson and look to 'cover' all aspects in multiple contexts over time.
- Developing inquiry practices, by both teachers and students, takes time as teachers and students need to learn to act, interact and learn in different and often new ways.
- Supporting student inquiry involves teachers "standing back" having set up their students to self-assess and monitor their own progress and projects
- Involving students in the development of criteria for making judgements is something to be worked towards
- Peer and self-assessment usefully go together
- A credit view of students is fundamental
- Student science learning must be useful and useable outside the classroom.
- Sensitive assessment of student science learning via inquiry can provide opportunities for student voice and empowerment

5.2 Overall messages

Overall the report offers some very important messages to policymakers, professional leaders and providers and teachers. These include:

- Teacher adaptation of the material provided through SAILS is valued. This is an important, and in my view essential message given differences across the participating countries and because of the increase in diversity of student backgrounds and experiences to be found within schools and individual classrooms. It sends a strong signal about the value of science teaching and assessment that is student-centred and responsive.
- Most aspects of science inquiry can be assessed in any task but some tasks lend themselves more readily to particular aspects. Accompanied by explicit commentary to this effect, this message will assist teachers in understanding the integrated nature inquiry learning in science.
- Teachers would be wise to choose 2-3 aspects of the SAILS inquiry framework to focus on. This message connects with the previous one - while most tasks can foster most

competencies, some tasks foster some competencies more readily and more authentically than others and it is not necessary for teachers or students to focus on all of these aspects all the time. The implication then is that teachers need to look over the longer term to work with their students to provide opportunities to encounter engage with and develop the different understandings and skills of inquiry in science.

- The case studies and case study analysis makes it clear that there are many different ways to achieve and demonstrate the same aspect of the inquiry process and hence there are many different ways to assess /make visible the same aspect. This leads to the merit in teachers using a variety of assessment tools.
- The diagram of the assessment cycle, taken from Harlen places students in the centre of the assessment process- the priority is student involvement.
- Students can struggle to make sense of new and different assessment processes including expectations of self-assessment linked to the use of rubric descriptors and levels. There is evidence in the cases of teachers beginning by setting and using criteria themselves and having trialled this coming to the realisation that they could share the criteria and this task with students, and even involve students in the development/ negotiation of criteria. In this way the report affirms the importance of starting with something that is comfortable/ manageable and the value of learning from and acting on reflection on experience. A pathway of development towards students at the centre of the assessment process is thus embedded in the text.
- In terms of manageability for teachers seeking to change their practice, the examples illustrate the value of interplay of focus on individuals, groups, class: teachers can sample from a group/ number of students to inform practice.

6. PSC Response to EAP Reports

We are grateful to our two EAP members for their contributions to the SAILS project through attendance at general assembly meetings, reviewing and commentary on draft project reports and presenting these final reports on core aspects of the SAILS approach and outputs:

- SAILS Teacher Education Programmes and Community of Practice
- SAILS Inquiry and Assessment Framework and instruments for IBSE skills

We welcome Prof Deb McGregor's thoughtful report and reflections on the TEPs. She attended three TEPs in three different countries, and provided some very useful on-the-spot praise, comments and ideas, and critically evaluated the results from all 12 TEPs. She also gave detailed feedback at the Hannover and Dublin GA meetings. We appreciate Prof McGregor's overall positive comments on the TEPs: "*Teachers who participate in SAILS in-service experiences appear to be appreciating and understanding how inquiry skills teaching and assessment differ to their 'usual' classroom practices (driven by policy and examination agendas). The effective professional learning appears to be consistently underpinned by good quality resources and effective questioning frameworks*". The detailed comments on the three individual TEPs she attended provide a valuable set of observations from a critical friend, and will serve teacher educators well when organising future workshops. The highlights from the various TEPs provide a rich resource for the SAILS community and beyond. For example, while the SAILS TEPs emphasized socio-cognitive aspects of teaching many teachers are not familiar with, some teachers and teacher educators may indeed find that the emphasis has been too great and has come at the expense of addressing reasoning issues such as understanding variables and scientific methods. The list of suggestions raised by Prof McGregor for future TEPs are important considerations for teacher educators and can be adopted by them depending on their national needs/context. Some of these aspects have already been successfully addressed in different SAILS TEPs. We believe that the excellent SAILS legacy website and vibrant Communities of Practice will enable effective communication of key messages of the project. 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.

We welcome Prof. Brownen's feedback on the "Final report on the assessment framework and instruments for IBSE skills" (D2.4). Her comment on "*the essential starting point in any assessment process is to decide what we wish to assess with this decision closely linked to what we wish to value and what we want students to learn*" is strongly aligned with the approach adopted by the SAILS team. Prof. Cowie has reviewed this framework document along with several of the assessment tools and instruments that have been developed over the course of this project. A considerable effort has been devoted by the project team to collaborate with teachers to collate assessment tools and instruments and produce 19 SAILS Inquiry and Assessment Units and over 100 case studies of trialling in the classroom. The value of this approach has been recognised by Prof. Cowie "*need for teachers to be able to use a range of tools and techniques to generate information on student learning and to provide feedback on their progress – written, oral, observation, and demonstration. It is a real strength that the cases illustrate variations in these practices in action".* Prof. Cowie's articulation of the principles that underpins SAILS assessment focus and approach and that values that ensue are insightful for practitioners developing their inquiry and assessment practices. We concur with her identification of key considerations for developing inquiry and assessment practices that should be conveyed to all teachers, educators, policymakers, professional leaders and providers.

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