MEETING THE CHALLENGE OF ASSESSING INQUIRY LEARNING IN SCIENCE

SAILS
Strategies for Assessment of Inquiry Learning in Science

ASSESSING INQUIRY LEARNING IN SCIENCE

Focus on assessment of inquiry skills and competencies

Inquiry skills are what learners use to make sense of the world around them. Inquiry approaches can help students develop deep conceptual understanding and encourage engagement with science. Inquiry approaches provide both the impetus and experience that helps students acquire problem solving and lifelong learning skills. These skills are important so that all citizens may make informed and reasoned decisions.

Within the SAILS project, inquiry in the science classroom is understood to be the intentional process of providing opportunities where students are actively involved in diagnosing problems, critiquing experiments and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments. In carrying out this project, SAILS has focussed on supporting the development of four inquiry skills (developing hypotheses, working collaboratively, forming coherent arguments, planning investigations) as well as the competencies of scientific reasoning and scientific literacy. The project team has developed and provided professional development programmes for second level science teachers, both in-service and pre-service, that support teachers' understanding of how inquiry approaches can be facilitated and assessed in the classroom.

SAILS Framework for Inquiry and Assessment

The SAILS Framework describes each of these inquiry skills and competencies and presents proven strategies for assessing them. Based on established research into cognition and assessment, it provides illustrative examples of classroom based assessment practices applied across the sciences. The SAILS team identified and selected inquiry activities that promoted these skills and competencies and developed assessment strategies appropriate for each skill and competency highlighted in these activities.

SAILS key findings

- Teaching and assessment considered as a dynamic and iterative process can effectively support inquiry learning.
- Learning science through inquiry can result in better understanding and more broadly applicable scientific knowledge, along with the development of transferable skills and competencies.
- With time and support, teachers can develop their confidence and competence in adopting inquiry and assessment of inquiry learning in classroom practice.
- Sustained collaboration is crucial in science education – between teachers and educators and across borders, both classrooms and countries.

Teacher Education Programmes:

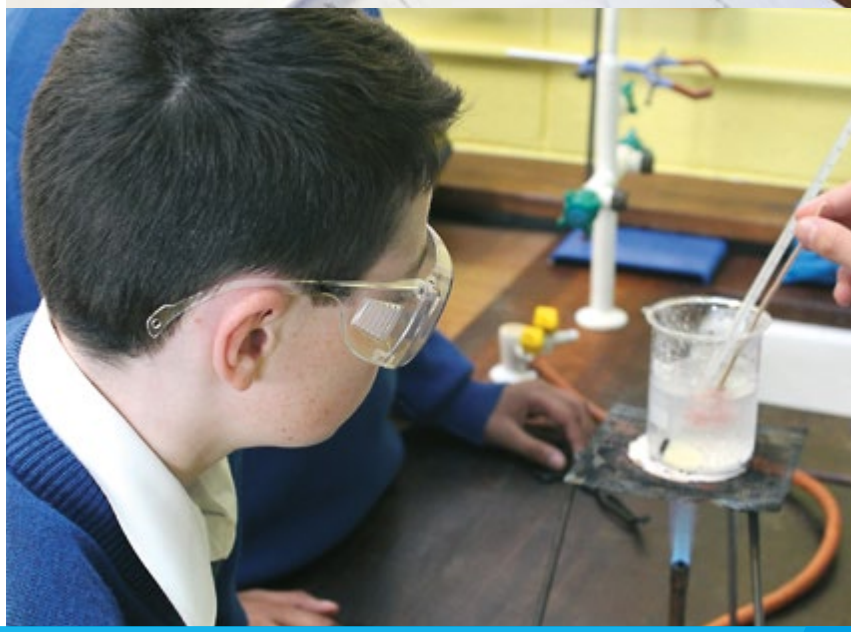
Teachers in the role of learners

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.

Assessment practices in the inquiry classroom

Through a dynamic collaboration between SAILS partners and teachers, nineteen **SAILS Inquiry and Assessment Units** have been developed 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. These units have been used as an integral component of the SAILS teacher education programmes, as they provide evidence that each inquiry skill and competence can be readily assessed. The units also show how teachers were able to adapt assessment strategies to suit their learning aims and also how they adapted the materials to suit their own students and curricula.

> Being involved in inquiry learning and attending workshops has changed my mind-set in terms of how I view and how I think about assessment. I now realise that there are so many more different types of assessment. Before I got involved in inquiry learning, for me assessment was, quite literally, just that test that you gave at the end of the topic. Now I understand assessment can be much richer.
>
> SAILS teacher









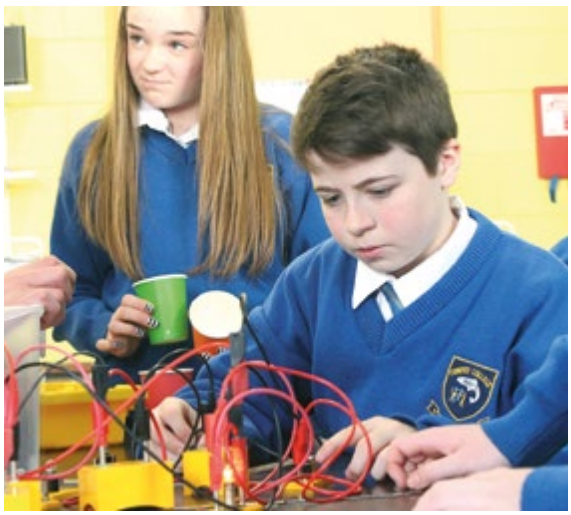


SAILS INQUIRY AND ASSESSMENT UNITS

The **SAILS Inquiry and Assessment Units** showcase a range of methods used to assess inquiry skills. The first section in each unit provides the key content and concepts. The second section gives ideas on how the activities can be implemented, how the skills and competencies involved can be assessed and how teachers have used the assessments. The third section provides a synthesis of the case studies of how the teaching approaches and assessment strategies were implemented in at least three countries.

Adopting teaching approaches to collect evidence of student learning

The units provide clear examples for teachers of how inquiry skills can be assessed alongside content knowledge, scientific literacy and scientific reasoning. They 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 units relate to classroom practice and include examples of assessment items and assessment criteria. The SAILS units contain ready-to-use learning aids, greatly enriched by models of how teachers may support their students with frequent and personalised feedback when they are engaged in biology, chemistry and physics inquiries. The integration of inquiry skills and disciplinary knowledge can significantly extend teachers' pedagogical content knowledge.



Example of suggested teaching approach on the concept of electricity

- At the start of the lesson, the teacher initiates a rich discussion by asking questions that relate implicitly to the use of electricity in everyday life. For example: How did people in the past adapt to living in darkness and how do people do that today?
- After identification of the term 'electricity', students are asked to construct a mind map.
- Meanwhile, the teacher can ask some stimulating questions, for example: What is the possible origin of the word "electricity"? What do you think happens when an electric current flows?
- After completing their mind maps, students distinguish between scientific terms and everyday language.
- Students form groups and debate the terms on their mind maps.

From SAILS Inquiry & Assessment Unit: Electricity, activity A

Adopting strategies to assess student learning

Teachers have adapted and adopted many different assessment strategies to assess the same skill, as described in the case studies. The case studies provide a narrative of how the teachers approached inquiry in their classroom, how feasible the lesson was with the class group and how they assessed their students' learning. They also highlight any issues encountered, relating to cultural perspectives and other equity issues, such as gender. It is clear that teachers have adapted SAILS units to also focus on additional skills that the teacher wished to develop. The assessment criteria used were also modified to suit student age and their experience level with inquiry and, in some case studies, these criteria were also shared with the students so that they developed their experience with self-assessment and peer-assessment.

The collection of nineteen SAILS Inquiry and Assessment Units has been published, and electronic versions including case study reports, frameworks and related classroom materials are available for download at:

WWW.SAILS-PROJECT.EU










Example of assessment strategy using peer-assessment

- Students first made an attempt at writing conclusions for their investigation.
- They were given an arrow rubric to peer-assess these conclusions.
- The teacher also used this rubric for student feedback and to check the quality and accuracy of the peer-assessment.
- The students were given the opportunity to redraft, focussing on what they had missed out and improving their original ideas.
- The students were given four anonymised final versions of their peers' work and asked to rank them. They were then asked to reconsider their judgement using the rubric.
- The students worked in collaboration with the teacher to redefine the criteria used.

EMERGING SCIENTISTS
- Describe what they have found out in experiments.
- Make basic explanations of their findings and observations.

DEVELOPING SCIENTISTS
- Describe what they have found out in investigations, linking cause and effect, referring to variables.
- Draw straighforward conclusions from data presented.

CONFIDENT SCIENTISTS
- Intepret data, recognising obvious inconsistencies and errors.
- Identify patterns in data.
- Draw valid conclusions that may link more than one piece of supportiung evidence, to make scientific explanations of findings.
- Select and manipluate data and information and use them to contribute to conclusions.

EXPERT SCIENTISTS
- Write conclusions that are consistent with the evidence they have collected and explain them using accurate scientific knowledge and understanding.
- Process data, including multi-step calculations to identify relationships between variables.
- Accurately assess the strength of evidence, deciding whether it is sufficient to support a conclusion.

From SAILS Inquiry & Assessment Unit: Collision of an Egg, case study 3

IMPACT OF SAILS PROJECT

Innovative science teacher education programmes in inquiry and assessment

The most important predictor of students' achievements is the quality of the teaching they receive. In recent years, developments in teacher education have been organised under several conceptual frameworks. These include improving the scientific foundations of teaching, developing teachers' knowledge and skills alongside providing them with materials and tools, and preparing teachers for identifying and applying research results and carrying out teaching experiments to improve their own work. The SAILS Teacher Education Programmes carried out in each partner country have been carefully aligned with these frameworks. They prepare teachers to identify and assess inquiry, literacy and reasoning skills. By adopting the SAILS framework teachers come to realise how learning science in an inquiry context may result in better understanding and broadly applicable, transferable knowledge and skills.

Teachers more confident and competent in the assessment of their students' learning

Through the collaborative efforts of partners, the SAILS project has demonstrated how inquiry approaches can be used for teaching a range of scientific topics, and has helped science teachers become confident and competent in the assessment of their students' learning through inquiry. More than 2500 science teachers in 12 countries have participated in SAILS teacher education programmes. These teachers have strengthened their inquiry pedagogy and assessment practices by developing their understanding of the role of assessment.

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 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.

Professor Bronwen Cowie,
External Advisor to SAILS project

Students more involved in the learning process

Through SAILS, many teachers have successfully adapted their teaching approaches and have given students a more active role. For example, they organised experimental work so that students raised questions, decided on appropriate methods and analysed the data they collected. Teachers have also coached their students on working more collaboratively and communicating their ideas to others. This has resulted in students using one another as a resource and discussing their scientific thinking as they went about their inquiry activities. For many students, taking on the responsibility of inquiry helped them engage in the learning process and to find ways to work well with their peers. In some classrooms, the teachers developed peer-assessment exercises that allowed students to map their progress in developing inquiry skills and to target what they might do to improve in the next inquiry lesson. Two key characteristics of the SAILS approach have been observed: students are more involved in the active learning process; and students developed lifelong skills critical to thinking creatively, as they learn how to solve and discuss problems using logic and reasoning.

SAILS approaches have enabled teachers to both observe what students could do and to hear the reasons why students took certain decisions. It also revealed the range of inferences students made from their data and how students interpreted their results in terms of their scientific understanding. The teachers had more opportunities to assess their students' developing skills and understanding during the inquiry process and reported that it helped them get a clearer view of how students were doing and also what students needed to help them progress.

> Allow students to fail. We all learn from our mistakes. If students are not allowed to experiment and discover for themselves what works and what doesn't they are not getting an education, they are being drilled for exam success. Have fun. I have often been surprised by the new and innovative ways in which students approach a task and have learnt a lot from them over the years. Inquiry allows knowledge and wisdom to be grown and skills to be developed by the individual.

SAILS teacher

> 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.

Professor Debra McGregor,
External Advisor to SAILS project

Project description

The Strategies for Assessment of Inquiry Learning in Science (SAILS) project was funded under the EU Framework Seventh Programme (2012-2015) to support teachers in adopting inquiry based science education (IBSE) and assessment of inquiry skills and competencies in science at second level across Europe. More than 2500 teachers in the 12 participating European countries, who have participated in SAILS teacher education programmes, have strengthened their inquiry pedagogy and assessment practices through developing their understanding of the role of assessment.

The project team has collaborated with local science teachers to publish 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 particular, the units provide clear examples of how inquiry skills (developing hypotheses, working collaboratively, forming coherent arguments and planning investigations) can be assessed, alongside content knowledge, scientific literacy and scientific reasoning and illustrate the benefits of various types of assessments.

Project partners

Dublin City University, Ireland

Intel Performance Learning Solutions Limited, Ireland

Pavol Jozef Šafárik University in Košice, Slovakia

Jagiellonian University, Poland

Malmö University, Sweden

Kristianstad University, Sweden

University of Southern Denmark, Denmark

The Institute of Education of the Lisbon University, Portugal

King's College London, United Kingdom

University of Szeged, Hungary

ATiT, Belgium

University of Piraeus Research Centre, Greece

Hacettepe University, Turkey

Gottfried Wilhelm Leibniz Universität Hannover, Germany

Project Coordinator

Centre for the Advancement of Science and Mathematics Teaching and Learning (CASTeL)
Dublin City University,
Dublin 9, Ireland
Dr. Odilla Finlayson (project coordinator)
Dr. Deirdre McCabe (project manager)

Contact

info@sails-project.eu
T: +353 (0) 1 700 5276

www.sails-project.eu

This project has received funding from the European Union's Seventh Framework Programme for research technological development and demonstration under grant agreement no 289085