

PISA Scientific Literacy: a short guide for Key Stage 4 teachers

The Programme for International Student Assessment (PISA) evaluates education systems worldwide by testing the skills and knowledge of 15-year-olds in the key areas: reading, mathematics and science. The assessments take place every 3 years, and in 2015 science will be the 'major domain'. This means that around half of the questions in the 2015 PISA test will assess Scientific Literacy.

PISA is operated by the Organisation for Economic Co-operation and Development (OECD), which has published a detailed *draft science framework*¹ for 2015. The framework sets out the evolution of thinking and international research which has informed the development of Scientific Literacy assessment over recent years.

This short guide for teachers captures key elements from the Framework document that will be useful to you when delivering science at Key Stage 4. For more detail on what is going to be assessed, including information on question contexts and some example questions highlighting key points, please refer to the OECD Framework through the link below.

The Welsh Government also produced (2012) *a guide to using PISA as a learning context*² which provides further background to PISA; including how PISA style questions can support pedagogy and help improve teaching and learning. It is envisaged that support being made available through Welsh Government and your local Education Consortium will also prove useful in improving your pupils' performance in other external examinations.

Why does Scientific Literacy matter to us in Wales?

All your pupils need to understand that science is an integral part of their everyday lives. From the technology they use, the way they travel and communicate with others, to their health, food and energy use. They also need to understand the impact of their choices on their own wellbeing and that of others, and upon the environment, both local and global.

Pupils should understand that science will be at the core of meeting some of the challenges the world is facing, such as cures for disease, food shortages and climate change, and they should understand some of the methods that will be used by scientists to do this.

Some pupils may go on to be the scientists of the future, finding innovative solutions to world problems. Wales needs more well educated and qualified scientists of both genders to support our economic, social and environmental development. However, many more pupils will use science and scientific skills in their future careers. Whatever pathways your pupils take after they leave school, a sound level of Scientific Literacy is essential to prepare them for their lives in a rapidly changing world.

¹ www.oecd.org/pisa/pisaproducts/pisa2015draftframeworks.htm

² www.wales.gov.uk/topics/educationandskills/publications/guidance/pisaguide/?lang=en

What is Scientific Literacy?

Scientific Literacy is defined by the OECD as:

“the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen”

Scientific Literacy requires core knowledge of the concepts and theories of science. It also requires knowledge of the common procedures and practices associated with scientific enquiry, and how these enable science to advance. Pupils who are scientifically literate have knowledge of:

- the major concepts and ideas that form the foundation of scientific and technological thought;
- how scientific knowledge has been derived; and
- the degree to which such knowledge is justified by evidence or theoretical explanations.

As a 15 year old, Nia has a keen interest in scientific topics. She engages well on science-related issues both in class and more widely across school life, and has concern for technology issues, resources, and the environment. Nia regularly reflects on the importance of science from a personal and social perspective. While Nia is not currently planning to study science beyond Key Stage 4, she clearly recognises that science, technology and research are essential elements of contemporary culture. She also appreciates that a good understanding of scientific methods is advantageous in many types of work. She displays a good level of Scientific Literacy.

The components of Scientific Literacy

Scientific Literacy as defined by the OECD builds on a series of competencies, knowledge areas and attitudes.

Competencies	Knowledge	Attitudes
<ul style="list-style-type: none">• Explaining phenomena scientifically• Evaluating and designing scientific enquiry• Interpreting data and evidence scientifically	<ul style="list-style-type: none">• Knowledge of the content of science:<ul style="list-style-type: none">– Physical systems– Living systems– Earth and space systems• Procedural knowledge• Epistemic knowledge	<ul style="list-style-type: none">• Interest in science• Valuing scientific approaches to enquiry• Environmental awareness

(OECD 2013, PISA 2015 Draft Science Framework)

Competencies

A Scientifically Literate pupil should be able to demonstrate three competencies:

1. Explain phenomena scientifically:
 - Recognise, offer and evaluate explanations for a range of natural and technological phenomena
2. Evaluate and design scientific enquiry:
 - Describe and appraise scientific investigations and propose ways of addressing questions scientifically
3. Interpret data and evidence scientifically
 - Analyse and evaluate data, claims and arguments in a variety of scenarios and draw appropriate scientific conclusions.

Knowledge

The above competencies require knowledge, and the OECD defines this in 3 areas:

1. Content knowledge:
 - The facts, concepts, ideas and theories that science has established. For instance, how plants synthesise complex molecules using light energy, water and carbon dioxide.
2. Procedural knowledge:
 - The practices and concepts on which empirical enquiry is based. For instance, how controlling variables and using standard operating procedures can be used to determine the effect of surface area on reaction rate.
3. Epistemic knowledge
 - Understanding the role that arguments, observations, theories, hypotheses, models, and questions play in science. For instance, when discussing the widespread use of statins to reduce cholesterol, how peer review, challenging the data collected by drug companies and others, and testing hypotheses on their effectiveness and side effects, can allow us to make decisions about statin use.

The ability to explain scientific phenomena requires scientific knowledge. However, both the procedural and epistemic knowledge areas are also necessary to identify questions that are amenable to scientific enquiry, to judge whether appropriate procedures have been used, and to distinguish scientific issues from values or economic considerations. As your pupils progress in their lives, they will acquire knowledge from multiple sources, including the Internet and media. They will need procedural and epistemic knowledge to be able to decide whether the many claims that pervade contemporary society (eg through advertising or work-based assertions) have been derived using appropriate procedures and are warranted.

Attitudes

Scientific Literacy also recognises that how your pupils display their scientific competencies is a factor. Their attitude towards science will determine levels of interest, sustain engagement, and may motivate them to action (eg in opting for further scientific study, or lifestyle choices).

The 2015 Scientific Literacy assessment

The 2015 PISA Scientific Literacy framework sets out the detail of the distribution of score points for both knowledge areas and competencies. In summary, the ratio of questions assessing your pupils' content knowledge to those assessing procedural and epistemic knowledge will be about 3:2.

Approximately 50% of the questions will test the competency to explain phenomena scientifically, 30% the competency to interpret data and evidence scientifically, and 20% the competency to evaluate and design scientific enquiry.

In most cases, test units will assess multiple competencies and knowledge categories, with individual questions focussing on one form of knowledge and one competency. Cognitive demand will consist of low, medium and hard questions; with three classes of questions: simple multiple-choice; complex multiple-choice; and constructed (written or drawn) responses.

Competencies, knowledge areas and attitudes will be explored in contexts that relate to self, family and peer groups (personal), the community (local and national), and life across the world (global). Question contexts will be spread across personal, local/national, and global settings roughly in the ratio 1:2:1.

Stimulus material and questions will use language that is clear and simple, with the number of concepts introduced per paragraph being limited. Scientific Literacy questions will not assess reading or mathematical ability, as these are tested in other areas of the PISA assessment, though your pupils will need to understand the texts to be able to answer the science questions.

Scientific Literacy in the classroom – teacher support

Your regional Education Consortium has an Advisor/Leader of Learning available to support the teaching and learning of Scientific Literacy in your school at Key Stage 4.

Consortium Advisors/Leaders of Learning have been supplied with a Matrix Comparison document tracking the three 2015 PISA Scientific Literacy knowledge areas against the main Key Stage 4 science qualifications currently being delivered in Wales. Through discussion with your Consortium Advisor/Leader of Learning, this tool can be useful to review what you are currently delivering against what your pupils may face in the 2015 PISA assessment and the development of Scientific Literacy more generally. This will also be important as you prepare for science curriculum and qualification changes going forward.

Your Science Advisor/Leader of Learning will facilitate school to school peer learning in your local areas. They will also be able to guide you on the range of resources and enrichment available in support of Scientific Literacy delivery in Wales. As an outline guide, during 2014/15 you will have available:

- PISA-style Scientific Literacy sample questions in a class ready format
- Refreshed Guidance on STEM, including information on the Scientific Literacy approach
- An online INSET Module on Scientific Literacy for your further development
- An online directory of STEM enrichment programmes and materials
- A calendar of science events and activities for learners, teachers and parents
- Information for learners on science related careers and further learning