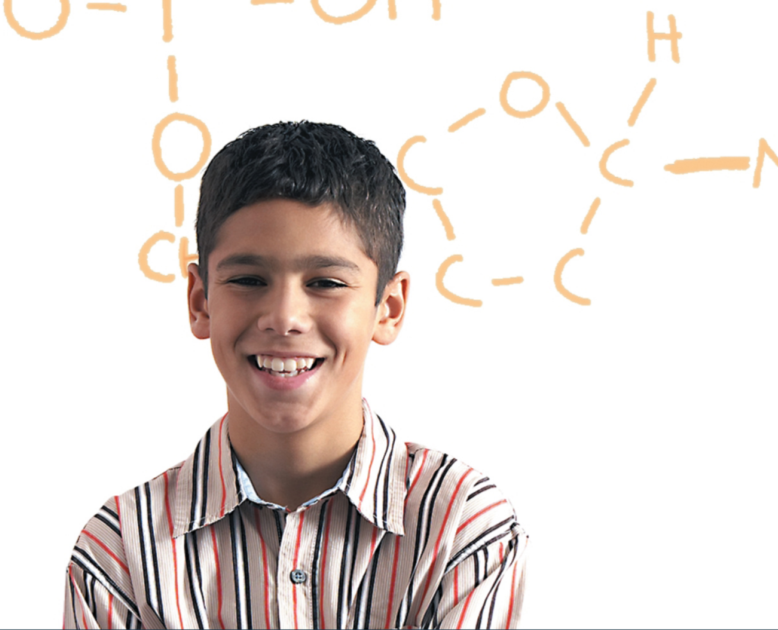

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# An International Comparison of Science Teaching and Learning

## Further Results from PISA 2006

WAXMANN

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# 1 Science Teaching and Learning

## 1.1 Introduction

School is the place where young people are systematically familiarized with science over a long period of time. In today’s world, scientific competencies are still primarily gained in school. It is, therefore, a place where students have the opportunity to develop a basic understanding of scientific concepts, scientific methods and scientific ways of thinking. In addition, students can start to comprehend the importance of science and may become interested in science topics.

The OECD Programme for International Student Assessment (PISA) is an assessment of 15-year-old students, which is carried out every three years in the participating countries. The age of 15 was chosen as, in most OECD countries, it represents the age when students reach the end of their compulsory education. A test at this age, therefore, represents a measure of the students’ accumulation of educational experiences over a number of years and gives an indication as to how well the students are prepared for the future. PISA assesses three main subjects – reading, mathematics and science. In each survey one of these subjects is the focus of the assessment – in PISA 2000 it was reading, in PISA 2003 it was mathematics and in PISA 2006 it was science. This means that the majority of the two-hour testing time is devoted to that subject. In addition to the assessment, students also complete a questionnaire which indicates their home background, attitudes toward school and, in 2006, their interest in science-related topics as well as the likelihood that they would follow a science-orientated career.

The international report on PISA 2006, (OECD, 2007a) described the science competencies that 15-year-old students develop. The report provided a detailed profile of the science knowledge and skills at the national and international levels and described performance in science for different sub-groups in relation to gender and other background influences. The framework for the assessment of scientific literacy also underlined the relevance of students’ attitudes and motivational orientations towards science. The report, however, did not systematically consider science learning environments in schools and their relationship to cognitive and motivational outcomes in terms of scientific literacy. Some of the differences in scientific literacy found in PISA 2006 may be attributed to different learning opportunities in school. Therefore, the conditions under which adolescents deal with science in school lessons should be investigated: What are the conditions? How systematically does the work in science take place? What are typical approaches to teaching science in school? Which didactical approaches can be found in the participating countries? What do the differences in these approaches mean for students' development of scientific literacy and science-related attitudes, orientations and interests?

With its main focus on science, PISA 2006 was able to examine, in detail, some facets of science teaching and learning in the OECD countries. Using questionnaires, students were asked to describe characteristics of their science lessons that provide opportunities for meaningful learning experiences. The major aim of this report is to investigate how science is taught in the OECD, to study the diversity of science teaching and learning, and to describe typical approaches taken in science teaching. The report also explores the relationship between patterns of science teaching and the level of scientific literacy and interest in science of 15-year-old students.

The questionnaires used for the description of science teaching and learning in PISA 2006 are based on current international research (Scheerens, Seidel, Witziers, Hendriks, & Doornekamp, 2005; Seidel & Prenzel, 2006, Seidel & Shavelson, 2007). Accordingly, the questions are targeted towards teaching and learning activities that are expected to have a positive effect on the development of scientific competencies. Conditions for effective science teaching and learning include the lesson time provided, the degree of interactive teaching, and the frequency of experiments, as well as an introduction to scientific research approaches, scientific modelling, and the application of knowledge and principles. Recent research in science teaching and learning shows that effective science teaching does not necessarily rely on one particular method (Aebli, 1998; Baumert & Köller, 2000a; Prenzel, Seidel, Lehrke, Rimmele, Duit et al., 2002). It is the orchestration, the adaptivity, and the dosage of teaching activities and approaches that is important. The didactical approach of the teacher has to take into account the specific situation and students' backgrounds (Seidel, 2006). Successful teaching is characterised by a variety of methods that carefully support student learning. Good practice in science teaching involves a clear cognitive structure and precise instructions, but also allows and encourages students to use their mind and to develop their own interpretations from scientific experiments.

Data from PISA 2006 enable lesson features to be described from the perspective of the students. In the questionnaire, they were asked which characteristics of science teaching and learning occur in their lessons. In principle, this procedure of describing teaching through students is considered reliable. This is especially true for student questionnaires at a national level where students' ratings are based on a more or less common cultural background. However, if learning contexts (e.g. types of schools) are differentiated within a country, differences in responses emerge due to variations in the bases for comparison. The same effect occurs if we compare ratings of students from different countries. Thus, an international comparison of science teaching and learning carried out on the basis of student questionnaires must be interpreted cautiously, as the country-specific reference points for student responses can be different between countries.

PISA 2006 took these methodological aspects into consideration when formulating the questionnaire items. The student questionnaire is focused on lesson characteristics which – according to international research on teaching and learning – support learning processes in general and are thus relevant in all the countries tested (Scheerens et al., 2005; Seidel & Prenzel, 2006; Seidel & Shavelson, 2007). In particular, the questions refer to observable events which make it easier for students to evaluate lesson characteristics in a way that is independent of subjective comparison. They ask about the frequency with which clearly definable teaching and learning activities occur in science lessons. With this methodology PISA can provide insights into international science teaching and learning. The data collected allow a description of the focus of teaching and learning activities in the context of an international comparison. Of particular interest in this context is whether specific teaching patterns can be identified in the ways in which countries make students familiar with scientific methods and scientific ways of thinking. Thus, the way in which teaching patterns are related to the scientific literacy and interests developed by 15-year-olds will be analysed.

PISA aims to provide reliable, valid internationally comparative data about secondary school students. To do this most effectively, an age based sample is at the core of the design. The fact that the PISA sample is based on age rather than grade does, however, impose some restrictions on the design of the survey. For example, PISA does not include sampling on the classroom level. Therefore, the reports from students cannot be aggregated at that level, making it difficult to provide a complete description of science teaching (Wittwer, 2008). Furthermore, many countries offer science as one comprehensive subject in their schools, while other countries divide science into different disciplines. Moreover, one must keep in mind that PISA asks about features of science teaching in the current school year, while, in fact, student performance in PISA is a result of many years of cumulative learning. When connections between instructional practices and students' test performance are analysed and interpreted; all of these aspects indicate the need for caution.

The report, therefore, provides information about questions regarding the context of science teaching and learning in the OECD countries, the time that students spend on science, the perceptions that students have about their science lessons and whether different patterns of science teaching are related to different levels of student performance in PISA.

## 1.2 Framework for the investigation of science teaching and learning

In the PISA 2006 science framework (OECD, 2006) it is stated that an understanding of science and technology, as well as positive attitudes towards science, are essential to a young person's preparedness for life in modern society. An understanding of science and technology enables people to fully participate in a society in which science and technology play a vital role. As a basis for the development of an international assessment of science, PISA 2006 asks "What is important for citizens to know, value, and be able to do in situations involving science and technology?" (OECD, 2006). The framework for the assessment of scientific literacy, summarised in Figure 1.1, provides directions to answer this question.

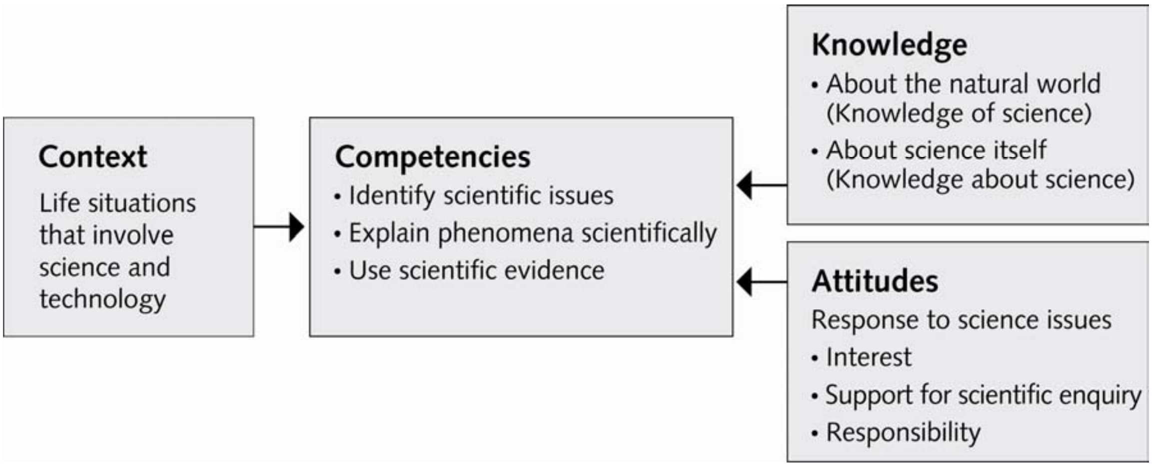


*Figure 1.1: Framework for scientific literacy in PISA 2006 (OECD, 2006)*

The core of this framework includes three competencies people will need to participate in modern society. The competencies are:

(1) Identifying scientific issues; this means, for example, being able to differentiate whether a question can be investigated scientifically, but this competency also encompasses a basic understanding of scientific enquiry

(2) Explaining phenomena scientifically; this competency enables people to make sense of certain situations that require an understanding of science as a process that produces knowledge and proposes explanations about the natural world.