CURRICULUM POLICY IMPLICATIONS OF THE PISA SCIENTIFIC LITERACY FRAMEWORK

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Abstract: Since 2000 the PISA-programme of the OECD assesses knowledge, skills and attitudes in the areas of reading, mathematics and science, areas which are seen as very important for the development of knowledge societies. Youngsters of age 15 in more than sixty countries are involved. The test items are based on three frameworks, not based on common curriculum standards but on knowledge requirements for future life. The PISA Scientific Literacy Framework deals with three competencies which are based on attitudes, contexts and knowledge, not only on science but also about science, i.e. procedural and epistemic aspects on which the work of scientists is based. The PISA-results are taken increasingly serious by media, ministers and members of parliament, resulting in visits to high ranking countries and quick measures, not always appreciated by teachers. In this paper it is argued that results should be interpreted with care and comments on interpretation of the results are given. Examples of implications for educational policy in various countries are shown. In view of the revised SL Framework (2015) recommendations are given for future international curriculum development.

Keywords: curriculum, PISA, scientific literacy, educational policy

INTRODUCTION

In 1997 the OECD took the initiative to develop PISA, the Programme for International Student Assessment, which monitors the outcomes of education systems regularly and provides a basis for international collaboration in defining and implementing educational policies. PISA focuses on students age 15 in the fields of reading, mathematics and science literacy and the tests are administered every three years since 2000, each time with emphasis on one field. In 2012 Mathematics was the main topic and the results will be published in December 2013. Preparations are in progress for PISA 2015, when Science for the second time will be the main field.

The frameworks are not based on common curriculum elements across the world (such as in TIMSS) but on skills and knowledge which students need in further life in the 21st century. The Science Literacy Framework (SLF) forms the foundation for construction of the assessment items. The core of the SLF has been based so far (OECD, 2009) on three scientific competencies: (1) identify scientific issues, (2) explain phenomena scientifically, and (3) use scientific evidence. These competences include both scientific knowledge and attitudes towards science, and should be applied to personal, social and global contexts. Scientific knowledge is split into knowledge of science and knowledge about science. The former contains the usual concepts in the fields of life, physical and earth science. The latter could be characterized as insight into the nature of science.
In the 2015 Scientific Literacy Framework more emphasis will be given to knowledge about science as this knowledge area will be split into procedural and epistemic aspects (OECD, 2013).

INTERPRETING RESULTS: TAKE CARE

The results of the PISA tests differ greatly between the participating 65 countries (OECD, 2010). For instance, in 2009 for Science the overall results per country varied between 575 (Shanghai-China) and 330 (Kyrgyzstan). Even within the group of OECD countries the differences are fairly large, with Finland (554) at the top and Mexico (413) at the bottom. Originally it was not the intention of the OECD to attribute high value to league tables. It was considered much more important to develop a common standard to identify bottlenecks and to monitor progress within countries. However, in media and politics the leagues tables have got more attention than intended.

In interpreting the results care should be taken, as has been stated by a number of authors:

a. PISA is not assessing all aims of science education in the participating countries as it is not based on current curricula (Mortimore, 2009); for instance students' laboratory performance is not assessed (Dolin & Krogh, 2010);
b. in the participating countries common test items and textbooks might be different from the PISA test items (Dolin & Krogh, 2010; Figazzolo, 2009; Mortimore, 2009; Hatzinikita, Dimopoulos & Christidou, 2008);
c. PISA results might partly be explained by scientific culture in society, for instance reflected in attention for science in the media, in science centres and in the nature of topics discussed at home and with friends (Lau, 2009);
d. the league tables should not be interpreted as precise ranking order; for instance in PISA 2006 the differences between Taipei (score 532, place 4) were not significantly different from Korea (score 522, place 11) and all countries in between;
e. it is not always clear with what motivation students participate in the PISA-study; this might be different between highly collective or individualistic cultures (Tan, 2013).

This is not to argue that the results have no value, only that they should be handled with care to make optimal benefit from them.

POLICY IMPLICATIONS

In many countries the PISA results have got public attention. In the United Kingdom alarming articles were seen in the media (Mortimore, 2008; Gardner, 2010). Journal articles have been devoted to the implications in for instance Germany (Kauertz et al., 2010; Knodel et al., 2013), England (Knodel et al., 2013), Denmark (Dolin & Krogh, 2010), Japan (Takayama, 2008; Knipprath, 2010), Shanghai (Tan, 2012; Sellar & Lingard, 2013), France (Dobbins & Martins, 2012), Israel (Feniger et al., 2012), Turkey (Gür et al., 2012), New Zealand (Baker & Jones, (2005), Europe (Grek, 20009) and the USA (Anderson et al., 2010) .

A general trend is to look across the border and some countries with positive PISA results came into the position of 'reference societies' (Schriewer & Martinez, 2004). For example, Finland and Shanghai have received many visitors from abroad to learn from the educational systems of these countries (Sahlberg, 2011; Tan, 2013). One may call this a PISA syndrome but unfortunately this term has already been used to refer to a neurological disorder which occurs due to a prolonged exposure to antipsychotic drugs[i].
Although benchmarking with other countries might be beneficial one should realize that problems in some countries could not always be solved with solutions from other countries. A striking example can be found in a publication of the Learning Curve Programme (Pearson,

2012) reporting on the top ranking of Korea and Finland according to educational output while their educational culture and tradition is in many aspects very different, such as the role of exams, teaching culture, class time, class size and salaries of teachers. What they have in common is not easily transferred: high status of teachers and teacher training, and high value of education in society.

In the Netherlands the Government has set some precise performance objectives related to PISA results: the Dutch scores should each three years increase with 5 points for mathematics, 4 points for reading and 2 points for science. One may wonder if such precise objectives are realistic. More effective might be that schools in the Netherlands have received additional funds to pay more attention to high achievers as both in TIMSS and PISA Dutch students score relatively low at the higher levels.

WHAT IS NEW IN THE PISA 2015 SCIENCE FRAMEWORK?

In the new framework (OECD, 2013) Scientific Literacy is defined as the ability to engage with science-related issues and with the ideas of science, as a reflective citizen. A scientifically literate person should be willing to engage in reasoned discourse about science and technology which requires the competencies to:

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 representations and draw appropriate scientific conclusions.

These competencies will only be tested using the knowledge that 15-year-old students can reasonably be expected to have of the concepts and ideas of science (content knowledge), the procedures and strategies used in all forms of scientific enquiry (procedural knowledge), and the manner in which ideas are justified and warranted in science (epistemic knowledge). See Figure 1.

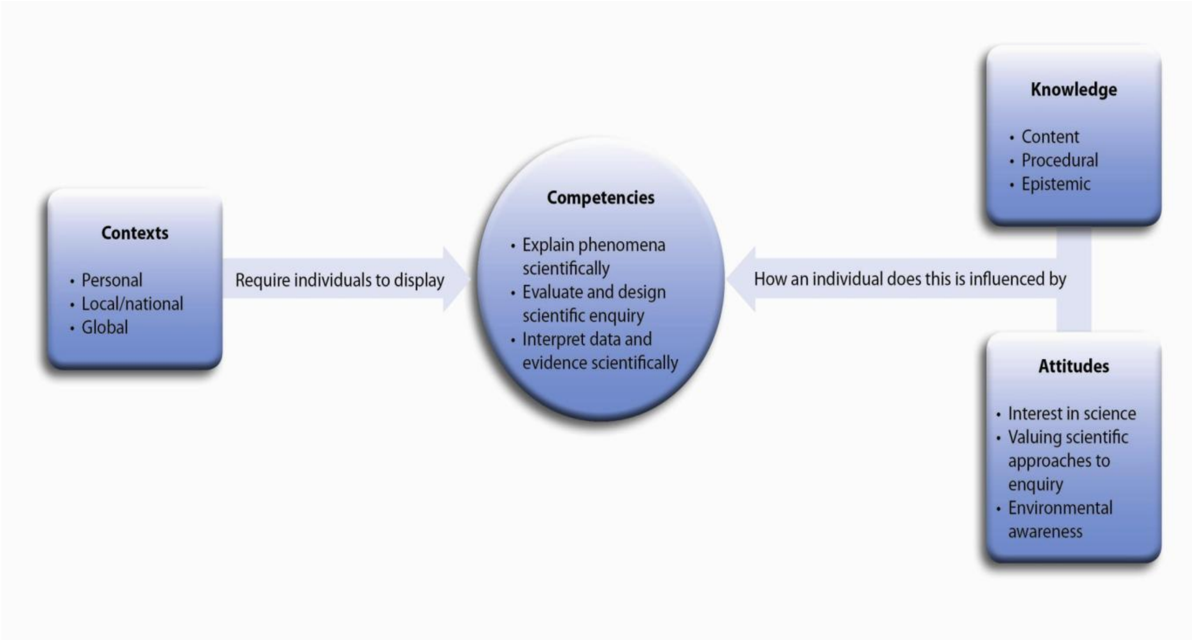

Figure 1. Components of the PISA 2015 Science Literacy Framework (OECD, 2013)

The *content knowledge* in the framework (physical, life and earth science) is likely to be fairly common to what is taught all over the world, although not described in detail. The *contexts* in the framework (at personal, local/regional and global levels) are almost similar to those in previous PISA SL frameworks. What is most innovative are the categories *procedural* and *epistemic knowledge*.

Procedural Knowledge

- The concept of variables including dependent, independent and control variables;
- Concepts of measurement e.g., quantitative [measurements], qualitative [observations], the use of a scale, categorical and continuous variables;
- Ways of assessing and minimising uncertainty such as repeating and averaging measurements;
- Mechanisms to ensure the replicability (closeness of agreement between repeated measures of the same quantity) and accuracy of data (the closeness of agreement between a measured quantity and a true value of the measure);
- Common ways of abstracting and representing data using tables, graphs and charts and their appropriate use;
- The control of variables strategy and its role in experimental design or the use of randomised controlled trials to avoid confounded findings and identify possible causal mechanisms;
- The nature of an appropriate design for a given scientific question e.g., experimental, field based or pattern seeking.

Figure 2. PISA 2015 Procedural Knowledge (OECD, 2013)

Epistemic Knowledge

1. The constructs and defining features of science. That is:
   - The nature of scientific observations, facts, hypotheses, models and theories;
   - The purpose and goals of science (to produce explanations of the natural world) as distinguished from technology (to produce an optimal solution to human need), what constitutes a scientific or technological question and appropriate data;
   - The values of science e.g., a commitment to publication, objectivity and the elimination of bias;
   - The nature of reasoning used in science e.g., deductive, inductive, inference to the best explanation (abductive), analogical, and model-based.
2. The role of these constructs and features in justifying the knowledge produced by science. That is:
   - How scientific claims are supported by data and reasoning in science;
   - The function of different forms of empirical enquiry in establishing knowledge, their goal (to test explanatory hypotheses or identify patterns) and their design (observation, controlled experiments, correlational studies);
   - How measurement error affects the degree of confidence in scientific knowledge;
   - The use and role of physical, system and abstract models and their limits;
   - The role of collaboration and critique and how peer review helps to establish confidence in scientific claims;
   - The role of scientific knowledge, along with other forms of knowledge, in identifying and addressing societal and technological issues.

Figure 3. PISA 2015 Epistemic Knowledge (OECD, 2013)

In my view procedural and epistemic knowledge are very important for interpreting claims from researchers, for instance in media reports. Just content knowledge is not sufficient to understand how science works. However, the description of knowledge is fairly theoretical and might be read as a syllabus for a course on the philosophy of science. I am convinced that this is not the intention, so the main challenge for PISA 2015 is to write test items which are feasible for 15 year olds at various ability levels.

RECOMMENDATION

If governments find it important that their students rank high in the PISA league tables one might hope that this is not just for ranking purposes but for the benefit of the future of their citizens. As all participating countries agree on the frameworks it is surprising that so little has been done to identify common ground in curricula and practices of teaching in view of the SL Framework.

In the Netherlands we have made efforts to interpret the PISA 2006 science results in view of the Dutch curricula (Eijkelhof, Kordes & Savelsbergh, 2013). The relatively high scores on real context-based PISA questions (Nentwig et al., 2009) might, for instance, be explained by the focus on contexts in Dutch science curricula.

An interesting development in this respect in the USA is the development of the Next Generation Science Standards (NRC, 2012) which seem related to the new SL Framework in several ways, such as the focus on scientific practices.

As European countries tend to score far below East Asian participating communities and as it is neither easy nor advisable to blindly copy educational systems, I recommend that a European initiative is taken to:

- Identify differences and similarities between the PISA Science Literacy Framework and educational practice at junior secondary level.
- To develop, trial and evaluate curriculum materials which might bridge the gap, for instance as regards procedural and epistemic knowledge.
- To give recommendations to educational authorities in the participating countries.

To avoid misunderstanding, I do respect the variety in education in European countries and I am not in favour of a European science curriculum. But I expect that we could more cooperate in developing science education which is beneficial for the future of our citizens. No better platform than the ESERA community could be found to take an initiative in this field.

NOTE

[1] http://en.wikipedia.org/wiki/Pleurothotonus

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