NEPS
National Educational Panel Study

Research Data

Competencies: Assessment of Scientific Literacy (including Example Items for Kindergarten, Grade 6, Students and Adults)
Status: 2014

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The Assessment of scientific literacy

One of the key objectives of the National Educational Panel Study (NEPS) is the assessment of those competencies that are considered to be of particular importance for educational pathways and participation in society. Scientific literacy is one of the relevant competencies NEPS measures across peoples´ life spans. Our rapidly changing and developing society increasingly demands scientific literacy in order to understand and make use of technological innovations, to adequately face environmental challenges, and to reflect on one`s own actions as a responsible citizen.

Based on the detailed description of the framework by Hahn et al. (2013) this paper presents a summary of the main framework features and example items for the scientific literacy tests for children in Kindergarten and grade six, as well as for students and adults.

1 Characteristics of the NEPS framework of scientific literacy

NEPS defines scientific literacy following the *concept of competence* as defined by Weinert (2001) and the concepts of *scientific literacy* developed by the American Association for the Advancement of Science (AAAS, 1993, 2009) and by PISA (Bybee, McCrae & Laurie, 2009; Bybee & PISA 2006 Science Expert Group, 2009; Bybee, 1997; Gräber, Nentwig, Koballa & Evans, 2002; OECD, 2006; Prenzel & Seidel, 2008; Prenzel, Schöps, Rönnebeck, Senkbeil, Walter, Carstensen & Hammann, 2007; Prenzel, 2000).

Although there is no doubt about the relevance of scientific literacy, there is a broad disagreement when it comes to defining the key scientific concepts a scientifically literate person should know or master. The NEPS therefore took a pragmatic approach: The PISA 2006 framework of scientific literacy (OECD, 2006), the *Benchmarks for Science Literacy* of the American Association for the Advancement of Science (AAAS, 1993, 2009) and the German National Educational Standards for Graduation after Grade 10 (*Bildungsstandards für den Mittleren Schulabschluss;* KMK, 2005a, b, c) were used as starting points for drawing up the framework (Hahn et al., 2013). These three reference frameworks were chosen because all of them outline contents, concepts, and contexts which are relevant in situations involving science. So in a first step the commonalities of the three frameworks were identified. In the second step, a special focus was placed on the PISA 2006 scientific literacy framework and the German National Educational Standards to see which of the chosen concepts showed a substantial overlap between the frameworks. PISA and the German National Educational Standards were chosen as reference points because they comply with the Federal Ministry of Education and Research's requirement that NEPS should be theoretically and methodologically linked to existing national and international large scale assessments.

Figure 1 gives an overview of the content overlap between PISA, the German National Educational Standards and NEPS in the *knowledge of science* (KOS) area.

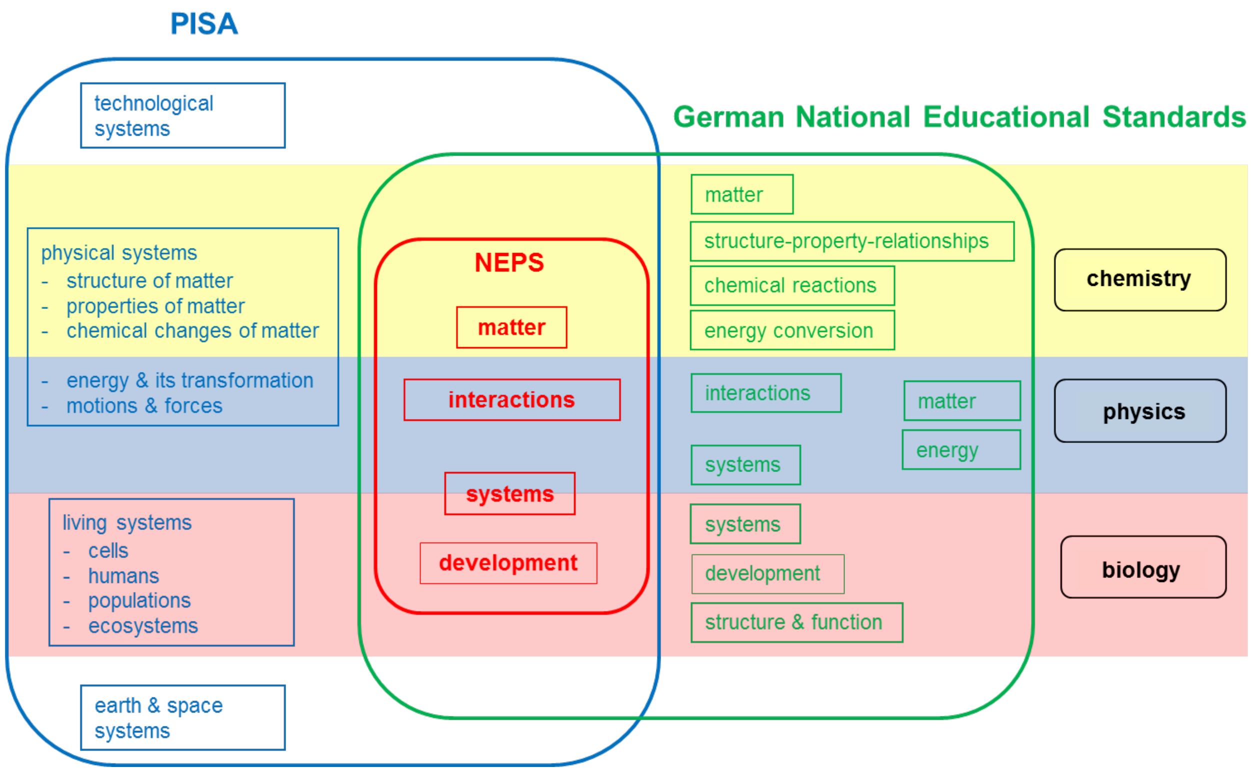


Figure 1. KOS content overlap between PISA, the German National Educational Standards and NEPS

1.1 The NEPS framework of scientific literacy

According to the NEPS, a person confronted with scientific questions or problems needs science competency in order to solve these problems (Klahr, 2000; Klahr & Dunbar, 1988; Mayer, 2007). This competency is based on scientific knowledge that – similar to the definition used by PISA (OECD, 2006) – consists of both, *knowledge of science* (KOS) or rather knowledge of basic scientific concepts and facts, and *knowledge about science* (KAS) the understanding of scientific processes (see also Hodson, 1992). Due to the large number of scientific concepts and with respect to limited testing time, the NEPS framework and the resulting tests could not include all aspects of KOS and KAS named in the literature. Consequently contexts and components were selected which cover key aspects of science and are of lifelong relevance. KOS and KAS are implemented in three selected contexts: *health, environment* and *technology.* Figure 2 shows the NEPS framework of scientific literacy.

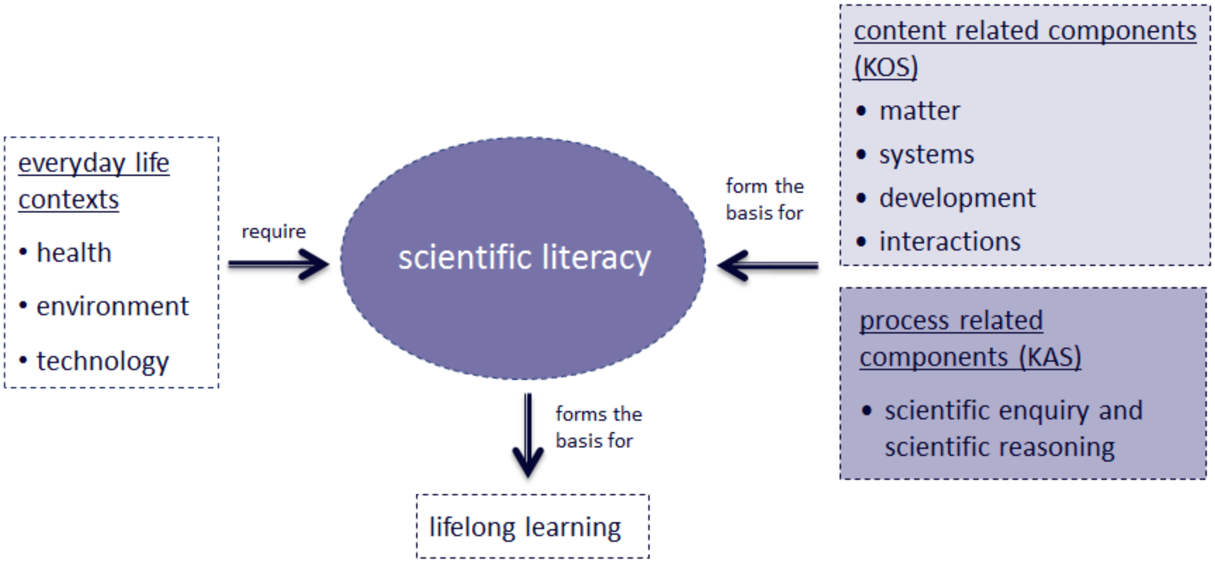


Figure 2. The NEPS framework of scientific literacy.

The science tests typically consist of 23 to 26 items depending on the age group (for example fewer items for younger children). Table 1 shows how many items were used to measure the context-component combinations of the test. Due to the limited testing time of a maximum of 30 minutes not every component could be tested in every context.

Table 1. Numbers of items for the different context-component combinations intended for the final test.

<table>
<tr><td></td><td></td><td colspan="3">Context</td><td></td></tr>
<tr><td>Component</td><td></td><td>Environment</td><td>Health</td><td>Technology</td><td>Total</td></tr>
<tr><td>Development</td><td>KOS</td><td colspan="2">3-4</td><td></td><td>3-4</td></tr>
<tr><td>Interactions</td><td>KOS</td><td></td><td colspan="2">3-4</td><td>3-4</td></tr>
<tr><td>Matter</td><td>KOS</td><td colspan="3">5-6</td><td>5-6</td></tr>
<tr><td>Systems</td><td>KOS</td><td>3</td><td></td><td>3</td><td>6</td></tr>
<tr><td>Scientific enquiry</td><td>KAS</td><td colspan="3">3-4</td><td>3-4</td></tr>
<tr><td>Scientific reasoning</td><td>KAS</td><td colspan="3">3-4</td><td>3-4</td></tr>
<tr><td colspan="5">Total item number</td><td>23 - 28</td></tr>
</table>

1.2 Item format

The majority of the NEPS science items are constructed as simple multiple choice (MC) items. These kinds of items display an item stem giving the test persons background information on the item topic. The test question is followed by four different answers. One of the answers is correct whereas the other answer options function as distractors. NEPS science tests also use the multiple true false (MTF) format. Structurally similar to the MC format, it also has an item stem containing background information, a test question and four answers. Different from the MC items here the test person has to decide for every single MTF answer whether it is true or not. The test contains very few open answer test items, a maximum of 1 or 2 items per test.

Similar to the PISA approach, the NEPS test items have until recently been organized in units (testlets). The units are developed based on a combination of contexts and components described in the science framework. A unit starts with a stimulus consisting of a text that can be supplemented by tables, graphs or images. The unit stimulus ‘‘tells a story’’ for setting the stage and providing the information for the test items. This allows the items to explore a topic from different perspectives and to assess multiple aspects of performance. The stimulus is typically followed by two to four test items - sometimes further information is provided in the item stem. Each unit assesses science competency within either one of the four KOS- or one of the two KAS-components, respectively, and is situated in one of the three NEPS contexts. Hence, each unit covers one context and one component. For each age cohort, the final science test in the main study consists of 23-26 items corresponding to 28-30 minutes of testing time.

The strategy of organizing items in units has changed starting 2013. This decision stems from probable methodological problems like item dependency within a unit and problems with item positioning effects.

1.3 Assessment conditions and general remarks

The final scientific literacy test of the main studies takes 28 to 30 minutes depending on the cohort being tested. In the student and adult cohorts the test takes 28 minutes. The test takes 29 minutes when it contains the metacognition question where the test persons have to judge how many items they answered correctly. When the metacognition item is not included the test takes 30 minutes (for all preschool and school cohorts).

In schools starting grade six entire classes get tested. In universities, students get tested in groups during their courses. Adults are tested at home in a one-on-one situation.

The test situations from Kindergarten to grade three are different. In Kindergarten children are tested in a one-on-one interview situation. The test items are part of a game called “A Summer Party in Kindergarten”. Item stem and questions are read to the children. They then have to choose the right answers from picture cards (see example item “animal quiz”). The children accompany the two protagonists Paul and Lena through the summer party and have to help them solve small scientific problems or answer scientific questions. The item formats are the same as in the other age cohorts. Figure 3 shows the play board which is the basis for the game.

Figure 3. Play board of the "Summer Party in Kindergarten".

In grade 1 the assessment mode switches to small group testing with test groups of up to 14 children. The items are still read to the children but differently from the testing in Kindergarten the children have their own test sheets. Similar to the testing in Kindergarten the items do not contain any text. The children listen to the item stem, the question and the possible answers and have to choose the right picture on their test sheet.

In grade 3 the entire class of children is tested and for the first time in the panel the science items consist of text and pictures. In order to create a fair testing situation for both good and not so good readers the items and answers are still read to the children.

2 The NEPS science test – Item examples

The following figures show item examples for different age groups. For further information on test development procedure or test quality, see Hahn et al. (2013).

Please note that the items presented in this report have been removed from the tests for different reasons, for example, better items already existed for the respective component-context combination or that the item discrimination was not good enough.

ANIMAL QUIZ

This is a young bird.

Which one of these birds might be its mother?

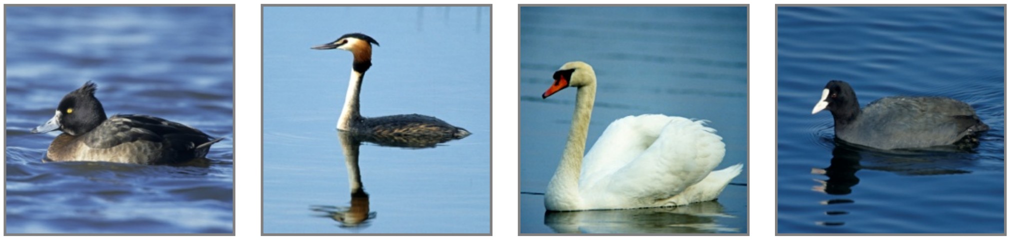


Figure A-1. Example of an item measuring science competency in Kindergarten (context: environment; component: development)

POURING JUICE

Paul and Lena are thirsty. They would like a glass of juice. Their teacher pours both of them a glass full of juice. “Lena always gets more than me!“ says Paul.

How can Paul and Lena verify if they have the same amount of juice?

	A: Holding the glasses on top of each other
	B: Holding the glasses right next to each other.
	C: Holding the glasses crooked next to each other.
	D: Holding the glasses crooked on top of each other.

Answer cards for the children:

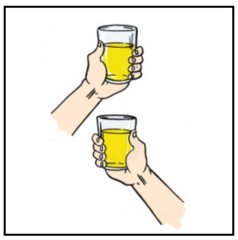
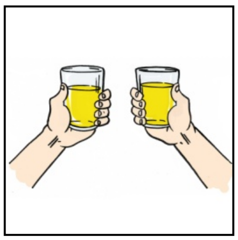
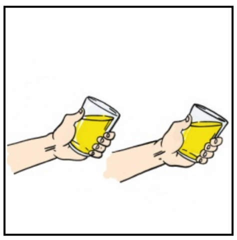
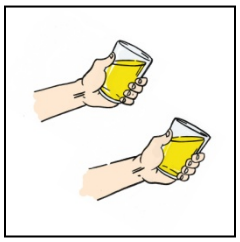
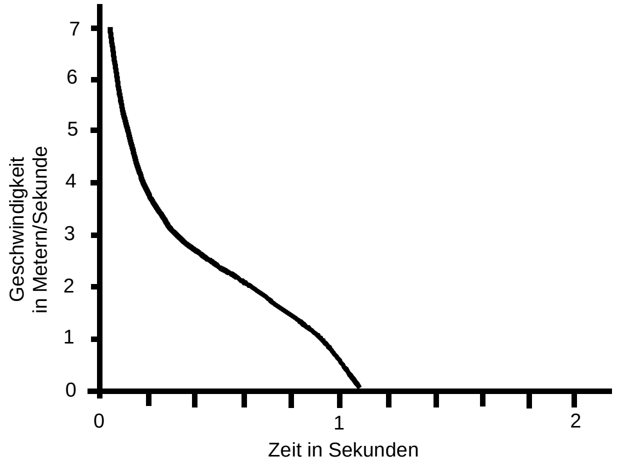
   

Figure A-2. Example of an item measuring science competency in Kindergarten (context: technology; component: scientific inquiry and scientific reasoning; aspect: measurement/comparison)

BADMINTON

This game is played with a shuttlecock, The shuttlecock consists of 16 goose or duck feathers and a cork head which is coated in rubber (see picture).

The picture below shows how the speed of the shuttlecock changes after it got hit by the racket.



Which conclusions can be drawn from the picture?

Check the right answer! Please check one box only!

()	After a few meters the shuttlecock falls to the ground.
()	The shuttlecock starts spinning.
()	The shuttlecock rapidly loses speed.
()	The shuttlecock follows a curve.

Figure A-3. Example of an item measuring science competency in grade six (context: technology; component: scientific enquiry and scientific reasoning)

Need to cool off?

Most household refrigerators work through compression. An evaporator in the refrigerator's interior vaporizes a liquid refrigerant. The energy needed for evaporation is taken from the refrigerator's interior in form of warmth. A carbonator sucks in the gaseous refrigerant and compresses it to 8 bar. The highly compressed gas moves into the evaporator, releases the heat into the surrounding, and liquefies again. A valve reduces the pressure to 1 bar and the liquid refrigerant moves back into the refrigerator's interior.

In an open top vessel the refrigerant's boiling point lies at about -30 °C. Why does it vaporize at room temperature in the evaporator?

Check the right answer! Please check one box only!

0	The boiling point has nothing to do with the condensation point.
0	The boiling point of liquid increases with pressure.
0	All gas liquefies at a pressure of 8 bar.
0	Through the increase in pressure the gas cools down to -31 °C.

Figure A-4. Example of an item measuring students´ science competency (context: technology; component: matter)

CARDIOVASCULAR SYSTEM

The caffeine in coffee stimulates circulation. People with high blood pressure should avoid coffee and stick to decaffeinated beverages. However scientist now suspect that even decaffeinated coffee increases blood pressure.

What would an accordant study look like?

	Test group	Measurement	Time of taking the measurement
Trial A	A test group drinks first decaffeinated coffee and then caffeinated coffee.	Blood pressure	Before and after drinking
Trial B	Group 1 drinks decaffeinated coffee. Group 2 drinks caffeinated coffee.	Blood pressure	After drinking
Trial C	Group 1 drinks decaffeinated coffee. Group 2 drinks water.	Blood pressure	After drinking
Trial D	Group 1 suffers from high blood pressure, group 2 is healthy. Both groups drink decaffeinated coffee.	Blood pressure	Before and after drinking

Check the right answer! Please check one box only!

0	Trial A
0	Trial B
0	Trail C
0	Trial D

Figure A-5. Example of an item measuring adults´ science competency (context: health; component: scientific inquiry and scientific reasoning; aspect: planning experiments)

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