

Assessing Competencies in Science



Olaf Köller

**Leibniz Institute for Science and Mathematics Education (IPN)
Kiel, Germany**

Evaluering af kompetencer i matematik og naturfagene – hvorfor og hvordan?

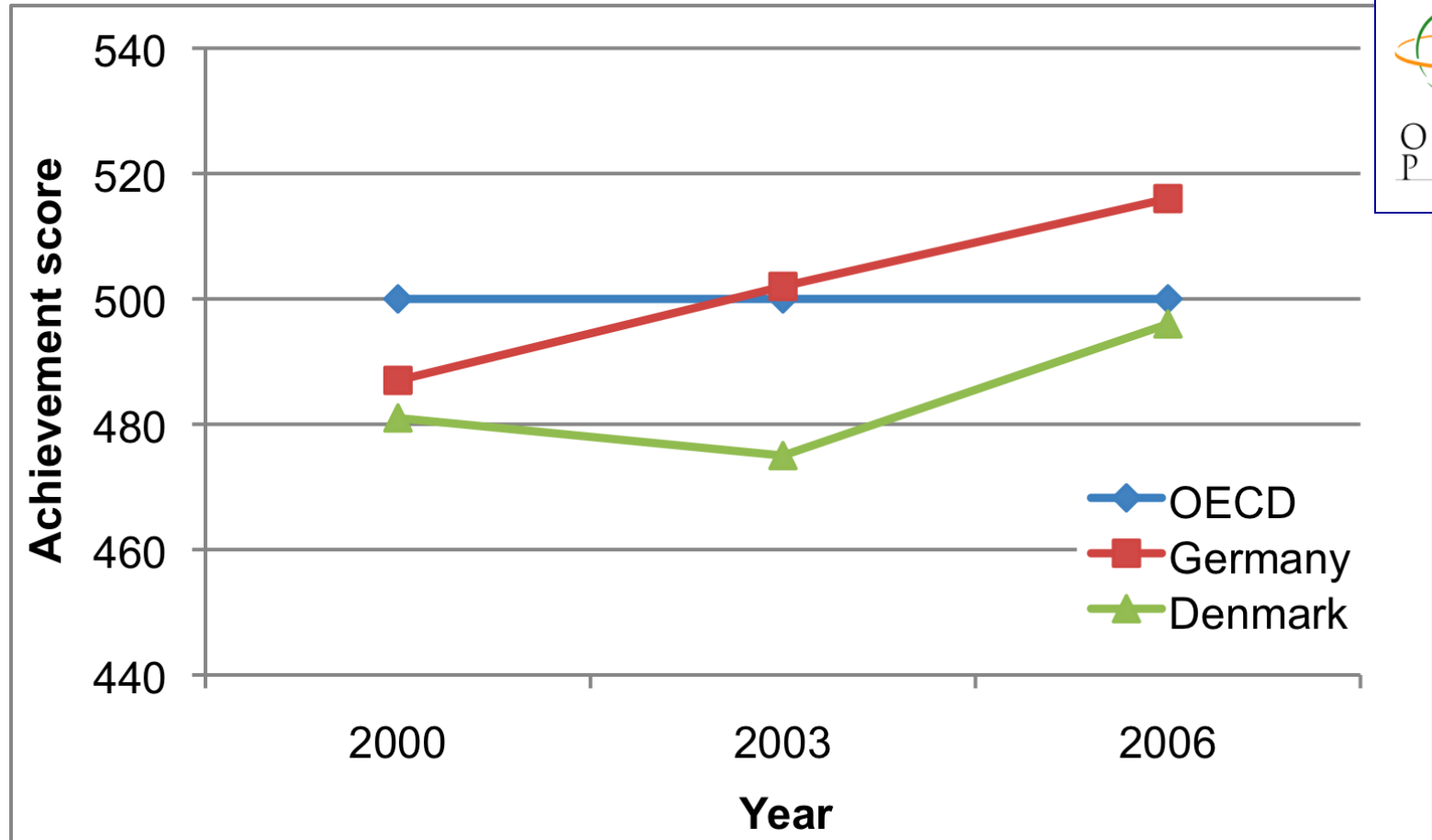
Prof. Dr. Olaf Köller

Leibniz Institute for Science and Mathematics Education, Kiel, Germany

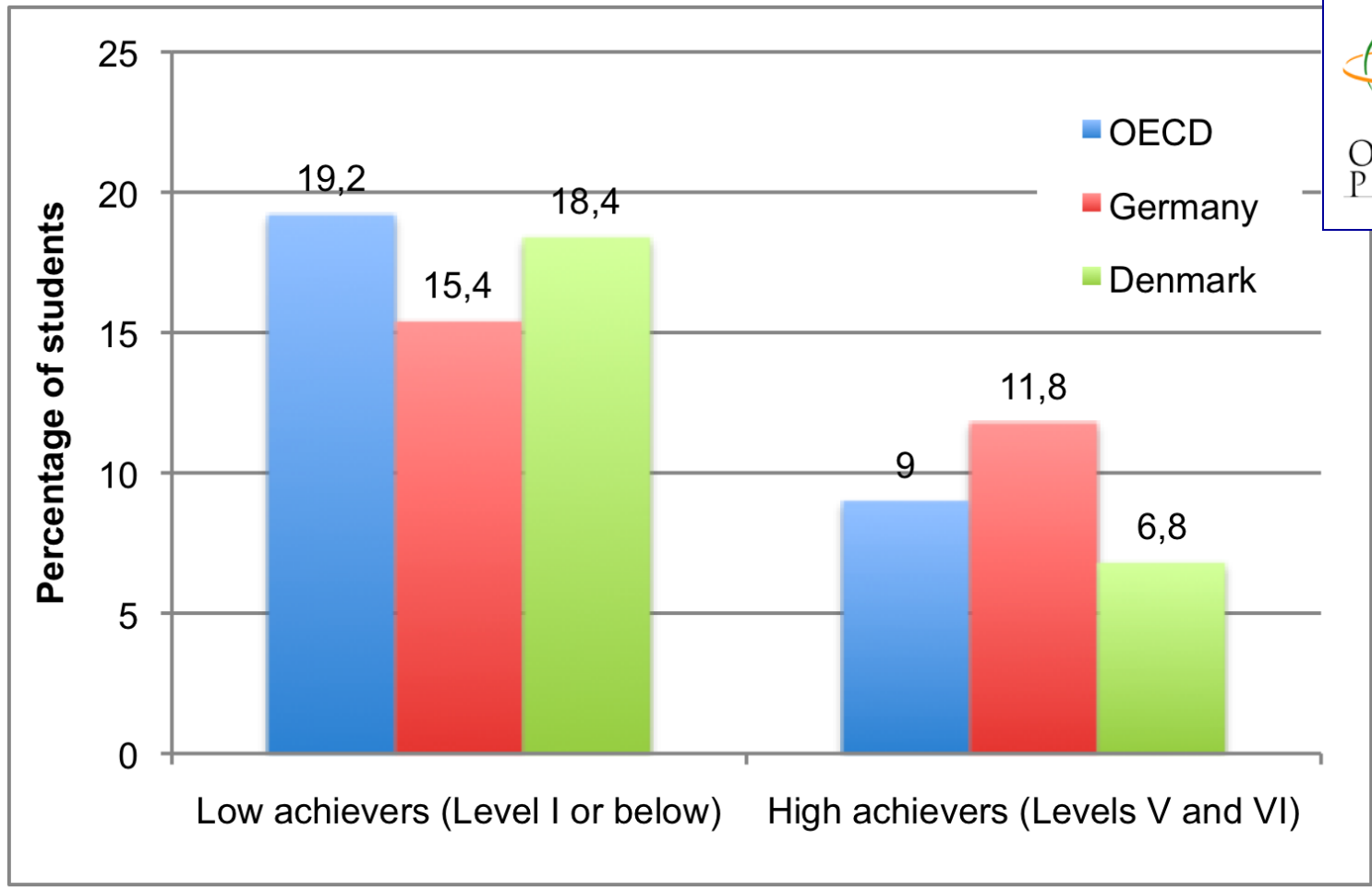
Overview

- Look back in anger: Science achievement of Danish and German students in PISA
- What are competencies?
- What does this mean for assessment?
 - What should we assess in science?
 - Is PISA sufficient to assess the effectiveness of national educational systems?
 - Educational standards and national assessment
 - Assessment at different levels (system, school, class, individual student)
- What does this mean for you?

Look Back in Anger: Science Scores of 15year Old Students in PISA



High and Low Science Achievers in PISA 2006



Lessons from PISA



- Disappointing Results of Danish and German students in 2000
- Results became better in 2006
- Still substantial percentages of failing students in both countries
- Smaller percentages of failing students in countries with
 - effective pre-school and school programs for low-achieving students
 - convincing monitoring systems based on educational standards
- Assessment of educational achievement necessary for monitoring school and teaching quality

What is Measured in PISA? What are Competencies?



- A competency is a combination of skills, knowledge, characteristics, and traits that contribute to performance in a particular domain.
- When we put a series of competencies together, it is called a competency model

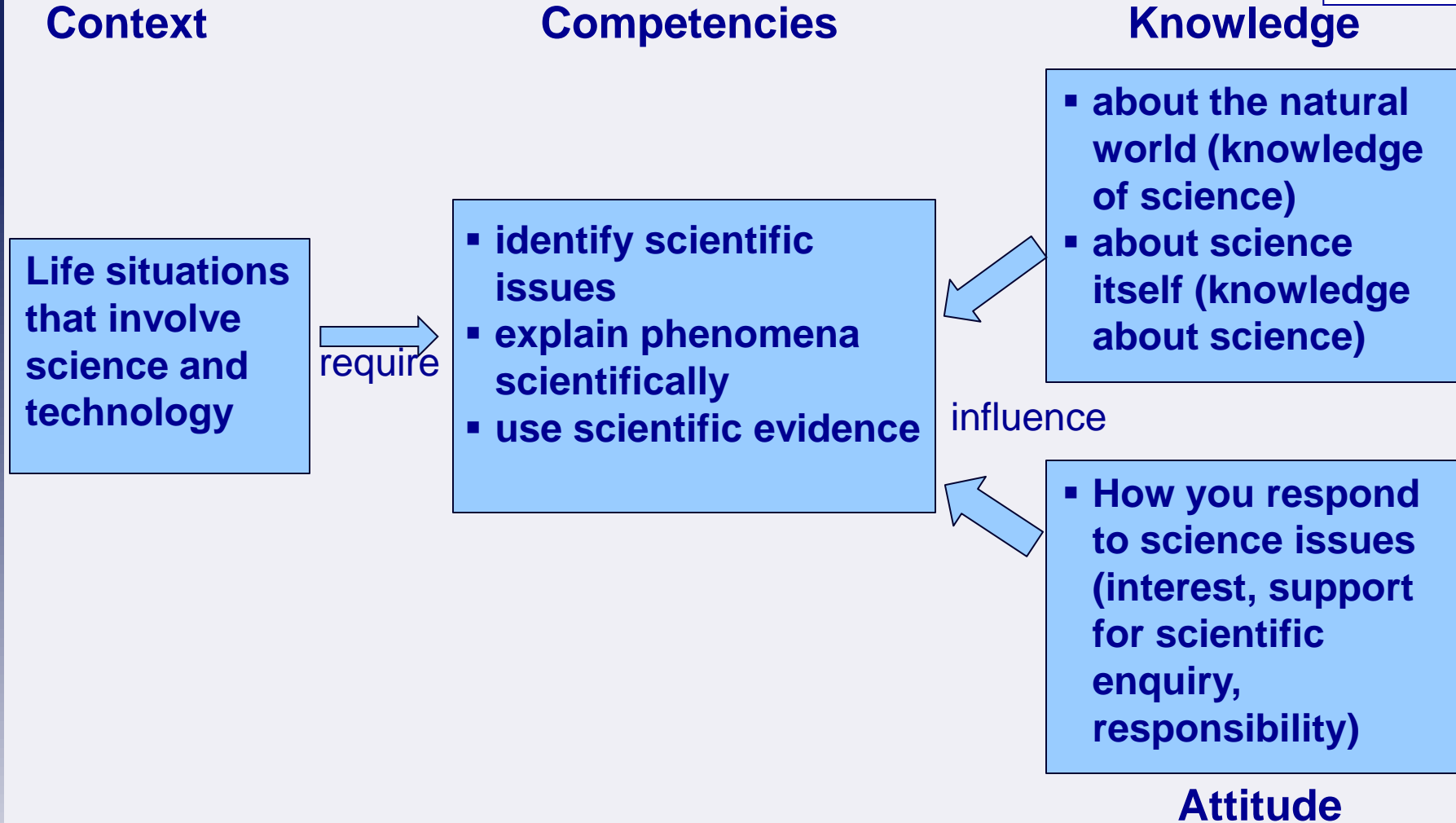
Science Competency and Scientific Literacy: Two Sides of the Same Coin?



Scientific literacy refers to an individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues.

PISA 2006 Framework

PISA 2006 Science Framework



Limitations of PISA

- Focus on competencies but no knowledge measures
- Rather no emphasis on content areas that are usually essential for science
- Missing distinction between biology, chemistry, geography, and physics
- Item development does not take into account educational goals of individual countries
- No direct relation between proficiency levels and national educational goals, e.g., in terms of minimum standards or regular standards

- Conclusion: PISA is a very powerful program for international comparisons but not sufficient for national assessment of educational progress

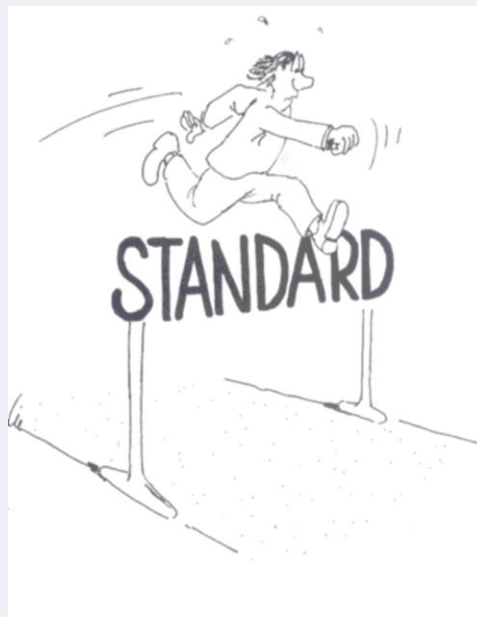
An Example for a National Framework: NAEP Science Content Topics and Subtopics

Physical Science	Life Science	Earth and Space Science
<p>Matter</p> <ul style="list-style-type: none"> ▪ Properties of Matter ▪ Changes in Matter <p>Energy</p> <ul style="list-style-type: none"> ▪ Forms of Energy ▪ Energy Transfer and Conservation <p>Motion</p> <ul style="list-style-type: none"> ▪ Motion at the Macroscopic Level ▪ Forces Affecting Motion 	<p>Structures and Functions of Living Systems</p> <ul style="list-style-type: none"> ▪ Organization and Development ▪ Matter and Energy Transformations ▪ Interdependence <p>Changes in Living Systems</p> <ul style="list-style-type: none"> ▪ Heredity and Reproduction ▪ Evolution and Diversity 	<p>Earth in Space and Time</p> <ul style="list-style-type: none"> ▪ Objects in the Universe ▪ History of Earth <p>Earth Structures</p> <ul style="list-style-type: none"> ▪ Properties of Earth Materials ▪ Tectonics <p>Earth Systems</p> <ul style="list-style-type: none"> ▪ Energy in Earth Systems ▪ Climate and Weather ▪ Biogeochemical Cycles

The New Paradigm

(The Holy Grail)

Educational Standards in Germany as a Basis for National Assessment



Prof. Dr. Olaf Köller

Leibniz Institute for Science and Mathematics Education, Kiel, Germany

Educational Standards in Germany: Four Areas of Competencies in Science

- Content Knowledge
- Nature of Science/Scientific methods
- Decision making and evaluation of scientific knowledge
- Communication (e.g., interpretation of graphs and tables)

Subdimensions of Content Knowledge (Basic Concepts)

Biology	Physics
System	Matter
Structure and Function	Interaction
Development	System
	Energy

Standards and Assessment in Science: Challenges in Germany

- International LSA not sufficient to assess standard-based outcomes
- Consequence: Building up a system of national assessment
- Foundation of a national institute for educational progress (IQB)
- Huge reliable and valid item pools were necessary
- Who should write the items?
- How to test nature of science, decision making and evaluation of scientific knowledge?
- Paper-pencil or computer-based testing?
- Many people prefer open ended responses instead of MC

Extended Response Item from NAEP

National percentage "Complete" in 2005

Overall	Below Basic	At Basic	At Proficient	At Advanced
23	8	22	42	69

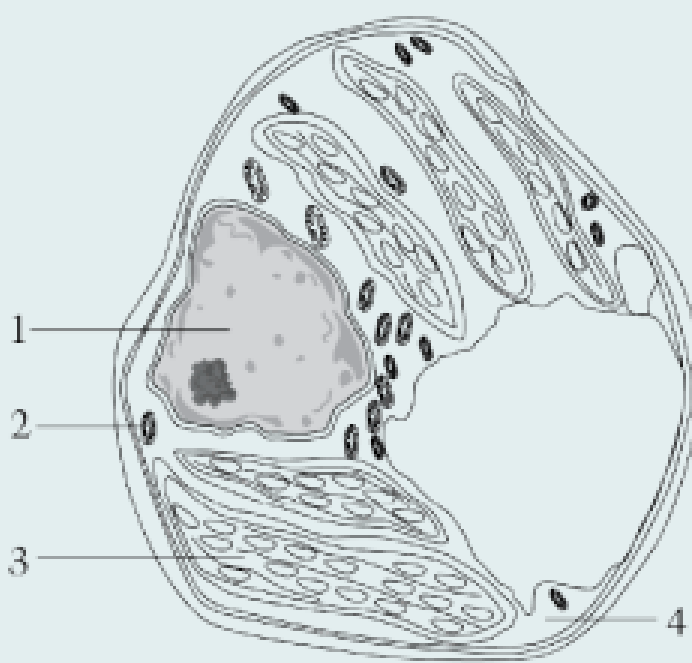
Maria has one glass of pure water and one glass of salt water, which look exactly alike. Explain what Maria could do, without tasting the water, to find out which glass contains the salt water.

One thing she could do is evaporate
each glass of water. The glass with
salt water in it should have salt left
in it when the water has evaporated.

MC Item from NAEP

National percentage correct in 2005

Overall	Below Basic	At Basic	At Proficient	At Advanced
53	40	54	67	83



The diagram shows a cross-section of a plant cell. Label 1 points to the nucleus, which is a large, dark, oval-shaped structure containing a nucleolus. Label 2 points to a chloroplast, which is an oval-shaped organelle with internal stacks of thylakoids. Label 3 points to the cell wall, the thick outer boundary of the cell. Label 4 points to a small, dark, oval-shaped structure, likely a vacuole or another organelle.

In the picture of a cell, which label indicates the part of the cell that contains most of the cell's genetic material?

- 1
- 2
- 3
- 4

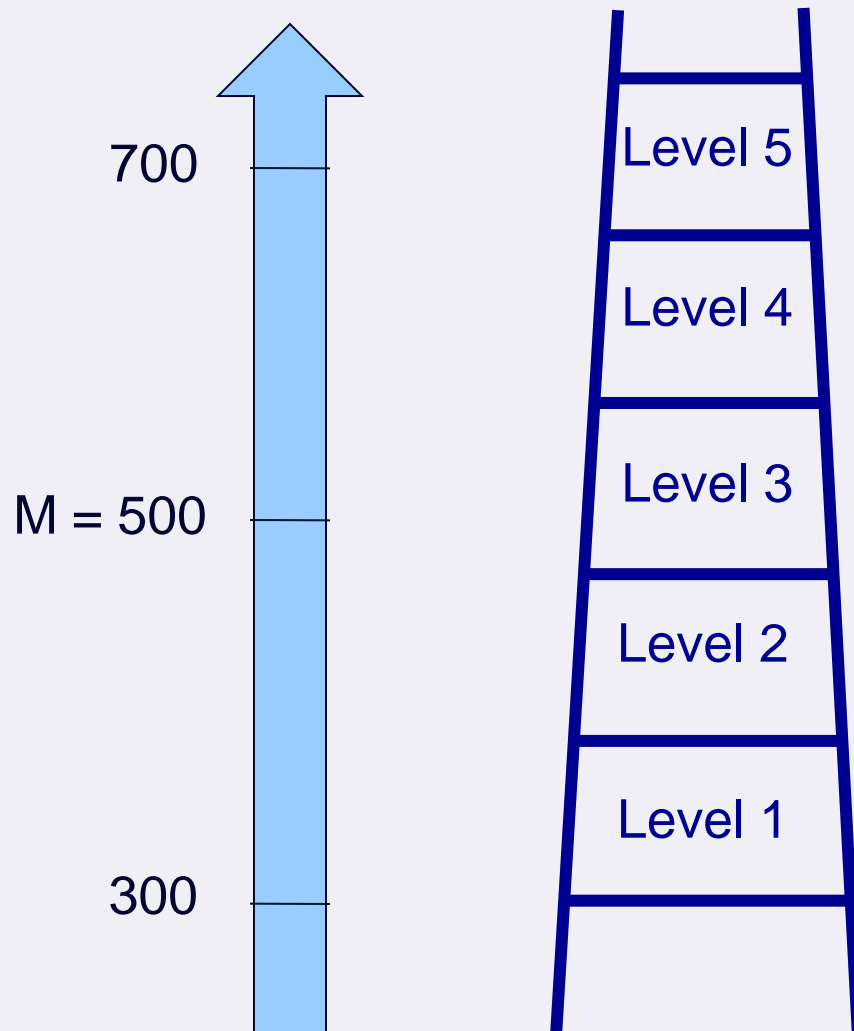
Standards and Assessment in Science: Solutions in Germany

- First round of test development only for content knowledge and nature of science/scientific methods
- Teachers developed the items, they were supervised by teacher educators and psychometricians
- Hard job for teachers to develop good items
- Items for biology, chemistry, and physics
- Paper-pencil tests
- 50% MC-Items, 25% short answer, 25% extended response

Development of Standard-based Assessment in Germany

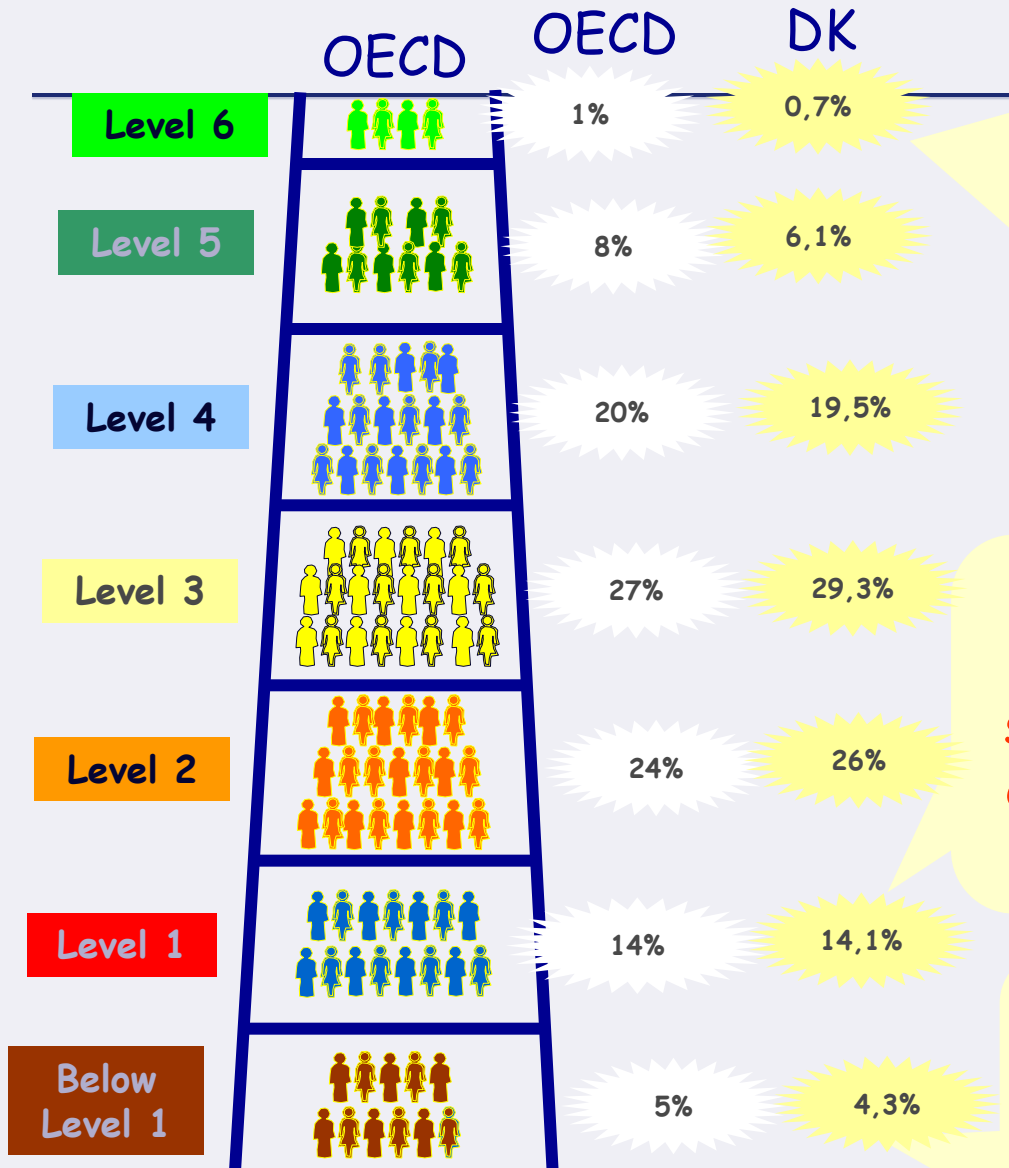
- First phase of test development between 2005 and 2010 (ongoing process)
- National assessment (sample-based)
 - About 40.000 students from all 16 federal states in Germany
 - End of Grade 9 (every three years, first time in 2009)
 - End of Grade 4 (every five years), but only German and math
- State-wide assessments (every year, but restricted to German, foreign language, and math)
 - Whole population of 3rd graders
 - Whole population of 8th graders
- Some standardized tests are available for individual schools and classes, but no systematic student monitoring system

Standards, Students' Test Scores and Proficiency Levels



Remember: Students and items are on the same scale

PISA Proficiency Levels in Science



Science Level 6
 Student can consistently identify, explain and apply scientific knowledge and knowledge about science in a variety of complex life situations

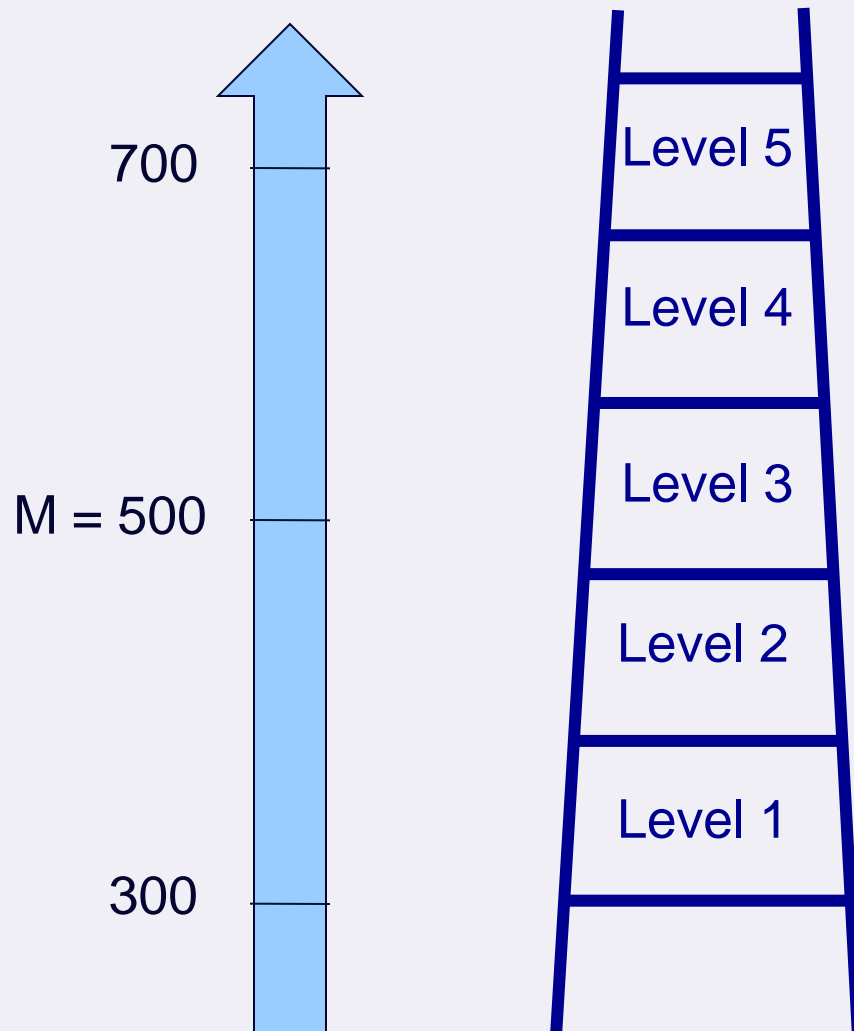
Science Level 1
 Student have such a limited scientific knowledge that it can only be applied to a few, familiar situations

Below Level 1
 Unable to use scientific skills in ways required by easiest PISA tasks.

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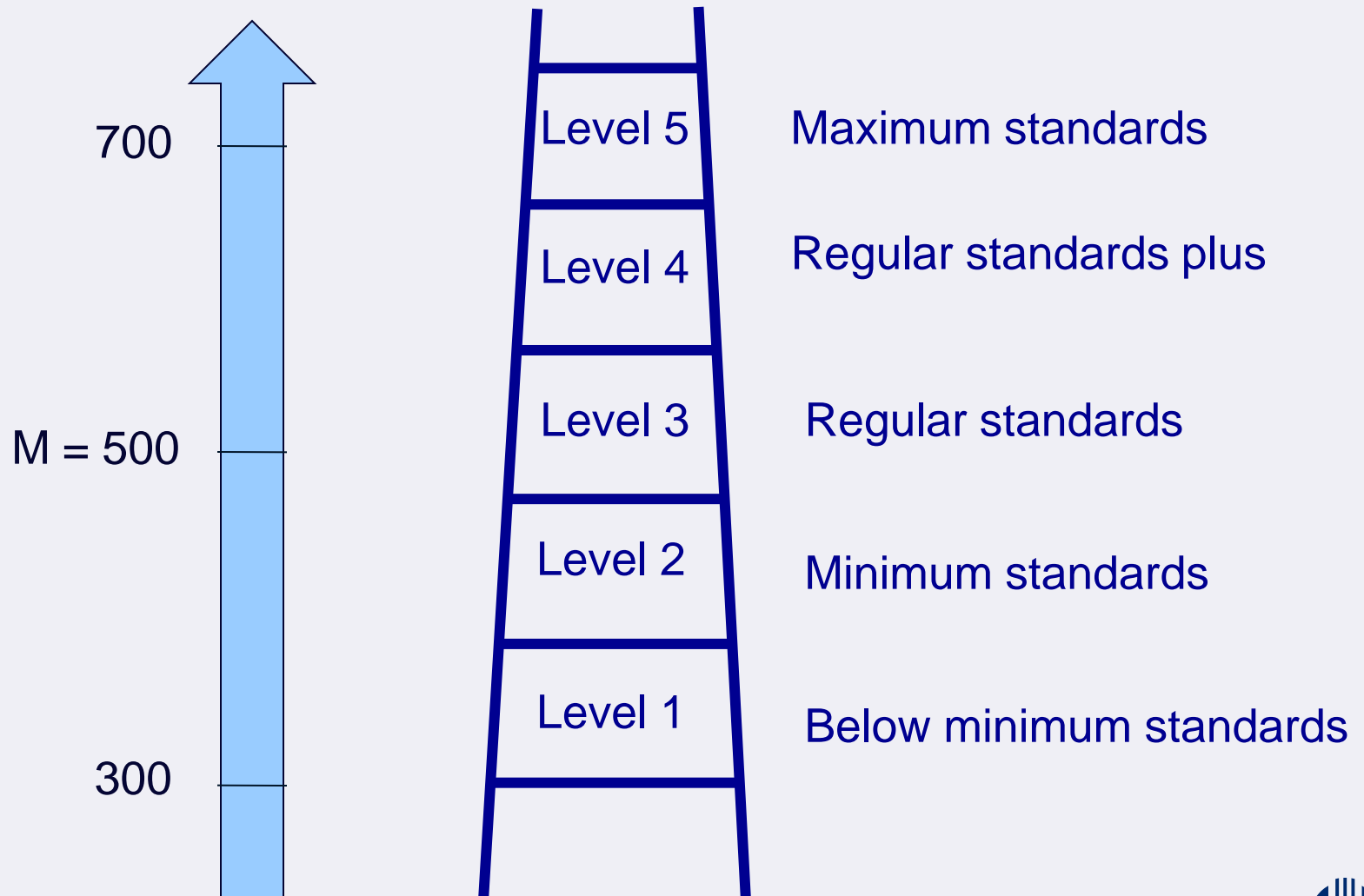
Leibniz Institute for Science and Mathematics Education, Bayreuth, Germany

Standards, Students' Test Scores and Proficiency Levels



Question: Which level represents competencies that fit to the expectations of the standards?

Solutions in Germany



Prof. Dr. Olaf Köller

Leibniz Institute for Science and Mathematics Education, Kiel, Germany

What does this mean for teachers and their assessments in school?



Prof. Dr. Olaf Köller

Leibniz Institute for Science and Mathematics Education, Kiel, Germany

What does this mean for teachers?

- First of all: Don't change your assessment practice in school
- However, be aware of what's going on in assessment
- Try to understand what the findings of PISA tell you and whether this has any implications for teaching science
- Don't give up contends, but vote for a combination of contends and competencies
- Try to be open-minded with respect to national assessment activities and such activities in your school
- Read about standards
- If you like standards: Vote for proficiency levels and clear rules how proficiency levels are linked to the standards

Thank You very much
Questions Contact:
koeller@ipn.uni-kiel.de



Prof. Dr. Olaf Köller

Leibniz Institute for Science and Mathematics Education, Kiel, Germany

