Trends in Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA)

Dominador D. Mangao
Research & Development Division
SEAMEO RECSAM, Penang, Malaysia
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Overview

Global Assessments

PIRLS, TIMSS, PISA, ICCS, EGRA

Regional Assessments

PASEC

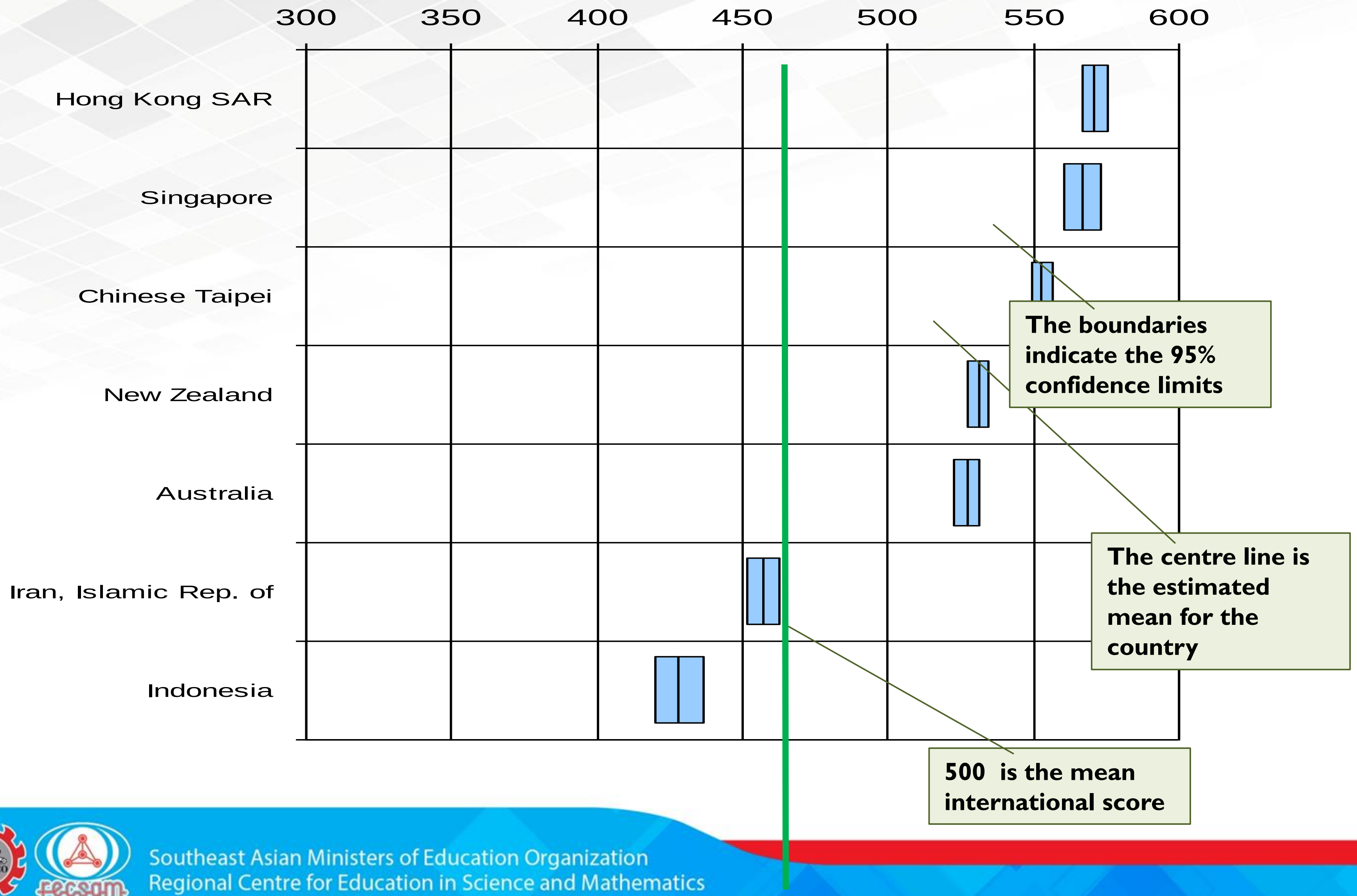
SEAMEO Assessment

SEA-PLM

PIRLS (Progress in Reading Literacy Study)

- PIRLS International Study Center, Lynch School of Education, Boston College together with International Association for the Evaluation of Educational Achievement (IEA)
- Sample – Grade 4
- Subject – Reading
- Focus – Curriculum
- Other – student, parent, teacher and school questionnaires.

PIRLS 2011


300
350
400
450
500
550
600
Hong Kong SAR
Singapore
Chinese Taipei
New Zealand
Australia
Iran, Islamic Rep. of
Indonesia
The boundaries indicate the 95% confidence limits
The centre line is the estimated mean for the country
500 is the mean international score

TIMSS- Trends in Mathematics and Science Study)

- TIMSS International Study Center, Lynch School of Education, Boston College together with the International Association for the Evaluation of Educational Achievement (IEA). IEA has a headquarters in Hamburg, Amsterdam.
- Sample – Grade 4 and Grade 8
- Subjects – Mathematics and Science
- Focus – curriculum
- Other – student, teacher and school questionnaires

TIMSS

- **TIMSS** monitors trends in mathematics and science achievement every four years, at the 4th and 8th grades providing 20 years of trends since 1995 .
- TIMSS 2015 was the sixth such assessment
- **TIMSS Advanced** in mathematics and physics for students in their final year of secondary school (conducted in 1995, 2008, and 2015)
- **TIMSS Numeracy**, introduced for 2015, measures learning outcomes at the 4th grade for countries where most children are still developing fundamental mathematics skills.

Some of the ways governments and ministries use TIMSS and PIRLS results include:

- Measuring the effectiveness of their educational systems in a global context
- Identifying gaps in learning resources and opportunities
- Pinpointing any areas of weakness and stimulating curriculum reform
- Measuring the impact of new educational initiatives
- Training researchers and teachers in assessment and evaluation

TIMSS and PIRLS

- collect extensive data about the contextual factors that affect learning, including

(a) school resources,

(b) student attitudes,

(c) instructional practices, and

(d) support at home.

This information can be examined in relation to achievement to explore factors that contribute to academic success.

PISA – Programme for International Student Assessment

- Organisation for Economic Cooperation and Development (OECD)
- Reading, mathematics, science
- Also problem solving, financial literacy
- Student and school questionnaires
- Sample is 15-year-olds
- 72 systems in PISA 2015
- Focus in preparedness for the future – i.e. not curriculum based.

ICCS – the International Civics and Citizenship Study

- Preparing young people to undertake their roles as citizens
- Two dimensions of civics & citizenship
  - Student knowledge and understanding
  - Attitudes, perceptions and activities
- Focus of ICCS reporting
  - International comparisons
  - Variations within countries
  - Factors explaining variation
  - Indonesia and Thailand in 2009

EGRA - Early Grade Reading Assessment

- US AID/RTI
- Also Early Grade Mathematics Assessment **(EGMA)**
- Implemented in over 70 countries in 100 languages.

PASEC - Programme for the Analysis of Educational Systems of CONFEMEN

- The Conference of Education Ministers of Countries which include French as a Language of Communication (CONFEMEN)

First assessment 1991; 24 participating countries in a series of assessments.

The first phase of PASEC had tests at the beginning and end of Grades 2 and 5, but is now moving into a new phase with just one test in each of Grades 2 and 6.

Involved Cambodia, Lao and Vietnam in 2012

Regional participation

	PIRLS			PISA					TIMSS					ICCS	EGRA	PASEC
Country	**2001**	**2006**	**2011**	**2000**	**2003**	**2006**	**2009**	**2012**	**1995**	**1999**	**2003**	**2007**	**2011**	**2009**	*****	**2012**
Brunei																
Cambodia															●	●
Indonesia		●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Lao PDR																●
Malaysia							●	●		●	●	●	●			
Myanmar																
Philippines									●	●	●				●	
Singapore	●	●	●				●	●		●	●	●	●			
Timor Leste																
Thailand				●	●	●	●	●	●	●		●	●	●		
Vietnam								●							●	●

Southeast Asia Primary Learning Metrics

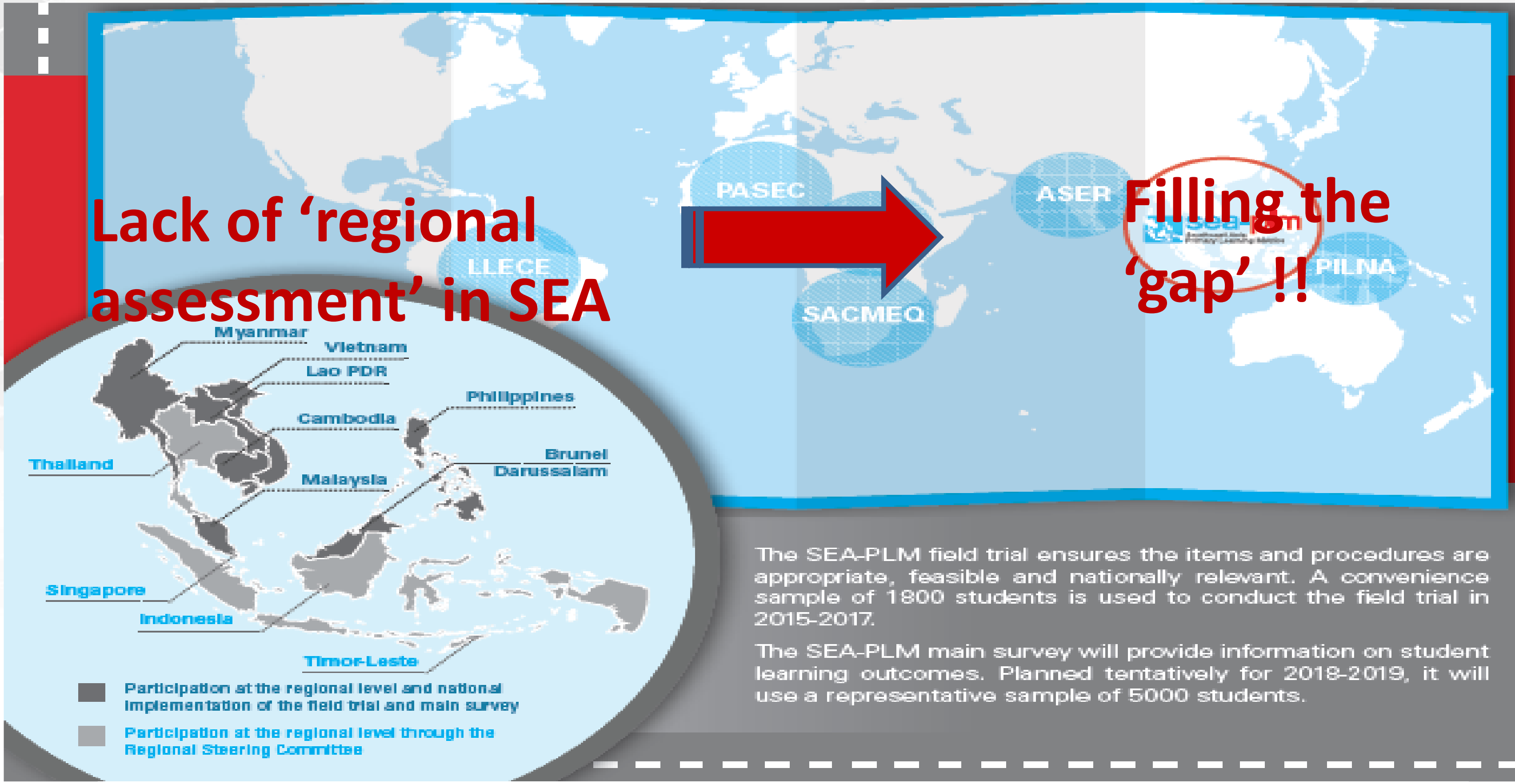
sea-plm Southeast Asia Primary Learning Metrics **=** **A Regional Commitment and Set of Standardized Quality Tools -> to Assess Learning in the Region**

Characteristics:

- First regional large-scale learning assessment in Southeast Asia
- Targets Grade 5 students
- Common metrics: reading, writing, maths, global citizenship
- Collects contextual data from students, parents and schools
- Reflects contexts and curricula of ASEAN/SEAMEO countries

Lack of ‘regional assessment’ in SEA

Filling the ‘gap’ !!



7 participating countries

Group 1: Brunei Darussalam, Cambodia, Lao PDR, Myanmar

Group 2: Malaysia, Philippines, Viet Nam

Integration into national and regional structures

40th HOM (Nov 2017) endorsed the following:

1. Consolidation of lessons learned leading to a solid design of the first ever assessment for the Southeast Asia region;
2. Implementation of the SEA-PLM Main Survey (2019) in 7 countries including data collection (sample of 5000 students) within each country; and
3. Leverage SEA-PLM as a regional mechanism for assessing quality of learning within the Southeast Asia countries

High Quality Data on Learning Outcomes

Regional Efforts to Measure the 21st Century Skills in ASEAN

Technical Standards and Code of Conduct

Detailed Analyses of Contextual Data (‘equity’)

Benchmarking and Harmonization

Inform Curriculum Revision, Pedagogy, Teacher Development

Strengthen National Learning Assessment Systems & Capacity

Reform cycle

Education reform is not a straight line activity

What do countries learn by participating?

- Gauge of educational health

  Calls to action when results surprise

  – PISA: eg Germany, Japan

  Setting of national expectations that are consistent with performance throughout the world

What do countries learn by participating?

- Influence on curriculum orientation and content
  - TIMSS (the role of statistics, probability and data in the mathematics curriculum)
  - PISA and its literacy orientation
  - Non-continuous text as an element of reading
- Capacity development
  - Assessment task development
  - Research design, sampling, scaling, analysis…

What do countries learn by participating?

- Trend information
  - Is our performance increasing or decreasing?
  - Have gender differences narrowed?
  - Has participation of girls increased?
- Policy development
  - Inform options for policy
  - Identify correlates of outcomes (e.g. teacher qualifications, resource access)

TIMSS 2007 Science Framework

- Defines **science content** in terms of three broad fields of science: physical science (physics and chemistry), life science, and earth science.
- **Cognitive dimension**: knowing, applying and reasoning
- Science frameworks have overarching dimensions that cross the content and cognitive dimensions.
- TIMSS includes an overarching dimension called **scientific inquiry**, which attempts to measure students' abilities to engage in (paper-and-pencil) inquiry tasks.

TIMSS 2015 Science Framework

- At each grade, the science assessment framework is organized around two dimensions:
- Content dimension – specifies the subject matter to be assessed
- Cognitive dimension – specifies the thinking processes to be assessed

Target Percentages of the TIMSS 2015 Science Assessment Devoted to Content and Cognitive Domains at the Fourth and Eighth Grades

Fourth Grade

Content Domains	Percentages
Life Science	45%
Physical Science	35%
Earth Science	20%

Eighth Grade

Content Domains	Percentages
Biology	35%
Chemistry	20%
Physics	25%
Earth Science	20%

Cognitive Domains	Percentages	
	Fourth Grade	Eighth Grade
Knowing	40%	35%
Applying	40%	35%
Reasoning	20%	30%

Science Cognitive Domains

The cognitive dimension is divided into three domains that describe the thinking processes students are expected to use when encountering the science items.

1. Knowing
2. Applying
3. Reasoning

Knowing

Items in this domain assess students' knowledge of facts, relationships, processes, concepts, and equipment. Accurate and broad-based factual knowledge enables students to successfully engage in the more complex cognitive activities essential to the scientific enterprise.

Recall/Recognize	Identify or state facts, relationships, and concepts; identify the characteristics or properties of specific organisms, materials, and processes; identify the appropriate uses for scientific equipment and procedures; and recognize and use scientific vocabulary, symbols, abbreviations, units, and scales.
Describe	Describe or identify descriptions of properties, structures, and functions of organisms and materials, and relationships among organisms, materials, and processes and phenomena.
Provide Examples	Provide or identify examples of organisms, materials, and processes that possess certain specified characteristics; and clarify statements of facts or concepts with appropriate examples.

Applying

Items in this domain require students to engage in applying knowledge of facts, relationships, processes, concepts, equipment, and methods in contexts likely to be familiar in the teaching and learning of science.

Compare/Contrast/ Classify	Identify or describe similarities and differences between groups of organisms, materials, or processes; and distinguish, classify, or sort individual objects, materials, organisms, and process based on given characteristic and properties.
Relate	Relate knowledge of an underlying science concept to an observed or inferred property, behavior, or use of objects, organisms, or materials.
Use Models	Use a diagram or other model to demonstrate knowledge of science concepts, to illustrate a process cycle relationship, or system, or to find solutions to science problems.
Interpret Information	Use knowledge of science concepts to interpret relevant textual, tabular, pictorial, and graphical information.
Explain	Provide or identify an explanation for an observation or a natural phenomenon using a science concept or principle.

Reasoning

Items in this domain require students to engage in reasoning to analyze data and other information, draw conclusions, and extend their understandings to new situations. In contrast to the more direct applications of science facts and concepts exemplified in the applying domain, items in the reasoning domain involve unfamiliar or more complicated contexts. Answering such items can involve more than one approach or strategy. Scientific reasoning also encompasses developing hypotheses and designing scientific investigations.

Analyze	Identify the elements of a scientific problem and use relevant information, concepts, relationships, and data patterns to answer questions and solve problems.
Synthesize	Answer questions that require consideration of a number of different factors or related concepts.
Formulate Questions/ Hypothesize/Predict	Formulate questions that can be answered by investigation and predict results of an investigation given information about the design; formulate testable assumptions based on conceptual understanding and knowledge from experience, observation, and/or analysis of scientific information; and use evidence and conceptual understanding to make predictions about the effects of changes in biological or physical conditions.
Design Investigations	Plan investigations or procedures appropriate for answering scientific questions or testing hypotheses; and describe or recognize the characteristics of well-designed investigations in terms of variables to be measured and controlled and cause-and-effect relationships.

Evaluate	Evaluate alternative explanations; weigh advantages and disadvantages to make decisions about alternative processes and materials; and evaluate results of investigations with respect to sufficiency of data to support conclusions.
Draw Conclusions	Make valid inferences on the basis of observations, evidence, and/or understanding of science concepts; and draw appropriate conclusions that address questions or hypotheses, and demonstrate understanding of cause and effect.
Generalize	Make general conclusions that go beyond the experimental or given conditions; apply conclusions to new situations.
Justify	Use evidence and science understanding to support the reasonableness of explanations, solutions to problems, and conclusions from investigations.

Science Practices: Fundamental to Scientific Inquiry

1. Asking questions based on observations: Scientific inquiry includes observations of phenomena in the natural world with unfamiliar characteristics or properties.

- These observations lead to questions, which are used to formulate testable hypotheses to help answer those questions.

2. Generating evidence: Testing hypotheses requires designing and executing investigations and controlled experiments in order to generate evidence to support or refute the hypothesis.

- Scientists must relate their understanding of a science concept to a property that can be observed or measured in order to determine the evidence to be gathered, the equipment and procedures needed to collect the evidence, and the measurements to be recorded.

3. Working with data: Once the data are collected, scientists summarize it in various types of visual displays and describe or interpret patterns in the data and explore relationships between variables.

4. Answering the research question: Scientists use evidence from observations and investigations to answer questions and support or refute hypotheses.

5. Making an argument from evidence: Scientists use evidence together with science knowledge to construct explanations, justify and support the reasonableness of their explanations and conclusions, and extend their conclusions to new situations.

Science Practices Fundamental to Scientific Inquiry

- These science practices **cannot be assessed in isolation,** but must be **assessed in the context of one of the science content domains**, and by drawing upon the **range of thinking processes specified in the cognitive domains**.
- Some items in the TIMSS 2015 science assessment at both the 4^{th} and 8^{th} grades will assess one or more of these important science practices as well as content specified in the content domains and thinking processes specified in the cognitive domains.

Programme for International Students Assessment (PISA)

- **“What is important for citizens to know and be able to do?”**
- In response to that question and to the need for internationally comparable evidence on student performance, OECD launched **the triennial survey** of **15-year-old students** around the world known as PISA.
- PISA measures student performance in mathematics, reading, and science literacy.
- Assesses the extent students have acquired key knowledge and skills that are essential for full participation in modern societies.

- Students' proficiency in an innovative domain is also assessed (in 2015, this domain is **collaborative problem solving).**
- The assessment **does not just ascertain whether students can reproduce knowledge**; it also **examines how well students can extrapolate from what they have learned** and **can apply that knowledge in unfamiliar settings**, both in and outside of school.
- This approach reflects the fact that modern economies reward individuals not for what they know, but for **what they can do with what they know.**

PISA offers:

a. insights for education policy and practice

b. helps monitor trends in students' acquisition of knowledge and skills across countries and in different demographic subgroups within each country.

PISA results reveal:

- what is possible in education by showing what students in the highest-performing and most rapidly improving education systems can do.
- allow policy makers around the world to gauge the knowledge and skills of students in their own countries in comparison with those in other countries

PISA findings

- set policy targets against measurable goals achieved by other education systems,
- learn from policies and practices applied elsewhere.
- While PISA cannot identify cause-and-effect relationships between policies/practices and student outcomes, it can show educators, policy makers and the interested public how education systems are similar and different – and what that means for students.

PISA

- Conducted every 3 years, each PISA data cycle assesses one of the three core subject areas in depth (considered the major or focal subject), although all three core subjects are assessed in each cycle (the other two subjects are considered minor domains for that assessment year).
- Assessing all three subjects every 3 years allows countries to have a consistent source of achievement data in each of the three subjects while rotating one area as the primary focus over the years.

PISA

- In addition to the core assessments, education systems may participate in optional assessments such as financial literacy and problem solving.
- In 2015, science literacy was the major subject area, as it was in 2006.
- In addition to the core assessment in science, reading, mathematics literacy, the 2015 cycle included two optional assessments: financial literacy and collaborative problem solving.

PISA Science Framework

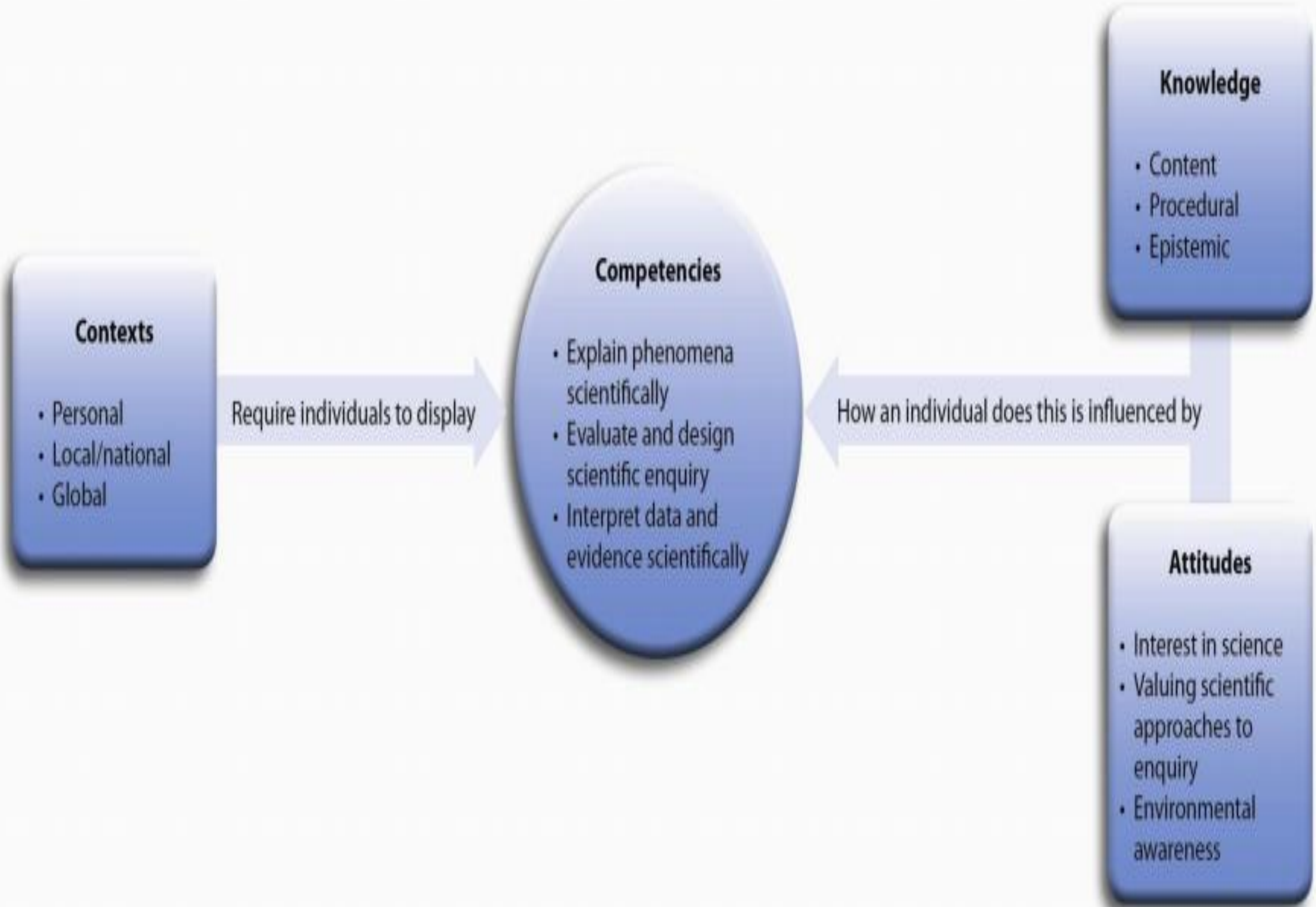
- The PISA science literacy framework also has content and cognitive dimensions, similar with TIMSS's overarching dimensions.
- PISA's **content dimensions** includes both knowledge of the natural world (in the fields of life systems, physical systems, Earth and space systems, and technology systems) and knowledge about science itself (scientific inquiry and scientific explanations).

PISA Science Framework

- PISA's **cognitive dimension** describes important competencies required for scientific literacy: identifying scientific issues, explaining scientific phenomena, and using scientific evidence.

Organization of the Domain

For purposes of assessment, the PISA definition of scientific literacy may be characterized as consisting of 4 interrelated aspects:


Contexts
• Personal
• Local/national
• Global
Require individuals to display
Competencies
• Explain phenomena scientifically
• Evaluate and design scientific enquiry
• Interpret data and evidence scientifically
How an individual does this is influenced by
Knowledge
• Content
• Procedural
• Epistemic
Attitudes
• Interest in science
• Valuing scientific approaches to enquiry
• Environmental awareness

Contexts	Personal, local, national and global issues, both current and historical, which demand some understanding of science and technology.
Knowledge	An understanding of the major facts, concepts and explanatory theories that form the basis of scientific knowledge. Such knowledge includes both knowledge of the natural world and technological artefacts (**content knowledge**), knowledge of how such ideas are produced (**procedural knowledge**) and an understanding of the underlying rationale for these procedures and the justification for their use (**epistemic knowledge**).

Competencies	The ability to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically.
Attitudes	A set of attitudes towards science indicated by an interest in science and technology; valuing of scientific approaches to enquiry, where appropriate, and a perception and awareness of environmental issues.

Figure 2. Contexts for the PISA 2015 Scientific Literacy Assessment

	Personal	Local/National	Global
Health & Disease	Maintenance of health, accidents, nutrition	Control of disease, social transmission, food choices, community health	Epidemics, spread of infectious diseases
Natural Resources	Personal consumption of materials and energy	Maintenance of human populations, quality of life, security, production and distribution of food, energy supply	Renewable and non-renewable natural systems, population growth, sustainable use of species
Environmental Quality	Environmentally friendly actions, use and disposal of materials and devices	Population distribution, disposal of waste, environmental impact	Biodiversity, ecological sustainability, control of pollution, production and loss of soil/biomass
Hazards	Risk assessments of lifestyle choices	Rapid changes [*e.g.*, earthquakes, severe weather], slow and progressive changes [*e.g.*, coastal erosion, sedimentation], risk assessment	Climate change, impact of modern communication
Frontiers of Science and Technology	Scientific aspects of hobbies, personal technology, music and sporting activities	New materials, devices and processes, genetic modifications, health technology, transport	Extinction of species, exploration of space, origin and structure of the Universe

Figure 3a. PISA 2015 Scientific Competencies

Explain phenomena scientifically
Recognise, offer and evaluate explanations for a range of natural and technological phenomena demonstrating the ability to: • Recall and apply appropriate scientific knowledge; • Identify, use and generate explanatory models and representations; • Make and justify appropriate predictions; • Offer explanatory hypotheses; • Explain the potential implications of scientific knowledge for society.

Evaluate and design scientific enquiry

Describe and appraise scientific investigations and propose ways of addressing questions scientifically demonstrating the ability to:

- Identify the question explored in a given scientific study;
- Distinguish questions that are possible to investigate scientifically;
- Propose a way of exploring a given question scientifically;
- Evaluate ways of exploring a given question scientifically;
- Describe and evaluate a range of ways that scientists use to ensure the reliability of data and the objectivity and generalisability of explanations.

Interpret data and evidence scientifically

Analyse and evaluate scientific data, claims and arguments in a variety of representations and draw appropriate conclusions demonstrating the ability to:

- Transform data from one representation to another;
- Analyse and interpret data and draw appropriate conclusions;
- Identify the assumptions, evidence and reasoning in science-related texts;
- Distinguish between arguments which are based on scientific evidence and theory and those based on other considerations;
- Evaluate scientific arguments and evidence from different sources (e.g. newspaper, internet, journals).

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

Procedural Knowledge

- 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

Epistemic Knowledge

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 questions 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

Epistemic Knowledge

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 (observations, controlled experiments, correlational studies.

Epistemic Knowledge

- How measurement error affects the degree of confidence in scientific knowledge;
- The use and role of physical, systems 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.

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