

Computational Thinking & Critical Thinking

5 Desember 2020

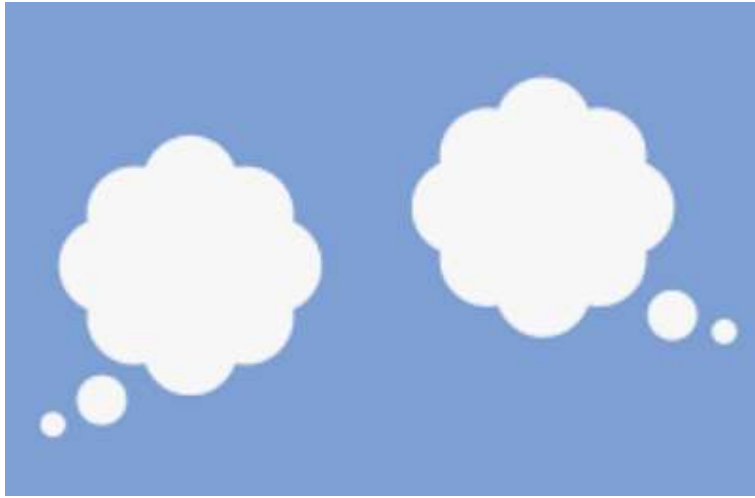
Oleh : Inggriani Liem, Bebras Indonesia



<http://bebras.or.id>

Computational Thinking
Computational Science
Next Generation Science
K12 Science Framework
Critical Thinking
Visible Thinking
Thinking Routine





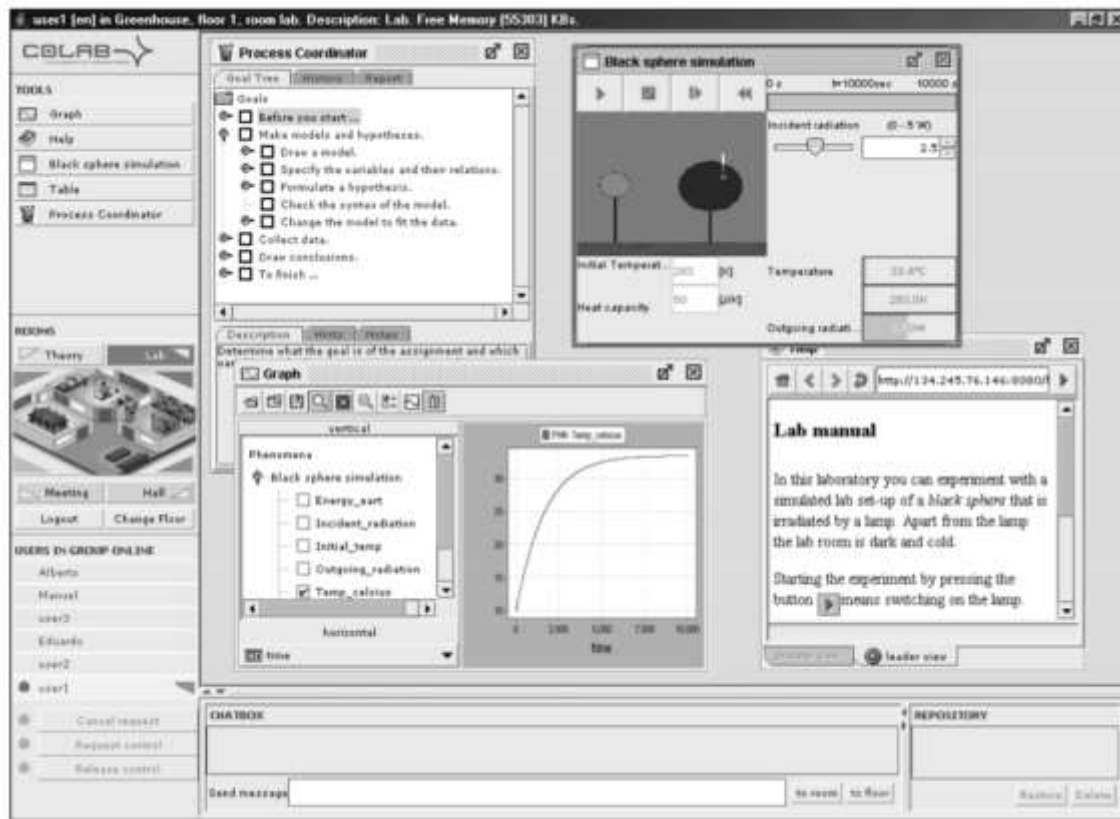
*Berpikir itu asyik
dan menantang!*

Soal-soal yang “sederhana”, terkait kehidupan sehari-hari,
Tidak mungkin dihafal, harus dinalar

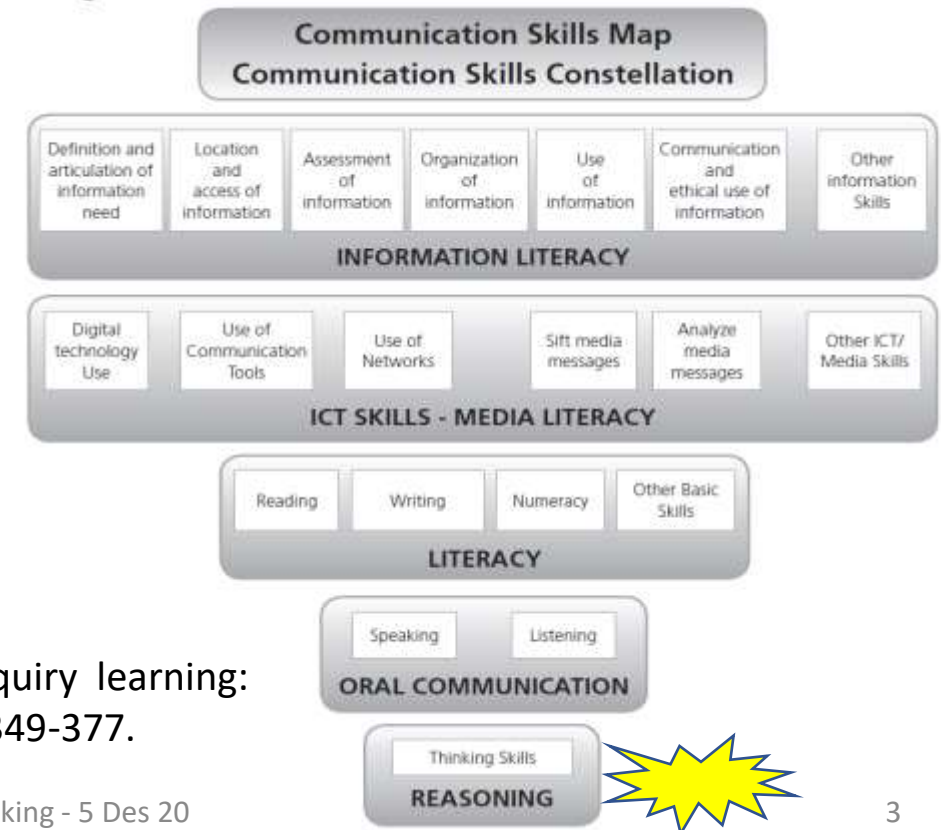
Dikaitkan dengan sains, matematika, literasi, dll
Membuat kita berpikir, mulai mengenal, memahami,
mengaplikasikan, mengevaluasi, mencipta
Mengenal fakta, Menalar sederhana s.d. Aras tinggi

Percobaan Science – Modeling & Simulation

Gambaran Masa Kini – Computational Science

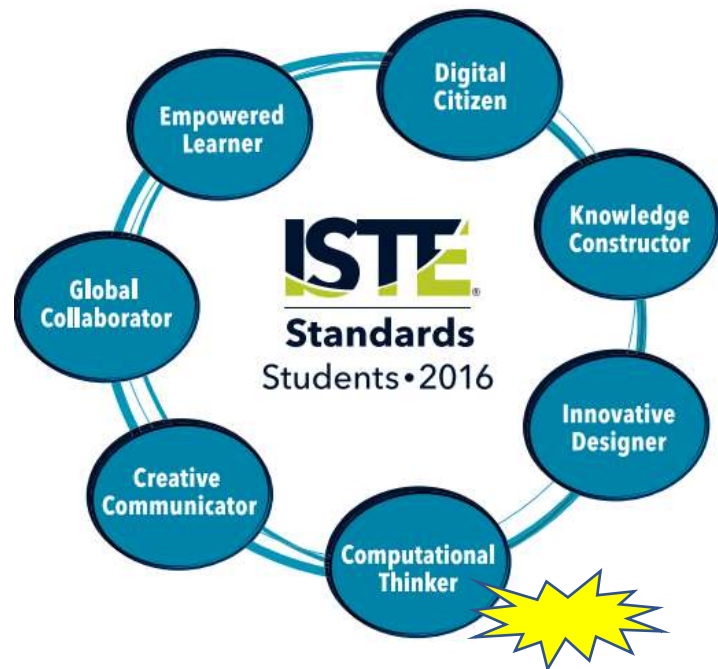


Percobaan, pengamatan, interpretasi seperti dalam eksperimen seperti ini membutuhkan kemampuan literasi baca-tulis, numerasi, sains dan literasi digital

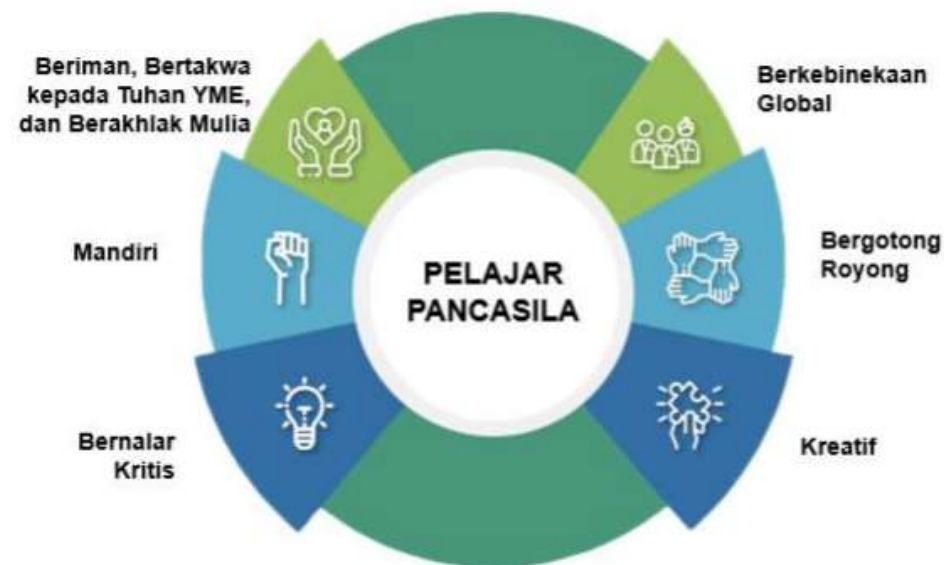


(1) Bell, T., Urhahne, D., Schanze, S., & Ploetzner, R. (2010). Collaborative inquiry learning: models, tools and challenges. International Journal of Science Education, 32(3), 349-377.

(2) <https://unesdoc.unesco.org/ark:/48223/pf0000158723>



Gambar 2.1 Profil Pelajar Pancasila



“Computational Thinking is the new literacy of the 21st century.”

JEANNETTE WING



Computational thinking will be a fundamental skill used by everyone by the middle of the 21st century. Just like reading, writing, and arithmetic. (Wing, 2011)

Nadiem Usung Computational Thinking Jadi Kurikulum, Apa Itu?

TECH - Anif Budiansyah, CNBC Indonesia | 16 February 2020 15:18

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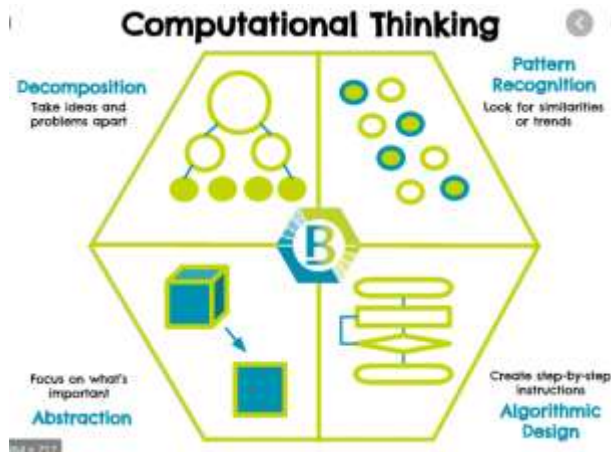
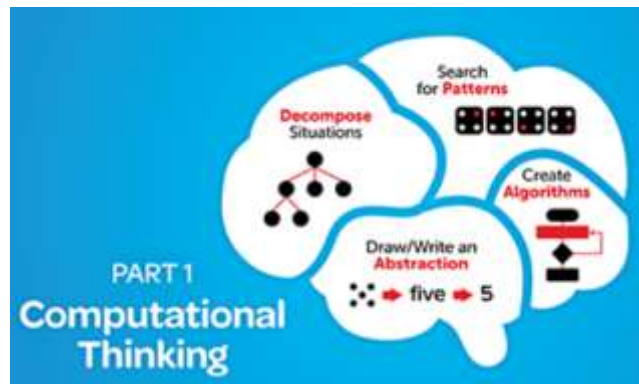


Jakarta, CNBC Indonesia - Kementerian Pendidikan dan Kebudayaan (Kemendikbud) mencanangkan dua kompetensi baru dalam sistem pembelajaran anak Indonesia. Dua kompetensi tambahan itu adalah Computational Thinking dan Compassion.

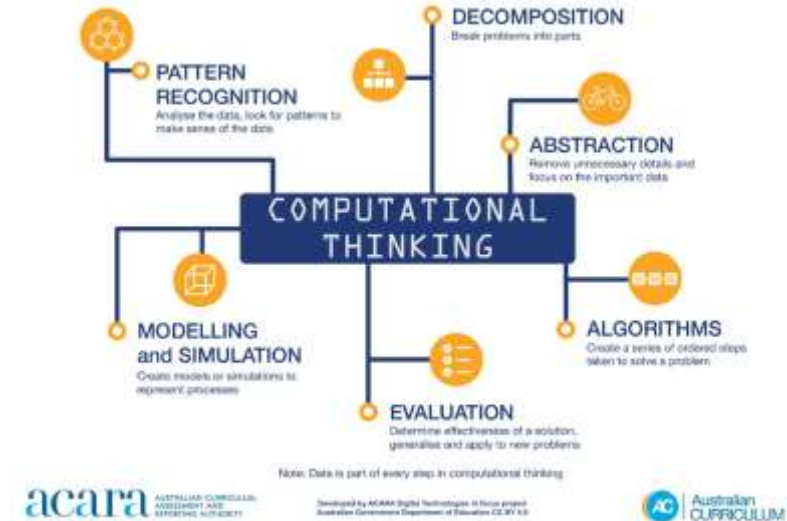
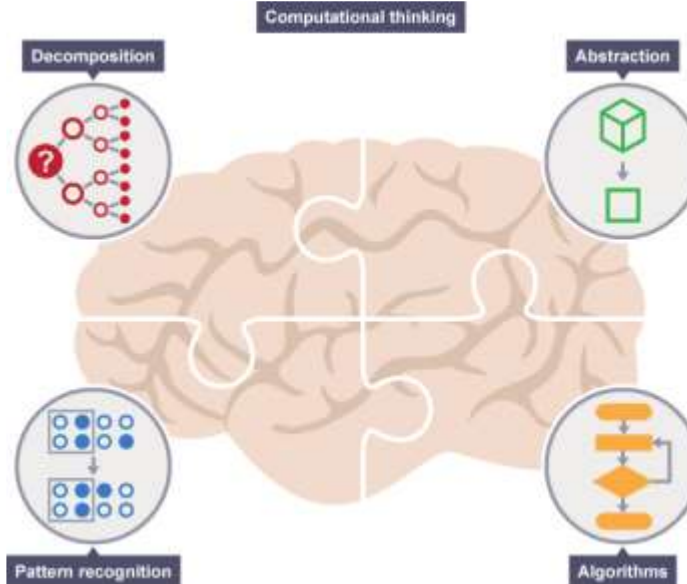
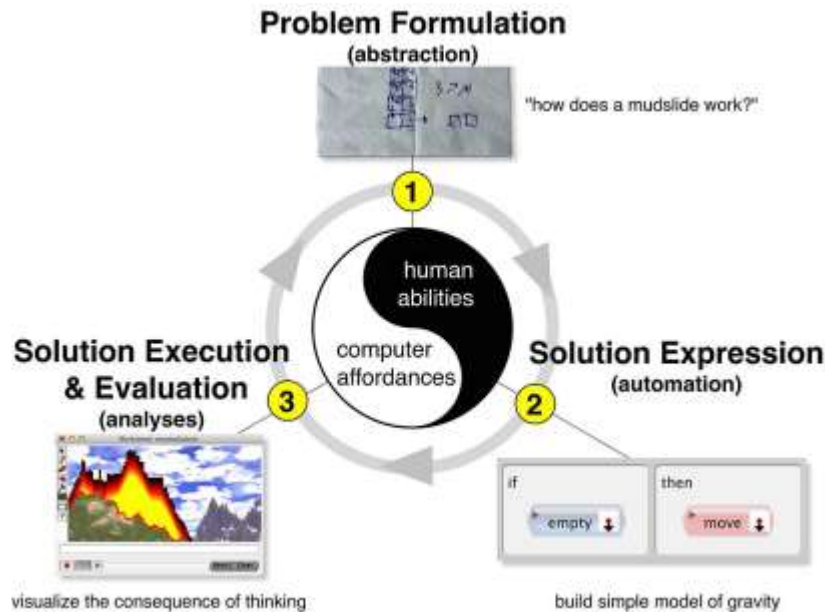
What is Computational Thinking ?

"Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent."

"CT involves **problem-solving skills** and particular **dispositions**, such as confidence and persistence, when confronting particular problems"
"the ability to think with the computer-as-tool"



What is Computational Thinking - CT?



https://en.wikipedia.org/wiki/Computational_thinking <https://www.bbc.co.uk/bitesize/topics/z7tp34j>

<https://www.digitaltechnologieshub.edu.au>

Nonton Video CT:

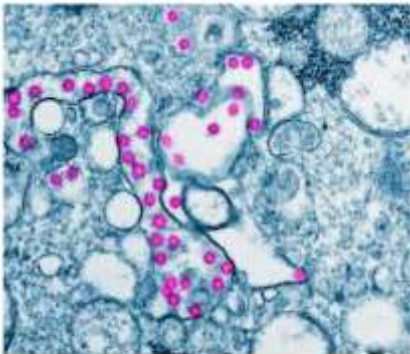
Video Computational Thinking : untuk disimak secara mandiri

<https://k12cs.org/computational-thinking/>

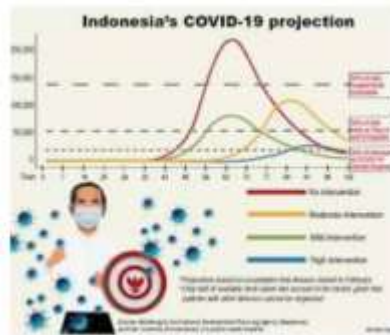
(untuk mendapatkan gambaran contoh-contoh lebih nyata dari pentingnya CT)

Bagaimana mengasah CT ?

- Bebras Challenge – Latihan Mengukur *CT skill*
- By Data Analysis – lihat soal-soal AMK dan PISA
- By Modeling & simulation
- By Programming – bukan Coding, bukan hanya Mapel Informatika



How Computer Modeling Of COVI...
nprillinois.org



Grim result from COVID-19 modeling ...



The Hardest Programming Languages
assignmentexpert.com



Dabar
Medan untuk teknik dan ilmu komputer & informatika



Latihan Berpikir Komputasional Untuk anak usia 5-18 tahun

Bebras

International Challenge on Informatics and Computational Thinking

Bebras Internasional: <http://bebras.org>

Bebras Indonesia <http://bebras.or.id>

Online platform, in bahasa Indonesia: <https://olympia.id>

<https://latihanbebras.ipb.ac.id>

Download : <http://bebras.or.id/v3/pembahasan-soal>

Gratis! Hubungi Biro Bebras terdekat

<https://bebras.or.id/v3/bebras-biro/>



*Memerdekakan
pembelajaran sebagai beban
menjadi pembelajaran
sebagai pengalaman
menyenangkan
(Renstra Kemendikbud 2020-
2024)*



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PANDAI**

Google.org

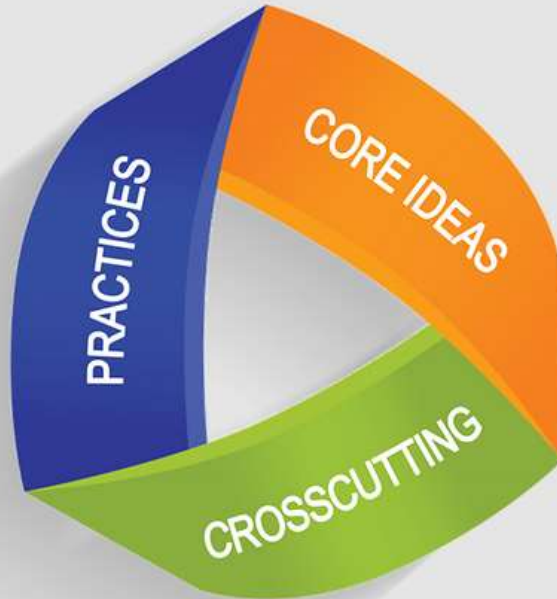
*Pendidikan adalah
penyemaian benih
kebudayaan
(Ki Hajar Dewantara)*

*Pendidikan CT adalah
penyemaian benih
kebudayaan digital*

<https://www.nextgenscience.org/>

THE THREE DIMENSIONS OF SCIENCE LEARNING

Within the Next Generation Science Standards (NGSS), there are three distinct and equally important dimensions to learning science. These dimensions are combined to form each standard—or performance expectation—and each dimension works with the other two to help students build a cohesive understanding of science over time.



^ CROSSCUTTING CONCEPTS

Crosscutting Concepts help students explore connections across the four domains of science, including Physical Science, Life Science, Earth and Space Science, and Engineering Design.

When these concepts, such as “cause and effect”, are made explicit for students, they can help students develop a coherent and scientifically-based view of the world around them.

✓ SCIENCE AND ENGINEERING PRACTICES

✓ DISCIPLINARY CORE IDEAS

[MORE ABOUT 3D LEARNING >](#)

^ SCIENCE AND ENGINEERING PRACTICES

Science and Engineering Practices describe what scientists do to investigate the natural world and what engineers do to design and build systems. The practices better explain and extend what is meant by “inquiry” in science and the range of cognitive, social, and physical practices that it requires. Students engage in practices to build, deepen, and apply their knowledge of core ideas and crosscutting concepts.

^ DISCIPLINARY CORE IDEAS

Disciplinary Core Ideas (DCIs) are the key ideas in science that have broad importance within or across multiple science or engineering disciplines. These core ideas build on each other as students progress through grade levels and are grouped into the following four domains: Physical Science, Life Science, Earth and Space Science, and Engineering.

8 Practices NGSS

1. Asking Questions

Scientific questions lead to explanations of how the natural world works and can be empirically tested using evidence

2. Developing and Using Models

A model is an abstract representation of phenomena that is a tool used to predict or explain the world. Models can be represented as diagrams, 3--D objects, mathematical representations, analogies or computer simulations

3. Planning and Carrying Out Investigation

Planning and Carrying Out Investigations. An investigation is a systematic way to gather data about the natural world either in the field or in a laboratory setting

4. Analyzing and Interpreting Data

Analyzing and interpreting data includes making sense of the data produced during investigations. Because **patterns** are not always obvious, this includes using a range of tools such as tables, graphs and other visualization techniques.

5. Using Mathematics and Computational Thinking

Mathematical and computational thinking involves using tools and mathematical concepts to address a scientific question.

6. Constructing Explanations

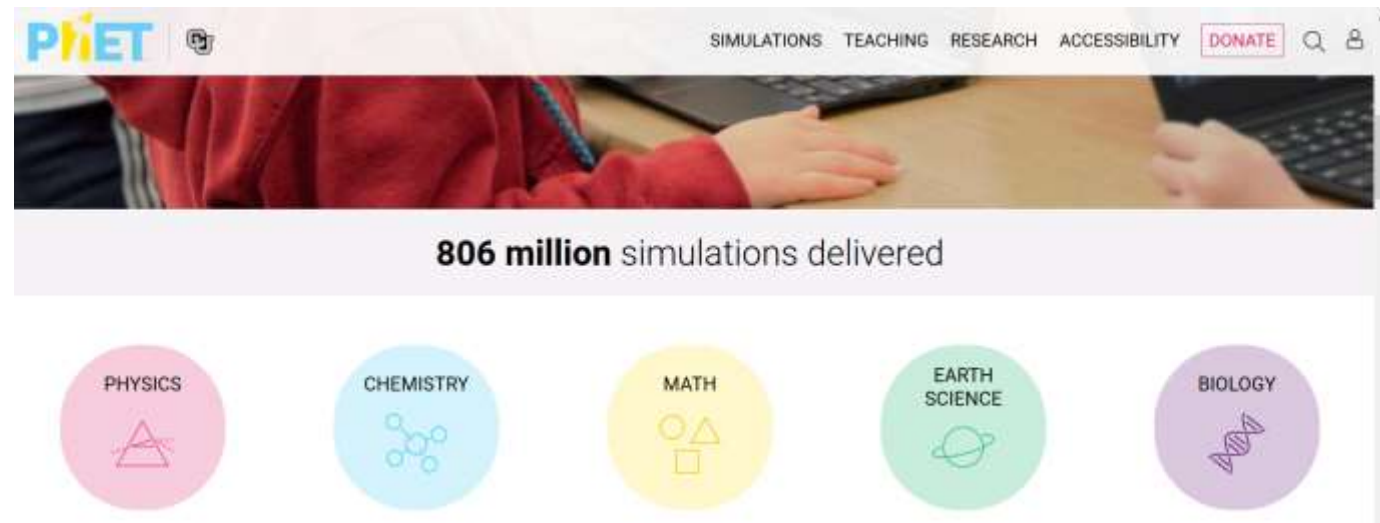
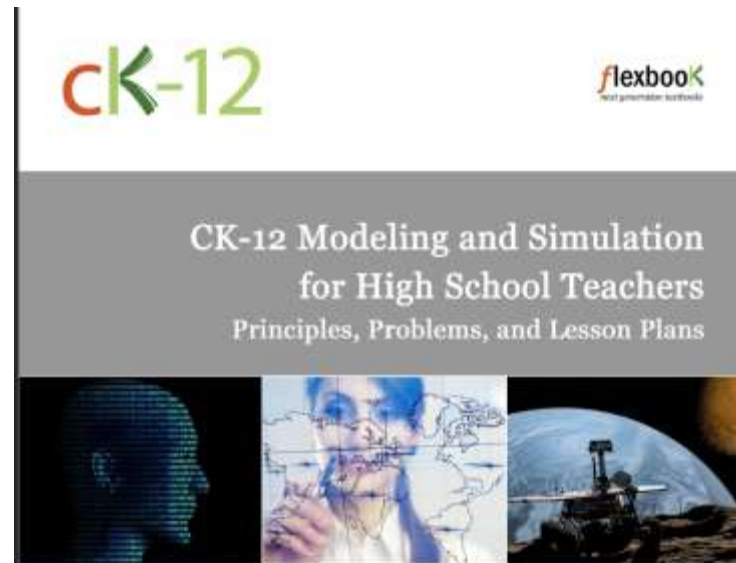
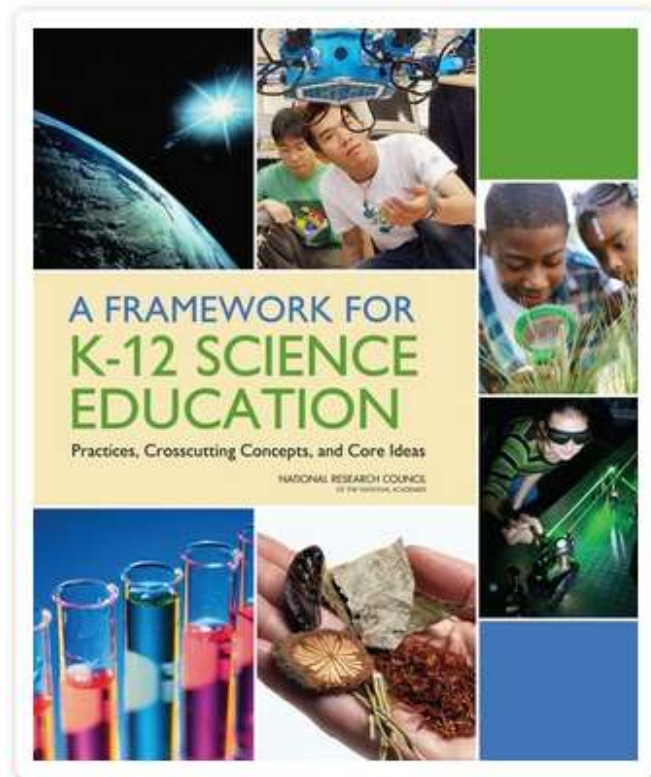
A scientific explanation is an explanatory account that articulates how or why a natural phenomenon occurs that is supported by evidence and scientific ideas

7. Engaging in Argument from Evidence

Scientific argumentation is a process that occurs when there are multiple ideas or claims (e.g. explanations, models) to discuss and reconcile. An argument includes a claim supported by evidence and reasoning, and students engage in debates to evaluate and critique competing arguments

8. Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating and communicating information occurs through reading and writing texts as well as communicating orally. Scientific information needs to be critically evaluated and persuasively communicated as it supports the engagement in the other science practices



<https://golabz.eu>

<https://phet.colorado.edu/>

<https://www.ck12.org/book/ck-12-modeling-and-simulation-for-high-school-teachers%3a-principles-problems-and-lesson-plans/section/2.4/>

Sarantos Psycharis, "STEAM IN EDUCATION: A LITERATURE REVIEW ON THE ROLE OF COMPUTATIONAL THINKING, ENGINEERING EPISTEMOLOGY AND COMPUTATIONAL SCIENCE. COMPUTATIONAL STEAM PEDAGOGY (CSP)", SCIENTIFIC CULTURE, Vol. 4, No 2, (2018), pp. 51-72

<https://core.ac.uk/download/pdf/211836954.pdf>

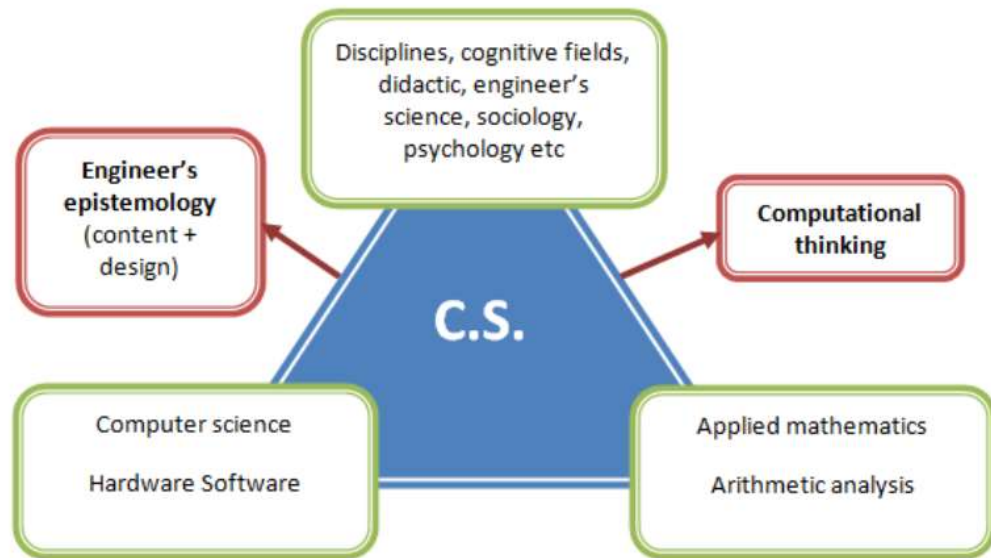


Figure 4. The C.S. cognitive area embedded with engineering design and CT

Space of computational environment

Hypotheses space
Experimental space
Prediction space

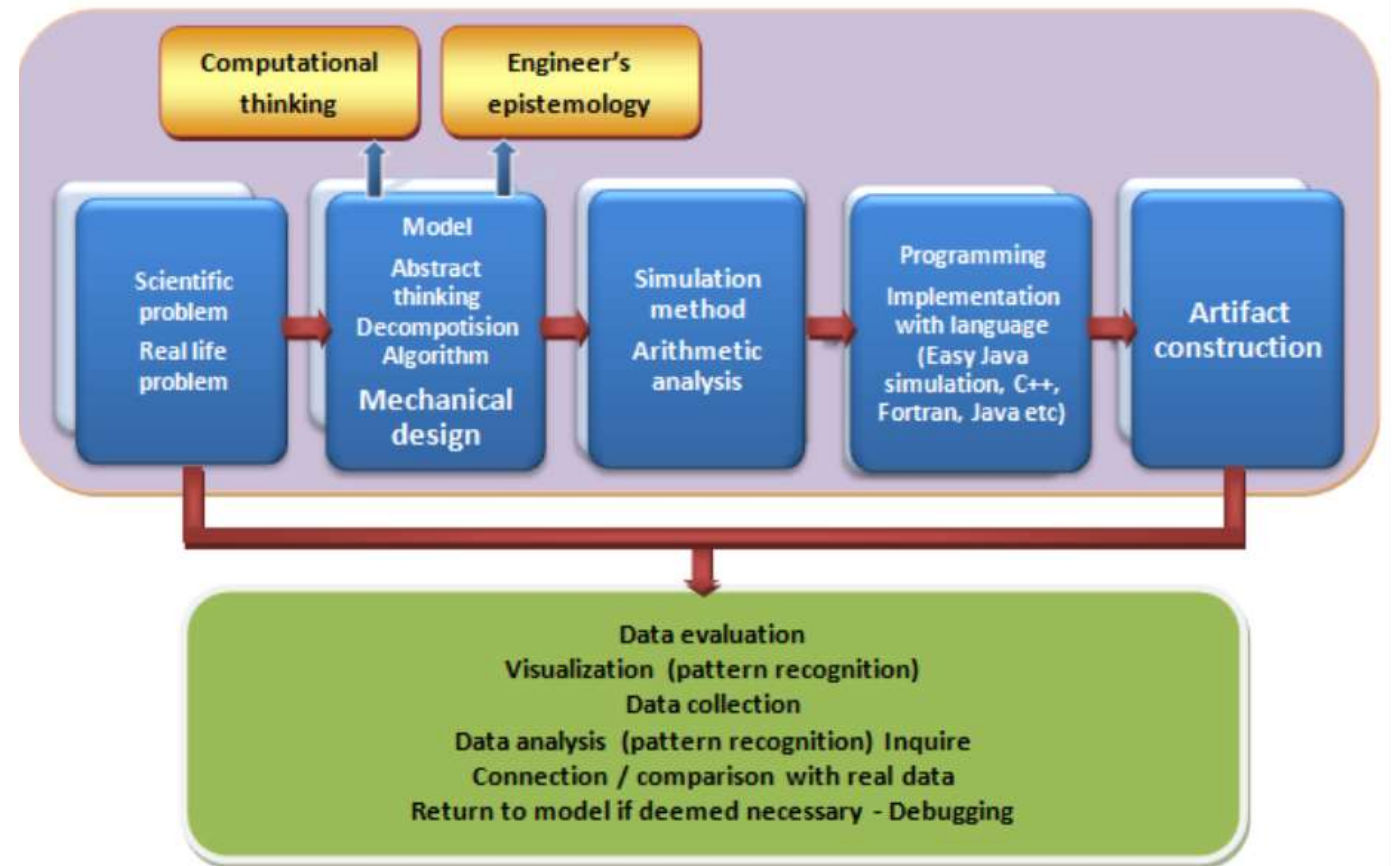


Figure 5. The Computational Science Experiment (CE experiment) with engineering design and CT

Sarantos Psycharis, "STEAM IN EDUCATION: A LITERATURE REVIEW ON THE ROLE OF COMPUTATIONAL THINKING, ENGINEERING EPISTEMOLOGY AND COMPUTATIONAL SCIENCE. COMPUTATIONAL STEAM PEDAGOGY (CSP)", SCIENTIFIC CULTURE, Vol. 4, No 2, (2018), pp. 51-72

<https://core.ac.uk/download/pdf/211836954.pdf>

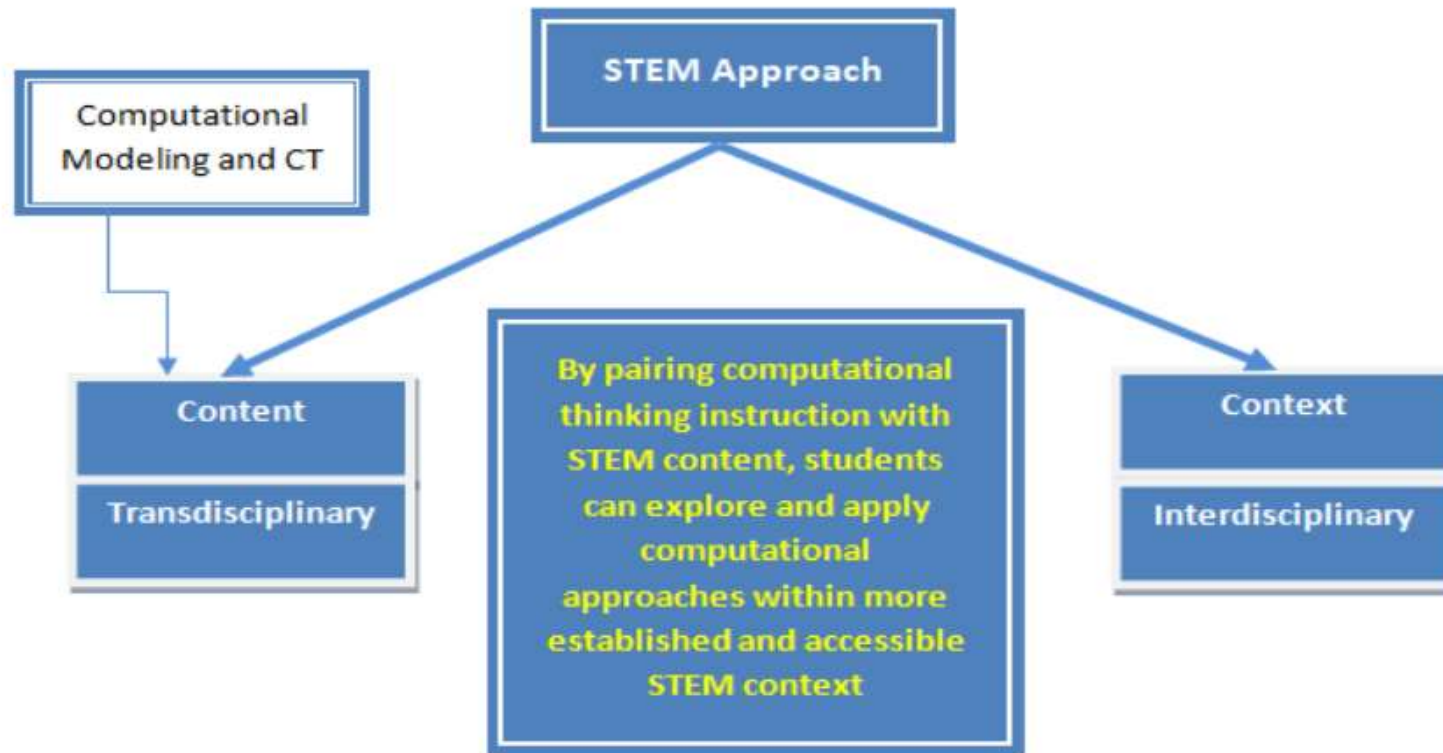


Figure 6. STEM integration as content and in transdisciplinary epistemology

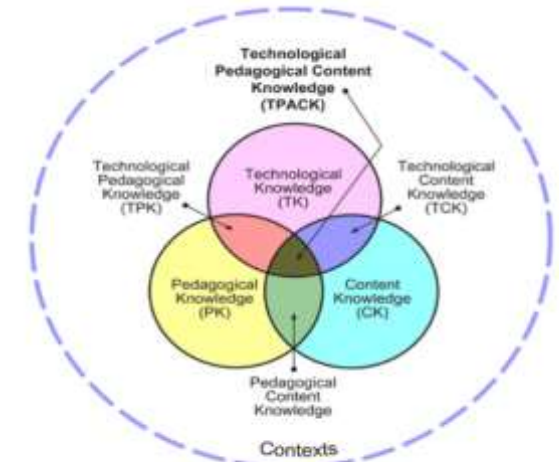


Figure 1. TPACK framework

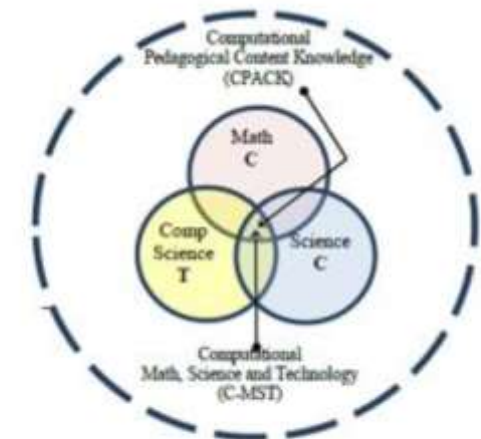


Figure 3. The CPACK Computational Pedagogy (Yasar et al., 2015, 2016)

Weintrop, D., Beheshti, E., Horn, M. *et al.* Defining Computational Thinking for Mathematics and Science Classrooms. *J Sci Educ Technol* **25**, 127–147 (2016).
<https://doi.org/10.1007/s10956-015-9581-5>

Data Practices	Modeling & Simulation Practices	Computational Problem Solving Practices	Systems Thinking Practices
Collecting Data	Using Computational Models to Understand a Concept	Preparing Problems for Computational Solutions	Investigating a Complex System as a Whole
Creating Data	Using Computational Models to Find and Test Solutions	Programming	Understanding the Relationships within a System
Manipulating Data	Assessing Computational Models	Choosing Effective Computational Tools	Thinking in Levels
Analyzing Data	Designing Computational Models	Assessing Different Approaches/Solutions to a Problem	Communicating Information about a System
Visualizing Data	Constructing Computational Models	Developing Modular Computational Solutions	Defining Systems and Managing Complexity
		Creating Computational Abstractions	
		Troubleshooting and Debugging	

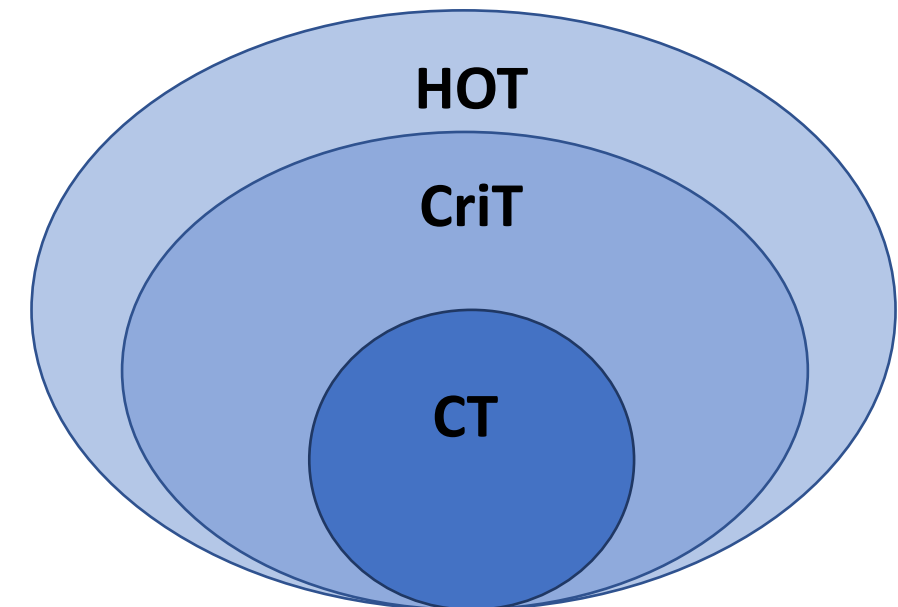
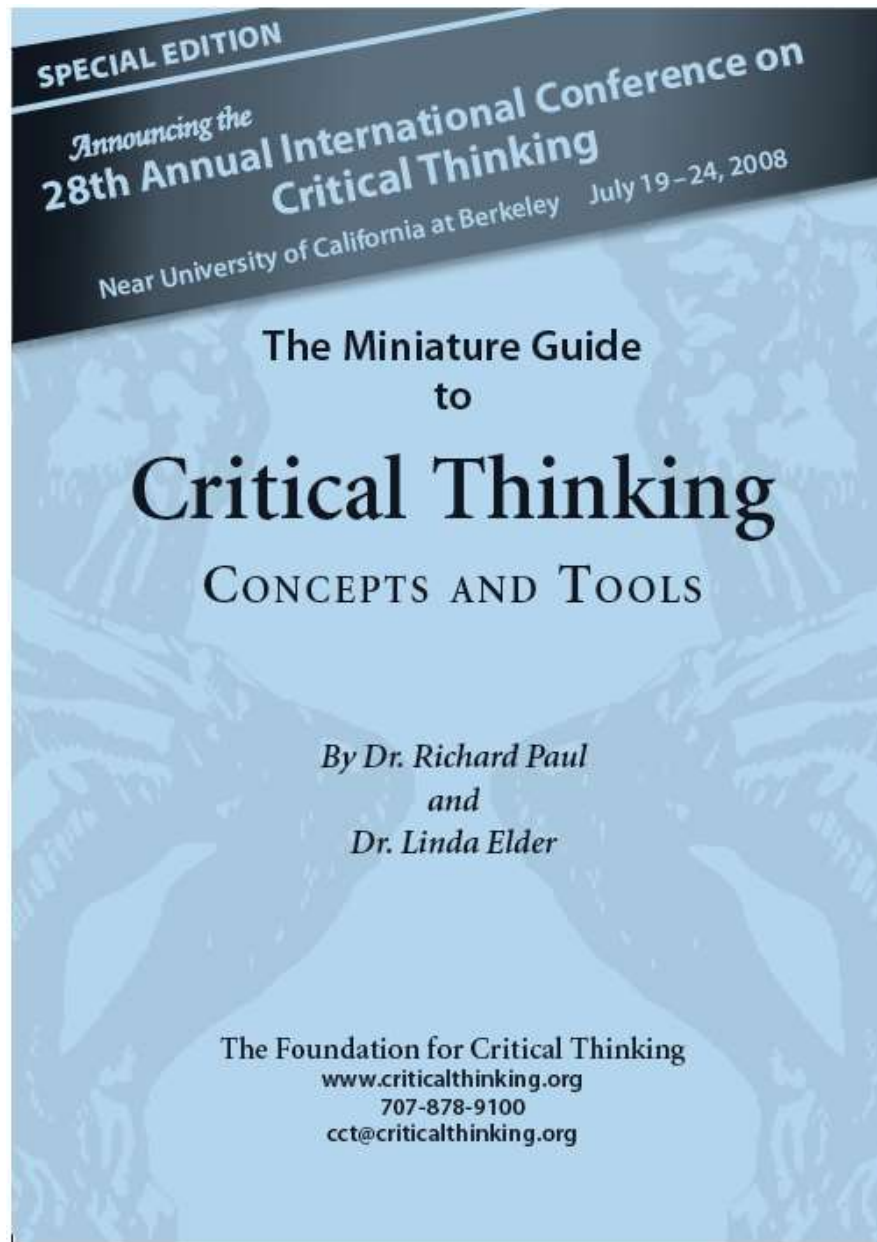
Denning (2007, 2009) raises the question of whether computational thinking itself is an aspect, or extension, of scientific inquiry and may in fact be subsumed within a broader framework of scientific principles:

...computational science is seen in the other sciences not as a notion that flows out of computer science, but as a notion that flows from science itself. Computational thinking is seen as a characteristic of this way of science. It is not seen as a distinctive feature of computer science. (Denning, 2009, p. 29)

Inquiry in **science** has become increasingly **computational** over the past several decades. ... **Computational thinking** practices enable unique modes of **scientific** inquiry that allow **scientists** to create models and simulations to generate data, and to understand and predict complex phenomena.

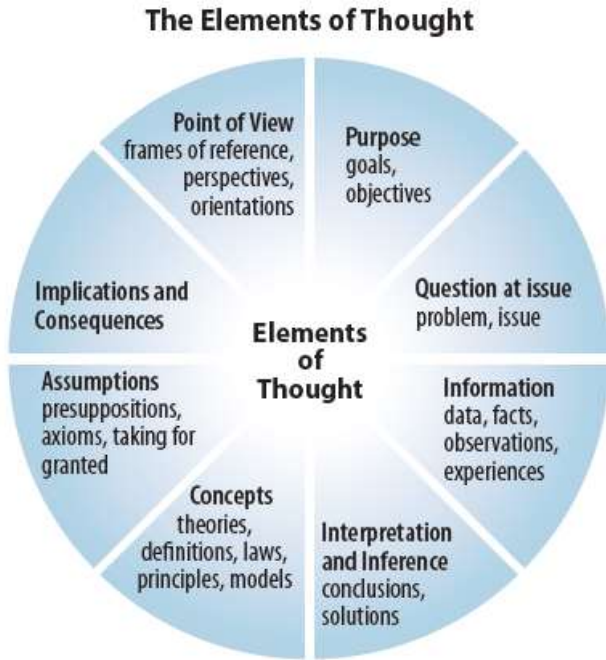
Critical Thinking

Buku Ini layak anda baca
dan latihlah diri anda menjadi
Master Thinker



Critical Thinking – CriT

<https://www.criticalthinking.org/>



Used With Sensitivity to Universal Intellectual Standards

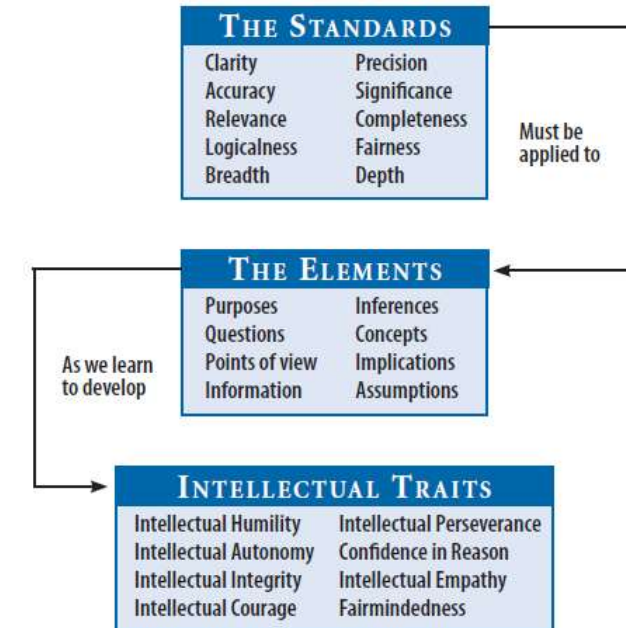
Clarity → Accuracy → Depth → Breadth → Significance
Precision
Relevance

To put them in a single sentence, whenever we think critically, we think with a **purpose**, raise **questions**, and embody a **viewpoint** by making **assumptions** and **inferences** and by using **information** and **concepts**, leading to **implications**.

Critical thinking is important because it relates to **nearly all** tasks, situations, topics, careers, environments, challenges, and opportunities. It's a “**domain-general**” **thinking skill**—not a **thinking skill** that's reserved for a one subject alone or restricted to a particular subject area.



Critical thinkers routinely apply intellectual standards to the elements of reasoning in order to develop intellectual traits.



Why Critical Thinking?

The Problem:

Everyone thinks; it is our nature to do so. But much of our thinking, left to itself, is biased, distorted, partial, uninformed or down-right prejudiced. Yet the quality of our life and that of what we produce, make, or build depends precisely on the quality of our thought. Shoddy thinking is costly, both in money and in quality of life. Excellence in thought, however, must be systematically cultivated.

A Definition:

Critical thinking is the art of analyzing and evaluating thinking with a view to improving it.

The Result:

A well cultivated critical thinker:

- raises vital questions and problems, formulating them clearly and precisely;
- gathers and assesses relevant information, using abstract ideas to interpret it effectively;
- comes to well-reasoned conclusions and solutions, testing them against relevant criteria and standards;
- thinks openmindedly within alternative systems of thought, recognizing and assessing, as need be, their assumptions, implications, and practical consequences; and
- communicates effectively with others in figuring out solutions to complex problems.

Critical thinking is, in short, self-directed, self-disciplined, self-monitored, and self-corrective thinking. It requires rigorous standards of excellence and mindful command of their use. It entails effective communication and problem solving abilities and a commitment to overcoming our native egocentrism and sociocentrism.

Critical thinking is the process of analyzing and assessing thinking with a view to improving it.

*Critical thinking presupposes knowledge of the most basic structures in thinking (the elements of thought) and the most basic intellectual standards for thinking (universal intellectual standards). The key to the creative side of critical thinking (**the actual improving of thought**) is in restructuring thinking as a result of analyzing and effectively assessing it.*

Critical thinking is self-directed, self-disciplined, self-monitored, and self corrective thinking

Thinking and Reasoning is important

Figure 4.2. PISA 2015/2018 framework for cognitive demand

Competencies				DOK		
				Low	Medium	High
Knowledge	Content Knowledge	Explain phenomena scientifically	Evaluate and design scientific enquiry	Interpret data and evidence scientifically		
	Procedural Knowledge					
	Epistemic Knowledge					

Scientific Literation – PISA Test

Epistemology: the theory of knowledge, especially with regard to its methods, validity, and scope. Epistemology is the investigation of what distinguishes justified belief from opinion.

Three Levels of Thought

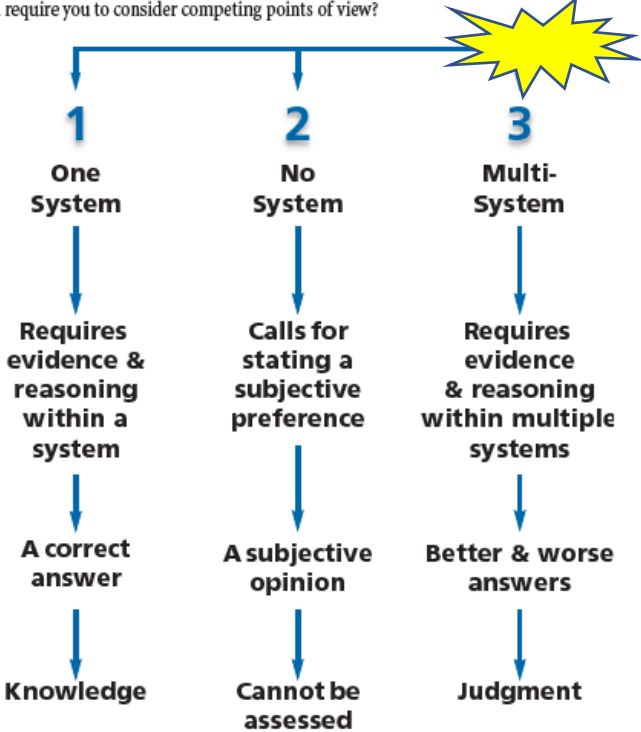


Lower order thinking is often distinguished from higher order thinking. But higher order thinking can be inconsistent in quality. It can be fair or unfair. To think at the highest level of quality, we need not only intellectual skills, but intellectual traits as well.



Three Kinds of Questions

In approaching a question, it is useful to figure out what type it is. Is it a question with one definitive answer? Is it a question that calls for a subjective choice? Or does the question require you to consider competing points of view?



<https://www.criticalthinking.org>

We want students to become proficient with the kinds of thinking they can use to develop their own understanding of things.

- Ask **questions**, identify puzzles, and wonder about the mysteries and implications of the objects and ideas of learning.
- Make **connections**, **comparisons**, and **contrasts** between and among things - including connections within and across the discipline as well as with one's own prior knowledge.
- Build ongoing and evolving **explanations**, **interpretations**, and theories based on one's ever-developing knowledge and understanding.
- Examine things from **different perspectives** and **alternative points of view** to discern bias and develop a more balanced take on issues, ideas and events.
- **Notice**, **observe** and **look closely** to fully perceive details, nuances and hidden aspects and to observe what is really going on as the foundational evidence for one's interpretations and theories.
- Identify, gather, and **reason with evidence** to justify and support one's interpretations, predictions, theories, arguments, and explanations.
- Delve deeper to **uncover the complexities** and challenges of a topic and look below the surface of things, recognising when one has only a surface understanding.
- Be able to **capture the core or essence** of a thing to discern what it is really all about.



*Kemampuan Belajar Mandiri
adalah syarat berhasilnya proses
pembelajaran aras tinggi*

<http://www.pz.harvard.edu/projects/visible-thinking>

Thinking Routine

<https://pz.harvard.edu/thinking-routines>

Project Zero's Thinking Routines Toolbox. This toolbox highlights Thinking Routines developed across a number of research projects at PZ. A vast array of PZ's work has explored the **development of thinking**, the concept of thinking dispositions, and the many ways routines can be used to support student learning and thinking across age groups, disciplines, ideals, competencies, and populations.



Core Thinking Routine
Circle of Viewpoints
Claim, Support, Question
Compass Points
Connect, Extend, Challenge
I Used to Think... Now I Think...
See, Think, Wonder
Think, Pair, Share
Think, Puzzle, Explore
What Makes You Say That?

PARTS, PURPOSES, COMPLEXITIES

LOOKING CLOSELY



Choose an object or system and ask:

What are its **parts**?

What are its various pieces or components?

What are its **purposes**?

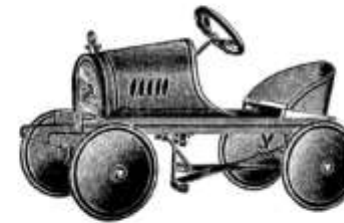
What are the purposes for each of these parts?

What are its **complexities**?

How is it complicated in its parts and purposes, the relationship between the two, or in other ways?

IMAGINE IF...

FINDING OPPORTUNITY



Choose an object or system:

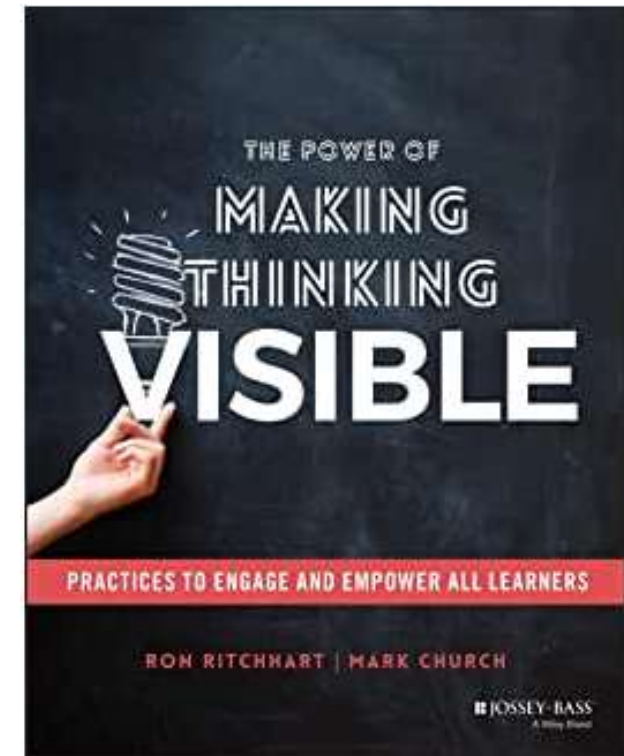
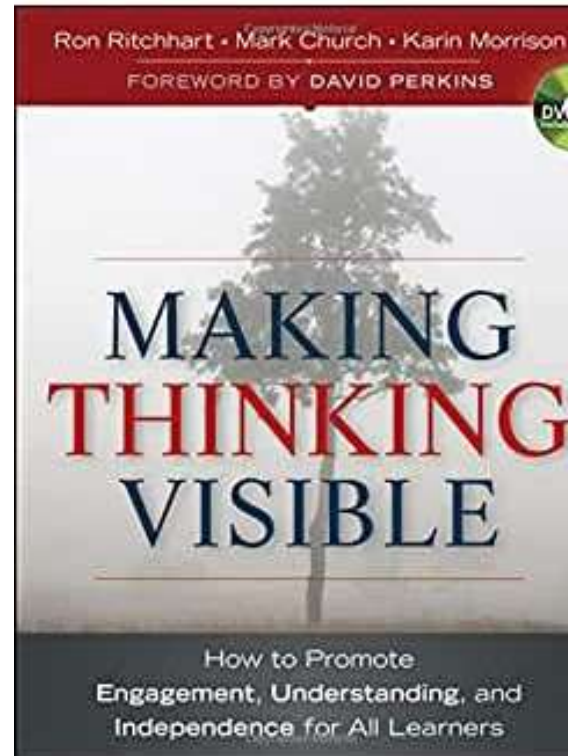
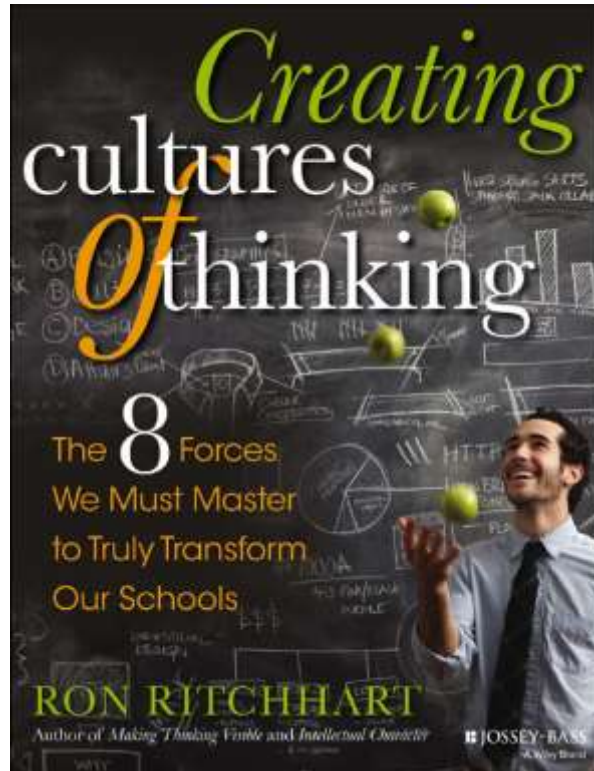
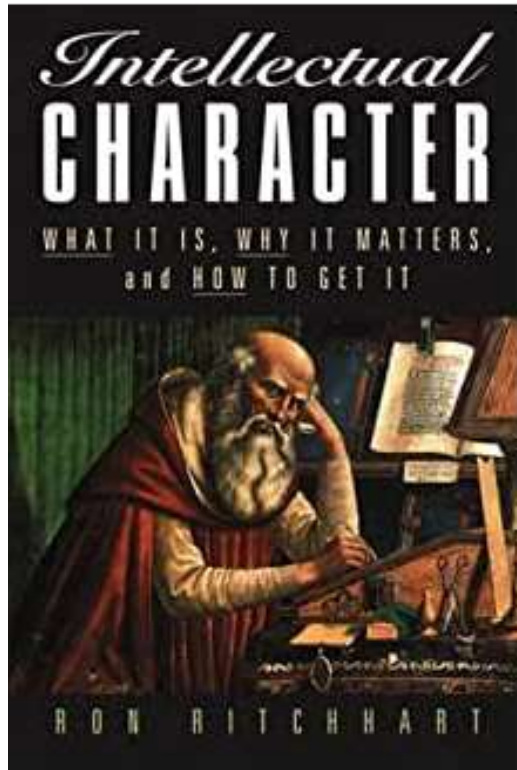
Consider the parts, purposes, and people who interact with your object or system, and then ask:

In what ways could it be made to be more **effective**?

In what ways could it be made to be more **efficient**?

In what ways could it be made to be more **ethical**?

Sangat disarankan untuk dibaca dan dinikmati
<https://www.ronritchhart.com/new-page>



Thank You

Online Platform for Learning CT in Bahasa Indonesia

<https://latihanbebras.ipb.ac.id>



<http://bebras.or.id>



Gerakan **PANDAI**
Supported by **Google.org**

<https://www.oecd.org/pisa/publications/pisa-2021-assessment-and-analytical-framework.htm>

Tackling coronavirus (COVID-19) - Browse OECD contributions



PISA 2022 Assessment and Analytical Framework

Draft components of the PISA 2022 Assessment and Analytical Framework can be found below:

[PISA 2022 Creative Thinking](#)

[PISA 2022 Financial Literacy](#)

[PISA 2022 ICT](#)

[PISA 2022 Mathematics](#)

[PISA 2022 Questionnaire](#)

Kita tunggu
2022 Scientific Literacy Framework

And, for the first time, the **Mathematics Framework** for PISA 2022 is available in an interactive and multi-language format on this [link](#).

PISA 2018 Analytic Framework

Scientific Literacy

Contexts for the PISA 2018 Scientific Literacy Assessment

	Personal	Local/National	Global
Health and disease	Maintenance of health, accidents, nutrition	Control of disease, 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

Table 4.6. Content knowledge in the PISA 2018 science assessment

Physical systems, including:

Structure of matter (e.g., particle model, bonds)
Properties of matter (e.g., changes of state, thermal and electrical conductivity)
Chemical changes of matter (e.g., chemical reactions, energy transfer, acids/bases)
Motion and forces (e.g., velocity, friction) and action at a distance (e.g., magnetic, gravitational and electrostatic forces)
Energy and its transformation (e.g., conservation, dissipation, chemical reactions)
Interactions between energy and matter (e.g., light and radio waves, sound and seismic waves)

Living systems, including:

Cells (e.g., structures and function, DNA, differences between plant and animal cells)
The concept of an organism (e.g., unicellular vs. multicellular)
Humans (e.g., health; nutrition; subsystems such as the digestive, the respiratory, the circulatory, the excretory and the reproductive and their relationship)
Populations (e.g., species, evolution, biodiversity, genetic variation)
Ecosystems (e.g., food chains, matter and energy flow)
Biosphere (e.g., ecosystem services, sustainability)

Earth and space systems, including:

Structures of the Earth (e.g., lithosphere, atmosphere, hydrosphere)
Energy in the Earth (e.g., sources, global climate)
Change in the Earth (e.g., plate tectonics, geochemical cycles, constructive and destructive forces)
Earth's history (e.g., fossils, origin and evolution)
Earth in space (e.g., gravity, solar systems, galaxies)
The history and scale of the Universe and its history (e.g., light year, Big Bang theory)

Content Knowledge

Table 4.7. Procedural knowledge in the PISA 2018 science assessment

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 or other instruments, 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 measurements of the same quantity) and accuracy (the closeness of agreement between a measured quantity and its true value) of measurements;

Common ways of abstracting and representing data using tables, graphs and charts and their appropriate use;
The control of variables and its role in experimental design;

The use of randomised controlled trials to avoid confounded findings and to identify possible causal mechanisms;
The nature of an appropriate design for a given scientific question, e.g., experimental, field-based or pattern-seeking.

Procedural Knowledge

Table 4.8. Epistemic knowledge in the PISA 2018 science assessment

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 question, and what constitutes appropriate data;
- The values of science, such as a commitment to publication, objectivity and the elimination of bias;
- The nature of reasoning used in science, such as deductive, inductive, inference to the best explanation (abductive), analogical and model-based;

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, including both 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.

Epistemic Knowledge