21st Century Skills: Challenges in Defining, Teaching and Assessing Them

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Today's Presentation

- 21st Century Skills – What are they? Why so much interest?
- Making sense of a crowded field: Relevant background ideas about the domain
  - derived from the work of a United States National Research Council Committee
- An example of the conceptual, practical and interpretive challenges: OECD's PISA Program and assessment of problem solving (2012) and collaborative problem solving (2015).
- What are some of the implications of this collective work for education and educators?

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Skills Identified in an Influential OECD Survey

1. Creativity/innovation
2. Critical thinking
3. Problem solving
4. Decision making
5. Communication
6. Collaboration
7. Information literacy
8. Research and inquiry
9. Media literacy
10. Digital citizenship
11. Information and communications technology operations and concepts
12. Flexibility and adaptability
13. Initiative and self-direction
14. Productivity
15. Leadership and responsibility
16. Other (please specify)

Source: Adapted from Ananiadou, and Claro (2009).

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Clarifying the Larger "Educational Problem"

- Why such great interest in 21st Century Skills?
- What exactly is everyone after -- what do people see as missing from the current education system?
- What's different relative to the 20th or 19th centuries?
- **Some possible answers:**
- # 1 -- The Holy Grail of Education – TRANSFER
- #2 – Not so different than in the past with the exception of technology mediated activities
- #3 – What's different is that everyone needs to develop a high level of Competency given the nature of life and work in the 21st century

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Study & Report Context

- Education is a shared endeavor, including schools, teachers, nonprofit groups, informal learning institutions, taxpayers, parents, and the students themselves.
- Business and educational leaders are asking this shared endeavor to infuse development of "21st century skills" such as problem solving, critical thinking, and collaboration into teaching and learning.
- A variety of names are used to refer to these skills.
- To help the public understand the research related to these skills, several foundations charged the U.S. NRC….

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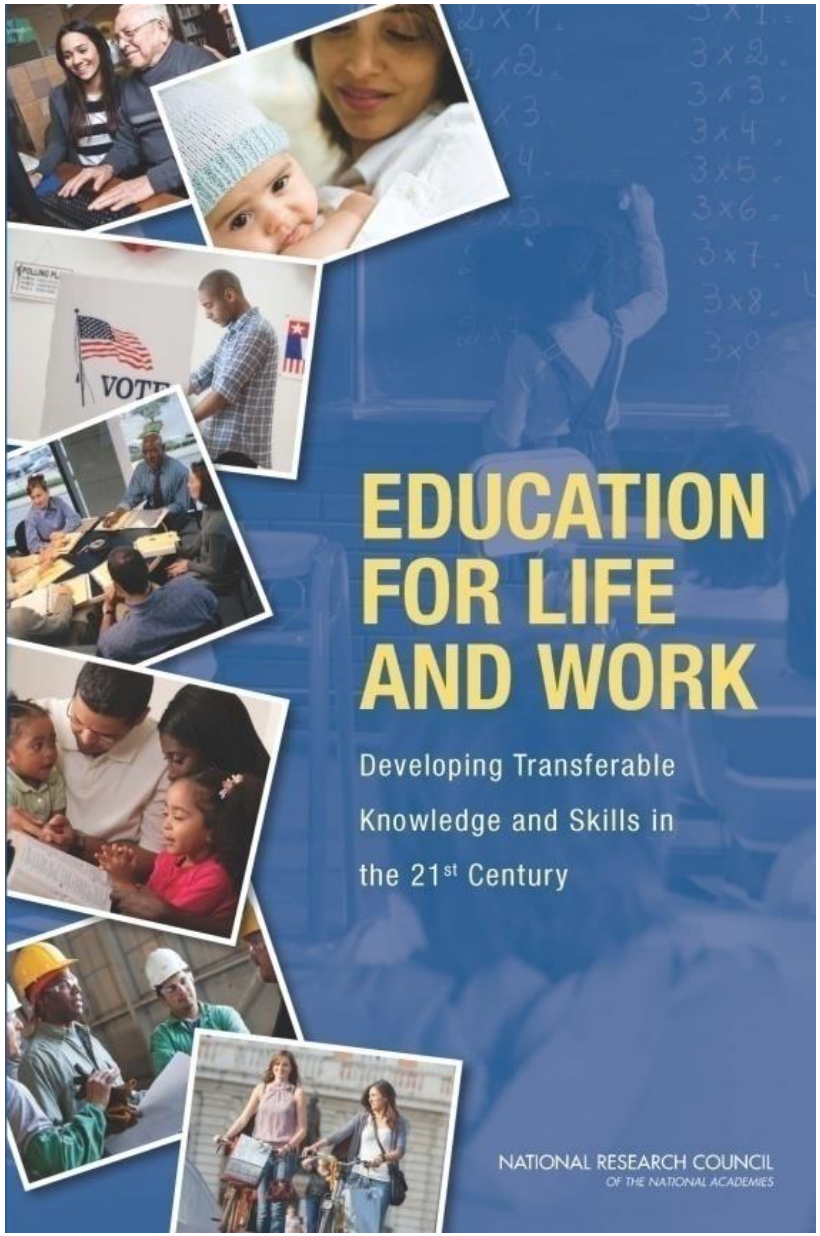
Committee Charge

- Define the set of key skills referred to as "deeper learning," "21st century skills," and by other labels
  - Examples of the labels were shown earlier in OECD list; many other lists as well
- Review research on their importance for positive adult outcomes
- Describe how the skills relate to each other and to the learning of reading, mathematics, and science and engineering
- Discuss how to teach and assess them and the implications for teacher education and professional development



Committee on Defining Deeper Learning and 21st Century Skills

Division of Behavioral and Social Sciences and Education

National Research Council

Clarifying Terms & Identifying Domains of Competence

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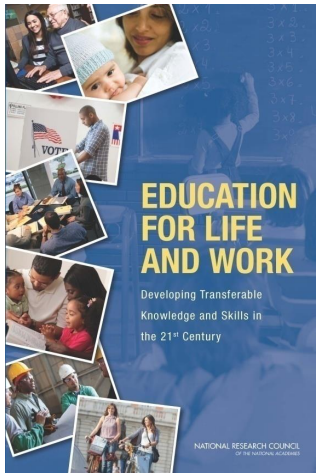

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Clarifying Terms

- Deeper learning is *the process of learning for transfer*. It enables an individual to take what was learned in one situation and apply it to new situations.

- The product of deeper learning is *transferable knowledge*, including content knowledge in a subject area and procedural and strategic knowledge of how, why, and when to apply this knowledge to answer questions and solve problems in the subject area.

- We refer to this transferable knowledge as *"21st century competencies"* to reflect that both skills and knowledge are included.

Three Domains of Competence

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Three Domains of Competence: Competency Clusters

- The **Cognitive Domain** includes three clusters of competencies:
  - cognitive processes and strategies
  - knowledge
  - creativity
    - These clusters include competencies such as critical thinking, **problem solving**, information literacy, reasoning and argumentation, and innovation.
- The **Intrapersonal Domain** includes three clusters of competencies:
  - intellectual openness
  - work ethic and conscientiousness
  - positive core self-evaluation
    - These clusters include competencies such as flexibility, initiative, appreciation for diversity, and metacognition (the ability to reflect on one's own learning and make adjustments accordingly).
- The **Interpersonal Domain** includes two clusters of competencies:
  - teamwork and collaboration
  - leadership
    - These clusters include competencies such as communication, **collaboration**, responsibility, and conflict resolution.

Evidence of Importance for Each Competency Domain

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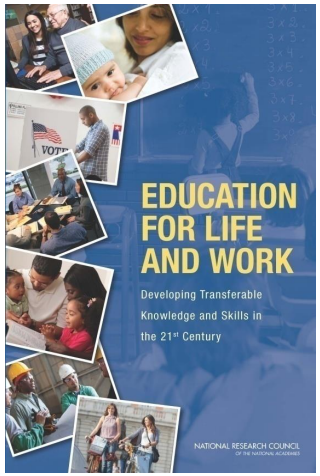

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Evidence of Importance

What do existing studies say about the importance of these domains?

- **It's messy:**
  - Mostly correlational, with no or few control variables
  - Many, many overlapping measures of subdomains
  - Longitudinal studies begun before modern measures were available
  - Personality and developmental psychologists work largely independently of one another
  - Economists often lump everything into a single ”noncognitive” category

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Methodological Challenges: Adequacy of Measurement

- The datasets are limited and the inferential designs and analysis methods are weak
- The measures for each competency domain are global and undifferentiated proxies
  - a “bunch of stuff” in a big bucket
- Many of the more specific domain constructs lack valid, reliable and useable measures
  - This is especially the case for the intrapersonal and interpersonal domains
  - Also applies to some of the cognitive competencies

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Nevertheless: Evidence of Importance for Adult Outcomes

- Cognitive competencies show modest positive correlations with desirable educational, career, and health outcomes.
- Achievement, especially math achievement, predicts most strongly to labor market outcomes
- Literature on "Big Five" is correlational; conscientiousness correlates most strongly with job performance
- Anti-social behavior is often predictive as well

Teaching for Transfer & Deeper Learning in the Disciplines

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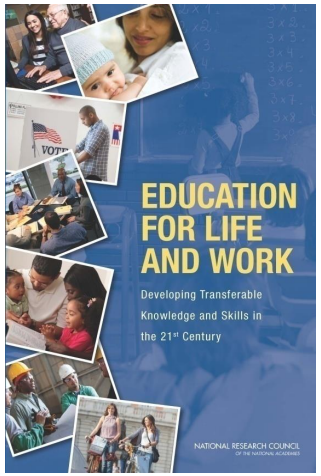

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Teaching for Transfer

- Emerging evidence indicates that cognitive, intrapersonal and interpersonal competencies can be taught and learned in ways that promote effective transfer.
- Transfer is not domain general – it is domain specific.

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Transfer is Supported When:

- Learners understand general principles, as emphasized in the recent U.S. standards in mathematics, science and English language arts.
- Learners understand factual and conceptual knowledge in a subject area and also applicable problem-solving strategies.
- Learners recognize how, when, and why to apply their factual, conceptual, and procedural knowledge and skills.

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To Design Instruction for Transfer:

- Begin with clearly-defined learning goals and a model of how learning is expected to develop.
- Use assessments to measure and support progress toward goals.
- Provide multiple, varied representations of concepts and tasks.
- Encourage questioning and discussion.
- Engage learners in challenging tasks, with support and guidance.
- Teach with carefully selected sets of examples and cases.
- Prime student motivation.
- Use formative assessment to provide feedback.

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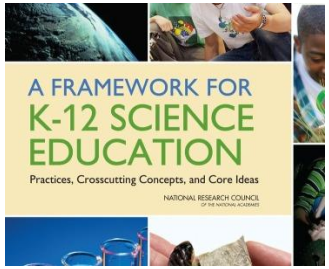
Deeper Learning and 21st Century Competencies in the Disciplines

- The U.S. math and English CCSS and the NRC Science Framework and NGSS each call for deeper learning



- The standards documents emphasize some 21st century competencies

- A cluster of cognitive competencies – including critical thinking and constructing and evaluating evidence-based arguments – is strongly supported across all three disciplines.

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- Competencies such as constructing arguments with evidence, oral and written discourse, and non-routine problem-solving have distinctly different expressions in different disciplines.

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Mathematics

Deeper Learning/21st C. Skills Only

- Complex Communication II (Social/inter-personal aspects)
- Cultural Sensitivity, Valuing diversity
- Adaptability
- Complex Communication I
  - Critical reading

Areas of Strongest Overlap

- Constructing & evaluating evidence-based arguments
- Non-routine problem solving
- Complex Communication I
  - Disciplinary discourse
- Systems thinking
- Critical thinking
- Motivation, persistence
- Identity
- Attitudes
- Self-development
- Collaboration/Teamwork
- Self-regulation, Executive Functioning

Discipline-based Standards Documents Only

- Disciplinary Content, including specific forms of representation
- Discipline-specific entailments of reasoning/ argument (e.g., mathematical proof; mathematical induction)

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Science & Engineering

Deeper Learning/21st C. Skills Only

- Self-regulation, Executive Functioning
- Complex Communication II (Social/interpersonal aspects)
- Cultural Sensitivity, Valuing diversity

Areas of Strongest Overlap

- Constructing & evaluating evidence-based arguments
- Non-routine problem solving
- Complex Communication I
  - Disciplinary discourse
  - Critical reading
- Systems thinking
- Critical thinking
- Motivation, persistence
- Identity
- Attitudes
- Self-development
- Collaboration/Teamwork
- Adaptability

Discipline-based Standards Documents Only

- Disciplinary Content
- Quantitative literacy (especially scale and proportion)
- Epistemology and history of science

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English Language Arts

Deeper Learning/21st C. Skills Only

- Systems thinking
- Complex Communication II (Social/interpersonal aspects)
- Cultural Sensitivity, Valuing diversity
- Motivation, persistence
- Identity
- Attitudes
- Self-development
- Collaboration/Team work
- Adaptability

Areas of Strongest Overlap

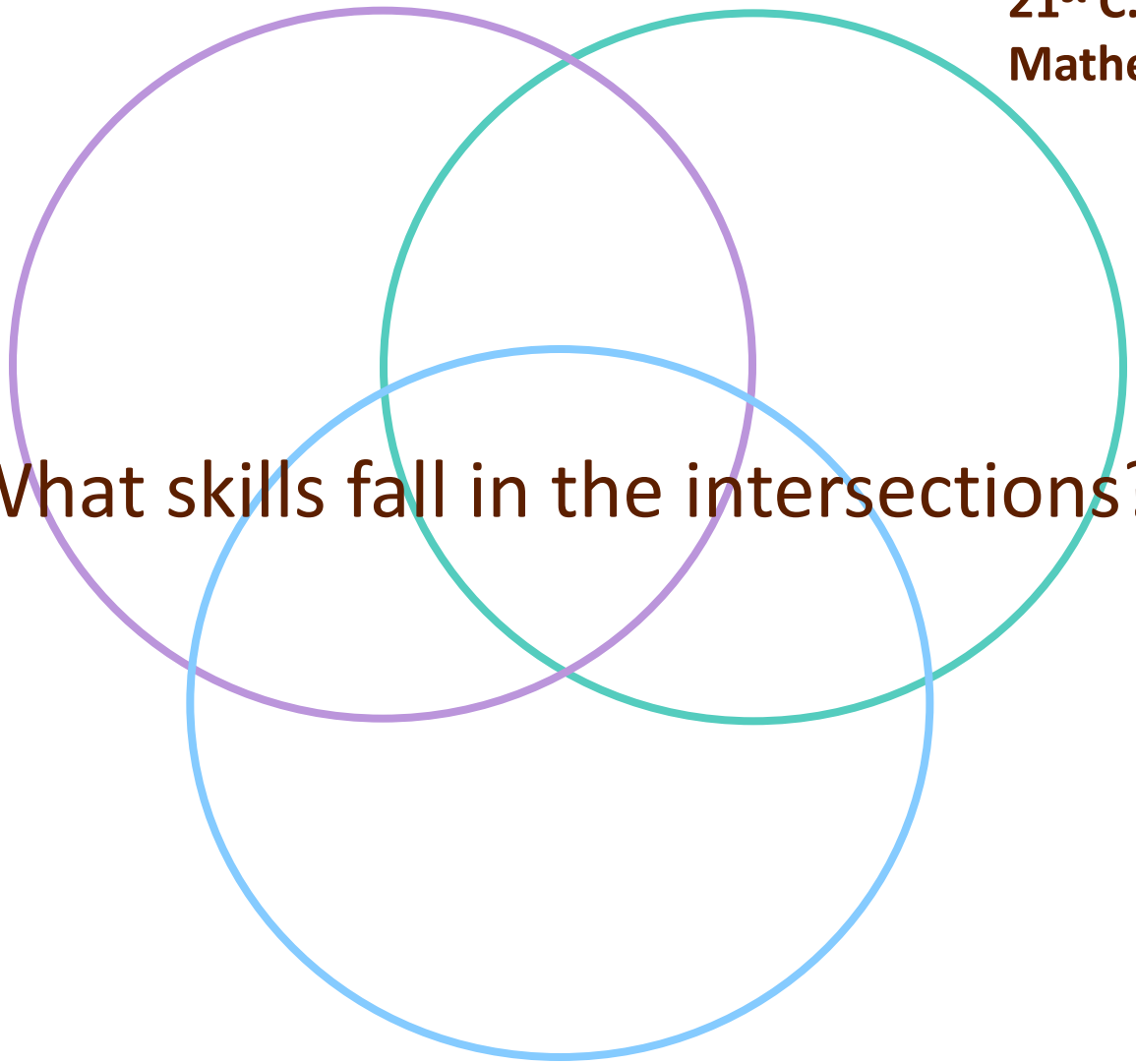
- Constructing & evaluating evidence-based arguments
- Non-routine problem solving
- Complex Communication I
  - Disciplinary discourse
  - Critical reading
- Critical thinking

Discipline-based Standards Documents Only

- Disciplinary Content of Literature (Saga of human experience)
- Conventions of written and oral language
- Literal Text Comprehension
- Rhetorical effectiveness

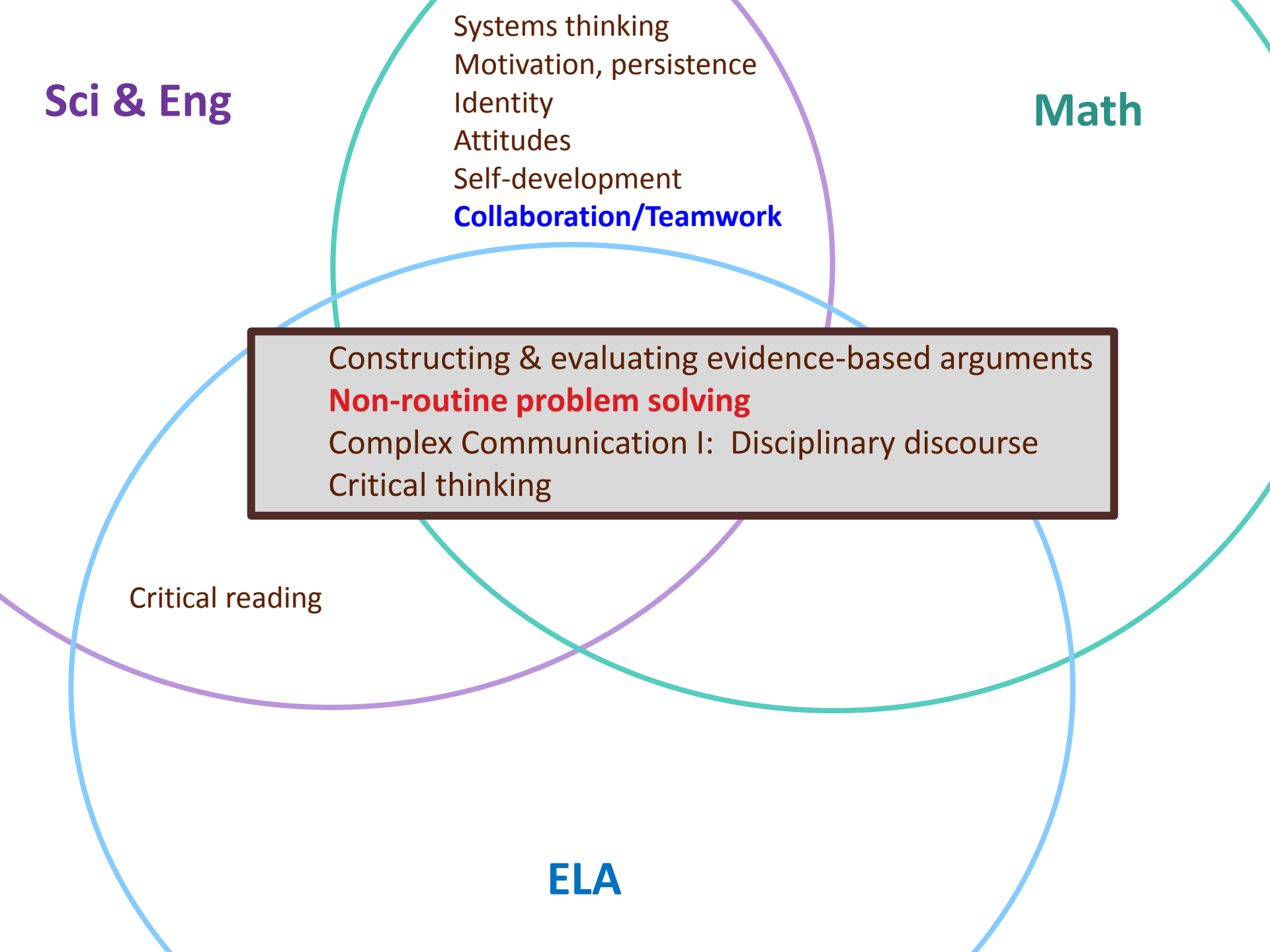
21st C. Skills in Science & Engineering

21st C. Skills in Mathematics



What skills fall in the intersections?

21st C. Skills in English Language Arts


Sci & Eng
Math
ELA
Systems thinking
Motivation, persistence
Identity
Attitudes
Self-development
Collaboration/Teamwork
Constructing & evaluating evidence-based arguments
Non-routine problem solving
Complex Communication I: Disciplinary discourse
Critical thinking
Critical reading

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Deeper Learning in the Disciplines

- Developing the full range of competencies within the disciplines will require additional instructional time and resources, beyond typical current practice.

- Deeper learning within each discipline aims to increase transfer within that discipline.

- Research is needed on whether, and to what extent, teaching for transfer within an academic discipline can facilitate transfer across disciplines.

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Instructional Challenges

- Teachers and administrators are often unfamiliar with the instructional principles that support deeper learning and teaching for transfer.
- Teacher preparation programs will need to help future teachers envision and enact new strategies to foster deeper learning.
- Teachers will need support from administrators and each other, along with ongoing, practice-based professional development.

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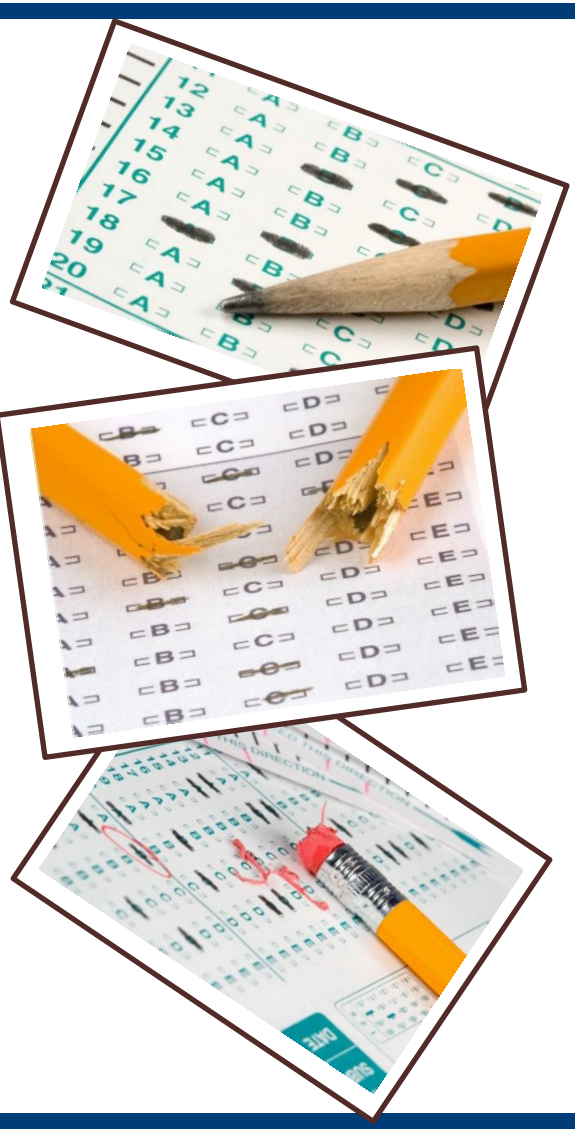
General Assessment Challenges

- Current educational policies and accountability systems often rely on standardized assessments that focus primarily on recall of facts and procedures.
- Such assessments are easily scored and quantified for accountability purposes but they are not optimal for assessing 21st century competencies.
- The extent to which the 21st century competencies articulated in frameworks and standards documents will be emphasized in the educational system depends on their inclusion in assessments.
- We lack valid, reliable measures of 21st century competencies, particularly in the intrapersonal and interpersonal domains.



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Defining and Assessing 21st Century Competencies: *Collaborative Problem Solving*

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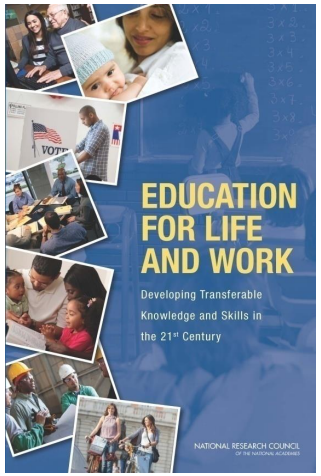

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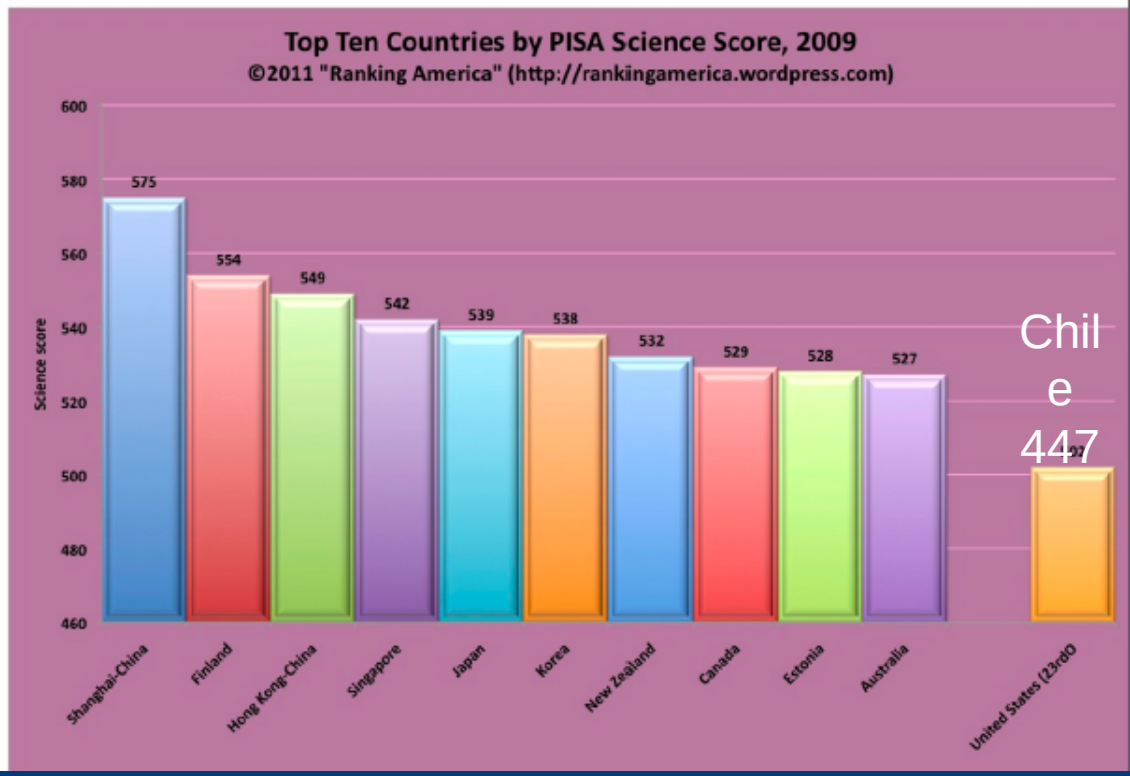
About PISA

- Programme for International Student Assessment (PISA)
  - Internationally standardized assessment run by Organisation for Economic Co-operation and Development (OECD).
  - Develop **framework and associated technologies for assessing** collaborative problem solving
- Assess **high school students** in countries around the globe
- Overall goal development of reliable indicators of **collaboration processes and problem solving outcomes**
  - Theoretically sound and scalable for reliable administrations.



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PISA's Framework for Problem Solving

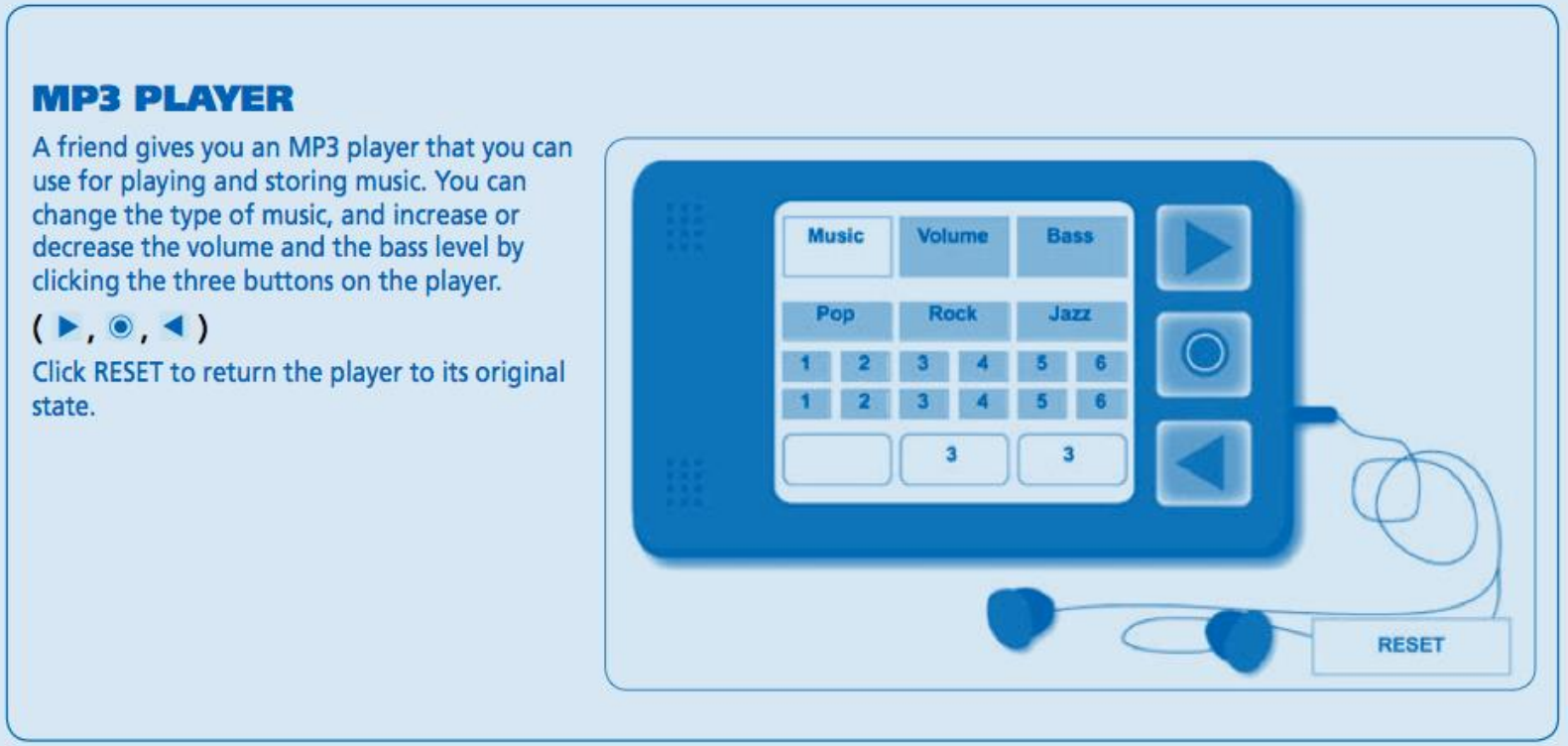
- Domain-General Description (and Assessment) of Four Broad Phases of the Problem Solving Process

1. **Exploring and Understanding**
2. **Representing and Formulating**
3. **Planning and Executing**
4. **Monitoring and Reflecting**

- Actual contexts used for problem solving in PISA are rather generic and don't rely on domain-specific knowledge and expertise -- "MicroDYN" systems and "finite-state automata"

■ Figure V.1.4 ■

MP3 PLAYER: Stimulus information



In the unit *MP3 PLAYER*, students are told that they have been given an MP3 player by a friend. They do not know how it works and must interact with it to find out, so the *nature of the problem situation* for each item in this unit is *interactive*. Since the focus of the unit is on discovering the rules that govern a device intended for use by an individual, the *context* of each item in the unit is *technology* and *personal*.

■ Figure V.1.7 ■

MP3 PLAYER: Item 3

Question 3: MP3 PLAYER *CP043Q01*

Shown below are four pictures of the MP3 player's screen. Three of the screens cannot happen if the MP3 player is working properly. The remaining screen shows the MP3 player when it is working properly.

Which screen shows the MP3 player working properly?

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Some Concerns About PISA Problem Solving

- What cognitive science tells us about problem solving and the challenge that poses as to PISA's definition and assessment
  - **General Problem Solving** – what you do when you lack domain knowledge – associated with "weak methods"
  - **Domain Specific Problem Solving** – what you do when you develop domain expertise – associated with "strong methods" based on schematic and strategic knowledge
  - Transfer is a **within-domain** phenomenon: teach for transfer
  - To what extent is PISA measuring "real problem solving"?
  - What will happen when they add collaboration to the situation?

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PISA Collaborative Problem Solving (1)

	(1) Establishing and maintaining shared understanding (knowledge flow/ resources)	(2) Taking appropriate action to solve the problem (task behaviour)	(3) Establishing and maintaining team organisation (organisation/mgmt)
(A) Exploring and Understanding	(A1) Discovering perspectives and abilities of team members	(A2) Discovering the type of interaction to solve the problem, along with goals	(A3) Understanding roles to solve problem
(B) Representing and Formulating	(B1) Building a shared representation and negotiating the meaning of the problem (common ground)	(B2) Identifying and describing tasks to be completed	(B3) Describe roles and team organisation (communication protocol/rules of engagement)

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PISA Collaborative Problem Solving (2)

	(1) Establishing and maintaining shared understanding (knowledge flow/ resources)	(2) Taking appropriate action to solve the problem (task behaviour)	(3) Establishing and maintaining team organisation (organisation/mgmt)
(C) Planning and Executing	(C1) Communicating with team members about the actions to be/ being performed	(C2) Enacting plans	(C3) Following rules of engagement, (e.g., prompting other team members to perform their tasks.)
(D) Monitoring and Reflecting	(D1) Monitoring and repairing the shared understanding	(D2) Monitoring results of actions and evaluating success in solving the problem	(D3) Monitoring, providing feedback and adapting the team organisation and roles

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PISA Collaborative Problem Solving (3)

- Collaborative problem solving will be measured via the use of computer based tasks
- Each student interacts with a “simulated collaborator” via an interactive chat box – follows a set of scripted moves.
- Scores will be reported at one of three general levels – below, at or above proficiency
- What will happen – we have to wait and see!
- But let’s consider an alternative perspective

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Defining Collaborative Problem Solving

"**Collaborative Problem Solving**" is a complex construct. How should it be broken out?

- **Collaboration** taken on its own implicates other competencies, such as communication, leadership, planning, and interpersonal adaptability.

- **Problem solving** taken on its own also implicates other competencies, such as critical thinking, persistence, self-regulation, and domain knowledge.

- Is **collaborative problem solving** meant to contrast with other kinds of problem solving (e.g., individual)?

- Is collaboration a means to improve problem solving or is **collaborative problem solving competence** an end in itself?

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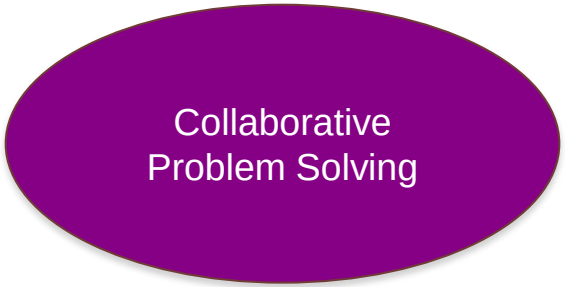
Defining Collaborative Problem Solving

- Is **Collaborative Problem Solving** the conjunction of two independent competencies?

- Or does **Collaborative Problem Solving** have unique emergent properties?



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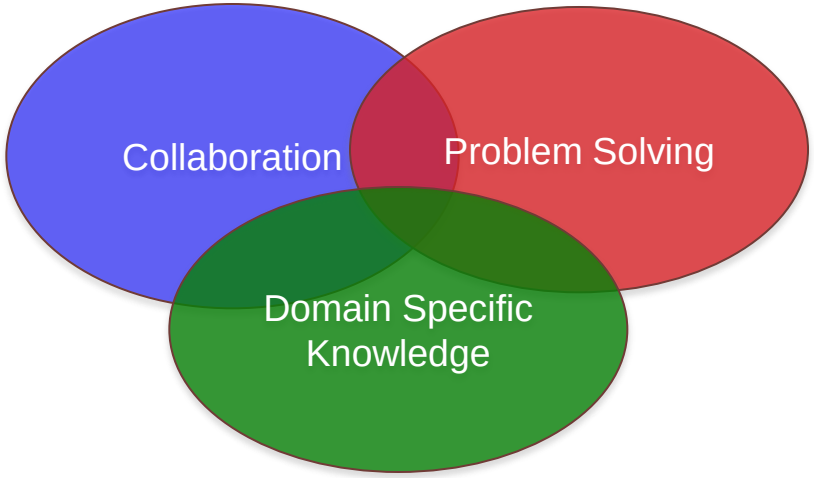
Defining Collaborative Problem Solving

- If problem solving inherently entails domain specific knowledge, does **Collaborative Problem Solving** necessarily inherit that as well?



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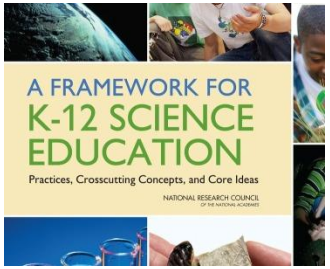
Collaboration & Problem Solving in and across the Disciplines

- A cluster of cognitive competencies – including **non-routine problem solving** – is strongly supported across all three disciplines.



- Emphasis on "**non-routine**" **problem solving** places a premium on domain specific knowledge that can support transfer and strong problem solving methods

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- However, problem solving has distinctly different expressions in different disciplines.

- Collaboration is treated more variably.

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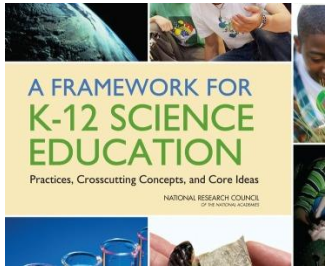
Problem Solving in and across Disciplines

- What counts as a problem, what counts as a solution, and the standards used to evaluate potential solutions look quite different across disciplines



- Closely related to disciplinary variations in standards of evidence and argument and norms for discourse

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- Science "practices" are the most developed treatment among the Standards documents.

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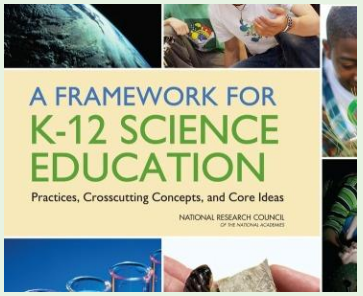
Example: NGSS Practices

PRACTICES FOR K-12 SCIENCE CLASSROOMS

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information



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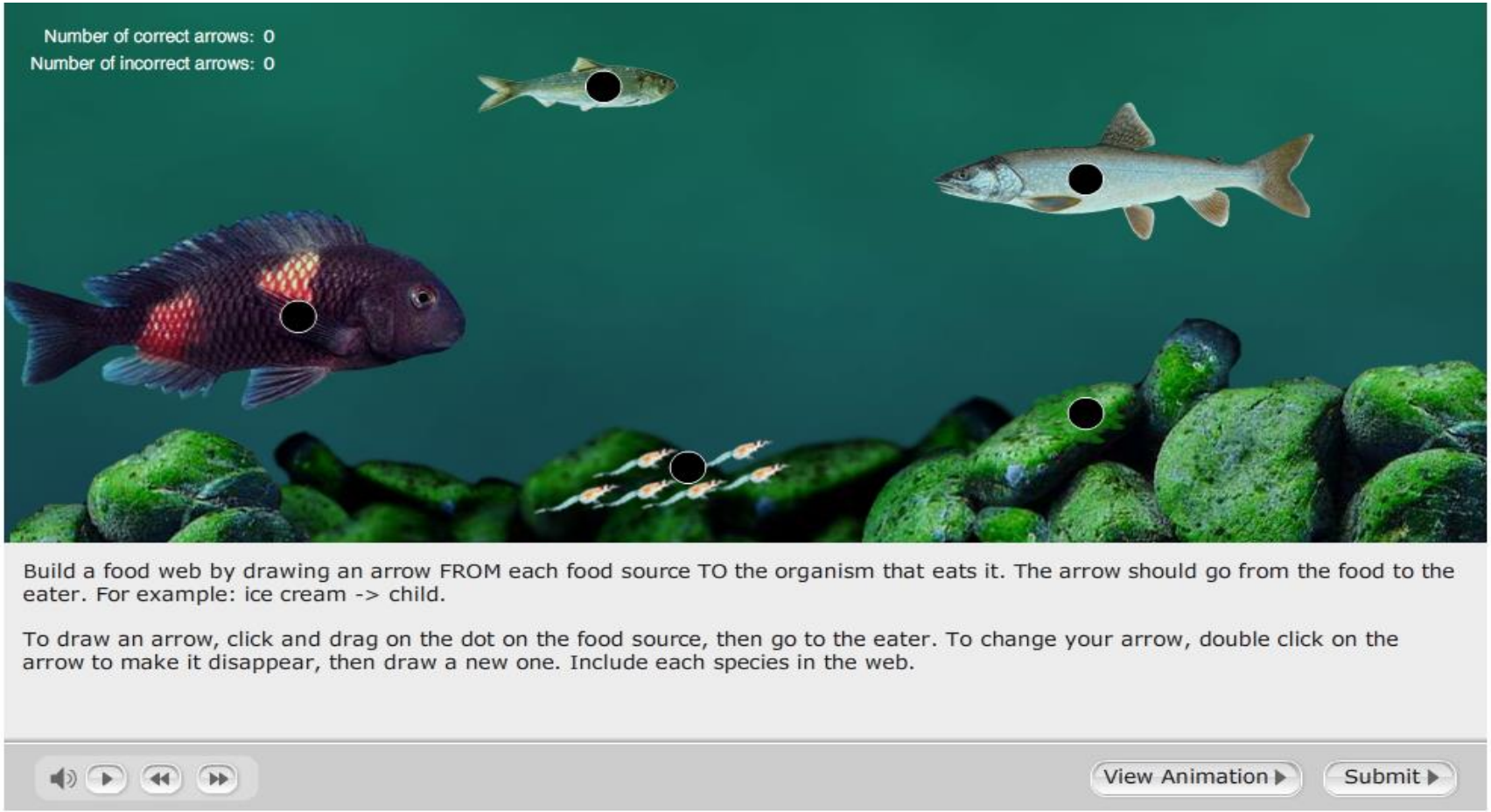
Science Learning & Problem Solving: Life Science Simulation

Students
- view animation to observe relationships among organisms
- draw food web illustrating those relationships.



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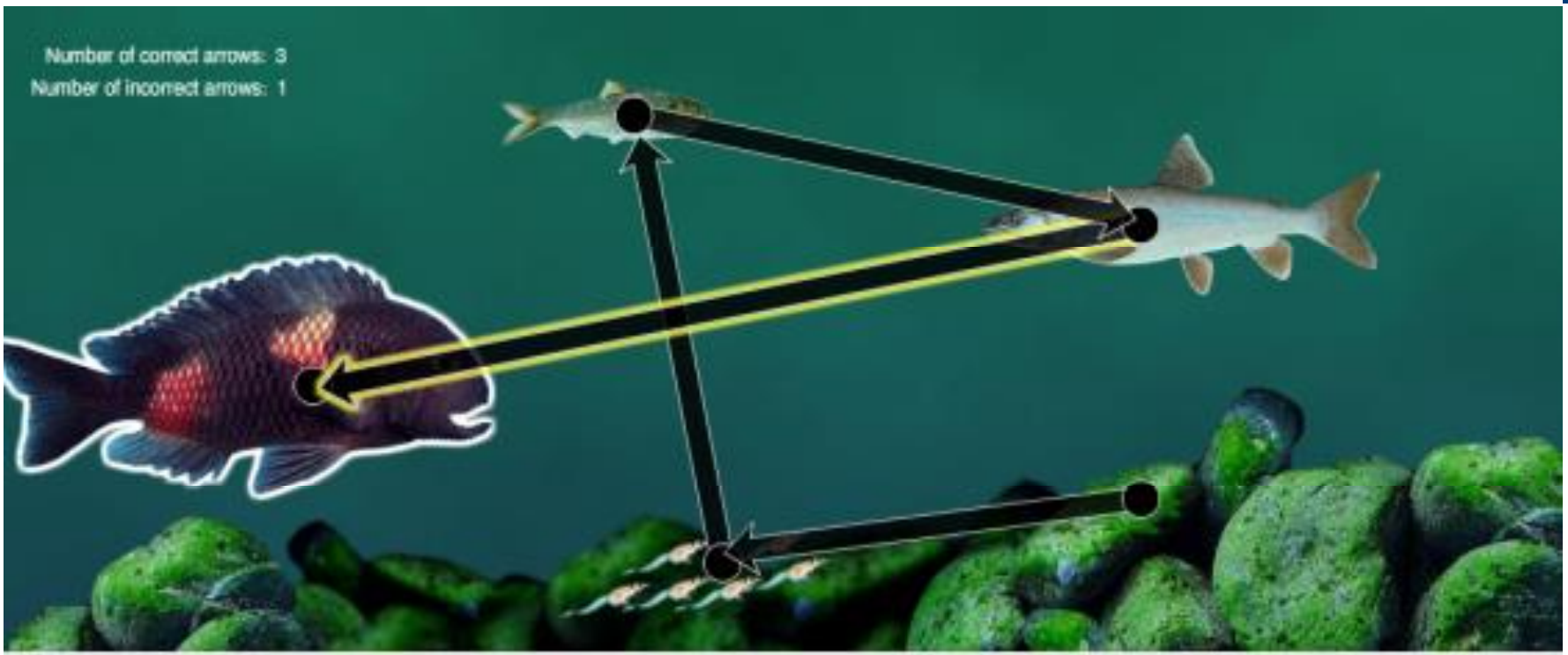
Science Learning & Problem Solving: Life Science Simulation



Build a food web by drawing arrows. Each arrow should show the transfer of matter between organisms. Be sure to include each species in the food web.

Click on the dot and drag it to draw an arrow. To change an arrow, double click on the arrow to make it disappear, then draw a new one.

View Animation ▶ Submit ▶

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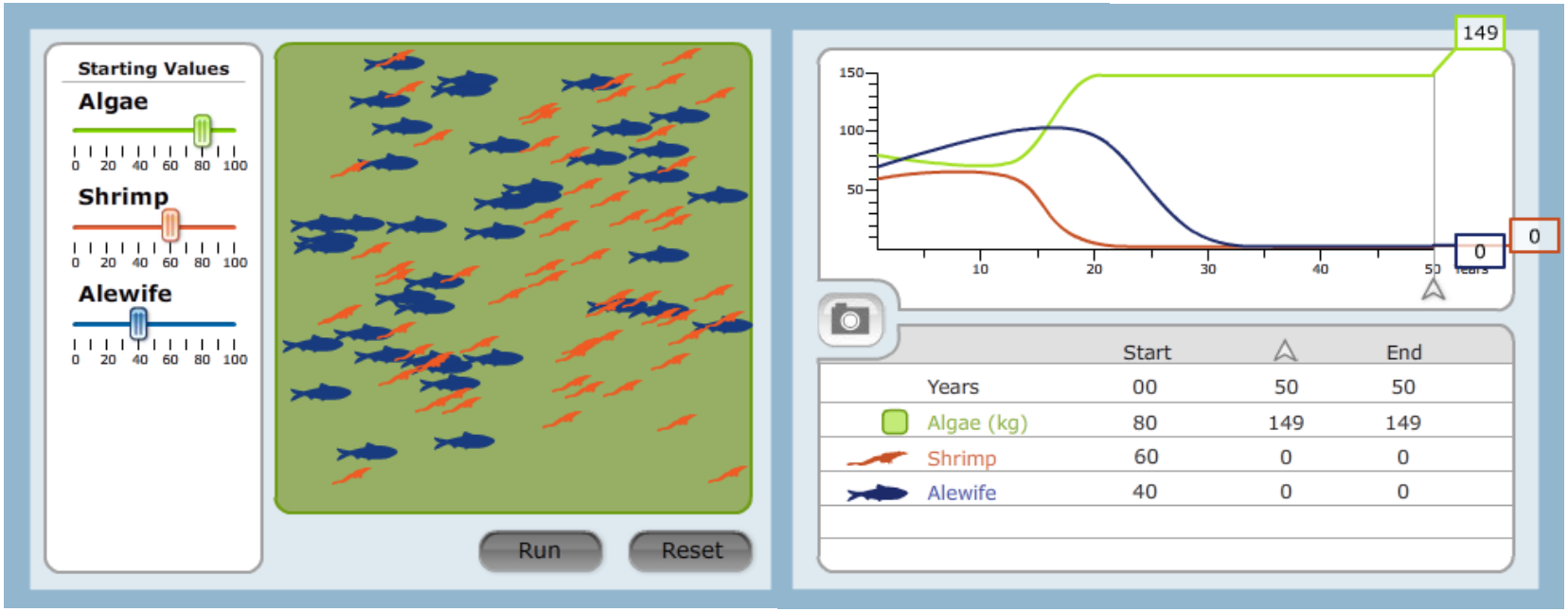
Science Learning & Problem Solving: Life Science Simulation



In the experiment that you just analyzed, the amount of alewife was set to 20 at the beginning.

Another student hypothesized that the result might be very different if she started with a larger or smaller amount of alewife at the beginning.

Run three experiments to test that hypothesis. At the end of each experiment record your data by taking pictures of the resulting graphs.

After three runs, you will be shown your results and asked if it makes any difference if the beginning amount of alewife is larger or smaller than 20.

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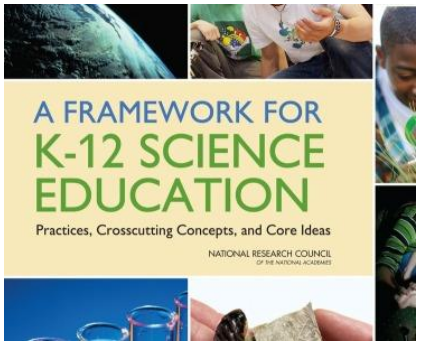
Collaboration in NGSS Practices

- **Engaging in Argument from Evidence:** Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated.
- **Obtaining, Evaluating & Communicating Information:** Science cannot advance if scientists are unable to communicate their findings clearly and persuasively or to learn about the findings of others. A major practice of science is thus the communication of ideas and the results of inquiry—orally, in writing, with the use of tables, diagrams, graphs, and equations, and by engaging in extended discussions with scientific peers.



Framework, pp. 52, 53

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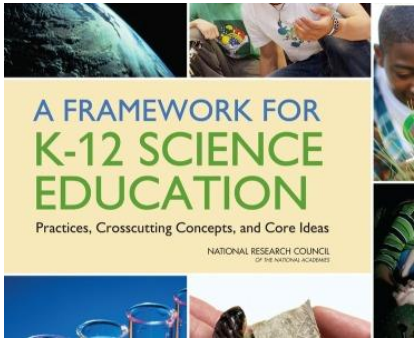
Collaboration and Community in and across the Disciplines

- Complex Communication (close kin to collaboration) split into disciplinary discourse norms vs. interpersonal communication, with the former more emphasized in standards documents.



- At what level is a collaborating group defined in a discipline?
  - Could be a working group in a classroom
  - Could be the "scientific community" – much more extended in time and space

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- Collaboration as a form of pedagogy

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Resolving Some PISA-Related Conundrums About PS & CPS

- Why did countries who do well on the PISA math, science and reading assessments also generally do well on the 2012 Problem Solving assessment?
- What will happen on the 2015 PISA Collaborative Problem Solving assessment?
- **Hypothesis:** PISA Problem Solving performance and Collaborative Problem Solving performance may be reflecting high quality Domain Specific instruction that develops these and other competencies within specific disciplines
- Should countries run out and develop Collaborative Problem Solving Curricula?
- I and others don't think so – problem solving and collaboration should be part of regular disciplinary instruction

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Today's Presentation

- 21st Century Skills – What are they? Why so much interest?
- Making sense of a crowded field: Relevant background ideas about the domain
  - derived from the work of a United States National Research Council Committee
- An example of the conceptual, practical & interpretive challenges: OECD's PISA Program and assessment of problem solving (2012) and collaborative problem solving (2015).
- What are some of the implications of this collective work for education and educators?

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End of the Day Conclusions

- 21st Century demands multiple competencies
- They are important for success in school, work and adult life
- They can be developed in instructional settings that highlight the combination and integration of deep disciplinary principles and practices
- There are specific disciplinary and general instructional design principles to guide the work
- Much of what is required will involve the transformation of teacher knowledge and practice
- Transformation of educational systems and priorities will also be needed
- Design of high quality and valid assessments is key

gracias por su atención