Successful K-12 STEM Education & Education for Life and Work

Some Critical Connections and Implications

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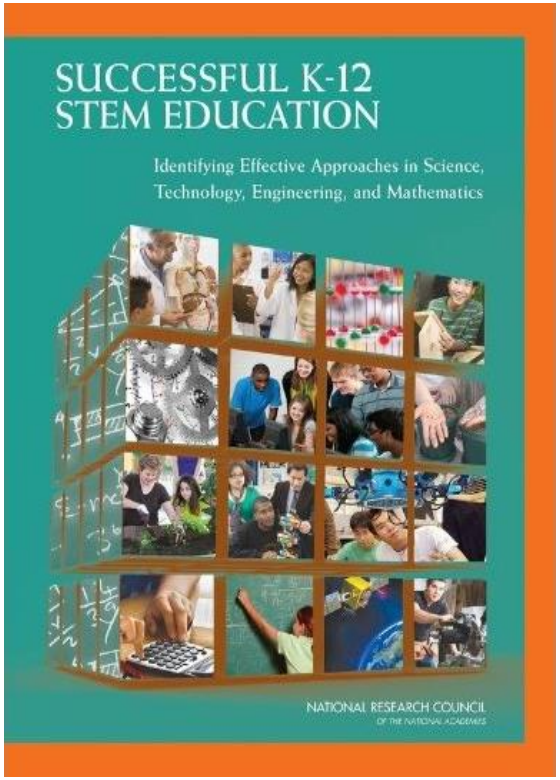
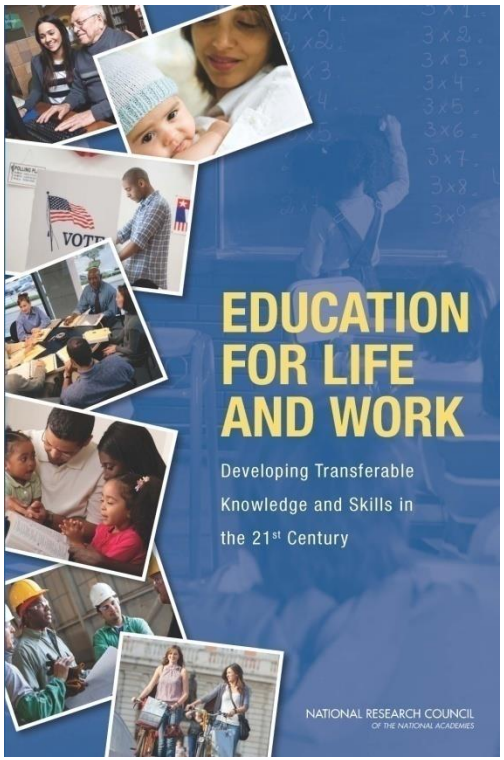
Successful K-12 STEM Education:
Identifying Effective Approaches in Science, Technology, Engineering and Mathematics



Committee on Highly Successful Schools or Programs for K-12 STEM Education

Division of Behavioral and Social Sciences and Education
National Research Council

Education for Life and Work:
Developing Transferable Knowledge and Skills in the 21st Century



Committee on Defining Deeper Learning and 21st Century Skills

Division of Behavioral and Social Sciences and Education
National Research Council

Education for Life & Work: Topics & Issues

- Study Background Information
- Defining & Clarifying Key Terms
- Domains of Competency
- Evidence of Importance
- Deeper Learning in the Disciplines
- Teaching for Transfer: Instructional Design Principles
- Assessment Challenges
- Instructional Challenges
- Implications & Recommendations

Study Sponsors

- Carnegie Corporation of New York
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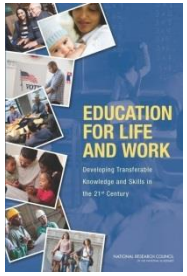
Study Context

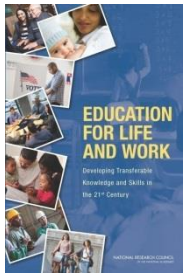
- Education is a shared endeavor, including schools, teachers, nonprofit groups, informal learning institutions, taxpayers, parents, and the students themselves.
- Business and educational leaders are asking this shared endeavor to infuse development of "21st century skills" such as problem solving, 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 NRC…..

* Examples of the labels



Committee Charge

- Define the set of key skills referred to as "deeper learning," "21st century skills," and by other labels
- Describe how the skills relate to each other and to the learning of reading, mathematics, and science and engineering
- Review research on their importance for positive adult outcomes
- Discuss how to teach and assess them
- Identify features of interventions that develop them



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 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.

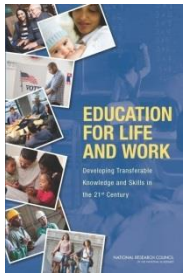
Three Domains of Competence*

- Cognitive: reasoning and memory
- Intrapersonal: self-management
- Interpersonal: expressing ideas and interpreting and responding to others' messages

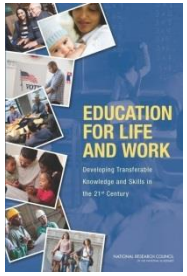
* Sources drawn upon for the analysis & synthesis

Three Domains of Competence

- The **Cognitive Domain** includes three clusters of competencies:
  - cognitive processes and strategies
  - knowledge
  - creativity
    - These clusters include competencies such as critical thinking, 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.



The 3 domains are intertwined



Evidence of Importance

- The available research linking specific competencies with adult outcomes evidence is limited and primarily correlational in nature.
- Cognitive competencies show positive correlations (of modest size) with desirable educational, career, and health outcomes.
- In the interpersonal and intrapersonal domains, conscientiousness is most highly correlated with desirable outcomes, while anti-social behavior is negatively correlated with them.
- Years of schooling strongly predicts adult earnings, perhaps because students develop a mix of cognitive, interpersonal and intrapersonal competencies. Therefore, increasing educational attainment may be a useful complementary strategy for developing 21st century competencies.

COMMON CORE STATE STANDARDS FOR

Mathematics

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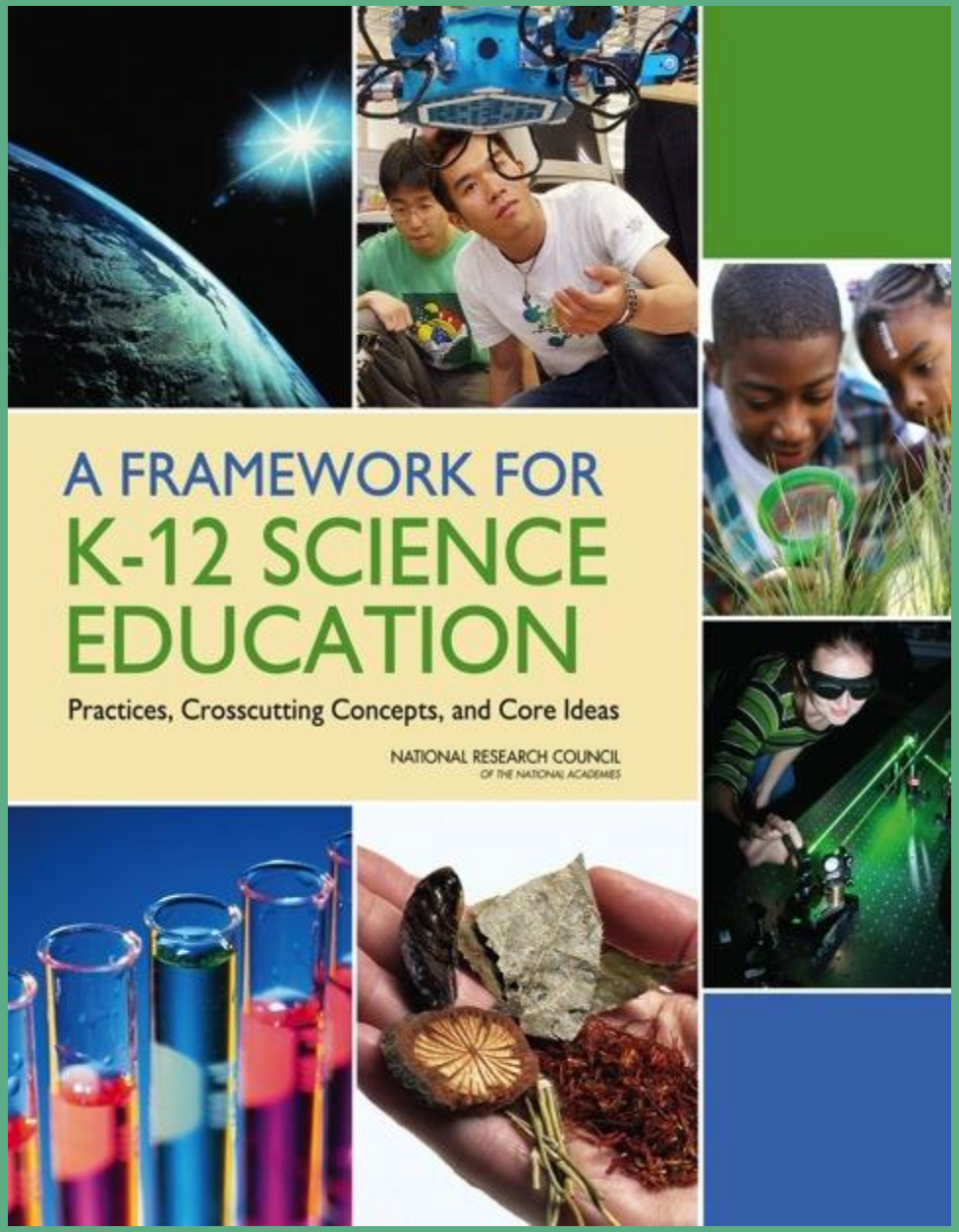


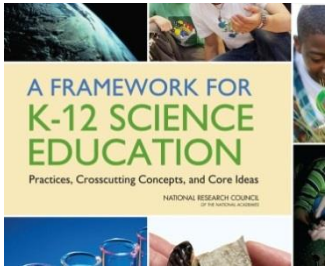
New Definitions of Competence

- Both the CCSS for Mathematics and the NRC Science Framework have proposed descriptions of student competence as being the intersection of knowledge involving:
  - **important disciplinary practices** and
  - **core disciplinary ideas,** with
  - **performance expectations** representing the intersection of core content and practices.

- Both view competence as something that develops over time & increases in sophistication and power as the product of coherent curriculum & instruction

Deeper Learning in the Disciplines

- The math and English CCSS and the NRC Science Framework 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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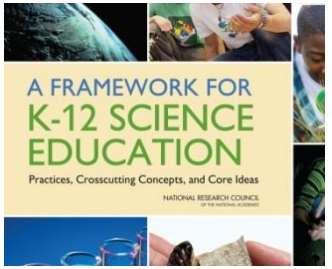
- However, competencies such as constructing arguments with evidence, oral and written discourse, and non-routine problem-solving have distinctly different expressions in different disciplines.

Deeper Learning in the Disciplines

- Coverage of competencies in the intrapersonal and interpersonal domains is uneven.
- Where standards documents do not explicitly overlap with 21st century competencies, there is little evidence of conflict between them.



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Mathematics

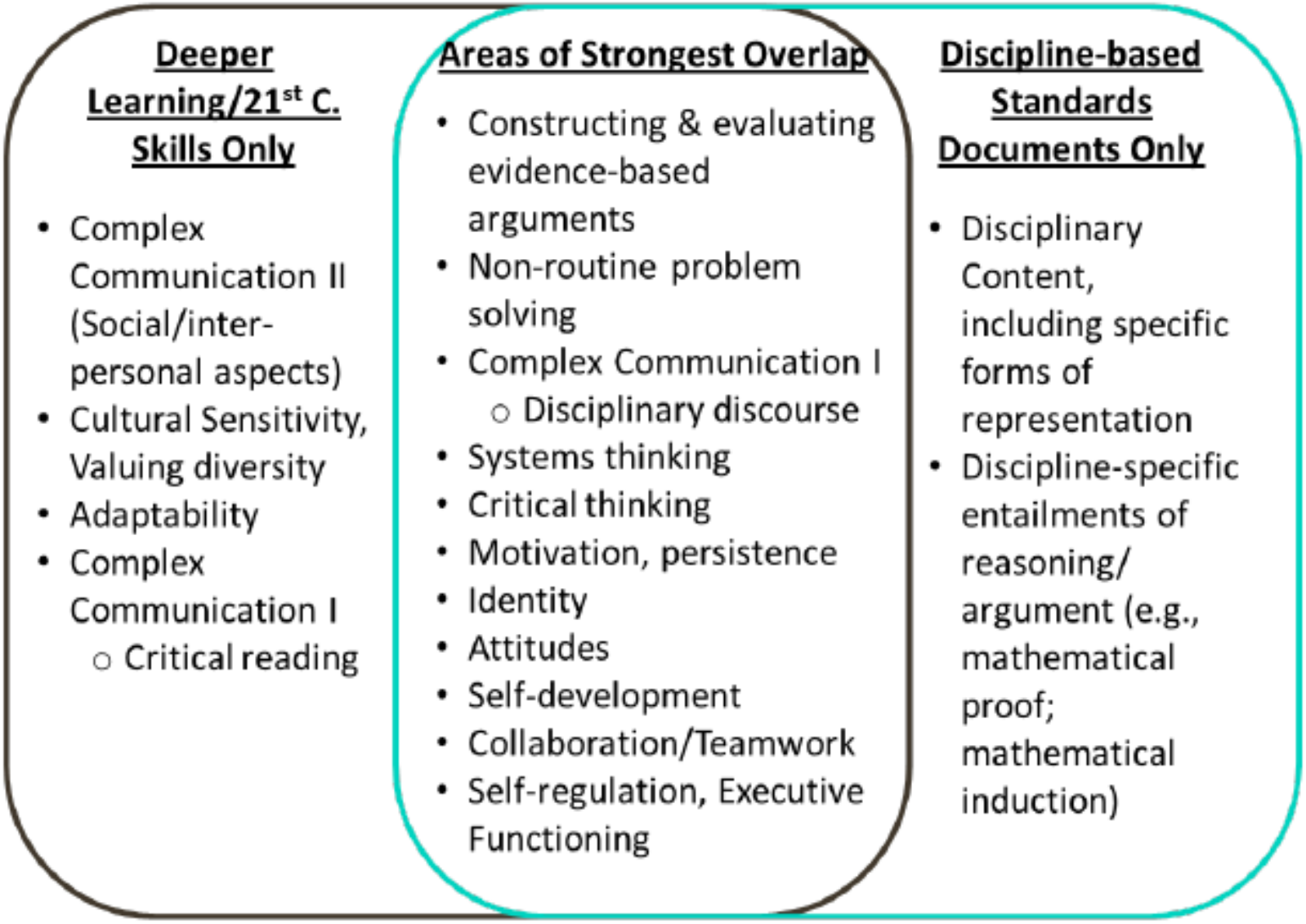


FIGURE 5–2 Overlap between CCSS math standards and 21st century skills.

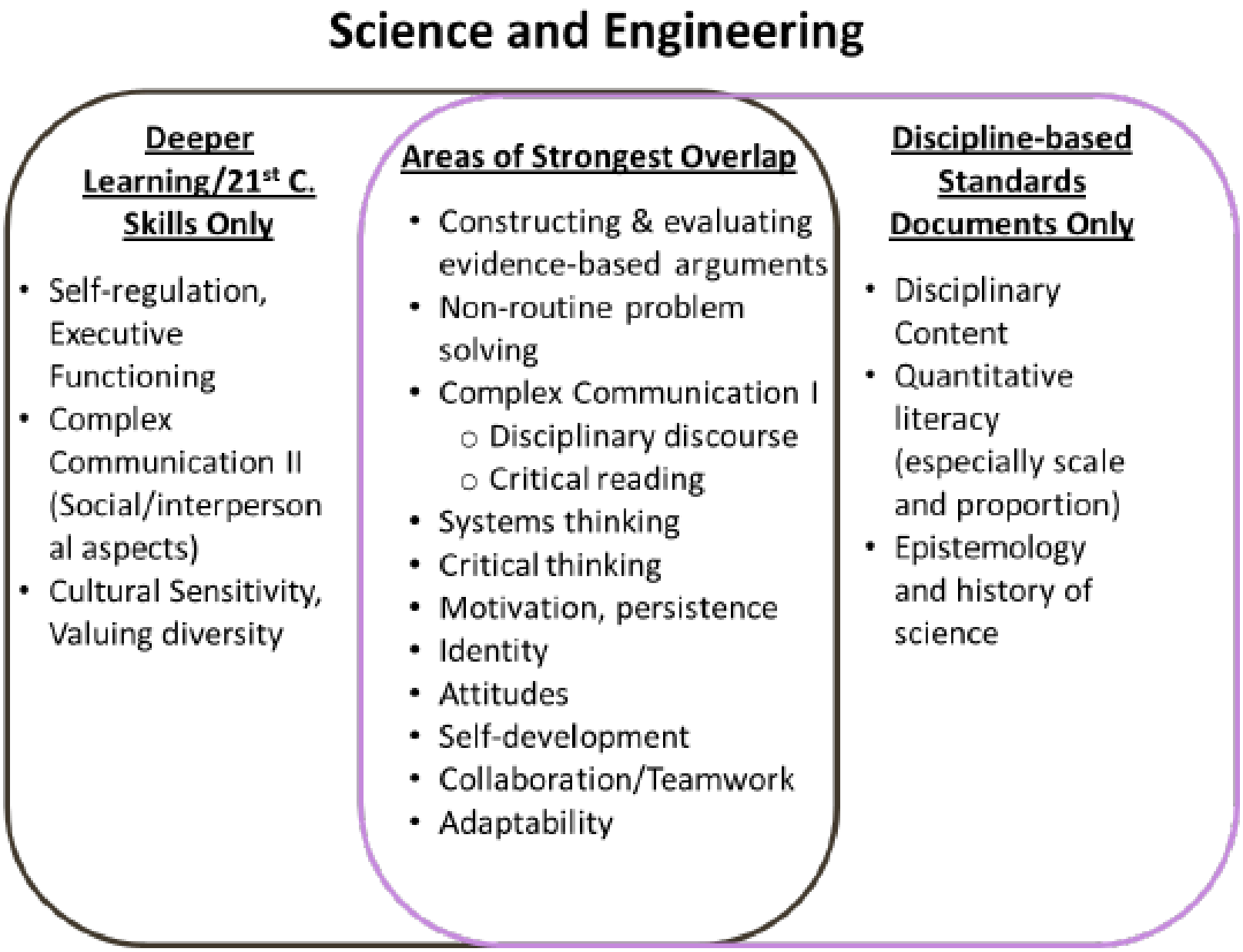
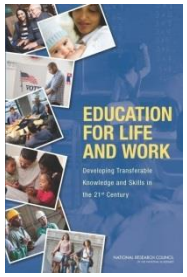


FIGURE 5–3 Overlap between science standards framework and twenty-first century skills.



Deeper Learning in the Disciplines (cont)

- 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.

Teaching for Transfer

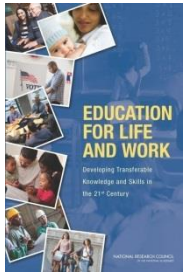
- Emerging evidence indicates that cognitive, intrapersonal and interpersonal competencies can be taught and learned in ways that promote effective transfer.

Transfer is supported when:

- Learners understand general principles, as emphasized in the CCSS and NRC Science Framework.
- 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.

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.

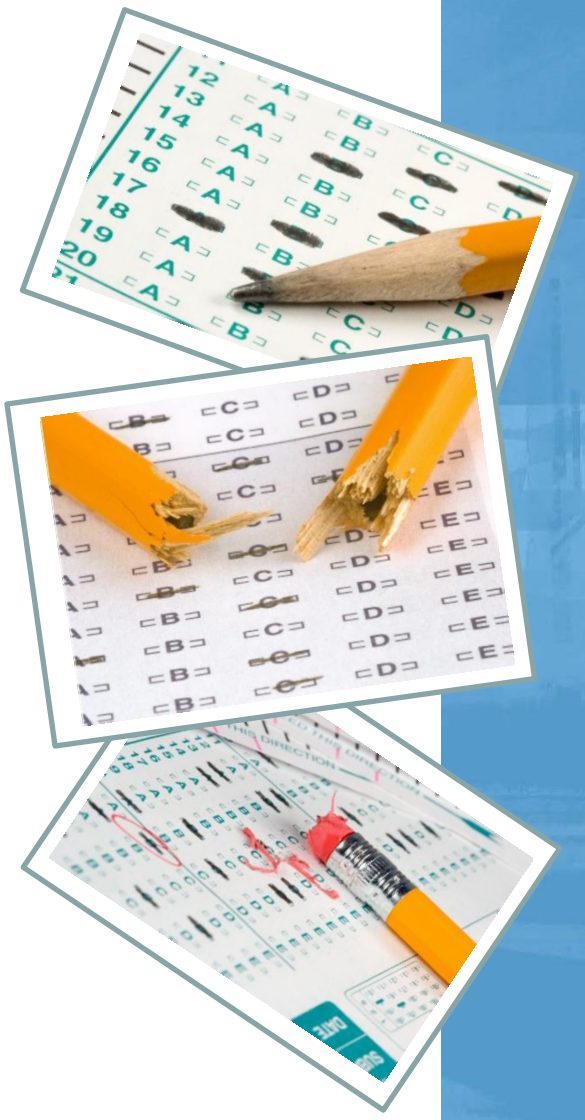


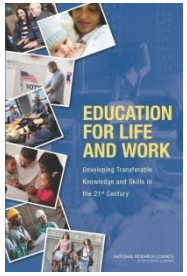
Applicability of Design Principles across domains

- The instructional principles just shown are based on extensive research on learning in the cognitive domain.
- They could plausibly be applied to design instruction that would support the acquisition of transferable interpersonal and intrapersonal competences.

Assessment Challenges

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





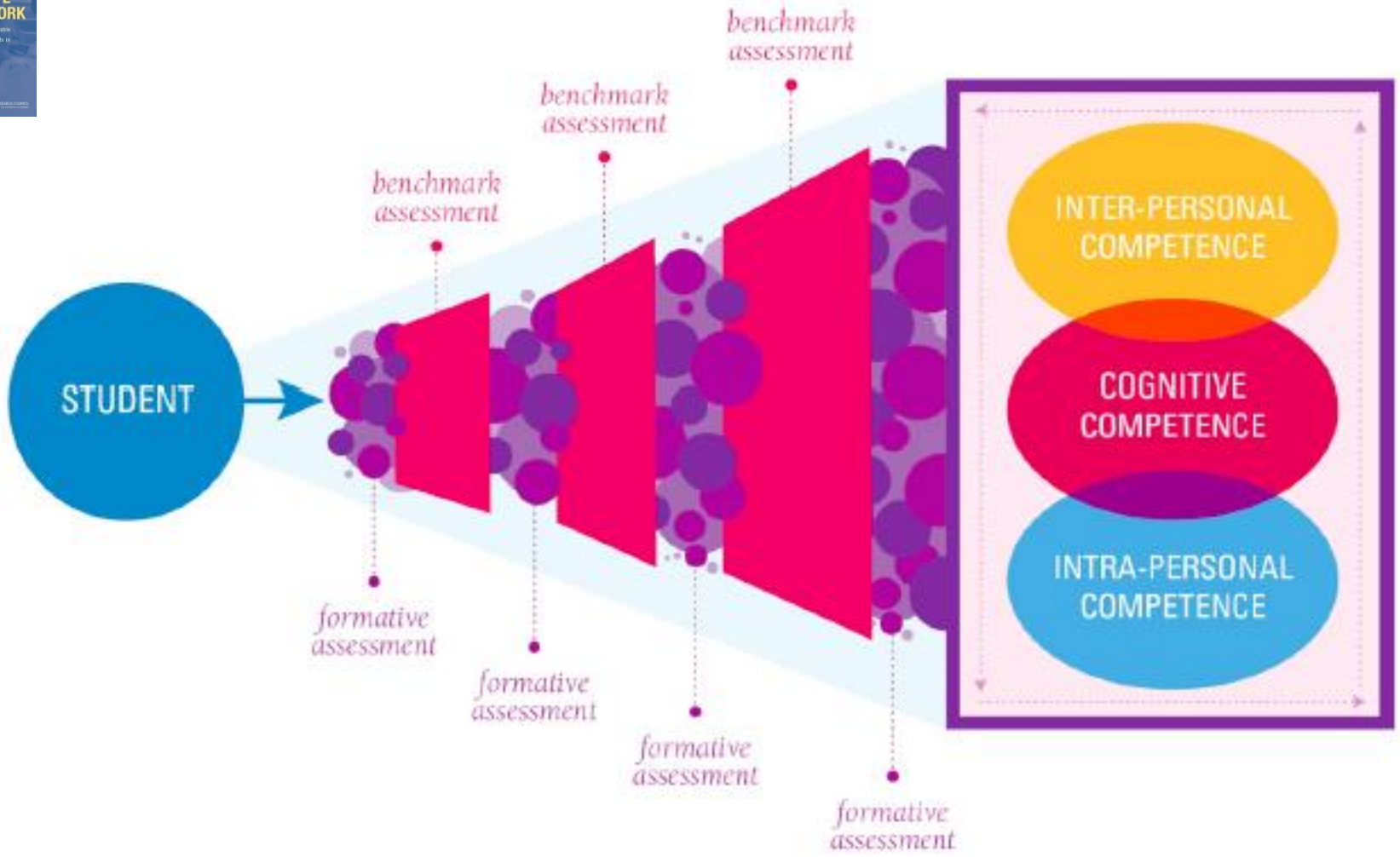
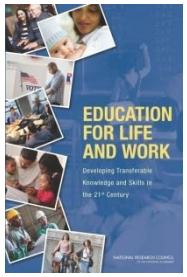


FIGURE 6–2 A coherent assessment system.
SOURCE: Adapted from Herman (2010a).



Instructional Challenges

- Teachers and administrators are often unfamiliar with the instructional principles that support 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.

Implications & Recommendations

Curriculum & Instruction

- Curriculum and instructional programs are needed that include research-based teaching methods to help students develop transferable knowledge and skills.

- Policymakers should support the development and use of curricula that foster instructional techniques that focus on the process of thinking rather than only the products.

Implications & Recommendations

Assessment

- The extent to which teachers will focus on helping students develop 21st century competencies will be strongly influenced by the degree to which these competencies are included in district, state, and national assessments.

- Currently, educational policies and accountability systems rely on assessments that emphasize recall of facts and procedures, posing a challenge to wider teaching and learning of 21st century competencies.

Implications & Recommendations

Assessment

- With the support of the U.S. Department of Education, two large consortia of states are developing new assessments aligned with the Common Core State Standards.

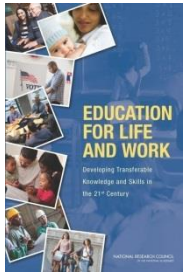
- Through these consortia, states should work to ensure that these assessments – as well as those eventually developed based on new science standards – include tasks that call upon facets of 21st century competencies as applied in each major content area.

Implications & Recommendations

Teacher Education

- New approaches to teacher preparation and professional development will be needed to help current and prospective teachers understand how to teach for deeper learning, as well as the role of deeper learning and 21st century competencies in helping students master core academic content.

- Currently, the instructional practices described in the Report and that characterize successful STEM education are rarely reflected in the knowledge and practices of teachers and school administrators.



Implications & Recommendations

Research

- Foundations and federal research agencies should support studies to fill research gaps on teaching and learning for transfer. In particular, research is needed to:
  - increase our understanding of the relationships between 21st century competencies and adult outcomes;
  - shed light on how to design instruction to help students develop transferable knowledge and skills in the interpersonal and intrapersonal domains; and
  - determine whether and to what extent knowledge and skills developed in one discipline or subject area can transfer to another.