Linking Science and Reading Across Grades 3-8: Strategies and Results

Nancy Romance, Florida Atlantic University
Michael Vitale, East Carolina University

NSF/IERI Research Project (REC-0228353)

12th Annual Literacy Symposium
University of Central Florida, Orlando, FL
April 2, 2010
Setting the Context...

1. National achievement trends in reading and science
2. Overview of Science IDEAS Model
3. Research evidence in support of the effect of the Science IDEAS Model on reading comprehension
4. Theoretical underpinnings supporting an interdisciplinary approach to reading comprehension through science
5. Science IDEAS 3-part reading comprehension strategy
   a. Overview of the strategy
   b. Application to reading comprehension
   c. Research findings: Grades 3-5 and transfer to Grades 6-7
6. Benefits resulting from grade-articulated, school-wide implementation
7. Potential policy implications for reading comprehension
Linking Trends in Reading Comprehension and Science

- **Assessment Perspectives Relating to Reading Comprehension Reform**
  - NAEP (reading, science)
  - TIMSS (science)
  - PISA (reading, science)

- **Implications of Reductions in K-5 Content-Area Instruction for Reading Comprehension**
  - Reduced time allocated for content areas - Science, Social Studies
  - Instructional perspectives re: Time-to-Learn (e.g., Clark & Linn, 2003)
    - Instructional time - provides foundation for learning (allocated time, rate of engagement, successful learning experiences)
    - Amount of Instructional time affects cumulative conceptual learning
    - Cumulative conceptual learning affects comprehension (and reading comprehension)
6 Instructional Elements of the Science IDEAS Model

– **Prior Knowledge/Cumulative Review**: Process for accessing and/or representing prior curricular knowledge and relevant experiences to support cumulative learning

– **Hands-on Science**: Guided/open-ended inquiry; concept verification

– **Reading Comprehension**: Strategy for guiding student reading of informational text using multiple non-fiction sources on the same and related topics to engender deep understanding (comprehension)

– **Propositional Concept Mapping**: Strategy for accessing, organizing and representing knowledge for teachers and students

– **Writing and Journaling**: Strategy for guiding students to represent their own understanding/thinking and questions, and for note-taking

– **Application Tasks**: Expansion tasks that engage student in learning more about what they are learning
First-Hand Investigations

Linking observations with ability to reason with evidence…

Students are constructing a density column
Conceptually-Oriented Hands-On Activities

First-Hand Investigations: Building/Amplifying Prior Knowledge

Student actively engaged in motivating hands-on science activities with emphasis on Matter and Energy
Students collect and analyze data and record their observations (meaningful writing about science)

Discussions help to extend, re-organize and summarize information garnered from multiple sources
Demonstrating Science Concepts

Observing and describing scientific phenomena through classroom demonstrations and/or individual student investigations – students are observing a model of a convection cell.
Science journals provide a rich context for student self explanation – what has happened and why….

Students can record ideas and questions and link to concepts being learned.

Students use journals all year
Science IDEAS Elements: Student Journals

Student generated Concept Maps

Descriptive illustrations: What things are? What they are used for?
Multiple Formats for Writing to Learn

- Journaling
- Note-Taking
- Recording and posting data and observations
- Reporting and displaying evidence of student work

Anchoring Activities and Discussion
Visually representing concept relationships....

(e.g., linking phases of matter with kinetic / thermal energy)
Communicating in science can begin in primary (K-2) with models students construct.
Visual Displays – Multimodal Approach

Linking graphic displays with reading and writing in grades 2-3

- Solar system
- Phases of moon
- Students research across multiple sources as they learn expository writing
• Classroom libraries
• Leveled readers that accompany science text series
• Class sets of trade books – such as:
  • National Geographic
  • Delta Science Readers
  • Ranger Rick Series
  • Lerner
  • Scholastic

Second-Hand Investigations: Supports Inquiry and Deepens Understanding
Reading Multiple Sources on a Topic – Building Additional Background Knowledge

Conceptual Development Emphasis: Learning more about what is already known broadens and deepens knowledge…

For each major unit/topic area - students read up to 10 sources on a specific or related topic…

Teachers use Reading Comprehension Strategy – applying it to all text-based materials

30 Ways to Share a Non-Fiction Book
Constructing Propositional Curriculum Concept Maps

Classroom teachers use grade level planning time to construct conceptually-organized curriculum maps for instruction.

Teachers realized the potential of using multiple sources.
Planning Multi-Day, Integrated Lessons

CURRICULUM CONCEPT MAP FOR FACTORS THAT EFFECT WATER EVAPORATION

Water Evaporation

- Phase of Matter Change Process
  - Liquid Changing to a Gas
    - Water as the Liquid
    - Water Vapor as the Gas

- Morning Dew Disappearing,
  - Damp Cloth Drying,
  - Heated Water Disappearing From a Pot,
  - Wet Sidewalk Drying

- Faster or Slower Rate
  - Combined Effects of 3 Different Factors
    - More Heat-Speeds Evaporation
    - More Surface Area-Speeds Evaporation
    - More Air Flow-Speeds Evaporation
CURRICULUM CONCEPT MAP FOR FACTORS THAT EFFECT WATER EVAPORATION

Water Evaporation
- Activity 12 - Reflection
- Activity 7 - Reading
- Activity 13 - Add. Reading

Involves examples can occur at

Activity 1 - Prior Knowledge
Activity 2 - Real Examples

Phase of Matter Change Process
- Liquid Changing to a Gas

- Water as the Liquid
- Water Vapor as the Gas

Morning Dew Disappearing,
- Damp Cloth Drying,
- Heated Water Disappearing
- From a Pot,
- Wet Sidewalk Drying

Activity 10 - Application

Activity 6 - Journaling
Activity 11 Prob. Solv.
Activity 8 - Concept Map
Activity 9 - Writing

Faster or Slower Rate
Depends upon Combined Effects of 3 Different Factors

- More Heat-Speeds Evaporation
- More Surface Area-Speeds Evaporation
- More Air Flow-Speeds Evaporation

Activity 3 - Demonstration
Activity 4 - Hands-On Act.

Copyright 2002 by Michael R. Vitale and Nancy R. Romance
Grade 2 Classroom: Organizing Concepts for Meaningful learning and Review

- Teacher creates maps to help students visualize how concepts are related
- Maps are displayed and/or referred to continuously
Propositional Concept Maps: Situates Learning in Terms of Concept Relationships

Teacher Use
1. Planning a unit of study
2. Blueprint for instruction
3. Assessment

Student Use
1. Studying
2. Writing
3. Comprehension
Student Construction of Concept Maps

• Model concept mapping several times

• Begin student concept mapping by reviewing materials that have just been learned

• Guide student construction of maps in the process of comprehension
– Classroom Level

• Designated uninterrupted block of time allows for
  – Hands-on inquiry lessons (first-hand investigations)
  – Notebooks/Journaling, writing explanations
  – Reading using multiple sources on the topic
  – Constructing propositional concept maps
• Students maintain science journals across entire year
• Classroom libraries include science texts, non-fiction books and leveled readers
• Evidence of student work on walls and in hallways illustrating expository writing in science
• Related narrative non-fiction used (e.g., weather unit – Cloudy with a Chance of Meatballs; Night of the Twister) used along with content based trade books
Implementation Guidelines...

- **School Level- Science IDEAS**
  - Principal creates a master schedule ensuring fidelity to time requirements
  - Principal organizes (and facilitates) grade level planning for each new reading/science 9-week curriculum unit
  - Principal monitors teacher fidelity of implementation re: reading in science
  - Principal uses reading science as a context for learning team meetings [LTM], for school newsletter, for parent events (e.g., Parent Science Night)
  - Principal includes reading in science as part of the School Improvement Plan

- **School Level- Reading in Literature**
  - Principal schedules ½ hour daily for reading in literature
Science IDEAS: Patterns of Research Evidence

• Research Findings: 1992-2001

Science IDEAS: Multi-Year Findings (MAT Science)

Note-- Year 1 students = grade 4; average/above average
Year 2 students = grade 4; average/above average
Year 3 students = grades 4,5; at-risk
Year 4 students = grades 4,5; average/above average/at-risk
Science IDEAS: Patterns of Research Evidence


Science IDEAS: Multi-Year Findings (ITBS/SAT Reading)

Note--
Year 1 students = grade 4; average/above average
Year 2 students = grade 4; average/above average
Year 3 students = grades 4,5; at-risk
Year 4 students = grades 4,5; average/above average/at-risk
Science IDEAS – A Research Overview – NSF/IÉRI Funded Project
2003-2007
Patterns of Research Evidence for Science IDEAS Model: Grades 3-8

  - Grades 3 - 8: Student achievement in Reading
  - 2006-2007 ITBS Achievement Trajectories

Note- Figure shows adjusted GE means on the ITBS Reading subtest for the Science IDEAS and Control students by Grade Level. Covariates were Gender and At-Risk status. Difference between Science IDEAS and Control students was significant, F(1, 7145) = 22.53, p > .001. The Treatment x Grade Interaction, was not significant. Girls out- performed Boys in Reading--- F(5, 7145) = 24.14, p < .001.
• NSF/IERI Project Research Findings: 2002-2007
  – Grades 3 - 8: Student achievement in Science
    2006-2007 ITBS Achievement Trajectories

Note- Figure shows adjusted GE means on the ITBS Science subtest for the Science IDEAS and Control students by Grade Level. Covariates were Gender and At-Risk status. Difference between Science IDEAS and Control students was significant, \( F(1, 6457) = 18.8, p > .001 \), as was the Treatment x Grade Interaction, \( F(5, 6457) = 4.81, p > .001 \) supporting the increasing differences in performance with Grade Level.
Patterns of Research Evidence for Science IDEAS Model

• NSF/IERI Project Research Findings: 2001-2007
  – Mini-Study in Grade K-2 - (Data are for Grade 1 and Grade 2 students only)
    • Results - Science IDEAS obtained significantly higher achievement in reading and science (ITBS)
      – Treatment main effects (Adjusted GE)
        » ITBS Reading (Science IDEAS: +.42 GE)
        » ITBS Science (Science IDEAS: +28 GE)
      – Other significant main effect for ITBS Reading (Adj. GE)
        » Contrast- Ethnicity Differences due to White vs. Non-White (White: +.38 GE)
      – Simple effects analysis for Treatment x Grade Interaction (Showed magnified effect of treatment in Grade 2 (Science IDEAS: +.72 GE), no effect in Grade 1)
    • Study conclusion: In-depth science instruction representing adaptation of Science IDEAS model could be feasible and effective in primary grades.
Science IDEAS: Patterns of Research Evidence

  - Year-Long Schoolwide Study in Grade K-2 - (Data are for Grade 1 and Grade 2 students only)
    - Results – HLM analyses showed Science IDEAS obtained significantly higher achievement in science and reading (ITBS)
      - Treatment main effects
        » ITBS Science \( t_{(21)} = 20.34, p < .001, \text{Std. Coefficient} = .77 \)
        » ITBS Reading \( t_{(21)} = 4.46, p < .001, \text{Std. Coefficient} = 1.35 \)
      - Other effects
        » Treatment x Grade not significant for both ITBS Science and Reading
        » Ethnicity (Percent White significant for both ITBS Science and Reading.
        » At-Risk (Free/Reduced Lunch) not significant.

- Study conclusion: Expanded in-depth science instruction (45 min./day) effective for accelerating achievement in grades 1-2.
Supporting Theoretical Framework for Linking Science and Reading Comprehension
Science IDEAS: A Knowledge-Based Interdisciplinary Model Designed to Support Meaningful Learning in Science and Reading Comprehension

3 Major Findings...

• Prior Knowledge is a major determinant of future learning
• Understanding involves organizing/re-organizing knowledge around core concepts
• Learning involves knowing when to use prior knowledge and skills for future learning (metacognition)
Other Research Initiatives Linking Science and Literacy

- **Cervetti & Pearson** (2006) - studies addressing the role of reading in the service of learning science; Roots and Seeds project; ‘lead with science and follow with reading’
- **Duke et al.** (2000, 2002, 2007) - studies using informational texts in primary grades; reading informational genres; 3.6 minutes – scarcity of informational texts in primary
- **Guthrie, Perencevich, et al** (2002, 2004) - studies using CORI as a model to engender reading comprehension and motivation to learn in content domains
- **Hirsch** (1996, 2006) - essays on the organization and importance of knowledge in comprehension; situation model
- **Klentschy** (2003) - effects of multiple years of in-depth science instruction with K-6 ELL students
Other Research Initiatives Linking Science and Literacy

- *McNamara & Kintsch* (1996) - studies focused on text coherence and cohesiveness as factors influencing comprehension
- *Romance and Vitale* (2001, 2006) - studies addressing the effect of in-depth cumulative content learning on science and reading achievement in upper elementary
- *Weaver & Kintsch* (1995) - studies on the role of knowledge in comprehension
- Many others as the field of researchers investigating the benefits associated with linking science and literacy in the K-8 classroom continues
Science IDEAS Reading Comprehension Strategy – Overview and Research Demonstrating Transfer Effects from Grades 3-5 to Grades 6-7
Science Learning and Literacy Skills are Closely Related in the School Curriculum

Science Process Skills = Literacy Skills

- Observing
- Posing questions
- Predicting
- Comparing/contrast ing
- Sorting/classifying
- Determining cause and effect
- Making explanations from evidence
- Making inferences
- Asking and answering questions
- Identifying problems and solutions
- Evaluating
What Does It Take To Build Understanding From Text?

• Learning from text is intertwined with prior knowledge derived from a variety of sources....
  1. Prior knowledge one already has about topic
  2. Knowledge gained through hands-on experiences
  3. Knowledge gained from reading multiple sources
  4. Knowledge gained from organizing concepts using concept maps
  5. Knowledge retained from cumulative review

• Prior knowledge interacts with the cohesive structure of text to support comprehension and cumulative learning
Science IDEAS employs a three-part knowledge-based model of comprehension

- Prior Knowledge Access and Summarization sub-strategy (+ fluency development)
- Concept mapping sub-strategy
- Expository Writing sub-strategy

Science IDEAS – and the Rand Reading Report (Snow, 2000) consider comprehension as...

- Accessing and linking prior knowledge to what is being read for meaningful comprehension
Science IDEAS: Patterns of Research Evidence

  - Multi-Year Study: Direct and transfer effects of a Reading Comprehension Strategy in content-oriented (Science IDEAS) and narrative (Basal Reading/Language Arts) settings in grades 3-4-5
Science IDEAS: Patterns of Research Evidence

  - Multi-Year Study- Direct and transfer effects of a Reading Comprehension Strategy in content-oriented (Science IDEAS) and narrative (Basal Reading/Language Arts) settings in grades 3-4-5
Science IDEAS: Patterns of Research Evidence

  - Multi-Year Study- Direct and transfer effects of a Reading Comprehension Strategy in content-oriented (Science IDEAS) and narrative (Basal Reading/Language Arts) settings in grades 3-4-5

Teach. Judgment of Year-End Student Reading Proficiency
Jones sacrificed and knocked in a run.
Woods was knocked out of his crease on the first over after lunch.
Policy Implications for Reading Comprehension Instruction: Grades 3-8
Curricular Policy Implications for Improving Reading Comprehension

- Increasing the amount of instructional time allocated to cumulative, content-area reading has the potential to enhance student reading comprehension proficiency (achievement)

- The three-part Science IDEAS reading comprehension strategy is feasible for use by teachers and students and has a strong evidence-based research foundation

- Increased instructional time in combination with the use of the Science IDEAS knowledge-based reading comprehension strategy has a substantial transfer impact from grades 3-5 to grades 6-7

- Present Grades 3-5 curricular policy needs to be modified to reflect established research base supporting the importance of content-area reading in upper elementary and beyond (reading to learn)
Benefits to Students and Teachers
Benefits Associated with linking Science and Literacy in K-8 Classroom

• Benefits to students in terms of
  – Science learning (and scientific literacy)
  – Literacy development (reading comprehension and writing)

• Benefits to teachers in terms of
  – Ease of implementation of model
  – More motivated students
  – More active student engagement
  – Focus on student learning
Inquiry-Based Science and Literacy: Learning by Doing and Reading

• Benefits derived by students who are learning science...
  – It is inherently interesting for “all” students
  – It is motivating and engaging because it involves learning by doing
  – It is generally a preferred subject area for some students who might otherwise be bored by school
  – It provides a rich content area that easily promotes vocabulary development and reading comprehension proficiency
  – It builds additional background knowledge to support subsequent science learning and meaningful understanding (comprehension)
Linking Science and Literacy in the School Curriculum

- **Additional benefits to students from engaging in first-hand investigations...**
  - Engage in scientific discourse
  - Learn how to link evidence with claims and reason scientifically to draw conclusions (scientific literacy)
  - Read more often and with greater interest and at a much higher level across a variety of genres
  - Can use a variety of representations to demonstrate their understanding of concepts being learned (e.g., concept maps)
  - Use writing as a means to express their understanding by constructing expository passages and can apply knowledge to narrative composition
  - Build a more in-depth understanding of the world around them
<table>
<thead>
<tr>
<th>Benefits to students in terms of a literacy context....</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Engage in the discourse of science (including building an extensive vocabulary)</td>
</tr>
<tr>
<td>- engage in authentic learning tasks that support making observations, generating claims, gathering evidence as part of a scientific argument framework</td>
</tr>
<tr>
<td>- reason with evidence and research skills</td>
</tr>
<tr>
<td>- write (and publishing) their own informational text</td>
</tr>
<tr>
<td>- read across a variety of literary genres (e.g., informational materials, magazines, newspapers, Internet, posters)</td>
</tr>
</tbody>
</table>
A Final Thought....

- Without linking science and literacy for developing more meaningful, in-depth science learning and reading comprehension proficiency for students, we are likely to continue to repeat what we have been doing with the same results......
Contact Information

Dr. Nancy Romance
Florida Atlantic University
romance@fau.edu

Dr. Michael Vitale
East Carolina University
vitalem@ecu.edu