Toward a Curricular Policy for Advancing School Reform by Integrating Reading Comprehension within Time-Expanded Science Instruction in Grades K-5

Michael R. Vitale, *East Carolina University*

Nancy R. Romance, *Florida Atlantic University*

Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Philadelphia, March 23, 2010

This research was supported by NSF/IERI (REC 220853) and USDOE/IES (Project R305G04089)

Overview

- **School Reform and K-5 Science Instruction**
  - Status of K-5 school reform
  - Effects on reductions of K-5 content-area instruction
- **Increasing Time for Science in Grades K-5**
  - A curricular strategy – Logical and empirical foundations
  - Evidence supporting the replacement of reading with science
    - Effects of the multi-year Science IDEAS research initiative
    - Effects of mini-studies focusing on Science IDEAS elements
  - Implications for curricular policy and practice
- **Perspectives for Engineering Curricular Policy Changes**
  - Focus school reform accountability on content in grades 3-8 (Focus on reading in K-2 only)
  - Adopt interdisciplinary approaches as a foundation for K-5 learning
  - Use “scale-up” as a context for implementation and sustainability
- **Implications for School Reform Policy and Research**

Reform Trends Linking Literacy and Science

- **Assessment Perspectives Relating to the Status of Reform**
  - NAEP (reading, science)
  - TIMSS (science)
  - PISA (reading, science)
- **Accountability-Driven Reductions in K-5 Content-Area Instruction (Due to Literacy Emphasis)**
  - Content areas affected- reduced time for 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 required for in-depth (cumulative) learning reflects technical characteristics of instructional model
      - Curricular structure / grade-level articulation / classroom content sequencing
      - Classroom teaching strategies

Reform Trends Linking Literacy and Science

- **Increased Content-Area Learning as Basis for K-5 Reform**
  - Literacy as "content-free" reading is a continuing reform problem
  - Reform must focus on meaningful content-area learning rather than "literacy":
    - Increase time for cumulative/meaningful content-area learning in grades K-5 to maximize student academic preparation for success in grades 6-12
    - Increase use of projections of *future* content-area learning success as success measures vs. grade-level-specific, short-term, test-preparation objectives
- **Argument for Content-Area-Driven Reform**
  - **IF** <cumulative content-area learning is key for literacy development> **THEN** <potential success of K-12 reform is unlikely>
  - **SOLUTION**- <Develop content-area-oriented models which embed reading comprehension and writing in content-area instruction to make optimal use of instructional time in grades K-5>

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 replacing traditional reading instruction with in-depth science with K-6 ELL students

Research Initiatives Linking Science and Literacy

- *McNamara & Kintsch* (1996) - studies focused on prior knowledge and text cohesiveness as factors influencing comprehension
- *Palincsar & Magnussom & Hapgood* (2001, 2003, 2004, 2007) - studies addressing the role of first and second hand investigations on science learning and literacy
- *Pearson et al.* (1995, 2002, 2008) - studies addressing use of informational text for building reading comprehension
- *Romance and Vitale* (2001, 2006, 2008) - studies addressing the effect of in-depth, cumulative content learning in science on reading achievement in upper elementary (and transfer to middle school)
- *Weaver & Kintsch* (1995) - studies on the role of knowledge in comprehension

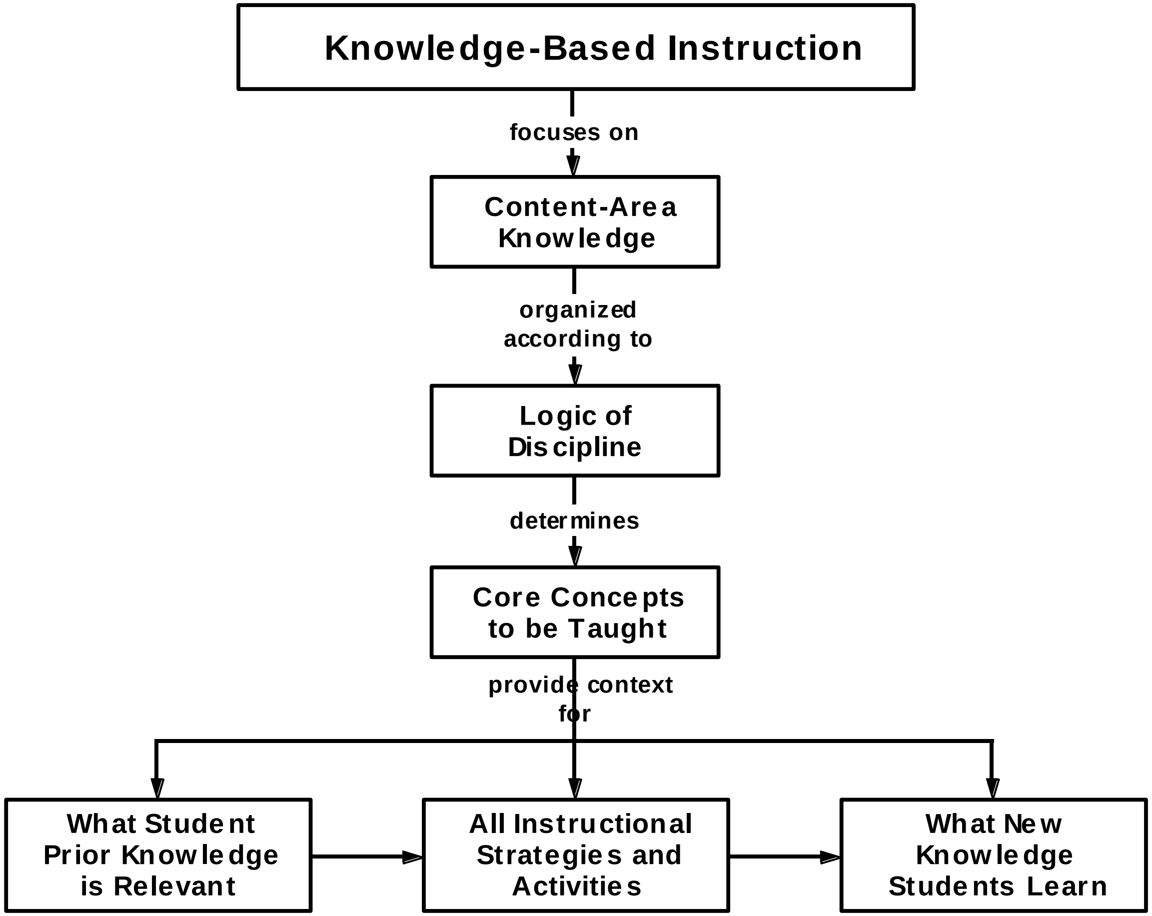
Overview of
Science IDEAS Model

Integrating Reading into Science

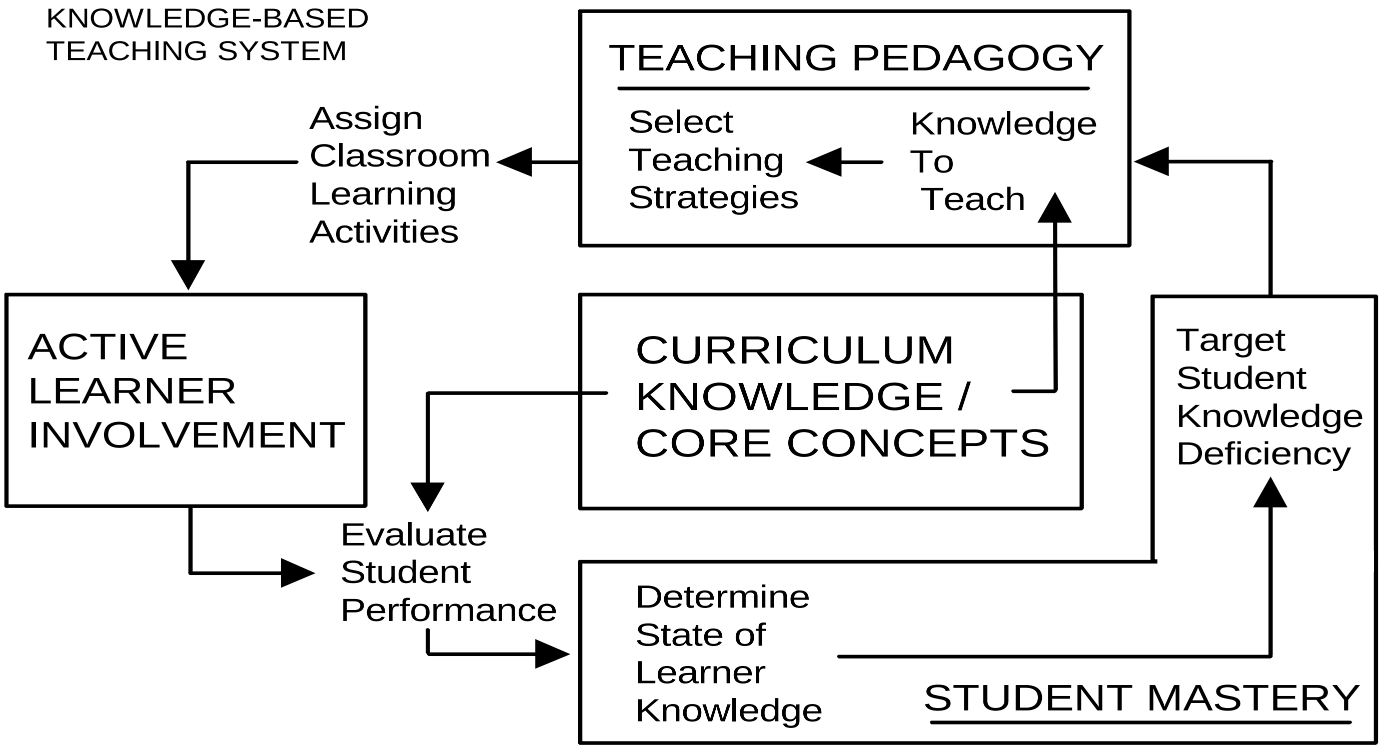
Overview of *Science IDEAS* Model

- ***Science IDEAS* Model: Grades 3-4-5**
  - Implemented schoolwide in grades 3-5 with supportive teacher professional development and classroom support
  - Replaces typical daily 1½ to 2-hour Reading/Language Arts block with in-depth science lessons that naturally integrate reading comprehension and writing within science
  - Uses a “knowledge-based” instructional architecture as an operational framework for concept-oriented, multi-day lessons
  - Concepts and concept relationships provide a curricular context for all teaching/student activities and assessment (via collaborative teacher grade-level planning)
- ***Science IDEAS* Model: Grades K-1-2**
  - Implemented schoolwide in grades K-2 with supportive teacher professional development and classroom support
  - Follows daily 45 minute science instructional block (does not replace Reading/Language Arts)

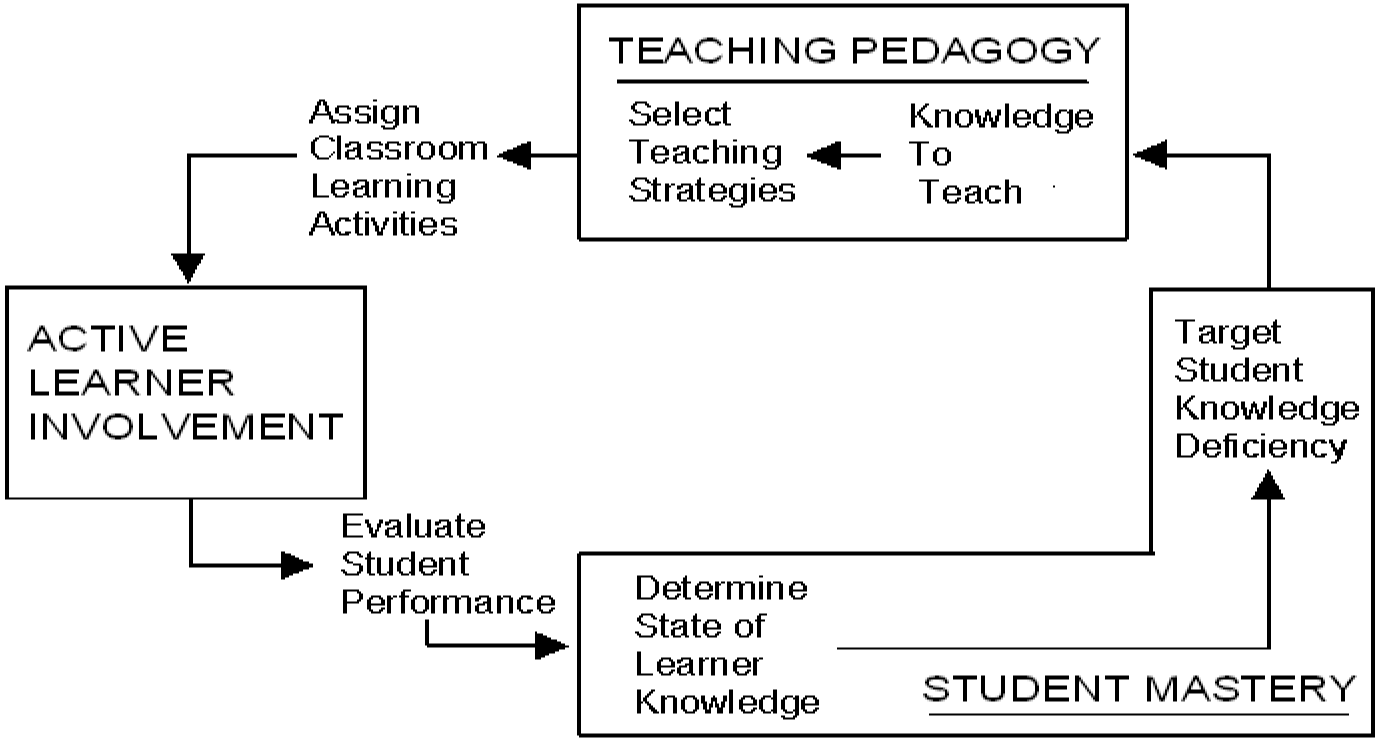
Science IDEAS Model: Interdisciplinary Foundations



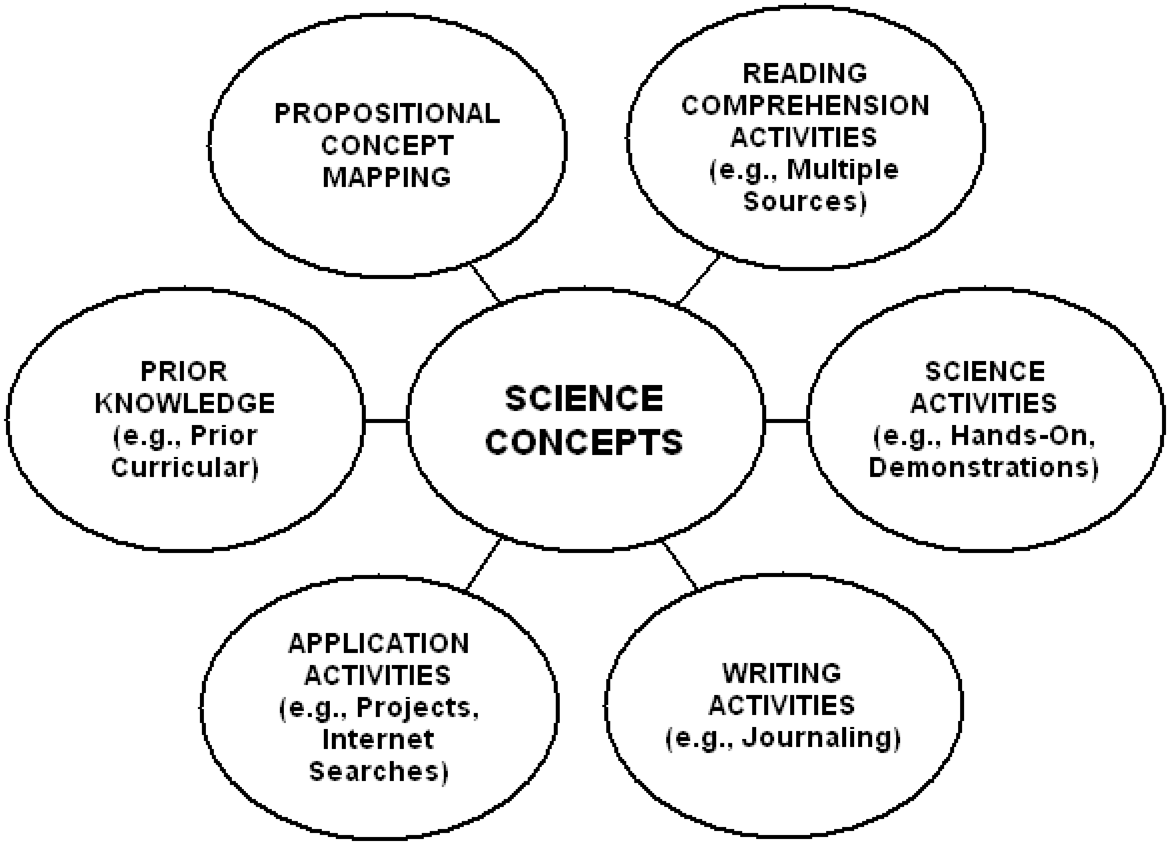
Science IDEAS Model: Interdisciplinary Foundations



Note- Instruction as a “Content Free” Process
(vs. Knowledge-Based Instruction)



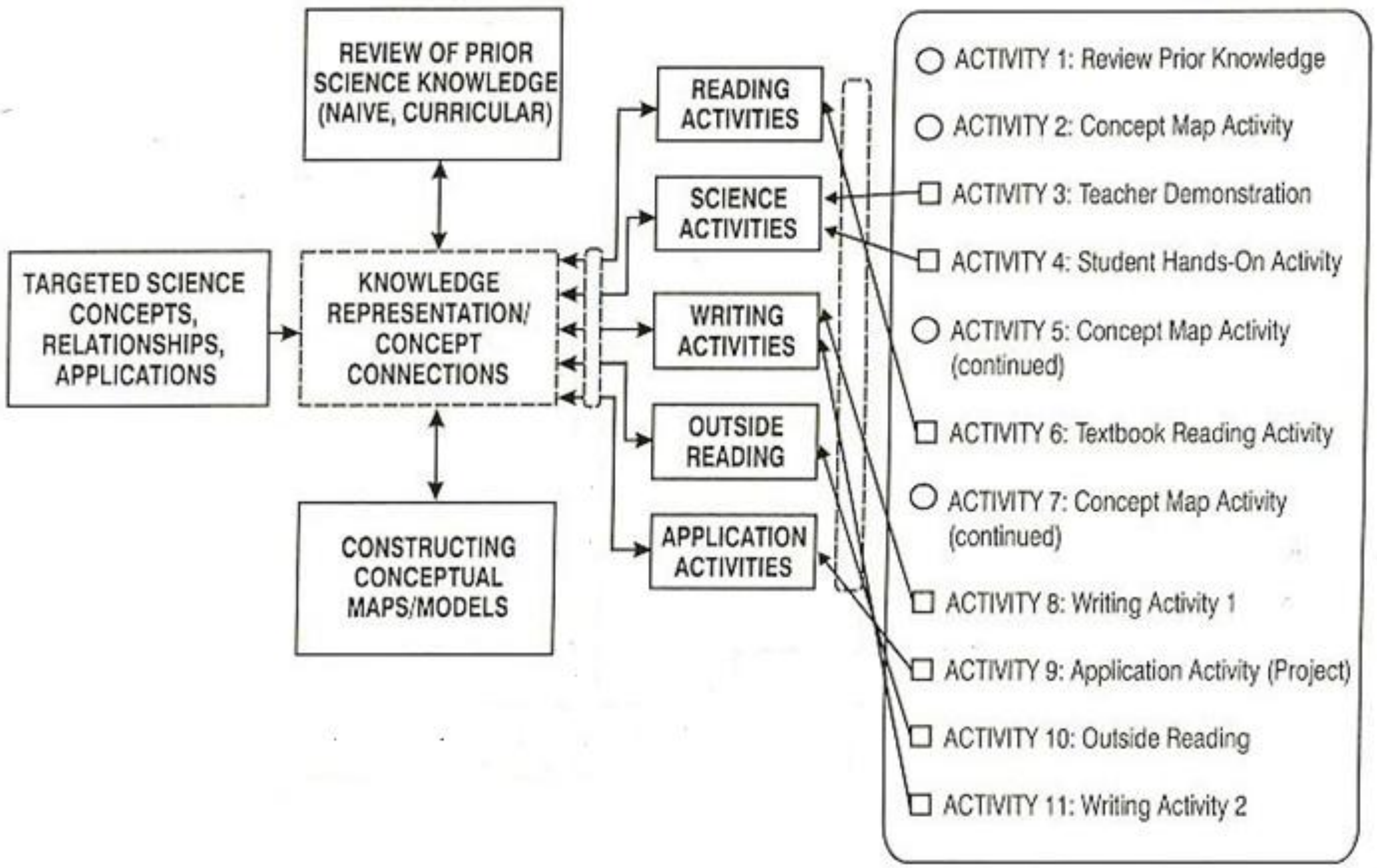
Science IDEAS Model- Initial Representation



Science IDEAS Model: Instructional Elements

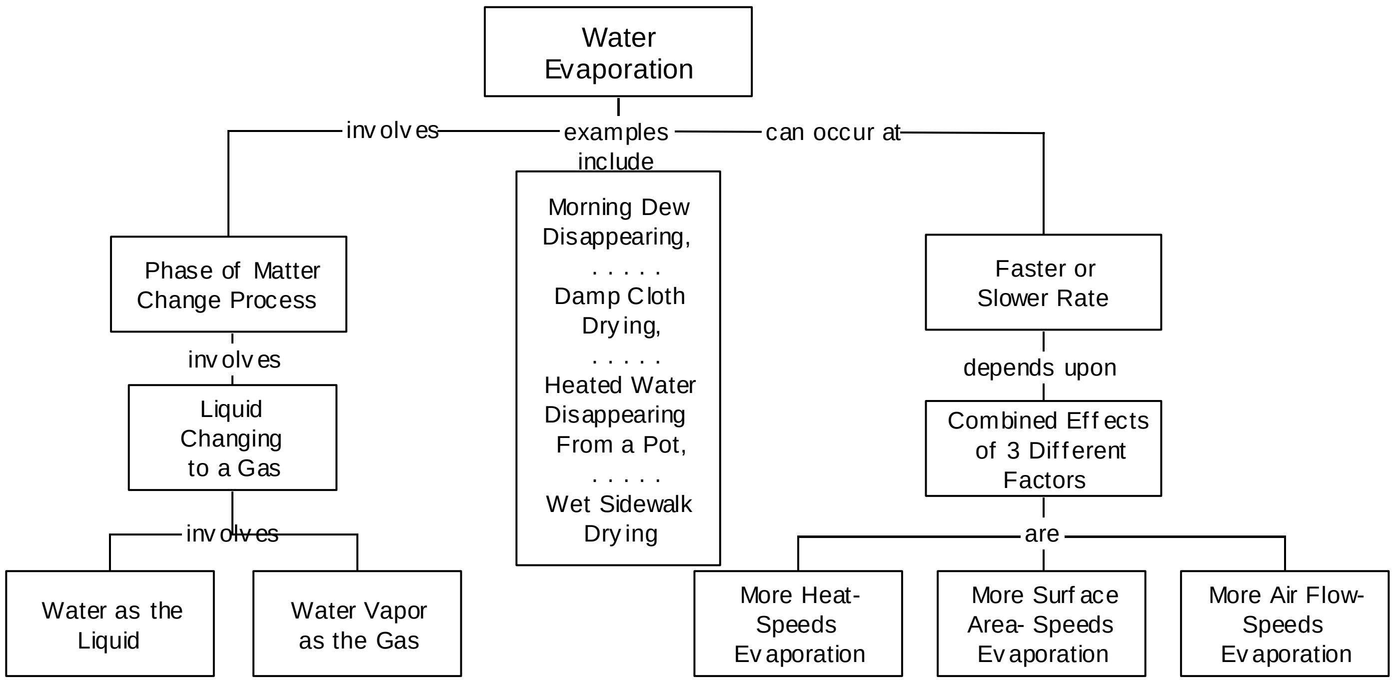
- **Science IDEAS elements function as a set of integrated learning activities used in grades 3-4-5**
  - ***Science Investigation / Inquiry:*** Use of hands-on activities with guided /open-ended inquiry, concept verification
  - ***Reading Comprehension***: Specific strategy for guiding student reading of informational text to enhance deep understanding
  - ***Propositional Concept Mapping***: Strategy for visual organization and representation knowledge in coherent fashion
  - ***Journaling and Writing***: Guiding students to record their understanding/thinking and questions as a basis for review/writing
  - ***Application Activities / Projects***: Activities for application of concepts across varied contexts
  - ***Prior Knowledge / Cumulative Review***: Strategy for accessing prior curricular knowledge and for scheduling curricular review

Science IDEAS Model: Multi-Day Lesson Planning

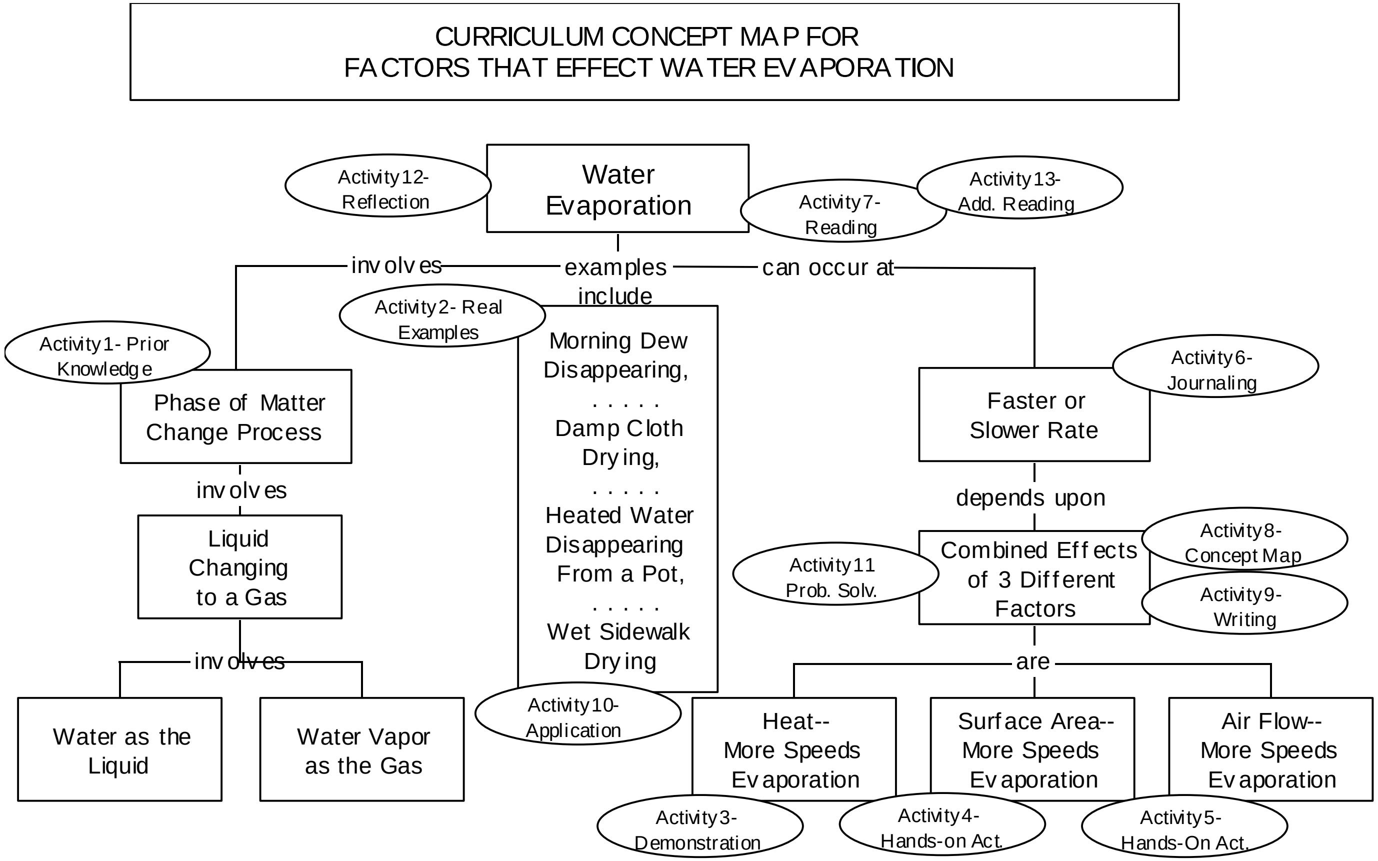


Science IDEAS: Curricular Concept Maps as Multi-Day Lesson Frameworks

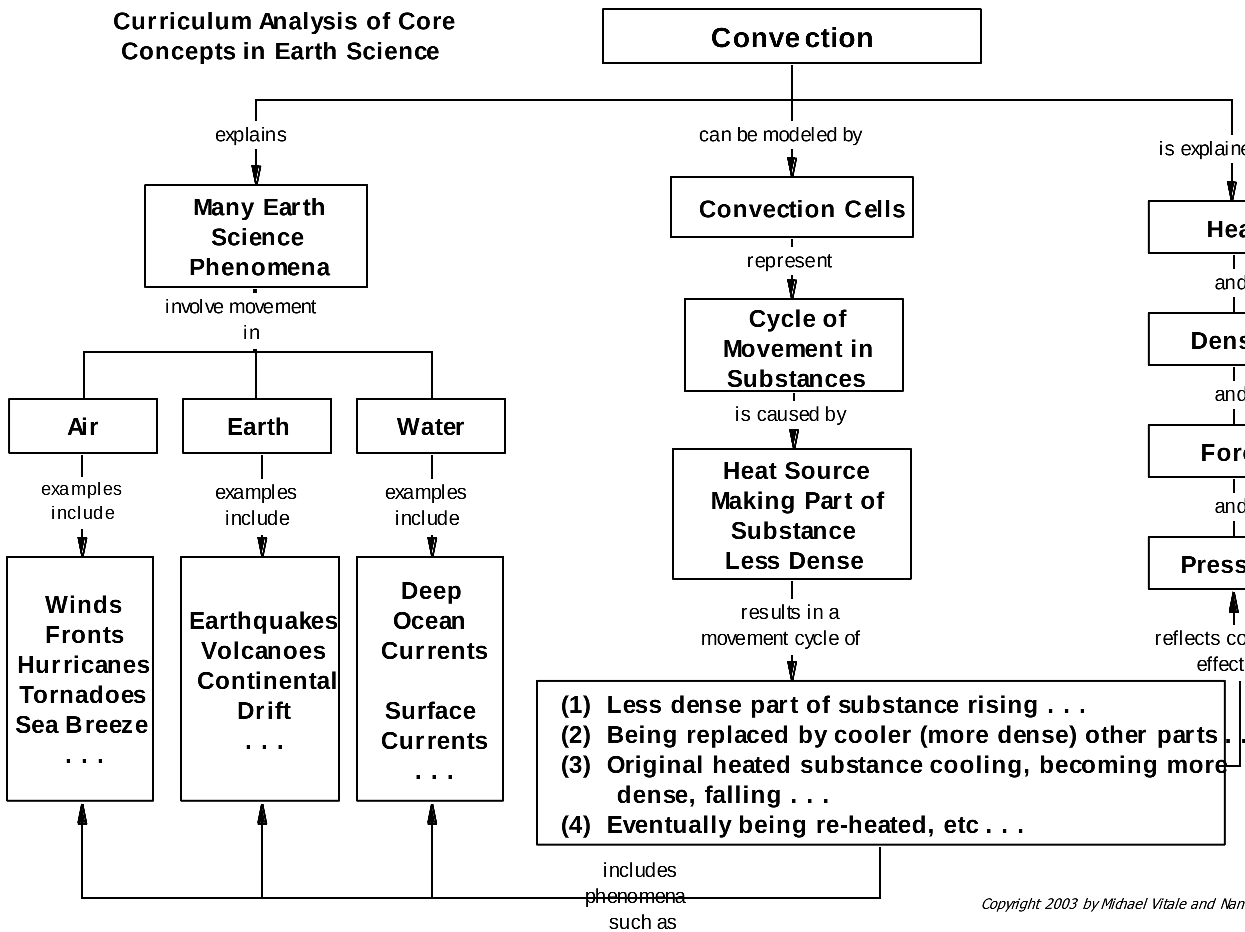
CURRICULUM CONCEPT MAP FOR
FACTORS THAT EFFECT WATER EVAPORATION



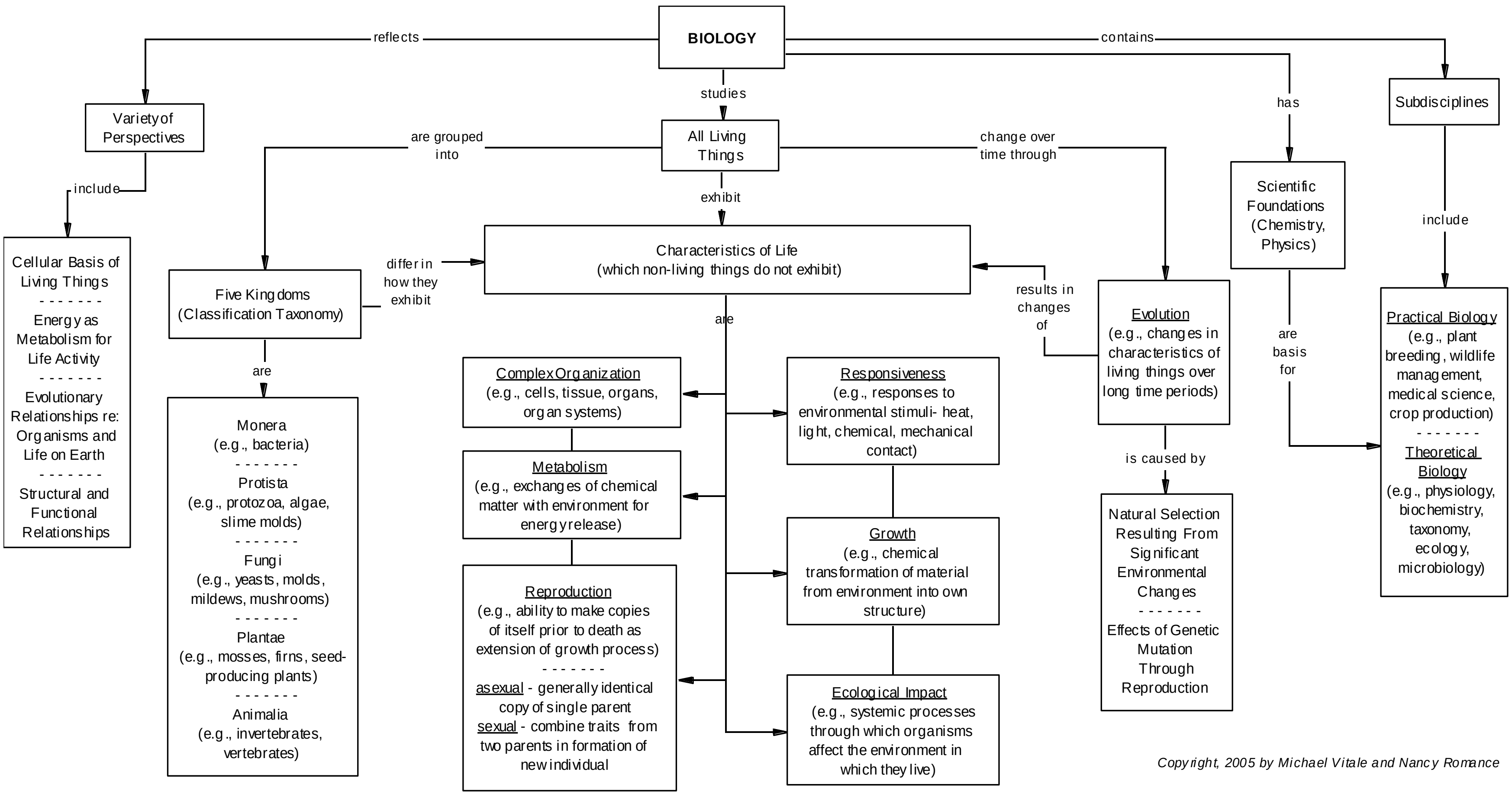
Science IDEAS: Curricular Concept Maps as Multi-Day Lesson Frameworks



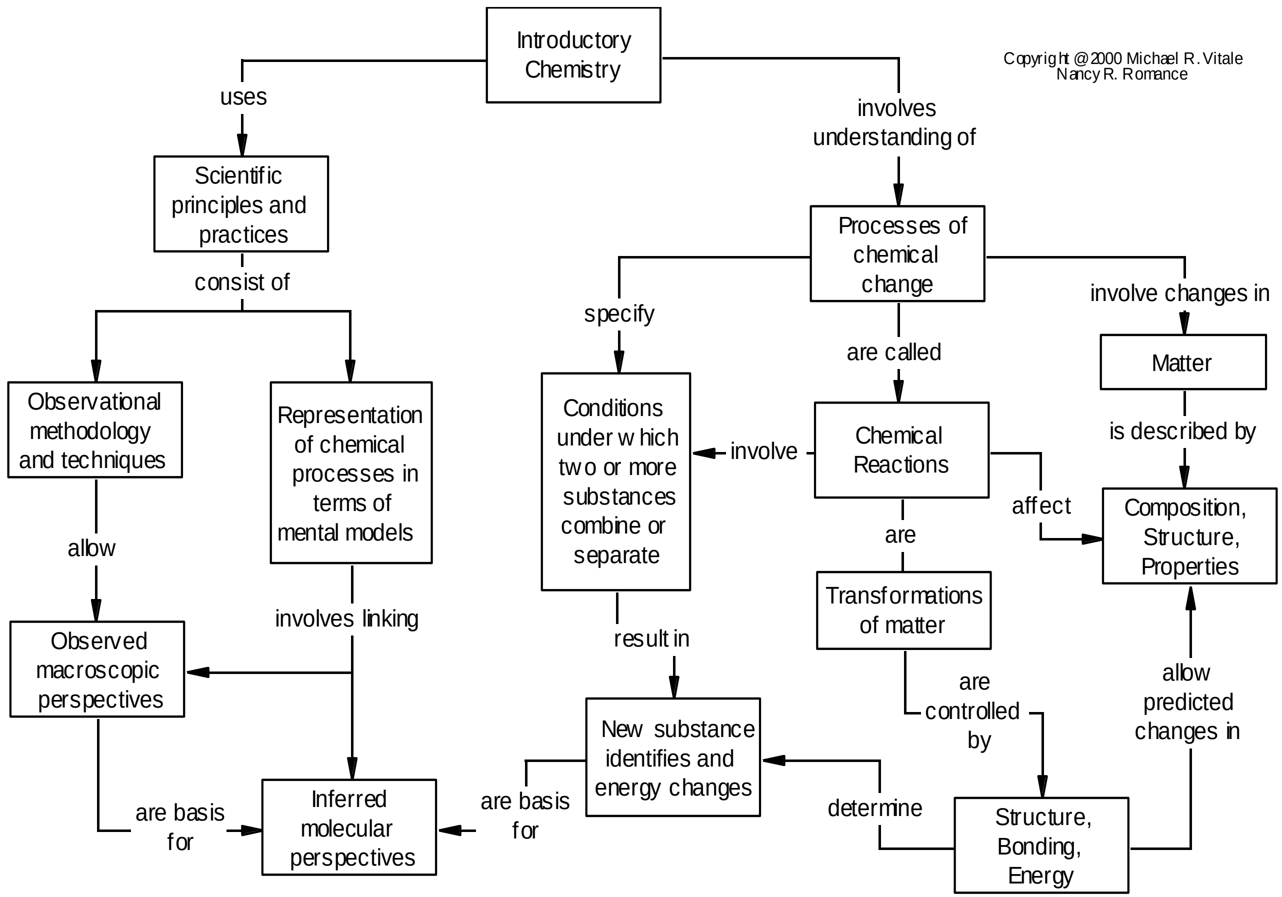
Curricular Concept Map Representing “Big Ideas”



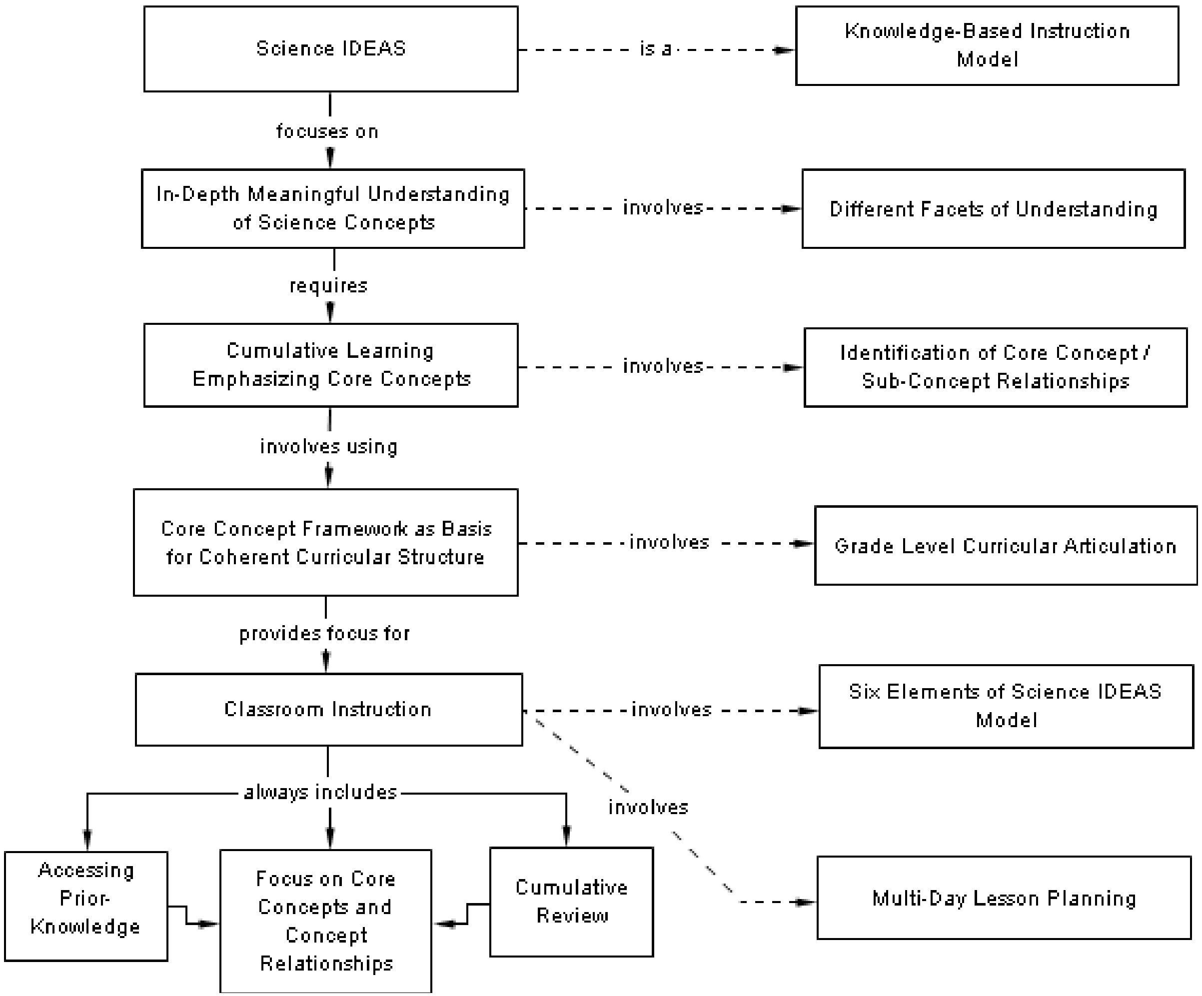
Curricular Concept Map Representing "Big Ideas"



Curricular Concept Map Representing “Big Ideas”

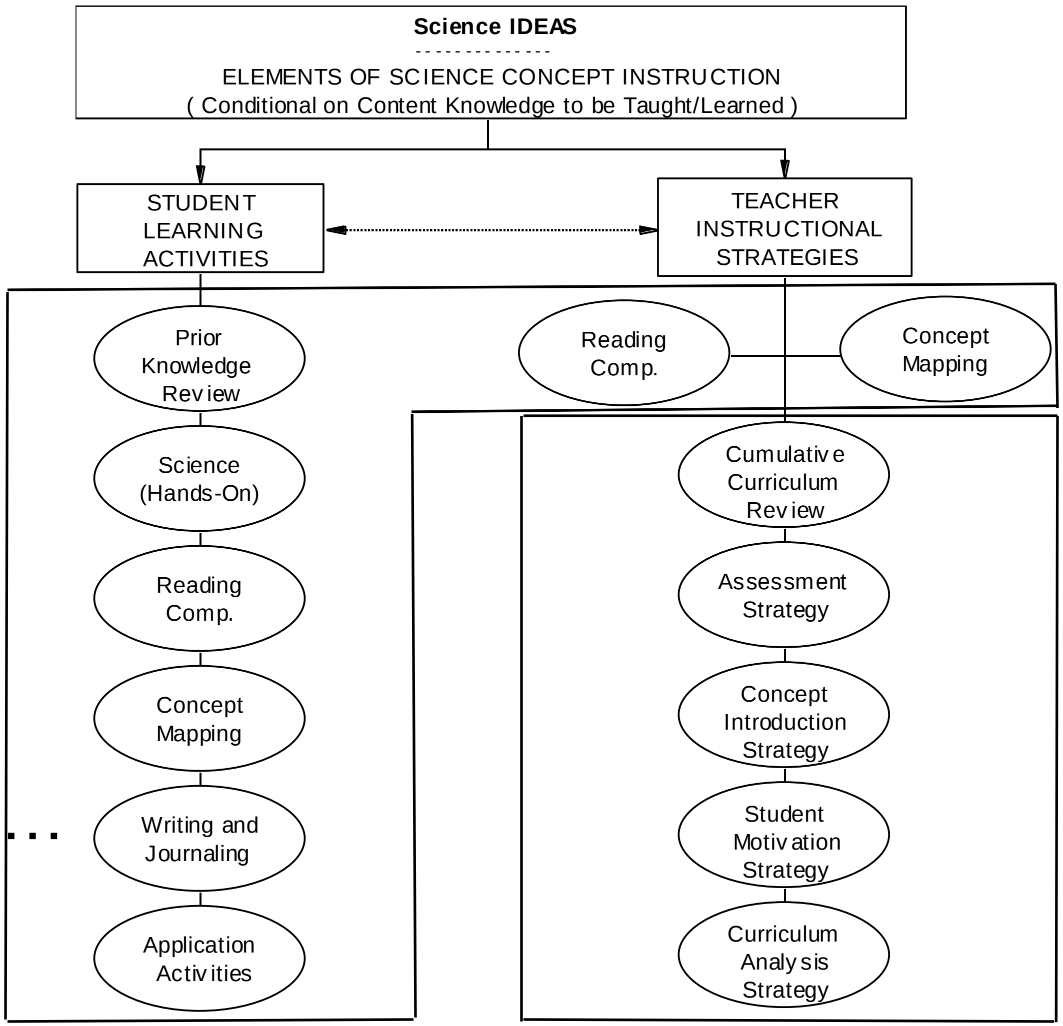


Overall Schematic of *Science IDEAS* Model



Future Evolution of the *Science IDEAS* Model

Original Science IDEAS Elements…



Advanced Science IDEAS Elements…

Michael R Vitale, *Center for School Development*

Science IDEAS

Patterns of Research Evidence

1992 - 2007

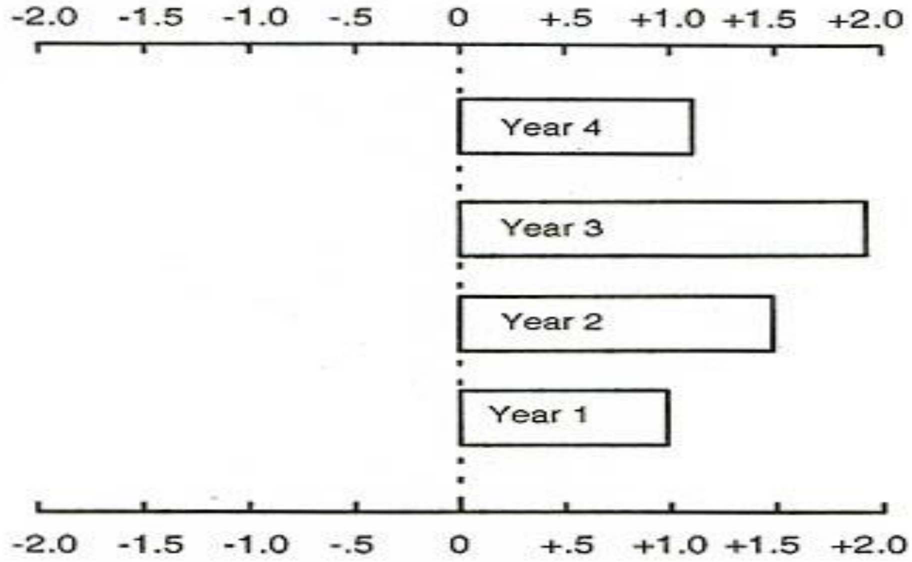
Science IDEAS: Patterns of Research Evidence

- **Research Findings: 1992-2001**
  - Higher student achievement in favor of *Science IDEAS*
    - *Science* - with differences in *adjusted means* ranging from + .9 Grade Equivalent (GE)-Years to +1.8 GE-Years (on nationally normed MAT)
    - *Reading Comprehension* - with differences in *adjusted means* ranging from + 2.5 GE-Months to +4.5 GE-Months (on nationally normed ITBS, SAT)
  - Treatment effect consistent across at-risk and non-at-risk students
    - Treatment main-effect and at-risk main-effect significant
    - But no interaction between treatment and at-risk status

Science IDEAS: Patterns of Research Evidence

- **Research Findings: 1992-2001**

Science IDEAS: Multi-Year Findings (MAT Science)



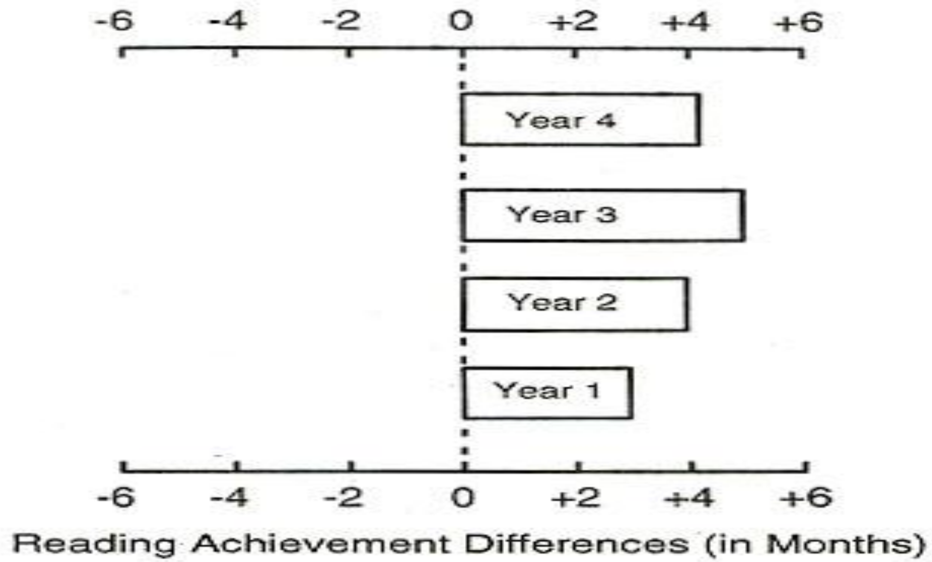
Science Achievement Differences (in Years)

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

- **Research Findings: 1992-2001**

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

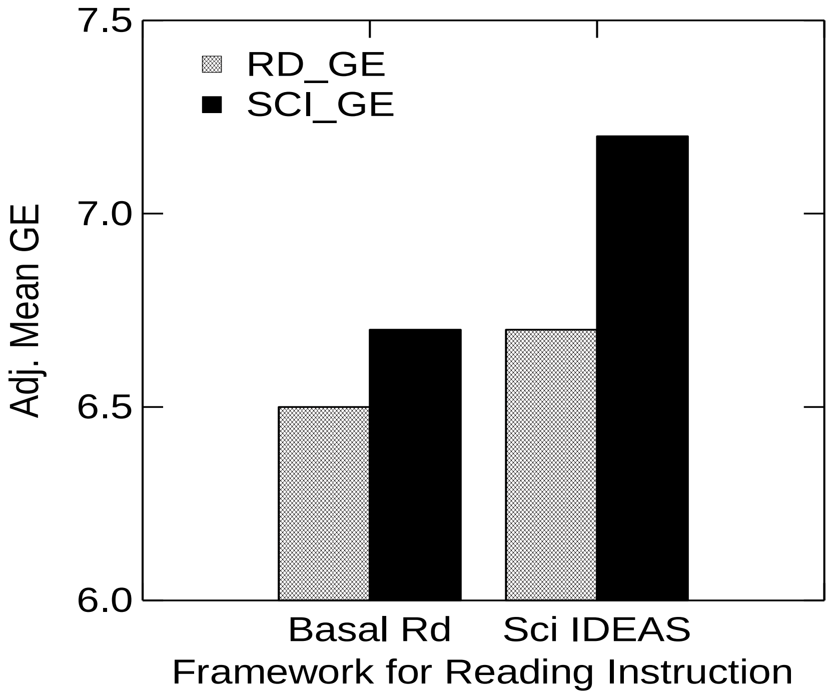


Note-- Year 1 students = grade 4; average/above average
Year 2 students = grade 4; average/above average
Year 3 students = grades 4,5; at-risk
Year 4 students = grades 4,5; average/above average/at-risk

Science IDEAS: Patterns of Research Evidence

- **NSF/IERI Project Research Findings: 2002-2007**
  - Grades 4 & 5: Student achievement in Science and Reading

2003-2004 ITBS Achievement Outcomes

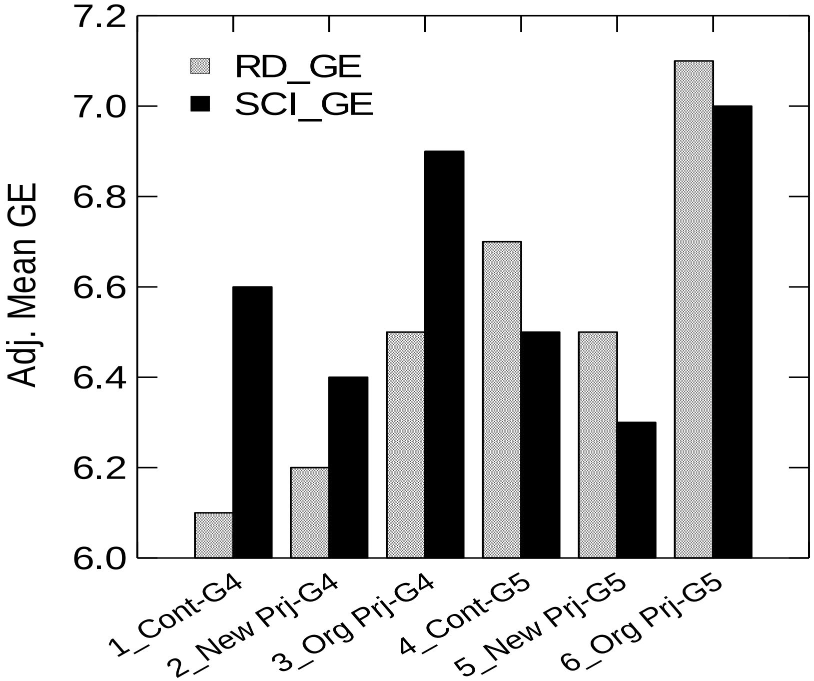


Note- Shown are differences in *adjusted grade equivalent means* on ITBS Reading and Science for grade 4-5 Science IDEAS and Basal Reading classrooms. After statistically equating students for differences on the preceding years FCAT Reading achievement, Science IDEAS students displayed significantly higher ITBS achievement on both Reading and Science.

Science IDEAS: Patterns of Research Evidence

- **NSF/IERI Project Research Findings: 2002-2007**
  - Grades 4 & 5: Student achievement in Science and Reading

2004-2005 ITBS Achievement Outcomes



Proj. = Science IDEAS Schools by Experience (1, 3 Yrs)

Note- After statistically equating students for differences on the preceding years FCAT Reading achievement, *Science IDEAS* students in schools with 3 years experience displayed significantly higher ITBS achievement than Basal Reading schools on both reading and science.

Results for *Science IDEAS* schools in their initial year were varied, suggesting that more than 1 year for implementation experience is required before the *Science IDEAS* model is implemented with consistency.

Science IDEAS: Patterns of Research Evidence

- **NSF/IERI Project Research Findings: 2002-2007**
  - Grades 3 - 8: School Demographics for Science IDEAS and Control Schools: 2006-2007

Project Schools	N. Schools	Pct. Minority	Pct. Free/ Reduced Lunch
Science IDEAS	13	60	46
Control	12	60	45

  - Grades 3 - 8: Student Achievement Measures
    - ITBS Science Subtest
    - ITBS Reading Subtest

Science IDEAS: Patterns of Research Evidence

- **NSF/IERI Project Research Findings: 2002-2007**
  - Grades 3 - 8: Student achievement in <u>Science</u> and <u>Reading</u>

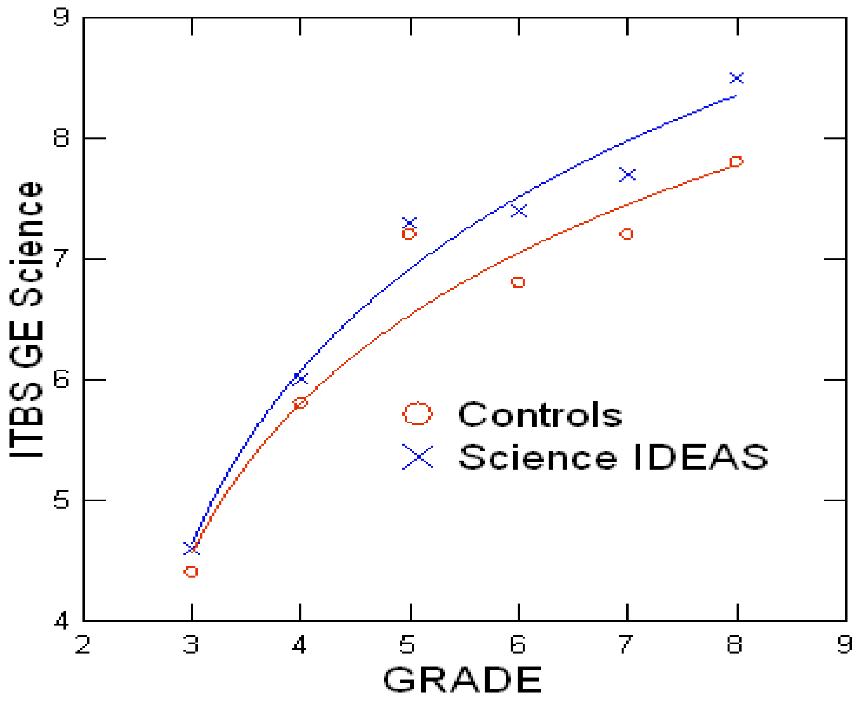
2006-2007 ITBS Achievement Outcomes

- Higher student achievement in favor of *Science IDEAS*
  - *ITBS Science - adjusted mean difference* = +.38 GE in Science (Grade level differences ranged from +.1 GE to +.7 GE). Both Treatment Main Effect and Treatment x Grade Interaction were significant. Covariates were Gender and At-Risk Status (Title I Free/reduced Lunch).
  - *ITBS Reading Comprehension - adjusted mean difference* = +.32 GE in Reading (Grade level differences ranged from +.0 GE to +.6 GE). Treatment Main Effect was significant, but not the interaction. Covariates were Gender and SES Status (Title I)
- Treatment effect consistent across at-risk and non-at-risk students
- Girls outperformed Boys on ITBS Reading, but no Gender effect on Science

Science IDEAS: Patterns of Research Evidence

- **NSF/IERI Project Research Findings: 2002-2007**
  - Grades 3 - 8: Student achievement in <u>Science</u>

2006-2007 ITBS Achievement Trajectories

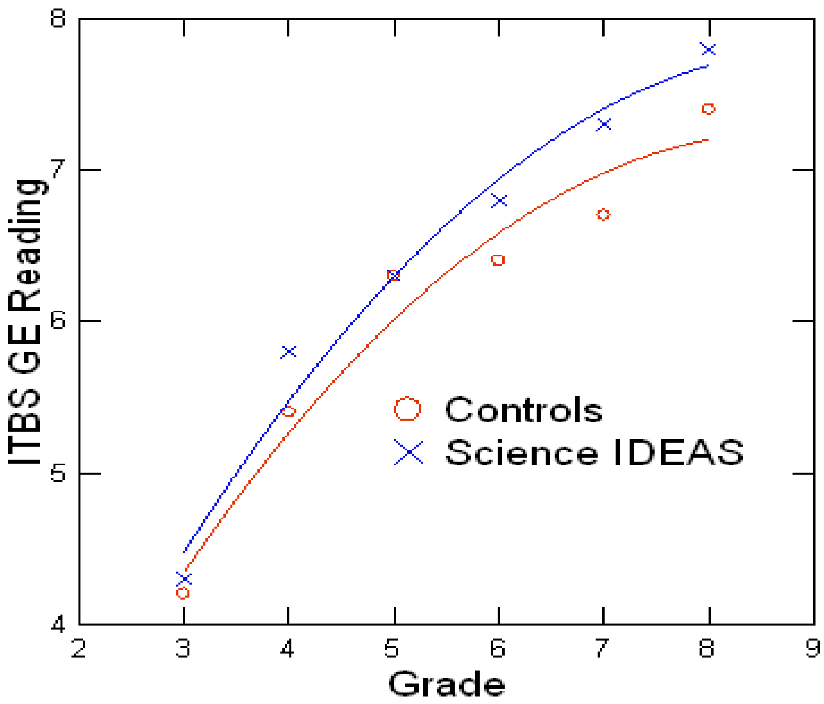


Note- Figure shows adjusted GE means on the ITBS Science subtest for the Science IDEAS and Control students by Grade Level. Covariates were Gender and At-Risk status. Difference between Science IDEAS and Control students was significant, $F(1, 6457) = 18.8$, $p > .001$, as was the Treatment x Grade Interaction,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

Science IDEAS: Patterns of Research Evidence

- **NSF/IERI Project Research Findings: 2002-2007**
  - Grades 3 - 8: Student achievement in <u>Reading</u>

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.

Science IDEAS: Patterns of Research Evidence

- **NSF/IERI Project Research Findings: 2002-2007**
  - <u>Mini-Study (8 Weeks) in Grade 5</u>- Exploring Instructional Context-Dependency of Reading Comprehension Strategy Effectiveness
    - Results - Science IDEAS (vs. Basal) obtained significantly higher achievement in Reading and Science (ITBS)
      - Main effect - Instructional Treatment (Adjusted GE)
        - » ITBS Reading (*Science IDEAS*: + .38 GE)
        - » ITBS Science (*Science IDEAS*: +.34 GE)
      - Main effect - Reading Comprehension Strategy Use *not* significant. However the interaction between Instruction and Reading Strategy use was significant

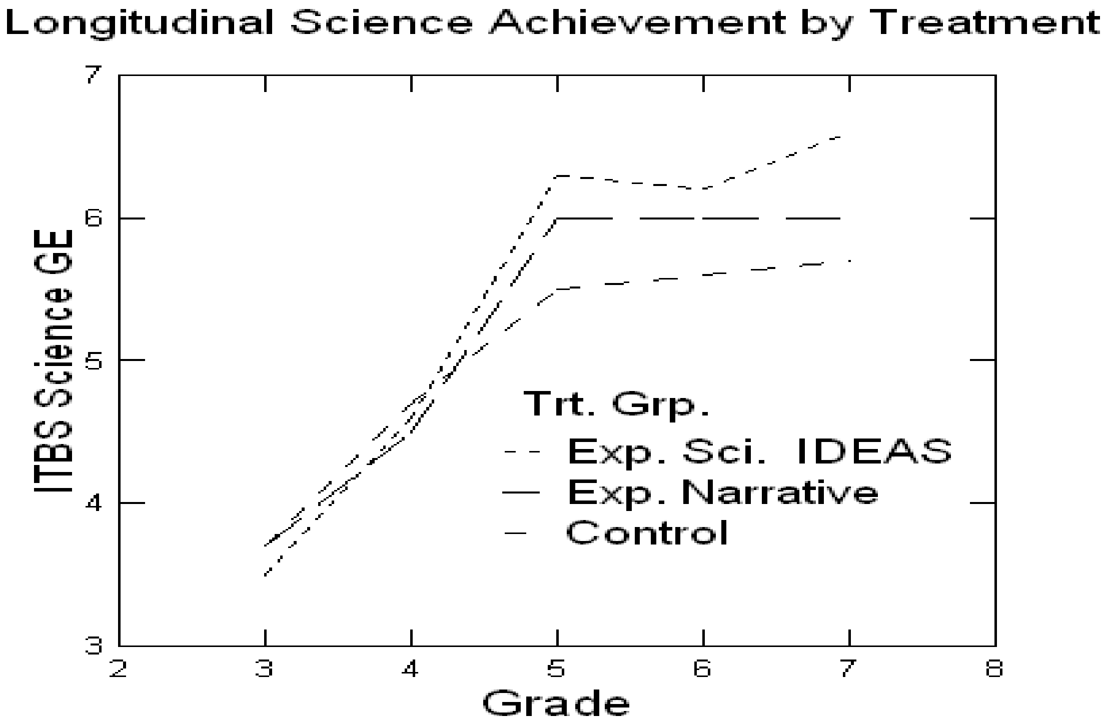
        Simple effects analysis of Treatment x Strategy interaction showed Strategy use for Science IDEAS significantly improved achievement in both science (+.17 GE) and reading (+.53 GE), but not for Basal classrooms
    - Study conclusion - Reading Comprehensive Strategy was only effective with content-oriented instruction, not with narrative (basal) instruction

Science IDEAS: Patterns of Research Evidence

- **NSF/IERI I IES Project Research Findings: 2002-2007**
  - 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
  - Results - Science IDEAS (vs. Basal, vs. Controls) obtained significantly higher achievement in Reading and Science (ITBS)
    - Linear models analysis used ethnicity (minority vs. non-minority) and at-risk status (free/reduced lunch) as covariates
      - ITBS Treatment Effects: Grades 3-7
        - » ITBS Science (Treatment, Treatment x Grade significant)
        - » ITBS Reading (Treatment, Treatment x Grade significant)
      - Teacher Judgment of Reading Proficiency: grades 3-6
        - » Teacher Judgment (Treatment , Treatment x Grade significant)
  - Study conclusion - Reading comprehensive strategy was more effective with content-oriented instruction than with basal. Both more effective than basal instruction without strategy use. Trends showed transfer of effect from elementary to middle school grades.

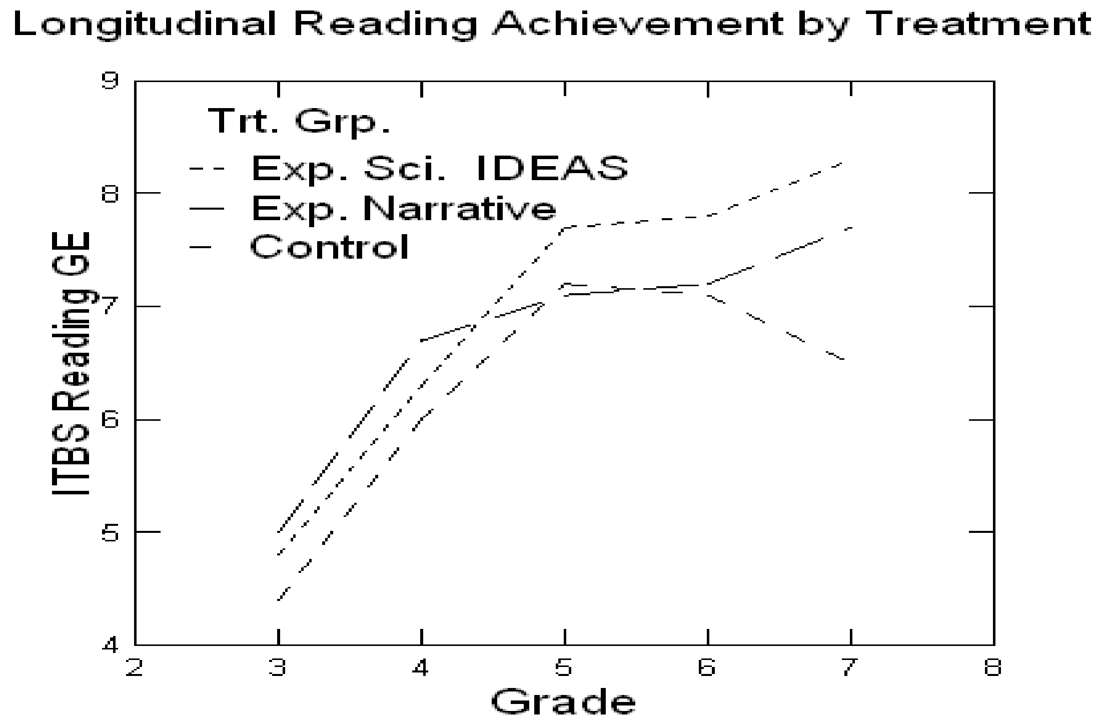
Science IDEAS: Patterns of Research Evidence

- **NSF/IERI I IES Project Research Findings: 2002-2007**
  - <u>Multi-Year Study</u>- 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

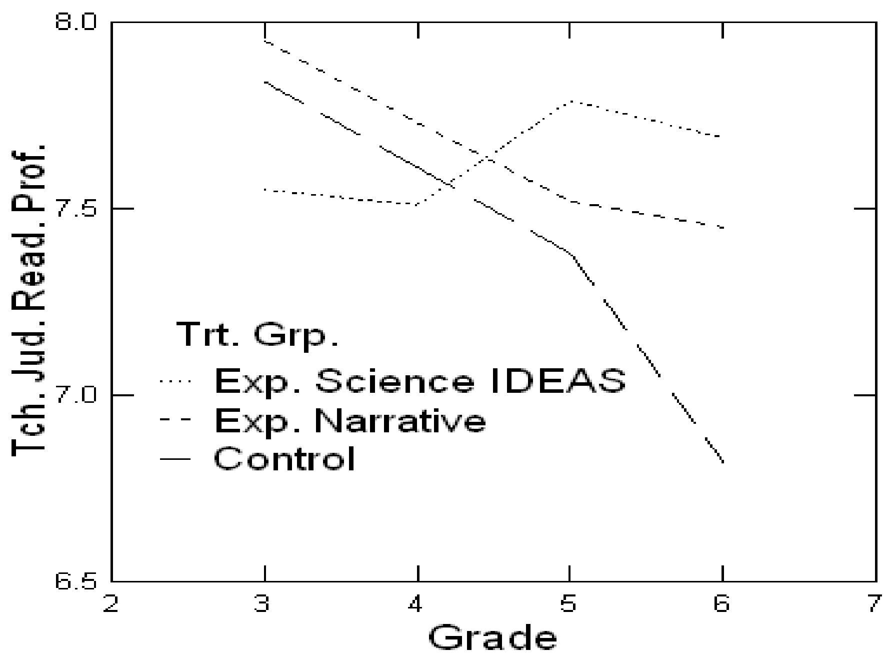
- **NSF/IERI I IES Project Research Findings: 2002-2007**
  - <u>Multi-Year Study</u>- Direct and transfer effects of a Reading Comprehension Strategy in content-oriented (Science IDEAS) and narrative (Basal Reading/Language Arts) settings in grades 3-4-5



Science IDEAS: Patterns of Research Evidence

- **NSF/IERI I IES Project Research Findings: 2002-2007**
  - <u>Multi-Year Study</u>- 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



Science IDEAS: Patterns of Research Evidence

- **NSF/IERI Project Research Findings: 2001-2007**
  - Mini-Study (8 Weeks) 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

- **NSF/IERI Project Research Findings: 2001-2007**
  - 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 ($t_{(21)} = 20.34$, $p < .001$, Std. Coefficient = .77)
        - » ITBS Reading ($t_{(21)} = 4.46$, $p < .001$, 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.

Perspectives for Engineering Changes in Curricular Policy

Change Accountability Practices in School Reform

- **Raise Reform Expectations through Assessment**
  - Change structure grade 3-8 reading comprehension accountability assessment
    - Grades 3-8 : Focus on meaningful content-area understanding vs. “general” reading skills
    - Grades K-2 : Use nationally-normed reading tests
  - Interpret performance in grades 3-8 to projected levels of success in HS content-area courses (via achievement trajectories)
  - Emphasize NRT achievement of students in K-2 and in HS content-area courses as the focus of accountability
- **Disaggregate student performance to measure school effectiveness**
  - Students continuously enrolled K-5 or K-8
  - Students enrolled for only complete school years
  - Remaining students enrolled only for portion of school year

Adopt Interdisciplinary Perspectives for K-5 Learning

- **Knowledge-based architectures**
  - *Intelligent tutoring systems* (Luger)
    - Explicit representation of knowledge (e.g., hierarchical concept relationships) distinct from pedagogy
    - Curricular knowledge-base as operational framework for all components of instruction (e.g., Curricular sequencing, teaching/learning activities, assessment re: *Science IDEAS*- use of a knowledge-based architecture)
  - *Related approaches to applied knowledge representation and curriculum*
    - Novak & Canas: Propositional concept mapping as knowledge representation
    - Sowa; Dillon & Tan: Computer-oriented representation of conceptual knowledge (Conceptual graphs, Object-oriented conceptual modeling)
    - TIMSS (Schmidt et al.): Importance of conceptual, coherent, grade-articulated curricular structure

Adopt Interdisciplinary Perspectives for K-5 Learning

- **Cognitive-science research perspectives**
  - Bransford et al. (How People Learn- Chapters 1 2 3): *Science IDEAS*-emphasis on cumulative organization/access of knowledge in learning and applications
  - Kintsch et al.: Interaction of prior knowledge, cohesiveness of instructional media (e.g., text or non-text learning experiences)
- **Knowledge-oriented learning models**
  - Anderson et al.: Research-based instructional dynamics re: meaningful learning
  - Sidman et al. Inferential transfer of learning
- **Instructional design/Systems engineering models**
  - Dick et al. (e.g., Gagne): Systems engineering of educational applications
  - Engelmann & Carnine: Instructional design/development
  - Posner et al.: Optimal scheduling of cumulative review

Use Scale-Up as Framework for Policy Change

- **General Perspectives on Scale Up**
  - **Intervention Evolution**
    - Initiation
    - Sustainability (as implementation control capacity)
    - Expansion
  - **Systemic Multi-Phase Scale-Up Sequence**
    - Capacity development- Building specialized expertise for implementation support
    - Organizational infrastructure- Building capacity to manage intervention
    - Added value- Map intervention as enhancement of district value structure
    - Transfer of implementation responsibility- Process through which external support resources develop capacity, organizational infrastructure to the levels that allows implementation by district

Use Scale-Up as Framework for Policy Change

- **Major Science IDEAS Scale Up Initiative -** Building School Capacity and Infrastructure for Sustainability and Expansion
  - Specialized Teacher Expertise
    - Development of science content understanding
    - Classroom implementation of Science IDEAS model
  - Teacher Leadership Cohort
    - Serves as in-school mentors and problem solvers
    - Organizes and delivers summer professional development institutes
    - Serves on school and district curricular committees
  - Principal Leadership for Science IDEAS
    - Support and management of grade level curricular planning
    - Monitoring and reporting implementation fidelity
  - District Management Capacity and Infrastructure for Science IDEAS
    - Computer-based systems for monitoring implementation status / fidelity
    - Directing observation of Science IDEAS classrooms and professional development on sampling basis
    - Requiring principals new to school to support Science IDEAS

Use Scale-Up as Framework for Policy Change

- **Major Science IDEAS Scale Up Initiative -** Establishing the "Added Value" Necessary for Sustainability and Expansion
  - "Added Value" as a Concept in Scale-Up - Evidence that an intervention addresses and raises the quality of instructional, curricular, and leadership components valued by school district
  - Categories of "Added Value" addressed by project (and research evidence)
    - School "grades" (Florida accountability status – All project schools have maintained or increased to an "A" rating.)
    - Achievement trends (Project schools have positive trends on FCAT reading, writing, science tests)
    - Classroom observation by area and district-level administrators (PD, classrooms, student work, student interviews)
    - Teacher-reported scenarios showing in-depth student understanding
    - Involvement of parents in student-focused school meetings

Use Scale-Up as Framework for Policy Change

- **Major Science IDEAS Scale Up Initiative –** (continued…)
  - Examples of "value-oriented" evidence from observing Science IDEAS classrooms (sample)
    - Students
      - Motivated and engaged in learning tasks
      - Clear evidence of high quality work by all students
      - Display of high level of relevant background knowledge which is applied to new learning tasks
      - Enjoy reading as much as they enjoy "doing" science
    - Teachers
      - Confidence in applying the Science IDEAS Model
      - Increased expectations about what all students can achieve
      - Active engagement in curricular planning with peers at and across grade levels
      - Encourage more in-depth classroom discussions
      - Recognize the potential of the model to engender the in-depth understanding that supports reading comprehension

Implications for Curricular School Reform

- **For Grades K-5 - Elementary**
  - Increase allocated instructional time for cumulative, in-depth, content area learning (to develop capacity for meaningful comprehension)
  - Adopt content-area instructional models that are consistent with a knowledge-based approach (including use of grade-articulated, core concept, curriculum frameworks)
  - Integrate reading comprehension and writing within content-area curricula (science, social studies) in K-5
  - Focus professional development on insuring K-5 teachers have in-depth understanding of the content-areas they are to teach

Implications for Curricular School Reform

- **For Grades 6-12 - Secondary**
  - Adopt instructional models that are consistent with a knowledge-based approach (including use of core concept curricular frameworks for content-area courses that build in-depth understanding)
  - Explicate the prerequisite content-area understanding that students need to transition successfully from grade 5 to grades 6-8 and from grade 8 to grades 9-12 (i.e., develop articulated curricular focus that insures prior-knowledge development in grades K-5 and grades 6-8)

Priorities in Support of Curricular Policy Research

- **Investigating Interdisciplinary Research Perspectives** - Integrate and apply interdisciplinary consensus research to problems of meaningful, cumulative learning in science across grade levels.
- **Approaching Reading Comprehension as a Special Case of Meaningful Content-Area Comprehension** – Interpret reading comprehension problems in terms of general comprehension dynamics (e.g., organization of accessible prior knowledge, cohesiveness of text and non-text learning environments rather than as "skill" deficiencies).
- **Designing Research-Based School Applications from an Instructional Systems Perspective** - Engineer development of scale-up capacity for curricular design, validation, implementation, and management for instructional innovations that have potential systemic (policy) impact.
- **Developing Longitudinal, Multi-Grade, Cumulative Achievement Trajectories as a Framework for Decision-Making in School Reform –** Establish systemic K-12 perspectives for evaluating cumulative success of school reform.

Toward a Curricular Policy for Advancing School Reform by Integrating Reading Comprehension within Time-Expanded Science Instruction in Grades K-5

Michael R. Vitale, *East Carolina University*

Nancy R. Romance, *Florida Atlantic University*

Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Philadelphia, March 23, 2010

This research was supported by NSF/IERI (REC 220853) and USDOE/IES (Project R305G04089)