Implications for Science Education Research and Development from the NSF/IERI Science IDEAS Scale-Up Project

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Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Garden Grove, CA
April 20, 2009

This research was supported by NSF/IERI (REC 220853)

Presentation Overview

- **Focus Questions**
  - Intervention effectiveness, methodological challenges
  - Problems with partner districts that limited/threatened project design
  - Intervention “scale-up” and “sustainability” status
  - Generalizability of research resulting from the project
  - Project conclusions:
    - science education research
    - science intervention scale-up
- **Overview of NSF/IERI Science IDEAS Scale Up Project**
  - General perspectives on scale up
  - Purpose of NSF/IERI project
  - Science IDEAS model
  - Research design (Science IDEAS, Scale-Up)
- **Major Project Findings**
  - Science IDEAS intervention
  - Scale-Up model
- **Implications /Conclusions of the Scale-Up Project**
  - Issues in K-5 curricular policy for increasing time-for-science
  - Issues in the design of scale-up initiatives
  - Summary as answers to specific focus questions

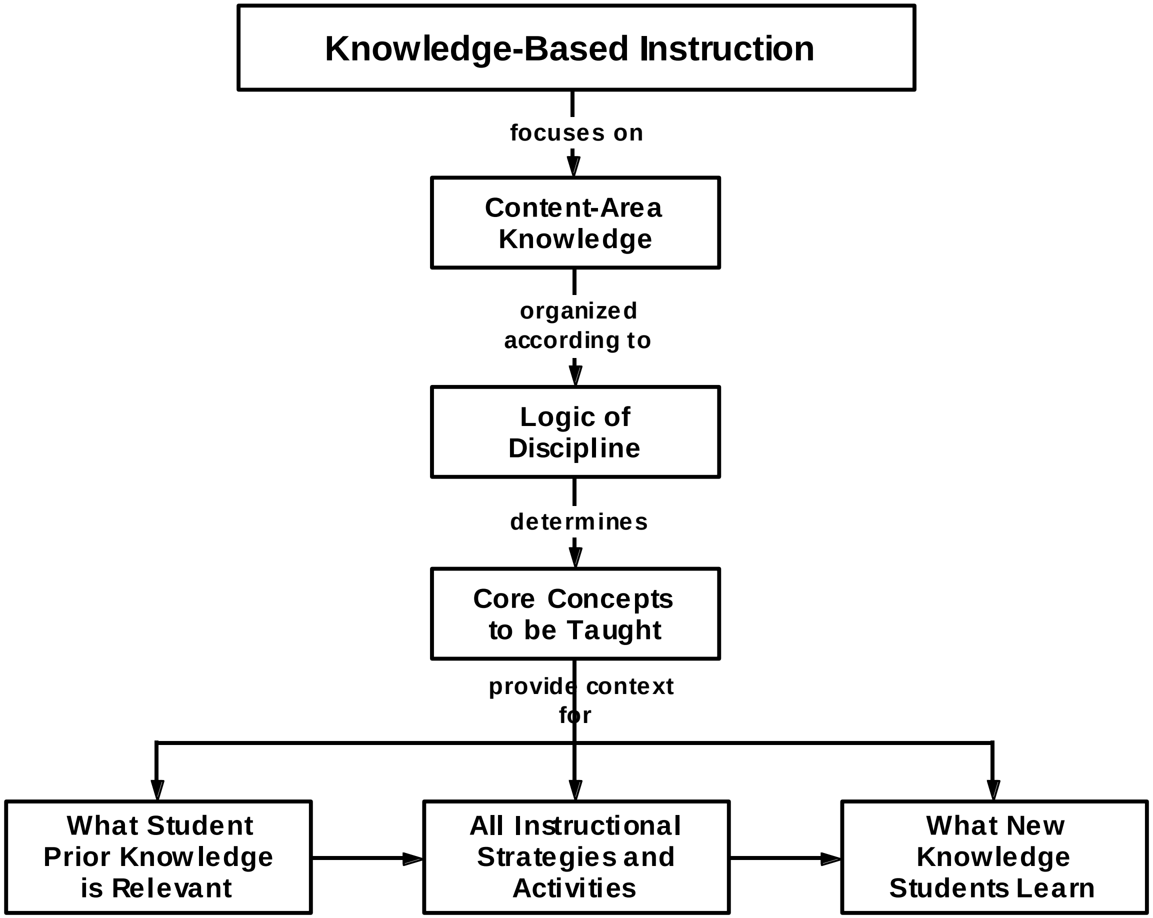
NSF/IERI Science IDEAS Scale Up Project

- **General Perspectives on Scale Up**
  - ***Intervention evolution*** - Initiation, sustainability, expansion
  - ***Multi-phase scale up sequence***- Capacity development, establishing value, organizational infrastructure development, transfer of implementation responsibility (as phased process)
- **Science IDEAS Scale Up Project (NSF/IERI)**
  - ***Project goals*** - Develop / validate a model implementation system for the effective scale-up of *Science IDEAS* that includes all components needed by school systems to assume implementation responsibility for sustainability and expansion in a form that is generalizable to other interventions
  - ***Project operational strategy*** - Provide support necessary to implement *Science IDEAS* in an increasing number of schools (from 2 to 12 schools - in grades 3-5) as a methodology for studying scale-up

Overview of *Science IDEAS* Model

- ***Science IDEAS* Model: Grades 3 4 5**
  - Implemented schoolwide in grades 3 4 5 with phased teacher professional development and classroom support
  - Replaces typical 1½ to 2-hour Reading/Language Arts block with in-depth science lessons which integrate reading comprehension and writing
  - Uses a knowledge-based instructional architecture as an operational framework for selection of “strategies” used in planning concept-oriented, multi-day lessons
    - Science IDEAS *strategies* specify types of learning activities
      - Science Investigation (Hands-On) / Inquiry
      - Reading Comprehension
      - Propositional Concept Mapping
      - Writing Activities and Journaling
      - Application Activities (e.g., Projects)
      - Prior Knowledge / Curricular Review (Within Topic/Unit, Cumulative)
    - Concepts and concept relationships provide a curricular context for all teaching/student activities and assessment (via collaborative teacher grade level planning)
    - Curricular review occurs naturally across multi-day lessons and is augmented by explicit strategy/scheduling

Overview of *Science IDEAS* Model



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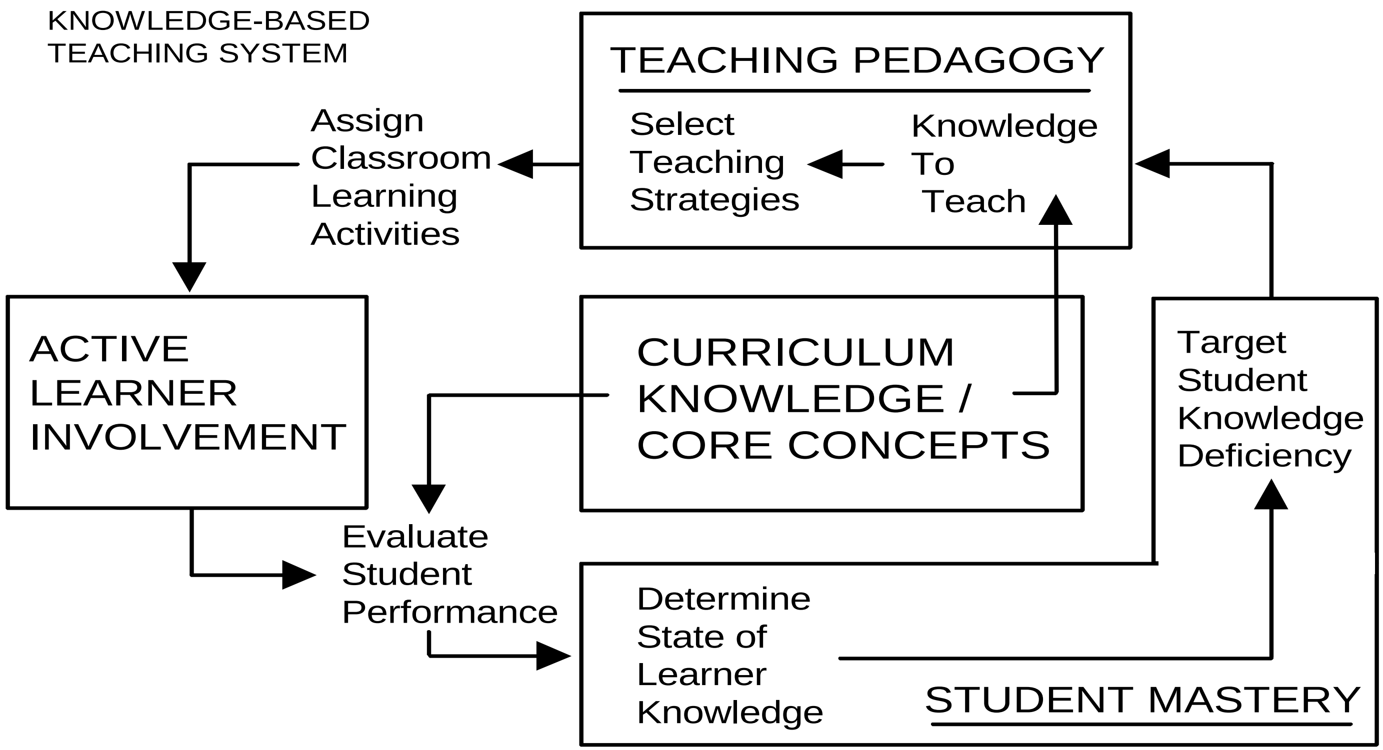
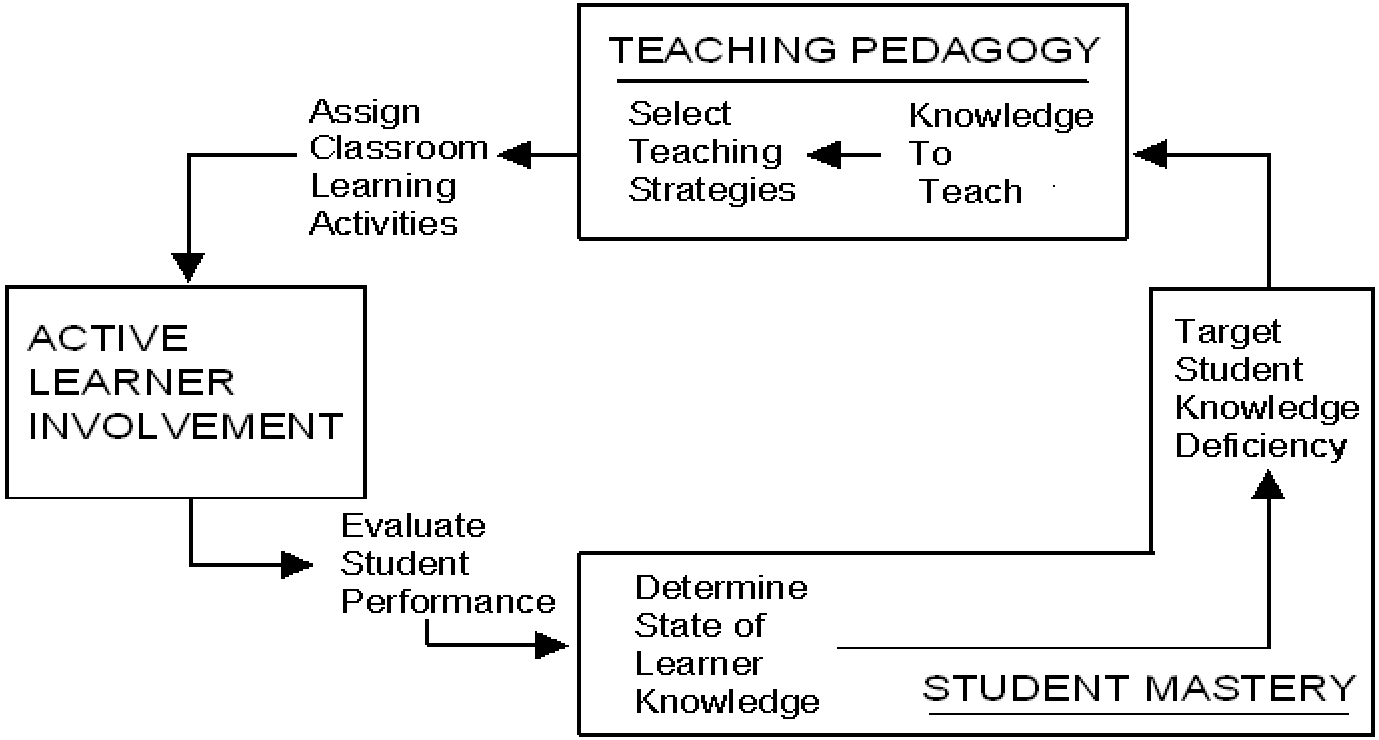
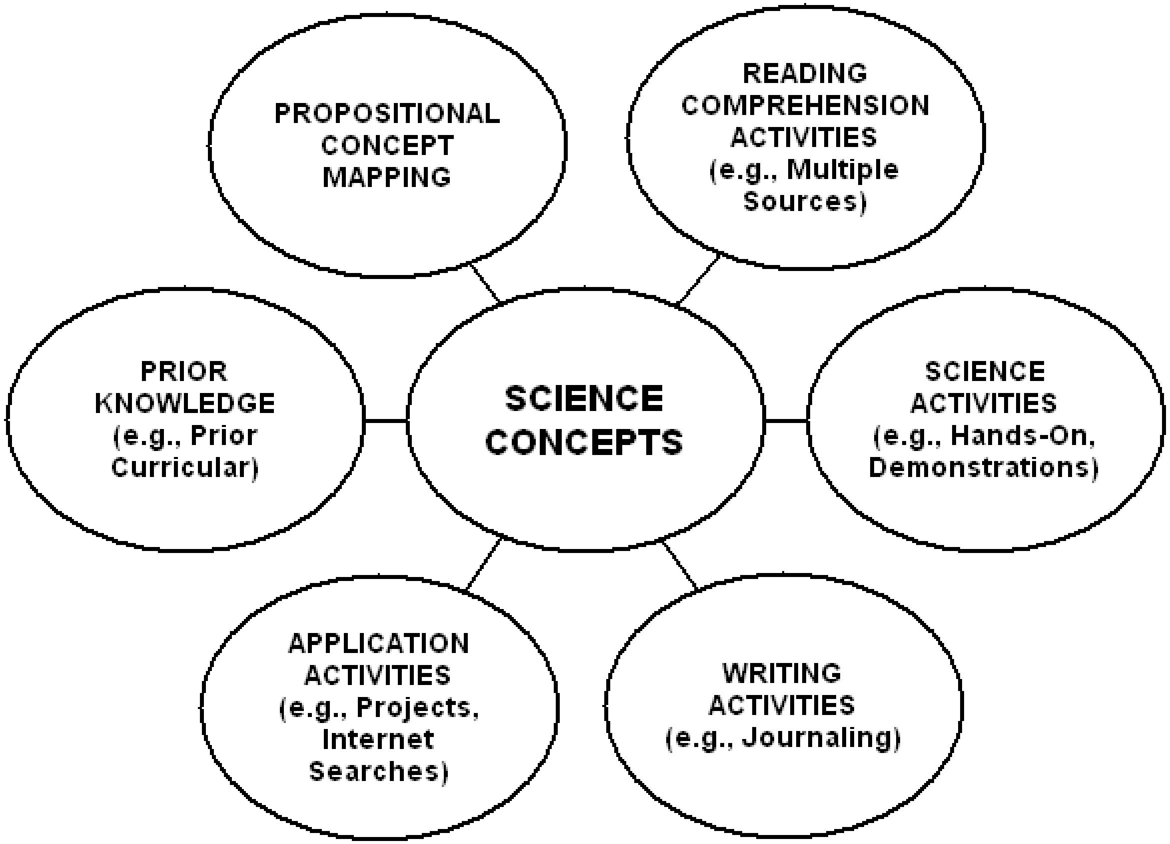


Instruction Operating as a "Content Free" Process
(vs. Knowledge-Based Instruction)



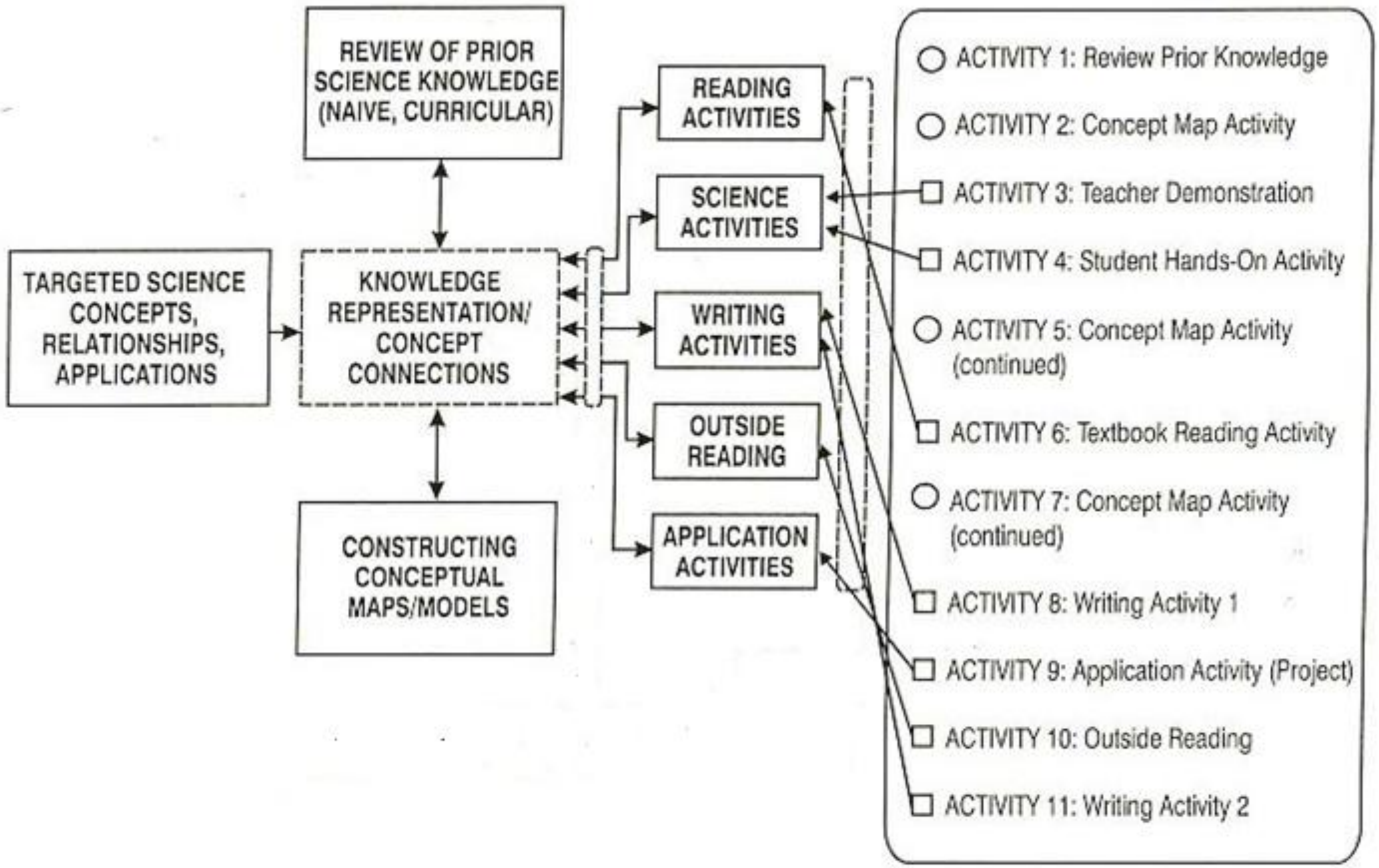
Overview of *Science IDEAS* Model



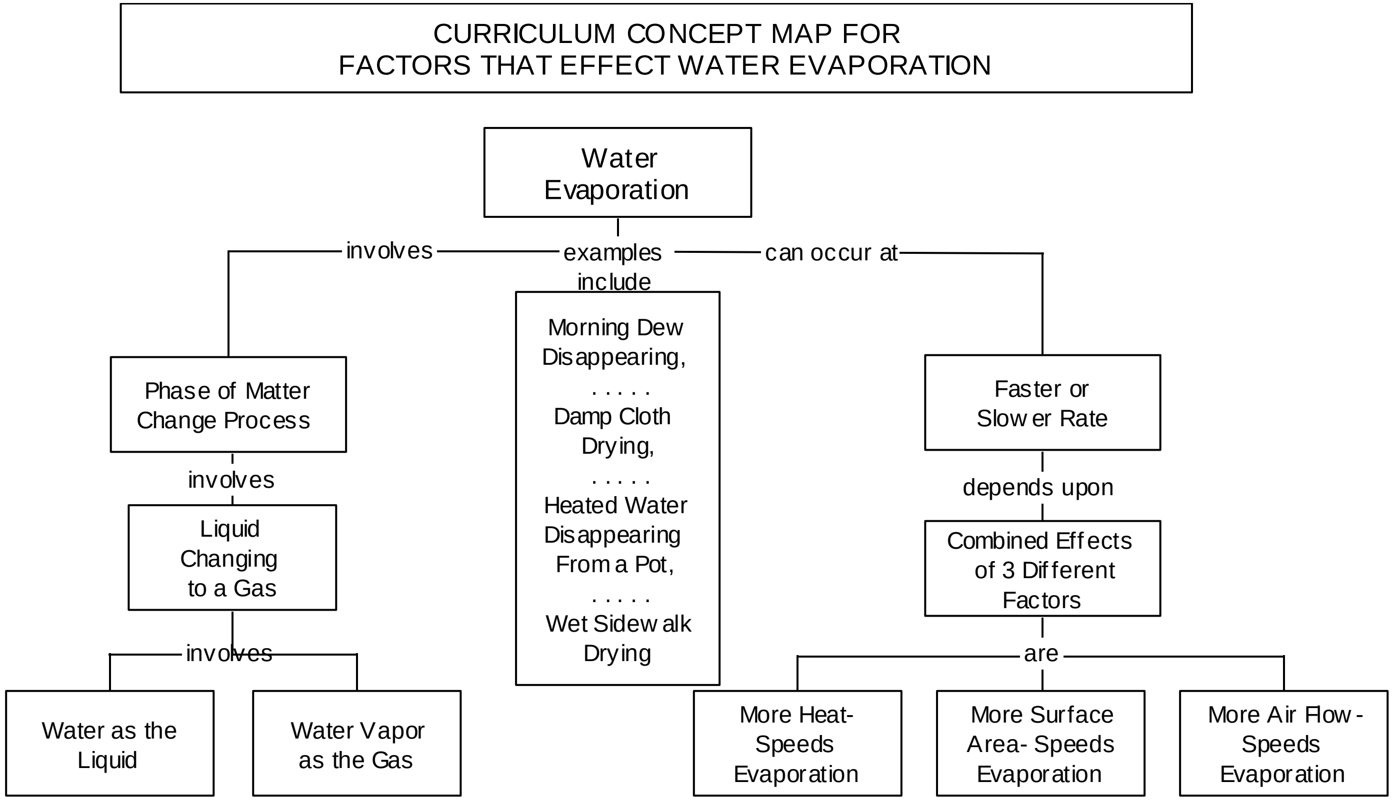
Overview of *Science IDEAS* Model

- **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

Architecture of the *Science IDEAS* Model



Curricular Concept Map as Multi-Lesson Framework



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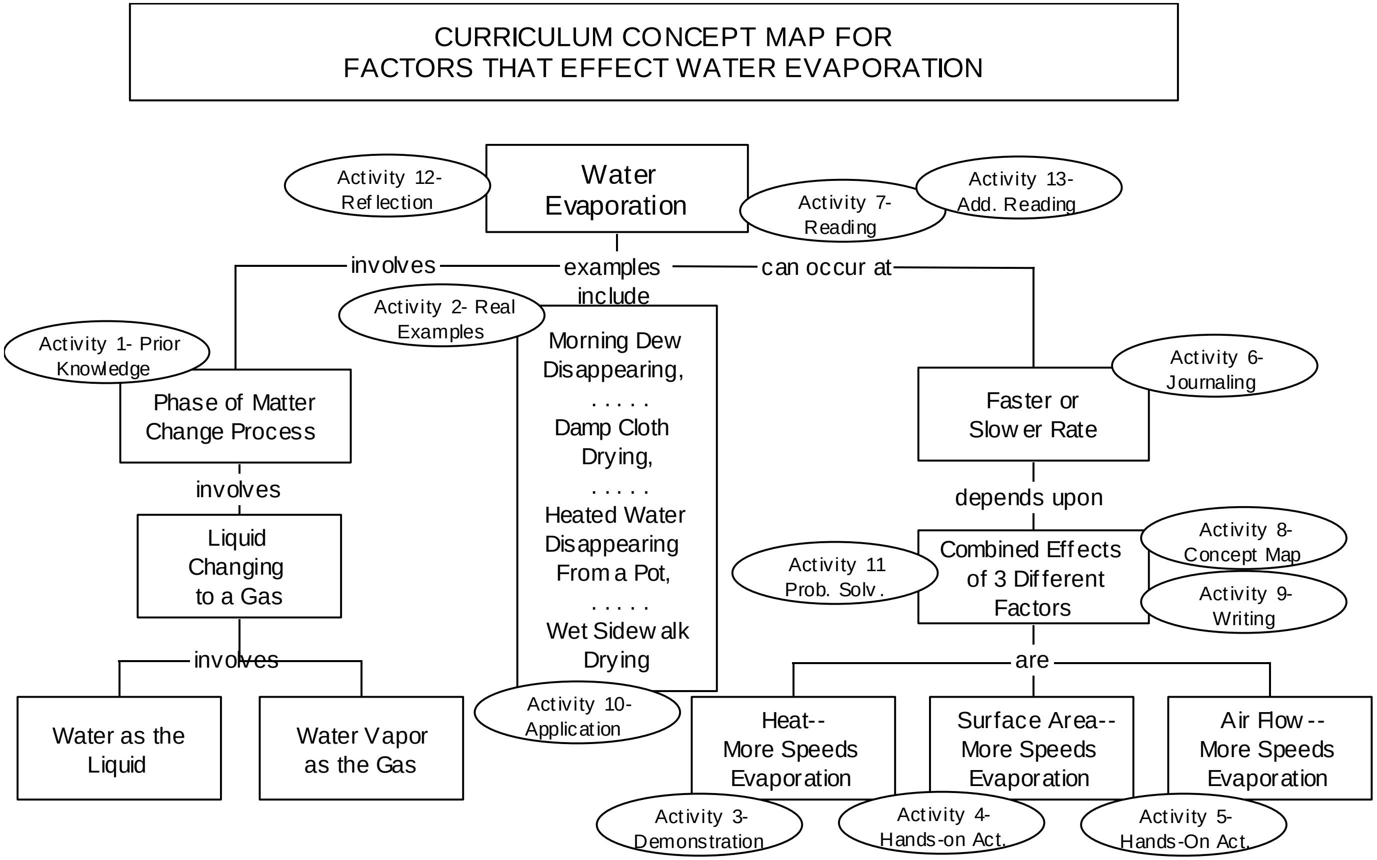
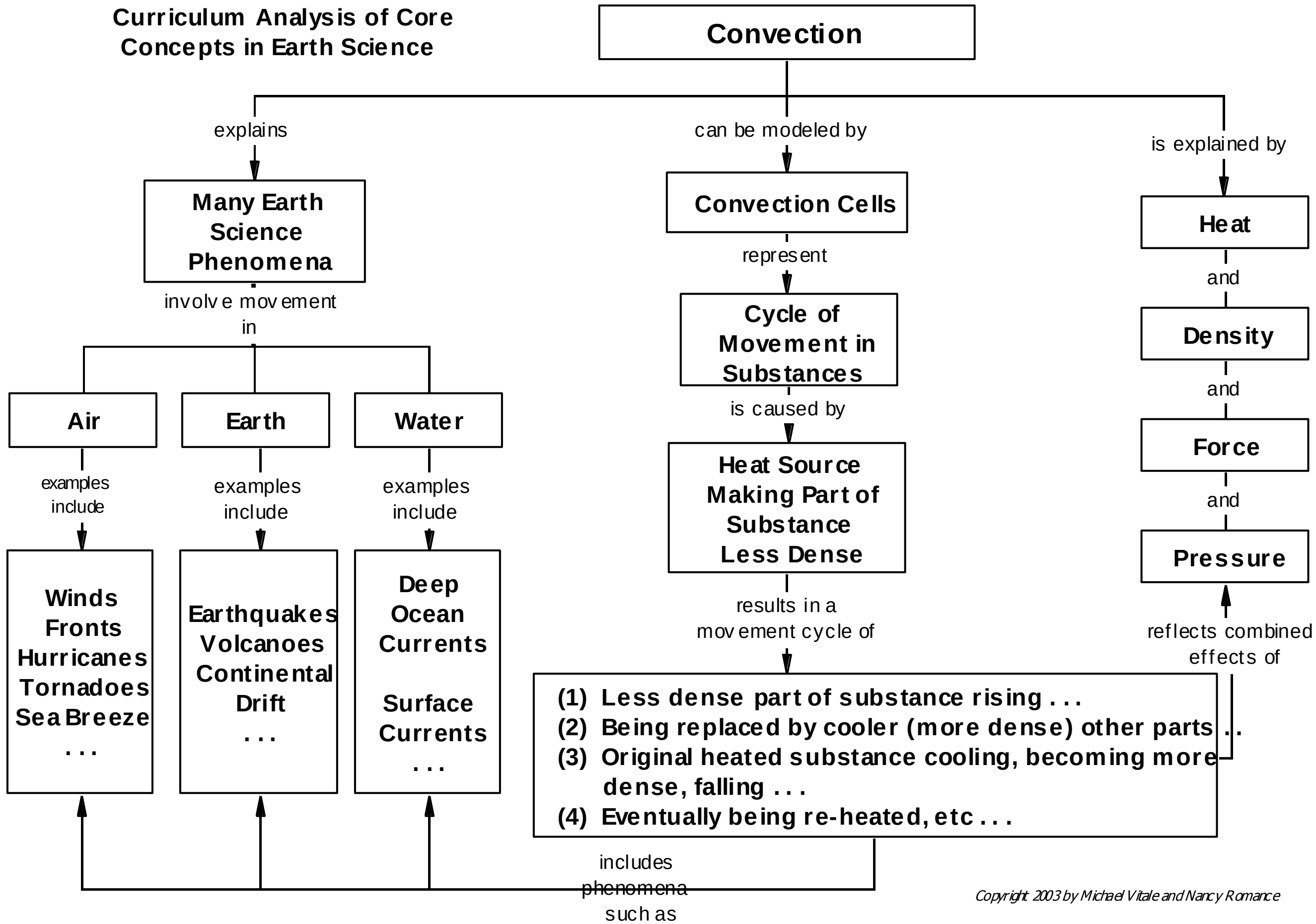


Curricular Concept Map Representing “Big Ideas”

Curriculum Analysis of Core Concepts in Earth Science



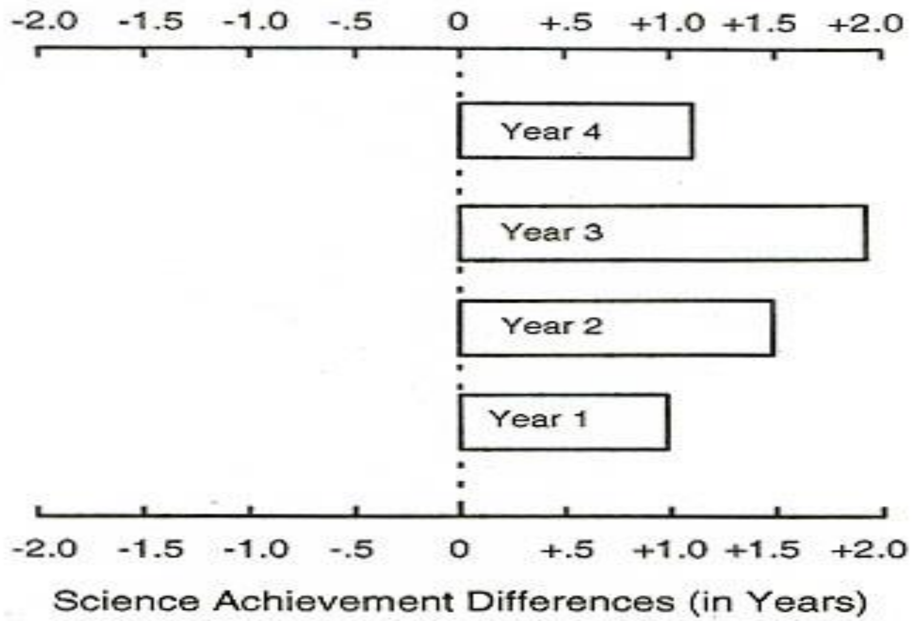
Science IDEAS: Prior Pattern of Research Evidence

- **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: Prior Pattern of Research Evidence

- **Research Findings for Science Achievement: 1992-2001**

Science IDEAS: Multi-Year Findings (MAT Science)

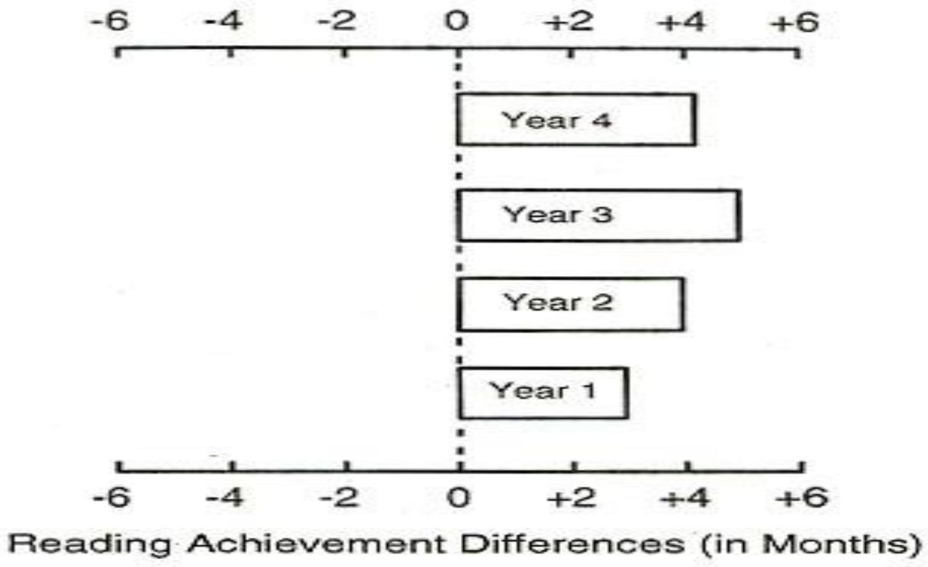


Note-- Year 1 students = grade 4; average/above average
Year 2 students = grade 4; average/above average
Year 3 students = grades 4,5; at-risk
Year 4 students = grades 4,5; average/above average/at-risk

Science IDEAS: Prior Pattern of Research Evidence

- **Research Findings for Reading Achievement: 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

Note on Science IDEAS and Reading Comprehension
(A Knowledge-Based Perspective)

- Knowledge to be learned provides a coherent framework for all instruction and assessment
- Coherent framework of learning tasks/activities across range of meaningful settings provides cumulative learning experiences for student comprehension (e.g., concept understanding / application)
- Continuing organization and access of prior conceptual knowledge by students across multiple learning tasks provides a continuing foundation for new learning (i.e., comprehension) as a form of expertise
- Reading comprehension is addressed as a special case of general meaningful comprehension
- Effectively integrating reading / writing within science has implications for changing K-5 curricular policy to increase time for science

NSF/IERI Science IDEAS Scale Up Study

- **Project Research Design (1): Science IDEAS Implementation**
  - Implement model in increasing number of schools (from N=2 to N=12) in grades 3-4-5
  - Provide necessary multi-year implementation support
    - Teacher support
      - PD focus on science knowledge, classroom model implementation
      - Grade-level planning and problem solving
    - Principal support (e.g., general planning, resource acquisition, instructional leadership)
  - Obtain longitudinal data from project and control schools
    - Student achievement: grades 3-8 (ITBS Reading/Science)
    - PD evaluation / classroom implementation fidelity monitoring

NSF/IERI Science IDEAS Scale Up Study

- **Project Research Design (2): Research / Development on Scale-Up**
  - **Explicit implementation requirements**
    - Classroom Level
      - Science taught daily during an uninterrupted 1 ½ - 2 hour time bock
      - Language arts (using literary genre) taught for 30 minutes daily
      - Students not pulled from class during the Science IDEAS block
      - Students maintain science journals
      - Classrooms have science texts, non-fiction reading materials, resources for hands-on activities
      - Classroom/school display of teacher and student work (e.g., unit concept maps; writing from visuals)
      - No other major school initiatives for 3 years
    - School Level (Principal)
      - Master schedule ensuring fidelity to time requirements
      - Establishment of School Science IDEAS Committee
      - Support for in-year teacher professional development
      - Organization/facilitation of grade level planning for all 9-week units
      - Monitoring and reporting of classroom implementation
      - Supporting use of school / classrooms as “model” sites for visitors

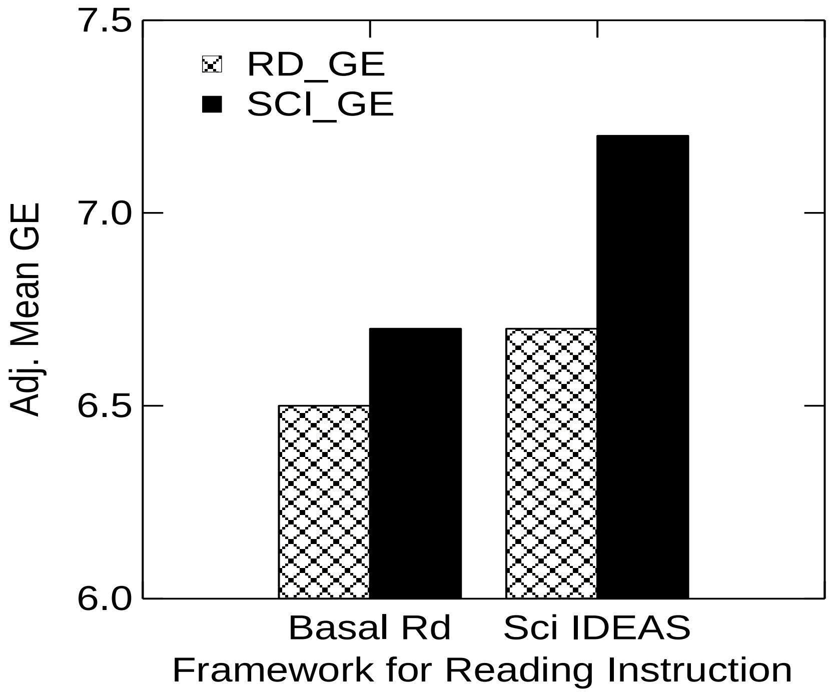
NSF/IERI Science IDEAS Scale Up Study

- **Project Research Design (2): Research / Development on Scale-Up (Continued)**
  - **Specific requirements for successful scale-up (e.g., initiation, sustainability, expansion)**
    - School capacity development
      - Leadership training enabling Science IDEAS teachers to provide intra-school classroom support and professional development
      - Initial design of Science IDEAS web-site to provide resources for Science IDEAS teachers
    - Organizational infrastructure development (for top-down management)
      - Implementation status monitoring
        - » Classroom level/teachers (e.g., strategy use, implementation fidelity)
        - » School level/principal (e.g., scheduling, pull-outs, grade level planning)
      - Achievement trends for science and reading
  - **Identification of (and response to) barriers to use of multi-phase model for scale up**

NSF/IERI Project Findings: Science IDEAS Intervention

- **Interim Student Achievement Findings**
  - Grades 4 5: Student achievement in <u>Science</u> and <u>Reading</u>

2003-2004 ITBS Achievement Outcomes

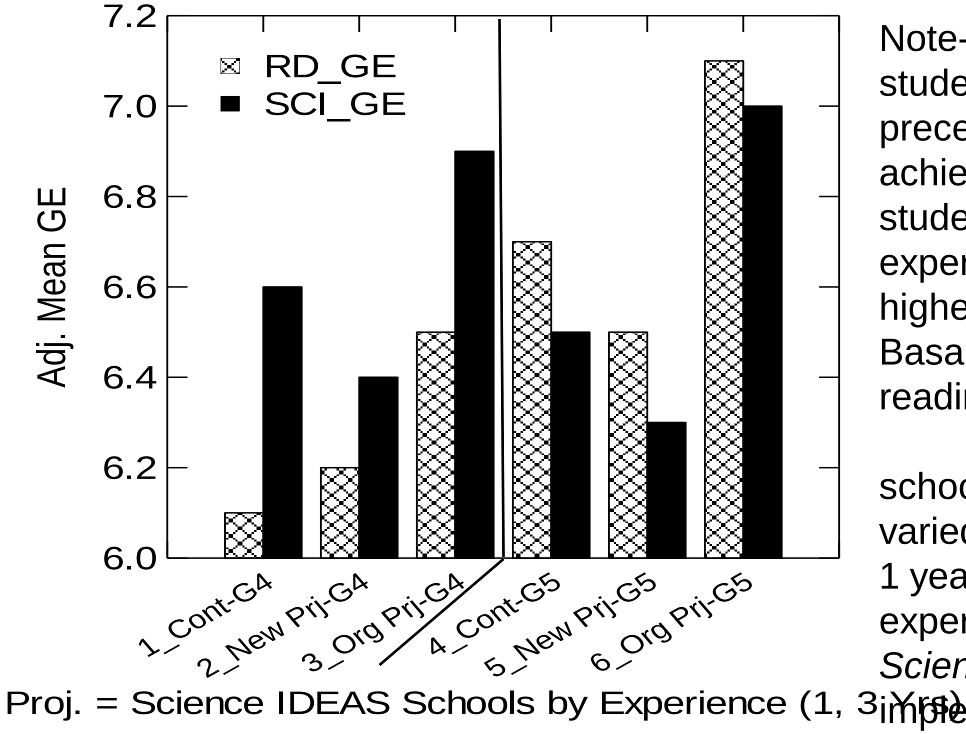


Note- Shown are differences in *adjusted grade equivalent means* on ITBS Reading and Science for grade 4-5 Science IDEAS and Basal Reading classrooms. After statistically equating students for differences on the preceding years FCAT Reading achievement, Science IDEAS students displayed significantly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

NSF/IERI Project Findings: Science IDEAS Intervention

- **Interim Student Achievement Findings**
  - Grades 4 5: Student achievement in Science and Reading

2004-2005 ITBS Achievement Outcomes



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.

NSF/IERI Project Findings: Science IDEAS Intervention

- **Interim Student Achievement Findings: 2006-2007**
  - 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	12	60	46
Control	12	60	45

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

NSF/IERI Project Findings: Science IDEAS Intervention

- **Interim Student Achievement Findings: 2006-2007**
  - Grades 3 - 8: Student achievement in <u>Science</u> and <u>Reading</u>

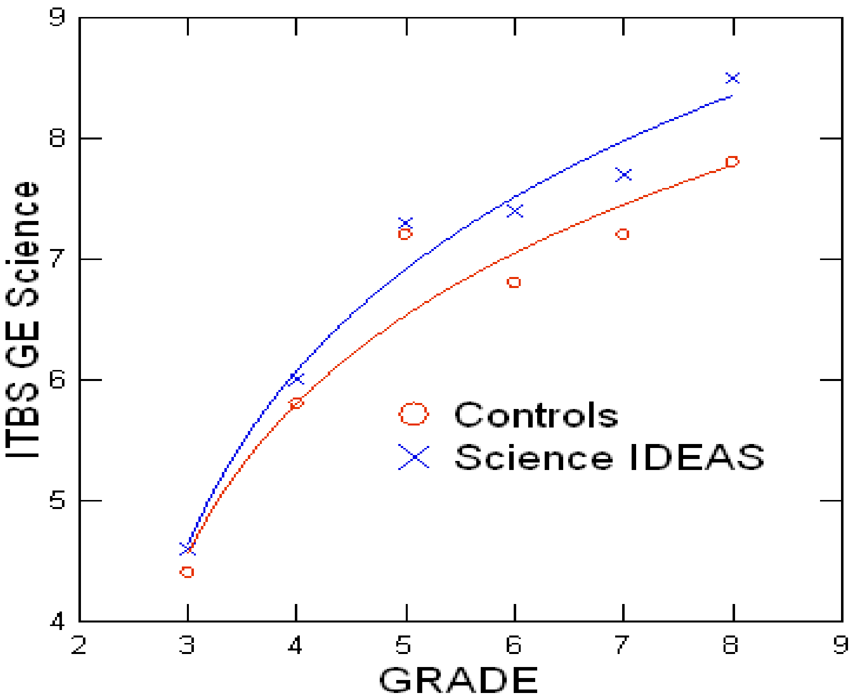
2006-2007 ITBS Achievement Outcomes

- 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 Science (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

NSF/IERI Project Findings: Science IDEAS Intervention

- **Interim Student Achievement Findings: 2006-2007**
  - Grades 3 - 8: Student achievement in <u>Science</u>

2006-2007 ITBS Achievement Trajectories

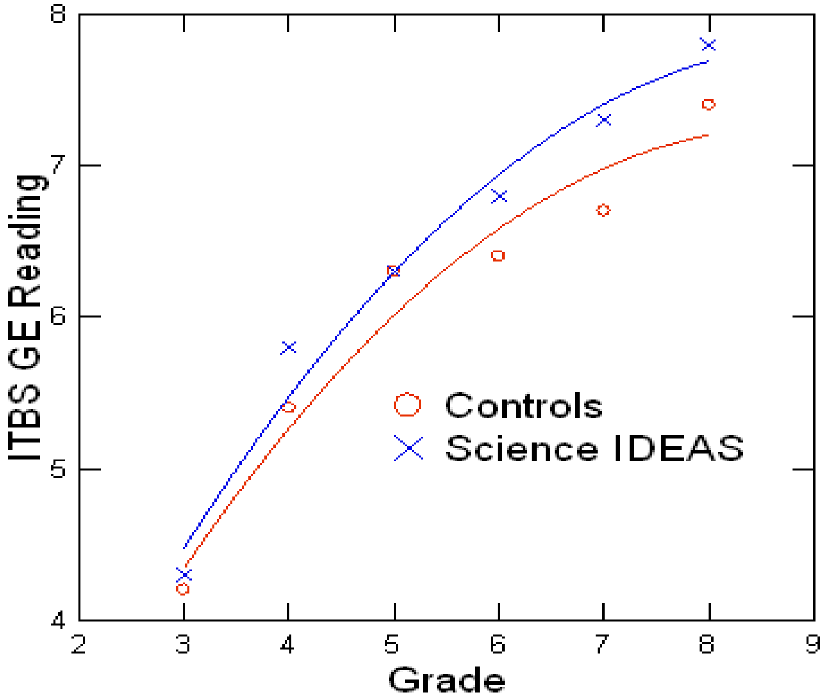


Note- Figure shows adjusted GE means on the ITBS Science subtest for the Science IDEAS and Control students by Grade Level. Covariates were Gender and At-Risk status. Difference between Science IDEAS and Control students was significant, F(1, 6457) = 18.8, p > .001, as was the Treatment x Grade Interaction,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

NSF/IERI Project Findings: Science IDEAS Intervention

- **Interim Student Achievement Findings: 2006-2007**
  - 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, $F(5, 7145) = 24.14$, $p < .001$.

NSF/IERI Project Findings: Science IDEAS Intervention

- **Interim Student Achievement Findings**
  - Mini-Study in Grade 5- Exploring Instructional Context-Dependency of Reading Comprehension Strategy Effectiveness
    - Results - Science IDEAS (vs. Basal) obtained significantly higher achievement in Reading and Science (ITBS)
      - Instructional Treatment main effects (Adjusted GE)
        - » ITBS Science (*Science IDEAS*: +.42 GE)
        - » ITBS Reading (*Science IDEAS*: +.38 GE)
      - Main effect of Reading Comprehension Strategy Use not significant. However the interaction between Instruction and Reading Strategy use was significant

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

NSF/IERI Project Findings: Science IDEAS Intervention

- **Interim Student Achievement Findings**
  - Mini-Study in Grade K-2 - (Data are for Grade K-1 and Grade 1-2 students only)
    - Results - Science IDEAS obtained significantly higher achievement in reading and science (ITBS)
      - Treatment main effects (Adjusted GE)
        - » ITBS Science (*Science IDEAS*: +.28 GE)
        - » ITBS Reading (*Science IDEAS*: +.41 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 in science showed magnified effect of treatment in Grade 1-2 (*Science IDEAS*: + .72 GE*),* no effect in Grade K-1)
    - Study conclusion: In-depth science instruction representing adaptation of Science IDEAS model could be feasible and effective in primary grades.

NSF/IERI Project Findings: Scale-Up Model

- **Criteria Addressing Scale-Up Feasibility of the Science IDEAS Model**

Grades K-2 and 3 4 5: *Evaluation of Professional Development (PD) by Teacher Leadership Cadre: 2005 - 2007*

PD Institute	2005	2006	2007
Grades 3-4-5 Level I (10 Day Institute)			
Mean Evaluation Ratings	3.65	3.63	3.54
Teacher Science Knowledge			
Science Pre-Test	45%	48%	49%
Science Post-Test	88%	92%	86%
K-2 (3 Day Institute)	NA	3.59	3.43

Note. Evaluation ratings expressed on a 1 (negative) - 4 (positive) scale.

NSF/IERI Project Findings: Scale-Up Model

- **Criteria Addressing Scale-Up Feasibility of the Science IDEAS Model**

Grades 3 4 5: *Instructional Implementation Fidelity Characteristics of Science IDEAS Classrooms in 2006-2007*

Characteristic	Grade 3	Grade 4	Grade 5
<u>Classroom Mean</u>			
Minutes Scheduled Daily	101	104	108
Minutes Taught Daily	83	85	93
<u>Pct. Classrooms Teaching Science IDEAS Daily</u>			
120 Minutes (or More)	30%	26%	34%
Between 90 - 120 Minutes	58%	61%	68%

Note. N classroom observations = 247

NSF/IERI Project Findings: Scale-Up Model

- **Criteria Addressing Scale-Up Feasibility of the Science IDEAS Model**

Grades 3 4 5: *Mean Instructional Implementation Fidelity Characteristics of Science IDEAS Classrooms in 2006-2007*

Characteristic	Grade 3	Grade 4	Grade 5
Classroom Fidelity Ratings (Scale: 0 1 2 3)	2.02	1.97	1.92
Pull-Outs (Per Week)	8.2	6.9	6.3
Classroom Displays (Scale 0-2 = Good)	1.7	1.8	1.6
Classroom Affect (Scale 1-4=Positive)	3.9	3.9	4.0

Note. N classrooms observed = 247

NSF/IERI Project Findings: Scale-Up Model

- **Criteria Addressing Scale-Up Feasibility of the Science IDEAS Model**

  Grades 3 4 5: *Percent of Teachers Implementing Science IDEAS with Fidelity by Grade 3-4-5 for 2006-2007 Academic Year*

Fidelity Rating	Grade 3	Grade 4	Grade 5
0 (No Implementation)	5	2	4
1 (Partial Implementation)	17	20	24
2 (Implementation with Fidelity)	42	49	42
3 (Outstanding Implementation)	36	28	30

Note 1. N of teacher observations by project staff = 271

Note 2. Reliability estimates (percent of categorical rater agreement) ranged from .65-.80.

NSF/IERI Project Findings: Scale-Up Model

- **Perspectives on Basic Elements of the Scale-Up Model**
  - **Systemic capacity development issues for sustainability / expansion successfully addressed**
    - Specialized teacher expertise
      - Science concept understanding
      - Science IDEAS implementation
    - Teacher leadership cohort
      - Delivered PD series to new schools/teachers
      - Provided in-house school support for new teachers
      - Leadership (with principal) in grade level planning for multi-day lessons/cumulative review
      - Established Science IDEAS school committee
      - Provided support to new schools
    - Principal leadership
      - Developed and field-tested principal-implemented fidelity process
      - Developed “talking points” for Science IDEAS model as overall school priority

NSF/IERI Project Findings: Scale-Up Model

- **Perspectives on Basic Elements of the Scale-Up Model**
  - **Systemic capacity development issues for sustainability / expansion successfully addressed (Continued)**
    - Development of "model" school sites as basis for expansion
      - "Strong" implementation of Science IDEAS model in multiple schools
      - Served as reference sites for schools considering adoption of model
      - Provided evidence of feasibility of model application
      - Strengthened evidence of effect of model on student achievement
      - Adapted Science IDEAS model to K-2 (modified 45 minute/day) to strengthen overall schoolwide priority

NSF/IERI Project Findings: Scale-Up Model

- **Model Refinements via "Lessons Learned" Through Scale-Up Initiative**
  - **Operational standards for developing elements of effective scale up model as "reverse-engineered" Instructional Systems Design (ISD) with "value-added" facet**
    - Use of ISD for start-up, sustainability, expansion requirements
    - Use of ISD for identifying areas for capacity development
    - Development of systemic "value" components that support intervention
  - **Distinguishing (and addressing) two complementary perspectives for scale-up design**
    - <u>Bottom up</u> (e.g., For researchers who want to scale-up an intervention, what are the requirements for optimal fidelity of implementation)
    - <u>Top down</u> (e.g., For superintendents who want to implement an intervention Districtwide, what process should be followed and what tools are necessary to accomplish this goal)

NSF/IERI Project Findings: Scale-Up Model

- **Model Refinements via "Lessons Learned" Through Scale-Up Initiative**
  - **Insure dynamic scale-up initiative keeps within scope of available implementation support**
    - Maintain resource capability for all project commitments (e.g., PD, classroom support, implementation monitoring, communication of implementation status to school participants and central administrators)
    - Build capacity development of participants as a necessary foundation for expanding scope of intervention
  - **Develop and implement explicit plans for establishing systemic value of intervention as basis for sustainability, future expansion**
    - Identify and communicate with appropriate school / district personnel on a continuing basis
    - Work to establish the relevance / contribution of intervention to school / district systemic value structure

NSF/IERI Project Findings: Scale-Up Model

- **Model Refinements and "Lessons Learned" Through Project Scale-Up Initiative**
  - **Web-based teacher support tools (in progress)**
    - Science curriculum framework linking standards with instructional content: Grades K-5
    - Video modeling of Science IDEAS instructional strategies
    - Support for teacher multi-day lesson planning
    - Provide access to Science IDEAS instructional resources
    - Support for teacher collaboration / planning / sharing
    - Classroom tool for assessing mastery of science concepts
  - **Web-based scale-up management-support tools (in progress)**
    - Implementation planning tool
      - Consists of operational framework for specifying scale-up tasks linked to timelines over 3-year period
        - » Science IDEAS implementation
        - » Systemic capacity development
      - Supports monitoring of planning task completion

NSF/IERI Project Findings: Scale-Up Model

- **Model Refinements and "Lessons Learned" Through Project Scale-Up Initiative**
  - **Web-based scale-up management-support tools (in progress)**
    - Instructional implementation management tool (for central administrators)
      - School reported implementation data re: time scheduled, pull-outs, % time spent reading, implementation fidelity by classroom/teacher/grade/school
      - Report Structure- Implementation status description and trends of obtained data within and across years
      - Complementary management strategy for validation of school-reported status data via school visitations

NSF/IERI Project Findings: Scale-Up Model

- **Model Refinements and "Lessons Learned" Through Project Scale-Up Initiative**
  - **Web-based scale-up management-support tools (in progress)**
    - Establishment of longitudinal student achievement trajectories
      - Comparing longitudinal achievement trends of project schools with controls
      - Relating student achievement growth to implementation fidelity
      - Providing capacity for predicting expected improvement in student achievement resulting from school adoption / implementation of model
      - Establishing predictive validity of student success in middle/high school from participation in Science IDEAS model in grades K-5 (vs. controls)

NSF/IERI Project Findings: Scale-Up Model

- **Model Refinements and "Lessons Learned" Through Project Scale-Up Initiative**
  - **Issues reflecting large-scale / multi-year complications**
    - Maintaining ongoing project communication with central administrators, principals, and teachers in the face of changing school personnel/priorities
      - Communication of status of project (e.g., implementation, achievement outcomes)
        - » Person to person dialog
        - » Participants acting as advocates
        - » Regularly updated management reports
      - Communication of status of project (e.g., benefits to students via parent contacts)

NSF/IERI Project Findings: Scale-Up Model

- **Model Refinements and "Lessons Learned" Through Project Scale-Up Initiative**
  - **Issues reflecting large-scale / multi-year complications**
    - Establishment of "added value" of project re: advancing district systemic goals to central school administrators, principals, teachers, parents
      - Encouragement of direct classroom visits/observation (e.g., student engagement, learning performance, interest, cumulative learning)
      - Teacher-reported scenarios (e.g., student behaviors demonstrating in-depth science understanding in classroom/out-of-school settings)
      - Student "take-homes" to parents (e.g., share / explain work completed)
      - Hard data / data projections (e.g., achievement outcomes / projections re: District priority achievement outcomes)
      - Management reports addressing systemic priorities (e.g., preparing students for success in high school)

Implications of Science IDEAS Scale-Up Project

- **Implications for science education research and practice**
  - Use integration of reading in science as basis for advocating increased time for science in grades K-5
    - To increase student reading comprehension proficiency
    - To prepare students for future success in secondary science
  - Pursue interdisciplinary research perspectives for addressing the problem of meaningful, cumulative, learning in science
- **Implications for scale-up research and practice**
  - Approach design of scale-up initiatives from an instructional systems perspective
  - Design initial (start-up) phase of scale-up initiatives in a manner that includes all of the elements required for subsequent expansion
  - Insure that the design of a scale-up model provides for the evolution of the implementation and sustainability of the intervention without the active involvement of the research initiator(s)
  - Make the establishment of the “added value” of the intervention a high-priority element of the overall scale-up initiative

Summary as Answers to Specific Focus Questions

- **Intervention effectiveness, methodological challenges**
  - Science IDEAS was effective in accelerating science and reading achievement in grades 3-4-5 and in impacting subsequent science and reading achievement in grades 6-7-8
  - Major methodological challenge was developing a scale-up model that linked a research intervention to a subsequent scale up initiative
- **Problems with partner districts that limited/threatened project design**
  - Implementation of a small paradigmatically different research initiative in large districts requires potential conflicts with districtwide policy and initiatives to be resolved
  - Continuing personnel changes in central administrators and principals require substantial communication attention
  - Local district pressures for schools to allocate extensive instructional time to preparation for State accountability tests impacted Science IDEAS instructional time

Summary as Answers to Specific Focus Questions

- **Intervention “scale-up” and “sustainability” status**
  - Project participating schools increased from 2 to 12 over a 5-year period.

    Present implementation of all participating schools, given limited support the present year:
    - 7 schools are strong or model implementations schoolwide
    - 4 schools are strong, but not 100% schoolwide
    - 1 school was strong, but presently has become inconsistent
    - 2 schools only implemented in very “spotty” fashion

    New schools added 2008-2009 and expected 2009-2010:
    - 1 school- new Science-Mathematics Magnet
    - 1 school- Environmental Center
    - 1 school- low SES with new principal who was in project school
  - Strong vs. weak principal leadership was a major factor in schoolwide implementation of Science IDEAS (but would not be problem with “top-down” implementation)

Summary as Answers to Specific Focus Questions

- **Generalizability of research resulting from the project**
  - Science IDEAS model
    - Consistently effective in improving science and reading achievement
    - Feasible to implement if supported effectively
  - Multi-Phase Scale-Up Model
    - Indications are that scale-up model developed will support the start-up, sustainability, expansion of Science IDEAS
    - ISD scale-up framework and majority of web-based tools (e.g., planning, status monitoring, achievement projections) are generalizable to any instructional intervention in grades K-5

Summary as Answers to Specific Focus Questions

- **Project Conclusions**
  - Science IDEAS model findings
    - Provides basis for increasing time allocated to science in K-5
    - Encourages a greater emphasis on interdisciplinary perspectives in science education research
  - Multi- Phase Scale-up model findings
    - Instructional systems design (ISD) provides a useful framework for engineering comprehensive scale-up initiatives
    - Major criteria for determining scale-up effectiveness are possible to accomplish
      - Consistent replication of achievement outcomes demonstrated in original, controlled research studies
      - Sufficiently robust scale-up models for engendering sustainability / expansion without active involvement of original researchers (i.e., through school-based implementation)

Implications for Science Education Research and Development from the NSF/IERI Science IDEAS Scale-Up Project

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April 20, 2009

This research was supported by NSF/IERI (REC 220853)

(Addendum)

Interdisciplinary Perspectives on Meaningful 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

(Addendum)

Interdisciplinary Perspectives on Meaningful 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
  - Engelmann & Carnine: Instructional design/development
  - Dick et al. (e.g., Gagne): Systems engineering of educational applications
- Curricular review
  - Cepeda et al.: Optimizing distributed practice

(Addendum)

Some Related Perspectives from Research in Literacy Development and Science Education

- *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. (1999; 2000; 2003) –studies using informational texts in primary grades; reading informational genres; 3.6 minutes – scarcity of informational texts in primary

- *Guthrie, Perencevich, et al* (1999; 2000; 2001; 2002; 2003; 2004) – studies using CORI as a model to engender reading comprehension and motivation to learn in content domains

- *Hirsch* (1996; 2001; 2003) – essays on the organization and importance of knowledge in comprehension; situation model

- *McNamara & Kintsch* (1996)-studies focused on text coherence and cohesiveness as factors influencing comprehension

(Addendum)

Some Related Perspectives from Research in Literacy Development and Science Education

- *Palincsar & Magnussom* (2002; 2003; 2004)- studies addressing the role of first and second hand investigations on science learning and literacy

- *Pearson & Duke* (2002)- studies addressing use of informational text for building reading 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

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