Lesson Study (Jugyokenkyuu) and Science Education:

A NATURAL AFFINITY

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Chicago Lesson Study Group

Abstract

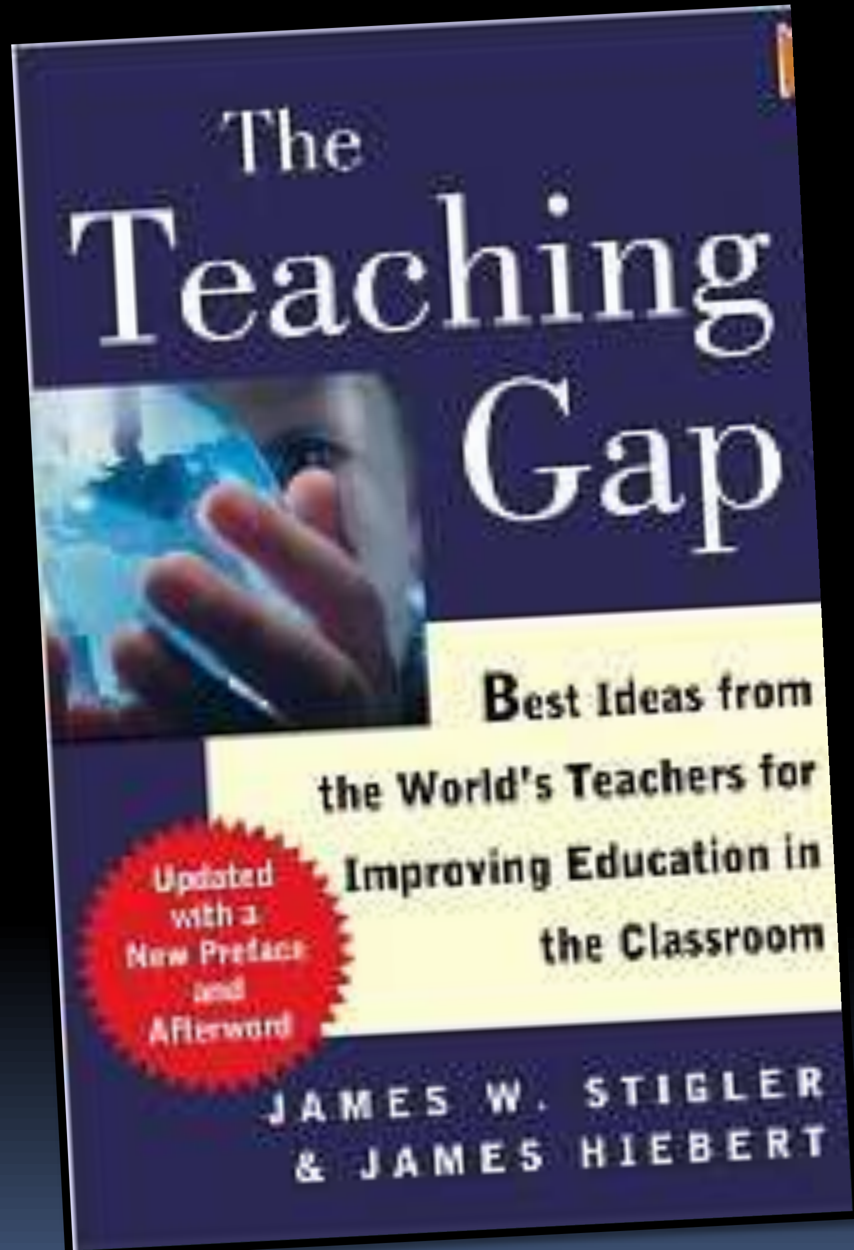
We find remarkable compatibility when we compare some well-established priorities of science education against distinctive features of lesson study. Among the most evident are: an inquiry orientation, collaboration and teamwork, reliance on evidence, and promotion of scientific habits of mind. In this session, we will examine this *natural affinity* and discuss exciting implications for science teaching and learning. Experiences of the Chicago Lesson Study Group will illustrate the promising potential for coherent integration of lesson study in our own science education programs.

Agenda

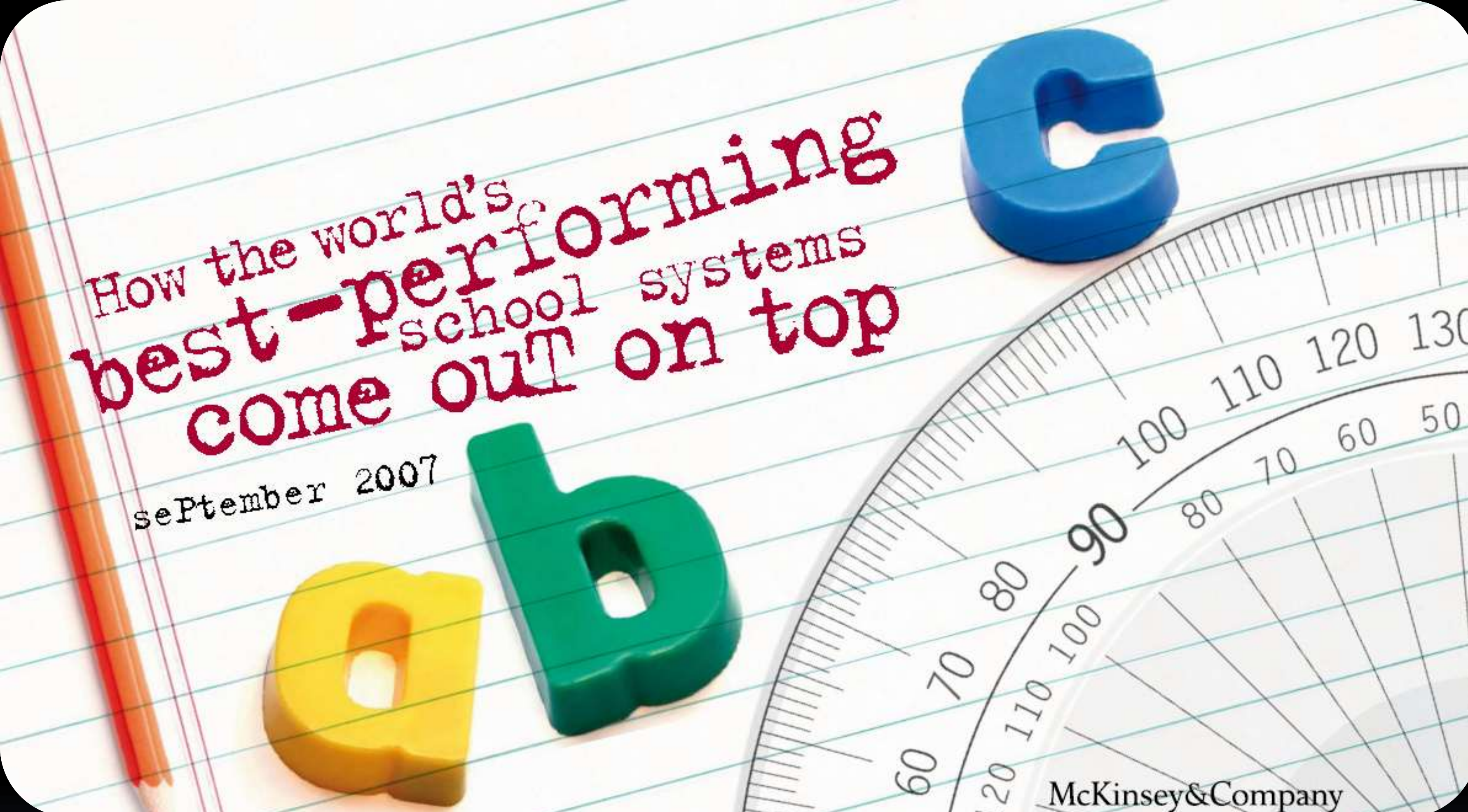
- Why lesson study?
- key characteristics of *jugyokenkyuu*
- *jugyokenkyuu* and science education
- *example #1: a shocking research lesson*
- *example #2: a sound research lesson*
- example #3: the *mass hysteria* research lesson
- Conversation

Why lesson study?

Is it worth it?



Stigler, J. W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom. New York: Free Press.*



1. "The quality of an education system cannot exceed the quality of its teachers"
2. "The only way to improve outcomes is to improve instruction"
3. "High performance requires every child to succeed"

How the worl
best-pe
sc
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Exhibit 21: Japan: Learning communities

Enabling teachers to share best practice, learn from each others strengths and weaknesses, and jointly develop and disseminate excellent practice

Lesson study

Teachers work in teams to analyse and develop model lessons. The study requires each teacher to reflect in depth on their own practice, with the assistance of their peers. The final sample lessons are recorded and distributed.

Demonstration lessons

Teachers demonstrate excellent practice to a wider group of instructors, followed by discussion and feedback sessions. The lessons are used to give each teacher access to examples of excellent practice, to recognise development, and to hold teachers accountable for the quality of their instruction

- **Japan:** The learning culture in its schools is centred on 'lesson study' (kenkyuu jugyou). Groups of teachers work together to refine individual lessons, jointly planning, executing and then evaluating different instructional strategies for achieving a specific learning objective. Groups of teachers visit each others classrooms to observe and understand the practice of other teachers (Exhibit 21). There is a strong emphasis on making sure that best practices are shared throughout the school: "When a brilliant American teacher retires, almost all of the lesson plans and practices that she has developed also retire. When a Japanese teacher retires, she leaves a legacy."[55]

McKinsey&Company

edweek.org

Published Online: February 17, 2010

COMMENTARY

Teacher Learning: Sine Qua Non of School Innovation

By Stephanie Hirsh

You wouldn't know it from current discussions about teacher effectiveness, but the talent and expertise needed to raise student achievement already exist in many, if not most, schools. Unfortunately, too few of them have a culture that encourages teachers and administrators to work together on a regular basis, to consult each other more often on matters of teaching and learning, to share responsibilities for instructional improvement, and to implement professional-learning opportunities that address both their needs and their students'.

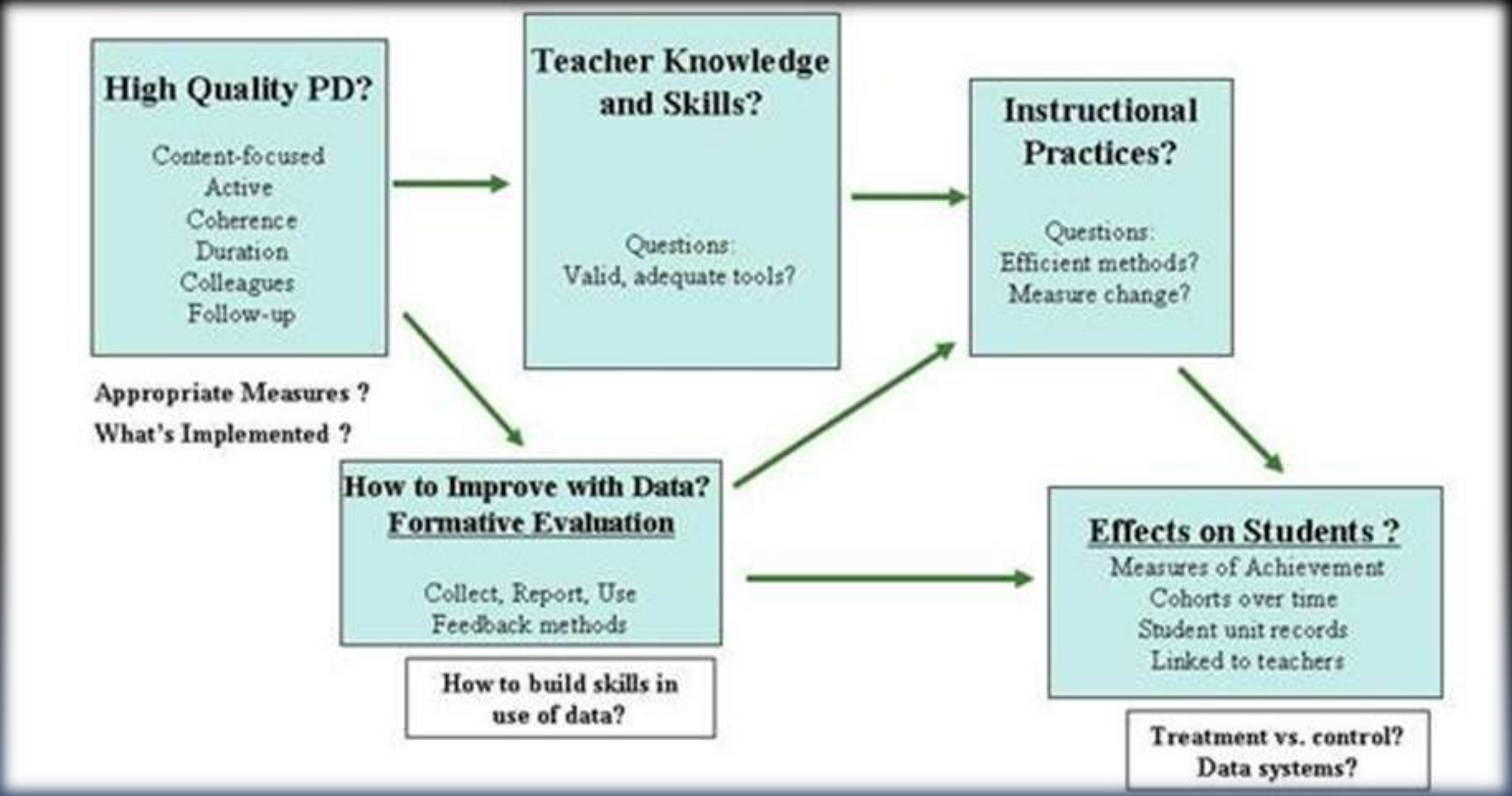
High-Quality PD

"Research on teacher learning shows that fruitful opportunities to learn new teaching methods share several core features:

- ongoing (measured in years) collaboration of teachers for purposes of planning with
- the explicit goal of improving students' achievement of clear learning goals,
- anchored by attention to students' thinking, the curriculum, and pedagogy, with
- access to alternative ideas and methods and opportunities to observe these in action and to reflect on the reasons for their effectiveness . . ."

Hiebert, J. (1999). Relationships between Research and the NCTM Standards. *Journal for Research in Mathematics Education, 30*(1), 3-19.

CCSSO



Blank, Rolf. (2007). *Improving Evaluation of Professional Development in Math & Science Ed.* NSF REC Grant (2005 to 07). Council of Chief State School Officers. http://www.ccsso.org/projects/Improving_Evaluation_of_Professional_Development/

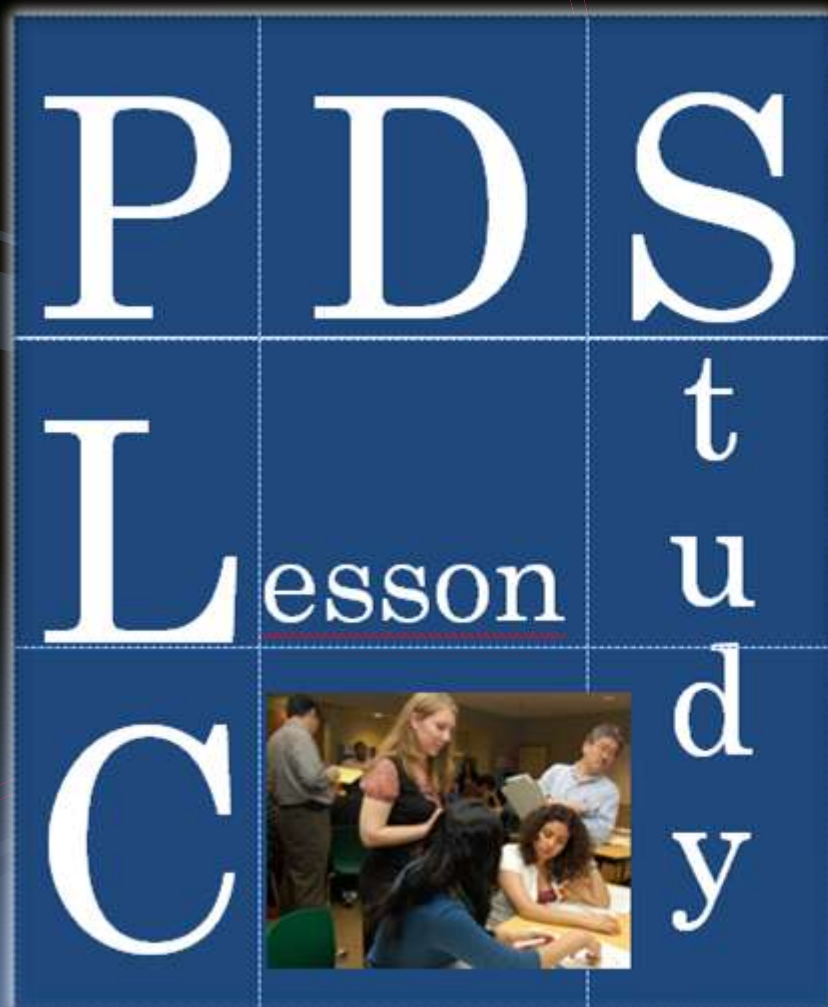
Three characteristics set Lesson Study apart from typical professional development programs:

- Lesson Study provides teachers an opportunity to see teaching and learning in the classroom in a concrete form. Teachers focus their discussions on planning, implementation, observation, and reflection on classroom practice. By looking at actual practice in the classroom, teachers are able to develop a common understanding or image of what good teaching practice entails. This in turn helps students understand what they are learning.
- Lesson Study keeps students at the heart of the professional development activity. It provides an opportunity for teachers to carefully examine the student learning and understanding process by observing and discussing actual classroom practice.
- Lesson Study is teacher-led. Through it teachers can be actively involved in the process of instructional change and curriculum development.

http://hrd.apecwiki.org/index.php/Lesson_Study_Overview#Lesson_Study_in_Japan

At the intersection of Professional Development Schools and Professional Learning Communities:

Jugyokenkyuu (Lesson Study)



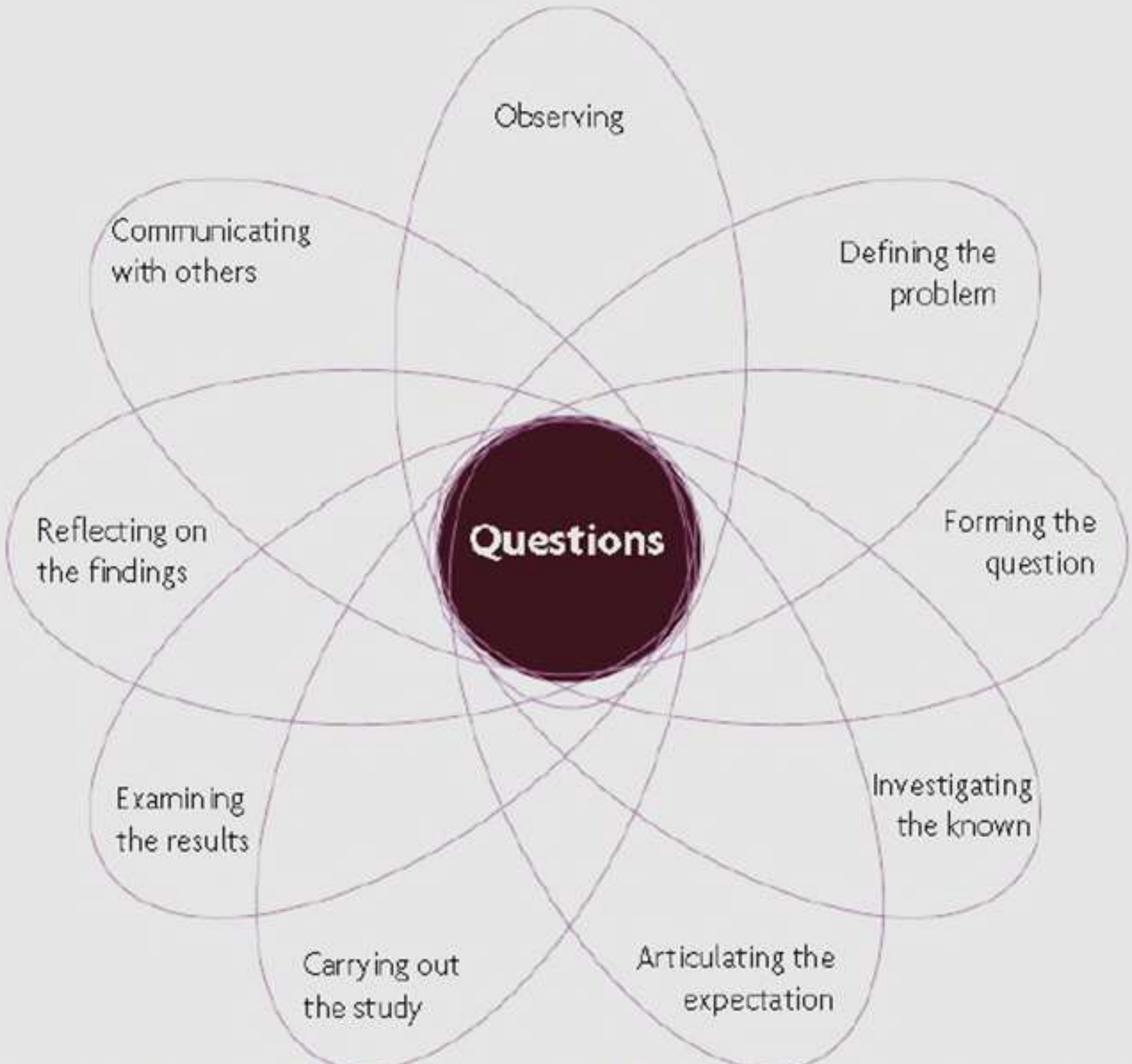
Key Features of Lesson Study

… and how they correspond to distinctive characteristics of science and science education.

Lesson Study Overview

- Set Team Learning Goals
  - School Improvement, Teacher Learning & Student Learning
- Research Lesson Design (~5-weeks)
- Research Lesson (Internal or Public)
  - Briefing→ Teaching→ Observing→ Debriefing
- Revising and Re-teaching (optional)
- Reflecting, Sharing Insights, Reporting

Activity model for scientific inquiry.



Harwood, W. (2004). An Activity Model for Scientific Inquiry. *The Science Teacher, 71(1), 44.*

Three Major Forms of Lesson Study

Example of Lesson Study Groups	Description	Main Purpose
School-Based Lesson Study	•Usually all teachers from a school participate •Establish a school Lesson •Form several subgroups that engage in a lesson study cycle	•Achieving systematic and consistent instructional and learning improvement in the school as a whole •Developing a common vision of education at the school through teacher collaboration
Cross-School Lesson Study (District-wide)	•Organized as an intra-school Lesson Study group •Usually subject-oriented groups (e.g., math teachers from each school in the district gather to conduct lesson study) •Meet once or twice a month	•Developing communication among the schools in the district •Exchanging ideas between the schools •Improving instruction and learning in the district as a whole
Cross-Districts Lesson Study (Regional or Nation-wide)	•Usually a voluntarily organized group •Group of enthusiastic practitioners with purpose of improving teaching and learning or curriculum in a certain subject •Meet once or twice after school on off-school days	•Developing new ideas for teaching chosen topics •Investigating curriculum sequences and contents •Developing curriculum

http://hrd.apecwiki.org/index.php/Lesson_Study_Overview

Some Key Processes

Term	Meaning
kyozaikenkyu	instructional material research
kenkyu jugyo	research lesson
hatsumon	posing key questions
bansho	blackboard writing
kikanshidoi	in-between desk instruction
neriage	extensive whole-class discussion

http://hrd.apecwiki.org/index.php/Glossary_of_Lesson_Study_Terms

Anticipating Student Responses

Why this is so essential…

Teaching → Learning?

PRINCIPLES OF LEARNING

Learning Is Not Necessarily an Outcome of Teaching

Cognitive research is revealing that even with what is taken to be good instruction, many students, including academically talented ones, understand less than we think they do. With determination, students taking an examination are commonly able to identify what they have been told or what they have read; careful probing, however, often shows that their understanding is limited or distorted, if not altogether wrong. This finding suggests that parsimony is essential in setting out educational goals: Schools should pick the most important concepts and skills to emphasize so that they can concentrate on the quality of understanding rather than on the quantity of information presented.

What is your basis for anticipating student responses?

How can we best anticipate student responses?

- Familiarity/Empathy
  - with prior cohorts of students
  - with current cohort of students
- Extrapolation
  - from experiences/ideas of schooling
- Grounding
  - published systematic research
  - **research lesson design and full cycle**
- Others?

jugyokenkyuu and science education

Are they compatible?

CHANGING EMPHASES

The *National Science Education Standards* envision change throughout the system. The professional development standards encompass the following changes in emphases:

LESS EMPHASIS ON	MORE EMPHASIS ON
Transmission of teaching knowledge and skills by lectures	Inquiry into teaching and learning
Learning science by lecture and reading	Learning science through investigation and inquiry
Separation of science and teaching knowledge	Integration of science and teaching knowledge
Separation of theory and practice	Integration of theory and practice in school settings
Individual learning	Collegial and collaborative learning
Fragmented, one-shot sessions	Long-term coherent plans
Courses and workshops	A variety of professional development activities
Reliance on external expertise	Mix of internal and external expertise
Staff developers as educators	Staff developers as facilitators, consultants, and planners
Teacher as technician	Teacher as intellectual, reflective practitioner
Teacher as consumer of knowledge about teaching	Teacher as producer of knowledge about teaching
Teacher as follower	Teacher as leader
Teacher as an individual based in a classroom	Teacher as a member of a collegial professional community
Teacher as target of change	Teacher as source and facilitator of change

NRC. (1996). *National Science Education Standards: observe, interact, change, learn*. Washington, DC: National Academy Press.

Essential Features of Classroom Inquiry and Their Variations

FEATURE	Less..........Learner Self –Direction..........More More..........Direction from Teacher or Material..........Less			
1. Learner engages in scientifically oriented questions	A. Learner engages in question provided by teacher, materials, or other source	B. Learner sharpens or clarifies question provided by teacher, materials, or other source	C. Learner selects among questions, poses new questions	D. Learner poses a question
2. Learner gives priority to evidence in responding to questions	A. Learner given data and told how to analyze	B. Learner given data and asked to analyze	C. Learner directed to collect certain data and guided in how to analyze it	D. Learner determines what constitutes evidence, as well as how to collect and analyze it
3. Learner formulates explanations from evidence	A. Learner provided with evidence and explanation	B. Learner given possible ways to use evidence to formulate an explanation	C. Learner guided in process of formulating explanations from evidence	D. Learner formulates explanation after summarizing evidence
4. Learner connects explanations to scientific knowledge	A. Learner given all connections between explanations and existing scientific knowledge	B. Learner given possible connections between explanations and existing scientific knowledge	C. Learner directed toward areas and sources of scientific knowledge in order to make connections to explanations	D. Learner independently examines other resources and forms connections to explanations
5. Learner communicates and justifies explanations	A. Learner given steps and procedures for justifying and communicating explanations	B. Learner provided guidelines to use to sharpen justification and communication of explanations	C. Learner coached in development of guidelines for justification and communication of explanations	D. Learner forms reasonable and logical arguments to communicate explanations

Adapted from the National Research Council 2000. Inquiry and the National Science Education Standards, A Guide for Teaching and Learning. Washington, DC: National Academy Press, P. 29.

Next Generation Science Standards

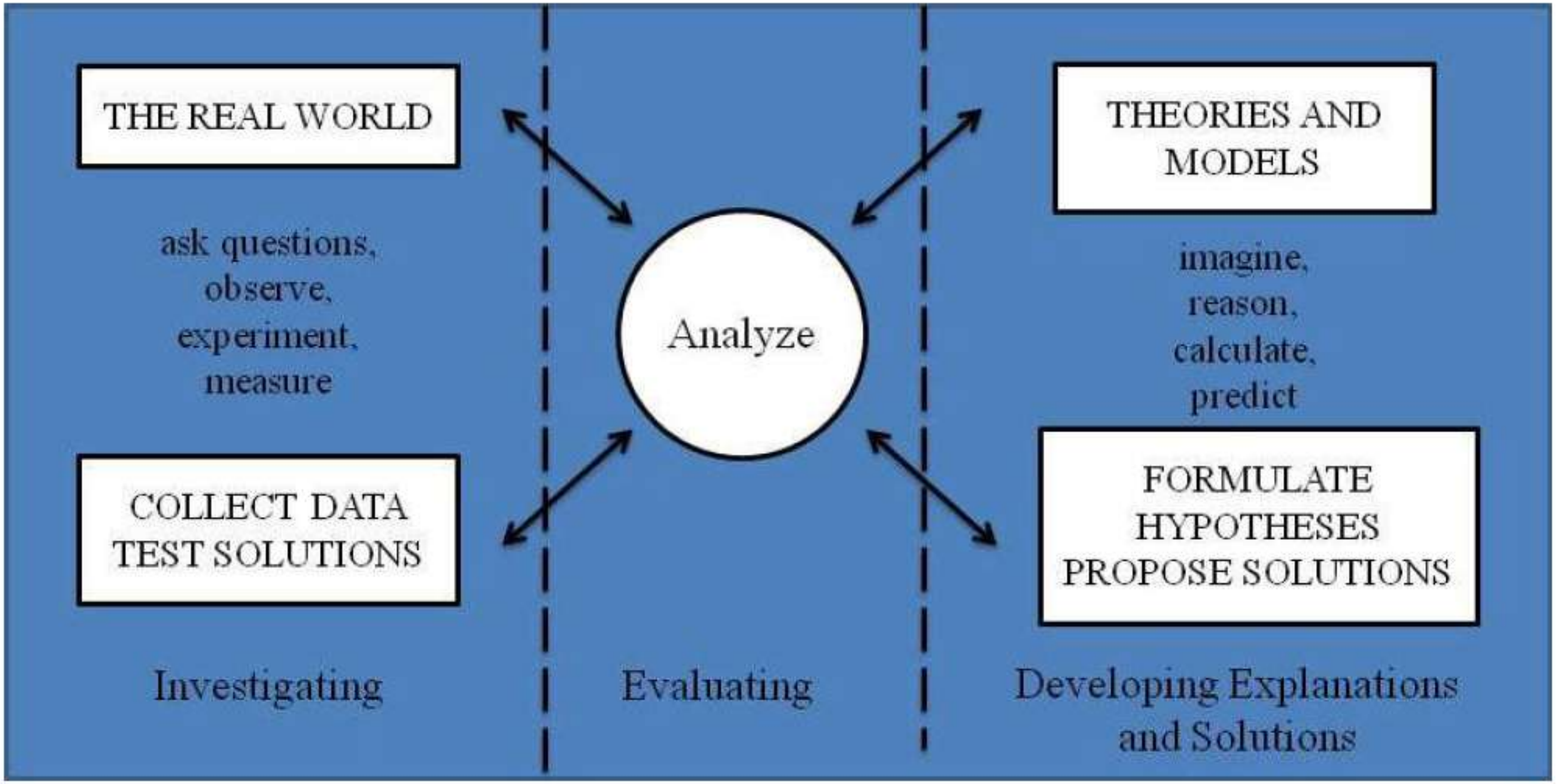


FIGURE 3.1 The three spheres of activity for scientists and engineers.

National Research Council. (2011). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academies Press.

BSCS 5E Instructional Model

Engage	The instructor assesses the learners' prior knowledge and helps them become engaged in a new concept by reading a vignette, posing questions, doing a demonstration that has a non-intuitive result (a discrepant event), showing a video clip, or conducting some other short activity that promotes curiosity and elicits prior knowledge.
Explore	Learners work in collaborative teams to complete activities that help them use prior knowledge to generate ideas, explore questions and possibilities, and design and conduct a preliminary inquiry.
Explain	Learners should have an opportunity to explain their current understanding of the main concept. They may explain their understanding of the concept by making presentations, sharing ideas with one another, reviewing current scientific explanations and comparing these to their own understandings, and/or listening to an explanation from the teacher that guides them toward a more in-depth understanding.
Elaborate	Learners elaborate their understanding of the concept by conducting additional activities. They may revisit an earlier activity, project, or idea and build on it, or conduct an activity that requires an application of the concept. The focus in this stage is on adding breadth and depth to current understanding.
Evaluate	The evaluation phase helps both learners and instructors assess how well the learners understand the concept and whether they have met the learning outcomes. There should be opportunities for self assessment as well as formal assessment.

Example #1: Not so Shocking!

Teacher Candidates and Faculty Peer Review

Electrical Circuits (1/3)

Project 2061 took a close look at the topic of electrical circuits. This happens to have been the subject of considerable research on students' learning difficulties, in terms of both the necessary input of learning effort and the likely output of fruitful knowledge. On the input side, how learnable are circuit ideas? Some researchers have spent their careers trying to understand why students—from elementary school to college—have so much difficulty in understanding not just the differences in behavior of series and parallel circuits, but even the very notion of what a circuit is. Even when researchers have thought they understood the nature of students' difficulties and misconceptions, they still have had trouble figuring out how to overcome them. So, at best, a great deal of extra classroom time would have to be spent on getting students to understand electrical circuits.

Electrical Circuits (2/3)

On the outcome side, how important is it to science literacy for students to understand electrical circuits? The judgment has to be made on the basis of the importance of that knowledge itself, the prior knowledge required to learn it, and what other knowledge it will lead to or support. By itself, electrical circuitry does not have much to offer science literacy. Practical knowledge of electrical circuits may be required for students who will specialize in physics or engineering, and it would also be of value to do-it-yourselfers to understand what is happening in, say, a three-way switch arrangement, but even they would be well advised to follow standard wiring diagrams rather than figure it out on their own. On the other hand, the idea of an electric current plays an important role in science literacy because of its relationship to magnetic fields in electric motors, power generators, Earth’s magnetic field, and more. For those links, however, less need be known about currents than is necessary for making sense of series and parallel circuits.

Electrical Circuits (3/3)

Project 2061 concluded, therefore, that series and parallel electrical circuits as a subject was best left out of the goals for the core science curriculum on the grounds that it would require a high instructional cost and provide a low payoff. Paradoxically, one of the most popular instructional units among elementary- and middle-school science educators is the hands-on science activity “batteries and bulbs,” in which students investigate series and parallel circuits. It may be that this engaging activity can be adequately justified by its contribution to understanding scientific reasoning— hypotheses, evidence, modeling, observation, and so on—even if students are not likely to retain knowledge about series and parallel electrical circuits. And of course any student with an interest in electrical or electronics technology ought to have some opportunity outside of the common core to study circuits. In any case, the point here is not to single out conclusions about the topic of electrical circuits for special attention but to illustrate the kind of analysis that is needed in deciding which topics ought to be included and which left out.

For more about electrical circuits…

1. Search for the term "electric" in Chapter 7 of Designs for Science Literacy at: http://www.project2061.org/publications/designs/ch7.pdf
2. Check the research base (albeit not up-to-date) in Resources for Science Literacy. Simply search for "electric" (or "electric circuit") in the search field on this page: http://www.project2061.org/publications/rsl/online/RESEARCH/COG_TOC.HTM
3. The Illinois Learning Standards for Science do not speak to electric circuits explicitly. The only goal found for electricity at the elementary level was: "12.C.2a Describe and compare types of energy including light, heat, sound, electrical and mechanical." Of course, we can look to *Benchmarks for Science Literacy* and the *National Science Education Standards*, too. http://www.isbe.net/ils/science/pdf/goal12.pdf
4. The new *Handbook of Research on Science Education* has a relevant chapter. There are at least **444 published studies about electric circuits** (Duit, Neidderer, & Schecker, 2007, p606). Reference: Duit, R., Neidderer, H., & Schecker, H. (2007). Teaching Physics. In S. K. Abell & N. G. Lederman (Eds.), Handbook of research on science education (pp. 599-629). Mahwah, N.J.: Lawrence Erlbaum Associates.

7-Es: Experience the 5-E Instructional Model with Electrical Circuits

- Engage: Set up the challenge "Make Light"
- Explore: Alternative ways to "Make Light"
  - or ~~*not*~~
  - or *heat*
- Explain: Construct Meaning from Solutions
  - seeing the "circuit" as *path*
- Elaborate: The Circuit Inside
- Evaluate: The "Post Lesson Discussion"

“Make Light”

7E Conclusions

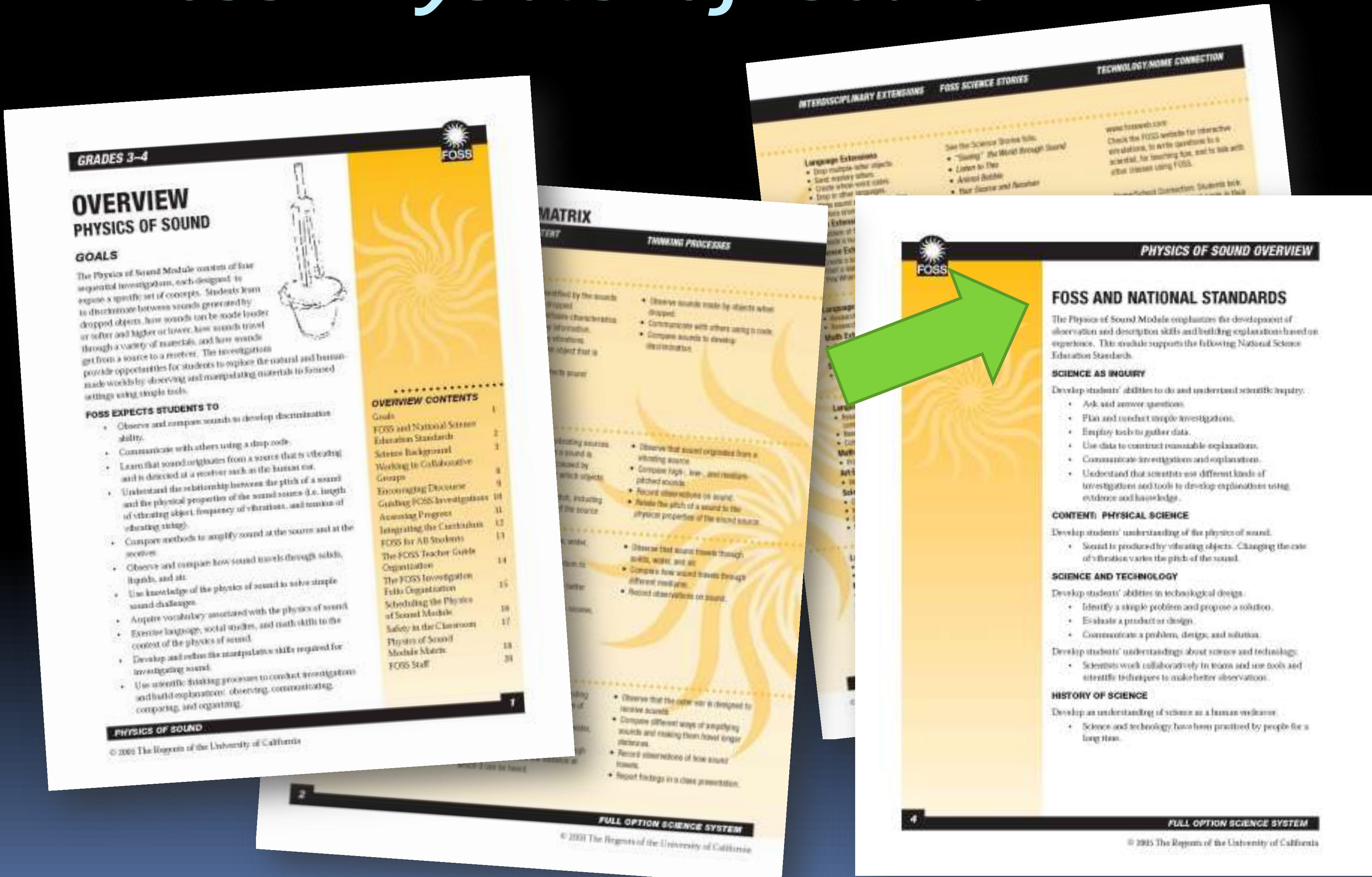
- Did the teacher candidates learn something about electricity?
  - Yes, and this was very limited.
  - This is forgivable since T&L415 is decisively ***not*** a physics or physical science class.
  - Mostly the teacher candidates were confronted with how terribly little they had learned in elementary school, high school, and college! (Which is, of course, disturbing enough.)
- Did the teacher candidates experience a reasonable representation of a 5-E learning cycle model?
  - We are confident that they did.
  - It was striking how naturally the 5-E model mapped into the lesson study template.
- Did the teacher candidates consider the utility of the 5-E instructional model?
  - Feedback from students at the subsequent meeting was very positive.
  - Consensus was that the experience was far more effective that simply reading and discussing.

Example #2: Physics of Sound

Our team's first science research lesson…

"Physics of Sound" Research Lesson

FOSS *Physics of Sound*



Science Scope and Sequence, K-8

Grade	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
K	Characteristics of Living Things **Animals Two By Two (FOSS) and Weather (STC)***		Properties That Make Materials Useful **Fabric (FOSS) and Weather (STC)***	
	Weather* **Weather (STC)**			
1	Plants and How They Grow **New Plants (FOSS)**	Solids and Liquids **Solids & Liquids (FOSS)**	Rocks, Soil, and Dirt **Pebbles, Sand, Silt (FOSS)**	Organisms and their Environment **Organisms (STC)**
2	Weather **Weather (F0SS)**	Forces and Motion **Balance & Motion (FOSS)**	Making Measurements **STC Balancing & Weighing**	Animals and How They Live **Insects (FOSS)**
3	Water and the Water Cycle **Water (FOSS)**	Earth Materials and their Uses **Earth Materials (FOSS)**	Sound **Physics of Sound (FOSS)**	Cycles Of Living Things **Structures of Life (FOSS)**
4	Human Body: Form and Function **Human Body (FOSS)**	Chemical Testing **Chemical Tests (STC)**	Electricity and Magnetism **Magnetism & Electricity (FOSS)**	Earth Features and Changes **Land and Water (STC)**
5	Microorganisms and other Small Things **Microworlds (STC)**	Time and Motion **Measuring Time (STC)**	Levers, Pulleys and Machines **Lever & Pulleys (FOSS)**	Solar Energy **Solar Energy (FOSS)**
6	The Changing Earth **IES Dynamic Planet** The Earth in the Solar System **IES Solar Systems**	Rocks and Geological Time **IES Fossils**	Climate and Weather **IES Climate & Weather**	Energy Resources **IES Energy Resources**
7	Human Biology and Organ Systems **My Body & Me (SALI)**	Cell Structure and Function **Micro-life (SALI)**	Genetics **Our Genes, Our Selves (SALI)**	Ecology and Evolution **Ecology & Evolution (SALI)**
8	Water **Water (IEY)**	Materials Science **Material Science (IEY)**	Work, Energy, and Efficiency **Energy (IEY)**	Environmental Impact **Environmental Impact (IEY)**

(FOSS) – Full Option Science System; (STC) – Science, Technology and Children; (IES) - Investigating Earth Systems; (SALI) - Science & Life Science; (IEY) – Issues, Evidence & You

* Full day Kindergarten - STC Weather will be taught across entire school year

What it looked like…

What we looked for…

1. Was there sufficient discussion among the students within each group?
2. Were the instruments (cup and string) adequate to show difference in pitch?
3. Did students correctly identify relation between tension and pitch, i.e. tighter = higher?
4. Did all of the students get a chance to work with the instruments? If not, was this important?
5. Do students realize that there are two variables and only one at a time should be varied?
6. Should the length of the string be specified, since the goal of the lesson was to see the effect of varying the tension?
7. How specific should the directions of the teacher be to ensure the goal of the lesson is achieved?

A Glimpse at the Post-Lesson Discussion…

c(m+s)i
Chicago Math & Science Initiative

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(FOSS) – Full Option Science System; (STC) – Science, Technology and Children; (IES) - Investigating Earth Systems; (SALI) - Science & Life Science; (IEY) – Issues, Evidence & You

* Full day Kindergarten - STC Weather will be taught across entire school year

SEC Content Topics

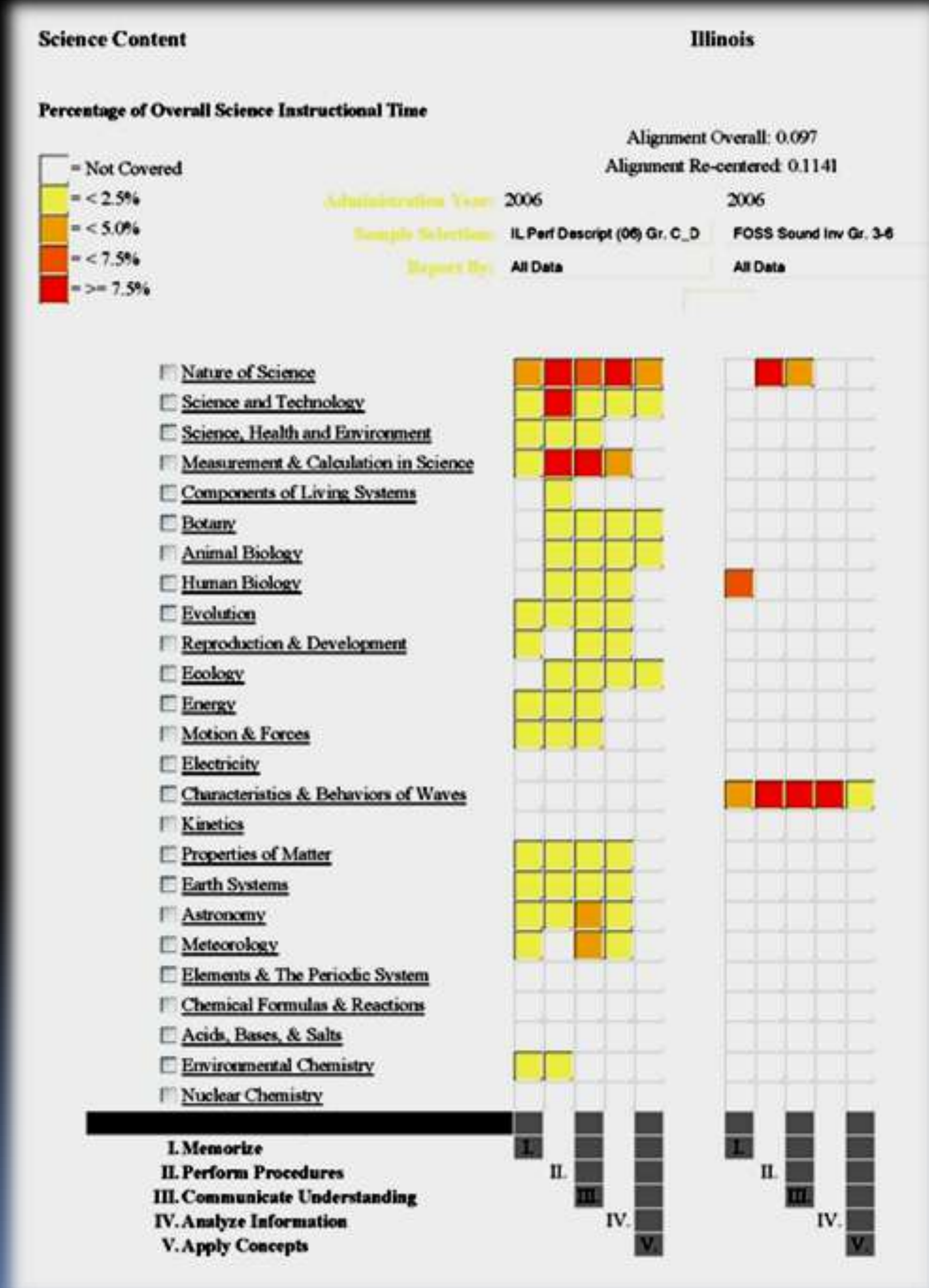
Mathematics, Science, English Language Arts

The SEC provides a neutral, research-based language to describe content of English language arts, mathematics, and science.

NCLB anyone?

Time on Topic					Elementary Mathematics Topics
<none>				1	**Number sense / Properties / Relationships**
●	①	②	③	101	Place value
●	①	②	③	102	Patterns
⓪	●	②	③	103	Decimals
⓪	①	●	③	104	Percent
⓪	①	②	●	105	Real numbers
⓪	①	②	●	106	Exponents, scientific notation
⓪	●	②	③	107	Factors, multiples, divisibility
⓪	①	●	③	108	Odds, evens, primes, composites
⓪	①	②	●	109	Estimation
⓪	●	②	③	110	Order of operations
⓪	●	②	③	111	Relationships between operations
<none>				2	**Operations**
⓪	①	②	③	201	Add, subtract whole numbers
⓪	①	②	③	202	Multiplication whole numbers
⓪	①	②	③	203	Division whole numbers

FOSS Physics of Sound



Example #3: $\vec{F} = M\vec{A}$

Remember this?

Science Lesson Plan for Pre-service Secondary Teachers

For the lesson on: October 29, 2008
At: DePaul University
Instructor: Evelyn Mazzucco

Lesson plan developed by: Evelyn Mazzucco, Emily Hergenrother, & Steven Rogg

1 TITLE OF THE LESSON

Teaching & Learning Newton's Second Law: Mass Hysteria

2 PARTICIPANTS

This lesson is designed for adult preservice secondary teachers enrolled in T&L 439 "Teaching and Learning Secondary Science". The T&L ("Teaching and Learning") program at DePaul University leads to a Masters of Education degree with secondary teaching certification in biology, chemistry, environmental science, or physics.

3 GOALS OF THE LESSON:

1. 2008-09 general goal for the Chicago Lesson Study Group:
   Increase student self-efficacy.
2. 2008-09 specific goal for the science team:
   Increase student self-efficacy in science through success in a challenging experience requiring analytical thinking about natural phenomena.
3. This lesson: **Teaching**- Experience teaching a common concept (F=MA) in an uncommon way: The Learning Cycle as framed by the BSCS 5-E model (Bybee et al., 2006).
4. This lesson: **Learning** – See the learning experience from the perspective of high school students. Anticipate student responses to each step of the 5-E BSCS Learning Cycle. This will be embedded in the activity sequence and made explicit during the research lesson panel discussion.
5. This lesson: **Curriculum** – Recognize probable strengths and weaknesses in published curriculum materials. This lesson was based on the Active Physics™ *Predictions* module Activity 6: "*The modern cart and book experiment*". During lesson design, the team discovered a discrepancy (p. 166, paragraph 4) that could lead to confusion. During the Panel Discussion, the lesson design team will discuss how they revised the lesson accordingly.
6. This lesson: **Technology** – Experience using computer-based motion detector to capture and analyze (make sense of) data. Use of the Vernier™ system is a means to readily collect sufficient numbers of data points for multiple trials.
7. This lesson: **Professionalism**-introduce preservice teachers to Lesson Study as a viable form of professional development. The lesson was prepared during lesson study, will be experienced as a research lesson, and will be discussed with participants during the post-lesson panel. Since participants are preservice educators, they will be invited to participate in the post lesson panel as participant-observers.

4 RELATIONSHIP OF THE LESSON TO THE STANDARDS

4.1 Related Prior Learning Standards (Topics/Objectives)

TEACHING & LEARNING NEWTON'S SECOND LAW: MASS HYSTERIA

- Engage:
  - Observe and describe the static system
  - Predict what will happen in the dynamic system
- Explore:
  - Qualitative Observations – Run the cart
  - Quantitative Data Collection – Produce graphs.
- Explain: Compare achieved and predicted graphs
- Elaborate:
- Evaluate: The "Post Lesson Discussion"

GOAL OF THIS RESEARCH LESSON

- Chicago Lesson Study Group general goal for 2008-09 :
  - ***Increase student self-efficacy***.
- Specific goal for the science team:
  - ***Increase student self-efficacy in science through success in a challenging experience requiring analytical thinking about natural phenomena***.

LESSON GOALS (CONTINUED)

- **Teaching-** Experience teaching a common concept (F=MA) in an uncommon way: The Learning Cycle as framed by the BSCS 5-E model (Bybee et al., 2006).
- **Learning** – See the learning experience from the perspective of high school students. Anticipate student responses to each step of the 5-E BSCS Learning Cycle. This will be embedded in the activity sequence and made explicit during the research lesson panel discussion.
- **Curriculum** – Recognize probable strengths and weaknesses in published curriculum materials. This lesson was based on the Active Physics™ *Predictions* module Activity 6: "*The modern cart and book experiment*". During lesson design, the team discovered a discrepancy (p. 166, paragraph 4) that could lead to confusion. During the Panel Discussion, the lesson design team will discuss how they revised the lesson accordingly.
- **Technology** – Experience using computer-based motion detector to capture and analyze (make sense of) data. Use of the Vernier™ system is a means to readily collect sufficient numbers of data points for multiple trials.
- **Professionalism** – introduce preservice teachers to Lesson Study as a viable form of professional development. The lesson was prepared during lesson study, will be experienced as a research lesson, and will be discussed with participants during the post-lesson panel. Since participants are preservice educators, they will be invited to participate in the post lesson panel as participant-observers.

Activity Six

The Modern Cart and Book Experiment

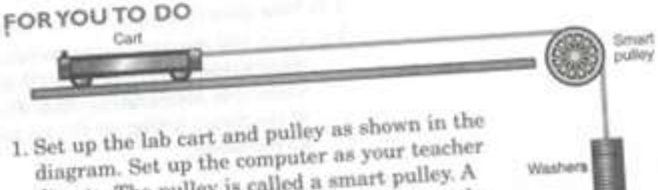
WHAT DO YOU THINK?

An earthquake in Mexico in 1980 killed 10,000 people and caused billions of dollars worth of property damage.

- **What forces would be required to "hold back" an earthquake from occurring?**
- **How much mass moves during an earthquake?**

Record your ideas about these questions in your *Active Physics log*. Be prepared to discuss your responses with your small group and the class.

FOR YOU TO DO



1. Set up the lab cart and pulley as shown in the diagram. Set up the computer as your teacher directs. The pulley is called a smart pulley. A photo beam and photocell are used to time the motion of the spokes of the pulley as it spins.

   a) How will the time between spokes change as the cart accelerates?

“The Modern Cart and Book Experiment”

“When hanging weights are used to provide accelerating forces, the results are not quite proportional. That is, doubling the hanging mass does not double the acceleration (this can be found by using force diagrams). In FYTD, students are asked only to compare results, so perhaps the lack of proportionality will not be noticed. But in Physics to Go, question 6, it seems that it is counted on. If masses are known, the calculation is simple. But it is NOT proportional. What one finds is that accel = accel due to gravity x hanging mass/(hanging mass + cart mass), This is close to proportional in the case that the cart mass is much larger than the hanging mass, which might be the case in #6. As the teacher, you should be aware of this fact.”

Active Physics Predictions – Magic and Motion. Activity Six: The Modern Cart and Book Experiment. p. 166.

Mass Hysteria Conclusions

$$A_{\text{exp}ected} = g_{m/s^2}\left(\frac{m_g}{m_g + m_c}\right)_g = 9.8_{m/s^2}\left(\frac{50g}{50g + 900g}\right) = 0.52_{m/s^2}$$

-OR-

“Mutationem motus proportionalem esse vi motrici impressae, et fieri secundum lineam rectam qua vis illa imprimitur.”

Conclusions & Discussion

What up?

"How Students Learn: science…"

A community-centered classroom that relies extensively on classroom discussion, for example, can facilitate learning for several reasons…

- It allows students' thinking to be made transparent—an outcome that is critical to a learner-centered classroom. Teachers can become familiar with student ideas... Teachers can also monitor the change in those ideas with learning opportunities, the pace at which students are prepared to move, and the ideas that require further work—key features of an assessment-centered classroom.
- It requires that students explain their thinking to others. In the course of explanation, students develop a disposition toward productive interchange with others (community-centered) and develop their thinking more fully (learner-centered)...
- Conceptual change can be supported when students' thinking is challenged, as when one group points out a phenomenon that another group's model cannot explain (knowledge-centered).

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7E References

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Resource Links

Source	URL
Lesson Study Alliance	http://LSAlliance.org
Chicago Lesson Study Group	http://LessonStudyGroup.net
APEC Lesson Study Wiki	http://hrd.apecwiki.org/index.php/Lesson_Study
Achieve Next Generation Science Standards	http://www.achieve.org/next-generation-science-standards
Project 2061	http://www.Project2061.org
Survey of the Enacted Curriculum (SEC)	http://seconline.wceruw.org