Observing for Evidence of Learning: Professional Development that Makes a Difference

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In recent years cognitive science research has taught us a great deal about how students learn various subjects. A wide gap remains, however, between what we know about how students learn and the degree to which this knowledge guides instructional practice. This paper highlights the benefits of using lessons learned from cognitive science to guide and continuously improve instructional practice to positively impact student achievement.

How Students Learn Science?

In contrast to reading and mathematics, which primarily involve developing proficiency with an established set of skills and knowledge, the study of science involves understanding the world we live in and how it functions. Everyone develops his or her own working understanding of the world through daily interactions with the environment. An individual's working understanding of the world, sometimes referred to as the person's "private universe," becomes very entrenched over time and is often fraught with misconceptions and beliefs. The challenge in science education is to provide learning experiences that align students' private universes with current scientific understanding.

Thus teaching science requires an approach that draws heavily from cognitive science and learning theory. A synthesis of research published in 2008 by Banilower, Cohen, Pasley, and Weiss concluded that "instruction is most effective when it elicits students' initial ideas, provides them with opportunities to confront those ideas in light of new evidence, helps them formulate new ideas based on the evidence, and encourages students to reflect upon how their ideas have evolved" (p. 7). These experiences are necessary to adequately address misconceptions and align students' private universe with the most current scientific knowledge. According to the National Research Council (2003), without these opportunities students "may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom" (p. 14).

Effective Science Learning Experiences for Students

Students learn science best when teachers use appropriate instructional strategies and instructional materials to:

- Elicit students' initial understanding
- Engage students intellectually with important science content
- Provide opportunities for students to collect and examine evidence
- Help students use that evidence to formulate a new understanding
- Encourage students to reflect upon the evolution of their understanding

Implications for Educators

Years of research are beginning to pay off. The growing consensus among educators and researchers about how students learn has the potential to align instructional practices, professional development, and teacher evaluation around a common vision of effective learning experiences for students in each subject area. The implication for teachers is that every teacher of reading, mathematics, and science is responsible for applying the research about how students learn in every lesson. The implication for professional development providers and instructional coaches is that they are responsible for helping teachers understand the research and develop the skills they need to apply the research about how students learn in the classroom. The implication for administrators is that they are responsible for evaluating teachers' based on their ability to apply the research about how students learn.

An Example in Science

Professional development providers at the Center for Inquiry Science of the Institute for Systems Biology (ISB) had the opportunity to apply these lessons from cognitive science in the science classrooms at 21 middle schools in 4 Seattle-area school districts. RMC Research Corporation conducted the evaluation of this 5-year project, Observing for Evidence of Learning (OEL), funded by the National Science Foundation (NSF) in 2005 as part of its teacher professional continuum program.

Prior to the OEL project, the participating middle schools had adopted hands-on science modules (science kits) as their core science curriculum as part of an NSF-funded Local Systemic Change (LSC) project. Although the curriculum was in place and teachers received training on science content and the use of the materials, implementation of the modules remained mechanical at the conclusion of the LSC project. Classroom observations revealed that many teachers were failing to take full advantage of the instructional potential of the materials, and students frequently did not develop the desired depth of understanding of the science concepts addressed. The OEL model was developed to help move teachers toward more effective use of the modules.

RMC Research conducted rigorous research on the efficacy of the OEL professional development model, which empowers school-based teams of science teachers to collaborate to continuously improve science teaching and learning using the adopted science curriculum materials (Weaver & Lewis, 2010). The OEL model has 2 components. The first is a well-defined, research-based professional development process called the OEL Essential Elements, which involves school-based teams of science teachers completing 6 distinct phases

OEL Essential Elements

Teachers participants in OEL professional development complete 6 distinct phases composed of clearly defined essential elements:

Collaborative Lesson Development Phase (Day 1)

- Teachers develop statements that clearly identify the big ideas that students will learn
- Teachers check their own understanding of the big idea by discussing their current understanding
- Lesson development focuses on activities that address the science big idea
- Teachers craft questions to move students' thinking to higher levels of cognitive demand
- Lesson development is truly collaborative in nature
- Scientists provide guidance on the unit's scientific content

Lesson Delivery and Observation Phase (Day 2)

- The teacher carries out the lesson according to the team lesson plan
- Observers focus on observing students and collecting data
- Observers maintain the integrity of their role as observers

Individual Reflection Phase (Day 2)

- Teachers reflect on the student experience observed by honestly asking themselves, "Was it evident that the students gained a deeper understanding of the big idea addressed?"

Team Debriefing Phase (Day 2)

- Debriefing focuses on a discussion of the evidence of student learning observed that relates to the big idea
- Discussion maintains focus on student learning rather than student actions

Collaborative Generalization to Practice Phase (Day 2)

- Teachers make connections between the student learning and successful aspects of the lesson design
- Teachers make connections between instructional strategies used in the lesson and student learning
- Teachers make generalizations about how effective strategies can be applied to future lessons

Individual Implementation Phase

- Teachers consider successful teaching and learning strategies for their own lesson planning
- Teachers enact effective strategies in their own classroom

over the course of an OEL cycle. Each cycle requires approximately 12 hours of teamwork over 2 days. Typically, all of the science teachers in a school complete 3 or 4 OEL cycles during a school year.

The second component of the OEL model is a clear purpose: finding ways to use the instructional materials to engage students in the effective science learning experiences.

During a typical OEL cycle, the science teachers in a school participate in 2 professional development sessions led by a trained OEL facilitator. After establishing professional norms, rules for collaboration, and other operating procedures for the learning community, the first task is to identify a science concept in an upcoming lesson that students have difficulty grasping or that teachers find challenging to teach. Next the team reviews the selected science lesson and identifies the big idea or enduring understanding students are expected to learn and the effective learning experiences for students that are most appropriate for that purpose.

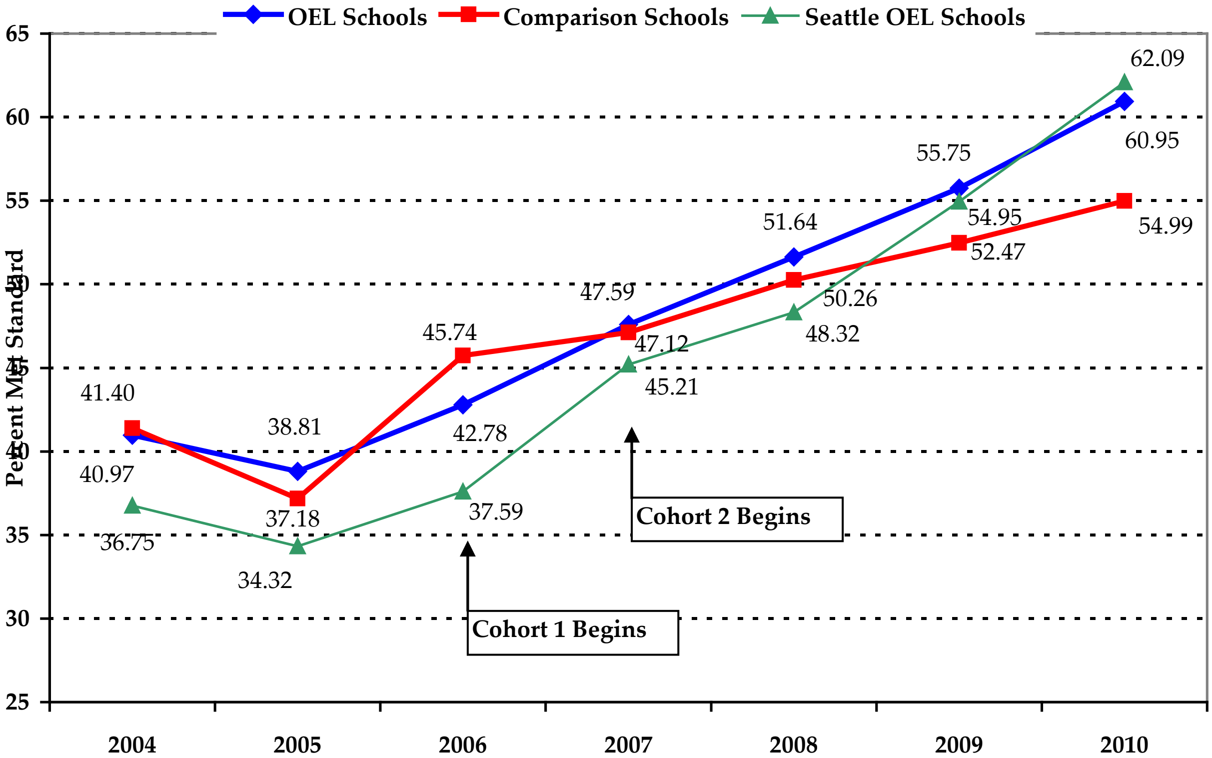
This phase also requires the teachers to check their own understanding of the science concept addressed in the lesson. The team draws upon the content knowledge of a practicing scientist from ISB to clarify the concept and to formulate learning targets that clearly address the big idea. The next step in the process is refining the lesson to ensure that it engages students in one or more effective science learning experience. This task frequently involves collaboratively crafting prompts and questions to launch the lesson and guide student learning as the lesson progresses. The team schedules the next OEL session at a time when a volunteer can teach the revised lesson while the other teachers observe how students respond. During the implementation of the revised lesson, teachers focus on the students, documenting concrete evidence of learning through engagement in effective learning experiences. For example, if prompting students to reflect on change in their understanding of a science concept is a goal of the lesson, the observers would record examples of student statements that demonstrate this outcome.

The teachers individually reflect and prepare for the lesson observation debriefing by using a form to organize the evidence they gathered according to the relevant effective learning experiences. The OEL facilitator then leads the team through the debriefing phase, which involves sharing the evidence observed, analyzing the degree to which the evidence represents the desired student response, and examining the prompts that elicited the response. The team portion of the OEL cycle concludes with the teachers summarizing what they learned from the process and developing at least one generalization to practice statement the teachers agree to apply to subsequent lessons. These statements generally specify effective teaching strategies or guidelines for formulating questions that engage students in the desired higher cognitive activity.

Research Results

The impact of the OEL professional development on student achievement was significant. To evaluate the impact RMC Research conducted a scientifically rigorous quasi-experimental analysis of the school-level science achievement data. A comparison school in Washington State was identified for each of the 21 middle schools participating in the OEL project. The comparison schools were selected to closely match the OEL schools with respect to grades served; enrollment; percentage of students who qualified for free or reduced-price lunch; percentage of students who were transitional bilingual; and percentage of students who were Asian, Native American, Black, or Hispanic. The percentage of Asian students was the only demographic on which the 2 groups of schools differed by more than 3%. Due to the high concentration of Asian students in the Seattle area, finding suitable matches in other Washington metropolitan areas was a challenge. As a result, the treatment group included 7% more Asian students than the comparison group. RMC Research calculated the

Exhibit 1
OEL Schools vs. a Matched Set of Nonparticipating Comparison Schools



Note. OEL schools: n = 21, comparison schools: n = 21, Seattle OEL schools: n = 11.

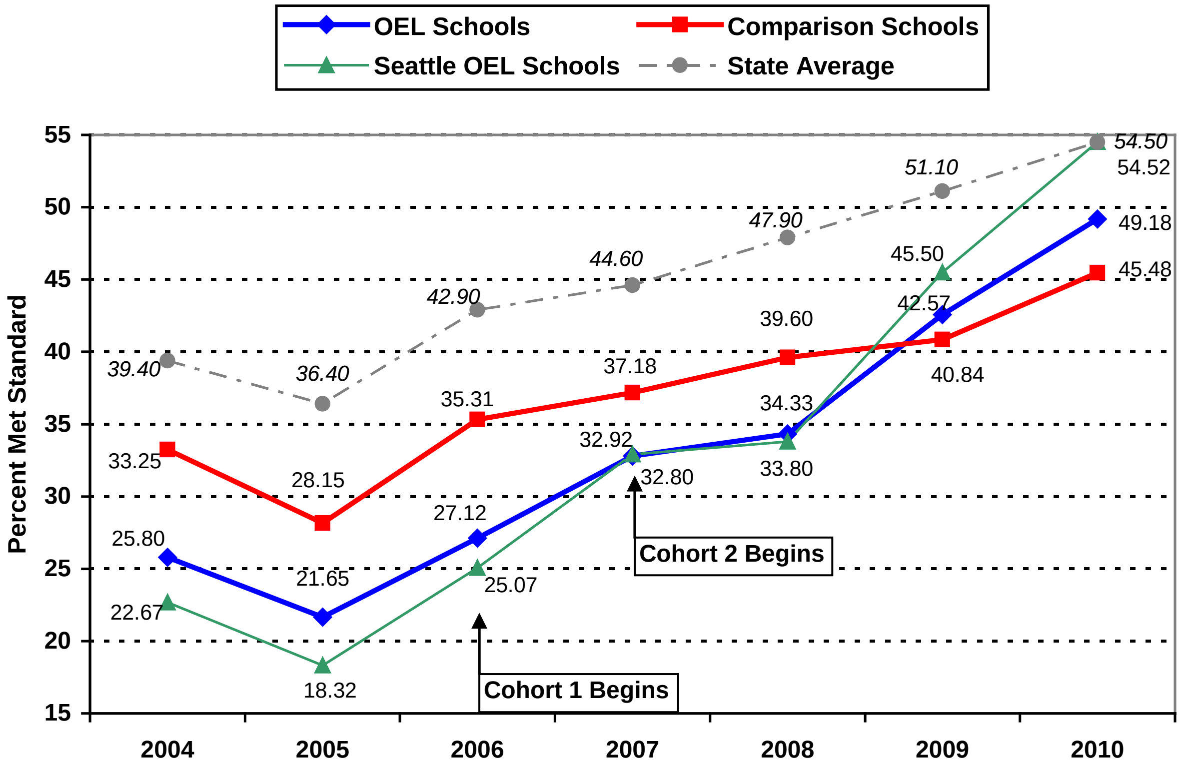
correlation between the percentage of Asian students in the schools and student achievement in science and concluded that the difference between the groups bore no significant influence on the results of the study.

Finding 1—Exhibit 1 shows the average percentage of students who met the Grade 8 state assessment science standard in the OEL schools, the comparison schools, and the subset of OEL schools in Seattle. Prior to the project, the science achievement of the OEL schools was as unpredictable as that of the comparison schools. After the onset of the OEL project, the OEL schools demonstrated steady improvement in student science achievement at a rate that exceeded that of the comparison schools. By the 2010 state assessment the difference between the OEL schools and the comparison schools was statistically significant at $p < .05$.

Most of the gains documented by the evaluation can be attributed to the OEL schools in one district: Seattle Public Schools. In 2006 the science achievement of Grade 8 students in Seattle was well below that of the students in the comparison schools. With the aid of the OEL project the participating Seattle schools quickly closed the gap, and by the end of the project in 2010 the Grade 8 students in the OEL schools were significantly outperforming their counterparts in the comparison schools.

Analysis by Socioeconomic Status—To analyze the results with respect to socioeconomic status (SES), RMC Research used the percentage of students who qualified for free or reduced-price lunch (FRL) as a proxy for the socioeconomic status of the community served by each school. After calculating the average percentage of students who qualified for FRL across the analysis period, RMC Research divided the OEL schools and the comparison schools into 2 groups. Schools in which less than 40% of the students qualified for FRL were classified as

Exhibit 2
Comparison of Low Socioeconomic Schools



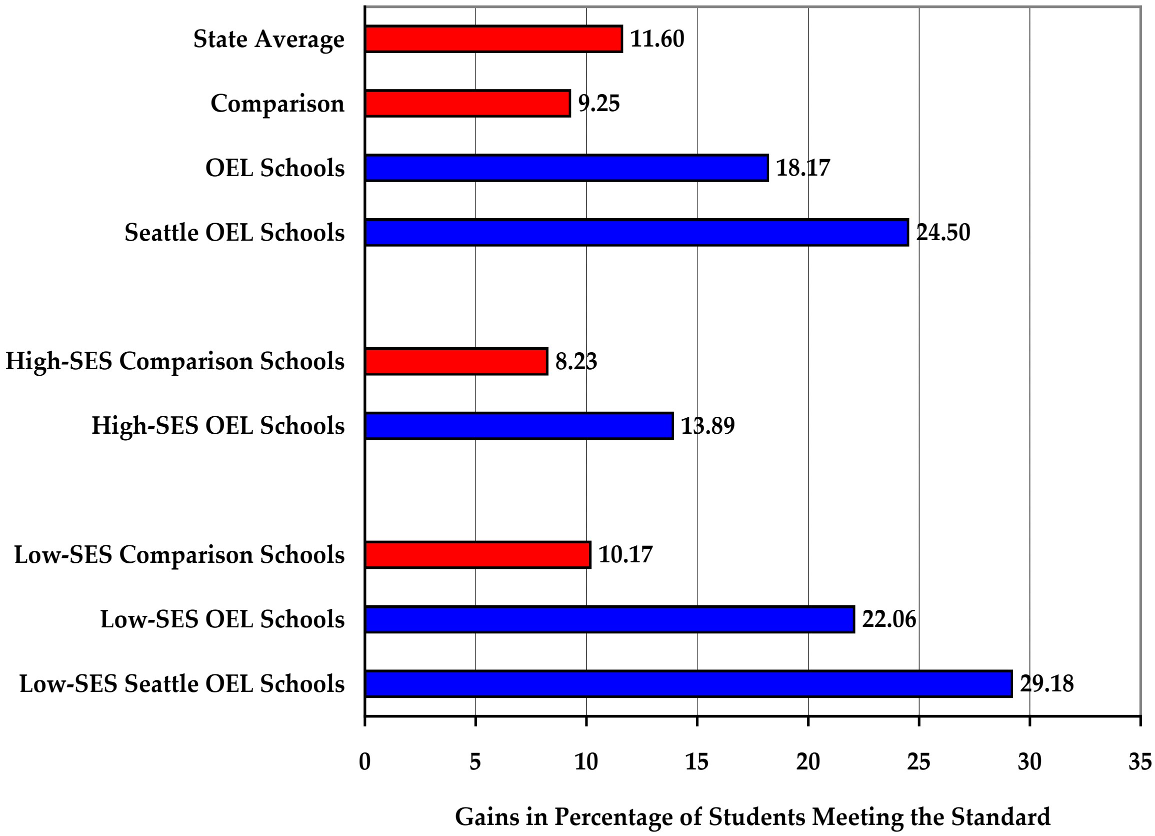
Note. OEL Schools: n = 11, Comparison Schools: n = 11, Seattle OEL Schools: n = 6.

high-SES schools, and schools in which more than 40% of the students qualified for FRL were classified as low-SES schools.

Finding 2—Exhibit 2 compares the percentages of Grade 8 students who met the science standard in the low-SES schools over a 7-year period. Prior to the project, the students in the low-SES OEL schools scored well below their counterparts in the comparison schools and both groups scored well below the state average. After the onset of the OEL project, the low-SES OEL schools began to close the gap. In 2009 the Grade 8 students in the OEL schools outperformed their counterparts in the comparison schools and the gap widened further in 2010. The gains were the most pronounced among students in the Seattle OEL schools. The students in the low-SES Seattle schools surpassed their counterparts in the comparison group and by 2010 they were achieving at the level of the statewide average.

The success of the Seattle schools can be attributed at least partly to the work of the science teachers on special assignment (TOSAs) who served as science curriculum leads and instructional coaches for several years prior to the OEL project. The science TOSAs facilitated many of the OEL professional development sessions and also emphasized the effective science learning experiences for students in other interactions with science teachers. The most experienced TOSA in Seattle commented, "This project has provided a very structured and purposeful way for me to interact with many of our science teachers . . . [to] promote improving classroom practices." The science TOSAs in the other districts participating in the OEL project

Exhibit 3
Gains in Student Achievement 2006 to 2010



Note. Blue bars denote the gains in OEL schools and red bars denote gains in the matched comparison schools or the state average.

did not incorporate OEL into their work to the same extent.

Summary of Findings

Exhibit 3 shows the change in the percentage of students who met the Grade 8 science standard between 2006 (the OEL project baseline year) and the conclusion of the OEL project in 2010. These data reveal that:

- OEL schools demonstrated greater gains in Grade 8 science achievement than their matched comparison school and the state average.
- The low-SES schools made greater gains than the high-SES schools, the comparison schools, and the state average. The increase in the percentage of students who met the Grade 8 science standard in the low-SES schools in Seattle was nearly 3 times higher than the increase in the comparison schools and the state average over the project period.

Conclusion

According to City, Elmore, Fiarman, and Tietel (2009) of the Harvard Graduate School of Education, "In most instances, principals, lead teachers, and system-level administrators are trying to improve the performance of their schools without knowing what the actual practice would have to look like to get the results they want at the classroom level." The OEL professional development model directly addresses this issue by drawing upon years of cognitive science research to articulate a clear vision of both effective science instruction and learning experiences for students. The OEL project in Washington State worked to establish substantial agreement among the participating teachers, administrators, and professional development providers regarding what good science instruction looks like in practice. As a result the research shows that OEL, when implemented with fidelity, is a successful means of improving instructional practice and increasing student science achievement.

Many professional development models employ a well-defined process, but most focus on instructional materials or strategies. As the early LSC projects demonstrated, professional development of this nature too often results in mechanical use of the materials and strategies that falls short of achieving the desired student achievement outcomes. In contrast, the OEL project drew upon cognitive science research to provide a clear vision of effective science learning experiences for students. Achieving that vision became the collective mission of the participating science teachers, and the OEL professional development model was the means through which the teachers collaborated to make that vision a reality in the classroom. By understanding the reasoning behind the instructional materials and inquiry teaching strategies, the teachers were able to move beyond mechanical use toward increasingly more purposeful and effective use of the instructional materials and strategies to achieve their instructional intent.

The success of the OEL professional development model as shown by the research findings suggests that a similar structure could be effective for other disciplines as well. In each case the professional development would serve a purpose relevant to and grounded in the cognitive science research about how students learn that discipline.

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