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USING HLM TO ANALYZE ON-GOING TEACHER PROFESSIONAL DEVELOPMENT AND IMPLEMENTATION OF SCIENTIFIC CLASSROOM DISCOURSE COMMUNITY STRATEGIES

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ABSTRACT: One-hundred-and-sixty classroom observations of secondary science and language arts teachers were made throughout the 2007-2008 academic year to determine the extent of their use of professional development, specifically using strategies to construct a scientific classroom discourse community (SCDC). Each observation was scored using a 36-item instrument of various SCDC instructional strategies designed to match the professional development. These observation scores and teacher demographic information were used to build a hierarchical linear model to explore for statistically significant relationships over time. The length of time that the teachers received professional development was chosen as the exclusive predictor of teacher change because the overall model fit associated with this variable was better, co-varied less across levels, and ultimately because it was most conceptually significant. Thus, sustained professional development over time, greater than one year, appears to be more effective, and necessary, for greater fidelity of implementation of SCDC teaching strategies. The results of the modeling also suggest that the professional development appears to work well for a variety of participants and is adaptable and equitable.

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Introduction

Studying Teacher Professional Development

The science teacher professional development research literature indicates that the community of teacher educators and in-service professional development providers understand very little about how teachers apply what they learn from professional development to their classrooms. This lack of understanding stems from the complexity of studying the phenomenon of teacher learning. Because of its complex nature, only a few studies have considered the interaction between teachers' professional development, their classroom practice, and student performance (Hewson, 2007). Indeed, a great deal of foresight and planning must be employed to design a study of the effects of professional development (PD), not to mention sufficient funding allotted to fund a sustained research endeavor over time. A recent report that sampled professional development initiatives for math and science teachers nationally from 2004-2007 reports that the professional development activities that have been found to affect teachers' classroom instruction were over 50 hours in length (CCSSO, 2008). The CCSSO (2008) report estimates that a third of the sampled evaluation studies reported "measurable effects of teacher professional development." O'Donnell (2008) highlights the issue of fidelity of implementation concerning K-12 curriculum intervention research. She comments "that there are too few studies to guide researchers on how fidelity of implementation to core curriculum interventions can be measured and related to outcomes, particularly within efficacy and effectiveness studies, where the requirements for fidelity measures differ" (p.33). Considering the current challenge of determining effectiveness of, and fidelity to, teacher professional development over time hierarchical linear modeling (HLM) is a useful tool with which to explore possible relationships between professional development, teachers' practice, and systemic variables. In this exploratory study of fidelity to implementation of teacher professional development, as measured through a PD-aligned classroom observation instrument, we present a preliminary longitudinal model of teachers' use of instructional strategies from the Communication in Science Inquiry Project (CISIP).

Issues Affecting Science Education Reform

Inquiry

Since the publication of the *National Science Education Standards* (National Research Council (NRC), 1996) and the *Benchmarks for Scientific Literacy* (American Association for the Advancement of Science (AAAS), 1993), science teacher educators, professional development providers, and science teachers themselves have grappled with how to incorporate more inquiry into classroom science instruction. For example, in the 1970s when other NSF-funded science curriculum projects were observed researchers found that "the methods the teachers used and the topics they chose to teach to students were largely unaffected by federal curriculum efforts…that inquiry methods, central to many of the curricular materials…seldom appeared in the classrooms they observed" (Cuban, 1992, p. 227). Clearly, we have learned that curriculum materials alone do not affect change in teaching practices. Yerrick and Roth (2005) also note key differences between present and past reform recommendations in that in the past teachers' content knowledge and pedagogy were often the main concerns with little attention to student diversity or learning needs.

Communication, Language, and Science

Lemke's (1990) identification of triadic dialogue (initiate-respond-evaluate, otherwise known as "IRE") as a means for knowledge transmission and discourse structure from teacher to student in science education is the antithesis of science education reform. However, it is a favored staple of whole group discussion pedagogy in science classes. The use of scientific inquiry as a teaching paradigm provides students with opportunities to engage with scientific questions, make observations, and make meaning from their own experiences. Gee (2005) states that students need to experience science in order to be able to create meaningful discourse and develop conceptual understandings. This follows in the Vygotskian tradition of social learning and language (1986) and the educational theories of Dewey (1938). Numerous authors have written about the sociocultural, sociolinguistic, and philosophical elements of scientific classroom discourse communities that highlight the importance of language in learning science (Yerrick &

Roth, 2005). In their book *The New Science Literacy* and *Crossing Borders in Literacy and Science Instruction* Their and Daviss (2002) point toward a productive marriage of science, language, and learning that are on the leading edge of science education reform.

Achievement Gap: Equity and Science Education Issues

Educational researchers have established that there is a persistent achievement gap in national and international test scores (Berliner & Biddle, 1995) due to racial isolation and concentrated poverty of public school children, especially in urban inner-city schools (Kozol, 2005; Berliner, 2006). Anyon's (1981) early work revealed a striking correlation between social class and teachers' pedagogy and the enacted curriculum. In her case studies of five elementary schools Anyon observed elements of social stratification. Anyon saw that students from the working class had access to school knowledge that was composed of fragmented facts and procedural, mechanical tasks while middle-class children were exposed to knowledge as a means to success meritocracy and children of the affluent professional class were provided with experiences that allowed them to develop cultural capital. Additionally, schools are under pressure from state and federal high-stakes testing (Nichols & Berliner, 2007), which often results in top-down implementation of test-prep curriculum that does not reflect the nature of science. Consequently, we would expect that science in schools with higher socioeconomic status (SES) would provide students with more opportunities to engage in inquiry-based science practices and students from lower SES schools and communities to have conceptually-impoverished science programs in which rote understanding for the purpose of "passing the test."

Wood, Lawrenz, Huffman, and Schultz (2006) argue for a comprehensive investigation into school-level variables to see what affects student achievement. In their study of the middle school environment using survey responses and factor analysis they found that none of the empirical factors for students, teachers, or principals were significant predictors of student achievement. The teacher variable included professional development in only a general sense. This speaks again to the difficulty of measuring fidelity to implementation by teachers as well as how that might translate into student learning. We would argue that while it is expensive and time-consuming to do so, researchers need to go into classrooms regularly and observe teachers with respect to the specific professional development program with which they are engaged. Teachers may not enact the professional development as intended, and students may initially resist new ways that teachers are teaching, but if professional development fails to make the first hurdle and become part of teachers' instruction then there will surely be no effect on student achievement.

Professional Development & Research Context

CISIP Model of a Scientific Classroom Discourse Community

The NSF-funded Communication in Science Inquiry Project (CISIP) provides school-based teams of secondary science and English/English Language Learner (ELL) teachers with year-round professional development with the goal of establishing scientific classroom discourse communities. The CISIP model focuses on: a) academic language development; b) written discourse; c) oral discourse; d) scientific inquiry; and e) learning principles (e.g., accessing prior knowledge, the use of conceptual frameworks and embedded metacognition (NRC, 2000, 2005). The professional development focuses on these model elements to varying degrees, largely within the context of middle and high school level science activities. The 2007-2008 academic year was the first pilot year after a two-year development phase. During the summer of 2007 high school and middle school teachers participated in one of two three-week CISIP summer institutes. Life science activities were presented within an inquiry-based framework that stressed the use of claims and evidence as a means for generating scientific explanations alongside the other CISIP model pedagogical strategies. Continuing during the 2007-2008 academic year, approximately every other month, four day-long professional development workshops were held to build on the material that was presented in the summer institute. The teachers had the opportunity to attend 96 hours' worth of professional development. However, some teachers had also participated in the development phase of CISIP in previous years and potentially had up to an additional 200 hours (over 2 years) of professional development experience.

Research Questions

Due to the pilot nature of the project the main focus of this study was to explore possible relationships between the demographic and observation variables. Consequently, the results should be considered in this light and treated as such. The main research questions for this investigation of the data were as follows:

1) Does the length of professional development significantly account for teacher implementation of the CISIP professional development model?
2) Does the length of time that teachers have taught significantly account for teacher implementation of the CISIP professional development model?
3) Does the level that teachers teach, middle school or high school, significantly account for teacher implementation of the CISIP professional development model?
4) Does the socioeconomic status of the school population with which the teacher significantly account for teacher implementation of the CISIP professional development model?

Methodology

Data collection

Teacher and School Demographics

One data collection method was the use of a teacher demographic survey that collected information on their educational and professional experiences. Some of this information, such as length of time teaching and length of involvement with the professional development, was used in the construction of the model. Additional inspection of data from recent state-generated documents on required state testing results, school district size, per pupil spending on classroom spending and total costs, socioeconomic variables (e.g., percentage of students eligible for free and reduced lunch), and average teacher salaries for each teachers' district were also included in the study. Based on Cuban's (1992) framework of internal and external factors that relate to curricular change, we selected these eight common variables for their potential correlation with teachers' implementation of professional development in their classrooms.

Classroom Observations

A significant part of the study was observing science and English/ELL teachers teaching in their classrooms throughout the year. One-hundred-and-sixty observations were made from October

2007 to May 2008 by the university research team either in pairs, during the fall of 2007, or individually, in the spring of 2008. These observations included 28 classroom visits to a comparison group of 13 secondary science teachers between February to April 2008 as part of a smaller study that also pre- and post-tested students' knowledge of genetics and heredity.

The CISIP classroom observation instrument, the "Discourse in Inquiry Science Classrooms" (DiISC) (formerly named as the CISIP Classroom Observation Instrument (COI), Appendix A) has been under development and refinement to be aligned with the professional development model for four years (Ozdemir, Lewis, and Baker, 2007). Initially the items were developed with reference to the research literature base of the role of writing, oral discourse, scientific inquiry (NRC, 1996), learning principles in science teaching and learning (NCR, 2000, 2005), and ELL strategies.

Study Data and Model Results

Data

A group of 23 secondary teachers that participated in the CISIP year-round professional development were observed during the 2007-2008 academic year. There were 15 science and 8 English, ELL, and library media teachers in the sample who had taught from 0 – 32 years as of the 2007 CISIP summer professional development. A comparison group of 13 science teachers was also observed during one unit of instruction in the spring of 2008. Tables 1 and 2 summarize the means and standard deviations of all the variables that were used in both levels of the model.

Table 1. Summary of level one variable means and standard deviations used in HLM.

HLM level one data	**Mean**	**SD**
Number of observations of teachers in CISIP professional development (N=23)	5.78	2.68
Number of observations of comparison group teachers (N=13)	2.0	.00
Average raw scores of all observations (total observation score/108)	.25	.11

Table 2. Summary of level two variable means and standard deviations used in HLM.

HLM level two variables	**Mean**	**SD**
Number of students attending teacher's school	1,612	871
State testing score (max = 5)	3.3	.94
Number of students in the district	19,819	14,568
Per pupil spending: classroom	$4,599	$805
Per pupil spending: total	$7,914	$1,456
% of students eligible for free or reduced lunch by school	57.8	17.8
Average teacher pay (district)	$49,494	$6,650
Teacher experience (number of years teaching)	11	8.6

Observations were conducted using the DiISC with 36-items, with each item having a customized item definition that employs a 0 to 3 point scale. Consequently, there are a maximum total number of 108 possible points per observation, or a 3.0 average score. However, due to the extensive and sometimes sequential nature of the items on the DiISC (e.g., the processes of inquiry) it is highly unlikely that any one lesson would ever achieve a maximum score. The mean total number of observations per teacher was 4.44 (SD = 2.8, median = 3.5), however, the limited number, only two per teacher, of observations of the comparison group lowered this mean. The teachers who participated in the CISIP professional development were observed a mean of 5.78 (SD = 2.68) times with a median of 6.0 observations per teacher. The average raw scores from all of the observations ranged from .00 to .62 with a mean of .25 (SD = .11).

Model Building

For the hierarchical linear model (HLM) two levels of data were prepared. The first level included the average raw observation scores on the DiISC. The second level (Table 2) included: a teacher identification number, a code for participation in the professional development or comparison group, the length of time, in months, that the teacher had participated in CISIP (as of October 1, 2007, the beginning of classroom observations), the grade level (middle or high school) each taught, the number of students attending each teachers' school (mean = 1,612, SD = 871), the state testing score (out of a maximum of 5) for the school (3.3, SD = .94, the number of students in the district (mean = 19,819, SD = 14,568), the classroom (mean = $4,599, SD = $805) and total (mean = $7,914, SD = $1,456) per pupil spending costs, the percentage of students eligible for free or reduced lunch at each school (mean = 57.8%, SD = 17.8%), average teacher pay in the district (mean = $49,494, SD = $6,650), and the number of years the teachers have taught (mean = 11, SD = 8.6).

We built a model that describes, with statistical significance, the teachers' change in implementing the professional development model of a SCDC over time. We attempted to use both a factored measure and the raw DiISC measures. Only the raw measure yielded significant change over time. The model equations that resulted from using the raw measurements were:

Level 1: $\text{PD Use} = \Pi_0 + \Pi_1(\text{Time}) + e$

Level 2:
$$\Pi_0 = \beta_{00} + r_0$$
$$\Pi_1 = \beta_{10} + \beta_{11}(\text{PD Length}) + r_1$$

Parameter estimations are shown in Table 3, while the overall model fit statistics are shown in Table 4. Because the model was ultimately based on the raw metric, and lacked a fully comparable control group, the conclusions we made are not generalizable to other professional development programs or other groups of participants. Further investigation is necessary, especially as there is significant variance in both the intercept and the slope to be further modeled (see Table 5).

Table 3. *Overall model.* PDLENGTH = the length of time in months the teachers received professional development as of October 1, 2007.

	Effect (variable)	B	*se*	*T* Ratio	d*f*	*p*-value
Intercept, Π_0						
	intercept, β_{00}	0.33	0.043	7.63	35	< 0.01
Slope, Π_1						
	intercept, β_{10}	-0.00048	0.00018	-2.67	34	0.012
	PDLENGTH, β_{11}	0.000017	0.000006	2.88	34	0.007

Table 4. *Overall model fit.*

	σ^2	Deviance	d*f*
Overall model	0.0061	-260.94	4

Table 5. *Variance component analysis.*

Residual	Variance component	σ	d*f*	χ^2	*p*-value
intercept, r_0	0.02	0.15	11	24.14	0.012
time slope, r_1	0.00	0.00063	10	19.95	0.029
level-1, e	0.0061	0.08			

Results

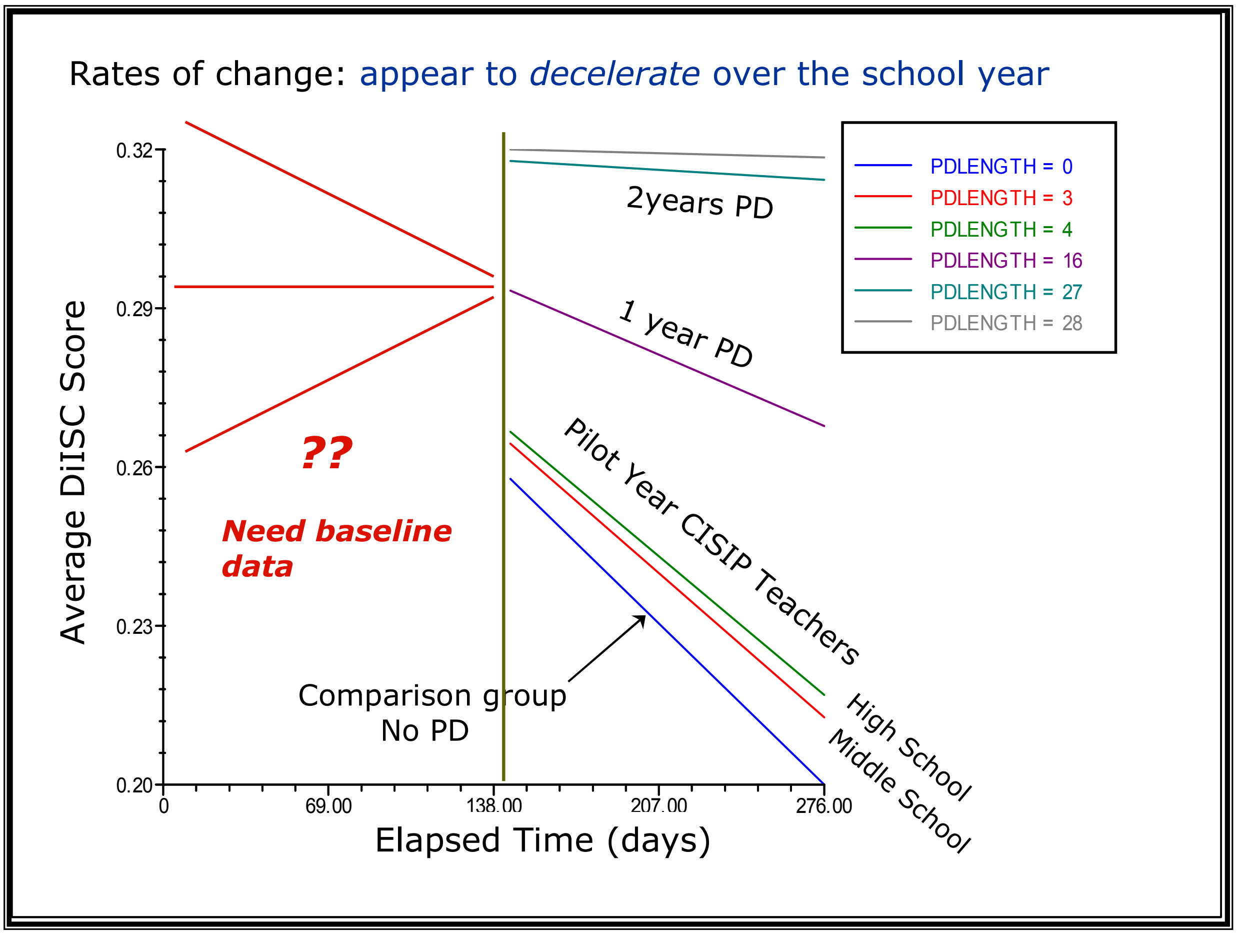
Table 6 displays, as per our research questions, possible predictors of teachers' change over time in implementing the professional development. Figure 1 shows the regression lines, using the raw average DiISC scores, produced by the model for six subgroups of teachers based on their length of participation from June 1, 2007 (the beginning of the professional development for the high school teachers) to May 2008. The graph suggests that as teachers received more professional development, they generally demonstrated higher rates of professional development implementation. The starting points for each subgroup within the sample, when regressed to a zero point, seemed to be comparable. Therefore, we find evidence that the professional development was associated with teacher change, although such claims are tentative and subject to further verification with more rigorous research designs and analyses.

The length of time (in months) that the teachers received professional development and socioeconomic status (SES) were both found to uniquely predict teacher change over time (see Table 4). When together in the same model, however, both predictors were insignificant. Consequently, the length of time that the teachers received professional development (PDLENGTH) was chosen as the exclusive predictor of teacher change because the overall model fit associated with PDLENGTH was better (or less poor, as deviance statistics suggested), PDLENGTH co-varied less across levels, and ultimately because PDLENGTH was more germane to the investigation. Because SES was significant, further research, both by the authors and others, will and should include more teachers and/or schools, time points, or multivariate outcomes.

Table 6. *Possible predictors of degree of professional development implementation.*
PDLENGTH = the length of time in months the teachers received professional development as of October 1, 2007. LEVELTEACH = middle school or high school, SES = school's student population that qualifies for free or reduced lunch.

Possible predictors	B	*se*	*t* Ratio	d*f*	*p*-value
PDLENGTH, β_{11}	**0.000017**	**0.000006**	**2.88**	**34**	**0.007**
LEVELTEACH, β_{01}	0.019	0.028	0.66	34	0.512
LEVELTEACH, β_{11}	0.000087	0.00012	0.74	34	0.463
SES, β_{01}	-0.14	0.07	-1.92	34	0.063
SES, β_{11}	**0.00057**	**0.00028**	**-2.04**	**34**	**0.049**

Figure 1. *Regression lines for subgroups of teachers.* The lines themselves start at October 1, 2007 when classroom observations began. The lines from bottom to top represent the following: a) the comparison group of the teachers who did not receive professional development (N=13, PDLENGTH = 0 months), b) the pilot group of middle school teachers (N = 7, PDLENGTH = 3 months), c) the pilot group of high school teachers (N = 8, PDLENGTH = 4 months), d) the development year 2006-2007 continuing teacher (N = 1, PDLENGTH = 16 months), e) the development year 2005-2006 continuing middle school teachers (N = 3, PDLENGTH = 27 months), and f) the development year 2005-2006 continuing high school teachers (N = 4, PDLENGTH = 28 months). The three lines leading up to the October 1, 2007 observation starting line reflect the absence of baseline data and a hypothetical range of regression lines that could be possible extensions of the 1-year PD regression line from the model.



Conclusions & Recommendations

As a result of the HLM and the inspection of the DiISC data, our conclusions are limited to the scope of the DiISC, with all of its strengths and limitations. Long-term CISIP professional development appears to be more effective, and necessary, for greater implementation of teaching strategies that foster the development of scientific classroom discourse communities. The results of the modeling would also suggest that the professional development appears to work well for a variety of participants, is adaptable and equitable. Additionally, if the ultimate goal is to find results that are generalizable outside the scope of the study itself, the first task in future investigations is to revise the DiISC. Both a Rasch and other item response theory (IRT) analysis would be useful in this respect. Once the measure is improved, less substance would be removed in the processes of z-scaling and factor analysis. Consequently, there would then be more variance, or strength, in that measure with which to build a model for generalization and replication. Finally, those who design and or study professional development should bear in mind the importance of observing teachers frequently over long periods of time in order to be able to employ HLM to its fullest potential.

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Appendix A

Discourse in Inquiry Science Classrooms (DiISC)

Teacher Name: ___________________________________ **Grade(s): ____ Science___ English___**

Subject: ____ **Lesson Plan Attached:** Yes No

School: ____ **District: __________________________**

Observer: ____ **Date: __________ Time: ___________**

Student Demographics (mark on continuum)

Male/Female Ratio: 100% M ---------------------------- 50% M/50% F ----------------------------- 100% F

Ethnic Diversity: **Low** -- **Medium** --- **High**
(100% one group) (equal % of all groups)

ELLs: _________ ***Students with IEPs:*** ________

Brief description of classroom activity, classroom features, other significant information

(I) Inquiry Scale

This scale measures the degree to which teaching takes place in a student-centered classroom where students are engaged in hands-on activities to explore the natural world with varying degrees of investigative independence.

1. Teacher creates an environment that supports inquiry	**Observed: 0 1 2 3**
Teacher provides students with: a) guidelines and time for (hands-on) exploration b) tools and techniques for analysis of data c) opportunities to elaborate on conceptual understanding	**Rubric:** *0= teacher lecture, vocabulary worksheet; 1= low level inquiry, directed, convergent activity; 2= medium, somewhat divergent; 3= high, open-ended exploration*
2. Teacher engages students in asking scientific questions for the purpose of investigation (hands-on or other means)	**Observed: 0 1 2 3**
Teacher provides students opportunities to: a) formulate questions about the natural world b) present explanations for questions c) distinguish between scientific and non-scientific questions	**Rubric:** *0= teacher generates question or no investigation; 1= limited opportunity, rote, cookbook activity; 2= students directed to form scientific questions to be investigated; 3= students form and explain reasoning behind the scientific questions for their investigation*
3. Opportunities for students to design and plan exploration of the natural world individually or in groups	**Observed: 0 1 2 3**
Teacher provides opportunities and guidance to: a) plan and conduct scientific investigations individually b) plan and conduct scientific investigations in groups c) justify procedures before carrying out investigations	**Rubric:** *0= no activity or activity has a set procedure; 1= students are all expected to design the same procedure; 2= students design a procedure but are not required to justify; 3= students design, plan, and justify their approach to exploration of a topic*
4. Opportunities for early stages of scientific exploration: making observations, recording data, and constructing logical representations (e.g., graphs)	**Observed: 0 1 2 3**
Teacher provides opportunities to: a) make observations through doing the activity b) record and use data c) record and represent data in logical forms that show patterns and/or connections	**Rubric:** *0= no exploration; 1= limited opportunity to engage in exploration; 2= students collect and/or manipulate data; 3= extensive exploration*
5. Opportunities for later stages of scientific exploration, explaining phenomena via claims and evidence, making predictions, and/or building models	**Observed: 0 1 2 3**
Teacher provides students opportunities to: a) make claims, provide evidence, and develop explanations b) revise explanations and models using data and logic c) make predictions and build models	**Rubric:** *0= no use of data for scientific explanation; 1= teacher-led, incidental use of claims and evidence; 2= students generate scientific explanation and/or models; 3= includes all of 2 and teacher directs students to evaluate their scientific explanations and revise*
6. Generating scientific arguments and constructing critical discourse about limits and sources of error	**Observed: 0 1 2 3**
Teacher provides students opportunities to: a) think of other ways to interpret data using scientific knowledge and logic to generate scientific arguments b) identify limits and exceptions of interpretations of data c) discuss the effects of error on results and suggest ways to reduce error in collecting data	Rubric: 0= no evaluation of scientific arguments or conclusions; 1= teacher provides possible sources of error in their investigations; 2= students generate sources of error and alternative explanations are generated; 3= students are directed to revise and evaluate their scientific explanations, consider alternative explanations, and sources of error

(OD) Oral Discourse Scale

This scale measures the degree to which teachers bridge everyday experiences and scientific discourse by providing students with opportunities to build scientific vocabulary and engage in peer-to-peer discussions that lead to building scientific explanations and exploring the nature of scientific communication (i.e., a scientific classroom discourse community).

8. Teacher promotes discourse through questioning	**Observed: 0 1 2 3**
Teacher asks questions: a) that require analysis and comparison b) that are divergent and have multiple possible answers c) to redirect for more information, to evaluate answers, and to uncover students' reasoning	**Rubric:** *0= no questioning; 1= teacher conducts IRE with convergent questions; 2= teacher asks divergent questions but doesn't engage all students in the discussion; 3= teacher probes for understanding and directs student-to-student discourse.*
9. Teacher promotes peer-to-peer discussion	**Observed: 0 1 2 3**
Teacher: a) provides opportunities for small group discussion and negotiation of meaning with specific questions or tasks b) monitors student participation in groups c) facilitates large group discussion among students or student presentation	**Rubric:** *0= no student-to-student talk; 1= teacher allows students to talk; 2= teacher monitors students' discourse; 3= teacher structures student interactions to promote rich peer-to-peer discussion*
10. Teacher (or instruction) bridges everyday experiences and scientific discourse	**Observed: 0 1 2 3**
Teacher: a) is sensitive to gender issues of discourse (using topics of interest to all students) b) connects everyday (e.g., pop culture) and scientific discourse c) distinguishes between everyday meaning of words and their scientific meanings	**Rubric:** *0= teacher just talks about science with no links; 1= teacher gives examples that not all students relate to; 2= teacher provides clear and relatable examples and makes connections to science; 3= teacher extends and builds on example(s) ensuring understanding*
11. Teacher models scientific discourse and vocabulary	**Observed: 0 1 2 3**
Teacher models how to: a) use scientific terminology b) use logical connectives in explanations (why-because) c) argue from evidence, compare, and analyze	**Rubric:** *0=no modeling; 1= teacher uses but doesn't explain scientific vocabulary or discourse; 2= teacher uses scientific vocabulary or discourse and explains meaning; 3= teacher's direct instruction explicitly models the use of scientific discourse and structure*
12. Teacher engages students in discussion that emphasizes the nature of science	**Observed: 0 1 2 3**
Teacher provides students with opportunities to: a) discuss that science is tentative and fallible b) discuss results and methods (replication of experiments) with skepticism and openness c) engage in public sharing of knowledge (incorporating NOS)	**Rubric:** *0= no discussion of NOS; 1= teacher transmission of information about NOS; 2= whole group or small group discussion of NOS; 3= teacher facilitates in-depth discussion of the NOS with whole group*

(W) Writing Scale

This scale measures the degree to which teachers provide students with opportunities to pre-write, write, and share their writing in order to acquire the language patterns and vocabulary to communicate scientific ideas, use science notebooks, and write in a variety of genres. Writing supports the development of a scientific classroom discourse community.

13. Formal writing in a genre that reflects the nature of science	**Observed: 0 1 2 3**
Teacher provides students with opportunities to: a) write for different audiences and purposes b) use expository, reflective, and expressive formats (e.g., newspaper article, poster, a lab report / scientific investigation report) c) emphasize the nature of science	**Rubric:** *0= no formal writing; 1= writing is unstructured or simply restated from text; 2= teacher provides a limited data set to students to write with a purpose; 3= teacher provides students a clear structure incorporating high level of inquiry, specific audience, and reflects the NOS*
14. Engaging students in <u>prewriting</u> associated with science concepts	**Observed: 0 1 2 3**
Teacher provides opportunities for students to: a) use brainstorming strategies and/or create concept maps b) develop questions and outlines c) take notes and/or use scientific terminology or symbols during scientific inquiry investigations	**Rubric:** *0= no writing;1= teacher promotes general note-taking; 2= teacher provides a structure for note-taking; 3= teacher has students generate their own ideas for the purpose of formal writing*
15. Engaging students in recursive writing processes using rubrics to review and revise	**Observed: 0 1 2 3**
Teacher provides time and opportunities for students to: a) review and revise through multiple drafts b) engage in peer-to-peer editing c) use rubrics that guide revision * Homework does not qualify here.	**Rubric:** *0= feedback provided but no revision of student work; 1= minimal time provided and students revise without a rubric; 2= students use rubrics to revise their writing; 3= students revise through either teacher feedback and/or peer editing with the use of rubrics*
16. Engaging students in writing to acquire the language patterns and vocabulary to communicate scientific ideas	**Observed: 0 1 2 3**
Teacher provides opportunities for students to use: a) scientific terminology and/or symbols or equations b) language patterns of science c) structural patterns of scientific writing (e.g., claims-evidence)	**Rubric:** *0= no writing by students; 1= minimal use of writing by students, note-taking; 2= students have the opportunity to write scientifically; 3= teacher monitors students as they engage in scientific writing*
17. Teacher provides direct instruction in writing content, forms, and processes	**Observed: 0 1 2 3**
Teacher: a) provides instruction about the nature of scientific writing b) provides templates for each genre (lab report, brochure) c) explains function and appropriate time to use genres	**Rubric:** *0= no direct instruction about how to write scientifically; 1= teacher provides template for how to write; 2= teacher explains why and when a scientific form is to be used; 3= teacher models how students would use a specific genre of writing*
18. Engaging students in using science notebooks as a learning tool	**Observed: 0 1 2 3**
Teacher provides instruction in how, or opportunities, to: a) use notebooks as a learning tool b) organize science notebooks c) record data, reflections, and/or handouts	**Rubric:** *0= no use of science notebooks; 1= student work (e.g., worksheets) pasted in notebooks with no elaboration; 2= students record data in notebooks, reference past activities, etc.; 3= students synthesize and/or revise work from their notebooks*

(ALD) Academic Language Development Scale

This scale measures the degree to which teachers use visual aids, supplemental resource materials, clear instruction throughout the lesson, and lessons that build on students' language and culture. It also measures instruction for student interactions and academic learning strategies and opportunities for students to acquire scientific vocabulary.

19. Providing students opportunities to acquire vocabulary	**Observed: 0 1 2 3**
Teacher provides opportunities for: a) reviewing and repetition of vocabulary and tasks b) building academic language from the vernacular c) interpreting words from contextual clues	**Rubric:** *0= teacher does not provide vocabulary building opportunities; 1= students are given incidental, unstructured opportunities; 2= teacher provides structured opportunities for students to acquire vocabulary; 3= teacher monitors students for understanding of vocabulary as they perform tasks*
20. Teacher uses clear instruction throughout lesson by modeling expectations	**Observed: 0 1 2 3**
Teacher: a) varies speech and enunciates clearly b) explicitly defines content and language objectives of the lesson c) gives simplified directions	**Rubric:** *0= teacher's directions are unclear and confusing; 1= clear directions, but objective is vague; 2= teacher provided clear objectives and directions; 3= teacher monitors for understanding of objectives and directions*
21. Using visual aids and gestures to communicate with students	**Observed: 0 1 2 3**
Teacher: a) uses visual imagery, organizers (e.g., thematic boards, word wall displays, concept maps) b) employs gestures c) uses manipulatives for abstract and concrete concepts	**Rubric:** *0= teacher does not use visual aids or gestures; 1= minor use of a visual aid or gestures; 2= consistent use of gestures and/or visual aids or a well-developed example of a specific visual or manipulative; 3= teacher monitors understanding of visual aids and/or manipulatives*
22. Building lesson on students' language *(vernacular or non-English)* OR culture	**Observed: 0 1 2 3**
Teacher incorporates into instruction: a) culturally-relevant examples (family, pop culture, ethnic traditions) b) native language when appropriate c) cultural artifacts (*anything human-made*) and community resources (*eating rice & beans, force on tortilla press, force on toes of a ballerina*)	**Rubric:** *0= teacher does not incorporate links to language or culture; 1= minor use of students' language or culture; 2= teacher bridges students' language and culture consistently through lesson; 3= lesson is planned and executed using familiar language with culturally relevant links to science content*
23. Teacher addresses multiple levels of academic language proficiency *(differentiated instruction and/or assessment)*	**Observed: 0 1 2 3**
Teacher: a) provides activities of varying academic linguistic demands b) uses assessments that match academic language proficiency c) adjusts pedagogy to the language proficiency * If organization is unclear, be sure to ask teacher how lesson was differentiated for students.	**Rubric:** *0= one lesson delivered the same way to all students; 1= teacher allows for students to self-pace using same set of activities; 2= differentiated assessments or projects are provided to accommodate students' various levels of academic language proficiency; 3= teacher organizes individual students' activities based on their academic language proficiency*

24. Provides direct instruction for using academic learning strategies	**Observed: 0 1 2 3**
Teacher provides instruction in: a) summarizing b) organizing information for understanding (taking notes, data organization, mnemonics) c) making inferences from data (evidence supported)	**Rubric:** *0= teacher provides no direct instruction; 1=teacher mentions in passing that students might use an academic learning strategy; 2= teacher models how to use a specific strategy for students to use; 3= teacher models and monitors students in using the strategy*
25. Teacher provides instruction for interactions among students	**Observed: 0 1 2 3**
Teacher provides instruction in: a) how the groups will be organized and function (defines roles, collaborative structure, social norms of behavior in a group, inclusive interactions) b) using collaborative inquiry skills (how to paraphrase and ask questions for clarification) c) structures of accountability (academic and socially as a group)	**Rubric:** *0= teacher does not give instruction for how groups will be organized; 1= teacher directs students to work together; 2= teacher provides roles for students within groups; 3= teacher provides roles and establishes individual accountability within each group and monitors activity.*
26. Uses supplemental resource material ***(Note: lesson could be done without these)***	**Observed: 0 1 2 3**
Teacher: a) provides supplemental materials (e.g., trade books) b) provides access to reference materials (e.g., bilingual dictionary) c) uses technology to support language development (e.g., Internet)	**Rubric:** *0= no supplemental resources are available to students; 1= student independently uses an additional resource; 2= teacher directs students to use supplemental resources; 3= teacher models use of supplemental resource(s)*

(LP) Learning Principles Scale

This scale measures the degree to which the teacher aligns lessons with the CISIP model. This includes providing opportunities for students to assess prior knowledge, make conceptual connections, and engage in metacognition. The teacher also models thinking, establishes community norms, and promotes an academic focus that supports learning science.

28. Accessing students' prior knowledge	**Observed: 0 1 2 3**
Teacher provides students opportunities to: a) access their prior knowledge b) compare prior knowledge with normative ideas in science c) reflect and/discuss initial ideas and conceptions <u>Note</u>: Accessing prior knowledge means determining what students know before teaching the unit, oral or written.	**Rubric:** *0= lesson is delivered without determining what students know about the concept(s) to be studied; 1= teacher conducts an informal survey of the class but doesn't direct all students to self-assess; 2= teacher directs all students to determine what they know on a topic before starting the lesson; 3= lesson involves a comparison of students' prior knowledge with normative ideas*
29. Teacher modifies instruction based on students' prior knowledge	**Observed: 0 1 2 3**
Teacher: a) identifies alternative conceptions b) revises instruction based on students' understanding c) uses conceptual change strategies * If teacher's degree of modification is unclear, be sure to ask teacher how lesson was changed from original plan.	**Rubric:** *0= teacher doesn't make any modifications based on students' prior knowledge; 1= teacher identifies students' prior conceptions and minimally addresses them; 2= teacher revises original lesson to accommodate students' level of understanding; 3= teacher uses pro-active conceptual change strategies (e.g., a discrepant event) to shift students prior conceptions*
31. Teacher and/or students situate factual knowledge (experiences, ideas, data, and explanations to past lessons and/or real-world experiences) within a conceptual framework *(fact to concept relationship)*	**Observed: 0 1 2 3**
Teacher provides opportunities to: a) link facts and experiences to promote patterned reasoning b) assimilating new information into existing frameworks of past lessons and real-world experiences c) place factual knowledge in a conceptual framework	**Rubric:** *0= no conceptual framework utilized, just factual information; 1= teacher provides informal opportunities for students to generate understanding of topics; 2= teacher provides formal structure for generating understanding of facts within a conceptual framework; 3= teacher provides opportunities and monitors student understanding*
32. Teacher provides opportunities for students to review key concepts *(focus on the review, not the discourse)*	**Observed: 0 1 2 3**
Teacher provides opportunities for conceptual understanding: a) through multiple and rich representations b) by linking formal science to ideas beyond the classroom c) by reviewing key concepts	**Rubric:** *0= teacher does not provide opportunities for reviewing concepts; 1= teacher provides informal review of key concepts; 2= teacher provides formal opportunities for reviewing; 3= teacher provides multiple formal opportunities for reviewing*
34. Teaching with embedded metacognition for students to elaborate and summarize their understandings	**Observed: 0 1 2 3**
Teacher: a) models thinking in analysis of tasks or learning b) provides advanced organizers and/or develops graphic tools c) provides opportunities for students to elaborate and summarize	**Rubric:** *0= no opportunity for students to engage in connected metacognitive activity with the science concepts they are learning; 1= students have the opportunity to summarize what they have learned; 2= students have the opportunity to distinguish what they do and don't understand in a structured activity; 3=students have the opportunity to reflect metacognitively and define methods to expand their understanding*

35. Teaching self-monitoring for understanding *(focus on direct instruction of strategies)*	**Observed: 0 1 2 3**
Teacher directly instructs students how to: a) reflect on their understanding, abilities, and affective states b) evaluate their own progress and quality of completed tasks c) identify what they have and have not been learned	**Rubric:** *0= teacher provides no direct instruction of strategies for student awareness of what they know and don't know or what resources they could use to find out; 1= teacher instructs students how to summarize what they have learned; 2 = teacher instructs students how to distinguish between what they know and what they don't know; 3= teacher instructs students how to reflect metacognitively and define methods to expand their understanding*
36. Teacher provides students opportunities to develop awareness of their own learning strengths and challenges	**Observed: 0 1 2 3**
Teacher provides opportunities for students to: a) self-assess effectiveness of their learning approaches b) understand unique learning approaches c) set the intensity or the speed of work Note: Focus on learning approaches	**Rubric:** *0= no opportunities provided; 1= students are allowed to self-pace work; 2= students are directed to evaluate their learning approaches to the task at hand; 3= teacher provides resources to self-assess their strengths and challenges*
37. Promoting executive control of learning *(student choice about what and how they learn)*	**Observed: 0 1 2 3**
Teacher provides opportunities for students to: a) make choices and decisions about what and how to learn b) recognize that learning is under their control c) organize and sequence their own activities	**Rubric:** *0= students are not given a choice of activities; 1= students are allowed to self-pace the activities provided for them; 2= students have a choice of activities to choose from; 3= students generate their own activity focus*
38. Teacher establishes or reminds students of community norms for discourse	**Observed: 0 1 2 3**
Teacher: a) negotiates, or reminds students of, guidelines for respecting each other's ideas b) establishes clear rules and expectations for discourse to promote everyone's participation c) provides opportunities for internalizing norms	**Rubric:** *0= community norms for scientific discourse are not in place or being generated; 1= teacher has community norms posted in the classroom; 2= teacher refers to classroom norms to remind students and promote equitable participation; 3=teacher involves students in establishing or maintaining community norms*
39. Communicating lesson expectations with guidelines *(oral or written)*, or rubrics, or exemplars	**Observed: 0 1 2 3**
Teacher: a) uses rubrics to inform students of performance expectations b) provides exemplars of student work c) provides easy to follow guidelines	**Rubric:** *0= no communication of teacher expectations; 1= general guidelines & performance expectations only; 2= specific guidelines & performance expectations with rubrics; 3= specific guidelines & performance expectations with rubrics and exemplars*
42. Teacher uses feedback strategies that have an academic focus *(NOT just praise; "be more specific")*	**Observed: 0 1 2 3**
Teacher: a) uses both oral and/or written feedback b) give timely feedback c) encourages student self-reflection	**Rubric:** *0= teacher does not provide students with any feedback; 1= teacher provides minor feedback; 2= teacher provides sufficient feedback that encourages students to reconsider their ideas; 3= uses multiple forms of feedback*