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Moving Forward in Science Reform: Alliance for Science Outcomes, Year 1

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Moving Forward in Science Reform: Alliance for Science Outcomes, Year 1

Currently, any discussions of science reform seem to lead directly to discussions of science standards. Debates about accountability include national, statewide, as well as district-level standards (National Research Council, 1996; Illinois State Board of Education, 1997). These new visions of desirable learning outcomes in our classrooms are also reflected in ideas about standards and reform specific to science instruction (American Association for the Advancement of Science, 1993; National Science Teachers Association, 1991).

These calls for reform and the new definitions for success have penetrated our discussion of science teacher preparation and educators are working hard to pave the new roads to accomplishing these goals. Wright & Wright (1998) discuss the systemic reforms of the educational process that are required to accomplish these new goals, including the changes in attitudes and expectations for all educators. On the other hand, Spillane (1999) addresses the sometimes-tenuous relationship between state standards and policies at the local level. This revised vision of the classroom includes a new understanding of the role of the teacher and appropriate instructional activities. With the teacher now conceived as the facilitator and the constructivist epistemology embedded in the science curriculum, creating a process for planning that meets standards as well as respects the active learner model is proving difficult. However, educators do not see this marriage of constructivism and standards-based reform as inevitably doomed and some have suggested ways to address both. "Many of the problems with constructivist…science probably can be solved through improved curricula, quality control of problem sets, and better professional development" (Clune, 1998, p. 147).

Research is beginning to surface on how these new reforms are influencing student outcomes and educators are discussing new classroom rules, ranging from new science activities to a reconception of the classroom "space" (Parker & Gerber, 2000; Dispezio, 1999; Bishop & Barrow, 1998; Biehle, 2000).

Facilitating the realization of reform efforts into classroom practice is complex. In fact, student-centered approaches can be prone to "serious errors" in the definition of problems, teacher content knowledge, and a de-emphasis on subject matter content in favor of cross-disciplinary problem-solving (Clune, 1998). Schmoker and Marzano (1999) discuss the problems for teachers inherent in the massive written standards and the typically ill conceived or non-existent process for addressing them. Kumar (1999) recommends changes in field-based teacher preparation, balanced science content and pedagogy, educational technology, professional accountability, equity, and research. Clearly, effectively preparing teachers to lead the reform is a key first step. Loucks-Horsley (1998) identifies several important tenets of effective professional development experiences. These experiences should be defined by an image of effective classroom-learning experiences, should model strategies that teachers will use with students, and should build links between the teachers and other parts of the educational system to ensure continuous improvement. Darling-Hammond (1999) advises that professional development should be on going, embedded in teachers' daily activities, and connected to work with students. In addition to preparing teachers to develop new curricula aligned with standards, teachers and administrators need to be critical in their selection of pre-published curriculum materials. Educators can take advantage of established frameworks and critical questions to guide evaluation of curriculum decision making (Goldsmith & Kantrov, 2000).

Classroom teachers feel this increased pressure to address standards, especially at the level of curriculum development. This report describes one Illinois region's efforts to equip teachers with the necessary process for developing curricula that address statewide standards.

The Lake County Regional Office of Education has developed a multi-dimensional training program, "Lake County Alliance for the Continued Improvement of Science," to assist teachers in mapping curricula to the Illinois state standards as well as prepare and implement inquiry-based science throughout the elementary grades. Evaluation of the project focuses on creating inquiry-based science curricula aligned to Illinois state standards. Evaluation activities included analysis of curriculum maps, lesson plans, and a survey of teachers' perceptions of inquiry-based learning activities in their classrooms. This report focuses on curriculum maps and teachers' perceptions of their classrooms.

Alliance for Science was developed to "provide staff development that is easily transferable to the context of classroom activities" (Reichel, 1999, pg. 2). A series of staff development training workshops was provided during which groups of teachers developed curriculum maps intended to include all three science content areas (life, physical, and earth science) built on an inquiry-based instructional framework. The workshops addressed various important themes, including:1) Creating curriculum maps to align lessons to state standards; 2) Developing inquiry-based science units; 3) General staff development on issues such as constructivism and inquiry-based science concepts. In addition to hands-on workshops, Alliance for Science supports schools by sponsoring Family Science Nights, supporting science committees established at some of the schools, and by sponsoring problem-oriented study groups that connect teachers across the region who are trying to address specific science curriculum issues in their schools.

This paper will focus on Year One (of three) of Alliance for Science outcomes, specifically the mapping of Illinois science standards to classroom curricula and infusing inquiry-based science into the classrooms of Lake County, IL.

The following questions will be addressed:

1. To what degree do the science curricula align to state science standards?
2. To what degree do teachers report integration of inquiry into the science curriculum?
3. What are the differences across grade levels on integrating inquiry-based science into the classroom?
4. Is there a correlation between teaching experience and integration of inquiry-based science?

Method

The alignment to state standards and infusion of inquiry into science was assessed through analysis of science curriculum maps and a written survey of participating teachers. Reflection on various issues related to adherence to state standards was obtained in open-ended written statements provided by the respondents. The analysis of curriculum maps, survey responses, and written comments were used to develop answers to the evaluation questions.

Project Sample

Schools in the "Alliance for Science" staff development study selectively participate in the different components depending on their specific curricular needs. In total, 519 teachers in 37 schools within 18 school districts participated in some aspect of the project. Because of the on-going nature of the professional support of Lake County educators by the Regional Office of Education, many school districts have participated in similar programs from the office in previous years. Therefore, total sample sizes participating in different aspects of the training reflect only those schools and districts participating in the professional development workshops in the 1999-2000 academic year. Participation in previous years has not been documented.

Curriculum Map Sample

There were a total of 11 curriculum maps completed in year 1 from the 18 school districts.

<u>Survey Sample</u>

There were 202 teachers within the 18 participating school districts in northern Illinois who completed self-administered surveys in the spring of 2000. Surveys were distributed by the project director and mailed to the evaluators. The average years teaching experience was 13.8 years, ranging from first year to 42 years of teaching.

<u>Alignment to State Standards Workshop and Assessment Rubric</u>

There were 91 teachers participating in the Alliance for Science Curriculum Mapping workshops in 1999-2000. The average level of participation was 3.59 hours, with a low of 2 and a high of 9 hours of workshop training.

All of the Alliance for Science workshops were developed to "provide staff development that is easily transferable to the context of classroom activities" (Reichel, 1999, p.2). Before the project began, it was determined that "most Lake county districts emphasized the life and environmental sciences with less attention given to physical and earth science during the elementary years. In addition, the process of scientific inquiry was frequently reduce to 'recipe-based science'" (Reichel, 1999, p. 1). To responde to these issues, staff developmen workshops were provided during which groups of teachers developed curriculum maps (scope and sequence) intended to include all three science content areas (life, physical, and earth science) and use science inquiry and science processes.

To determine if the standard was addressed and at what level of specificity, four descriptors were used - explicit, implicit, generic, and not observed. Differences were noted in the extent to which the contents were: 1) Explicitly related to the standard by using a direct or specific science content or inquiry reference; 2) Implicitly related to the standards by using an indirect or non-specific science content or inquiry reference; 3) Generically related to the standard by basically paraphrasing its wording and lacking a science content or inquiry reference; or 4) Not observed meaning the standard was not present in the curriculum map.

The curriculum maps were coded to determine the extent to which the science standards were present. Codes were used to identify the presence of each of the Illinois Learning Standards (1997) for science. The codes were then aggregated to represent the way the three content area goals for science (life, physical, and earth) are constructed).

Inquiry in the Classroom Instrument

A survey (see Appendix A) was developed by the researchers to assess teachers' perceptions of inquiry elements in their classrooms. The items were based on the training provided to participating teachers, which was aimed at providing teachers with the processes to effectively facilitate science learning. Aside from demographic variables, the instrument contained 12 items that identified activities consistent with the effective learning processes and used a four point scale (All of the time, Most of the Time, Some of the Time, Never) to measure the degree to which the activities were present during science. The training was based on the learning cycle (focusing, exploring, reflecting, and applying) information promoted by the National Science Foundation (1997) and the National Academy for Sciences (1977). For example, for the first item, teachers responded to "Students in my class engage in discussions about science." Space was also provided for teachers to include their own comments related to the items. Reliability analyses indicated that the instrument was moderately stable (Alpha reliability with $\alpha = .74$, n=166; only cases responding to all items of the survey were included in the analysis).

Results

1. <u>To what degree are teachers adhering to state science standards in their daily classroom activities?</u>

The results show a balance of emphasis between life, physical, and earth science in the curriculum maps (see Appendix B). Each content area was referenced 86 times across the 11 curriculum maps. Most of these were explicit references, with life=94%, physical=97%, and earth science references=94% explicit (as opposed to implicit or not observed). Chi square analysis shows no difference between the content area standards (χ^2=.64, p>.05) referenced in the curriculum maps.

2. <u>To what degree do teachers report integration of inquiry into the science curriculum?</u>

For each item, scores ranged from 0 - 3 points (0=Never, 3=Always). We used 1.50 as the cut-off for the item means. Therefore, an item with a mean <1.5 (indicative of inquiry activity evident only "Sometimes" or "Never") was considered to indicate that the component of inquiry learning cycle generally **was not** evident in the classrooms. Correspondingly, an item mean >1.5 (indicative of being evident "Most of the Time" or "Always") was interpreted as indicating that the component of the inquiry learning cycle generally **was** met in the classrooms.

Looking at the items individually, the only standard that teachers report meeting only "sometimes or never" asks if "students have time for several trials." The mean for this item was 1.48.

Of the teachers who responded to this Likert scale item, 37 wrote comments which explain how and why time was an issue for them. Two of the comments were provided by those who circled "All of the Time" in response to the questions. Their perception was that:

"It doesn't make much sense to not let them fully explore"

"More than one trial gives better data to draw conclusions from"

Four of the comments were provided by those who circled "Most f the Time in response to the question. Their comments included:

"We give adequate time to perform the trials - We only repeat if necessary"

"In most instances it's most of the time. There are times too when it's all of the time."

The remaining 31 comments included those who responded "Some of the Time" (n=24) or "Never" (n=4). For most of these teachers, adequate time to accomplish this task seems to be an issue. Typical comments written by those who indicated "Some of the Time" included:

"This is the biggest lack in our Science Program, enough time. The second grade had so many units that are quite lengthy that we don't even have enough weeks in the year to do them justice."

"We do all of the science curriculum and what's suggested for the experiments. We don't have time for extras or experiments."

"It is so difficult to fit in several trials! Our curriculum is very full!"

Some teachers offered solutions for this issue:

"It is always hard to find time to fit in science. Works best when lessons can be taught cross-curriculum."

"Again, this time issue does impede those times when students come up with real questions. Next year overlap units so students can reach their hypothesis."

So, while the time constraint is not uniformly expressed across the 200 participating teachers, a sizeable number of teachers are struggling with this issue and exploring ways to accommodate their competing curricular needs. It is important to note that while we have presented a logical argument for the 1.5 cutoff, it is in some ways arbitrary. Because the item mean was very close to our cutoff, interpretation should be done with caution.

Several items had a mean score much higher than 1.5. The components of the learning cycle teachers report **most** often are (means are in parentheses):

- lessons include what students know and don't know (2.35)
- students discuss science (1.88)
- students analyze science data (1.85)
- students apply what they learn (1.82)
- students use science knowledge in real life situations (1.64)
- students defend results (1.60)
- students engage in science explorations (1.59)
- students use science knowledge in new contexts (1.54)

Teachers reported incorporating what students do and don’t know (mean score of 2.35) most frequently. As might be expected, most of the comments written by the teachers were positive. Fifteen of the comments (58%) were provided by teachers who circled "All of the time" in response to the item. Their statements included:

"I always find out previous/background knowledge before I begin the lesson and discussion."

"We always build upon what the students know and had had experiences (with)."

"I always check in several times to see what they know and don't know. This drives how and what I teach."

"All good lessons include this!"

These comments seem to indicate that this is an essential element in their teaching.

There were three negatively worded items and these all had near 0 means (.53, .007, .14), which indicate teachers report that students **never** withhold their ideas about science, **never** disregard their own questions, and **never** avoid small groups. Interpretation of these items is tentative because reliability analysis shows that the survey's stability is slightly increased when these items are deleted (to α = .75-.76).

The mean Total Score (sum of items 1-12) was 22.8. It appears that across all the components of inquiry-based learning activities, this group of teachers reports inquiry tenets are present "Somewhat" to "Most of the Time" in their classrooms.

Total Score	0 -12 (Inquiry components evident never or only somewhat)
	13 - 24 (Inquiry components evident somewhat to most of the time)
	25 - 36 (Inquiry components evident most of the time to always)

<u>3. What are the differences across grade levels on integrating inquiry-based science into the classroom?</u>

Total Scores on the teacher survey were compared across grade levels. Teachers in multi-age or multi-grade classes were omitted from analysis (n=9). ANOVA results revealed no significant differences between grades, with $F=1.312$, $p<.24$, $n=193$.

<u>4. Is there a relationship between teaching experience and integrating inquiry-based science into the classroom?</u>

A Pearson correlation reveals no relationship between the years of teaching experience and perceptions of inquiry-based activities ($r=-.08$, $p<.281$, $n=184$). The smaller n is a result of missing data (only cases responding to all questions were included in the analysis).

Discussion

With such a strong emphasis on standards, it is important to understand how successfully schools are able to align the science curriculum with state standards and the extent to which inquiry is integrated into the curriculum.

The 11 curriculum maps submitted for review show strong evidence that at the level of curriculum planning, schools have aligned consistently, explicitly, and equally to the state standards for life, physical, and earth science.

In terms of the integration of inquiry into the classroom activities, teachers in this project generally reported integrating inquiry "somewhat" to "most of the time." Clearly, the is to have inquiry-based science occurring "most of the time" or "always" in the classroom. The only area teachers reported as not being addressed related to allowing students to have time for several trials during science inquiry, a reality of a full curriculum that is not surprising.

There does not appear to be a grade-level difference in teachers' perceptions of integration of inquiry-based science in the classroom activities. This indicates that teachers in Kindergarten through 9th grade are reporting they are creating and implementing inquiry-based science for their grade level consistently.

Finally, there does not appear to be a relationship between teaching experience (as measured in years of teaching) and perceptions of integrating inquiry into the science curriculum. Veteran teachers do not perceive their classrooms as any more or less inquiry-based than more novice teachers.

It is important to get a clear understanding of barriers to integrating inquiry and aligning the science curriculum with state standards. These barriers most likely occur in many areas, including teacher understanding of the standards as well as appropriate curriculum-mapping processes as discussed by Clune (1998), Kumar (1999), and Schmoker & Marzano (1999). But a more holistic understanding of the entire system within which these teachers are participants is important to gaining a fuller understanding of the local-state relationship in these matters (Spillane, 1999). Time and infrastructure to support a closer link between state goals (articulated in standards) and classroom activities is clearly mandated.

As pressure mounts to create standards for schools, teachers must be equipped with an effective process for integrating these standards into their curriculum. Curriculum mapping is one process that teachers have reported as helpful and effective for addressing this need. Evidence from this evaluation of year 1 indicates that the hands-on, problem-oriented approach to mapping science curricula to state standards is very effective. This same approach to training teachers in the inquiry process has been very successful in integrating inquiry into science has reported by teachers.

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Appendix A

Lake County Alliance for the Continuous Improvement of Science

2000 Teacher Survey (4 point Likert Scale)

Students in my classroom…

1. engage in discussions about science.
2. engage in active, in-depth science explorations.
3. withhold their ideas about science (negative item)
4. use what they have learned about science in new contexts.
5. are encouraged to disregard their own questions about science (negative item).
6. have adequate time to perform repeated trials during science.
7. analyze their science data.
8. use what they learn about science in real-life situations.
9. incorporate what students do and do not know.
10. avoid small groups during science. (negative item)
11. defend the results of their scientific investigations.
12. apply what they learn about science.
13. use appropriate electronic equipment as a part of learning science.
14. use computers as part of learning science.
15. use computer networks as a part of learning science.

Appendix B

Standard Category	**Standard Explicitly Referenced in Curriculum Map**	**Standard Implied in Curriculum Map**	**Standard not observed or not referenced specifically enough to be coded**	**Total References**
Life	81 (94%)	0	5 (6%)	86 (100%)
Physical	83 (97%)	0	3 (3%)	86 (100%)
Earth	81(94%)	0	5(6%)	86 (100%)
Total References	245 (95%)	0	13 (5)	258 (100%)