School-Based Curricular Frameworks: Supporting Local Science Education Reform

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Overview

Teachers are often charged with developing curriculum guides in departmental teams under a mandate of school administrators, district supervisors, and state education bureaucracies. These documents, once written, may go unused on a bookshelf until the next round of accountability looms upon the horizon (Anderson, 1995; Bush, 1971; Evertson, 1990; Nolan & Francis, 1992). Given this common reality, the value of these exercises and their subsequent products is questionable. This paper reports on the outcomes of a multiyear National Science Foundation (NSF) funded project in Iowa that addressed this challenge as a part of its long-term project goals, and will report on the following:

- a high quality professional development experience of working, inquiring, and learning together to create local curricular frameworks, and
- an evaluative instrument used to provide insight on developmental challenges and to document growth and progress.

The Iowa Scope, Sequence, and Coordination (SS&C) Project was one of five SS&C original sites (Iowa, North Carolina, California, Puerto Rico, and Alaska) committed to science teacher enhancements, alignment of science curriculum, and toward teaching fewer concepts in greater detail. This work provides a model to states, districts, and science educators nationwide as a dynamic teacher and curriculum development process oriented toward student-centered science instruction. For the first three years of the project, the work was centrally coordinated through the National Science Teachers Association (NSTA). NSF managed the second phase of the project centrally with each funded site operating more independently.

The Iowa SS&C Project was committed to the creation of a shared vision and collaborative work. The project members worked from the premise that quality professional development and learning opportunities are the basic components in the continuing preparation of teachers and are vital factors in determining the success of educational reform (Blunck, 1993; Fullan, 1994; Joyce, 1990; Lieberman, 1995; Liu, 1992; Spector, 1986; Voelker, 1977). The investment of energy to create a learning community is necessary if such reform efforts are to result in measurable, sustainable, progress (Anderson, 1998; Kruse, 1994). The basis of a learning community is contextual and is oriented to working, inquiring, and learning *together* (Sergiovanni, 1994). Such learning communities are constructed through team learning, "…[developing] the skills of groups of people to look for the larger picture that lies beyond individual perspectives" (Senge, 1990, p. 12). The results are common, unambiguous goals (i.e., a shared vision) and products, which align with the vision. The Iowa Scope, Sequence, and Coordination Project participants adhered to these principles, developing and refining their shared vision and products with time.

The Project: Iowa Scope, Sequence, and Coordination

The Iowa SS&C was a NSF funded teacher enhancement project active from 1990-97 through two distinct funding phases. In both phases, the participating teachers came from sites ranging from relatively large metropolitan districts to very small, rural districts. The original seven districts that committed to the project (about 120 participants) during 1990-94 were recruited from among interested districts in Iowa prior to the first funding period. Sixteen school districts (about 175 participants) participated during 1994-97, including six of the original seven and nine new districts nominated by members of the original group.

Following the philosophy of the learning community, leadership was shared between the participating teachers and the project staff from the Science Education Center at the University of Iowa. This partnership for reform at the secondary level used a mentor-protégé/lead-teacher model with the participants, particularly the lead teachers, assuming considerably more decision-making responsibilities with time. Thus, the teachers' practical knowledge was melded with project goals and premises (van Driel, Beijaard, & Verloop, 2001).

The centrality of teachers in local districts as the agents of reform, facilitated by higher education partners, is supported by Goodlad (1994), who put forth an "[essential] new setting—a center for pedagogy—that brings schools and universities together in a close renewing relationship" (p. 195). Embracing this philosophy, a parallel for a center of pedagogy was formed through the shared vision and spirit found in the Iowa partnerships for educational improvement. Iris Weis (1991, p. 20) referred to the Iowa SS&C partnership between the project staff and the teachers and their communities as a "structured grassroots" effort.

The Iowa SS&C Project partners were guided by a commitment to the following:

- *Improvement of K-12 science education through professional development activities and continuous collaborations:* The teachers planned and designed constructivist learning experiences and curricular frameworks using an STS (Science-Technology-Society) context, emphasizing the concept of reflection in action (Schön, 1983). Participants learned to use varied context-based schemes for assessment to help students explore and understand science through inquiry.
- *Development of a network for continuing teacher enhancement:* Communication between lead teachers, teacher participants, administrators, and central staff was a high priority. New teachers and administrators were quickly mentored into this learning community.
- *Development of lead teachers:* The long-standing successes of the Iowa SS&C and its predecessor, the Iowa Chautauqua Project (ICP), was largely attributed, to the development of teachers as leaders in the reform process (Burry-Stock, Yager, & Varrella, 1996; Varrella, 1997). A network was established between ICP and SS&C, which by Lieberman's (1995) measure, fueled progress, and facilitated consensus on intent and product. By vesting the lead teachers in the on-going planning and designing of the learning experiences for their colleagues, the lead teachers' leadership skills, depth of epistemological commitment, and abilities were continually honed.
- *Development of collaborative reform efforts:* Sustained reform can be brought about only through collaboration among all stakeholders (Anderson et al., 1994; Lieberman, 1995; Lieberman & McLaughlin, 1992; Sergiovanni, 1994; Sizer, 1992). The Iowa SS&C

Project developed partnerships and alliances between schools, colleges, local businesses, and industries for continued communication and cooperation (Burry-Stock, 1996; Robinson, Enger, Varrella, & Yager, 1997).

The NSES and the Tenets of SS&C: A Framework for Developing Frameworks

During its early years (1990-92), prior to the promulgation of the National Science Education Standards (*NSES*), the Iowa SS&C project was guided by the principals of Project 2061 (Rutherford & Ahlgren, 1989). Since the Iowa project was part of the larger Scope, Sequence, and Coordination collaboration, its early framework development was influenced by the newly created *Scope, Sequence, and Coordination: The Content Core: A guide to Curriculum Designers* (National Science Teachers Association, 1992). However, with the publication of the first *NSES (National Research Council, 1992)* sampler, the emphasis among Iowa project schools shifted toward this series of guidelines. Teachers found the draft *NSES* standards useful, informative as a guide, more supportive of local decision making, and less restrictive than the *"The Content Core"* noted above. The *Benchmarks for Science Literacy* remained a popular resource and continued to be utilized as a key reference as well.

Developing local customized frameworks required that daily school science be placed within a context of an entire scope, sequence, and coordination for any given science program. Based upon research on learning and an emphasis on STS (Science-Technology-Society), the Iowa SS&C worked from the general SS&C emphasis on integration of all sciences into the instructional plan, i.e., "every science [discipline] every year." This sequence encompassed:

1) Scope–A coherent science curriculum, at minimum, should span all required science years at the secondary level (usually grades 6-10).

2) Sequence–A science program should involve appropriate sequencing of instruction, and take into account how students learn. Students should encounter concepts, principles, and laws of science at successively higher levels of abstraction over several years, experiencing the natural world through active, hands-on science, before they learn the terms, symbols, and equations that scientists use to explain that world.
3) Coordination and integration – biology, chemistry, Earth/space science, and physics share topics and processes. Integration among the *NSES* (National Research Council, 1996) science content areas leads students to an awareness of the interdependence of the sciences and the place of these disciplines in the larger body of human knowledge. The STS emphasis on relevancy, that is, exploring and understanding the natural world in the context of human experience, facilitated an integrated and practical study of science in the Iowa SS&C project districts.

The Construction of Frameworks: An Iterative and Collaborative Process

Though many school districts had curricular frameworks in place prior to joining the project, these frameworks tended to be disposable "curriculum guides" that did not possess the dimensions and depth of an integrated vision for the science program. As noted by one teacher during a framework focus group discussion, “We have a curriculum guide [in our district] now, but nobody uses it.”

The brief chronology outlined below will assist the reader to follow the cycles of development and improvement featured in the subsequent discussion and analysis.

Timeframe	**Major Events, Related to Framework Development**
1990-93 (Phase One)	Seven school districts join the Iowa SS&C Project. Two individual districts and one consortium of four small rural districts write three draft frameworks. One project district opts not to continue after three years, due to lack of administrative support.
1993-4	The six remaining districts work with project staff to examine the nature of the collaboration and the quality of the project. Revisions and refinements result in the first detailed frameworks that will serve as models for the basis of all future framework design. The partners (project staff and project schools) jointly identify new districts to participate in the follow-on project.
1994-1997 (Phase Two)	Sixteen districts continue the work of the Iowa SS&C as conceptually refined and funded in 1994. Each of the small rural districts that had formed the consortium in 1990-93 upgraded and contextualized their common framework to better suit individual district needs.
1995-6	The project staff, lead teachers, and external evaluator envision the need for a "framework rubric." The purpose of the rubric will be twofold: a) to measure progress, and b) to serve as a reflective tool for the district teams in the last iteration of framework development to be completed during the summer and fall of 1996.

The frameworks served as the structure to support and couch the development of theme-based units of instruction (modules) into a series of issue-based, local, and relevant science studies (Yager, 1996) building on the scope and sequence for each district. During the 1994 and 1995 framework development workshops, teachers met, discussed, investigated, and evaluated their own, as well as other regional and state frameworks. The draft *NSES* (National Research Council, 1994) served as the primary reference and organizer. Though their conceptual frameworks took on as many forms as there were school sites and districts, they all contained three essential elements: a vision, a rationale, and a guiding scope and sequence defined primarily by the *NSES* and Project 2001.

Collaborative Development

The collaborative and naturalistic strategy of inquiry utilized to develop the Iowa SS&C frameworks was akin to Guba and Lincoln's (Guba & Lincoln, 1989) model exploring relationships among processes, and focusing on sequential details of the process and experiences of participants. The iterative and developmental process was a form of "participative inquiry," as described by Reason (1994), fueled by "holistic and systemic thinking." Action research became a pivotal methodology to reflect and share experiences, using the participative inquiry approach. As the university-based team became mentors and monitors of progress, first line accountability shifted to the project's lead teachers. Two professional development strategies, one centralized and one decentralized dominated the project's collaborative approach to team building, teacher enhancement, and production of curricula. First, participant teams from all districts attended weeklong joint summer sessions hosted by the University of Iowa each June. At these workshops, existing frameworks were refined and first draft frameworks were created for new districts joining in phase two. These workshops were extremely successful when measured by participant satisfaction, impact at the school sites, and by product — i.e., written frameworks (Burry-Stock, 1995, 1996; Liu, Varrella, & Yager, 1995; Robinson et al., 1997). Collaborative writing, research, reflection, problem solving, and curriculum writing with a minimum of "training" activities or "talking heads" dominating the workshops. At least three times during the week all writing teams would meet in a joint session to review their progress, solve common problems related to content and context, and share special resources or moments of serendipity. The project staff and the lead-teachers, especially those from phase one, served as "consultants" to the working teams. In this role, they sometimes functioned as part of the writing teams, while at other times they provided technical support ranging from resource access to computer skills.

The second professional development strategy engaged participants in three-week decentralized workshops at local schools. Products were examined, refined, and expanded at these workshops. Site-based framework development emphasized the day-to-day manifestations of the curricular framework in light of district goals, local resources, local choices for theme-based instruction, and student profiles.

Emergent Frameworks

Through the constant dialog and discourse on frameworks during the 1994-95 academic year, a series of general characteristics for frameworks emerged. First, a rationale explaining the significance and contributions of the framework would serve as the introduction to each framework. Second, the frameworks would emphasize the *NSES* priority of inquiry. Third, content and conceptual understanding would emerge from studying science in the context of human experience (i.e., the STS approach). The first set of Iowa curriculum frameworks were guided by a series of questions:

1. How does a framework provide science students with relevant science learning opportunities?
2. What does a framework represent to the individual teacher (e.g., how should it be used)?
3. How does a framework help the teacher do a better job?
4. How does the framework communicate information about the science program and what the science teachers do [to administrators, school boards, teachers, parents]?
5. How can the development of a framework benefit a teacher's professional growth?

These questions required looking at curriculum frameworks with a fresh perspective akin to the premises of Settlage and Meadows (2002), who emphasized the need for contextual priorities, more sensitivity to relevance for the learners, and a need to “[look] at issues in new ways” (p. 125).

Methods

Framework Rubric Development

The framework rubric (see the Appendix), was recommended by external project evaluator, Dr. Burry-Stock, as a strategy to evaluate the relative quality of the frameworks, which by 1995 were showing remarkable progress in scope, sequence, and quality. The Iowa SS&C PI, SS&C staff, and the external evaluator formed the expert team of science educators who developed and refined the rubric.

The first iteration of the rubric was based on the draft *NSES* (National Research Council, 1994) and was field tested during the summer workshops of 1995. The lead teachers provided feedback on two occasions in 1995 and 1996 through focus groups, first during the summer workshops of 1995 and later at a biannual project meeting. From these discussions, the role of the rubric was extended beyond the evaluation of frameworks. The lead teachers felt strongly that it should also be used for formative purposes and should serve as a template of best practice (Loucks-Horsley, 1996) for teachers and other educators.

With the publication of the final *NSES* (National Research Council, 1996), the rubric was aligned and referenced to the published *NSES*. The rubric included seven measurable attributes of a sound framework using the Iowa SS&C definition. Items 2 – 7 are *NSES*-based, and item 1 was the justification and explanation of each detailed district framework (i.e., the district’s rationale). The complete rubric contained sections (also referred to as themes) including the following:

1) a rationale;

2) reflection of the national goals and outcomes regarding science literacy;
3) unifying themes reflecting the content standards for grades 5-12 inclusively and inquiry reflecting the content standards for grades 5-12;
4) discipline-specific content standards for grades 5-8 in physical, life, Earth & space science; science and technology, science in personal and social perspectives; and history and nature of science;
5) discipline-specific content standards for grades 9-12 in physical, life, Earth & space science; science and technology; science in personal and social perspective; and history and nature of science;
6) content against a student-oriented pedagogical backdrop; and
7) assessment standards for grades 5-12.

The rubric was designed as a common measure of quality, using a simple ordinal scale. Instrument validity rested on the expertise of the seven science education experts who developed the rubric. Specifically, construct validity was derived from the theoretical concept of standards and "descriptions and explanations" (Janesick, 2003, p. 69) included in the rubric. That is, the construct validity related to generalizing from the measure, i.e., the rubric, to the concept of the measure (Trochim, 2003), in this instance the *NSES*.

Rubric Details

The descriptive rubric statements were synthesized from the *NSES* (National Research Council, 1996) and where appropriate, page references were included. The first element in the rubric, "1. Rationale," was the only departure from the *NSES* as the central reference. The rubric included a list of criteria and gradations of quality as expected of analytic rubrics (Andrade, 2000; Popham, 1997). The scoring system included seven sections with detailed subsections and a scoring range of 1 – 5.

A progressive rating scheme of five intervals distinguished the "*Evident*" (score of 5 points) from the "*Non Evident*" (score of 1 point). In evaluating the frameworks, reasonable success in meeting the stated criteria in the rubric (see the Appendix) rated a score of a "3" or perhaps a "4." Detailed elements would more likely receive scores of "4" or even in rare instances, a "5."

The total number of points for each of the categories varied according to project goals and details (see the column in Table 2 below, "Possible Points"). Specifically, the rationale category of the framework rubric had seven characteristics, so that a "5" on each characteristic would result in a rationale score of "35." Likewise, the national goals and outcomes were composed of three characteristics for a possible score of "15." Unifying themes held their own major heading with five characteristics, for a possible score of "25." Inquiry had two characteristics for maximum score of "10." The content standards for grades 5-8 had 22 characteristics for a potential score of "110." The content standards for grades 9-12 had 28 characteristics for a possible score of "140." The general content standards heading was comprised of four characteristics for a maximum score of "20." The assessment category contained 10 subcategories for a total of 50 points. Hence, the "ideal" framework could achieve a score using this rubric, of "405."

Sample

All Iowa SS&C district level frameworks were included in the study. The level of experience with framework development and tenure within the SS&C varied among the schools (recall that nine new schools were added in the second phase of the project), therefore not all frameworks were completed in the same year. However, all frameworks produced—one for each participating school district—were evaluated (N = 15). Although there were 16 participating districts, one small Catholic School, St. Malachy's of Creston, Iowa, aligned and cooperated with the public school in the community of Creston, hence there were 16 districts and 15 frameworks.

Evaluation of the Frameworks

The SS&C staff felt in order to have an unbiased review of the frameworks, that at least some individuals other than regular project staff should evaluate the rubrics. A three-member team was assembled to independently score all the frameworks. An average score, using the three independent scores was created for each district framework evaluated. The team was familiar with the *NSES* and Iowa SS&C framework characteristics. To avoid scoring bias, two team members that had not collaborated with any of the districts in their framework development activities were chosen. The review team leader had been integrally involved with the Iowa SS&C framework and rubric development activities of the districts and served as the team trainer and third evaluator.

Results – Impact on Teachers and Frameworks

Teachers' Conceptual Development and Work

Though the teachers' framework labor in phase one began with *general* themes for instruction and focus questions, it evolved into assertions and ambitions, and finally manifested in the form of *specific* individual district frameworks. The strategic basis for the creation of higher quality and more consistent district frameworks grew from early framework development, much like the generation of grounded theory (Miles & Huberman, 1994). The lead teachers, with assistance from the project staff, captured the essence of the frameworks through a series of practical questions and answers:

1. What is a rationale?
    a. A defensible explanation of why a program is structured and taught the way it is.
    b. It is the lead-in for the entire framework, written in a manner easily understood by all stakeholders in the system.
2. What are the cornerstones that should guide a framework?
    a. Learning theory (considering learning from both a practical and research-based perspective)
    b. Contextually based science teaching (using an STS—in the context of human experience—approach)
    c. *National Science Education Standards* (as the primary reference)
    d. Best science teaching practices(aligning science-learning goals with learners' preconceptions and relevant experiences)
3. What are some characteristics of a well-defined scope and sequence?
    a. The scope and sequence must exist for all teachers at all grade levels, communicating what experience students have studied and have yet to explore and study.
    b. The frameworks should encapsulate a science experience having a minimum duration of five years, encompassing grades 6-10 for the Iowa SS&C. The topics/themes/big ideas must be clearly stated and allow for a flexible/fluid study of science disciplines each year that breaks away from the traditional grade-level "layer cake" for life science in 7^{th} grade, earth science in 8^{th} or 9^{th} grade, biology in 10^{th} grade, chemistry in 11^{th} and physics in 12^{th}.

c. The “layer cake” replacement consists of a more authentic integration every year of the traditional science disciplines, as well as nature of science, technology, and societal aspects.
d. The topics/themes/big ideas are revisited at increasingly higher levels of complexity/abstraction/depth as the student grows through their personal experience in the science program.
e. The flow of experiences and modules--from one to another—must be explicit and represent a true spiraling of the curriculum (Bruner, 1960).

The teachers’ growing intrapersonal clarification of concept, process, and product was demonstrated by their growing abilities to articulate SS&C principles to their colleagues, as well as through creative applications within their own schools. For example, related to the “rationale,” one teacher noted, “The [rationale] complements the spirit of the standards.” This was a significant statement indicating that this lead teacher had begun to connect his framework worldview (i.e., the “plan”) with day-to-day teaching. Participants with a more sophisticated understanding of the rationale were able to articulate their shared vision in innovative ways. For example, one rural district established a scope and sequence that coordinated the science program with art, mathematics, and industrial technology classes. In this instance, the district team valued the rationale as a place to confirm and describe their carefully articulated integration across subject matter boundaries for the administration and community.

Framework Quality

By 1995, a series of identified framework models had emerged, as had the draft framework rubric. The number of iterations necessary for the teacher teams to develop a scope and sequence for their science curriculum had been reduced significantly thanks to pioneering efforts of the previous years. By 1995, fifteen frameworks had been created for the sixteen districts (recall that one was “shared”). Only five of the districts chose to complete an additional iteration in 1996 (see Table 1). The other districts chose to devote their energies to module (integrated, theme-based units of study) and program development, which were extensions of their local frameworks.

Table 1

Number of Iowa SS&C frameworks produced and revised for 1994, 1995, and 1996.

Framework Status	**Framework production year**		
	1994	***1995**	**1996**
New frameworks developed.	3	12	0
Frameworks revised.	0	3	5
Number of frameworks	**3**	**15**	**5**

*One of the explicit Iowa SS&C Project goals was the development of a curricular framework for every participating district. This goal was reached in 1995 when all 16 participating districts had produced at the very least, a draft framework. (Recall that two schools in Creston used the same framework.)

Three district teams that participated in developing 1994 versions of frameworks (average score of 167) paved the way for future frameworks (see Table 1). By 1995, 16 school district teams (thirteen new to the task, and three returnees), had developed frameworks, and their scores averaged 191. In 1996, five teams (exclusively phase two schools) returned to complete a final iteration of their frameworks. The average total score for those final products was 233 points. The latter iterations in 1996 especially reflected the transformative and ever-improving nature of framework development in the Iowa SS&C learning community (see Table 2 and Figure 1). These last frameworks approached a level of overall balance indicated through the average score of 2.9 points/item (233 points/81 rubric characteristics), nearing an acceptable average of 3.0 (i.e., 244 points/81 rubric characteristics).

Of the sixteen districts that completed frameworks, seven had been involved in multiple iterations spanning more than one summer framework workshop (see Figure 1). A closer examination of these districts traces the improvement experienced through the revision process.

Table 2

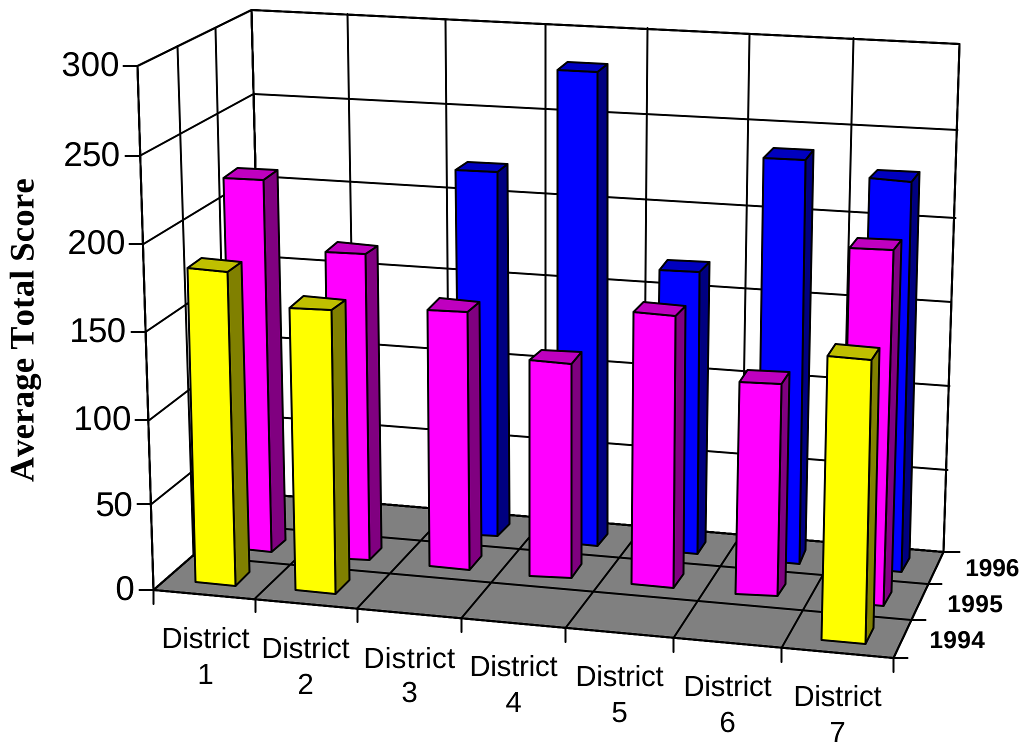
Total points possible and average points by category for Iowa SS&C district frameworks produced in 1994, 1995, and 1996 using the Iowa SS&C Frameworks Rubric.

Framework Category**	**Total points possible***	**Average total points for frameworks evaluated in**		
		1994	**1995**	**1996**
Rationale	35	14	14	18
Goals & outcomes	15	7	9	14
Unifying themes	25	16	10	13
Inquiry	10	7	7	8
Content grades 5-8	110	59	58	65
Content grades 9-12**	140	34	64	76
General content standards	20	12	11	18
Assessment	50	18	18	21
Average Total Score		**167**	**191**	**233**

*405 points are the total possible for the framework rubric that includes 81 "ratable" elements.

**The framework rubric captured the full complement of expectations for grades 9-12 as defined in the *NSES*; however, most of the frameworks *only* spanned grades 6-10, which represented the Iowa SS&C Project grant focus for the period of 1994-97.

Of this subset of seven districts, three of these districts completed a framework in year one (1994) of the three-year project (1994-97). Those three districts plus four other additional districts completed a framework in year two (1995). In 1996, five of the seven districts continued to revise their frameworks again. Figure 1 includes actual total scores for *only* the subgroup of seven districts completing multiple iterations of their framework. Note that each year, the score for the overall framework increased for *every* district included during the two or three year cycle of improvement. Time was cited as a constraint by members of nine district teams that were not able to re-write frameworks, a factor recurrent in the literature (Anderson, 1995; Donahoe, 1993; Varrella, 2000).



	District 1	District 2	District 3	District 4	District 5	District 6	District 7
1994	183	165					159
1995	222	182	153	127	159	124	204
1996			220	282	169	238	229

Figure 1. Total framework points assigned to those seven districts completing multiple iteration of their framework during the framework development timeframe of 1994 – 1996.

Discussion of Results

The above results demonstrate growth in framework development and concurrent expansion of teacher understanding regarding the nature and application of frameworks in planning a science program. These results also underscore some of the persistent challenges in science education reform. For example, the districts struggled with assessment and the content standards for grades 9-12. The fifteen frameworks' average score for assessment (see Table 3) was 2.0 for 1995 (15 frameworks) and 2.7 for 1996 (five revised frameworks), which does not approach the established threshold of a "3," the agreed upon level of "reasonable success." Since the scores are averages for 10 different characteristics under the category of "Assessment" in the rubric, uneven progress in this challenging area was common and kept averages lower than in any other category. Content for grades 9-12 also challenged the participants. Subcategories of this heading sought support for "science and technology student experiences," "history and nature of science," and discipline-specific topics of investigation. The average score for "content" for grades 9-12 was 2.3 (1995) and 2.8 (1996), reflecting uneven progress across items in the rubric and some reticence on the part of high school teachers to accept an integrated, hands-on philosophy.

Content for grades 6-8 fared somewhat better than 9-12. Subcategories of this heading sought support for "science in personal and social perspectives," "history and nature of science," and in discipline-specific topics of investigation for middle school children. The average scores were 2.7 (1995) and 3.0 (1996).

The areas of "goals and outcomes" and "general content standards" showed marked and consistent improvement among the more advanced frameworks. These frameworks consistently addressed the "Content Standards General" category. The averages were 2.8 for 1995 and 4.5 for

Table 3

Iowa SS&C district framework evaluations including the number of characteristics and the average scores for frameworks produced in 1995 and 1996.

Framework Category**	**Number of characteristics***	**Average score on the 5 point rubric scale for frameworks produced in :**	
		1995	**1996**
		15 frameworks evaluated	**5 frameworks evaluated**
Average for Rationale	7	2.0	2.7
Average for goals & outcomes	3	3.0	4.6
Average for unifying themes	5	2.0	2.8
Average for inquiry	10	3.5	4.0
Average for content 5-8	22	2.7	3.0
Average for content 9-12**	28	2.3	2.8
Average for general content standards	4	2.8	4.5
Average for assessment	10	1.8	2.1

*405 points are the total possible for the framework rubric that includes 81 “ratable” elements.

**The framework rubric captured the full complement of expectations for grades 9-12 as defined in the *NSES*; however, most of the frameworks *only* spanned grades 6-10, which represented the Iowa SS&C Project grant focus for the period of 1994-97.

1996. This rubric category identifies features of the framework that show connectedness among the disciplines, and progression in a developmentally appropriate manner, from concrete to abstract understanding. Science literacy (i.e. “Goals and Outcomes”) was a core theme of the project, which manifested in the majority of the frameworks. Literacy was interpreted in two

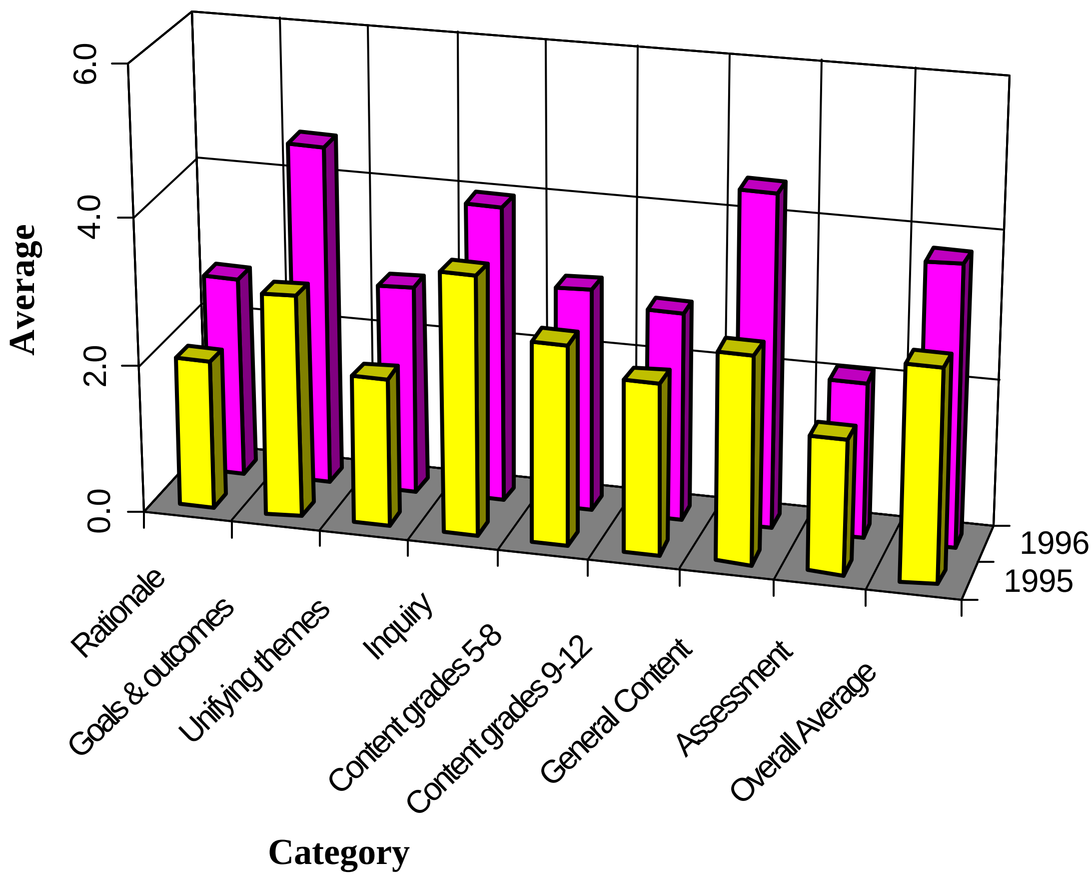


Figure 2. *The above is a summary of the average points (5 point rubric characteristic scale) by framework for 1995 and 1996 products.*

general ways: 1) to include characteristics of the science program that foster a richness of experience in understanding the natural world, and 2) to develop programs reflecting an expectation that students shall engage intelligently in public discourse and debate about matters of scientific, technological, and social concern (e.g., cloning). The average score for this heading was 3.0 and 4.6 for 1995 and 1996 respectively. Inquiry was the third common area with a demonstrated consistency across the frameworks. This aspect of the framework sought to identify features of the science programs that "develop student abilities necessary for conducting scientific inquiry." The average score for the fifteen frameworks was 3.5 and 4.6 for 1995 and 1996 respectively. Progress in these three areas is a positive indication of the expanding worldview of the teams even though, predictably, the reform in the content and assessment areas lagged behind other areas.

Challenges, Successes, and Implications

Evidence indicated that teacher teams, when accorded the time, the expertise of consultants and peers, and a supportive climate in their school sites, could construct an articulated and reform-oriented science program. Results were particularly encouraging when long-term commitment and multiple iterations typified the program's efforts, reflecting the guiding principles of this NSF-supported project.

The results provide evidence of a synergy between curricular innovation and reflective teachers as the route to reform (Pogrow, 1996). Fetters and her colleagues (2002) described this synergy as empowerment of the teachers, and found, as is shown in this study, that an emphasis on cycles of reflection and action working *with* the teachers generates "true partner[ships] in managing complex change" (p. 127). The result of these partnerships is growth in understanding among the partners, higher quality of products, and stakeholder investment implementation of the product (i.e., the frameworks).

Some aspects of authentic learning in science continue to elude practitioners. By measure of the "Assessment" heading of the Iowa SS&C framework rubric, we persist in falling short of defining just what tasks and performances would satisfy our collective expectation regarding assessment. Linking assessment to performance and application, to relevant experiences, to taking action based upon prior experiences, and to the developmental state of inchoate learners, continues to be an area in need of quality research and improvement.

The integration of the science experience, within and across science subject areas, surfaced as an additional challenge among the practitioners. Yet when situated within a context of divergent forces unequally balanced toward the status quo—text publishers, teacher preparation programs, teacher licensure, standardized testing, and college entrance requirements—the modest gains made in this area take on greater significance. Nevertheless, if we hope to promote further integration of our middle and high school science curriculum, we must direct more attention to teacher training, public relations and a restratification of the science scope and sequence from kindergarten through graduate school.

Measuring the growth of a district's science education team, like measuring learning among students, is itself a developmental process. Although data were generated on an ordinal scale, the value of the result of this study was not about numbers, but rather about patterns. Six points emerged:

1. Time and persistence in school improvement are necessary ingredients; districts that were willing to revise and improve their frameworks produced measurably better products.
2. Teachers are capable and willing to commit to sustained professional development activities in an atmosphere of collaboration and equity.
3. STS as a teaching approach—an Iowa SS&C cornerstone—can influence teacher-planners' work and understanding of inquiry, content-concept relationships, and sensitivity to the learners' context and experiences.
4. Enabling factors for framework and curriculum writing workshops include:
    a. the creation of a "retreat-like" environment;

b. the convening of facilitators and experts (e.g., scientists) in one place;

c. the assembling of groups, meeting for a common purpose in an environment of equity, and emphasizing the free exchange of ideas; and

d. an emphasis on teacher-leader development as partners in reform and facilitators for change in their school through expansion of their work and collaboration with colleagues.

5. Long-term change efforts with an experienced cadre of teacher mentors results in a "second wave" of rapid progress in curriculum development and diffusion of innovation. This point has implications regarding student achievement as well, if one accepts the inference of Kahle and Boone (2000), from a study in Ohio, that there was a positive association between sustained professional development activities and student achievement.

6. C*ollaborative* and *sustained* curriculum reform, emphasizing the creation of a learning community yields significant results.

The rubric provided a common means to track growth and change. It served as a prototypical vehicle for evaluating the development of frameworks, and created common scaffolding for planning and working together, while giving room for individual district needs and priorities. It also served as a vehicle to assist in the examination of a powerful professional development model.

In our experience, any document that guides reform efforts in science education must be broadly descriptive rather than narrowly prescriptive. A tight niche makes for inevitable extinction. It is apparent that nature *and* science education favor diversity, as evidenced by the remarkable growth among these diverse and equally successful participating schools.

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Appendix

Selected Elements of] Iowa Scope, Sequence, & Coordination Project Framework Rubric

Page numbers in parentheses refer to the National Science Education Standards (National Research Council, 1996).

1. Rationale

Elements	Not Evident	2	3	4	Evident
1.1 The rationale of the framework is succinctly written.					
1.2 The rationale explains how district goals align with the framework.					
1.3 The rationale explains how Science-Technology-Society is infused into the framework.					
1.4 The rationale explains how constructivism is incorporated into the framework.					
1.5 The rationale describes how the Iowa SS&C tenets fit into the framework.					
1.6 The rationale exp lains how National Science Education Standards fit into the frameworks.					
1.7 The rationale is written so that it is meaningful to a diverse audience.					

Comments:

3.1 Content Standards Grades 5-12 — Unifying Themes

3.1 The broad unifying themes and processes are evident at all grade levels. The broad unifying themes and processes complement the analytic, more discipline-based perspectives presented in the other content standards (p 115).	Not Evident	2	3	4	Evident
3.1a systems, order, and organization (p 116).					
3.1b evidence, models, and explanation (p 117).					
3.1c change, constancy, and measurement (p 117).					
3.1d evolution, and equilibrium (p 119)					
3.1e form and function (p 119).					

Comments

7. Assessment Standards Grades 5-12

Elements	Not Evident	2	3	4	Evident
7.1 The framework explains the purpose of the assessments used (p. 78).					
7.2 Examples of assessments that assess achievement and are used for grading are included at all levels in the framework. (p. 79).					
7.3 Assessments that probe for understanding, higher order reasoning and the application/utilization of knowledge are included at all levels in the framework (p. 82).					
7.4. Assessments at all levels are based on the content standards (p. 79).					
7.5. Assessment examples included in the framework reflect the nature of the classroom learning environment, i.e., they are based on and test in the context of study, similar to activities of scientists, and can be applied to everyday experiences (p.83).					
7.6 Assessments at all levels are fair. They strive to be developmentally appropriate, use a familiar setting, are unbiased, students are given adequate time to demonstrate their achievement (p.83-4).					
7.7 Assessment examples included in the framework are issue based, set in a variety of contexts, and show personal relevance for students (p. 83).					
7.8 Assessment examples included in the framework include those used for the purposes of determining students' initial understandings and abilities (p. 87).					
7.9 Assessment examples included in the framework are diverse, i.e., include opportunities for students to explain orally, in writing, or through illustration how a work sample provides evidence of understanding (p. 88).					
7.10 Assessment examples included in the framework provide students with opportunities to evaluate and reflect on their own scientific understanding and abilities (p.88).					

Comments