The Role of Teaching and Learning in Systemic Reform: A Focus on Professional Development

Opportunities for teachers to participate in quality professional development programs is seen as a critical component in science education reform.

The purpose of systemic reform is to improve student learning, which cannot be accomplished without excellent teaching. It is not a surprise, then, that professional development plays a critical role in the success of systemic reform, as it directly influences the quality of teaching and learning in science and mathematics classrooms. This paper draws on my experiences in designing and conducting evaluations of professional development in the context of systemic initiatives at local and state levels, in providing technical assistance to professional developers, and in capturing the experiences of seasoned professional developers in a book on best practice. In the paper I sketch briefly (1) what I believe we know about the role of professional development in systemic reform and (2) what we still need to learn.

What We Know

1. It is a long distance from the policy level to the student, and professional development is on the way.

   In my role as Director of Professional Development and Outreach for K-12, at the National Research Council’s Center for Science, Mathematics, and Engineering Education, I have the task of overseeing the Center’s efforts to “disseminate” the National Science Education Standards (National Research Council, 1996). It is a constant source of amazement how many people think that you can literally give the book to teachers and expect them to use the Standards in their teaching. These standards are a product of a national consensus; the many sets of standards developed at other levels of the system (e.g., by states and districts) similarly result from broad consensus. Their intention has never been to be “implemented” directly, but to guide a system’s design for what educators expect of and how they work with students.

   Bybee (1996) describes a schema for system change that applies equally well for mathematics reform as it does for science reform; it includes changes in purpose, policies, programs, and practices. According to this schema, purposes relate to the general agreement on the need for science and mathematics literacy for all; standards are the policies that guide education towards those purposes. But in order to move to students, programs need to influence practice, which is the only way that students will have different and better opportunities to learn. This is where professional development enters the picture. Professional development is one of the critical links in this chain, one that can take purposes and policies and influence student learning through its impact on teaching.

   We have learned that there is great distance between systems and students. Although there are many routes that may be chosen (e.g., through new assessment, curriculum, or instructional programs), professional development is a required stop along the route. For students to reach the goals to which the system aspires, teacher learning and changing are essential.

2. Investment in people as the primary agents of change is critical.
For students to reach the goals to which the system aspires, teacher learning and changing are essential.

Many proponents of systemic reform concentrate on the need to change policies at the state and local levels. Their vision came in part from the California experience of the 1980s and early 1990s, when the state began to enact a vision that put into place the critical elements of state frameworks, assessments, curriculum adoption criteria, and professional development (Honig, 1990). As other states enact this policy-level focus, they would do well to examine the California situation carefully, as it has evolved. At this point, many of these critical elements are either lost (i.e., the state assessment) or being threatened (e.g., some of the state frameworks). Policies are as good as the politics that helps them get established and they may have a shelf-life only as long as a current administration.

What is encouraging in California is that the teachers and other educators who have “grown” this reform, not as much from the grassroots but from the developing infrastructure, are keeping the reform alive and well in many locations. The infrastructures are the statewide professional development networks, two of which have been supported through the NSF statewide systemic initiative, the Mathematics Renaissance and the California Science Implementation Network, and others as well, such as the California Subject Matter Projects. The investment in people through professional development that has been made by these projects has created a strong fabric that is resistant to change. These teachers can never return to pre-reform practices, because they can articulate what is important and why. In evaluating the California statewide systemic initiative, we have seen what we call “inside-out” systemic reform, i.e., changes in the system that result because people are changing and are influencing the structures, procedures, and, in some cases, the policies, that guide teaching and learning (Aquarelli & Mumme, 1996). Of the several hundred schools and thousands of teachers who have been touched by the two SSI networks, we have hundreds of examples of network teachers and administrators taking on new leadership roles within buildings and districts (e.g., teachers becoming principals and curriculum supervisors, principals and teacher leaders becoming assistant superintendents), in their local and state professional associations, and as members of state and local committees whose roles it is to make curriculum, assessment, and instructional decisions. We have documented dozens of instances of these mathematics and science initiatives influencing changes in other content areas in schools and districts, the nature of professional development offered by county offices and higher education institutions, and teacher preparation programs, both on campus and in clinical settings. Most interesting, perhaps, is the statewide influence of these professional development networks on assessment and standards development. For example, when CLAS, the new performance assessment system, was canceled by the governor in 1995, a collaborative of districts facilitated by science professional developers was determined to have the kinds of testing program for students that CLAS had offered. Through their collaboration, the CLAS test was revised for use in districts and schools last fall and an NSF-funded project begun at the same time to develop similar tests for the state and other interested systemic initiatives. Another example is the writing of state-mandated science standards, taken on voluntarily by the coalition of state professional development projects, once again determined not to lose the essence of the reforms for which they had worked so hard.

Fullan (1993) emphasizes the importance of all educators being change agents, that it takes people to make change. In a newer article (1996) he “turns systemic reform on its head,” arguing for the very people-driven networks that we are seeing stay the course of reform in California. California serves as a warning to those systemic initiatives who have relied heavily on their policy initiatives and neglected the building of strong networks dedicated to professional learning at the individual and school level. They say that it takes a village to raise a child; it takes the people in it to educate the child. As California may have been seen early as a prototype for systemic reform, it may also be a proving ground for how to sustain reform when there is turbulence in the system. That people and their traditional strategies last tenaciously through policy changes has been a curse of many reform initiatives. That people, once changed, can in fact remain changed, may turn this curse into a blessing. Professional development may sustain systemic reform when change at the system level fails.

3. The professional development needed by systemic reform is not the same kind as supported
change initiatives in the past.

The new paradigm for professional development that Dennis Sparks first called to our attention in 1994 is not about one-time, one-teacher-at-a-time, expert-driven workshops or institutes, held for teachers far from their schools and classrooms. Professional development for systemic reform is larger in (1) scale (i.e., it serves more people in a wide variety of roles), (2) scope (i.e., it pays attention to more elements of the system, e.g., curriculum, assessment), and (3) duration (i.e., it is intensive and extends over time). It has many of the characteristics of effectiveness identified through research and in the practice of experienced professional developers, such as collaborative work, expertise derived from research as well as expert practice, an emphasis on content understanding, and continuous evaluation (see a synthesis of the national standards related to professional development by Loucks-Horsley, Stiles, and Hewson, 1996). Further, like teaching, professional development is dynamic. Rather than selecting from an established set of models to support professional learning, professional developers who successfully design initiatives in the interest of systemic reform use a decision-making process that involves identifying their goals, understanding their context, and creating a unique combination of specific learning strategies that is tailored to their initiatives. A design model and 16 strategies derived from best practice in professional development design have been articulated by the National Institute for Science Education’s Professional Development Project (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

4. A strong infrastructure and deliberately developed capacity for change are needed to support the people and change the paradigm.

For educators in large numbers to learn about, try out, and maintain changes in their practice requires a support system with a shared vision of teaching and learning, such as those visions articulated for mathematics and science in the national standards (NCTM, 1989; NRC, 1996), but with greater attention to creating shared images of what the vision looks like in practice in the classroom interactions of teachers and students, in instructional materials, in student work and assessments. The support system is staffed by people whose job it is to introduce, facilitate, and support changes in the direction of the vision. These people have demonstrated skill in teaching young people as well as the abilities to address the learning needs of adults and build professional networks, both inside and outside of schools, to support ongoing learning (Lieberman & McLaughlin, 1992). They have a keen knowledge of the change process and how to work with people at different stages of change (Hall & Hord, 1987); skills in communication, problem solving, decision making, team building, and time and task management (Fullan, 1991); and the ability to use pressure and support appropriately (Louis & Miles, 1989).

Effective infrastructures build capacity for ongoing change at the local level through design and use of a variety of professional development strategies that help teachers change their practice, through support of collaborative work inside of schools to support individual change and design and implement programs of study, and through building capacity for leadership in various members of the school and community (Friel & Bright, 1997).

5. Professional development must pay careful attention to content knowledge.

With a renewed focus on concept development as a valued outcome of science and mathematics education, teachers are no longer able to “cover” for lack of preparation in the area they teach (which assignment is usually not their choice). Shulman’s (1987) work in defining and explicating the term “pedagogical content knowledge” has added a new and critical dimension to professional development. Whereas generic professional development (e.g., learning generic teaching skills such as cooperative learning, effective instruction, and questioning techniques), was a hallmark for the 1980’s, we have learned the keen importance of teachers knowing how to teach particular content understanding, the conceptions students are likely to
hold about certain mathematics and science concepts, what students of a certain age are developmentally able to learn, and what examples, analogies, and representations help them learn it. Such knowledge is difficult to learn in preservice education, and is often the province of the experienced expert teacher (Shulman, 1987). This need for learning from a master teacher underlies the use and success of mentor and advising teacher programs (Shulman & Colbert, 1990).

6. Instructional materials can play a critical role in teacher as well as curriculum change.

Most educators think of teaching and curriculum as two different components of the system, but we are quickly learning the power of materials to help teachers learn (Loucks-Horsley et al., 1998; Friel & Bright, 1997). Materials developed to teach students important concepts and skills represented in national standards, with teaching strategies that address a constructivist view of learning, help teachers try out new behaviors and experience for themselves what new forms of teaching look and feel like. In particular, teachers can see how these approaches work with students. Two professional development strategies use curriculum materials to support teacher learning (Loucks-Horsley et al., 1998). The first is curriculum implementation, in which a set of instructional materials is selected, teachers learn how to use them, try out materials, reflect on their experiences, and are supported over time to refine their use. The second is curriculum replacement (Burns, 1995), in which teachers try out a unit that embodies new teaching perspectives and strategies, and document and discuss their experiences in order to “try on” new ways of helping students learn. Both strategies promise to influence both how teachers teach and the materials they use to do so.

7. Professional development and organizational development must be inseparable.

The largest professional association devoted to staff development, the National Staff Development Council, defines professional development as involving both individual and organizational development. This is because we know that individuals are unlikely to sustain what they learn when their organization does not support them to do so. It is one reason why the “last wave of reform” in science education, which provided opportunities for individual teachers to attend summer institutes away from their schools and districts, fell far short of its potential to change teaching and learning in substantial ways. For teachers to change what they do with their students, the organizations within which they work must change, in two ways. First, their school districts must support teachers’ changes (e.g., provide materials support and time for collaborative planning and reflection; focus teacher evaluations on the changes). Second, the organizations must themselves become learning organizations, valuing experimentation and collaboration, encouraging deep examination and analysis of teaching and learning, and creating opportunities for extending and enhancing practice (Senge, 1990; Shanker, 1990). Such schools, described by Rosenholtz (1989) as “learning enriched” are characterized by high levels of student as well as adult learning. Without organization development, individual teachers are unlikely to sustain their learning; with it, not only do teachers learn, but their students do as well.

What We Need To Know

Professional development is a field in which “definitive research” on what is effective does not exist (Frechling et al., 1995). Like teaching, it is too complex to understand by asking simple questions, it is highly influenced by factors out of control of either the professional developer or the researcher, and its success depends greatly upon the goals and context, which are indiosyncratic to a given situation. The ideas discussed above capture what I believe we know; they have come from a combination of research, literature, and the “wisdom of practice”. In each case, we have some evidence, but we need closer study, some more existence proofs (i.e., examples of where and how these things work) to increase our certainty. As works-in-progress, professional development efforts lend themselves to examination. While much can be learned from them to further the education community’s understanding of how different factors interact, including the people, the context, and the passage of time,

Professional development initiatives could benefit from understanding the effects and trade-offs involved in selecting different strategies, such as teacher leadership cadres, demonstration sites, and regional professional development centers.
they themselves can benefit from ongoing reflection and feedback. Such examination holds great promise for increasing our understanding of the role of professional development in systemic reform.

As we examine current initiatives, here are some questions I think are important to ask:

1. How can we move from understanding how individual teachers learn and how to help them? How do we support the growth of millions of teachers?

Mathematics educators, in particular, have become very expert at understanding how teachers learn and what can help them (Ball, 1996). Science educators, on the other hand, have increased our understanding about what system components are needed to improve the potential of success for change (St. John et al., 1994). The issue of scaling up, however, is still perplexing, as articulated well by Elmore (1996). We need to learn form the many systemic efforts currently underway, what mechanisms, strategies, and system elements make learning possible for such magnitude as all teachers in the nation.

2. What are some ways of using scarce resources well, so that teachers have equitable access and opportunity to learn?

It is widely acknowledged that for teachers to make the changes envisioned in national and state standards, many hours and resources must be devoted to their learning. Yet by any metric, there are not enough resources available to provide every teacher in this country the opportunities they need. Professional development initiatives could benefit from understanding the effects and trade-offs involved in selecting different strategies, such as teacher leadership cadres, demonstration sites, and regional professional development centers. What resources actually go to professional development and in what various ways have they been focused? What are some examples of leveraging resources and how might they work in different settings? What are the relative advantages and disadvantages of large-scale, less intense strategies, and those that go deep with fewer people? How can leadership development, assessments, and instructional materials broaden the reach and impact of professional development?

3. How do professional developers select among different strategies, what combinations seem to work in what situations, and are particular strategies more useful for particular purposes?

In our current book, we have identified 15 strategies and suggested that they can serve different purposes (Loucks-Horsley et al., 1998). Are there guides to selecting and combining various professional learning strategies?

4. What outcomes can be expected to result from professional development programs, and how can they best be assessed?

This relatively straight-forward question is fraught with pitfalls and subject to a multitude of responses. The demand on educators for accountability dictates that professional development must have something to show for itself beyond participant satisfaction. Yet there are many well regarded arguments for why professional development cannot and should not be examined for its impacts on some critical outcomes, e.g., student learning (Hein, 1997). Is this a political question, or can researchers shed some light on the plausibility of drawing relationships between a professional development opportunity and such variables as student learning or teacher behavior change?

5. How can professional development contribute to greater coherence in the educational system?

The recent and ongoing releases of data from the Third International Mathematics and Science Study point to the critical importance of coherence in our approaches and support for teaching and learning. With either no helm or too many, teachers are forced to teach too many things superficially, with minimal time for reflection and improvement of their approaches to help students think and learn more deeply. How can professional development help not only teachers, but educators with broader decision-making responsibilities, focus and make critical choices that will ultimately benefit students?

References


Susan Loucks-Horsley is Director of the Professional Development Project at the National Institute for Science Education, Mathematics, and Engineering and is the Program Director for Science and Mathematics at WestEd. Her work at the NRC includes promoting, supporting, and monitoring the progress of standards-based education, especially the National Science Education Standards. At WestEd, she primarily leads the evaluation team for the California Statewide Systemic Initiative, which supports mathematics and science reform throughout the state. The focus of Loucks-Horsley’s work is developing approaches, products, and training tools for the professional evaluation and development of both educators and teaching programs.
Is Thematic Integration the Best Way to Reform Science and Mathematics Education?

Attention to paradigmatic change in teaching pedagogy is central to the success of thematic integration in science and mathematics.

Many of the current writings regarding curriculum development emphasize teaching and learning suggest that to provide a more relevant, and consequently more motivational, learning experience for the student, teachers need to integrate the various disciplines (Jacobs, 1989; Lipson, Valencia, Wixen, & Peters, 1993; Berlin, 1991). The idea of subject area integration, though having a long history, continues to be a popular trend in educational circles. Accordingly, attempts to decompartmentalize education and integrate individual disciplines, to implement block scheduling, or to institutionalize elementary and middle school philosophy are quite common in school change and school reform research (Aldridge, 1989; Berlin & White, 1994; Davison, Miller & Metheny 1995). In addition, there is a fervor regarding the latest neuroscience findings and their relationships to the learning of children. In this milieu of school and curricular reform, the time has come to re-evaluate the current approach to thematic integration of the curriculum.

Integration models have been shown to increase instructional time and to help to enhance the learning of children (Jacobs, 1989). In addition, Colvin and Ross (1991) suggest that integration can change teaching techniques from the dissemination of isolated facts to a technique to help students construct knowledge that is meaningful and interrelated. The key to successful integration is that it must encourage a deeper understanding of one discipline, say science, by using another discipline, say mathematics. Though the integration of subjects provides for meaning to follow the activity, efforts to help teachers diversify their integration models to include multiple integration teaching strategies have proved deceptive. In most instances, attempts to integrate have been held to only one method of integration—thematic—with little change in teaching methodology or pedagogy. We will argue that thematic integration without the accompanying paradigmatic change in teaching pedagogy results in little benefit to the learner, especially in science and mathematics. Further, the ramifications to the rigor of the individual disciplines of science and mathematics modeling only thematic integration are quite diminished. Consequently, we have become more cautious when viewing the integration practices as observed in textbook and classroom presentations.

Alternative Approaches to Integration

Several models of integration have been discussed in the literature (See Jacobs, 1989; Davison, et al., 1995; Lonning & DeFranco, 1997; Miller, Metheny, & Davison, 1997). One type of integration (such as discipline-specific) found readily in the secondary school classroom integrates the various subject content areas within a given discipline. Consider as an illustration the integration of biology, anatomy, chemistry and physics in one unit or lesson. A student could be studying the heart as a biological system in...
biology, the structure of the heart in anatomy, the makeup of the blood in chemistry and fluid motion in physics. Discipline-specific integration continues to maintain the integrity of the discipline while attempting to provide relevancy to the student with appropriate examples and experiences.

Another model, content-specific integration, attempts to integrate the content area objectives of one discipline with the content area objectives of a different discipline. An activity is planned which will involve instruction in each of these objectives. It is “content-specific” because it does not deviate from the previously developed curricula, but rather infuses one objective from each discipline (see Miller, et al., 1997). Suppose that the teachers are beginning a unit in science on the lever and a unit in mathematics on proportions. In an activity such as this, the students would be problem solving, using proportional reasoning in mathematics while solving for the law of the lever in a physical science class. Content-specific integration could develop the contextual understanding of both disciplines in one set of unit activities.

Process integration is a type of integration that, more specifically, is concerned with the process of learning. By conducting experiments and collecting data, analyzing the data, and reporting the results, students experience the processes of science and perform the needed mathematical operations at a standards level. In this integration model, the teacher relies heavily on the nature and philosophical beliefs of the national standards in mathematics and science. Looking at science and mathematics from a process approach (i.e., the doing of science and mathematics) becomes more important than actual mastery of the discipline content commonly presented in textbook approaches. Students would be classifying, predicting, estimating, and hypothesizing as major learning requirements. The use of these processes as the approach to student learning becomes the important part of the curriculum, not the end product as measured by various institutionalized tests.

Thematic integration, as the name infers, integrates various disciplines around a central theme. Thematic, by its nature, is a holistic approach to learning. The thematic approach begins with a theme, which then becomes the medium for all the disciplines to interact. Teachers plan together and develop these units prior to instruction. The purpose is to provide relevancy to the learner regarding the school disciplines and the interaction of the natural world. Several researchers suggest that the brain’s tendency to consider the entire experience just might reflect the need for thematic integration. For example, Ausubel (1963) claimed that the learner’s brain has a pre-existing cognitive structure into which new learning must be assimilated. Thus the brain functions like a scaffold or set of pigeon holes and new information is processed according to the learner’s prior experiences. In this way the

<table>
<thead>
<tr>
<th>Process Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scientific Processes</strong></td>
</tr>
<tr>
<td>• Experimenting</td>
</tr>
<tr>
<td>• Observing</td>
</tr>
<tr>
<td>• Predicting</td>
</tr>
<tr>
<td>• Inferring</td>
</tr>
<tr>
<td>• Testing Hypotheses</td>
</tr>
<tr>
<td>• Controlling Variables</td>
</tr>
<tr>
<td>• Communication</td>
</tr>
<tr>
<td>• Using Space Relationships</td>
</tr>
<tr>
<td>• Patterns and Relationships</td>
</tr>
<tr>
<td>• Relevancy</td>
</tr>
<tr>
<td>• Using Numbers</td>
</tr>
<tr>
<td>• Measuring</td>
</tr>
<tr>
<td>• Interpreting Data</td>
</tr>
<tr>
<td>• Classifying</td>
</tr>
<tr>
<td>• Defining Operationally</td>
</tr>
<tr>
<td>• Using Time Relationships</td>
</tr>
</tbody>
</table>

| | |
learner processes, not isolated bits of information, but patterns of knowledge that fit together in a meaningful way. Sylwester (1995) maintains that the neural networks we are born with will adapt to the changing environments. Consequently, it is the teachers and the parents who need to guide and shape an environment that is stimulating enough for students to work alone or in groups to solve specific problems. Gardner’s (1993) work with Multiple Intelligences has led to interesting discussions in the new brain theories. As Sylwester explains, innate brain capabilities and experiences combine together to form the basis of each individual’s development on multiple intelligences. What this suggests is that the school’s role in curricular design not be simply to accommodate individual differences, i.e., multiple intelligences, but rather to enhance the development of these intelligences through appropriate experiences. In theory, thematic integration should provide the “big ideas” necessary to stimulate these experiences and consequently to enhance learning.

As an example, consider a central theme of the reintroduction of the wolf into Yellowstone National Park. Around a theme such as this, teachers can plan lessons to incorporate each discipline. (See Figure 1.)

As the figure implies, each discipline melds content and activities that will enhance the relevancy of the theme. Specifically, science activities all focus around the concept of habitat and predator-prey relationships, appropriate to the grade level and abilities of the student. Thematic integration strategies, like this one, can add to the body of knowledge and provide pertinent learning opportunities for the students. Generally, they tend to involve timely topics that are of genuine interest to the students. Examples have included the theme of space travel following the Challenger accident, or on a smaller scale the theme of ‘kites’ during windy March days (McDonald & Czerniak, 1994).

Thematic integration is usually developed by an individual teacher, or a group of teachers, and generally at the same grade level. Within the middle school philosophy, thematic integration is considered central. Teachers plan their unit in groups, first coming up with a theme and then assigning content activities to that theme. Though this does provide relevancy and connectivity, several issues with thematic integration remain problematic. There are certain tradeoffs, and many are at the expense of the rigor of the scope and sequence of the individual discipline.

**Issues in Thematic Integration**

In an examination of the tradeoffs of thematic integration, let us first look at the needs of teachers being asked to teach in a thematic way. Several requisites come to mind. First, teachers are themselves taught in isolated disciplines in both content and methodologies. Teacher training institutions have not adequately prepared teachers to make the transition from an isolated subject-based curriculum to a more integrated one, even at the elementary
level. Consequently, teachers in the elementary and secondary school system have difficulty thinking in a holistic and integrated fashion. Through no fault of their own, elementary teachers do not have the depth or breadth of content knowledge to be comfortable to deviate substantially from the textbook presentation.

Second, teachers are not provided adequate teacher inservice on appropriate integration techniques and team building within the school. The professional development tends to be organizational and logistical, rather than centering around appropriate curriculum revision. Consequently, there is a tendency for professional development activities to be procedural and recipe-oriented, rather than conceptual in nature. Most professional development is a one-shot, shotgun approach; however, on-going professional development must occur, and the commitment of the school district to this endeavor must be valued.

Third, integration takes considerable time to develop. Many schools seeking a thematic approach to integration do not provide for adequate planning time to meet with other professionals and to do research on the theme strand. Instead, the little time provided is quickly used up with house-keeping chores, while attention to curricular reform tends to be superficial.

Fourth, with the advent of the new forms of teaching and content delivery, teachers must also be prepared to assess the learning in new ways. In practice, this does not occur because most teaching continues in the traditional manner and, consequently, so does the testing. The pedagogical thinking of thematic integration requires that teachers shift in their paradigmatic views of teaching, learning, and assessment (Miller, et al., 1997). The National Standards in both mathematics and science suggest assessment that is more authentic. Alternative forms of assessment would seem a necessary component to assess the learning from thematic integration. Teaching, learning, and assessment practices grounded by a more constructivist pedagogy must juxtapose with the holistic approaches embedded in thematic integration. In essence, thematic integration has changed the curriculum organization of the classroom, but not the pedagogical philosophy of the teacher.

Curriculum planners and administrators generally assume that the curriculum is well articulated vertically. Most district curriculum planners subscribe to a scope and sequence based upon individual disciplines (actually based on the Tyler Model). Thematic integration many times will disregard the district curriculum in lieu of activities and objectives the planning grade level teachers deem appropriate. In essence, it throws out clearly articulated scope and sequence charts. The goals and objectives normally included in a grade level curriculum become disaggregated. It would not be uncommon for students to be exposed time and again to similar concepts. Granted that planned multiple exposures to a concept is important in a vertical curriculum, thematic integration attacks this problem in a manner that is at best haphazard.

**Thematic Integration and Constructivist Teaching**

Many educators are discussing the role of constructivist teaching in the schools. The major thrust in the National Science Education Standards (1996) and the Curriculum and Evaluation Standards in School Mathematics (1989) is the trend toward constructivist teaching techniques in the classroom. Clearly, in order for this initiative to be successful, teachers must first understand, practice, and implement constructivist teaching practice. Brooks and Brooks (1993, pp. 103-118) have assembled a list of descriptors for constructivist teaching practice. The following twelve descriptors suggest a more constructivist classroom:

1. Encourage and accept student autonomy and initiative.
2. Use raw data and primary sources, along with manipulative, interactive, and physical materials.
3. When framing tasks, use cognitive terminology, such as classify, analyze, predict, create, and so on.
4. Allow student thinking to drive lessons, and shift instructional strategies or alter content based on student responses.
5. Inquire about students’ understandings of those concepts.
6. Encourage students to engage in dialogue, both with the teacher and with one another.
7. Encourage student inquiry by asking open-ended questions of students and encouraging students to ask questions of others.

**Alternative forms of assessment would seem a necessary component to assess the learning from thematic integration.**
8. Seek elaboration of students’ initial hypotheses, and then encourage a discussion.
9. Engage students in experiences that might engender contradictions to students’ initial hypotheses, and then encourage a discussion.
10. Allow wait time after posing questions.
11. Provide time for students to construct relationships and create metaphors.
12. Nurture students’ natural curiosity through frequent use of the learning-cycle model.

Classrooms using constructivist techniques would be doing inquiry based science and mathematics. The connectiveness and relevancy of the curriculum stems from the prior knowledge and experiences of the students. The teacher acts as a guide to lead the students into appropriate additional learning experiences and in some cases to correct preconceptions that are inaccurate. The goals and objectives are clear within the curriculum that has a scope and sequence. The difference then is in the methodology used to encourage students to explore new ideas and concepts. The constructivist teacher uses multiple teaching strategies to accomplish this goal.

Even though constructivist techniques are more holistic and thematic integration is also holistic, it does not follow that thematic integration is constructivist. Thematic integration is a method of curriculum organization. Constructivism is a teaching and learning methodology. Though they can and sometimes do overlap, they are separate and individual concepts. Figure 2 lists the constructivist teaching strategies in contrast with the thematic integration curriculum organization.

<table>
<thead>
<tr>
<th>Descriptors of Constructivist Teaching Practices</th>
<th>Present in Thematic Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Encourage and accept student autonomy and initiative.</td>
<td>No, only valid if teacher chooses.</td>
</tr>
<tr>
<td>2. Use raw data and primary sources, along with manipulative, interactive, and physical materials.</td>
<td>No, will not occur if teacher plans this into the lesson.</td>
</tr>
<tr>
<td>3. When framing tasks, use cognitive terminology, such as classify, analyze, predict, create, and so on.</td>
<td>No, will not occur unless teacher is aware of these processes and chooses to have students use them.</td>
</tr>
<tr>
<td>4. Allow student thinking to drive lessons, and shift instructional strategies or alter content based on student responses.</td>
<td>No, content has been planned in advance.</td>
</tr>
<tr>
<td>5. Inquire about students’ understandings of those concepts.</td>
<td>No, teacher must bring into account prior knowledge. Thematic planning in advance to the lesson is not conducive to infusing students’ prior knowledge.</td>
</tr>
<tr>
<td>6. Encourage students to engage in dialogue, both with the teacher and with one another.</td>
<td>No, the structure of the lessons in thematic integration does not automatically assume that peer learning will be encouraged.</td>
</tr>
<tr>
<td>7. Encourage student inquiry by asking open-ended questions of students and encouraging students to ask questions of others.</td>
<td>No, questioning strategies is a teacher skill and is not necessarily a component part of thematic integration.</td>
</tr>
<tr>
<td>8. Seek elaboration of students’ initial hypotheses and then encourage a discussion.</td>
<td>No, again, the methodology the teacher chooses to instruct students does not require constructivist strategies.</td>
</tr>
<tr>
<td>9. Engage students in experiences that might engender contradictions to students’ initial hypotheses, and then encourage a discussion.</td>
<td>No, not a component to teacher directed approaches to thematic integration.</td>
</tr>
<tr>
<td>10. Allow wait time after posing questions.</td>
<td>No, can be a component of any instructional strategy or teaching model.</td>
</tr>
<tr>
<td>11. Provide time for students to construct relationships and create metaphors.</td>
<td>No, should be a strategy used in any classroom.</td>
</tr>
<tr>
<td>12. Nurture students’ natural curiosity through frequent use of the learning-cycle model.</td>
<td>No, methodological in nature.</td>
</tr>
</tbody>
</table>
Conclusion

We have observed through the incidence of presentations at professional meetings, for example, that the topic of curriculum integration is currently in vogue. In this paper we have identified various meanings typically associated with the integration of science and mathematics. Most of these integration approaches preserve the integrity of the science and mathematics disciplines. We have, however, raised questions as to whether thematic integration fulfills this requirement. We have noted that thematic integration typically does not address either the content or process objectives of science or mathematics curricula.

Many educators today suggest that students learn more effectively when a constructivist teaching approach is used. Others suggest that thematic integration, being holistic in its design, is a natural way for students to draw on their own experiences in achieving curriculum integration. Is it possible for thematic integration learning to be constructivist? Perhaps the best approach to thematic integration is first and foremost pedagogical. Teachers need to become aware that simply connecting various disciplines together does not change methodology or pedagogy. As teacher educators, we need to realize that it is not enough to stress the connection between and among disciplines. Rather, we need to encourage teachers to think more about effective pedagogy than about curriculum organization. Accordingly, we propose that thematic integration, in order to respond to the concerns identified in this paper, must focus on key concepts (organizing ideas), rather than on specific curriculum content. We suggest that thematic integration is indeed a potentially powerful tool to assist teachers integrate concepts in science, mathematics, and other disciplines, but that teacher educators and curriculum designers must accept responsibility for helping teachers focus attention on key concepts, rather than on isolated items of information.

References


Kenneth W. Miller is an Associate Professor of Science Education, Department of Curriculum and Instruction, Montana State University Billings, Billings, Montana 59101

David Davison is Professor of Mathematics Education, Department of Curriculum and Instruction, Montana State University-Billings, Billings, Montana 59101
Writing Winning Proposals:
Five Rules in Honor of Proposal Reviewers

Practical information and recommendations are presented for writing winning proposals

What makes some people so successful in their grant proposal writing efforts? At times it may seem that a select group consistently receives funding for projects—as if you have to be in the loop to win grants or other research funding obtained through the process of writing and submitting winning proposals. Although it is helpful to read what successful proposal writers suggest (e.g., Battagalia, 1995; Moffat, 1994; Bailey, 1985), we think that the needs of proposal reviewers also warrant consideration. In considering their needs, we adopted an approach common in the field of technical communications that considers such reviewers from two viewpoints. As the audience of the proposals we write, these reviewers have the same needs any audience has for readable documents. Thus, the tool of audience analysis is appropriate in assessing their needs. Additionally, the fact that the proposals are read to support another task—making decisions about allocations of funding—points to the need for a task analysis. It is an axiom of technical communications that effective documents are rooted in these analyses, that is, in considerations of audience and use. For example, Wieringa and his colleagues characterize such an approach as, “the single fundamental core principle” of effective procedure writing (Wieringa, Moore, & Barnes, 1993, p.191). We think that this core principle is also valid for proposal writing. As stated by Wieringa and his colleagues, “The global principle, simply stated, is ‘honor thy user’” (Wieringa et al, p. 191).

Method

This article presents five recommendations for writing winning proposals suggested by the credo of “honor thy user,” with proposal reviewers seen as the honored users. We focused on two lines of inquiry in our assessments of the needs and interests of these users. First we considered, in a general sense, the nature of the processes involved in proposal review cycles. We also considered information provided directly from funding agencies regarding what they (their reviewers) want to see in proposals. The agencies listed below provided this input at workshops in which they provided recommendations to proposal writers:

• National Institute of Health
• National Science Foundation
• Environmental Protection Agency
• Department of Education

Rules for Writing Proposals

Considerations of the interests and needs of proposal reviewers suggest five rules for proposal writing, which have been organized into three groups in the following discussion.

Rules About Shooting Yourself in the Foot— or Not

Even the most minimal analysis of the processes by which proposals are reviewed suggests a few ways that many writers may unknowingly sabotage their efforts. Consider the following typical scenario. Your proposal has been received by a funding agency and is one of the 50 or more tomes (of perhaps 20 to 50 pages each) stacked in piles on the reviewer’s desk. The
Rule #1: Respond fully and clearly to proposal specifications as they are stated in the RFP.

The systems by which funding agencies review proposals are not like our judicial system, which requires a presumption of innocence until guilt is proven beyond a reasonable doubt. To the contrary, funding agencies typically screen proposals through a process that seems to presume each proposal is inadequate unless proven otherwise. This underlying philosophy, it should be remembered, reflects the constraints of reality rather than preferences of reviewers. The agencies who fund proposals expect that they will reject many proposals and have substantial interests in rejecting them for the right reasons. Thus, funding agencies provide RFPs containing detailed instructions to help ensure that the screening process is not arbitrary and capricious. Remember the RFP? That poor soul with a desk full of proposals to sort remembers it. In fact, he or she might have even helped design the proposal-review-checklist that is based upon the RFP specifications. Busy proposal reviewers often use worksheets such as checklists or scoresheets to assist them in evaluating proposals. If the connection between some critical bit of information in your proposal and the item on the worksheet can’t be readily made, it is apt to be missed. Typically, these forms follow the organization and word choices used in the RFPs. Consequently, it is important that your proposal address the topics requested in the RFP and that it does so in the same sequence as the RFP.

Rule #2: Honor key minimal expectations by meeting deadlines and editing your work.

To the best of our knowledge, no grant proposal has ever won a major literary award, and reviewers are not looking for Hemingway. Further, gold-edged paper is not warranted. Nonetheless, we strongly advocate that proposal writers adhere to a few general expectations of professionalism. Proposals must meet deadline requirements. Make sure that you know not only when the deadline is, but exactly how it is defined. Typically deadlines specify the date by which your entry must be postmarked. However, the RFP may state the date by which proposals must be received. Almost always, proposals that miss deadlines are disqualified. Additionally, we highly recommend that all proposals receive the editorial care and thorough reviews that they deserve.

If it is not possible to include thorough editing and review in the proposal review cycle, we recommend that, at a minimum, you edit and review your proposal to guard against the following three types of pitfalls:

1. Review your proposal for anything that might be problematic in terms of legal issues and the policies of your organization. Issues of concern are varied and significant, ranging from contractual implications embodied in the proposal to issues of potential conflict of interests.

2. Check the integrity of the final assembled proposal package. That is, make sure that all the pieces are there and in the right order.

3. Ensure that your proposal receives, at the very least, a once-over copy edit. Conspicuous typographical errors and profound violations of grammatical conventions make proposals difficult to read and can raise red flags for reviewers. Your proposal is, after all, a sample of your work. A conspicuous absence of copy editing may raise sufficient red flags to disqualify an otherwise sound proposal.

Rule #3: Give very serious attention to the abstract.

There are two general approaches to writing proposal abstracts. The first approach views the abstract as a simple summary of the proposal that you write because the RFP said to (or because you always have before). Practitioners of this approach, write the abstract during that window of free time that occurs right after they have
called the overnight express service (while waiting for the last pages of the proposal body to come off the computer’s printer). Champions of the alternative, more informed, approach view the abstract as potentially the only portion of a proposal reviewers will ever read. It is important to note that while no proposal ever wins solely upon an abstract, many lose because of their abstracts. Thus, the abstract must not only accurately summarize the proposal, but do so in a way that grabs the reader. It takes time and effort to write a solid abstract that serves these functions well. Make sure that you devote the resources to the task of writing the abstract that it deserves. Have others review it and, of course, check it carefully against the contents and wordings of the RFP.

**Rule Pertaining to Document Design**

We have discussed issues of document design (the old terminology from the world of paper publications for what is now called “look and feel” in electronic information systems). For example, the first rule addresses the need for your proposal to have a look and feel that relates to the look and feel of the RFP. You will further enhance your chances of success if you apply a bit of good judgment and standard word processing expertise in designing your proposal so that it is attractive and easy to use. Again, just as you don’t need to be an award-winning novelist to write a compelling proposal, you don’t need to be an expert in desktop publishing to produce a well-designed one.

**Rule # 4: Convey information visually as well as through words.**

How text is formatted and placed upon the page can provide a lot of information. Further, a little bit of sound document design strategy goes a long way. For example, it takes little effort to use well-designed headings to reveal the organizational structure of your document. Show the hierarchy of headings by using an ordered sequence of cues in the placement and/or typography of your headings. Use several cues to emphasize the importance of your highest level headings and then systematically make each lower-level heading look more like the text in the body of your proposal. For example, you might use a combination of three cues to distinguish the main headings in your proposal—format the headings using centered justification, bolding, and full capitalization. When formatting second level headings, manipulate one of the three text variables to make the text more similar to the body text—continue to use centered justification and bolding, but step down to initial-letter capitalization. Format third level headings using left justification rather than centering the text. Text variables that can effectively reveal such progressions include font size, font case, line justification, underlining, italics, outline-style numbering schemes, and outline-style patterns of indentation. Numbered lists, bulleted lists, charts, tables, and diagrams are also excellent tools for organizing and presenting certain types of information.

Do not, however, get carried away with typographic cues such as font changes and the use of underlining, bolding, and italics. Remember, if everything is emphasized, nothing is emphasized. A wealth of research in technical communications shows that such cues communicate most effectively when they are applied sparingly, consistently, and logically. For example, readers probably won’t understand more than about four levels of hierarchy in a system of headings and subheadings, so avoid sixth- and seventh-level headings. Avoid displays that are hard to read—such as extravagant font styles and large blocks of text set in all capital letters.

Consider the importance of white space. Elements such as headings, lists, and tables convey information, in part, by creating white space. Headings create a break in the paragraph-by-paragraph flow of text and show what is grouped with what. Lists, charts, and tables serve the same functions on smaller scales. It is much easier to scan through a list or a table than it is to read a running stream of text. Further, the white space that these techniques create makes a document seem less formidable and more inviting. While it may be tempting to shun white space in order to cram as much information as possible within page limits, the result is likely to be a document that is hard to read and harder to understand (Wieringa et al., 1993, Spyridakis and Wenger, 1990). Moffat (1994) documented a situation where reviewers objected to reading proposals for precisely this reason:

> At NSF . . . the agency issued new rules stating that the project descriptions could be only 15 pages long—in 10 to 12 point type. The latter requirement was added, says Steinberg, because there are always a few researchers who drop to a smaller font to fit everything in. Often, such proposals are returned for revision without even being read. (p.1921)

Ensure that your visual displays such as lists and tables are set up logically. For example, use bullets for listed items where order is irrelevant and numbered lists for items where sequence is important. Design displays to support the tasks for which they are intended.
Consider the table shown in Table 1, which has been copied from a table provided to university students in their registration materials. The table was designed as a tool for students (and faculty) to use to look up the scheduled times of final exams. Although it is possible to find exam times from the table, the table fails to effectively support users in the performance of that task. If you can figure out what is wrong with this table, you understand the basic concept of designing text to support user needs.

To find the time of an exam for a given class, using the table shown in Table 1, it is necessary to search the cells of the table to find the cell that states when that class meets during the semester. For example, if your class meets at 4:00 p.m. on Mondays, Wednesdays, and Fridays (and it is not ENG. 101, PED 101, or MAT 111), then you would search out the cell at the lower right corner of the table as an entry point. To make matters worse, you may need to find the time that is closest to when your class meets—check your work carefully. After completing that unnecessarily difficult task, it is necessary to track from the selected table cell to its corresponding row and column headings—to Thursday, Dec. 19 at 7:00 p.m. using our previous example. Notice that after tracking to one heading, you must hold the information it provides in some manner—in memory or by pointing to it—while you track the other heading. Finally, you are forced to mentally assemble the two pieces of information—day and time—to find the answer. The process is complicated because the table organization is incongruent with its intended use. The table is as illogical as a phone directory organized by phone numbers. An improved design of the table would map the days and times that classes meet to the column and row headings and place the exam times in the table cells. To use a table with this design, you would use those headings as pointers to find the cell that displays (in one place) the day and time of the exam. The moral of the story is straightforward: Design displays with their end use and end users in mind.

Tables, charts, and diagrams designed to effectively support users’ needs are efficient and powerful. In part, visual displays are effective because they are so efficient in allowing users to see relationships within bodies of information. An effective visual aid allows users to see things at a glance that might require several paragraphs to describe in words. A picture is worth a thousand words because it shows information about spatial relationships that cannot be effectively described in words. Graphics such as charts, tables, and diagrams, in very similar ways, effectively show logical relationships that words alone cannot be readily convey. Larkin and Simon (1987) devised a scheme for assessing the power of diagrams to convey spatial and logical relationships. These researchers proposed that because effective graphics (a) pack a vast amount of information in a small space and (b) show complex ideas in ways that viewers can perceive at a glance, they can function as a type of external memory. Like human working memory, the visual display can hold bits of information that the user must

### Table 1 - Example of a poorly designed table

<table>
<thead>
<tr>
<th>Exam Schedule – Fall 1997</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXAM TIMES</strong></td>
</tr>
<tr>
<td>8:00-11:00</td>
</tr>
<tr>
<td>11:30-2:30</td>
</tr>
<tr>
<td>3:00-6:00</td>
</tr>
<tr>
<td>7:00-10:00</td>
</tr>
<tr>
<td><strong>Friday</strong></td>
</tr>
<tr>
<td>December 12</td>
</tr>
<tr>
<td>9:30 a.m. TR</td>
</tr>
<tr>
<td>12:30 p.m. TR</td>
</tr>
<tr>
<td>11:00 a.m. MWF</td>
</tr>
<tr>
<td>6:00 p.m. MW</td>
</tr>
<tr>
<td><strong>Saturday</strong></td>
</tr>
<tr>
<td>December 13</td>
</tr>
<tr>
<td>9:00 a.m. MWF</td>
</tr>
<tr>
<td>12:00 p.m. MWF</td>
</tr>
<tr>
<td>2:00 p.m. MWF</td>
</tr>
<tr>
<td>7:30 p.m. TR</td>
</tr>
<tr>
<td><strong>Monday</strong></td>
</tr>
<tr>
<td>December 15</td>
</tr>
<tr>
<td>10:00 a.m. MWF</td>
</tr>
<tr>
<td>8:00 a.m. TR</td>
</tr>
<tr>
<td>2:00 p.m. TR</td>
</tr>
<tr>
<td>MAT 111</td>
</tr>
<tr>
<td><strong>Tuesday</strong></td>
</tr>
<tr>
<td>December 16</td>
</tr>
<tr>
<td>ENG 101</td>
</tr>
<tr>
<td>PED 101</td>
</tr>
<tr>
<td>6:00 p.m. TR</td>
</tr>
<tr>
<td><strong>Wednesday</strong></td>
</tr>
<tr>
<td>December 18</td>
</tr>
<tr>
<td>8:00 a.m. MWF</td>
</tr>
<tr>
<td>11:00 a.m. TR</td>
</tr>
<tr>
<td>1:00 p.m. MWF</td>
</tr>
<tr>
<td>7:30 p.m. MW</td>
</tr>
<tr>
<td><strong>Thursday</strong></td>
</tr>
<tr>
<td>December 19</td>
</tr>
<tr>
<td>3:30 p.m. TR</td>
</tr>
<tr>
<td>3:00 p.m. MWF</td>
</tr>
<tr>
<td>5:00 p.m. TR</td>
</tr>
<tr>
<td>4:00 &amp; 5:00 p.m. MWF</td>
</tr>
</tbody>
</table>

Tables, charts, and diagrams designed to effectively support users’ needs are efficient and powerful.
combine with other information to solve problems and/or form concepts. While the “at a glance” access to the information is slower than access to information in working memory, that access is still fast. And unlike human working memory, visual displays can hold lots of information, and the memory does not fade away when left unattended. Larkin and Simon assessed the degree to which diagrams, functioning as external memories, could simplify the solving of physics problems. They found that the graphics could be profoundly powerful tools.

The chart shown in Table 2 demonstrates these characteristics of visual aids. In that chart, information about specific components of a three-year program is presented, through words, in the chart cells. The relative placements of those cells also conveys information about how each component fits into the overall scope and sequence of the program. To convey all of the information captured in the chart using running text would probably require several pages.

One can read the chart shown in Table 2 in various ways to see different relationships among the elements. The reader can readily move back and forth across various “forest” and “trees” views. A few minutes of such study may be sufficient to answer a number of questions about the program activities described by the chart and to gain a general concept of the big picture of how the elements fit together. In the same amount of time, a user might be able to complete a first reading of a comparable text description. However, a running text display does not make it easy, during subsequent readings, to find information of known interest; by the time the users find what they are looking for, they may forget why they wanted it. Running text becomes even more limited when one wants to compare several bits of information. By contrast, when using the chart, it is a simple matter to find and assemble everything applicable to various questions (e.g., What happens in year three? Which activities occur at the University?). The chart “remembers” the logical relationships for us.

The central rule: Ensure that Your Proposal is Centered Upon and Driven by Relevant Concerns

The credo of “honorary user” points to the need for you to do what you can to help ensure that the reviewers perceive a relevant driving force within your proposal. Many experts stress the importance of targeting your proposal to the right source of funding (Battagalia, 1995; Moffat, 1994; Bailey, 1985), and reviewers are turned off by proposals that they perceive as “fishing trips.” For the purposes of this discussion, our final rule can be stated as follows:

**Table 2. Example of an effective chart based upon a chart from a winning proposal.**

<table>
<thead>
<tr>
<th>Students as Scientists: Pollution Prevention Through Education</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Site(s)</strong></td>
</tr>
<tr>
<td>Year 1</td>
</tr>
<tr>
<td>UNC-Wilmington</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Year 2</td>
</tr>
<tr>
<td>UNC-Wilmington</td>
</tr>
<tr>
<td>Western-NC</td>
</tr>
<tr>
<td>UNC-Charlotte</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Year 3</td>
</tr>
<tr>
<td>UNC-Wilmington</td>
</tr>
<tr>
<td>Western-NC</td>
</tr>
<tr>
<td>UNC-Charlotte</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Rule #5: If your project reviewers are scientists, then ensure your proposal demonstrates that your project is hypothesis-driven.

Notice that we have stated not only that your project must be hypothesis driven, but that your proposal must demonstrate that it is. Reviewers are likely to suspect fishing trips are at hand when they see phrases such as, “We wanted to see if. . .,” or “We want to look for. . .,” or “In order to move towards a better possible understanding of how maybe. . . .” Proposal reviewers are accountable for the prudent allocation of substantial chunks of money. What are you going to do with some of that money? Why is it worth doing? How will you assess that you are, in fact, achieving those objectives? Your proposal needs a strong, clearly-defined hypothesis — stated up front. As suggested above, this hypothesis must clearly link to the RFP in order to establish that your proposed ideas are in any way connected to what the agency is interested in funding. For example, it is likely that the RFP will include some sort of goals statement. Your research hypothesis should lead to similar goals. This correspondence of goals is one of the strands that connects the interests and needs of the funding agency with the research you propose.

As indicated above, we believe winning proposals contain many such connecting strands. However, a winning proposal must not merely be connected to the RFP, but presents a coherent and valid response to the RFP. To create coherency, ensure that readers can easily see how the strands that connect your proposed plans to the RFP are also connected to each other. To help ensure readers see your proposal as valid, use your research hypothesis as a driving force in your writing. That is, as you weave the words of your proposal, be responsive to the RFP and repeatedly show how all of your proposal elements are natural outcomes of your research hypothesis. The connections you make between your ideas and the RFP are analogous to the threads on the weaver’s loom.

<table>
<thead>
<tr>
<th>Table 3: Rules for Writing Winning and Losing Proposals.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rules for writing winning proposals</strong></td>
</tr>
<tr>
<td>Respond fully and clearly to proposal specifications as they are stated in the RFP. Reviewers sometimes assess proposals using scoresheets, which correspond to the RFP. If your proposal organization does not follow the same sequence as the scoresheet (i.e., the sequence of the RFP), reviewers may overlook elements (score them as not present).</td>
</tr>
<tr>
<td>Honor key minimal expectations by meeting deadlines and editing your work. You must meet deadlines and demonstrate a minimal command of the English language in your writing.</td>
</tr>
<tr>
<td>Give very serious attention to the abstract. It may be the only portion of your proposal a reviewer reads.</td>
</tr>
<tr>
<td>Convey information visually as well as through words. Use white space, lists, tables, and the power of the word processor to make an attractive easy-to-read document.</td>
</tr>
<tr>
<td>If your project reviewers are scientists, then ensure your proposal demonstrates that your project is hypothesis driven. Honor your users by offering what they value.</td>
</tr>
<tr>
<td><strong>Rules for writing losing proposals</strong></td>
</tr>
<tr>
<td>Write your proposal as if it is a mystery novel. Use suspense to engage the proposal reviewer’s attention and a surprise ending to show how clever you can be. Leave lots of open questions about how your ideas relate to the RFP (and to each other) and then, in the last page, reveal the elementary logic that ties it all together.</td>
</tr>
<tr>
<td>Ensure that your proposal arrives a day after the deadline, with $1.00 postage due. This strategy ensures that your proposal will be noticed.</td>
</tr>
<tr>
<td>Write your abstract by hand on the back of the proposal delivery envelope. This strategy shows how busy (and therefore important) you are and may invoke subliminal references to Abraham Lincoln. Reviewers will want to snatch you up before you become overcommitted to other work or assassinated.</td>
</tr>
<tr>
<td>Use narrow margins and small text with lots of random font changes. This strategy lets you pack lots of information onto every page while showing off some of the cool things your computer can do.</td>
</tr>
<tr>
<td>Do not reveal any driving force in your proposal – keep it vague and open to misinterpretation. This strategy helps maintain suspense in your proposal (see Rule 1) and, if you have adhered to the previous four rules, any misinterpretation of what you say would be an improvement. This strategy will help ensure that research work doesn’t compete with your fishing schedule.</td>
</tr>
</tbody>
</table>
To help ensure readers see your proposal as valid, use your research hypothesis as a driving force in your writing.

Each connection forms a strand that ties your interests to those of the funding agency. As you weave the words of your proposal, also clearly and continuously show how your proposed plans are connected to – driven by – your research hypothesis.

Conclusion

Considerations of the needs and interests of proposal reviewers suggest five rules for writing winning proposals. We have also used this approach to generate a list of five rules for writing losing proposals. Table 3 provides a summary of these rules.

References


Richard A. Huber, Associate Professor of Science Education, Curricular Studies Department, University of North Carolina at Wilmington, Wilmington, North Carolina 28403.

Christopher J. Moore, Technical Communications Specialist, Students as Scientists Project, University of North Carolina at Wilmington, Wilmington, North Carolina 28403.
Science Supervisors’ Stories: A Way to Communicate Pedagogical Values

Science supervisors use autobiographical stories to communicate pedagogical values to their novice science teachers.

How can science supervisors communicate their pedagogical values to the novice science teachers in their departments, schools, or districts? Novice teachers are the probationary teachers, anxious about how they will be evaluated but often with little or no idea of what their supervisors value (Brickhouse & Bodner, 1992; Bullough, 1989; Fuller, 1969). Not only are conceptions of effective teaching highly variable (Burry-Stock, 1995; Fuller & Brown, 1975; Wildy & Wallace, 1995), but the supervisor, as an expert practitioner, has a perspective that is quite different from that of a novice (Borko, Bellamy, & Sanders, 1992; Brickhouse & Bodner, 1992; Bullough, 1989; Carter, Sabers, Cushing, Pennegar, & Berliner, 1987; Reynolds, 1992). Accordingly, science supervisors need a way to communicate their pedagogical values to their novice science teachers. The purpose of this paper is to encourage science supervisors to communicate such values by telling autobiographical stories.

In a story, the storyteller imposes order and coherence on a stream of events so as to create meaning for a community of listeners (Ben-Peretz, 1995; Carter, 1993; Elbaz, 1991). Though not necessarily an accurate account of events, an autobiographical story is still a reliable reflection of the storyteller’s values (Barclay, 1986; Ben-Peretz, 1995; Carter, 1993; Kagan & Tippins, 1991; Ponticell & Zepea, 1995; Scholes, 1981). In fact, a story seems to be especially effective for communicating pedagogical values because it accommodates the ambiguities and complexities of a teacher’s practice (Carter, 1993).

This paper relates the stories nine science supervisors told about a novice science teacher each had supervised. Presumably, other novice science teachers would find the values embedded in such stories useful to know. Because storytellers express their values with metaphors (Beck & Murphy, 1993; Elliot, 1984; Kagan & Tippins, 1991; Marshall, 1990; Miller & Fredericks, 1988), this paper is an analysis of the metaphorical statements the supervisors made about teaching or teachers, how they are or how they should be. Thus the focus questions for this paper were: What kinds of stories did the nine science supervisors tell? What metaphorical statements did they make about teaching or teachers? And what pedagogical values were embedded in their metaphorical statements?

Method

The author collected the stories for this paper while doing a study of science supervisors’ criteria for assessing a novice science teacher’s
Kinds of Stories
All 10 stories were two-to-three-minute didactic first-person accounts of supervising a novice science teacher who had some professional difficulty, the result of either a personal shortcoming or situational obstacle. The themes of the stories varied only as to whether or not the supervisor worked with the novice teacher expressly to overcome that difficulty and whether or not the novice teacher ultimately succeeded (see Figure 1).

For example, Pete told about a novice teacher who, failing to show cumulative improvement, was denied tenure. In spite of his admonishments, she could not address her shortcomings (see Appendix A). On the other hand, Sara told about a novice teacher encumbered by a heavy French accent who, nevertheless, through her own mettle and imagination, became a confident and esteemed colleague (see Appendix B). Most of the stories, however, were about novice teachers succeeding with the express help of their supervisors. For example, Jim told of hiring a physics teacher who had no pedagogical training or experience. With Jim’s coaching, however, the novice eventually became a Teacher of the Year (see Appendix C).

The Stories
Eight of the nine science supervisors told a total of 10 stories about their experiences supervising novice science teachers. Nine of the stories were told in response to the stimulus question, whereas one story arose spontaneously during an earlier part of the interview.

Figure 1 - Themes of the Supervisors’ Stories

10 Stories About a Novice Science Teacher with a Difficulty

8 Stories Mention the Help of the Supervisor

6 Novices Succeeded

1 Novice Failed

2 Stories Do Not Mention the Help of the Supervisor

1 Novice Failed

1 Novice Succeeded

1 Story with No Mention of Outcome

Jim’s Story

Pete’s Story

Sara’s Story
Metaphorical Statements
The supervisors made metaphorical statements about a teacher or teaching in 7 of the 10 stories. Their statements are presented here in the context of each of the seven stories:

1. A novice teacher lost her job because, in addition to the fact that “she couldn’t bring all the pieces together, . . . she never heard, really heard” her supervisor’s criticisms. (Pete’s story)

2. A supervisor explained her decision to reappoint a novice teacher who willingly “does his time” with classes that aren’t “the cream of the crop.” He cheerfully maintained his commitment despite having “been thrown into perhaps a new teacher’s worst nightmare schedule.”

3. A novice teacher “brought a lot of life to our department” by, for example, coming up with imaginative motivations that got her classes involved. (Sara’s story)

4. Instead of “just spewing out information,” a novice teacher learned to select and focus her lessons on the essentials.

5. A timid rookie with no pedagogical preparation or experience, without even an undergraduate major in a science, was soon able to execute her biology lessons like a veteran: “She has a very businesslike personality in the classroom, very straight. . . . She runs those classes . . . and [even though] her classes are packed, every kid is on-task. You can hear a pin drop.”

6. Another novice teacher, also with no pedagogical preparation or experience, ultimately became a Teacher of the Year in part because “he had that little something that students grab onto, and he, in turn, grabbed onto them.” (Jim’s story)

7. A novice teacher “burned so many bridges with his sarcasm” that he ended up “build[ing] resentment stamps so that the kids . . . collect[ed] them, a few each day.”

Pedagogical Values
The supervisors’ metaphorical statements vividly expressed their pedagogical values, specifically the importance they placed on novice teachers (a) having a positive professional attitude, (b) executing an effective lesson, and (c) fostering a cooperative relationship with students. For example, individual supervisors valued novice teachers who were receptive and responsive to criticism and resolutely committed to teaching. Others appreciated when lessons were launched with an imaginative motivation, limited to the essential information, and squarely managed so that students were kept productively engaged. Finally, some supervisors expressed their regard for teachers who engendered their students’ cooperation instead of provoking their hostility or contempt.

Conclusion and Implications for Science Supervisors
The science supervisors’ stories were dramatic expressions of their pedagogical values. In fact, the values they expressed in their stories were in accord with the criteria they each used to assess a novice science teacher’s lesson (Zuckerman, 1997). Autobiographical stories thus could be a useful way for science supervisors to communicate their pedagogical values to novice science teachers. Accordingly, science supervisors should promote occasions for the telling of such stories.

Supervisors, however, first need to encourage novice teachers to listen to and educe pedagogical values from such stories. Then, as the novice teachers come to know those values, they become part of that community of practitioners (Ben-Peretz, 1995; Shulman, 1986). They develop a professional identity, thereby overcoming the isolation that is a significant threat to their professional development (Bullough, 1989; Lieberman & Miller, 1992).

The supervisors were able to articulate more precisely the attributes of a positive professional attitude and an effective lesson than they were the attributes of a cooperative relationship with students. In fact, although many practitioners, such as Jim, value most
this personal life-touching aspect of teaching, teacher evaluation systems still emphasize technique (Mohr, 1987; Moran, 1990; Ponticell & Zepeda, 1995). Accordingly, science supervisors need to listen to their own stories, especially the ones they tell about teachers who engender their students’ cooperation, so as to understand more precisely their own measure of this elusive artistic aspect of teaching. Then they can better communicate this value to their novice teachers.

References

Appendix A: Pete’s Story
We had a lady here who was a very bright and personable woman. The kids loved her, but she’d get in front of the room and let the kids distract her. Some kids would be doing their nails. But she’d be doing their nails; others would be doing their homework for another class; others would be doing their nails. But she’d come in the next time, and you’d bring that to her attention, and she would nod her head at you. “Yes, yes, I understand ... I understand.” You’d say, “All right now. The next time I come in, that’s the one thing I’m going to look at.”

You’d come in the next time, and she might have fixed it, but the time after that, it would be there again. She couldn’t bring all the pieces together. When you’d ask her to work on some-
thing else, the first problem would come back. She never could put the pieces together.

And so when she wasn’t given tenure and lost her job here, she felt terrible. But she never heard, really heard. She went to the next school and sent us back her first observation and evaluation. I read the first page, and then when I read the second page, I said, “She’s not gonna get tenure there either because here is the whole first page all positive and then, on the second page, it asks her to look at something.” And I said, “I know what’s happening to her. She’s reading the first page because it’s all positive, but she’s sending this to us without even realizing what the second page says.”

So the same thing happened to her there. She was there three years and didn’t get tenure there either. She just never heard.

Appendix B: Sara’s Story

I have a teacher in my department who started out as my student teacher. She was very unsure of herself because she speaks with a heavy French accent. When she first started to student teach, she was not sure that the class would understand her, and quite frankly, I was not sure either. She turned out, however, to be a wonderful, lively teacher.

One of the things that she did early on was to make an audiotape of her own lessons, and the first time she heard her voice, she almost cried. But then she worked on it, and realizing that she had this accent, started to compensate by using the board more. She also learned to laugh at herself, which I think is one of the wonderful techniques that a teacher has to use.

She has taught me a lot and has also brought a lot of life to our department. For one thing, she comes up with some very weird motivations. When she was a student teacher teaching a lesson on reflexes, she caught her finger in a drawer, or so everybody thought, including her professor, who came running up very upset. At any rate, she pretended to catch her finger in the drawer and started cursing first in French and then in English. That really got the class involved.

She has really grown into a wonderful, creative teacher who now teaches our research class, and what is very interesting to me is that I started out as her advisor, and now we have very much switched roles. In fact, when I walk into her research class in the middle of a discussion and I feel I have something to contribute, she makes me keep my mouth shut. She says, “No, no. You’re not supposed to say anything. You’re just here to listen.” So, it’s really good.

Appendix C: Jim’s Story

I’ll tell you a very satisfying story about Tom. I needed a physics teacher because one had suddenly left the district at the beginning of the year. Physics teachers were at a premium. So I called Tom. He had no teaching experience. In fact, he had just finished studying to be an engineer but had decided that he wanted to teach instead.

I met Tom on the steps. We signed him up as a long-term sub. I remember speaking to him, saying “Tom, you don’t have to go into teaching. There are more lucrative jobs out there as an engineer.” But he said no. He’d given it some thought, and he wanted to give it a shot.

I brought him down to the high school, and his first class was an AP physics class. The students—and their parents—were very demanding. When Tom first started, he didn’t even know how to write on the board with chalk, but he knew his physics and I could tell that he loved kids. But he didn’t know a thing about teaching. Three or four years later he received his tenure, and in the fifth year, the National Honor Society voted him Teacher of the Year.

Going back now, here’s a person that I had to teach to crawl before he could walk, but he had a love of students. He had that little something that students grab onto, and he, in turn, grabbed onto them. And he had knowledge of the subject. And to me, if you have those two, technique is just a matter of time. You can teach anybody technique, but you can’t teach anybody to love children. And it’s too late to learn the content if you’ve gone through college and didn’t pick it up then.

So, I look at Tom as probably my fondest teaching experience because it was a very frustrating one, but an extremely satisfying one as well, to see someone go in on that first day who couldn’t even write on the board. But then again, that was before I learned that technique is secondary, and those intrinsic values and knowledge of subject are the important things.

June Trop Zuckerman is Associate Professor of Secondary Science Education, Department of Secondary Education, SUNY-New Paltz, NY 12561-2499
Leading Environmental Education: Lessons from a Case Study of School Change

The sustainability of curriculum change is influenced by the interaction of competing priorities and institutionalized practices.

The following is a case study account of the implementation of a high school environmental education project. The article describes the interplay of competing priorities, institutionalized practices, and leadership strategies that occurred during the project. This is a first-person account by the first author of the paper who was the leader of the project at the time. The second author was involved in the conceptualization of the paper and the analysis of the events described.

The introduction to my new appointment at Swamplands High School involved a casual walk with the principal through the incomplete school buildings. He led me through a maze of half-built walls, across a newly laid expanse of paving, to a bright freshly painted building that was to be my workplace for the next two years. To my surprise the tour did not end there but continued through the facility to a perimeter road that overlooked an expanse of swampy rush and kykhu grass. In the past this area was a cow paddock, but now it was a swampland in winter and native shrubs were beginning to take hold.

“What do you think of this?” he asked. I surveyed the scene for a while then replied that it was either an enormous problem or a great opportunity. I explained that I thought the area could become an attraction for undesirable student activity or could be a study area for environmental science and vegetation rehabilitation. The principal then revealed his own desire to see some form of environmental theme being adopted by the school as part of its community profile.

The school had already had a poor start to its short life. The building program was behind schedule, and the press had focused on the disruption this had caused to students’ learning. It had become critical for the school to quickly establish a positive profile. With only limited resources available, the principal was ready to receive any credible idea. I recognized that the school was located in an important groundwater pumping area, was close to a number of lakes, and had chosen the heron as its logo, so an environmental focus for the school was a logical one. The notion of a school priority based on “caring for the environment” also fitted well with my own view of the purpose of schooling, so I set about looking for ways to bring about such a priority. What followed was a process of learning and evolution that at times showed great promise and at other times disappointment.

Getting Started

The initial steps in the process were somewhat hastily conceived, but fortunately this helped the project to evolve in a flexible way, creating considerable interest among students and some sections of the community. The immediate action was to recognize the swamp as an important curriculum resource—an outdoor classroom. This involved identifying environmental science activities and implementing them as part of the science program. Early in the new year I persuaded one of the science teachers to attend an environmental education workshop to obtain information and gather curriculum resource material.

I talked with teachers informally about the proposal, so the staff involved had a good sense of direction but weren’t bogged down by any need to clarify a mission for the project or develop a strategic plan. The project vision was not formalized until later, so the process was akin to that described by Fullan (1994, p. 31) as the “ready, fire, aim” sequence.
It soon became clear that the Environmental Study Area would need demarcation using fencing and signage to prevent degradation by students and the community. I saw this activity as an opportunity to expand the environmental project into the broader community and as a way to involve other teachers and parents. Such action was in accord with the views of Wasley (1991) who noted that such projects require teacher leaders and their colleagues to work effectively together.

Fencing for the Study Area required materials and labor and the principal advised me to apply for a grant for the development of school grounds through the school’s Parents and Citizens Association. The preparation of the submission was significant in that it forced me to reflect upon the purpose of the activity and to formally describe the intentions of the project. I began this process by preparing a position paper containing what might be regarded as a disguised vision. Circulating the paper at management meetings gave teachers a chance to discuss and comment, a tactic designed to raise awareness and interest. The paper also served as notice that this was an area of the curriculum that would require the cooperative involvement of many sectors of the school.

I also realized that the construction of the fence and signs for the Study Area would require considerable input from other teachers. At series of meetings to discuss the topic, I was surprised by the high level of moral commitment of teachers to environmental issues, especially among a group of six staff who formed a nucleus of support. Teachers with particular strengths voluntarily assumed responsibility for particular aspects of the project where specialist problems were to be solved. In some cases the involvement of these teachers lead to considerable ownership and commitment to the project. Elsewhere, Fullan (1994) described the importance of collective problem solving in building ownership and commitment to school improvement.

It was at this point that the balance of individual and collective input changed significantly. Whereas previously I had supplied much of the input, ideas now began to flow from various sources. A presentation to the school’s Parents and Citizens Association proved to be particularly fruitful as they agreed to support the grant proposal and were very supportive of environmental education. In fact, I was also surprised by the high level of moral commitment to environmental issues displayed by this parent group. One person was a member of the local Shire Council, and she helped arrange resources and disseminate knowledge of the project in important local forums. It seemed that the project was raising the awareness of environmental issues in the community. Input to the project came from a range of sources, and the vision for the project began to broaden to include an emphasis on environmental citizenship. The project was also beginning to be successful in establishing alliances with the broader community, a feature that Fullan (1994) emphasized as an important factor in facilitating school improvement.

Advantages began to accrue from the collaborative processes that had been used to establish the project. The project vision began to get clearer, and this was shared by a significant proportion of people across the school, albeit to varying degrees. Students were also involved in the collaborative planning and building of the perimeter fence. By encouraging students to contribute to the development of their school, especially by being involved in the decision-making process, it was expected that they would want to participate in future activities and would show greater interest in environmental issues.

**Attempted Consolidation**

Having completed the first step of establishing the Study Area, I proposed to the environment committee and the school administration that environmental education be a priority for the school. I felt that this was important because it meant that strategies to support environmental education would be formalized and that some resources would be provided to support the priority. In addition, I proposed the appointment of a coordinator to supervise the development of environmental education and to monitor the effectiveness of the strategies. In due course, the environment committee invited me to fill the position of environmental education coordinator in addition to my normal head of science duties.

One of the agreed strategies for implementing the priority was to integrate and embed environmental activities across the curriculum rather than teach environmental education as a separate subject. Swamplands was a new high school, so there seemed to be considerable opportunity for curriculum integration. However, there was also resistance from some quarters of the school to this cross-curricula approach. Some curriculum leaders were concerned about a perceived erosion of the time spent on their subject area. They could not see how gains in students’ test scores would be achieved by modifying the existing curriculum. Teachers in traditional subjects who were under pressure to cover the syllabus content had re-
Teachers in traditional subjects who were under pressure to cover the syllabus content had restricted opportunities to explore the alternative approaches characteristic of environmental education.

Restricted opportunities to explore the alternative approaches characteristic of environmental education. While some teachers were able to make adjustments to their courses, this practice was not widespread. The inflexibility of the timetable also made it difficult for teachers to take students out of the classroom for field investigations and community projects. So in spite of some genuine efforts to explore alternative approaches, most teachers found it difficult to make significant changes to their programs. These complicating features are not dissimilar to those identified by Ladwig, Currie, and Chadbourne (1994, p. 40) as impediments to change in large high schools: “Large senior high schools with their subject departments and multiple curriculum frameworks are often more complex organisationally than small [elementary] and [rural] high schools. These features complicate attempts to get common acceptance among staff.”

In addition to the cross-curriculum focus, we also attempted to introduce several specific out-of-class environmental projects. These started well but they were dependent on the goodwill of teachers and were not part of the formal learning program. They did not have a recognized status within the school and therefore were difficult to sustain. Over time, the inconsistent management of these programs caused student participation to fall away. Some of these activities were almost counterproductive in effect. Although I was the coordinator, I did not have any extra time to support the activities of the staff in their work for this priority, and this restricted my effectiveness as a networker and facilitator of teacher development. Wasley (1991, p. 181) emphasized that provision for adequate “legitimate time for professional growth” is critical to the improvement of teachers’ and hence school programs.

Where teachers had a strong personal commitment to the priority, their particular projects were very successful and they were able to contrive ways to develop their ideas as part of the formal school program. One particular example was an environmental art and photography exhibition in which students displayed considerable skill and sensitivity. However, the teachers involved received only limited support and found the activity particularly taxing, so the exhibition has not been repeated. It was seen as an extra burden, not recognized as an integral part of the school curriculum, so it did not develop as intended.

Certain other factors also interfered with the ongoing development of the project. The arrival of new staff in the school began to offer grade and rural high schools. These features complicate attempts to get common acceptance among staff.”

In addition to the cross-curriculum focus, we also attempted to introduce several specific out-of-class environmental projects. These started well but they were dependent on the goodwill of teachers and were not part of the formal learning program. They did not have a recognized status within the school and therefore were difficult to sustain. Over time, the inconsistent management of these programs caused student participation to fall away. Some of these activities were almost counterproductive in effect. Although I was the coordinator, I did not have any extra time to support the activities of the staff in their work for this priority, and this restricted my effectiveness as a networker and facilitator of teacher development. Wasley (1991, p. 181) emphasized that provision for adequate “legitimate time for professional growth” is critical to the improvement of teachers’ and hence school programs.

Where teachers had a strong personal commitment to the priority, their particular projects were very successful and they were able to contrive ways to develop their ideas as part of the formal school program. One particular example was an environmental art and photography exhibition in which students displayed considerable skill and sensitivity. However, the teachers involved received only limited support and found the activity particularly taxing, so the exhibition has not been repeated. It was seen as an extra burden, not recognized as an integral part of the school curriculum, so it did not develop as intended.

Certain other factors also interfered with the ongoing development of the project. The arrival of new staff in the school began to offer grade and rural high schools. These features complicate attempts to get common acceptance among staff.”

In addition to the cross-curriculum focus, we also attempted to introduce several specific out-of-class environmental projects. These started well but they were dependent on the goodwill of teachers and were not part of the formal learning program. They did not have a recognized status within the school and therefore were difficult to sustain. Over time, the inconsistent management of these programs caused student participation to fall away. Some of these activities were almost counterproductive in effect. Although I was the coordinator, I did not have any extra time to support the activities of the staff in their work for this priority, and this restricted my effectiveness as a networker and facilitator of teacher development. Wasley (1991, p. 181) emphasized that provision for adequate “legitimate time for professional growth” is critical to the improvement of teachers’ and hence school programs.

Where teachers had a strong personal commitment to the priority, their particular projects were very successful and they were able to contrive ways to develop their ideas as part of the formal school program. One particular example was an environmental art and photography exhibition in which students displayed considerable skill and sensitivity. However, the teachers involved received only limited support and found the activity particularly taxing, so the exhibition has not been repeated. It was seen as an extra burden, not recognized as an integral part of the school curriculum, so it did not develop as intended.

Certain other factors also interfered with the ongoing development of the project. The arrival of new staff in numbers meant that the previous level of commitment and ownership for the project was diluted. There was little consideration of strategies to include these people in the development of the environmental theme. In addition, the school began to offer grade 11 and 12 courses, and many teachers turned their attention to preparing students for the university entrance examination. As a consequence, teachers found it difficult to meet the expectations that we had set when we first agreed on the environmental education priority.

One year after the environmental education priority had been established, I left the school and another coordinator was appointed. She too gave considerable time and energy to establishing special projects and monitoring the effect of the strategies. However, it would appear that the program’s effectiveness was largely dependent on the presence of the coordinator who supported the network of participating teachers and led the planning of activities. The coordinator was necessary to maintain the focus of the cross-curriculum program in a school with a teaching culture dominated by the needs of subject departments and externally endorsed curriculum. Five years on, there is no coordinator, the project is no longer a school priority, and little remains of that early enthusiasm for environmental education.

Implications and Conclusions

The example of innovation described here highlights several issues concerning the sustainability of curriculum change. Firstly, it is important that teachers understand that introduction of an innovation is itself a change process, and information about people’s perceptions of the change need to be monitored and understood if the innovation is to be effectively implemented (Louks-Horsley & Stiegelbauer, 1991). In this case, environmental education became a priority and most teachers supported the initiative, but only a few made significant changes to their day-to-day activities to accommodate the initiative.
The constraints of the school’s organization and the competing priorities of some subject departments resulted in limited collaboration.

Secondly, all members of the school community need to be involved in the development of those project plans and strategies that are likely to influence them. Only when they have developed ownership of the project will they make a significant contribution, ensuring that the vision continues to evolve and remains an ongoing focus of development. The constraints of the school’s organization and the competing priorities of some subject departments resulted in limited collaboration. Consequently, some teachers did not identify with or value the project.

A third issue concerns teachers struggle to find time to work together to cooperatively plan and implement the project. The diversity and complexity of the teachers’ working day provides little opportunities for teachers to work collaboratively. Lear (1993) described similar issues in studies of schools endeavouring to implement whole-school integrated programs. While many benefits were generated by the project, it is questionable whether the priority was attainable without adequate support to allow teachers time for planning and reflection.

Fourthly, there is the need to provide opportunities for teachers to grow professionally as they explore innovations such as the environmental education project. During the implementation of the environmental education project, the role of the participating teachers as learners was given insufficient recognition in the development of the project. It is now clear that teachers did not fully understand how the project was contributing to the development of key student outcomes. As Fullan (1994) might attest, this was an opportunity missed and was a consequence of the school not recognizing its importance as a learning community for staff as well as students.

Finally, the project did not achieve an appropriate balance between individual input and collective purpose. It is now clear that formal endorsement of the project’s purpose and strategies should have been sought from a wider base of teachers. More opportunities for teachers to critically review ideas and strategies may have resulted in increased responsibility for the project outcomes.

So it is with mixed feelings that we finalize this account. A project that promised so much early in its development soon became unwieldy and difficult to sustain among the competing demands of the high school organization. What appeared at the outset to be a relatively simple project turned out to be quite complex. The irony is that reflection after the fact has led to a better understanding of this complexity. If the reflection process had been built into the project itself, a different kind of outcome may well have emerged.

References


Rodney Beresford, doctoral candidate, Science and Mathematics Education Center, Curtin University of Technology, Perth WA 6845, Australia

John Wallace is Senior Lecturer, Science and Mathematics Education Center, Curtin University of Technology, Perth WA 6845, Australia. e-mail: iwallace@info.curtin.edu.au
Constructing Understanding Through Integrated Science Concept Formation and Vocabulary

A model is described which promotes simultaneous cognitive construction of science concepts and the scientific nomenclature needed to understand and communicate those concepts.

An understanding of the relationship between scientific concepts and the vocabulary used to express those ideas is as essential to effective science learning as is an understanding of the relationships between natural phenomena and the scientific concepts that explain them. This paper describes the “Science Concept-Vocabulary Acquisition” (SCVA) model, which promotes simultaneous cognitive construction of science concepts and the scientific nomenclature needed to understand and communicate those concepts. This is not intended to imply that children should be taught the vocabulary of science because, as Slisko and Dykstra (1997) pointed out, a well-defined scientific language suitable for that simply does not seem to exist. Rather, and this is a big difference, the SCVA approach is designed to help students:

1. Learn to systematically examine and understand the meanings of, rather than accept and memorize the definitions of, scientific terms they may encounter in their studies;

2. Understand the meanings of those terms within contexts of their own personal learning experiences;

3. Thereby simultaneously examine their own existing intuitions and observations regarding the phenomenon under study.

Rooted in the principles of constructivist learning, the SCVA model accommodates an inclusive, multidisciplinary instructional approach and integrates computer technology and the Electronic Information Network into day-to-day classroom teaching.

The Changing Emphasis in Science Teaching

The reform efforts of the 1960s grew out of Jerome Bruner’s (1960) idea that a science curriculum should be “the most fundamental understanding that can be achieved of the underlying principles that give structure to the subject” (p. 31). The National Science Teachers Association (NSTA, 1962) concurred that a curriculum should emphasize “science proper” (p. 33), and virtually all new science programs of the 1960s and early 1970s promoted the idea that students should “be led to ‘think like scientists’” (Gagne, 1979, p. 1). The focus of science education shifted from the earlier goal of an understanding of nature for better personal living to a “major emphasis on the functional aspects of science: facts, concepts, and principles” (Lacey, 1966, p. 15). Little attention was given to the importance of language arts and other subjects for understanding the meaning and social relevance of scientific facts.

In time, however, the goal of making little scientists of all students was decried as ineffective. A national survey conducted in 1976-77 revealed only marginal public understanding and appreciation of the basic concepts and principles of science (Bybee, Harms, Ward, & Yager, 1980). Approximately 70% of the college science and engineering majors in one study, for example, answered simple physics questions in terms of the medieval intuitive concepts rather than the Newtonian mechanics they were taught in school and college science (Clement, 1982). People learned many scientific facts. However, for the majority, common intuitive preconceptions prevailed to the point that they were not displaced by subsequent exposure to more acceptable scientific principles or theories in school or college instruction (Prather, 1985). By the early 1980s, the emphasis began to shift toward...
By the early 1980s, the emphasis began to shift toward making science instruction compatible with the learning needs and styles of students. Growing interest in curricular integration and the emerging concept of constructivist learning has supported that change.

Justification of an Integrated Science Concept/Vocabulary Development Model

Science has its own language, procedures, and theoretical framework (Hurd, 1994; Kuhn, 1970), and there is a connection between reading, writing, and science learning (Holliday, Yore, & Alvermann, 1994; Konopak, 1991). “Scientific knowledge is both symbolic in nature and also socially negotiated,” Driver, Asko, et al. (1994) observed, and it is unrealistic to assume that concepts of science will be learned if science is studied apart from the language used to communicate its problems, principles, and theoretical frameworks. The SCVA model outlined in Table 1 acknowledges that objects of science are conceived in physical experiences and reside in language, with the effect that a crucial component of scientific understanding lies in the insights one has about why a concept carries a particular label.

As the British novelist, H. M. Tomlinson (1873-1958) noted, we tend to see things not as they are, but as we are. Scientists have tended to name things on the basis of how they see them, it seems, and an understanding of the meaning of the terms they chose is important to an understanding of phenomena they envisioned. But science is not merely factual information, and vocabulary study alone is not the key to effective science learning. Nor is science merely process, so hands-on/minds-on explorations alone are not the key to scientific understanding. Both preconceived facts and explorations into the unknown are always present at the expansion of scientific knowledge, and it is precisely at the points of expansion of scientific knowledge that scientists must develop the new vocabulary necessary to communicate the new knowledge and its meaning. Similarly, it is precisely at the

Table 1
The Science Concept-Vocabulary Acquisition (SCVA) Model

The SCVA model of instruction was derived from an earlier model by Vaughn and Estes (1986) that employed anticipation, realization, and contemplation. In the four-part model outlined below, contemplation has been extended to encompass consolidation and confirmation.

1. **Anticipation** (meaning)
   Learners must approach the task of learning with a conscious anticipation of connecting what they know to what they study as they construct concepts.

2. **Realization** (connection)
   Learning is realization, and what is realized is the connection between what is already known and what is being learned.

3. **Consolidation** (acquisition)
   Learners need a chance to consolidate the new with the known and to understand how it relates to prior experiences.

4. **Confirmation and Commitment** (verification and application)
   Learners need a chance to refine concepts, test conclusions, acquire skills, and develop the confidence to submit their conceptions to critical review in the light of conventional knowledge.

---

1 Typically, a student’s lack of interest in knowing more about things related to a topic has been considered a problem of student attitude, interest, or ability. As this instance indicated, however, it may be more a problem with teaching. In this case, it was vocabulary study that helped the children realize a need to know and thereby attain a readiness to learn.

2 The need to resolve cognitive disequilibrium can be very persistent and, in the absence of an opportunity to learn a more adequate scientific explanation (from a scientist or science teacher or some other credible source such as a textbook) a person may turn to and accept whatever ready alternative may appear most promising.
points of expansion of learning – when learners encounter new experiences or ideas – that individual students must bridge the gap between attainment of new knowledge and understanding of its meaning. The SCVA approach is designed to bridge that gap by engaging learners in simultaneous construction of the scientific concepts to be learned and the vocabulary necessary to understand and use the knowledge.

The SCVA approach draws learners into hands-on/minds-on learning, but does not leave them on their own to discover everything that is already known. Conversely, it engages students in a review of conventional scientific concepts and principles, but does not relegate them to the traditional role of passive recipients of what has been discovered by others. Rather, the SCVA model balances personal learning explorations with access to existing scientific facts and nomenclature that define science and enable meaningful communication of scientific knowledge. This gives students a chance to examine things and call them as they see them, and then check the efficacy of their conclusions in the light of currently acceptable (conventional) scientific theories and principles.

Review of a Science Concept/Vocabulary Acquisition (SCVA) Lesson

The SCVA approach has been used to teach a variety of science concepts in both elementary school courses and graduate teacher education classes. A sample elementary science lesson conducted with a mixed-ability class of fifth grade children is discussed below to highlight the four procedural phases of the model. The topic was “insects,” and most of the children had already developed pretty strong ideas (prior personal conceptions) about the class of animals. Among those was a common misconception that spiders were insects. How that misunderstanding was handled by the teacher, and how it was finally displaced in the lesson, are discussed to illuminate the role of the teacher in a constructivist learning arena of the type facilitated be the SCVA model.

A large can of mealworms (genus *Tenebrio*) and a few children’s books on insect-related topics had been on display in the classroom for several days. This had enabled the children to focus their prior perceptions through self-initiated observations of a specific insect across various periods of its life span. As David Ausubel (1978) noted: “The most important single factor influencing new learning is what the learner already knows” (p. 163). Students’ individual experiences vary greatly, however, and the teacher was careful to plan a lesson that would help to bring the learners to a more uniform basis of common experience and thereby provide more equitable learning opportunities for everyone in the class.

On the day of the lesson, specimens of other insects and insect-like animals were provided, along with magnifying glasses and a variety of printed resources including science textbooks. Several computers (wired to the Internet) were also available, with electronic references including the *Encarta Multimedia Interactive Encyclopedia* (1996 edition) and *American Heritage Talking Dictionary* (1995). One computer, equipped with a LCD projector and screen, was available for large-group use.

Phase 1: Anticipation

The lesson began with an assignment for each student to write “insect” on a sheet of paper, circle the term, and then write anything that came to mind about insects on the paper. This was the first step of a “think, pair, share” technique, described more fully by Tighe and Lyman (1988), that is designed to help learners focus their prior knowledge by clustering associations. The children were encouraged to check the display specimens and references to see if anything on their cluster of ideas was incompatible with what they believed “insect” means – or if they had left off anything important. This provided a structure for them to articulate their understandings of “insect,” from the perspectives of their prior experiences, and check the efficacy of their ideas using both nature itself (the specimens) and a variety of conventional science references.

Clustering is also a very effective means of non-obtrusive preassessment. Early in this lesson, for example, the teacher noticed that every cluster contained the term “spider” or “spiders.” The teacher said nothing, however, because an attempt to correct students’ thinking at this time could actually be counter-educational. Most students would have marked “spider” off their papers, because the teacher said it was wrong, but wouldn’t have understood why. They did not yet realize that they harbored a very common misconception of insects because they had not yet acquired (consolidated) the new knowledge they needed to realize they didn’t understand what the term means.

Once the children had thought through their clusters, they were divided into groups of four and asked to “pair” off and combine their observations into a variety of categories of information such as “kinds of insects,” “description of insects,” “value of insects,” “danger of insects,” and “danger of insects.” Next, the
two pairs of students “shared” their observations and compiled a categorical group overview of understandings about insects. The groups used the references, specimens, and electronic references quite vigorously. Still, the teacher noted, spiders were listed on every group’s list.

Phase 2: Realization

Constructivists believe that understandings gained from study are realized in the connections learners make between what they already know and what they encounter as new information. But this does not imply that everyone must realize the same thing in the same way, or at the same time. Levels of prior knowledge and interests vary widely in any group of students, and a diversity of resources would be required for learners to have an opportunity to build upon what they already know about a topic. To facilitate this, a variety of research materials including electronic dictionaries and encyclopedias, access to the Internet, and a large selection of science-related books (juvenile non-fiction) from the school library were available to the young researchers.

Each group member was invited to select a resource and explore one or more of the categories of concepts in the group’s overview, and add to or correct the information if necessary. The majority of children turned to the electronic resources initially. How

The majority of children turned to the group’s overview, and add to or correct the information if necessary. Various learners realized that changes needed to be made on their papers, and made them. But, the teacher noticed, the problem of spiders remained. The children still did not realize they didn’t understand the meaning of “insect.”

Phase 3: Consolidation

“Consolidation,” which means to unite into one system or whole, to make strong or secure, to make firm or coherent, is a logical extension of the realization phase. To facilitate an environment for consolidation, the teacher called the class into a total group session and projected a computer monitor onto a wall screen to show how to research word origins using the electronic dictionary. Then the teacher suggested that the class begin by re-examining (researching) “insect” and other terms they may need to check to be sure the meanings are clear. In keeping with the student-centered mode of the SCVA model, the computer was operated by a student with the other children gathered around the screen. The operator typed in “insect.” Placing the cursor under the second syllable of the term brought up a list of all words that contain the root word, “sect.” The list included words like section, dissection, intersection, midsection, bisect, and vasectomy. ( Giggle, giggle. Someone had been paying attention in family life education!)

A moment of discovery occurred as the basic notion of “cut” emerged from examinations of words containing “sect.” Why, a student wondered, would scientists use a word that means “cut” to name insects? After a bit more poking around in the dictionary, a student conceived an answer: “In sections!” she exclaimed. “In sections. Insect! Insects are in sections!” There was a moment of uncharacteristic quiet as the children reflected on that comment, followed by bumptious forays to the table of specimens to confirm the idea. Looking at a wasp, the three body parts did indeed seem to be loosely connected – as if cut into sections. Even though every student had brought a long-established personal concept of “insect” into the classroom, this idea emerged only in the language study that accompanied the science study. Clearly, the ability to understand the scientific meaning of “insect” was much more adequate and meaningful when accompanied by insight into the structure of language.

Additional discovery followed as the class decided to take another look at “insect” to see if there was more to be learned from it. The definition was again called to the screen:

insect n. 1. a. Any of numerous usually small arthropod animals of the class Insecta, having an adult stage characterized by three pairs of legs and a body segmented into head, thorax, and abdomen and usually having two pairs of wings. Insects include the flies, crickets, mosquitoes, beetles, butterflies, and bees. b. Any of various similar arthropod animals, such as spiders, centipedes, or ticks.

“Arthropod?,” a student asked, having seen the word in an earlier reading but not having given it much thought. An instant later, the class saw:

arthropod n. Any of numerous invertebrate animals of the phylum Arthropoda, including
the insects, crustaceans, arachnids, and myriapods, that are characterized by a chitinous exoskeleton and a segmented body to which jointed appendages are articulated in pairs.

Still intrigued with the results of their dissection of “insect,” a student asked “What does ‘pod’ mean?” By now the children knew how to cut through to the core information they needed and were soon learning the root term of “foot.” “Arthro” is the Latin for “joint,” and “pod” means foot – so it’s a “jointed foot?” Not exactly, but the students were soon satisfied that this was probably close enough in the eyes of the one who thought up the name.

Moving from term to prefix to suffix, the children explored the meanings of terms in the definition of arthropod. “Crustacean?” Soon they were fascinated with the knowledge that lobsters and their kin were characterized by “crusty” exoskeletons, and myriapods were arthropods with many feet. Excitement grew as the children examined other terms they had come across in their study of insects – but now realized they didn’t have any idea what they mean. Up to now, the terms were just meaningless words in a definition they had not really understood – and didn’t realize a need to understand. But now they had a desire to know (reason to research) the meanings.

“Arachnid? Look that one up,” someone suggested, and the keyboard clicked again. In a few seconds the student responded, “It said ‘spiders’ when we looked up insect!” Suddenly there was tension throughout the room, and the whole class was attuned to the problem. More keyboards clicked as students returned to their own group’s computers and called up “insect” for a first-hand look. There, just as the second student had noted, was the statement:

“...b. Any of various similar arthropod animals, such as spiders, centipedes, or ticks.”

Why would the dictionary say this, the class worried, when it also said spiders have only two major sections? This was a serious problem! “If you can’t believe a dictionary,” a now very impatient child exclaimed, “what can you believe?” It was at this point of cognitive disequilibrium that a uniquely teachable moment was created, and a switch in teaching methods was needed. According to the Piagetian concept of constructivist learning, such cognitive disequilibrium is an essential prerequisite for learning. However, there is a second equally essential prerequisite – the presence of a readily accessible and more satisfactory alternative idea to replace the one that has just betrayed the confidence of the learner. Otherwise, learners are likely to disavow the whole system and seek some other means of resolving the problems they face. (That says a lot about the essential role a teacher must play in such situations.) To meet this unexpected need, the teacher briefly assumed the lecturer’s mantle at a time when only that teaching mode was adequate for the task – and the only time that it was appropriate for the lesson – and explained:

“Really, (the dictionary) doesn’t say that spiders are insects. The ‘a’ part of the definition tells us the most accurate current usage of the term, and the ‘b’ part shows a less desirable way that some people use the word ‘insect.’ What it means is that a lot of people call spiders insects, because they don’t know any better. But as you just found out, they aren’t insects. They’re arachnids. So what can you believe? As you’ve just learned, you can believe in your own intellectual power and ability to learn, if you’ll just apply your mind to it and not give up until you understand what you study.”

There were a few grumbles, but the children soon became comfortable with the idea that dictionaries can show both how people should use words and how they may misuse them. Now the students knew they must use dictionaries – and their minds – a bit differently. Display specimens were viewed with new interest, and references were re-opened with new conviction as students employed their newly acquired learning skills to research heretofore meaningless terms...
they had encountered such as “exoskeleton” and “invertebrate.” Soon they realized that a scientific name usually reflects only one or a few of the distinctive features of a particular animal, but these are obviously some of the main features that scientists saw when they first observed and named the animal.

It is important to note that all the children had by now corrected their misconceptions of “spider,” quite likely forever. Soon, each group was busy rechecking its conceptual overview on the basis of the new knowledge it had acquired. Insupportable ideas were weeded out, and each group reached a collectively constructed consensus on the meaning of “insect” much as a team of professional research scientists might. Eventually the teacher had to call time, and the groups quickly resolved any last-minute concerns regarding specific terms that should be retained or deleted on their group clusters. Thus committed to the results of their work, the teams were ready to present their conceptualizations to their peers with confidence built upon systematic study.

Phase IV: Confirmation and Commitment

This phase of the SCVA model is based on the premise that requiring learners to commit their ideas to writing for review by others will encourage them to do their best, and this appeared to be the case. There was another moment of uncharacteristic quiet in the class as the groups’ reporters gathered at the chalkboard to present their overviews. The students knew they each had a responsible part in the development of their group’s work, and it was being exposed for all to see. It was an exciting moment, and maybe a bit intimidating for some.

Again, as the overviews spread across the chalkboard, it was important for the instructor to refrain from volunteering “corrections.” Rather, the teacher’s job was to encourage students to scrutinize the overviews and challenge a concept if they saw a problem. This student-centered approach doesn’t do much for the ego of teachers who covet recognition as experts in charge, but it does much to boost the confidence of children as partners in learning.

In the case of most inadequate ideas (there were few by this time), someone in the class realized the problem and used insights from her/his own research to seek a more adequate understanding. A couple of explanations were offered by the teacher, in cases where continuing student investigations would not likely resolve an issue in a timely manner, but most concerns were resolved with student forays into the various learning resources. The students made notes on their personal copies of the tentative overviews they had initially developed, using their new insights into the concept of Insecta.

This phase of the lesson helped to engender a sense of ownership of the information learned and also encouraged skeptical thinking, which is a hallmark of scientific inquiry. The learners had functioned like little scientists, in the fullest sense of the educational ideal of the 1960s-70s. But they had begun and ended with interest-based and largely self-defined study attuned to their individual backgrounds and self-realized needs-to-know in accordance with the student-centered ideals of constructivism. They were convinced of the worth of what they had learned and, we would conjecture, quite confident of both their own learning potential and the value of school.

Reflections on the Lesson

Most of the students possessed a rather extensive personal knowledge of insects at the beginning of the lesson, but it was derived from personal learning and constructed largely without benefit of systematic exposure to the resources of conventional scientific content. Exposure to extensive and easily accessible sources of scientific information throughout the lesson, in the form of printed and electronic references and hands-on specimens, contributed to systematic enhancement of content mastery. However, all this was insufficient to assure timely resolution of a common scientific misconception brought into the classroom. The children were adding much new information to their personal knowledge bases, but still maintained that spiders were insects until well into the late stages of the lesson. Something more was needed for effective learning.

Something more was provided through integration of science and vocabulary study to encourage analytical thinking with regard to vocabulary terms used to name the concepts the children studied. Only when confronted with the meanings of the vocabulary used to distinguish arachnids and insects did the learners realize that spiders are not insects, and why. Op-
portunity for this understanding was provided through a lesson that:

1. Began at each child’s personal level of experience and accommodated individual learning styles;
2. Enabled the learners to approach the subject from the perspective of personal interests and needs-to-know, without having to endure a prepared lesson that may have covered much of what they already knew;
3. Employed group learning methods to provide an arena for constant cooperation, collective thinking, and feedback;
4. Required each learner to articulate and commit to his/her ideas in the form of an individual cluster, and later a group overview;
5. Provided convenient individual and group access to a broad scope of conventional reference materials;
6. Assured that the students were never far from concrete examples of the object of study for use in checking their assumptions; and
7. Focused on the origins and meanings of vocabulary terms used in conceiving and communicating information about the object of study.

The learners derived much of the science content from the type of juvenile literature found in most school libraries. When given a wide and free choice of research materials, we found, students gravitated to a level of textual difficulty commensurate with their reading ability. The satisfaction of learning through reading at their personal comfort levels may be an incentive for further reading among many otherwise reticent readers, and it is anticipated this would culminate in both increased reading skills and extended science study.

The electronic version of the dictionary proved very efficient for the kind of word study necessary to answer basic language questions of science. It may be hard to imagine students excited about using a dictionary, but an electronic form enables students to do things they cannot do with other dictionaries. For instance, it allows a user to access a definition almost instantly, hear the word pronounced, and avoid the stultifying requirement of searching and page turning to analyze terms. Generally, once students learned what they could do with information available from the dictionary, the teacher was able to step aside and watch learning progress.

It was during those moments of self-directed discovery that the value of integrated science and language study became most evident. For most of their lives, the children had known about – but not necessarily understood – insects. When they approached the topic in the SCV A lesson, however, once-meaningless terms made sense as the connections with the objects they named were discovered. As the explorations continued, a singular question arose: Why do scientists use so many Latin names? Again turning to a quasi-lecture mode to cut through to essential information, the teacher explained that many scientific names have a Latin or Greek origin because the early scientists who coined the names were educated in those languages. The explanation was meaningful, given the circumstances of their inquiry, and the class was satisfied.

As with any lesson, however, this one was not without shortcomings. It had successfully taught numerous complex ideas and connections that were essential to an understanding of the meaning of the topic studied, but it failed to teach a singularly important concept related to the nature of insects. The idea of “metamorphosis” was not noted on any of the students’ clusters, even though it was observed in the can of meal worms and prominently mentioned or depicted in many of the library references and electronic references.

**Comments on Assessment of Student Performance**

Based on the premise that student performance should be evaluated using the same methods employed for teaching, assessments focused on examination of each student’s final cluster. Observations during the lesson had revealed several things to watch for in the students’ final perceptions. Identification of spiders as insects was a common problem, for example, but it was conspicuously marked out or erased on the final clusters of all learners. A notation of the three-part body structure of insects was present on every cluster, but in many cases it was obvious that it had been squeezed in as a result of learning late in the lesson. Such cases were appreciated as a late-stage realizations of an essential characteristic of the subject.

Notes were added as appropriate to denote spelling errors on the clusters, but these were few (the children had
paid attention to spelling as they used the dictionary, thereby learning to check their own work). Variations in the nodal connotations were perceived as a desideratum reflecting student individuality, and commendations were noted in cases of unique perceptions. “Metamorphosis” was added as a marginal notation on all clusters, along with suggestions for other improvements wherever appropriate. The suggestions were explained as areas for growth rather than indications of inadequacy, and were not considered for grading.

Some children had stood out more in the hands-on explorations, and some were more involved with the computers. Still others excelled at the collecting and manipulating information in group sessions, and others could infer fascinating connections from even the simplest children’s books. However, none of these factors constituted a basis for rewarding or penalizing individuals. All students had demonstrated substantial learning about insects, using whatever learning style served them best, and that was the lesson objective. All clusters were deservedly marked as “Excellent.”

Interpretive interviews were scheduled with six students, who had been purposefully selected as representative of the demographic scope of the class, to look for reasons the concept of metamorphosis never surfaced in the lesson. There seemed to be a more or less common perception that, in the words of one student, “It’s what happened when the mealworms in the can changed into insects, you know.” Butterflies were also mentioned, but again in the sense that metamorphism involved changing from something else into an insect rather than change within the life cycle of an insect. A butterfly or beetle looked as the learners anticipated an insect would look, but a mealworm didn’t. Anticipation, in this case, precluded realization of an obvious connection. After brief discussion of what they had seen going on in the can, the interviewees seemed comfortable with the realization that mealworms were insects – they had to be, they understood, because they had witnessed the change. The children had not realized what they had seen. However, when faced with a need to analyze their thinking, the six interviewees readily made the connections needed to understand the concept of metamorphosis as change within the life cycle of insects. Clearly, the teacher concluded, this must be a topic for a follow-up SCVA lesson – perhaps in a unit on the meaning of “change” itself.

The final question solicited open-ended observations of the students’ reactions to the lesson. “I liked it because I got to do what I wanted to do” was typical of the interviewees’ responses. A comment from the third interviewee was particularly touching. The class had known there would not be a traditional test, but each group would be expected to share its ideas with the class: “I was feeling good when we had to write (our overview) on the board,” she said, “and everybody else thought what we did was good, too.” She was proud that the work had met with approval of her peers. A question regarding this was added for the remaining three interviews, and the responses made it clear that anticipation of peer-review was a much more positive stimulus for performance than the prospect of teacher review.

Conclusion

The outcome of integrated science and language arts instruction in the SCVA lesson supported Alexander, Schallert, and Hare’s (1991) conclusion that knowledge of language is not distinct from an individual’s knowledge base. Rather, as they contended, knowledge of vocabulary overlaps discourse and content knowledge because “word knowledge entails two related components: the actual labels themselves and the concepts that are being represented by those labels” (p. 327). This was the case in the SCVA lesson, where students reported fascination with the learning process, satisfaction from acquisition of knowledge and skills needed to understand and validate a concept, and a sense of self-worth enhanced by successful learning. The students realized the euphoria of understanding as they wrestled with the meaning of things, and most likely they will appreciate that dimension of learning for the rest of their lives.

References


Thomas H. Estes is Professor of Reading and Director of the McGuffey Reading Center at the University of Virginia, Charlottesville, VA 22903-2495

J. Preston Prather is Professor of Science Education and Director of the Center of Excellence for Science and Mathematics Education at the University of Tennessee-Martin, Martin, TN 38238-5029
Visions: Teachers’ Perceptions of Reform Goals in Science Education

Results are presented from an examination of high school teachers’ perceptions of, and commitment to, the contemporary goals of science education.

Abstract
The purpose of this study was to discern high school teachers’ perceptions of, and commitment to, the contemporary goals of science education. Findings suggested that a minority of teachers hold past goal orientations as strongly as the majority who hold contemporary views, and resist the introduction of moral and ethical issues, integration among subjects and heterogeneous grouping practices. Results also revealed a shift in secondary science teachers embracing more contemporary orientations. Finally, analyses indicated that professional development factors, familiarity with science education journals, and years of teaching science were predictive of contemporary goal orientations. Implications related to reform issues and research are discussed.

Purpose of Study
“I am for ‘Peace, retrenchment, and reform’, the watchword of the great Liberal party 30 years ago” (John Bright, 1859).

Perhaps the contemporary science education community would be happy with the first two out of three. “Reform” has arguably been the watchword in science education for the past 30 years, yet it seems elusive: ebbing, flowing, and changing as different visions snap into the forefront of the science education community each passing decade. The early part of the 1990s has borne witness to yet another quest in an attempt to secure a collective vision of reform for the next millennium in science education. Project 2061 (American Association for the Advancement of Science, 1989) and Benchmarks (AAAS, 1993) have been the impetuses for a “grass-roots effort” to bring “vision and determination” to science education reform (AAAS, 1993, p.VII). Accordingly, these projects “press for nationwide acceptance of the goals and philosophies of Science for All Americans” (AAAS, 1993, p.379) while serving as a foundation for additional systemic reform initiatives (i.e., Designs for Science Literacy, Blueprints for Reform, Resources for Science Literacy, and Project 2061 Curriculum-Design & Resources System). The development of these initiatives has reached critical mass, as evidenced by the introduction of the National Science Education Standards (National Research Council, 1996). A renewed flurry of reform issues and the role of research applied to practice in science education have surfaced as key issues in recent research literature. Critical issues of reform were outlined and discussed at some length in a special issue of the Journal of Research in Science Teaching (Shymansky & Kyle, 1992), and Science Education (Kyle, 1991; Kyle, Linn, Bittner, Mitchener, & Perry, 1991). A common theme appears to be that understanding issues of reform requires “a new view of curriculum” (Shymansky & Kyle, p. 757); and that a sincere commitment to nurturing the relationship between research and practice in schools, and connecting this to the aim of schooling, is needed to bring about “a vision of hope” (Kyle, 1991, p. 407).
If reform efforts are to impact urban, suburban, and rural school systems, then advocates of reform must consider the perspectives and views of these practicing teachers.

A central task for science educators of the 1990s and beyond seems to be twofold. First, research into understanding the status of reform-related issues and goals amongst practicing teachers is warranted if truly grassroots efforts are to impact practicing teachers, and second, connecting research to the improved practice of science teaching is also a pressing concern. Yager (1992) reminded us that as a profession, we need to be clear about the questions we seek to address. O’Loughlin (1992) further reminded us of the “Bakhtinian” question, “Who is doing the talking?” and suggested that one’s understanding of any issue is multivoiced and socioculturally situated. This latter point is an important one; any vision the science education research community advances is inherently linked to a broad array of shared perspectives, and one’s understanding of that perspective is never formed in isolation of social, and local, and community factors. If reform efforts are to impact urban, suburban, and rural school systems, then advocates of reform must consider the perspectives and views of these practicing teachers. Of the issues facing science education reform, developing a better understanding of change in science education and, therefore, contributing to educational reform is a high priority (Shymansky & Kyle, 1990).

To investigate the perceptions of contemporary goals in science education among various professional organizations and practicing teachers is tantamount to a study of change. Both goals and perceptions are dynamic; major redirections of science education goals have been occurring, it appears, with the onset of each decade (National Science Teachers Association, 1971; NSTA, 1983; AAAS, 1993). The dissemination of goals is relegated primarily to the print media and is emphasized at meetings of professional science education associations. Hence, it seems prudent to assess the effectiveness of these efforts in communicating those goals to practitioners in science teaching and to discern the degree of conviction with which these goals are held by science teachers.

Recently, there has been a proliferation of published documents and policy statements by professional organizations concerning new directions for the goals of science education (AAAS, 1989; Carnegie Commission, 1991; NSTA, 1990, 1992, NRC, 1996). Past research has indicated that involvement in professional organizations, attendance at inservice workshops, and teaching middle school (but not secondary school) are moderately associated with purported commitments to 1980s goals of science education (McIntosh & Zeidler, 1988). Additionally, this same study indicated that secondary science teachers tended to prefer 1960s orientations to 1980s orientations. Past venues that allowed for the dissemination of the goals through government sponsored classes, workshops, and university institutes have been drastically cut. From 1950 to 1970 a half billion dollars was spent on the development and implementation of science education curricula (Yager, 1988). With the decrease of funding during the 1980s, a question arose as to the extent to which contemporary science education goals developed in the late 1980s and in the 1990s, were adopted by science teachers. Considering the heavy competition for limited federal funding earmarked for science education and the dismal condition of many state and local education budgets, the status of teachers’ perceptions of contemporary goal orientations was uncertain.

The purpose of this study was to examine high school teachers’ perceptions of, and commitment to, contemporary goals and trends of science education, by expanding the work of Zeidler & Duffy (1994) using a geographically diverse sample of high school teachers. Collecting data on teachers’ beliefs related to science education goals was accomplished by the development of a Contemporary Goals Survey. Information on professional development factors (e.g., available funding and teacher involvement in workshops, courses, and professional organizations) was also collected and validity and reliability estimates were established.

Four sections provide the results of this study: Part I - Homogeneity Within Sample; Part II - Comparison of Past and Contemporary Goals; Part III - Conviction to Goal Orientations; and Part IV - Professional Development Factors.

**Significance of Study**

Evolution is described as a process of punctuated equilibrium (Gould, 1977). As organisms evolve, they first go through a period of enormous...
diversity and numbers, then through natural selection they settle into a period of lessened diversity and reduced extremes. Metaphorically, perhaps the evolution of contemporary goals for science education may be thought of as an ontogenetic mirror of this biological process. As with evolution, contemporary goals (or life forms) are not necessarily “better” in some ethical sense; to claim so would run the risk of committing the philosopher’s “naturalistic fallacy”. To claim contemporary goals are better according to pedagogical criteria may depend on one’s educational ideology. But the shifts found in current reform trends (cited in the introduction) do represent a departure from a previous state of affairs. It is my contention that awareness and understanding of these differences is a necessary step for any kind of reflective practice in science education.

Reform efforts by national organizations that advance new philosophies (e.g., AAAS, 1989, 1993; NRC, 1996) and refine previous pedagogical efforts (e.g., NSTA, 1971) may be necessary steps to produce a vision of scientific literacy sensitive to an international economy. However, such efforts may fall short of their mark if science teachers in the public schools are unaware of, do not agree with, or are misinformed as to the nature of those goals. This study is designed to ascertain the degree to which the perceptions of contemporary goals are consistent with emerging trends in science education. Science supervisors, methods teachers, and other science educators not only need to be aware of how these emerging trends and possible future trends may impact curricula, but also need to be cognizant of the perception of these trends by classroom teachers, so that well-defined goals at the local level may be implemented consistently. Effective schools and effective supervision are characterized by the presence of well-defined goals (National Science Supervisors Association, 1980; Purdey & Smith, 1982).

Procedure Instrumentation

The survey instrument for the present study was designed from two sources: one reflecting science education goals (National Science Education Standards [NRC, 1996]; AAAS, 1989, 1993; Lead Paper on Science and Technology Education [NSTA, 1990]; Carnegie Commission Report [Carnegie Commission, 1991]; and the Contemporary Goals Survey [McIntosh & Zeidler, 1988]). The survey instrument was pilot tested for design and readability on 22 graduate students who were secondary school teachers. The final version consisted of a 32-item four-choice category (no emphasis, slight, moderate, and strong emphasis) with items randomly distributed throughout the instrument in a manner consistent with increasing the validity and decreasing the residual errors as suggested by Singer & Presser (1989) and Fowler and Mangione (1991). (Note that at the time of item development the National Science Education Standards [NRC, 1996] had not been printed.) Table 1 includes the final goals statements, which have been grouped in pairs representing contrasting orientations.

Face and content validity were verified by sending the questionnaire to five prominent teachers and researchers in science education who hold (or have held) elected positions in NSTA, National Association for Research in Science Teaching (NARST), or Association for the Education of Teachers in Science (AETS). Reliability estimates were established using Spearman’s rank order correlation coefficients (Blalock, 1979) and Spearman-Brown split-half procedures (Mehrens & Lehmann, 1987). Split-half reliability was found to be 0.72 (p = .0001). Each half also correlated to the total score with reliabilities of 0.89 and 0.84 (p = .0001). Considering the relatively small number of items for each half (16) to the total number of items (32), the reliability coefficients suggest reasonably good internal consistency. Additionally, old goal statements did not significantly correlate with contemporary goal statements (-0.02; p = .34) suggesting appropriate divergent internal validity. A questionnaire containing items to ascertain descriptive information pertinent to professional development factors (see Purpose) was also included. It should be noted that these reliability estimates are consistent with those previously reported for this same instrument (Zeidler & Duffy, 1994).

Population and Sample

Because past research (McIntosh & Zeidler, 1988) indicated that secondary school teachers were more likely
<table>
<thead>
<tr>
<th>Item number</th>
<th>Goal Statements</th>
<th>no emphasis</th>
<th>slight emphasis</th>
<th>moderate emphasis</th>
<th>strong emphasis</th>
<th>mean</th>
<th>weighted mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.</td>
<td>*Science education should not include career awareness.</td>
<td>234 (72.2)</td>
<td>57 (17.6)</td>
<td>23 (7.1)</td>
<td>10 (3.1)</td>
<td>0.41</td>
<td>1.90</td>
</tr>
<tr>
<td>2.</td>
<td>**Science courses should promote career awareness in the sciences.</td>
<td>2 (0.6)</td>
<td>44 (13.5)</td>
<td>175 (53.9)</td>
<td>105 (32.2)</td>
<td>2.18</td>
<td>2.33</td>
</tr>
<tr>
<td>16.</td>
<td>The most important knowledge that a science student should have are those facts, concepts principles and processes that are specific to each discipline.</td>
<td>36 (11.2)</td>
<td>144 (44.7)</td>
<td>107 (33.2)</td>
<td>35 (10.5)</td>
<td>1.44</td>
<td>2.11</td>
</tr>
<tr>
<td>3.</td>
<td>The most important knowledge that a science student should have are those facts, concepts, principles, and processes that are common to all science disciplines.</td>
<td>2 (0.6)</td>
<td>49 (15.0)</td>
<td>163 (50.0)</td>
<td>112 (34.4)</td>
<td>2.18</td>
<td>2.40</td>
</tr>
<tr>
<td>12.</td>
<td>Science education should demand the development of divergent thought processes associated with a range of societal, personal, social, and technological problems.</td>
<td>7 (2.2)</td>
<td>59 (18.5)</td>
<td>137 (42.9)</td>
<td>116 (36.4)</td>
<td>2.14</td>
<td>2.45</td>
</tr>
<tr>
<td>29.</td>
<td>Science education should focus on knowledge acquisition and process skill unrelated to the interactions of science, technology, and society.</td>
<td>167 (52.2)</td>
<td>83 (25.9)</td>
<td>49 (15.3)</td>
<td>21 (6.6)</td>
<td>0.76</td>
<td>2.30</td>
</tr>
<tr>
<td>4.</td>
<td>Science education should stress the interactions among science, technology, and society.</td>
<td>2 (0.6)</td>
<td>23 (7.0)</td>
<td>134 (40.9)</td>
<td>169 (51.5)</td>
<td>2.43</td>
<td>2.56</td>
</tr>
<tr>
<td>5.</td>
<td>Science courses should be offered in a similar ability (homogeneous) classroom.</td>
<td>46 (14.2)</td>
<td>93 (28.6)</td>
<td>93 (28.6)</td>
<td>88 (27.1)</td>
<td>88 (27.1)</td>
<td>2.43</td>
</tr>
<tr>
<td>23.</td>
<td>Science courses should be offered in a mixed ability (heterogeneous) classroom.</td>
<td>68 (20.0)</td>
<td>109 (33.5)</td>
<td>109 (33.5)</td>
<td>74 (22.8)</td>
<td>74 (22.8)</td>
<td>2.50</td>
</tr>
<tr>
<td>24.</td>
<td>Science should be presented as value-free without moral or ethical issues.</td>
<td>145 (45.3)</td>
<td>81 (25.3)</td>
<td>57 (17.8)</td>
<td>37 (11.6)</td>
<td>0.96</td>
<td>2.35</td>
</tr>
<tr>
<td>9.</td>
<td>Science should be presented as a value-laden subject that has both moral and ethical dimensions.</td>
<td>29 (8.8)</td>
<td>106 (32.3)</td>
<td>124 (37.8)</td>
<td>69 (21.0)</td>
<td>1.71</td>
<td>2.33</td>
</tr>
<tr>
<td>8.</td>
<td>Science courses should be organized around a single discipline.</td>
<td>89 (27.6)</td>
<td>134 (41.5)</td>
<td>73 (22.6)</td>
<td>27 (8.4)</td>
<td>1.12</td>
<td>2.27</td>
</tr>
<tr>
<td>21.</td>
<td>Science courses should be organized around themes such as energy, stability, evolution, systems, and inquiry.</td>
<td>17 (5.2)</td>
<td>86 (26.5)</td>
<td>137 (42.2)</td>
<td>85 (26.2)</td>
<td>1.89</td>
<td>2.06</td>
</tr>
<tr>
<td>25.</td>
<td>In science courses competition among students should be encouraged.</td>
<td>85 (26.1)</td>
<td>139 (42.6)</td>
<td>85 (26.1)</td>
<td>17 (5.2)</td>
<td>1.10</td>
<td>2.16</td>
</tr>
<tr>
<td>17.</td>
<td>Science education should stress cooperation rather than competition.</td>
<td>7 (2.2)</td>
<td>34 (10.6)</td>
<td>157 (48.9)</td>
<td>123 (38.3)</td>
<td>2.23</td>
<td>2.43</td>
</tr>
<tr>
<td>Item number</td>
<td>Goal Statements</td>
<td>no emphasis</td>
<td>slight emphasis</td>
<td>moderate emphasis</td>
<td>strong emphasis</td>
<td>mean</td>
<td>weighted mean</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>-------------</td>
<td>-----------------</td>
<td>-------------------</td>
<td>----------------</td>
<td>-------</td>
<td>---------------</td>
</tr>
<tr>
<td>18.</td>
<td>Science courses should help students acquire facts, concepts, and principles.</td>
<td>11 (3.4)</td>
<td>68 (21.1)</td>
<td>163 (50.5)</td>
<td>81 (25.1)</td>
<td>1.97</td>
<td>1.97</td>
</tr>
<tr>
<td>11.</td>
<td>Science courses should help students restructure their own knowledge, thereby acquiring new knowledge.</td>
<td>5 (1.6)</td>
<td>42 (13.1)</td>
<td>138 (43.0)</td>
<td>136 (42.4)</td>
<td>2.26</td>
<td>2.26</td>
</tr>
<tr>
<td>28.</td>
<td>Science education should provide a learning environment where scientific understanding precludes aesthetic considerations.</td>
<td>110 (34.5)</td>
<td>114 (35.7)</td>
<td>78 (24.5)</td>
<td>17 (5.3)</td>
<td>1.00</td>
<td>2.17</td>
</tr>
<tr>
<td>19.</td>
<td>Science education should provide a learning environment in which students are able to broaden and deepen their responses to the beauty of ideas, methods, tools, structures, objects, and living organisms.</td>
<td>5 (1.6)</td>
<td>31 (9.6)</td>
<td>124 (38.5)</td>
<td>162 (50.3)</td>
<td>2.38</td>
<td>2.59</td>
</tr>
<tr>
<td>27.</td>
<td>Science courses should cover as many topics as possible.</td>
<td>124 (38.2)</td>
<td>108 (33.2)</td>
<td>72 (22.2)</td>
<td>21 (6.5)</td>
<td>0.97</td>
<td>2.22</td>
</tr>
<tr>
<td>15.</td>
<td>Science courses should cover a few topics in depth.</td>
<td>24 (7.6)</td>
<td>94 (29.7)</td>
<td>141 (44.5)</td>
<td>58 (18.3)</td>
<td>1.74</td>
<td>2.28</td>
</tr>
<tr>
<td>6.</td>
<td>Science courses should be primarily designed to produce scientists to solve scientific problems.</td>
<td>75 (23.2)</td>
<td>143 (41.3)</td>
<td>81 (25.1)</td>
<td>24 (7.4)</td>
<td>1.17</td>
<td>2.23</td>
</tr>
<tr>
<td>1.</td>
<td>Science courses should be primarily designed to produce a scientifically literate citizenry.</td>
<td>3 (0.9)</td>
<td>18 (5.5)</td>
<td>112 (34.3)</td>
<td>194 (59.3)</td>
<td>2.52</td>
<td>3.90</td>
</tr>
<tr>
<td>20.</td>
<td>Science education should focus on knowledge acquisition and process skill development specific to each discipline.</td>
<td>14 (4.3)</td>
<td>114 (35.1)</td>
<td>130 (40.0)</td>
<td>67 (20.6)</td>
<td>1.77</td>
<td>2.34</td>
</tr>
<tr>
<td>13.</td>
<td>Science education should focus on attitudes, values, beliefs, risks, and economic considerations related to science, technology, and society.</td>
<td>11 (3.4)</td>
<td>88 (27.2)</td>
<td>140 (43.2)</td>
<td>85 (26.2)</td>
<td>1.92</td>
<td>2.37</td>
</tr>
<tr>
<td>26.</td>
<td>Science should be presented as a rigid unchanging discipline.</td>
<td>280 (86.4)</td>
<td>28 (8.0)</td>
<td>13 (4.0)</td>
<td>5 (1.5)</td>
<td>0.21</td>
<td>2.27</td>
</tr>
<tr>
<td>32.</td>
<td>Science courses should provide students with the opportunity for experiencing science as a process for extending understanding, not as unalterable truth.</td>
<td>3 (0.9)</td>
<td>24 (7.4)</td>
<td>86 (29.0)</td>
<td>212 (65.2)</td>
<td>2.56</td>
<td>2.98</td>
</tr>
<tr>
<td>14.</td>
<td>Science education should focus on the training of future scientists.</td>
<td>37 (11.4)</td>
<td>174 (53.7)</td>
<td>94 (29.0)</td>
<td>19 (5.9)</td>
<td>1.29</td>
<td>2.37</td>
</tr>
<tr>
<td>10.</td>
<td>Science education should stress the intrinsic nature of each subject area.</td>
<td>13 (4.1)</td>
<td>95 (29.8)</td>
<td>141 (44.2)</td>
<td>70 (21.9)</td>
<td>1.84</td>
<td>2.33</td>
</tr>
<tr>
<td>7.</td>
<td>Science courses should emphasize inquiry skills.</td>
<td>3 (0.9)</td>
<td>17 (5.2)</td>
<td>111 (34.2)</td>
<td>194 (59.7)</td>
<td>2.53</td>
<td>2.83</td>
</tr>
<tr>
<td>22.</td>
<td>Science education should emphasize higher order thinking skills.</td>
<td>1 (0.3)</td>
<td>18 (5.5)</td>
<td>110 (33.4)</td>
<td>200 (60.8)</td>
<td>2.55</td>
<td>3.90</td>
</tr>
</tbody>
</table>

* Old goals are in normal type.
** Contemporary goals are in bold type.
to hold earlier (1960s) orientations of science rather than 1980s views, when compared to their middle school colleagues, the present study focused on secondary school teachers to examine their beliefs in the present goals of science education. The population chosen for study was secondary science teachers whose high schools belong to the Association for Supervision and Curriculum Development’s (ASCD) High School Futures Planning Consortium III (HSFPC III), and secondary science teachers selected from 48 high schools in 26 states representing all regions of the country. While some may suggest that the HSFPC III population may not be representative of science teachers in general, but is indicative of schools where some commitment to educational reform was taking place, this study sought to include the latter group from a broader spectrum of high schools across the nation. At the time of this study, 24 high schools from various states were members of HSFPC III. Responses from 16 of the 24 HSFPC III schools were received (n = 113), whereas teachers from all 48 high schools in the latter group responded (n=218). The total number of respondents provided a sample size of 331 secondary science teachers. Hence, this study evoked a combination of purposeful sampling and maximum variation sampling techniques (Wiersma, 1995). Inasmuch as an effort was made to select schools that were urban, suburban, and rural, this particular sample and the corresponding response rate was inferred to reflect an appropriate diverse geographic and demographic cross section of respondents. However, as with most survey research, the reader must temper the results with the open question as to whether respondents are representative of nonrespondents.

Results and Discussion

Part I: Homogeneity Within Sample

The rationale to expand the original sample to include science teachers in general (beyond those whose schools are members of the Futures Consortium) was the impetus for the present study. However, the question may arise as to whether or not both groups could be pooled together to create a larger national sample. A Mann-Whitney U test (corrected for ties) was performed between both groups and yielded no significance (z = - .94, p = .34). This result suggested that there are no uniform differences concerning the perceptions of contemporary goals between both groups; we can now regard the pooled sample as one homogeneous group. This is interesting because it can be inferred (based on this sample) that, in general, secondary school teachers’ views concerning reform goals are similar to those teachers whose districts are part of a concerted effort to implement reform. All further data analysis were, therefore, performed on the pooled sample of n = 331.

Part II: Comparison of Past and Contemporary Goals

Items reflecting past (1960s) goal orientations were contrasted with items representing contemporary goals. A Wilcoxon Matched-pairs Signed-ranks Test (Blalock, 1979) revealed that the sample significantly favored contemporary goals to past goals (193 to 66, with 11 ties; z = 9.33, p = .00001). It is worth noting that this finding represents a shift in favor of contemporary views for secondary teachers since the 1980s (McIntosh & Zeidler, 1988). While this shift indicates beliefs that are more in line with current trends, it does not indicate the extent to which contemporary goals are favored nor the degree of conviction with which teachers hold particular goal orientations. This analysis is provided in Part III below.

Part III: Conviction to Goal Orientations

A descriptive analysis of the questionnaire was undertaken to provide a more detailed overview of the results. Response frequencies and percentages were tabulated for each statement. The questionnaire was coded from 0 to 3, with higher numbers representing stronger goal orientations. Table I provides an overview of item response frequencies, means, and weighted means. It is of interest to note that the weighted mean may be conceptualized as a “strength of conviction” index, inasmuch as it was performed on the moderate and strong emphasis categories. This would indicate how strongly those favoring particular goal orientations felt about their selection. It should be noted that the last two pairs of statements were not meant to be interpreted as contrasting orientations; rather they were included as validity checks for comparisons with prior items. Comparisons of the weighted means for moderate and strong emphasis suggest that contemporary goals are generally favored. However, following the procedure used by Zeidler and Duffy (1994), in which small differences of the weighted mean (less than 0.15) were considered to indicate inconsequential divergence in the strength of conviction between contemporary and past goals, five pairs of statements in the present study revealed similar convictions. These were tagged “red flag” items because of the potential interest the items reveal about the strength of
conviction one may have to previous trends, and are as follows: 29-12; 5-23; 24-9; 27-15; and 20-13. Surprisingly, in these cases, the strength of conviction for past goals was not substantially different from the corresponding contemporary goals. This suggested that while those who embrace past goals may constitute the minority, they embrace those orientations as strongly as those holding the majority view. In particular, these teachers may tend to discourage divergent thinking related to science-technology-society issues, resist the introduction of moral and ethical issues in science, favor discipline-specific subjects over integration among subjects, prefer to focus on skills and content specific to each discipline, oppose heterogeneous grouping practices, and focus on skills and content specific to each discipline, oppose heterogeneous grouping practices, and focus their teaching on the development of knowledge acquisition and process skills in contrast to developing “habits of mind” (values and beliefs related to the practice of science). Perhaps the lack of strong predilections regarding these perceptions may be explained, in part, by the “content conscious” nature of some secondary school teachers, a perception that would be consistent with the finding of McIntosh and Zeidler (1988).

Part IV: Professional Development Factors

An exploratory analysis was undertaken to determine if differences in definitive past and contemporary goals perceptions (lowest third of scores representing older goal orientations versus highest third of scores representing contemporary goal orientations) were associated with professional development activities (e.g., inservice workshop and conference attendance), frequency of reading science education journals, and years of teaching science. Discriminant analysis using Rao’s V for the stepwise method for selection of variables was selected because Rao’s V maximizes separation of group centroids (in this case—contemporary goal orientations versus dated goal orientations).

The results suggest that professional development factors, years of teaching science, and frequent reading of science education journals (in that order) produced significant stepwise changes in Rao’s V (p < .01), indicating that they were predictive of goal orientations. These variables also form one significant standardized canonical discriminant function (p < .001) that produced the following coefficients with respect to that function: Professional Development (0.55); Reading Science Education Journals (0.52); Years of Teaching Science (-0.66). Clearly, these results indicate that the first two variables are moderately associated with contemporary goal orientations, whereas the last variable is moderately but inversely related to contemporary goal orientation. Because this variable (Years of Teaching Science) was broken down among those teachers who have been teaching science for less than 5 years versus those who have been teaching science for over 15 years, it is plausible that those in the latter group (having weaker commitments to contemporary goal orientations) earned their undergraduate and possibly their graduate degrees prior to 1980, before many contemporary goals were initiated. These findings are, on the one hand, congruent with the findings of Scharmann and McLellan (1992), that professional development factors significantly shifted teachers’ goal orientations in a direction more consistent with the contemporary goals stated by professional science education associations.

On the other hand, the present findings depart from Scharmann and McLellan, who also reported that recent graduates did not possess an advantage over less recent graduates in holding more contemporary beliefs after a one-week professional development workshop. Perhaps the clear dichotomy of teaching experience in the present study (less than 5 years versus more than 15 years) could explain these seemingly conflicting results. Nevertheless, the results indicate while professional development factors and familiarity with current journals are important predictors of contemporary goals, it is also important to consider the currency of one’s degree. Furthermore, the results of the discriminate analysis demonstrated that these variables correctly predicted group membership for 73% of those teachers composing a contemporary orientation and 58% of those with past orientations. Although the recency of a teacher’s degree is beyond the control of science supervisors or department heads, encouraging teachers to remain current with the emerging trends in their field by reading relevant science education journals and nurturing professional development through conference or workshop participation are viable means by which contemporary goals orientations may be fostered. These results are also in line with Kahle’s (1997) claim that systemic reform can be accomplished if accompanied by a “culture shift” in teachers through sustained professional development.

Implications for Future Research

For the past 30 years, the science education community has been obsessed with its own vision concerning the acceptance by practicing teachers
of particular pedagogical and curriculum goals. Similar to the process of punctuated equilibrium, reform movements and goals of the last 30 years have seen enormous diversity and numbers, but beginning with the dissemination of Project 2061, the science education community has settled into a period of lessened diversity and reduced extremes. Although there seems to be consensus and movement toward contemporary goals, barring the red flags described above, it would not be judicious to believe (nor does the author believe it to be necessarily desirable) that the goals of professional organizations and practicing teachers’ beliefs are isomorphic. As with the process of punctuated equilibrium, the idea of a final endpoint is a phantom image; ideologies and needs of teachers, students, and the communities they serve are dynamic. Perhaps all a profession may ask is that its members actively engage in reflection- -questioning contemporary practice to examine if our needs are being met, while trying to project future needs and reform our goals accordingly.

Questions concerning curriculum reform are a current (and ongoing) issue for the science education research community, which asks: “What are the prevailing personal epistemologies of (science) teachers...and how do these compare with the epistemologies embedded in routine practices?” (Shymansky & Kyle, 1990, p. 19). The present author contends that this study provides a partial vision into the personal epistemologies of secondary science teachers with respect to the reform of science curriculum goals. There are, however, at least two open issues for science educators and others involved in reform efforts to consider. First, inasmuch as studies of high school science teachers have shown that simply possessing particular conceptions of science are not always translated into classroom practice (Lederman & Zeidler, 1987), or are conveyed to students in un-witting ways (Zeidler & Lederman, 1989), the question remains as to what extent evidence of science teachers’ stated goals are, in fact, embedded in routine practice? Second, Corbett and Wilson point out that there is a dearth of information in the reform literature of ideas concerning how students can become participants in a process of change, rather than simple recipients of change, and they make a case for researchers and reformers to “make a difference with, not for, students” (1995, p. 12). Until these issues are addressed, our visions of reform are likely to remain just a bit blurred.

References
American Association for the Advance-
American Association for the Advance-
Carnegie Commission. (1991). In the na-
tional interest: The federal government in the reform of K-12 math and science education. New York: Carnegie Com-
mision on Science, Technology, and Government.
National Research Council (1996). Na-


Dana L. Zeidler is Associate Professor of Science Education, College of Education, University of South Florida, Tampa, FL 33620-5650