ISSUES IN SCIENCE EDUCATION

PROFESSIONAL DEVELOPMENT LEADERSHIP

And the Diverse Learner

Jack Rhoton and Patricia Bowers, editors

National Science Teachers Association
National Science Education Leadership Association

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NSTA National Science Teachers Association
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Susan Loucks-Horsley
1947–2000

For more than a quarter century Susan Loucks-Horsley provided leadership for the science education community. Honoring her achievements and contributions requires one only to pause and reflect on her professional research, books, reports, and presentations. Her accomplishments far exceed in quality and quantity what most of us could only wish to attain. There is another quality of Susan that we must recognize and honor. In Susan's life and work, she always conveyed a freshness of appreciation for the other person. This interest in other people complemented her written contributions and achievements. Susan left the science education community with this deeper and more profound contribution. Personally, she conveyed a belief that, given the opportunity, each science teacher had the potential to improve, and that each teacher wanted her or his students to learn science. Susan let all she touched know that she understood their concerns and recognized their daily struggles to change. She supported their dignity, integrity, and worth as individuals. Susan Loucks-Horsley clearly recognized that the central issue of reform is not educational material; the essential factor is how leaders think and respond to the personal concerns of teachers, how they learn, and what has meaning for them. The foreword she wrote for this book reveals her belief that ultimately it is the individual science teacher who will make a difference in students' lives. Her life made a difference in the lives of others; now we have lost one of our best and brightest. We are left with her inspiration and dedication. Fulfilling her vision passes to all of us. As we look to the future without Susan Loucks-Horsley, we can be thankful for her professional achievements and contributions, and we must be grateful for her personal inspiration and grace.

Rodger Bybee

On the evening of August 8, 2000, Susan Loucks-Horsley died of injuries sustained in a fall.

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Foreword

Susan Loucks-Horsley

In the early 1980s, alarms were set off across the United States about the deplorable status of education, in general, and science education, in particular. In response, a flurry of activity led to many suggestions about what should be done. In the 1990s, various reform efforts at the local, state, and national levels blossomed, and change began gradually to occur. The *National Science Education Standards* and the *AAAS Benchmarks* emerged after long debates over what it is that students at various grade levels should know and be able to do in science. The notion that "less is more" gradually became a shared value.

Happily, few teachers today would advocate slavishly following a textbook as their science curriculum. Many teachers understand and value inquiry as an outcome for their students and a way of fostering important learning opportunities, and we are moving slowly in the direction of having a scientifically literate population. But, we must not become complacent. Although we have come a long way since the poor status of science education was presented to the American public in the 1980s, there is still a long way to go. Recognition of what our classrooms should look like and what our students should be able to do does not automatically translate into changes in the classroom or with our students. This is due, in part, to a lack of information. However, knowing what needs to be done does not mean knowing how to do it. This is where the critical role of professional development comes in, and it is essential that science leaders—at all levels—take on the challenges of being both the "leaders of learners" and the learners themselves. Unless teachers are being able to practice new ways of learning, teaching, and leading, this reform will fall far short of its potential.

Science teachers are the crucial link between the curriculum and students. Professional development is a concerted effort to help them understand and change their practices and beliefs as they improve the learning experiences they provide for students within their school and district. Professional development can also serve a broader purpose: to help teachers develop leadership and change agent skills. It prepares teachers to take a more informed and focused leadership role in fostering the implementation or improvement of the instructional program. Support for teachers is essential if teaching is to occur as espoused in the *Standards*, and if teachers are to expand their visions to influence others in their schools and districts. The nature of professional development programs in which teachers participate will, to a large extent, determine the changes in students' learning experiences.

As this book suggests, effective professional development programs and initiatives for science teachers have many characteristics in common. They help teachers see their students and classrooms differently as they learn to foster deep

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understanding of important science concepts, the skills and understanding of scientific inquiry, and an appreciation of the natural world. Effective programs engage teachers in ways that they, in turn, will help their students learn; support collaboration among teachers as they learn and craft learning experiences for their students; and help teachers examine their own practice and become "critical friends" to other teachers. Such programs support teachers over time so that they not only can change their practices, but also can sustain and renew those practices continuously.

Science leaders can broaden their own professional development role by thinking of themselves as designers of learning experiences—much as teachers consider their instructional goals, their students' needs, and the resources and constraints of their school and district, science leaders can craft long-term, multifaceted programs for teachers that reflect current research and the "wisdom" of other professional developers. For example, breaking out of the "professional-development-equals-in-service-workshops-and-summer-institutes" box brings science leaders into contact with a wide array of strategies from which to choose. These include case discussions, action research, coaching and mentoring, and examining student work. They can use student curriculum as a tool for teacher learning, helping teachers go far beyond the "mechanical use" of new curriculum materials as they deepen their understanding of science content, of student thinking, and of teaching strategies. As science leaders broaden their vision for professional development strategies, their designs begin to incorporate and even influence some of the other important elements of systemic reform, such as curriculum, assessment, and the development of a professional community. Examples in this book "push the envelope" of old conceptions of professional learning in ways that can fuel deep and sustainable changes in classrooms, schools, and districts.

This book is written for science leaders at all levels: teachers, science supervisors, science consultants, science coordinators, science specialists, administrators, higher education science educators, and policymakers. The comprehensive presentation promotes understanding of the circumstances in which professional development most influences student learning. It reviews programs in place that work, and it provides a wealth of practical ideas about actions to take in the professional development arena in order to implement and sustain reform in science education.

This is indeed an exciting time to be in science education. As we work together to strengthen our understandings and roles as leaders in the science education community, we at the National Science Education Leadership Association (NSELA) and the National Science Teachers Association (NSTA) welcome you to use the resources in this volume to build programs that enhance and enrich science teaching and learning in our nation's schools.

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About the Editors

Jack Rhoton is professor of Science Education at East Tennessee State University, Johnson City, Tennessee. Dr. Rhoton currently teaches science education at the undergraduate and graduate levels, and has also taught science at the elementary, middle, senior high school, and college levels. He has received numerous awards for service and science teaching, and has been an active researcher in K–12 science, especially the restructuring of science inservice education as it relates to improved teaching practices. Dr. Rhoton is the editor of the *Science Educator*, a publication of the National Science Education Leadership Association (NSELA), and director of the Tennessee Junior Academy of Science (TJAS). He also serves as editor of the TJAS *Handbook and Proceedings*. Dr. Rhoton's special research interest is in the area of professional development and its impact on science teaching and learning. He is widely published and has written and directed numerous science and technology grants. He has received many honors including the National Science Teachers Association (NSTA) Distinguished Service to Science Education Award.

Patricia Bowers is the associate director of the Center for Mathematics and Science Education at the University of North Carolina at Chapel Hill, where she teaches undergraduates and provides professional development training for math and science teachers. She also works closely with the UNC-CH Pre-College Program, which recruits underrepresented groups into math and science fields. She has been the project director for numerous grants, including 12 Eisenhower grants, and has received awards for service and science education. Dr. Bowers was a Science, Mathematics, and Reading Coordinator at the system level and worked as a classroom teacher and guidance counselor at the school level. Dr. Bowers is currently president of the North Carolina Science Teachers Association, and secretary of the North Carolina Science Leadership Association. She serves on several committees for the National Science Teachers Association (NSTA), and is a former district director and current board member of the NSELA.

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Preface

Jack Rhoton and Patricia Bowers

Nearly every major document advocating science education reform in recent years has focused on science content and concepts to be taught, how science teachers should teach, and guidelines for professional development. The vision of science teaching and learning espoused by school reformers presents a key challenge for teachers' professional development. The vision of practice and standards-based reform advocated by the nation's reform agenda requires that most teachers make a paradigm shift in their beliefs, knowledge, and teaching practices. The success of this agenda will hinge, in large measure, on professional development opportunities that will engage teachers in learning the skills and perspectives called for in the new vision of practice. Because teachers are the crucial link between the curriculum and students, professional development is a major element in developing teacher leadership and change agent skills. It prepares teachers to take a more informed and concerted leadership role in fostering the implementation or improvement of the instructional program, driven by the desire to improve student learning.

Effective professional development also provides occasions for teachers to genuinely address change and renewal and reach beyond the "make and take" and "idea swap" sessions to more global, theoretical conversations that focus on teachers' understanding of content, pedagogy, and learner. For long-lasting and effective change within the science classroom, professional development activities must plow a deeper furrow of inquiry into practice than is normally available to teachers.

Professional development must allow teachers to rethink their notions about the nature of science, develop new views about how students learn, construct new classroom learning environments, and create new expectations about student outcomes. Teachers will need not only to explore new ideas in professional development programs, but also to develop and inculcate habits that will enable them to continue professional development over time.

Even though a common vision is beginning to emerge about what effective professional development should look like, a large number of teachers have not had an opportunity to participate in such professional development in their working environments. However, there is a growing momentum for schools to examine teachers' professional development in light of standards-based reform. This publication positively addresses issues and practical approaches needed to lay the foundation upon which professional development approaches can work to build effective science programs in our nation's schools. In addition, it examines the linkage between professional development and effective science education programs.

The *Issues in Science Education* series shares ideas, insights, and experiences of individuals ranging form teachers to science supervisors to university personnel to agencies representing science education. They discuss how professional develop-

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ment can contribute to the success of school science and how to develop a culture that allows and encourages science leaders continually to improve their science programs.

Using nontechnical language, this text is intended to be accessible to a broad audience. It is written for science teachers, science department chairs, principals, systemwide science leaders, superintendents, university personnel, policymakers and other individuals who have a stake in science education. It will also serve as a supplementary text for university methods course, in elementary and secondary science education.

The 13 chapters in this volume, *Professional Development Leadership and the Diverse Learner,* are organized into two sections. The intent of the book is not to provide an exhaustive coverage of each major theme but, rather, to present chapters that effectively address the issues of professional development. Each chapter in the text illustrates the utility of professional development for practitioners and addresses general issues and perspectives related to science education reform.

Part I of the book, "Professional Development: Implications for Science Leadership," consists of six chapters that deal with program developments within the context of issues that impact the day-to-day work of professional developers, instructional leaders, and science teachers. Part II, "Professional Development and the Diverse Learner," contains seven chapters that address the needs of a greater diversity of learning, including students from different cultural and ethnic backgrounds as well as those with exceptional needs.

Meaningful and sustained change in science teaching and learning is fraught with many challenges and pitfalls. These challenges and obstacles demand effective professional development. The task of developing and sustaining healthy professional development practices is simply too complex for any one person to tackle alone. Therefore, this work is directed at all players in the science education community who have a stake in improving science teaching and learning. Moreover, administrators must create an atmosphere that supports and encourages participation in effective professional development programs. One of the greatest challenges of leadership is to develop a culture that creates "laboratories" of ongoing improvements. The final determinant of success in this effort will be measured through the quality of science programs delivered to our students.

Numerous examples throughout the book illustrate the utility of professional development for practitioners and others interested in the improvement of science teaching and learning. Many of the topics in this book are placed within the context of real world experience and combinations of original research. Some of the concepts covered include: standards-based professional development; the nature of science, assessment and evaluation, leadership, and professional development; strategies for professional development; learning and teaching critical thinking skills; using ENC and ERIC as a resource for professional development; diversity issues in teaching science; and science education in formal and informal settings.

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As we honor the memory and life of Susan Loucks-Horsley, we cannot escape the fact that her name is synonymous with professional development. Her many years of service and dedication to the science education community resulted in a body of writing of marked excellence, inspiring each of us to work harder, think deeper and take action on the subject to which she devoted her life—improving science education in our nation's schools. It was for this reason that Pat Bowers and I asked her to write the foreword to this book and to contribute two chapters to this document. We recognized that her works and writings have been influential forces in shaping the thoughts and actions on the direction of professional development in science education. And it will be so for years to come. There was also a human quality that permeated her work. Through my professional collaboration efforts with Susan, I recognized that she not only radiated an unparalleled warmth, glow, and passion for her work, but also was equally dedicated to uplifting each person with whom she came in contact. She was interested in people as individuals and recognized and appreciated the importance and role of each science teacher in his or her struggle and dedication to create effective learning environments for all students. She also worked hard to support teachers in their individual environments. Her memory is destined to linger in our thoughts as we work to fulfill her vision. The science education community will forever be the better for her influence, example, and inspiration.

Jack Rhoton

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This book would not have been possible without the help, advice, and support of a number of people. More fundamentally, the members of the NSTA/NSELA Editorial Board—Gerry Madrazo, Lamoine Motz, Carolyn Randolph, Susan Sprague, Emma Walton—reviewed the manuscripts and made valuable suggestions for improvement. We could not have achieved our goal without their assistance, and we are grateful. Our appreciation is extended to Shirley Watt Ireton, Beth Daniels, and Anne Early of NSTA Press, for their invaluable help in the final design in which you are now reading. No volume is any better than the manuscripts that are contributed to it; we appreciate the time and efforts of those whose work lies within the cover of this book.

We also want to thank and acknowledge the support, help, and suggestions of the NSELA Board of Directors. Special thanks to Becky Litherland, past president, for her suggestions and guidance in the early stages of the project. The support of President Jerry Doyle and Executive Director Peggy Holliday in the later stages of the project is gratefully acknowledged.

Finally, we would like to credit people who simply made room in their lives for us to do this work. We are indebted to the calm, good-natured support of the East Tennessee State University Division of Science Education office staff: Leslye Culbert and Connie Frances. Each of these individuals did excellent work in word processing and typing the many drafts of each manuscript. And lastly, a special thanks to James Kevin, ETSU adjunct professor, and Chris Bordeaux, ETSU graduate student, for applying their expert editing skills to each manuscript.

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Introduction

Jerry Doyle
NSELA President, 1999–2000

The numerous and vexing issues facing the science education leader today have created the need for leadership skills and knowledge that go far beyond those demanded in any previous era. The exceptional leader must be knowledgeable about science as a human endeavor; must be conversant with new developments in learning theory and how they impact classroom instruction; must have practical skills in chemical hygiene and lab safety needed to maintain a safe environment for students and teachers; must have the analytical skills needed to build a comprehensive assessment program and be able to move student achievement scores to higher levels; must be on the cutting edge of recent developments in technology that can be useful in science instruction; must have exceptional people skills and be able to work with a variety of interest groups who care about the science program; must know the structure of the school organization and be able to keep funds flowing toward the science department; must know where to find grant money and write "winning" grant proposals; must be able to create a vision and long-range plan for the science program; and must be able to coordinate a comprehensive staff development program to make that vision a reality.

The exceptional science education leader can master this overwhelming list of "musts" only if key resources are tapped. Pat Bowers and Jack Rhoton have compiled one of these key resources needed in the office of every science education leader. This volume includes an impressive array of pertinent articles from key leaders in the issue domains mentioned previously. It is my belief that this book will make you a more effective science education leader.

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The Role of the Science Leader in Implementing Standards-Based Science Programs

Harold Pratt

Harold A. Pratt is the president of Educational Consultants, Inc. and the former executive director of science and technology for the Jefferson County (CO) public schools. He will be the 2001–02 president of the National Science Teachers Association.

If there is one common factor in the best cases, it is the presence of one or more individuals who provide strong leadership for the mathematics or science reform effort...
—Report to the Center for Science, Mathematics, and Engineering Education

Because the goal for science education in the 1990s has been and will continue into the 21st century to be—standards-based reform, the number one question in the science education community is: What is required to accomplish it? According to St. John, who addressed this question in an evaluation report (St. John & Pratt, 1997) to the Center for Science, Mathematics and Engineering Education, when the best cases of reform are examined, leadership emerges as the most important factor.

Although it is not the place of this chapter to provide a detailed description of what is meant by standards-based reform, it can be summarized briefly as the restructuring of the content students learn, the way it is taught and evaluated, and the way the program is supported through professional development—all of which are aligned with a well-developed set of local, state, or national standards. Such a system of reform has often been referred to as "systemic" because all parts of the system are coordinated so that they are all addressing the same major goals and program outcomes.

Although much has been written (Smith and O'Day, 1991; Zucker and Shields, 1995; Knapp, 1997; Consortium for Policy Research in Education, 1995) about the nature of systemic or standards-based reform and what such a comprehensive program would look like if it were in place, not enough has been said about how a district proceeds through the reform process. The literature often seems to imply that improved curriculum, teaching, and assessment just appears from thin air. What is

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needed is a deeper understanding of the role and function of leadership in the reform effort. The most significant, but often unmentioned, ingredient in the reform of science education at the state and local level is a leader with knowledge and experience who is well placed in the system so that he or she is capable of making the system function in the desirable way. Leaders have much to do: drafting science-education-related policy; coordinating districtwide programs; creating curriculum frameworks; facilitating the selection of instructional materials; and developing assessment policy, procedures, and instruments. Whatever is included in their portfolio, what they know and can do is critical to the success of the local program.

The most significant, but often unmentioned, ingredient in the reform of science education at the state and local level is a leader with knowledge and experience who is well placed in the system.

The leader's knowledge of science is critical. The responsibilities listed in the last paragraph depend, to a large degree, on the nature of the discipline, how they are learned, and how they are best taught. When the major goal of the standards is understanding the subject matter content, the decisions about what science elementary teachers need to learn in their professional development experience, how subject matter is presented in textbooks at all levels, and the nature of the district's science assessment program are all examples of decisions that require knowledge of the content if to be quality decisions that keep the reform on track.

Knowledge of content by leaders is important and necessary, but not sufficient. Leaders should be skilled in designing, facilitating, and maintaining the changes called for in an ongoing improvement process. These include creating a vision of a quality program, designing professional development, managing change, facilitating individuals and groups, organizing groups and tasks, and building the capacity of the system to support the change.

Although most of the literature of reform and systemic change focuses on policy, programs, and practices that the leaders should be responsible for producing, this chapter will emphasize what is known about how leaders bring about these improvements and what the research says about the skills, behaviors, and leadership styles of effective leaders. Finally, this chapter will highlight the concept of distributed leadership as presented in the *National Science Education Standards.*

Importance of Leadership in Standards-Based Reform

The Center for Science, Mathematics, and Engineering Education, the group at the National Research Council (NRC) responsible for developing and supporting the use of the *National Science Education Standards* (National Research Council, 1996), commissioned a study of the best cases of science education reform in an effort to understand the process of reform. The report (St. John & Pratt, 1997) from Inverness

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Associates pointed to leadership as a key factor in producing the best cases of reform.

The study found that in the best cases, standards—either local, state, or national—were considered to be policy documents that were not "implemented" but, rather, they became tools for promoting deeper and more reflective approaches to selecting instructional materials, creating assessments, and designing professional development. Policy does not automatically give rise to desired practice. But in the best-case districts, the leaders found ways of using the standards to develop the capacity across all levels of the system to develop and sustain the vision of the standards in improved programs and practices.

The best-case districts have long-term, committed leadership.

In the best-case states and districts, one or more longer-term leaders played a very central role in the reform effort. These individuals typically were energetic and highly committed, with a history of involvement in science reform efforts, who possess multiple skills and knowledge. In addition, they were formally or informally placed in positions of influence where they were charged to bring about change. Although they may not have had true position power due to their place in the district or state formal hierarchy, they had the backing of their superior administrators and/or the influential power based upon their previous experience and successes.

Effective leaders are connected to many sources of support.

The leaders in the best case situations build and draw upon their connections at the local, state, and national level. They typically have been involved with the creation of state and national standards and have years of experience in the National Science Foundation or other externally funded innovative science projects. They were knowledgeable in the important ideas in the research and innovative programs before the standards themselves were written. To these leaders, the standards had more of a reinforcing and clarifying effect on the direction they had already established. They also were well-versed in the process of educational change and how to effect it in their own districts or state.

Effective leaders focus primarily on educational substance.

Another key factor that the study identified was that the best leaders focus primarily on educational substance while functioning well within the political realities of their system. Several writers have noted that standards at all levels are political, as well as educational, documents (Kirst, Anhalt, & Marine, 1997). To the educator, standards identify a vision of quality, teaching, learning, and system support. To those who are politically-oriented, standards represent a means of control over schools. For the political group, standards coupled with large-scale assessments represent tools that communicate expectations, with little attention to the means by which the expectations can be attained. The astute leaders fill this void in the political perspective by

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defining and gaining support for the curriculum programs and professional development that provide teachers and students with the opportunity of fulfilling the political expectations. The leaders do this, fully aware that they must mix and blend both dimensions if they are to be successful and satisfy the political expectations placed on them and the rest of the system.

Change requires increased professional development and support and, therefore, budget.

In the best cases, leaders use standards as vision to guide their reform efforts.

The leaders who developed the best cases for standards-based reform used the *Standards* as an overarching strategy for improvement rather than a litany of mandates to be implemented. It is their view—one they are able to communicate to teachers and administrators in their system—that standards provide a rich vision and resource for the kind of teaching and learning desired. In these cases, the leaders use standards and other policy documents to inform their local efforts and decisions about their efforts to bring about change. They find ways of using the assessment teaching, professional development, program, and system standards from the *National Science Education Standards* to fill the void between the mandated content standards and assessment expectations mentioned above.

In the best cases, state and district leaders work not just to build consensus for specific programs, such as a new set of instructional materials or the availability of learning technologies, but to build consensus and support for an infrastructure (money, time, resources, expertise) necessary for the long-term success of their reform effort. They know that the introduction of standards and other expectations without the necessary support is an indication that the reform process is more political than educational and more short-term and project-oriented than a long-term sustained effort. Change requires increased professional development and support and, therefore, budget.

What Research Says About Effective Leaders

Although leadership is often considered to be more of an art than a science, it is important to examine the research base for information on the styles of leadership that leaders must bring to the job. A committee at the NRC recently reviewed the research about effective leaders in a report entitled *Enhancing Organizational Performance* (Druckman, Singer, & Van Cott, 1997). The research revealed that there are three, well-known basic skills relevant to effective leaders and one new skill required in a rapidly changing technological environment.

Technical skills are defined as knowledge of product and services, work operations, procedures, and equipment. In science education, this would include an understanding of instructional materials, the ability to facilitate meetings, knowledge of instructional technology, and the ability to interpret educational reports for the public and other administrators.

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Conceptual skills include the ability to analyze complex events and perceive trends, recognize changes, and identify problems and opportunities. They also include the ability to develop creative, practical solutions to problems and the ability to conceptualize complex ideas through models and analogies. For the science education leader, this means understanding the role of standards and other policy documents and having the ability to use them as a practical guide to local program development. The leader who understands these documents as being both politically and educationally motivated is operating at the conceptual level. The science educator who can analyze instructional materials not simply by using an evaluation checklist but based upon a deep understanding of the science being presented and how students learn the science at various ages is making maximum use of his or her conceptual skills. The leader who simply follows the lead of other educators in the choice of materials, organization of professional development, and design of curriculum is operating more at the technical or operational level than at the conceptual level. The leader who can synthesize the research on student learning, professional development (adult learning), and the local political climate into a coherent total program that will be accepted by the community and staff must have deep conceptual skills to do so.

Interpersonal skills include understanding of interpersonal and group processes and the ability to understand the motives, feelings, and attitudes of people from what they say and do. Interpersonal skills also include the ability to maintain cooperative relationships with people, oral communication, and persuasive abilities. The effective leader who understands the deep conceptual ideas of science education and has the technical skills to make them work still must involve a wide range of individuals from many diverse roles to implement well-conceived ideas. Skills of tact, diplomacy, and conflict resolution will be constantly demanded of the effective leader in the process of soliciting ideas and suggestions during the formulation of a plan or program and persuading others to approve and implement it.

The leaders who developed the best cases for standards-based reform used the Standards *as an overarching strategy for improvement rather than a litany of mandates to be implemented.*

Self-learning skills are emerging as a new requirement for the 21st century leader. The rapidly changing educational technologies and their implications for student learning and the design of programs requires science education leaders to make decisions with little or no precedent. Faced with the rapid change in many school systems due to shifting political climate, changing student populations, or the introduction of cutting-edge technology, science education leaders must cope with increasing complexity and change with little previous experience or knowledgeable advisors. To cope with such complexity, leaders need the ability to analyze their own learning process and adjust their actions and decisions both to improve their own knowledge and skills and to make decisions that they have never made before. Recent re-

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search (Druckman & Bjork, 1994) has identified this self-learning skill as the ability to develop new mental models, learn from mistakes, and change assumptions and ways of thinking within and in response to a changing world.

Behavior of Effective Leaders

Researchers have long sought to discover why some leaders are more effective than others. In addition to the skills outlined above, leadership behavior—those observable actions such as making assignments or facilitating a discussion—are known to be critical to their success and effectiveness. The research synthesized by the National Research Council (Druckman, Singer, & Van Cott, 1997) suggested that there are eight types of behaviors specially relevant to effective leadership.

Clarifying roles and objectives. Subordinates and clients, such as teachers and principals, need to know what work they are to do and the results that are expected. The skill to clarify roles and objectives includes defining job responsibilities, assigning tasks, setting performance goals, and providing support and instructions on how to do the task. As an example, curriculum writing teams who meet without clear instructions, goals, deadlines, and criteria for judging their own work will digress into nonproductive discussions, false starts, and work that is unrelated to the task.

Supportive leadership. A leader who is supportive uses a variety of behaviors to show acceptance and concern for subordinates' needs and feelings. Research from several decades of study has demonstrated that supportive leadership increases the satisfaction and productivity of the people involved. There is some indication that less supportive leadership is necessary when satisfaction with the job and commitment to the task are already high, but even then supportive behavior is effective.

Planning and problem solving. Effective leaders create flexible and practical strategies to meet their objectives. But the planning must be accompanied by the ability to remain flexible, in the event that unforeseen problems disrupt the well-laid plan. Plans are rarely executed fully in the form in which they are originally conceived. The need for problem solving and flexibility in a complex, changing, and political environment should be the norm for effective leaders.

Monitoring operations and environment. Effective leaders use feedback to monitor progress on how well their plans are progressing. The leader who develops and communicates an idea without following and monitoring its implementation will find that good ideas do not implement themselves—people do. Leaders stay in touch with the people and learn from their response to do instructional materials, educational technologies, and innovative teaching strategies. Adjustments are made, plans are altered, support systems improved, and expectations modified—all in an effort to meet the changing environment in which the plan is being implemented.

Participative leadership. The research indicates that decision making improves when other members of the group have information and ideas that the leader does not have and they are willing to cooperate in finding ways to achieve their shared goals. Classroom teachers have knowledge and expertise that central office leaders do not have.

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The converse is also true. Curriculum leaders usually possess skills and resources not available to teachers. Only when these different perspectives and kinds of expertise are brought together by a leader who believes in mutual support and participation can effective curriculum teaching and professional development be planned and implemented.

Inspirational leadership. Studies on inspirational leadership indicate it is one of the strongest predictors of a group's commitment and performance. It is especially important in today's complex and changing environment, where major shifts in thinking and strategies on the part of the group are often required. Inspirational leaders stimulate followers to think about problems in new ways and, simultaneously, help them question old assumptions and beliefs that may be no longer valid. Inspirational leadership is more a result of the relationship between the leader and other members of the group and is not simply an innate and intrinsic quality of the leader.

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Positive reward behavior. Positive rewards consist of tangible components, such as pay increases, prizes, and recognition or praise for achievement and contributions to the group's goals. Praise is more likely to be effective when it is clearly based on observable contributions and not used by the leaders indiscriminately to control or manipulate.

Networking. Similar to the findings of St. John and the author (St. John & Pratt, 1997) described earlier, research from studies of effective leaders indicates that they develop and maintain networks of people from who they can draw resources, information, and support. In large, complex organizations, internal networks are as important as external networks.

Distributed Leadership in the *National Science Education Standards*

The *National Science Education Standards* recognized the importance of leadership in several standards and suggested a type of leadership referred to as distributed leadership (Bybee, 1993). Program Standard A stated: "Responsibility needs to be clearly defined for determining, supporting, maintaining, and upgrading all elements of the science program." Although all school personnel have responsibilities, clearly defined, leadership at the school and district levels is required for an effective science program (NRC, 1996, p. 211). The *Standards* point out the importance of leadership and distributes the responsibility among a variety of people, including teachers, administrators, and science coordinators.

Teaching Standards F mirrors the expectation that teachers assume a leadership role in the improvement of science programs:

> *Teachers of science actively participate in the ongoing planning and development of the school science program. In doing this, teachers:*

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- *Plan and develop the school science program.*

- *Participate in decisions concerning the allocating of time and other resources to the science program.*

- *Participate fully in planning and implementing professional growth and development strategies for themselves and their colleagues* (NRC, 1996, p. 51).

By defining leadership as an individual's ability to work with others to improve science teaching and learning to accomplish the goal of scientific literacy for all students, virtually everyone in the science education community is included. This concept is incorporated in Program Standard F:

- *Schools must work as communities that encourage, support, and sustain teachers as they implement an effective science program.*

- *Schools must explicitly support reform efforts in an atmosphere of openness and trust that encourages collegiality.*

- *Regular time needs to be provided and teachers encouraged to discuss, reflect, and conduct research around science education reform.*

- *Teachers must be supported in creating and being members of networks of reform.*

- *An effective leadership structure that includes teachers must be in place* (NRC, 1996, p. 222).

The messages of the NSES are clear: a) leadership structure and assignment of responsibility are needed for effective programs; and b) teachers are an important part of the leadership structure, so time and support must be provided to make it possible. The location in the system and the role of the individual can vary and be distributed among a variety of people, but we are reminded of what the research outlined earlier in the chapter tells us about the characteristic skills and behaviors of leaders in science education reform.

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