Untapped Potential

The Status of Middle School Science Education in California

THE CENTER FOR THE FUTURE OF Teaching & Learning at WestEd

Research conducted by:
The Lawrence Hall of Science at
University of California, Berkeley,
and SRI International

Untapped Potential: The Status of Middle School Science Education in California summarizes new research that examines the status of science education in the state's middle school classrooms. The research was conducted in support of Strengthening Science Education in California, a research, policy and communications initiative that brings together educators, researchers and others to examine the status of science teaching and learning, and to develop recommendations for improving science education in California. Partners in this initiative include the Center for the Future of Teaching and Learning at WestEd, the University of California, Berkeley's Lawrence Hall of Science, SRI International, Belden Russonello Strategists, Stone's Throw Communications, and Inverness Research.

Untapped Potential is the third in a series of research reports conducted and published by partners in the Strengthening Science Education in California Initiative. Findings in this report are based on the results of surveys conducted in 2010 and 2011 of elementary and middle school teachers and principals, as well as school district leaders in communities across California. These findings are enhanced by the analysis of secondary research data on students and teachers, and case studies of science education efforts in school districts in California. Our intent is to share the findings of this research with educators, policymakers, and the public in ways that stir debate and inform decision making which results in more and better science education for California students.

This report was produced by The Center for the Future of Teaching and Learning at WestEd in consultation with our partners:

BELDEN RUSSONELLO STRATEGISTS LLC
www.brspoll.com

INVERNESS RESEARCH
www.inverness-research.org

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY
www.lawrencehallofscience.org

SRI International
www.sri.com

STONE'S THROW
STRATEGIC COMMUNICATIONS
www.stonesthro.com

Funding for this initiative was generously provided by the S.D. Bechtel, Jr. Foundation

Research was conducted by the University of California Berkeley's Lawrence Hall of Science and SRI International

Copyright © 2012. The Regents of the University of California. Permission is hereby granted to use this report for nonprofit teaching, research or public service uses.

THE CENTER FOR THE FUTURE OF Teaching & Learning at WestEd

www.cftl.org

Strengthening Science Education in California

Untapped Potential

The Status of Middle School Science Education in California

The Center for the Future of Teaching and Learning at WestEd

Research conducted by the Lawrence Hall of Science at the University of California, Berkeley, and SRI International

Suggested citation:
Hartry, A., Dorph, R., Shields, P., Tiffany-Morales, J., & Romero, V. (2012). The status of middle school science education in California. Sacramento, CA: The Center for the Future of Teaching and Learning at WestEd.

The Center for the Future of Teaching and Learning at WestEd
1000 G Street, 5th Floor, Sacramento, CA 95814 • 831-427-3628 • www.cftl.org

Copyright © 2012. The Regents of the University of California.

CONTENTS

Exhibits ii

Strengthening Science Education in California Initiative Advisors iii

Strengthening Science Education in California Initiative Partners iv

Center for the Future of Teaching and Learning at WestEd Advisory Board v

Acknowledgements vi

Chapter 1: The Importance of Science Education 1

Chapter 2: Science in California Middle Schools 7

Chapter 3: Conditions that Support Science Learning in Middle Schools 11

Chapter 4: Creating Supports for Science Learning in Middle Schools 19

Chapter 5: Conclusion 25

EXHIBITS

Exhibit 1-1 Grade Level Configurations of Participating Middle Schools 6

Exhibit 2-1 Frequency of Use of Instructional Practices in Middle School Science Classrooms (percent) 8

Exhibit 2-2 Principals' Assessment of the Degree of Challenge in Students Not Being Prepared for Middle School Science 9

Exhibit 3-1 Teacher Science Background 12

Exhibit 3-2 Principal Assessment of the Degree of Challenge in Finding Qualified Teachers 13

Exhibit 3-3 Access to Equipment by Schoolwide Socioeconomic Status 15

Exhibit 3-4 "Major" or "Moderate" Challenges to Science Instruction 16

Exhibit 4-1 California Districts Reporting District Dedicated Staff to Support Middle School-level Science, by District Size (percent) 21

Exhibit 4-2 California Districts with Recent Middle School Science Education Initiatives, by Sponsoring Organization (percent) 22

Exhibit 4-3 California Districts with Support from External Organizations for Middle School Science (percent) 23

STRENGTHENING SCIENCE EDUCATION IN CALIFORNIA INITIATIVE ADVISORS

Maria Alicia Lopez-Freeman
Executive Director Emeritus
California Science Project

Suzanne Nakashima
Teacher
Lincrest Elementary School

Sue Pritchard
Teacher
Washington Middle School

Christopher Roe
Chief Executive Officer
California STEM Learning Network (CSLNet)

Jessica Sawko
Executive Director
California Science Teachers Association

STRENGTHENING SCIENCE EDUCATION IN CALIFORNIA INITIATIVE PARTNERS

Co-chairs

Stan Hitomi
Principal
Alamo Elementary School

Elizabeth Stage
Director
Lawrence Hall of Science

Members

Linda Bond
Senior Policy Consultant
Center for the Future of Teaching and Learning (CFTL) at WestEd

Rena Dorph
Director
The Research Group
The Lawrence Hall of Science
University of California, Berkeley

Margaret Gaston
Senior Policy Consultant
CFTL at WestEd

Ardice Hartry
Deputy Director
The Research Group
The Lawrence Hall of Science
University of California, Berkeley

Susan Harvey
Program Director
S.D. Bechtel Jr. Foundation

Holly Jacobson
Director
CFTL at WestEd

Stacey Kyle
Research Associate
CFTL at WestEd

John McDonald
Stone's Throw Communications

Michelle Phillips
Consultant
Inverness Research Associates

Patrick Shields
Director
Center for Education Policy
SRI International

Mark St. John
President
Inverness Research, Inc.

Laura Stokes
Research Associate
Inverness Research, Inc.

Juliet Tiffany-Morales
Research Analyst
Center for Education Policy
SRI International

Patsy Wilkes
Project Administrator
CFTL at WestEd

CENTER FOR THE FUTURE OF TEACHING AND LEARNING AT WESTED ADVISORY BOARD

Warren Baker
President Emeritus
California Polytechnic State University,
San Luis Obispo

Ken Barker
Response to Instruction and Intervention
Coordinator
Local District 2
Los Angeles Unified School District

Stan Hitomi
Principal
Alamo Elementary School
San Ramon Valley Unified School District

Davis Campbell
Senior Research Fellow
Center for Applied Policy in Education
University of California, Davis

Karl Pister
Chancellor Emeritus
University of California, Santa Cruz

Sandy Dean
Director
National Board Resource Center
Stanford University

John Sugiyama
Superintendent, retired
Emery Unified School District

Gerald Hayward
Director Emeritus
Policy Analysis for California Education

Aida Walqui
Director
Teacher Professional Development Program
WestEd

Victor C. Young
President
Cornerstone Literacy, Inc.

ACKNOWLEDGMENTS

The Lawrence Hall of Science at the University of California, Berkeley research team consisted of Lynn Barakos, Mac Cannady, Joo Chung, Rena Dorph, Valeria Romero, Ardice Hartry, Dori Jansen, Ellen Middaugh, and Juna Snow.

The SRI International research team consisted of Larry Gallagher, Harold Javitz, Carlin Llorente, Teresa McCaffrey, Sylvia Rodezno, David Sherer, Patrick Shields, Juliet Tiffany-Morales, and Katrina Woodworth.

We thank the S. D. Bechtel, Jr. Foundation for its support of this critical research to advance science education in California.

We thank Mimi Campbell and Eileen Behr for their contributions to the editing and production of this report.

We also extend our appreciation to the Strengthening Science Education Initiative Co-sponsors and Advisors, Inverness Research Inc., Stone's Throw Communications, and The Center for the Future of Teaching and Learning at WestEd's staff and board of directors for their insights and suggestions throughout the development of this report.

Finally, we thank the teachers, principals, and district administrators who responded to our surveys for enabling us to learn from and about them.

CHAPTER 1
THE IMPORTANCE OF SCIENCE EDUCATION

Science Instruction as a Priority for Middle Schools

A consensus has emerged in the United States and in California about the need for all students to graduate from high school better prepared for the world of postsecondary education, work, and citizenship. The globalization of the economy and continued technological advances mean that requirements for all jobs are constantly evolving. Our greatest societal challenges, from climate change to the lack of an adequate water supply to public health, will require greater innovation and scientific know-how. Those countries and states that respond with the best prepared workforce and citizenry will assume economic leadership.

These imperatives suggest that science should be a critical component of K–12 education. Yet only 62% of California students scored proficient in science on the most recent eighth-grade California Standards Test (CST). Even more alarming, only 20% of California students were proficient on the eighth-grade National Assessment of Educational Progress (NAEP) science exam in 2009.

The Imperative: Engaging Students in New Ways

Ideally, students should enter middle school invigorated by their prior exposure to science learning and with a strong background in the key concepts and practices of science. Yet our study of elementary science education in California revealed that most children rarely encounter high-quality science learning opportunities because the conditions that would support them are rarely in place (Dorph, Shields, Tiffany-Morales, Hartry, & McCaffrey, 2011).[1] Only about 10% of California public elementary school students regularly experience opportunities for high-quality science learning. Moreover, 40% of elementary teachers in grades K–5 reported that their students receive 60 minutes or less of science instruction per week.

As a result, students often enter middle school unprepared to engage in the science learning they encounter. Furthermore, middle school can be a time where many students lose interest in science. According to *A Framework for K–12 Science Education*, "Interest in science dramatically declines as students

[1] This study report, *High Hopes – Few Opportunities: The Status of Elementary Science Education in California*, Sacramento, CA: The Center for the Future of Teaching and Learning at WestEd., can be found at http://www.cftl.org/documents/2011/ Strengthening-Science_full.pdf

transition into middle school," and this persists into college, graduate school, and careers (National Research Council, 2011).

Parents, educators, and the general public believe in the need for strong science education in middle school. According to a recent public opinion poll, 57% of Californians feel that more time should be spent on science in middle school (Belden, Lien, & Nelson-Dusek, 2010). Among educators, we describe in this report that nearly 50% of middle school principals believe lack of student preparation is a major or moderate challenge in engaging students in high-quality science instruction, stressing the need for instructional programs that redress the gaps in student learning.

Along with this consensus about the need for students to engage more with science, similar agreement has evolved about how and what students should learn. The study that forms the dataset for this report was designed in accordance with a synthesis study conducted by the National Research Council's (NRC's) Board on Science Education. In 2006, the NRC convened a panel of experts to synthesize relevant research and make recommendations for the future of science learning opportunities in schools that are documented in *Taking Science to School* (NRC, 2007). *Ready, Set, Science!* (Michaels, Shouse, & Schweingruber, 2007) provides an educator-friendly summary of the panel's findings. The panel suggests high-quality science education must include opportunities for K–8 students to do the following:

- Learn about what scientists really do
- Learn and use the language of science
- Reason scientifically (e.g., engage in causal and mechanistic explanations of natural and physical phenomena, provide explanations based on evidence)
- Engage in the practices of science
- Build on prior knowledge, interest, and experience
- Learn core concepts related to big ideas in science (e.g., atomic-molecular theory of matter, evolutionary theory, cell theory) presented according to an understanding about the way children learn and build knowledge about these concepts.

This work has been succeeded by additional science learning consensus documents. The most recent, *A Framework for K–12 Science Education* (NRC, 2011), cites the inadequacy of U.S. science education as the rationale for developing a new framework and emphasizes science as both ideas and practices.

> The overarching goal of our framework for K–12 science education is to ensure that by the end of 12th grade, all students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on

> related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology. (NRC, 2011, Executive Summary, p. 1)

This framework is the basis for the new generation of national common standards for science education currently under development. California has been chosen as one of 20 states to lead a nationwide effort to develop the next generation of science standards. As a lead state partner, California will help guide the standards writing process, gather and deliver feedback from state-level committees, and work with other state partners to address common issues and challenges. Once the final set of standards is complete, states may voluntarily adopt it to guide science education in their schools.

The Context: California

In California, although science is a required subject in middle school curriculum under the California Education Code (CAL Educ Code §§ 51210 (d) and 51220 (e)), the specific number of instructional minutes students need to receive in science is not explicitly stated. The National Academy of Sciences recommends teachers teach one hour of science daily and suggests alternating lectures and laboratories (California Department of Education, 2007). What is important is not the number of hours of science students receive, but that students leave middle school prepared for success in math and science in high school. Student achievement in science is measured on the eighth-grade CST, which is a part—albeit a small part—of a school's Academic Performance Index (API). These conditions suggest that science should be a greater focus in California middle schools.

Science education in middle school classrooms is influenced largely by the California Science Framework adopted in 2004 (Curriculum Development and Supplemental Materials Commission, 2004). Building on the Science Content Standards (adopted in 1998), the California Science Framework "outlines the implementation of the content standards in California public schools, and connects the learning of science with the fundamental skills of reading, writing, and mathematics" (Curriculum Development and Supplemental Materials Commission, 2004, p. 2). The framework points to nine guiding principles by which science programs in middle schools would be deemed effective. These principles aim to ensure that science instruction is comprehensive, engaging for students, and designed to support the content standards specified for each grade level. Such an approach is intended to prepare middle school students for success in high school. Each grade level has a particular focus: earth sciences in sixth grade, life sciences in seventh grade, and physical sciences in eighth grade. The framework notes that this sequence is intended to provide students with a solid foundation of concepts,

theories, and principles that are taught at the high school level (p. 82). In addition, each grade level has an Experimental and Investigation strand that encourages students to participate in experiments and the process of inquiry in the classroom (Curriculum Development and Supplemental Materials Commission, 2004).

Clearly, standards and frameworks have not been enough. Recently, California was rated as one of only two states to receive high marks for the content, rigor, and clarity of its science standards (Fordham Institute, 2012). Most states received a grade of D or F. Yet on the National Assessment for Educational Progress, students in California middle schools lag behind the nation in science proficiency. In 2009 the average NAEP science score of eighth-grade students in California was 137 on a scale of 0–300, compared with the national average of 149 (U.S. Department of Education, Institute of Education Sciences, 2009). California's average was lower than that of 42 states. In addition, 2011 CST results demonstrated great disparities in science proficiency among eighth-graders. For example, 49% of African Americans and 53% of Latinos scored at or above proficient on the science portion of the CST compared with 78% of their white counterparts. Such findings further support the argument that although the state standards might be in place, the learning experiences students receive in middle schools may not be preparing them adequately for success in high school.

California's accountability system further contributes to the low priority that science receives in middle school. California's Academic Performance Index is a composite number that takes into account test scores for English-language arts, mathematics, science, and history-social science. Whereas English-language arts and mathematics account for nearly 85.7% of the content area weight included in API, science accounts for only 7.1%. Furthermore, federal accountability standards represented by the Adequate Yearly Progress (AYP) focus mainly on English-language arts and mathematics achievement; science plays an insignificant part of this calculation.

California's infrastructure for supporting science education has eroded over the past 10 years. It used to be typical for county offices of education to have science coordinators and for district offices to have science coordinators and/or coaches. Today, these support providers are scarce. Statewide programs and resources have also been hit hard. In 2001 the California Science Project (CSP), offering teacher and teacher leader professional development across the state, was funded at $4 million. In 2002–03, CSP funding increased to a total of $9.09 million, $4.84 million of which was state funds. Today, CSP has minimal funding—$1.2 million in 2011 comprising both state and federal funds.

A Blueprint for Great Schools, prepared for California Superintendent of Public Instruction Tom Torlakson, outlines many crucial recommendations for changing the system, including teacher preparation and materials adoption (Transition Advisory Team, 2011). Although such reform could support the improvement of science education, explicit attention will be required to ensure that this blueprint is applied to science learning in ways that increase the quality and quantity of science learning in California schools. Further, California will need a new road map for supporting science learning in public schools that aligns with national priorities for science education.

The Need: Timely and Actionable Data

Despite the expressed need for high-quality science education, very little research has been conducted on what middle school science learning opportunities look like in practice. This study was conducted in support of *Strengthening Science Education in California*, a research, policy, and communications initiative. Partners in this initiative are the Center for the Future of Teaching and Learning at WestEd; the Lawrence Hall of Science at the University of California, Berkeley; SRI International; Belden Russonello & Stewart; Stone's Throw Communications; and Inverness Research. The research conducted as part of this initiative was designed to provide data on the status of science education in California and identify how science education can be strengthened. Our objective is to portray accurately the state of science education in California. The ultimate goal is to inform policymakers and practitioners in their efforts to strengthen science education in California.

This initiative began with a public opinion survey, resulting in the 2010 report *A Priority for California's Future: Science for Students* (Belden et al., 2010), which underscored that Californians believe science education is vital to the future of the state and want science education to be a priority for our schools. During 2010–11, we undertook a series of data collection activities including K–12 science education surveys of district administrators, elementary and middle school principals, and elementary and middle school teachers; case studies of elementary schools; and data available through existing statewide datasets.

Details on the surveys of administrators and educators are as follows:

- **Survey of district administrators**. We selected a stratified random sample of 451 districts across the state from the full list of California unified, elementary, and high school districts. In each district, we asked the individual primarily responsible for science education to respond to a series of questions about district policies and practices. Questions were asked specifically about science in middle school

grades (usually grades 6–8), and this report draws on responses to those questions. Response rate: 62%.

- **Survey of middle school principals**. We selected a random sample of 300 middle schools in the state and surveyed the school principal about science education policies and practices. Response rate: 56%.
- **Survey of middle school teachers**. In each of the 300 middle schools in the principal survey, we selected up to five teachers (depending on school size) at random for a total of 781 teachers and asked them to complete a survey on their teaching of science, their preparation, and the support they receive. Response rate: 85%.

This report responds to the need for timely and actionable data on the status of middle school science education and describes the status of science education in California public middle schools. For this study, we focused only on schools that are considered "middle schools" by the California Department of Education. Middle schools in California come in a variety of configurations, but the majority cover either grades 6 to 8 or grades 7 to 8. We excluded K–8 schools because they include middle school grades in an elementary setting. Exhibit 1-1 describes the middle schools in this study.

Exhibit 1-1
Grade Level Configurations of Participating Middle Schools

Grade Configuration	Percentage of Schools
5–8	5
5–9	1
6–7	1
6–8	65
6–9	2
7–8	27

CHAPTER 2
ACCESS TO SCIENCE IN CALIFORNIA MIDDLE SCHOOLS

> [Science] *is an incredibly important subject…I think we could have a huge impact on the way children see the world if we, as teachers, could teach science the way we know it needs to be taught.*
>
> — *Middle School Science Teacher*

Unlike in elementary schools, where we found that many students have limited exposure to science learning opportunities, most students in middle school participate in science class. In sixth through eighth grades, almost all districts (95%) reported that more than three-quarters of their students are enrolled in science courses. Moreover, science instruction is departmentalized in most middle schools (87% from district survey), meaning that individuals and resources are dedicated primarily to teaching science. Departmentalization is designed to have multiple benefits: 1) teachers who are dedicated to a single subject and can become or are already experts in the content; and 2) better instruction because teachers can focus on creating a few high-quality lessons that are then offered to many students through different periods or classes.

Although students receive dedicated time for science and access to basic equipment and facilities, they are not necessarily engaged in high-quality science learning experiences during that time.

Most students participate in science class in middle school, but the quality and substance of science learning opportunities vary.

> [I would like more] *freedom to teach so that students are engaged and motivated by the content and activities* [and] *flexibility to adjust the pace based on student interest and ability rather than the rigid pacing guide I created to cover all the standards before the CST test.*
>
> — *Middle School Science Teacher*

Although students receive dedicated time for science and access to basic equipment and facilities, they are not necessarily engaged in high-quality science learning experiences during that time. As described in Chapter 1, high-quality science education must regularly include opportunities for students to learn about what scientists really do and use the language of science. It must provide opportunities for students to engage in the practices of science and scientific reasoning. Through these approaches, students should learn the core concepts related to the big ideas of science.

To learn more about the patterns of current instructional practices, we asked middle school science teachers about how frequently they used different practices. Exhibit 2-1 shows the distribution of their responses.

Exhibit 2-1
Frequency of Use of Instructional Practices in Middle School Science Classrooms (percent)

Practices that provide opportunities to:	Always/Often	Sometimes	Seldom	Never
Learn foundational facts and knowledge				
Read a textbook	28%	39%	29%	5%
Watch demonstration	38	52	9	1
Take notes and listen	57	36	7	0
Answer textbook or worksheet questions	44	43	12	2
Watch audio-video presentations	36	55	9	1
Engage in the practices of science				
Work in groups	73	25	2	0
Do hands-on activities	56	35	8	1
Record or analyze data	44	44	11	1
Design their own investigations	8	36	44	12
Do fieldwork	2	10	32	56
Support English language learning				
Read non-textbook materials	11	41	41	7
Write reflections	32	37	22	10
Present to the class	16	43	34	7

Source: 2011 Statewide Science Education Survey of Middle School Teachers.

We estimate that 14% of middle school teachers use a pattern of classroom practices that supports regular engagement in the practices of science.

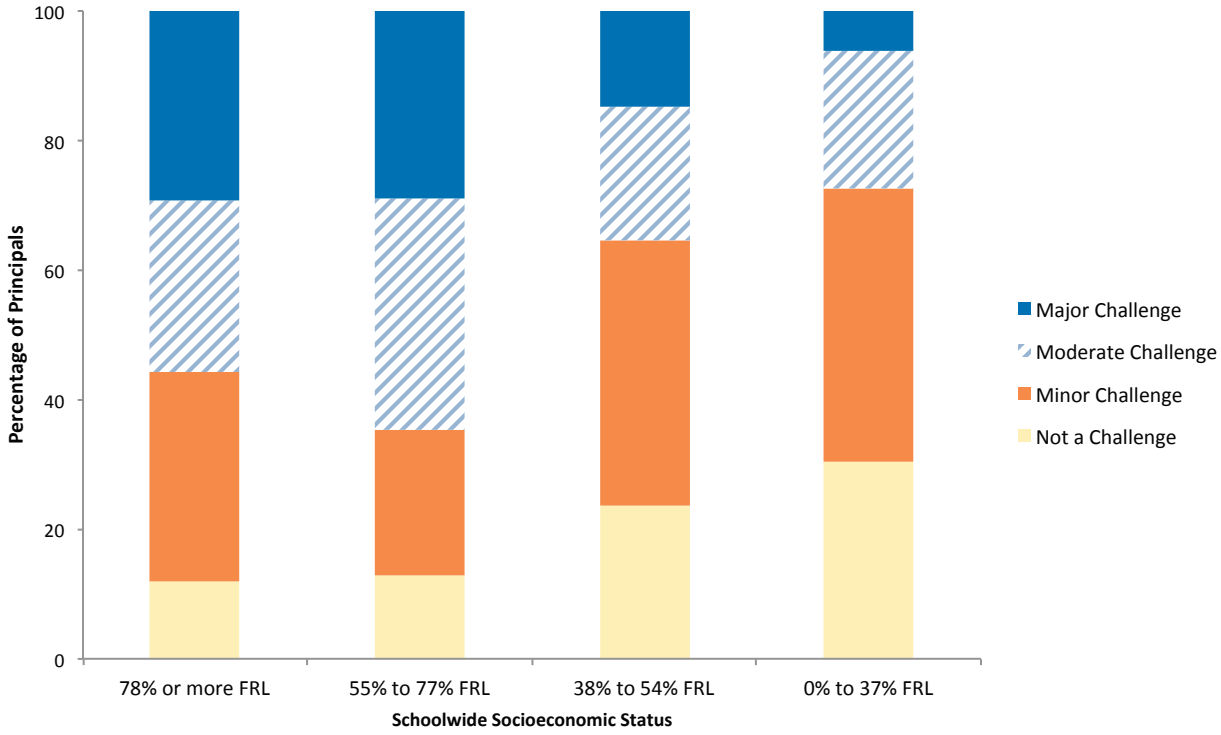
Across all middle school teachers in our sample, we estimate that 14% use a pattern of classroom practices that supports regular engagement in the practices of science. This pattern of practices includes regular student engagement in all the following: work in groups; do hands-on or lab science activities or investigations; design or implement their own investigation; participate in fieldwork; record, represent, or analyze data; write reflections; and present to the class. Teachers who use these practices regularly may reap myriad benefits. One teacher wrote, "I have a very strong hands-on, standards based approach to teaching science. I have found this to be very effective in maintaining discipline, engagement, and understanding the concepts in my classroom."

Despite these benefits, and despite time and departments dedicated to science, the percentage of teachers who are able to provide high-quality science learning experiences regularly is only slightly higher in middle school than it is in elementary grades (see Dorph et al., 2011).

The commonality of these instructional practices often varied by science discipline. Teachers who teach physics were more likely to offer science

demonstrations than non-physics teachers (45% of physics teachers vs. 28% of teachers who do not teach physics). We found the same trend for how frequently teachers offered hands-on activities (63% vs. 49%) or asked students to record and analyze data (55% vs. 30%). Similarly, physics teachers were less likely to ask students to read textbooks (25% vs. 32%) or other materials (9% vs. 14%) in class. Biology teachers were less likely than non-biology teachers to ask students to record and analyze data (39% vs. 49%).

Exhibit 2-2
Principals' Assessment of the Degree of Challenge in Students Not Being Prepared for Middle School Science



FRL: Participates in federal free or reduced-price lunch program
Source: 2011 Statewide Science Education Survey of Middle School Principals.

The lack of student preparation may explain some of the instructional choices teachers make, as they feel they cannot ask students who have little knowledge of science to design their own investigations. As one teacher said, "When I receive the students as seventh-graders, they have had almost no science; I must start from scratch and teach them everything from the basics through biology." Almost half of principals (47%) believed that lack of student preparation is a major (21%) or moderate (26%) challenge. This is particularly true for low-socioeconomic status (SES) schools: While 30% of principals in the lowest quartile SES schools thought that student preparation was a major challenge, only 6% of principals in highest quartile SES

schools thought this (Exhibit 2-2). This finding corroborates what we learned as part of the *High Hopes* research: 40% of elementary teachers reported that their students receive 60 minutes or less of science instruction per week. The lack of consistent science instruction in elementary schools presents another challenge for middle school teachers as they struggle to find a common ground or starting point for teaching science. One teacher commented, "Students come ill prepared from elementary years, and we get a mixed bag of students from five different feeder schools."

Further, the comments from middle school teachers also aligned with our findings about the learning experiences students were exposed to in their elementary years. That is, students may have good knowledge of facts but do not know how to conduct investigations. Said one teacher, "Students at my school are very good at worksheets, terrible at inquiry-based learning."

Many teachers in both elementary and middle schools recognize this problem and would like more support to address it. In our research with elementary teachers and this current research, we found that teachers want opportunities to meet cross-level to align learning experiences for students. As one middle school teacher said, "I would like to schedule time to work with the elementary teachers to discuss how their practices affect my classroom." In the survey of elementary teachers for the *High Hopes* report, we found only 10% felt that they received adequate support from the district to work with middle school teachers. Similarly, only 10% of middle school teachers felt they received adequate support from the district to work with elementary teachers.

CHAPTER 3
CONDITIONS THAT SUPPORT SCIENCE LEARNING IN MIDDLE SCHOOLS

> *Good teachers make all the difference.*
>
> *— Middle School Science Principal*

> *It is certainly tough to be a good teacher these days: work with large class sizes, spend my own money for lab/science materials that will interest the students, buy my own copy paper since I know the school budget is tight, have major discipline problems, have little to no support from parents...*
>
> *— Middle School Science Teacher*

As there is a consensus about the need for students to have opportunities to learn about the practices and language of science, there is also a growing consensus that teachers require a base level of knowledge and skills, with subject content knowledge deep enough and instructional method skills broad enough to deliver a high-quality curriculum to each and every student (National Board for Professional Teaching Standards, 1989). Whether all teachers are adequately prepared is a subject of debate. The recent *Framework for K–12 Science Education* describes the gaps in qualifying teachers to teach middle school science: "State licensure requirements and the content of state licensing exams suggest that the requirements in science are fairly weak for elementary teachers and probably inadequate for middle school teachers" (NRC, 2011, p. 182).

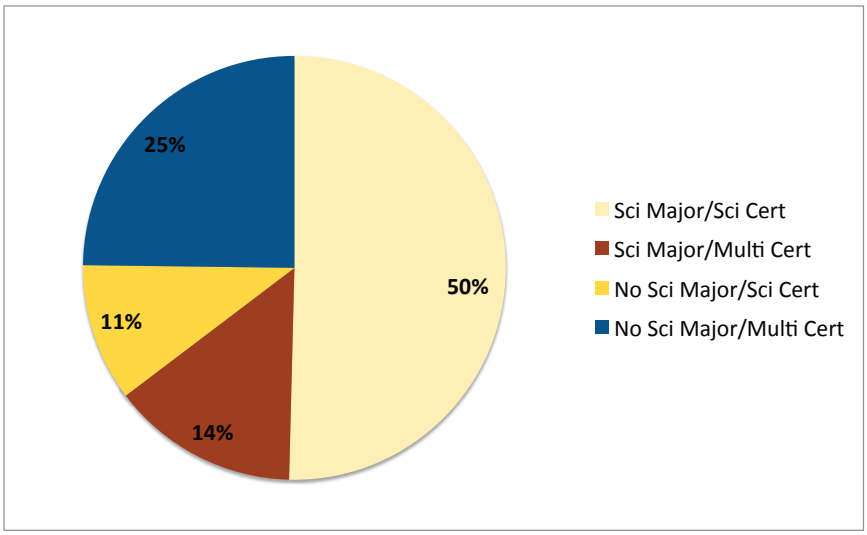
***The extent of teacher preparation in science varies*.**

We found that 75% of middle school teachers had a background in science, meaning that they had majored in a science discipline in college and/or obtained a single-subject credential in science (Exhibit 3-1). Because middle school science teachers often teach multiple subjects—57% of teachers teach two more science subjects—they must have a strong enough content background to teach students in each subject. Ideally, middle school science teachers would hold a single-subject credential that requires them to demonstrate subject matter competence in science. However, California allows middle school science teachers to hold a multiple-subject credential as well.[2]

[2] The Multiple Subject Teaching Credential authorizes the holder to teach in a self-contained classroom in which several subjects are taught by the same teacher to the same group of students. Most elementary schools are organized around self-contained classrooms. The Multiple Subject Teaching Credential is also an authorization to teach in middle school core programs and, with relevant supplementary authorizations, in subject-oriented departments (e.g., math or science). In addition to standard foundations, methods, and field-based practicum courses, preparation for this credential includes the study of language acquisition and instructional strategies for second language learners.

In 2010–11, 38% of middle school science teachers reported holding a multiple-subject credential rather than a single-subject credential in a science field (including general science). Almost a quarter of those middle school science teachers (24%) who reported holding a multiple-subject credential did not have a college major in a science subject. These teachers teach in all grade levels, sixth to eighth. Exhibit 3-1 shows the breakdown of teachers' science background. While middle school teachers with multiple-subject credentials received more professional development in science than their elementary school counterparts, they received less than teachers who already had a background in science.

Exhibit 3-1
Teacher Science Background



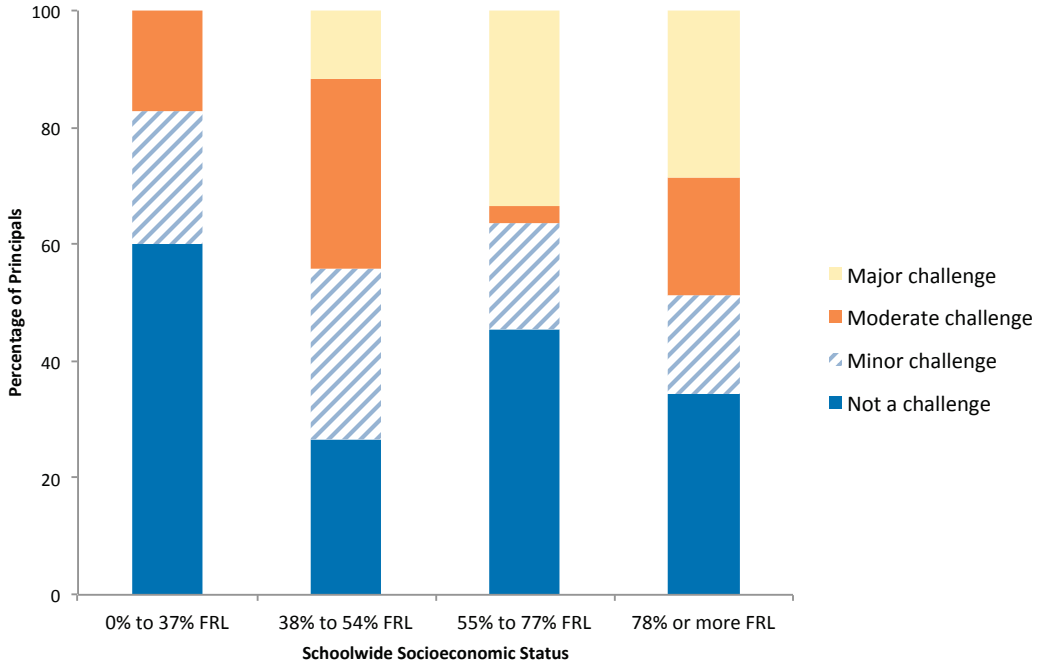
Source: 2011 Statewide Science Education Survey of Middle School Teachers.

Although no principals in schools serving the fewest low-income students thought finding qualified teachers was a major challenge, 31% of principals at the schools serving the most low-income students thought so.

One of the more common certifications that middle school science teachers hold, outside science, is math, perhaps because math and science are seen to be closely aligned. But, as one teacher said about the students in her school, "In sixth grade, they are supposed to get science, but because of the science teacher being also the math teacher, *only* math is taught."

One reason why teachers are asked to teach outside their area of expertise is that qualified teachers, particularly those with science degrees, are hard to find. Thirty-six percent of principals believed that it is a major or moderate challenge to find qualified science teachers. However, this finding varied significantly by the SES of the school. Although no principals in schools serving the fewest low-income students (highest quartile SES schools) thought finding qualified teachers was a major challenge, 31% of principals at schools serving the most low-income students (lowest two quartiles SES) thought so (Exhibit 3-2).

Exhibit 3-2
Principal Assessment of the Degree of Challenge in Finding Qualified Teachers



FRL: Participates in federal free or reduced-price lunch program
(X^2 = 28.054; df = 9; p = .001)
Source: 2011 Statewide Science Education Survey of Middle School Principals.

Teachers have limited access to high-quality instructional materials.

> *The district-adopted texts are not appropriate for these students. They need curricular materials that are engaging, develop higher order processing skills, and provide experiential opportunities.*
>
> — *Middle School Science Teacher*

Teachers use a variety of instructional materials in middle school science classrooms. In addition to the district-adopted materials, 81% created materials by themselves or in collaboration with colleagues. One-fifth (20%) had inherited materials from other teachers. Teachers try to choose materials based on their students' interests or reading levels. One teacher wrote that "[my class has] 98% English Learner [students] so I try to find accessible materials for their lower levels of reading comprehension."

Even with an interest to use more hands-on materials, teachers do not always have adequate resources to provide these lessons for students. One teacher wrote, "I would love to have access to science lab kits. I was told that 40% of my instruction should be hands-on learning for the students, but I don't have the resources to do hands-on learning even 10% of the time."

Teachers reported that they struggle to seek out or develop good-quality hands-on materials. According to one teacher, "Science needs to be hands on. It would be nice if I was supported in developing labs that teach the curriculum and if the administration appreciated that a science classroom should look different from a language arts classroom."

But any new materials would need to be feasible for implementation within existing school conditions. One teacher wanted more "…ideas for labs with larger class sizes, management strategies with labs, and inexpensive lab materials." Instructional activities that require extensive setup time or investment in materials will not work in today's large class sizes. Kits that were originally designed to be implemented with 20–25 students are difficult to use in classrooms that have populations above 35 students.

Access to facilities and equipment varies.

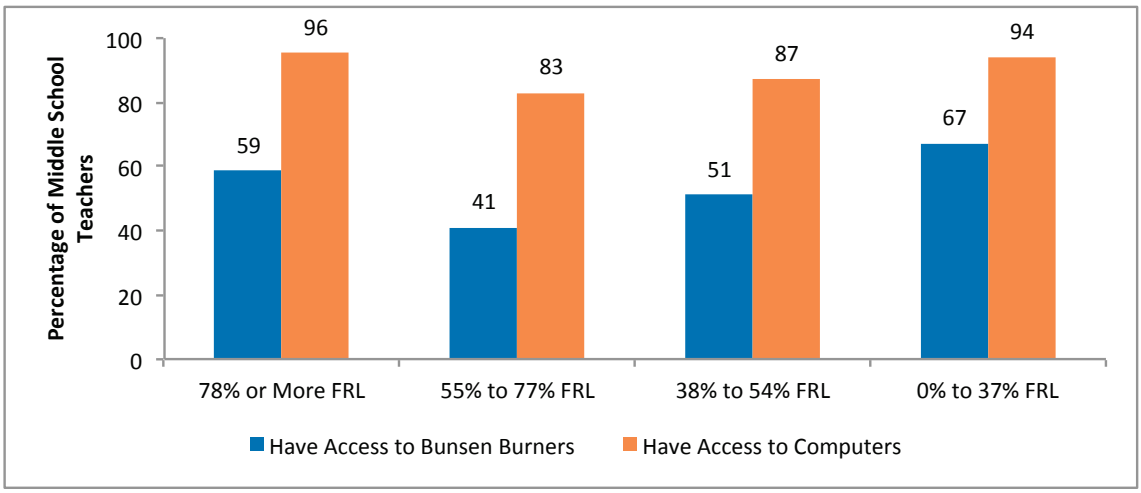
> *The main challenge for labs is my facilities. I have the equipment, but my classroom is a portable with one pump sink and carpeted floors.*
>
> — *Middle School Science Teacher*

In addition to having dedicated time, we found that science teachers have access to equipment and facilities, although this appears to vary significantly among schools. Basic equipment is found in most middle schools: Over 95% of middle school science teachers had white boards in their classroom, and over two-thirds had access to the Internet and important equipment such as measurement tools (e.g., graduated beakers) and a sink. Further, whether science teachers had access to these basic materials did not vary by schoolwide SES.

When it comes to more specialized or resource-intensive equipment, we did find some differences by SES and not always in predictable ways. For example, while overall 32% of teachers had access to an electronic whiteboard in their classroom, 41% of teachers in low-SES schools had this access, compared with 26% of teachers in high-SES schools. We also found that access to equipment such as Bunsen burners and computers was most likely in both the highest and lowest SES quartile schools and less likely in the middle two quartiles (Exhibit 3-3).[3] It is possible that compensatory funding for low-performing schools may provide some hedge against the current economic difficulties California faces (Bland et al., 2011).

[3] Although equipment such as electronic whiteboards and Bunsen burners is not required for high-quality science instruction, the fact that science teachers have access to them often indicates a willingness to spend limited resources on science. Further, just because teachers have access to specialized equipment does not necessarily mean that they have received training in how to use it to its full potential.

Exhibit 3-3
Access to Equipment by Schoolwide Socioeconomic Status



Bunsen burners: $X^2 = 20.940$; df = 6; $p = .002$
Computers: $X^2 = 17.037$; df = 6; $p = .009$
Source: 2011 Statewide Science Education Survey of Middle School Teachers.

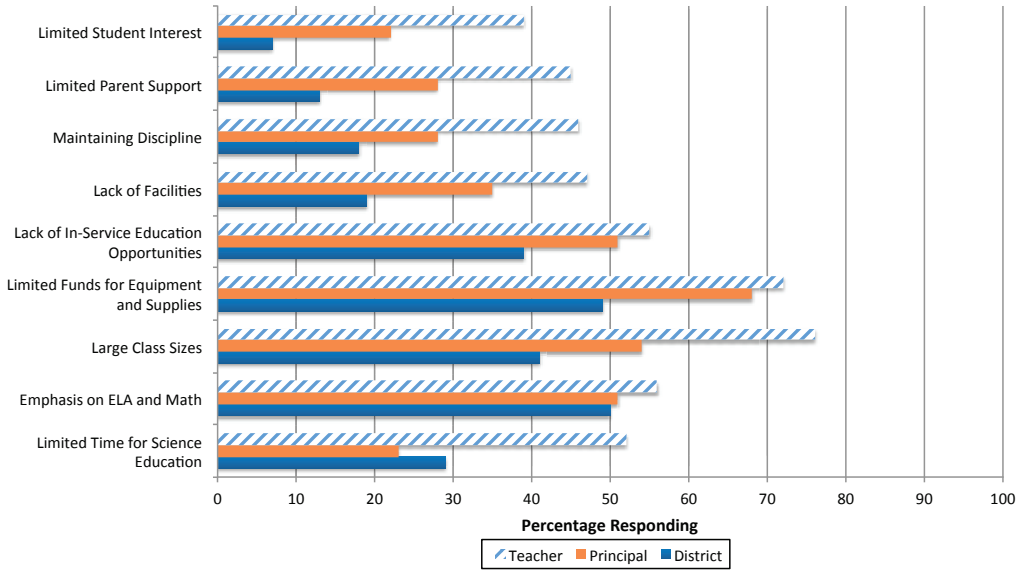
Time and consumable resources are in short supply.

> *Students love labs, but there is not the space to store labs that take multiple days, and it is already hard enough to teach all the standards in the school year.*
>
> *— Middle School Science Teacher*

We asked district personnel, principals, and teachers to describe the challenges they face in providing high-quality science in middle schools. Teachers, who have the most familiarity with implementing science instruction in the classroom, were more likely to see challenges than principals and district personnel (Exhibit 3-4). This suggests that the seriousness of the crisis and the urgency to address the issues in middle school science have not yet reached school or district administrators, making it less likely that they will adopt new initiatives to strengthen science education.

The seriousness of the crisis and the urgency to address the issues in middle school science have not yet reached school or district administrators, making it less likely that they will adopt new initiatives to strengthen science education.

Exhibit 3-4
"Major" or "Moderate" Challenges to Science Instruction



Source: 2011 Statewide Science Education Surveys of Middle School District Administrators, Middle School Principals, and Middle School Teachers.

Many of the challenges found at the elementary school level, such as inflexible arrangements for time for science learning and lesson preparation, were also found in middle schools. Although science is almost always departmentalized (87% of middle schools departmentalize science) and students attend science classes during specific periods of the day, teachers struggle to find the time to prepare for instruction adequately, to implement hands-on learning, and to cover fully the content standards. As one teacher said, "With only 55 minutes to a class, it is difficult to do labs or go into depth to make sure they have processed the content."

The general lack of funding, compounded with increasing class sizes, means that middle schools struggle to keep their materials and facilities up to date.

The general lack of funding, compounded with increasing class sizes, means that middle schools struggle to keep their materials and facilities up to date. Large class size can affect the individual student experience in many ways, including limited opportunities to actively conduct experiments. As one teacher wrote, "Students don't get to do things as in small classroom settings. Example—I didn't do anything with burners or gas so they will never experience that opportunity in my classroom. I try to replace by showing demonstrations." Large class sizes also mean that resources often need to be shared, such as when classrooms have too few computers for 39 students.

Teachers reported paying for the consumable materials required for hands-on learning out of their own pocket, without reimbursement. This not only puts a strain on the teacher, but it also limits the types of activities that can be offered to students. As one teacher said, "Labs that I can afford to pay for

myself lack some of the flair that more expensive equipment would allow. My budget from the district is small to nonexistent."

More important, teachers feel that they are pressed to teach too broadly. One teacher wrote we "really need to change the state standards—they have way too much to cover. This leaves little time for inquiry and deeper investigation." Trying to delve into the many topics that are required by the standards and appear on the state standards test leaves teachers with little "freedom to teach so that students are engaged and motivated by the content and activities."

While not as prevalent in middle schools as in elementary schools, the emphasis on English language arts and math continues to be a challenge. As one district person wrote, "Because some of our students have to take remedial English and math courses, they are not enrolled in science." Another agreed, writing, "As test scores in English language arts and math become all important, students needing intervention are being increasingly pulled from science to provide intervention time." One teacher felt that this is creating deep problems for students: "All the emphasis on education today is in English and math. No critical thinking skills are being taught." The impact of testing also affects middle school science instruction. "In my program improvement middle school, the major challenge is the emphasis on math and language arts because these areas are the tested and heavily weighted for our AYP and API."

This can affect how teachers teach science, placing an emphasis on book learning over inquiry:

> We constantly feel the pressure to focus on math and reading. While both are essential in science, the district wants us to do more than just using it to learn science. This starts to take away time from doing an inquiry lab with my students. For example, rather than doing a reading on chemical change, I would rather have the students do some reactions and have them come up what they all have in common, and they are all similar because new chemicals are forming. District would like us to do word problems galore on density but I would rather have them measure the volume of an object, look up its density in a chart, and then calculate its mass.

Students are often uninterested and unengaged.

> [My main challenge is] *student apathy and lack of the drive to do anything on their own. They don't want to do anything unless you are leading them and telling them what to do in each step. They don't think science matters.*
>
> — *Middle School Science Teacher*

The lack of student interest in science, which elementary teachers did not find a problem in the *High Hopes* study, appears as a moderate challenge in middle schools. One possible explanation may be a result of state and federal policy focusing instruction on English language arts and mathematics and placing a high premium on testing. As one teacher said, "My students come in with zero science instruction due to the district's and state's emphasis on math and English language arts (ELA) testing. Quite simply, the lower grades do not have time to teach science. The effect of this is that students have been burned out at school and do not care; they feel like they are valued only as test scores."

Some teachers felt that the lack of student interest happens before middle school. As one teacher said, "Students are not getting science in elementary and it is hurting students in middle school because they are coming in with the attitude that they do not like science since they've never done it. They have some serious misconceptions before they even step in the door and have difficulty thinking scientifically because of it." The result is that nearly 40% of middle school teachers felt they begin with an uphill struggle to motivate students to learn science (Exhibit 3-4). "A big challenge is changing the attitudes/bias that students have coming into Science. They hate seventh-grade Science, and I do believe it is due to their experience in Science." Some middle school teachers acknowledge that elementary teachers are limited by policy in the ways they can offer science to their students. As another teacher put it very succinctly, "We are overtesting students to the point of creating apathetic disinterest."

CHAPTER 4
CREATING SUPPORTS FOR SCIENCE LEARNING IN MIDDLE SCHOOLS

> *I think science in my school is shifting back to an emphasis on engaging the learner, making enjoyment of science and inquiry a priority, and making skills and investigation a universal goal.*
>
> *— Middle School Science Teacher*

Science education varies widely in California middle schools. While in many ways conditions are more positive in middle schools than in elementary schools, we found much evidence that resources are underutilized and opportunities are missed. Much of the instruction in classrooms is rote learning, focused on textbook and lecture and without exposure to the practices and language of science. Students at schools with limited resources (which are not always the schools where students are from the lowest socioeconomic strata) lack access to equipment and materials, such as electronic whiteboards and computers, which would support a richer learning environment. And many teachers believe that their middle school students lack interest in science.

While in many ways conditions are more positive in middle school than in elementary schools, we found much evidence that resources are underutilized and opportunities are missed.

Despite this, our research indicated that many individual teachers, principals, and district administrators are striving to find solutions to the challenges they face. Although large-scale initiatives are rare, many have found even incremental changes in a variety of areas can help. Many individual teachers seek out and receive professional development and access to expert knowledge. Districts provide personnel who are dedicated to science instruction. Finally, schools and districts develop partnerships with external organizations to deliver and/or fund high-quality science instruction.

Teachers seek and find professional development.

> [I've attended great] *workshops that teach hands-on, inquiry-based labs step-by-step (taught by other science teachers, usually specific to grade level) with written instruction to take back to the classroom. It's a great way to get new ideas and implement them into the classroom.*
>
> *— Middle School Science Teacher*

Although 75% of middle school science teachers have a background (college major or certification) in science, ongoing professional development helps them learn both new content and new pedagogical strategies. Because science changes so rapidly, even teachers with higher education degrees in science struggle to keep up with latest developments. Professional develop-

ment helps fill these gaps and offers teachers the opportunity to stay abreast of both the new scientific discoveries and improved methods for providing quality science instruction.

Teachers did report receiving professional development: Two-thirds of middle school science teachers received some professional development in science over the last three years. Professional development, when received, was frequently extensive in duration: Almost half of teachers (43%) received 16 or more hours of professional development. Most commonly, professional development was delivered through the district office.

Despite this, more than half of teachers rated the lack of professional development opportunities as a major or moderate challenge on our survey. Teachers would like to receive more professional development in both pedagogy and content, and they recognize that students benefit from their improved knowledge. One teacher summed this up by writing, "I would love to continue to learn about new discoveries in science and to develop a deeper understanding of chemistry and physics as well as research in teaching and learning." Another added, "My students benefit when I improve my content knowledge." Other teachers reported that the training they receive is often not directly related to their current needs: "I would like to have more in-services from district and county personnel to further my science teaching practices. I feel somewhat stuck and have [few] opportunities to learn new science-based strategies."

District personnel can support high-quality middle school science.

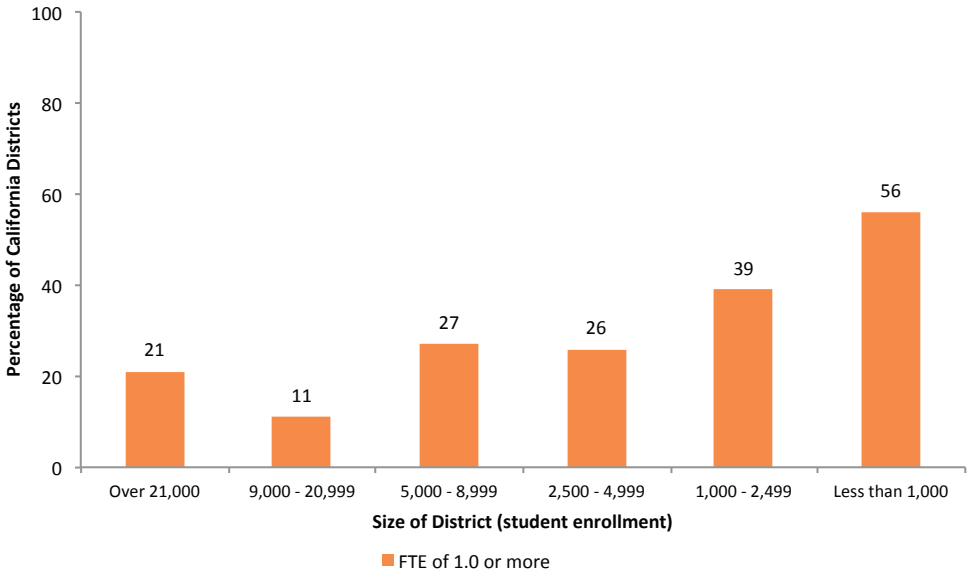
> *We have excellent support from administration in science. They encourage us to try new things and to make science education a hallmark of our school.*
>
> — *Middle School Science Teacher*

Having access to someone at the district office who provides ongoing support for science instruction can be a key component of a strong science program. District personnel can coordinate the selection of curricula or ensure that materials and other resources are easily accessible and up to date. They can also act as a liaison with state or county offices; help align science programs among elementary, middle, and high schools; or seek out professional development opportunities for teachers or offer one-on-one coaching.

In this era of funding cuts, districts have been challenged to provide consistent support for science. Currently, only slightly over half of districts (52%) have someone who is at least partially dedicated to supporting science instruction for middle schools. Across all districts, 31% have the equivalent of at least one full-time person. This is more common among smaller districts

than larger districts (Exhibit 4-1). About 12% of districts have reduced the number of science specialists in the last two years; about half of those said they did so because of budget constraints.

Exhibit 4-1
California Districts Reporting District Dedicated Staff to Support Middle School-level Science, by District Size (percent)



Source: 2011 Statewide Science Education Survey of Middle School District Administrators.

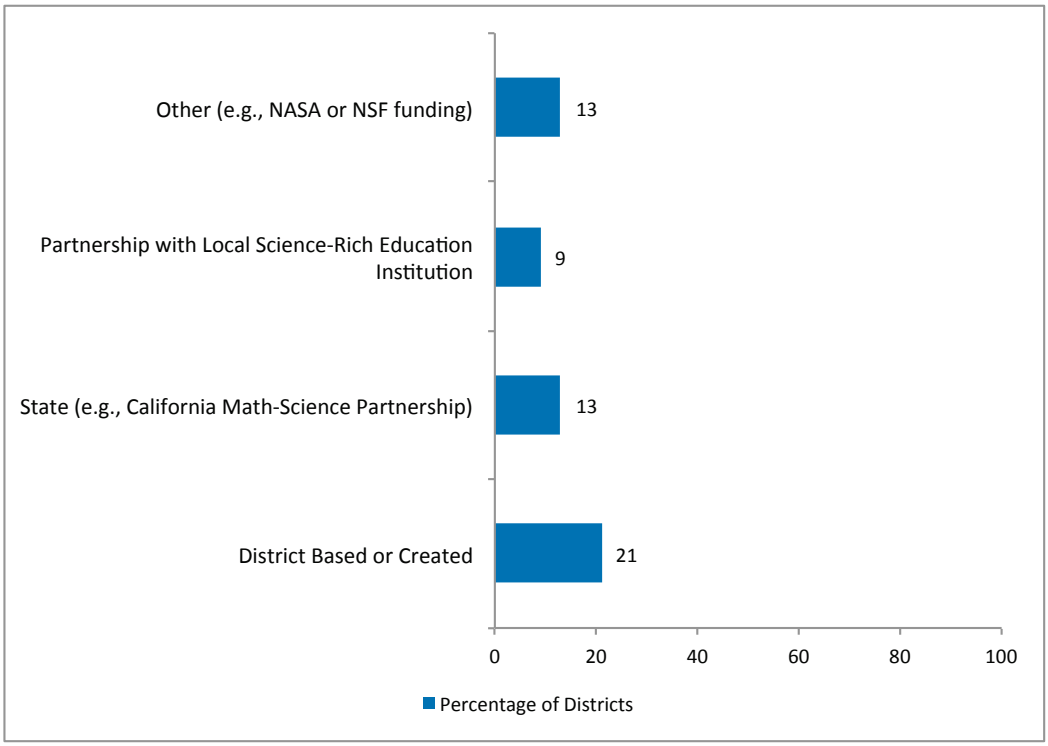
In response to an open-ended question about what additional support they would like to receive, one common theme was that teachers would like to see more support from the district office. In particular, they would like to see the district office become more involved in ensuring students come in to middle schools prepared to do science by addressing the neglect of science during the elementary school years.

> My district puts so much emphasis on language arts and math that science in elementary education is all but gone. Most students come into my class with very little understanding of science and how the world works. Yet I need to cover the 8th grade science standards (which there are too many to cover in the school year) which should be built upon some prior knowledge.

New initiatives and external support that can bolster science education in middle schools are rare.

Partnerships with external organizations can provide resources or an impetus for a new science initiative. Yet as we found true of elementary science in the *High Hopes* study, the majority of districts (59%) have not participated in a major middle school science initiative in the last five years. Exhibit 4-2 shows the sponsoring organizations behind various initiatives. (Note that some districts participate in multiple initiatives while others participate in none.) Of those that did, district-based initiatives, without deep external partnerships, were the most common.

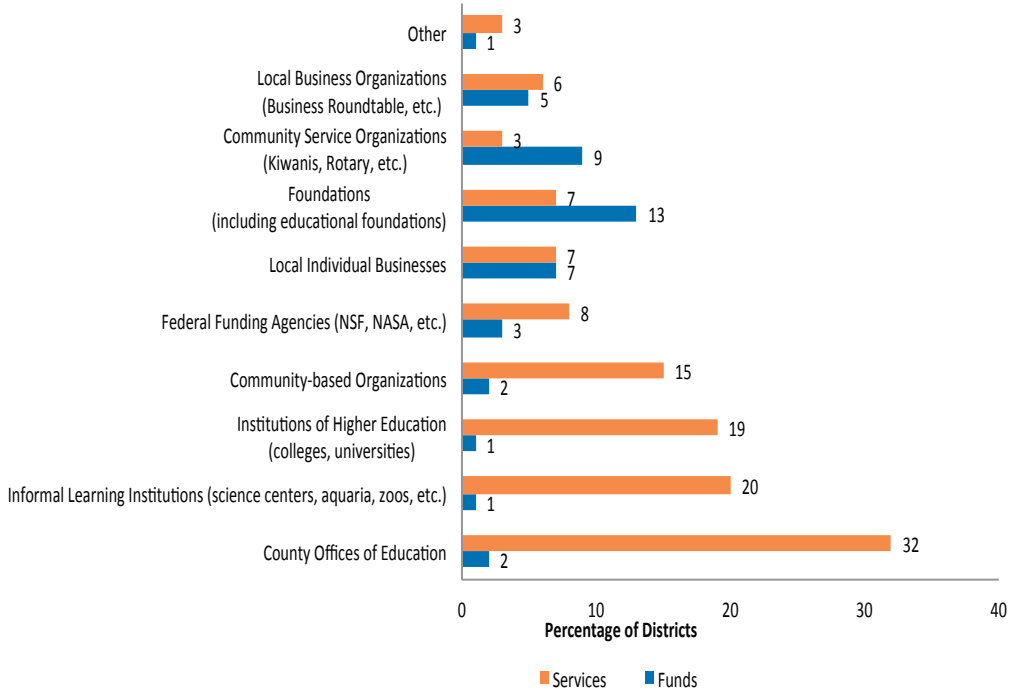
Exhibit 4-2
California Districts with Recent Middle School Science Education Initiatives, by Sponsoring Organization (percent)



Note: Districts may participate in multiple initiatives
Source: 2011 Statewide Science Education Survey of Middle School District Administrators.

Even without a major initiative, or maybe because of the lack of major initiatives, schools and districts look to external organizations to provide support. Slightly over half (55%) of middle schools principals reported receiving services from external organizations, and just over one-third (34%) report receiving funds. Exhibit 4-3 provides detail on the findings from district administrators.

Exhibit 4-3
California Districts with Support from External Organizations for Middle School Science (percent)



Source: 2011 Statewide Science Education Survey of Middle School District Administrators.

The types of supports schools and districts receive ranged greatly. One district person described receiving professional development and funding support from the local institute of higher education:

> We have a proactive science department. We get all science professional development paid for by [a program at our local college]. There are no out-of-pocket expenses for the district for our professional development. We also receive a small amount of dollars for our classroom through [the program]. We are in the process of a major project that will increase our connections with the elementary schools for science.

Other districts reported having used funds from foundations to initiate after-school programs in science for middle school students.

CHAPTER 5
CONCLUSION

California citizens, parents, and educators recognize the importance of education that prepares all students for college and careers. They believe that quality education can help protect our state from continuing economic decline. Californians are particularly interested in science education and believe that it is vital to the future of the state. The California education system, however, is far from meeting these ideals. The goal of a "full and balanced curriculum" is unrealized.

Students do not have the opportunities they need to participate in high-quality science learning experiences because the conditions that would support such learning are rarely in place. We estimate that only about one in seven California middle school students regularly are exposed to the kind of science learning experiences consistent with the emerging national consensus of what is needed. Across the state, middle school teachers confront large class sizes, limited access to equipment and necessary materials for science experiences, and students who all too frequently have lost interest in science.

Yet the state's middle schools are in many ways well positioned to offer science instruction. Teachers for the most part have a background in science content or science education, and most have received recent professional development in their field. Students have time reserved for science class. These conditions suggest great potential, but this potential remains untapped. Too few students are regularly engaged in high-quality science learning experiences. Middle school teachers find their students have lost interest in science or have not had adequate opportunities to engage in science learning in the elementary years. As a result, precious hours are lost to remediating students that could be better spent deepening their understanding of and engagement in science. Limited and reduced resources, combined with large class sizes and pedagogical preferences, produce barriers to investigative or hands-on science experiences. Districts and schools struggle to develop relationships with external partner organizations that might otherwise provide additional supports or benefits. Further, resources coming from outside organizations are scarce and offer no adequate substitute for shrinking state and federal investment in science instruction.

These shortcomings are rooted in part in the state and federal accountability systems that place the greatest emphasis on English language arts and mathematics, which consequently receive the lion's share of political and fiscal attention. In addition, over the past decade, the infrastructure for supporting science education in California has eroded significantly. Statewide programs have suffered with the budget crisis. The result is that California

does not have a coherent system that enables teachers and schools to consistently provide middle school students with high-quality science learning experiences.

In schools and districts, it is imperative to encourage and support educators to use instructional practices that promote the quality and quantity of science learning. During these challenging economic times, leadership and strategically targeted resources are critical. Leveraging both education and community resources is important to strengthen science education. In the long term, as California commits itself to helping to implement the new Common Core State Standards that are informed by the national standards and in line with the National Research Council's vision for science education, the state needs to allocate resources to make that vision a reality.

As a whole, California needs a new road map for supporting science learning in public schools. Policymakers must review and revise the accountability, resource allocation, and support systems that are driving science education out of our public schools. Strengthening science education must be a priority.

REFERENCES

Belden, N., Lien, C., & Nelson-Dusek, S. (2010). *A priority for California's future: Science for students.* Santa Cruz, CA: The Center for the Future of Teaching and Learning. Retrieved from http://www.cftl.org/documents/2010/2010SciCFTL4web.pdf

Bland, J., Sherer, D., Guha, R., Woodworth, K., Shields, P., Tiffany-Morales, J., & Campbell, A. (2011). *The status of the teaching profession 2011*. Sacramento, CA: The Center for the Future of Teaching and Learning at WestEd.

California Department of Education (CDE). (2007). *Taking center stage, act II*. Available at http://pubs.cde.ca.gov/tcsii/abouttcsii/aboutcsiiindex.aspx

Curriculum Development and Supplemental Materials Commission. (2004). *Science framework for California public schools, kindergarten through grade twelve*. Sacramento, CA. Retrieved from http://www.cde.ca.gov/ci/cr/cf/documents/scienceframework.pdf

Dorph, R., Shields, P., Tiffany-Morales, J., Hartry, A., & McCaffrey, T. (2011). *High hopes—few opportunities: The status of elementary science education in California*. Sacramento, CA: The Center for the Future of Teaching and Learning at WestEd.

Fordham Institute. (2012). *The state of state science standards.* The Thomas J. Fordham Institute. Retrieved from http://www.edexcellencemedia.net/publication/2012/2012-State-of-State-Science-Standards/2012-State-of-State-Science-Standards-FINAL.pdf

Michaels, S., Shouse, A. W., & Schweingruber, H. A. (2007). *Ready, set, science! Putting research to work in K-8 science classrooms.* Board on Science Education, Center for Education, Division of Behavioral Sciences and Education. Washington, DC: The National Academies Press. Retrieved from http://www.nap.edu/catalog.php?record_id=11882

National Board for Professional Teaching Standards. (1989). *What Teachers Should Know and Be Able to Do.* Retrieved from http://www.nbpts.org/UserFiles/File/what_teachers.pdf

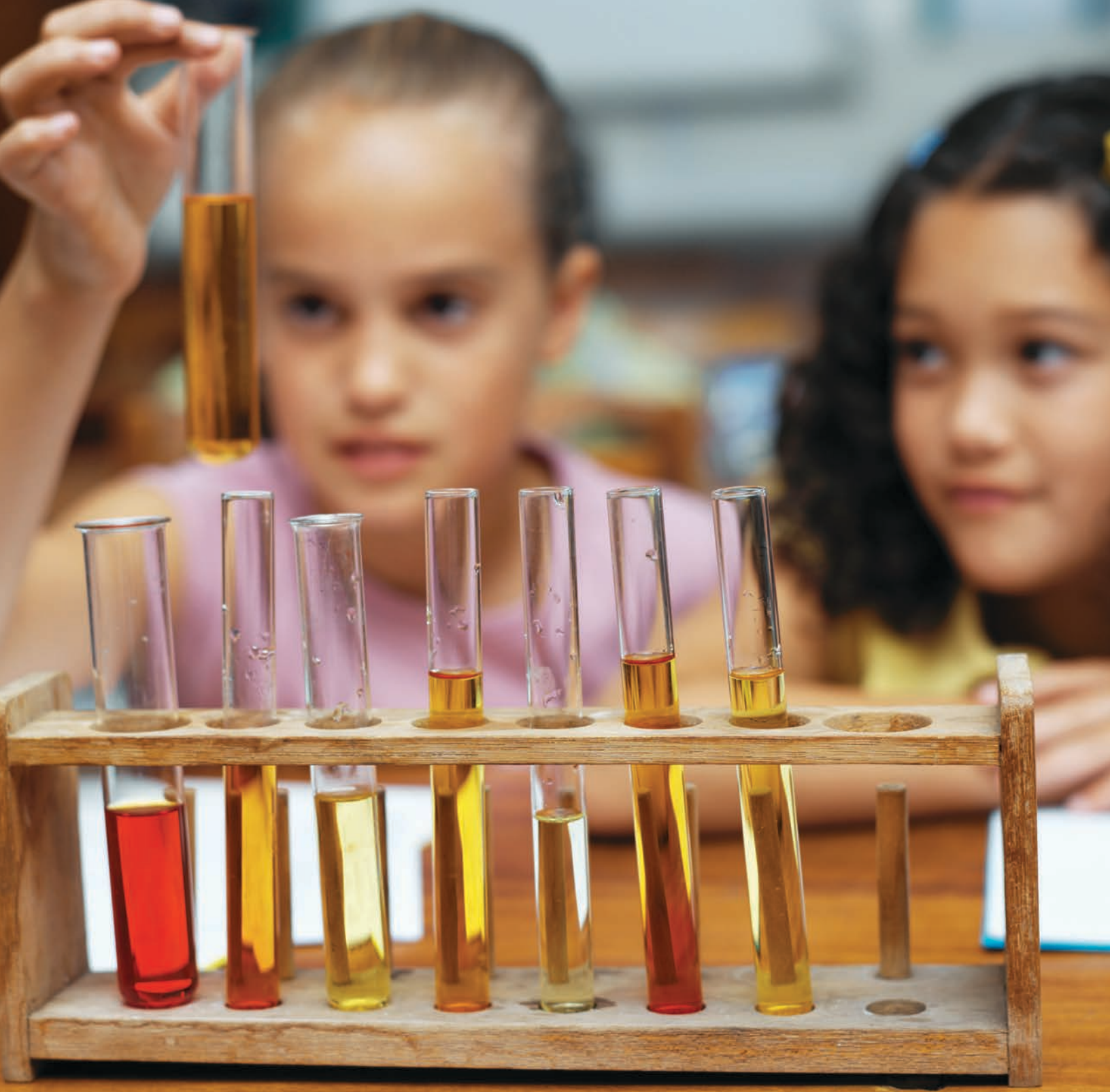
National Research Council (NRC). (2007). *Taking science to school: Learning and teaching science in grades K-8*. Committee on Science Learning, Kindergarten Through Eighth Grade. R. A. Duschl, H. A. Schweingruber, & A. W. Shouse (Eds.), Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press. Retrieved from http://www.nap.edu/catalog.php?record_id=11625

National Research Council (NRC). (2011). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Committee on a Conceptual

Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press. Retrieved from http://www.nap.edu/catalog.php?record_id=13165

Transition Advisory Team. *A blueprint for great schools.* (2011). Sacramento, CA: California Department of Education. Retrieved from http://www.cde.ca.gov/eo/in/bp/bpcontents.asp

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. (2009). *National Assessment of Educational Progress (NAEP). 2009 science: The nation's report card*. Retrieved from http://nationsreportcard.gov



About this Document

This report is available for download on our website, www.cftl.org. For information on purchasing print copies from the Center, please email info@cfl.org. Discounts are available for bulk orders of single publications.

The Center is pleased to have other organizations and individuals share its materials with their constituents. To request permission to excerpt part of this publication, either in print or electronically, please contact us.

THE CENTER FOR THE FUTURE OF Teaching & Learning at WestEd

STRENGTHENING SCIENCE EDUCATION IN CALIFORNIA

www.cftl.org