

A close-up photograph of two hands holding a small green frog. The frog is covered in dark brown mud, and the hands are also speckled with mud. The background is a bright yellow color.

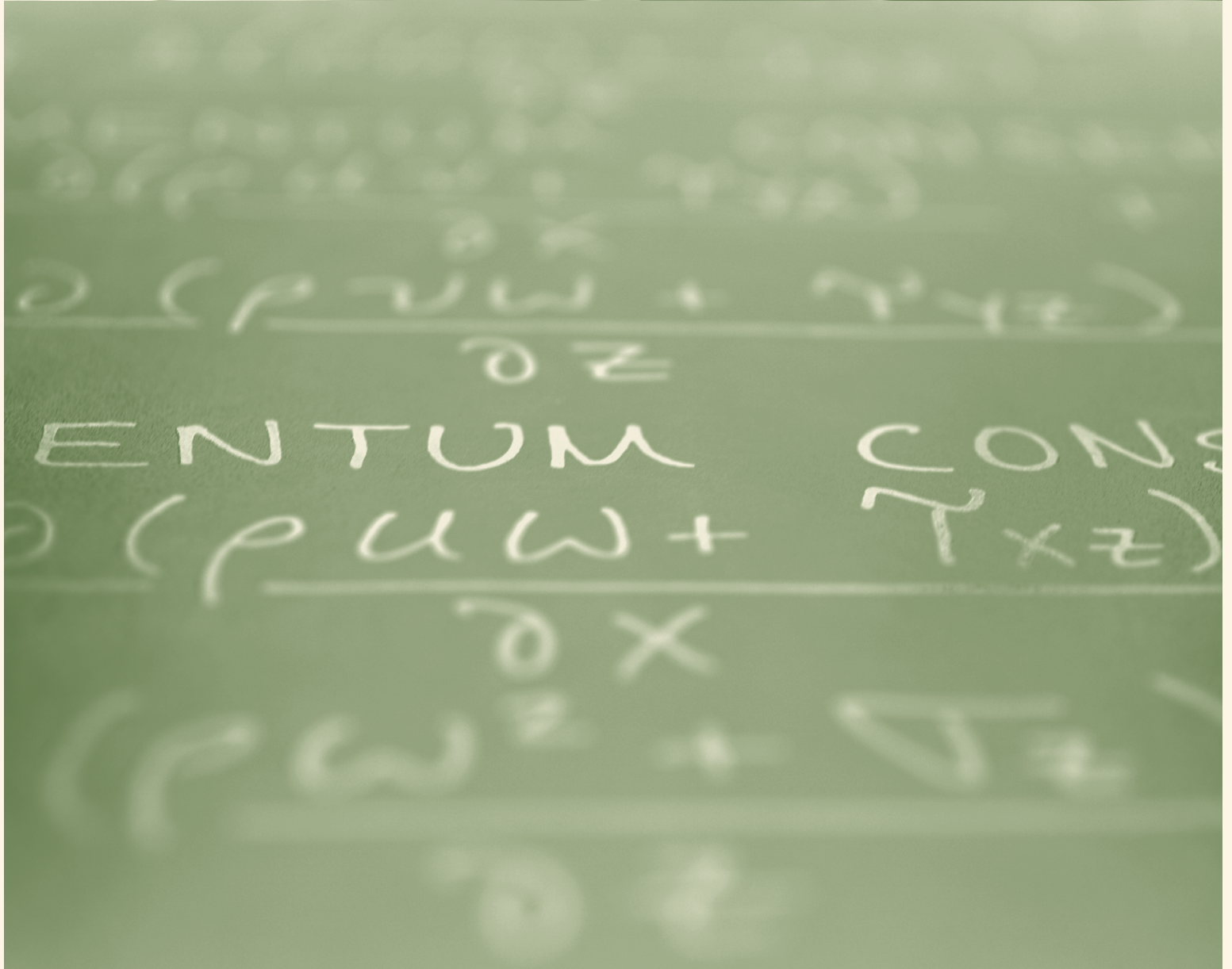
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What  
works in  
middle  
school  
science



Preparing adolescents to become  
the next generation of scientists





# What works in middle school science



Preparing adolescents to become  
the next generation of scientists

**2009 Kristen Campbell Wilcox**

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**Bolivar-Richburg Middle School/High School, Bolivar**

**Geneseo Middle School, Geneseo**

**Greene Middle School, Greene**

**Jefferson Middle School, Jamestown**

**Johnson City Middle School, Johnson City**

**Oliver W. Winch Middle School, South Glens Falls**

**Thomas C. Armstrong Middle School, Wayne**

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This report is a result of the work of all, although ultimately only the author is responsible for any omissions or misrepresentations.

K. Wilcox  
September 2009

# Middle School Science: Higher-Performing Schools

## **Bolivar-Richburg Middle School/High School, Bolivar**



## **Geneseo Middle School, Geneseo**



## **Greene Middle School, Greene**



**To provide a fuller description of each of the higher-performing schools included in our analysis, we have published an 8-12 page case study. These cases are available at [www.albany.edu/aire/kids](http://www.albany.edu/aire/kids) or <http://knowyourschoolsny.org>, and highlights from them appear throughout this report. We invite you to explore the fuller case studies and include here a brief description of each school.**

In Allegany County, one of the poorest in New York State, the Bolivar-Richburg School District was among the first rural districts in the state to centralize. Today it serves nearly 850 students, a little more than half of whom are in the middle/high school. Despite high levels of poverty, middle-level students have consistently scored well on the state's Intermediate-Level Science Examination. Educators in the district attribute their success to their personnel, including long-time, dedicated, and effective teachers; a commitment to engaging and maintaining student interest in science; a focus on meeting the needs of lower-performing students; instruction that fosters higher-level thinking while taking into account different learning styles; and using assessments to monitor progress and modify programs.

Geneseo Middle School shares a building with the high school and a campus with the elementary school and district offices in the rolling Genesee Valley, about a half-hour's drive southwest of Rochester. The community features working farms, a college campus, and a growing commercial area. About a quarter of the 1000 students overall are eligible for free or reduced-price lunch, although the percentage in the 500+ middle/high school is less. Four interrelated features may explain the school's consistent high performance in science: A strong alignment of school, district, and individual science teacher goals for students and learning experiences that support students' ability to achieve those goals; engaging students in the school and their study of science, including through the effective use of technology; dedicated staff who cooperate across grades and special and regular education; and a strong curriculum built and refined by all and well aligned across grades.

Although the population in the Chenango Valley is declining as income levels fall and the cost of living rises, the Greene Central School District still serves about 1200 students, including approximately 280 in a three-grade middle school. The middle school building was once the high school, and the science program benefits from having inherited the fairly spacious science laboratory/classroom facilities of the former high school. Teachers use that space to their advantage as they offer students a curriculum that is strongly tied to state standards and well coordinated across all grades, K-12. This coordination is made possible, in part, by district structures and a culture that support communication across all grades and subjects, creating a highly professional atmosphere. Within this setting, science teachers, in particular, express a commitment to engaging every student by making science fun and relevant to their lives, always in purposeful ways.



**Jefferson Middle School, Jamestown**



Not far from Lake Erie, the much smaller Chatauqua Lake nestles up to Jamestown, about an hour south of Buffalo. Jamestown itself is a small city with six elementary schools, three middle schools, and one high school. With parts of its industrial base disappearing, Jamestown schools face increasing levels of student poverty (more than 50% overall) and high transiency, the result, in part, of relatively high levels of rental property and relatively low rents. Jefferson Middle School has been lovingly renovated to provide students with a building they can be proud of, equipped with the technology and other features to support their learning. Dedication, collaboration, and pride mark a learning climate that expects students, no matter their background, to perform well and supports them to do so. The schedule maximizes time for instruction, and teachers use their professional judgment about how best to teach students the curriculum that has been jointly developed, mapped, and revised based on student performance and state standards.

**Johnson City Middle School, Johnson City**



Once home to the Endicott Johnson Shoe Corporation, Johnson City lies in New York's southern tier, next to Binghamton. The school district serves more than 2500 students in four buildings, one of which is the Middle School with its 575 students. The school sits atop a hill that provides a picturesque view of the Susquehanna Valley below. Committed to high achievement for all "one student at a time," the middle school has been consistently successful in science. The foundations of this success include: All teachers use instructional processes designed to support mastery by all students through reflective learning in inclusive classrooms; a respectful classroom environment within which students learn and a district within which teachers are encouraged to suggest improvements; curriculum aligned with state standards and coordinated by teachers across grades; and professional development relevant to teacher and student needs.

**Oliver W. Winch Middle School, South Glens Falls**



Oliver Winch has been identified as a School to Watch by the National Forum to Accelerate Middle-Grades Reform, an honor recognizing its high academic standards and developmentally appropriate learning opportunities. It is the one middle school in South Glens Falls, serving about a quarter of the district's 3300 students and receiving students from four different elementary schools. South Glens Falls lies across the Hudson River from the city of Glens Falls, not far from Saratoga Springs. In science education, Oliver Winch provides a supportive climate for students and staff to teach and learn in; students are known as individuals. Teachers describe the climate as "rich," with subject area teams, grade level teams, and regular-special education co-teaching teams. Science teachers are well prepared to teach science to adolescents and share a commitment to teaching the fundamentals in ways that engage students and help them see the relevance of science to their lives. And they provide a variety of learning experiences to maintain that engagement.

**Thomas C. Armstrong Middle School, Wayne**



The Wayne school district sprawls along the shore of Lake Ontario east of Rochester, serving students from a number of hamlets and rural areas, some 2615 students total in five buildings, including a 600+-student middle school. Across this large area and student population, socio-economic conditions vary widely, and students from all communities come together for the first time in the middle school. After a period of turmoil in the nineties, the school has turned around in the last decade. Student performance in science is consistently high and can be attributed to several factors, including: Districtwide practices that include a focus on literacy, differentiating instruction, and "backward design"; real-world connections to the curriculum; a cooperative and dedicated professional community; and a strict focus on New York State standards and assessments.

# Demographics of the seven higher-performing middle schools studied

District	School Name	Grade Span	Total Enrollment
Bolivar-Richburg Central School District	Bolivar-Richburg Junior-Senior High School	6-12	455
Jamestown City School District	Jefferson Middle School	5-8	390
Johnson City Central School District	Johnson City Middle School	6-8	575
Geneseo Central School District	Geneseo Middle and High School	6-12	540
Greene Central School District	Greene Middle School	6-8	284
South Glens Falls Central School District	Oliver W. Winch Middle School	6-8	828
Wayne Central School District	Thomas C. Armstrong Middle School	6-8	623
<b>New York State</b>		<b>P-12</b>	<b>2,759,648</b>



% of Students							% Proficient
F/R Lunch Eligible	ELL	African-American	Hispanic/Latino	White	Other	PPE*	Intermediate-Level Science, 2008
38	0	1	0	98	0	\$19,191	91
69	1	12	7	79	2	\$14,632	84
46	1	13	6	76	6	\$14,975	88
16	2	3	4	91	2	\$14,895	97
38	0	2	0	97	0	\$14,446	97
14	0	1	1	98	0	\$13,191	95
19	0	2	2	95	1	\$14,026	96
<b>44</b>	<b>7</b>	<b>19</b>	<b>21</b>	<b>52</b>	<b>7</b>	<b>\$17,330</b>	<b>71</b>

# Background and Overview of Findings

If it's not fun, they won't do it. —Greene Middle School Principal

“Keep it fun!” This is the response from educators when asked about how to inspire higher performance in science among adolescents. What distinguishes schools that consistently achieve better results than comparable schools, however, is all in the details of how “keep it fun” happens. Fun that is focused on what matters most in both engaging kids in science and preparing them for more complex and abstract science as they move on to high school is key.

Although keeping science fun for 11-15 year olds means different things for different students, teachers, administrators, schools, and districts, there are some broad-stroke best practices that apply to any school. This report shares findings of a study intended to identify and characterize what contributes to higher performance in science at the middle school level (for study Methods, see p. 37).

## Adolescent Scientists: What Keeps the Wonder Alive?

What understandings and ways of thinking are essential for all citizens in a world increasingly shaped by scientific inquiry and discovery? This has been an underlying question in discussions around educational reform efforts in the United States since the early 1980s (Britton, 1983). In middle school science education specifically, issues around what has been seen as insufficient preparation of middle school science teachers and what has been perceived as an overwhelming breadth of content included in the science curriculum have informed calls for reform (National Science Resources Center, 2008; American Association for the Advancement of Science, 1990; Center for Science, Mathematics, and Engineering Education, 1996).

An area of ongoing concern in regard to science education has been the achievement gap among students from lower socioeconomic backgrounds. In one three-year study,

researchers found that open enrollment in pre-Advanced Placement courses in science and an aligned curriculum need to be accompanied by other interventions in order for students to gain the confidence and motivation required to succeed in advanced courses (Friend & Degen, 2007). In other research, inquiry-based instructional methods were explored to see how they impact students' and teachers' approaches to scientific inquiry as active, engaged, and reflective (Jones & Eick, 2007; Latta et al., 2007). Another study exploring the alignment of textbooks and curriculum materials in the Benchmarks for Science Literacy (American Association for the Advancement of Science) and the National Science Education Standards (National Research Council) found that the textbooks generally did not align well in terms of assisting students in making connections between new material and prior knowledge, did not provide thorough and sufficient examples of ideas, and were lacking in alternative representations, such as models, diagrams, and analogies (Stern, 2004).



If they're interested, it's amazing. You'll watch ...a 'low-achieving student' become a high-achieving student if they want to become involved. –Bolivar-Richburg Teacher

Yet other studies have attempted to identify the influence of teacher preparation and professional development on the quality and content of middle school science instruction (Davis, 2002; Saderholm & Tretter, 2008). In several other studies, constructivist professional development strategies, a positive professional environment in which science teachers are involved in decision making (e.g., curriculum revision and material adoption), possibilities for advancement (e.g., National Board for Professional Teaching Standards Certification and conference presentations), and flexible professional opportunities (e.g., combining teaching and administrative work) were seen as important to retaining successful science teachers. (Khourey-Bowers & Simonis, 2004; Mangrubang, 2005).

Research regarding instructional programs and practices in middle school science points to a variety of “psychosocial” factors such as personal identity, peer acceptance, and autonomy that impact student performance in science (Swafford & Bryan, 2000). Specific recommendations from this research include using writing to promote metacognitive activity as well as collaborative and interdisciplinary experiences. In some studies the ways curriculum and assessments focus on “wide and shallow” versus “narrow and deep” conceptual understandings have been explored, pointing to the negative impacts of breadth versus depth on conceptual understanding in middle school science (Clark & Linn, 2003). Other research findings indicate the importance of aligning standards, performance-based classroom activities, and assessments to those processes and practices used by practicing scientists (Krajcik et al., 2007).

Previous research regarding the monitoring of student performance in middle school science has indicated the influence of mode of assessment (i.e., journaling, hands-on lab experimentation) on performance and points to the importance of providing a variety of modes of assessment in science

(Lorsbach et al., 2004). A study of pre-service science teachers' approaches toward science instruction indicates that they hold a simplistic and rigid vision of inquiry that emphasizes the scientific method to test variables, not ideas, which is reflected in the way they assess students' learning in science. These findings suggest restructuring K-16 science by adopting the more complex and scientifically appropriate inquiry model in lieu of the simplistic “scientific method” (Windschitl et al., 2008). Finally, little research has focused on the impact of particular interventions and ways of promoting achievement in science that go beyond the classroom and are specific for special needs and English language learning students.



# Key Elements to Higher Performance in Science

The results of our study confirm many of the previous research findings and suggest that higher performance in middle school science is most impacted by five factors:



## 1. Fairness and Fun

Educators have established a climate in which teachers and administrators ensure that every student is prepared to succeed in high school science and has had opportunities to experience science as both fun and relevant to their lives.

## 2. Focus

Teachers and administrators use a variety of data and frequently collaborate with each other to identify needs for professional development as well as changes to curriculum and instruction across grade levels.

## 3. Foundations

To ensure that students develop scientific knowledge and skills, educators continually review and revise the curriculum and use hands on and inquiry-based instructional practices designed to work with different learning styles.



## 4.

### Fluency

Educators in higher-performing schools work to integrate science with other content areas, building both scientific literacy and literacy skills more generally.

## 5.

### Fit

Higher-performing schools hire teachers who are qualified to teach science, want to teach middle-level students, and fit well with the culture of the school in general and science department, in particular.



## Success in middle school science

Each of these elements is described  
in more detail on the pages that follow >

# 1.

## Fairness and Fun: Debunking Myths about Science

We need to debunk the myth of you're not a science person,... and hopefully close that gap before they go on to high school. –Johnson City Administrator

The contextual factor that most stands out among schools whose students consistently achieve well in science is how they foster a climate of fairness and fun. In these schools educators ensure that all students have a fair opportunity to succeed in science regardless of their socioeconomic status, language background, or any other factor.

They also express a shared belief that it is incumbent upon school personnel to keep science fun in middle school. This in turn impacts the overall professional climate in the schools, where cooperation and ownership of student performance guide behavior.

**Keeping It Fair.** Creating a climate in which kids feel both capable of grasping the more abstract concepts of science as they move through middle school and associate science with something they like or want to do is multifaceted. For many of the higher-performing schools it begins with educators keeping options open for kids to succeed in more advanced science. The first hurdle, then, is debunking myths educators, kids, and parents may hold that some just can't do higher-level science. As one teacher explained it, perceptions of capability are extremely important in science education because they directly impact ways of adapting instruction that can either keep the natural curiosity many children have about science alive or not.

In some higher-performing schools like Jefferson, maintaining beliefs that all middle school students can be prepared to succeed in the more advanced high school science has been hard won, yet it has become a central mission backed by district and school leadership.



Student achievement is very important. We are very instruction-focused. We maintain the strong belief that all students, regardless of socioeconomics, can achieve high levels.

–Jefferson Administrator

Although “fairness” may seem to some an intangible and practically impossible practice to nurture or develop, the higher performers provide some insight into how to do this. In Bolivar-Richburg, a teacher notes the principal’s high expectations for the special needs students and describes how it is manifested daily:

The principal is very involved. ...On a daily basis he’s in the room, observing what’s going on with the students. He knows a little bit about each one of the [classified] kids. ...That’s very important because they know he expects a lot out of each student. Really, they’re held to the same standards as the kids in the general education environment. They may have different modifications to their curriculum, but they’re still expected to produce the same kind of quality work. I think that’s important. –Bolivar-Richburg Teacher

When fairness is turned into practice, it often means connecting science education goals to the district and school mission of “high standards for all students.” As in Johnson City, it may also mean looking very closely at student performance within the four levels of the state performance system, even if that isn’t how the school’s success is measured by the state. According to an administrator, “Our mission leads a lot to what defines success: high standards for all students... how we perform on state assessments, students performing at levels 3 and 4, and growth for students, students going from a 1 to a high 2. But unfortunately, NCLB [No Child Left Behind] and the state don’t look at that.”

Keeping options open so that all middle schoolers can succeed in science is a key contextual factor impacting higher performance and what one principal called the “underpinning” for not only what is done in science at the middle school, but also K-12 in the district.

**Keeping It Fun.** Keeping it fair is accompanied by another driving force: Keeping it fun. Engaging adolescents who are known to often lose interest or become, what one teacher characterized as “downtrodden,” by the time they get to middle school, is a central goal in higher-performing schools. In contrast with average-performing schools, higher performers typically show evidence of applying multiple efforts to keep students’ options open and motivation high in middle school so they will be more likely to pursue advanced science classes later on. Fun, then, is the result of purposeful planning to ensure students are stimulated, interested, and can connect to science.

One of the signs that a district has been successful in keeping kids interested in science is how many take advanced courses in high school. In Bolivar-Richburg, for example, an administrator explained the good news in this regard: “When they get up here, they’re excited about it [science]. We have more students now than we probably ever had [who are] taking courses like physics and they’re seeing the importance of it. You know they’re enjoying it.”

Higher-performing middle school teachers tend to see part of their job as increasing the numbers of students who stick with science beyond just the state requirements for a Regents diploma.

In some schools, inspiration to succeed in middle school science comes from “above,” in the forms of International Baccalaureate and eighth-grade Regents course offerings.

Efforts to keep students’ interest high in science are attributed to not only what happens within the middle school and high school, but preparation in elementary. In Greene, for example, a Cornell University Institute for Biology Teachers leader worked with elementary teachers to, as one put it, “get kids excited about science.” Although most educators in this study see science as one of the subjects kids naturally “love,” an Oliver Winch Middle School administrator voiced a common refrain, “somehow along the way they end up not having that love of science.”



There are always... things in our way that want to tell us that maybe some kids can’t do certain things. We’ve just had to say, “No, we really believe they all can.” So I think it’s more just getting over some perceptions of maybe those hard to teach kids, and saying that we have to do something different for them, and say, “No. No, we can. We can have the same expectations.” We might have to do something different so that they can achieve where they need to be, but they are perfectly capable of doing it.

–Wayne Administrator

My first and foremost goal is actually to get the kids to have fun and enjoy science so that they want to stay with it for a lot longer. –Bolivar-Richburg Teacher



Middle school science educators in this study share an awareness that “fun” has a lot to do with keeping science relevant. If adolescent students don’t see how science relates to their lives here and now, they lose interest pretty quickly; thus in higher performers a confluence of factors comes into play to keep the broadest spectrum of kids engaged and successful in tackling middle school science. This is a distinguishing factor between higher- and average-performing schools. Although educators in average performers share a belief that science should be relevant, they may lack a shared sense of responsibility to extend these beliefs into effective practice with all students. While keeping science relevant can involve sharing personal stories, watching “Billy Nye” videos, and doing goopy experiments, in higher-performing schools these instructional approaches are complemented by the other elements of best practice to ensure efficiency in curriculum delivery and the strongest effect on student performance.

## On the Continuum to Higher Performing

### Average Performing

Tracking at 7th and 8th grade prevalent. If not present in science, science is affected by tracking in ELA and/or math.

Belief that failure is predictable for some students.

Either past or present sense of discord in the school, community, and/or district.

Struggle with developing and sustaining professional learning community.

### Higher Performing

Move towards de-tracking or completely heterogeneous grouping. Opening Earth Science Regents to all eighth-grade students interested in taking it.

Mission to keep options open for all students to study advanced science beyond Regents requirements.

Shared sense of ownership for student success and engagement in science K-12.

Support for cooperative work (e.g. curriculum mapping, assessment review) and professional development opportunities to support this work. Community organizations and/or colleges involved.

At the high school level we have become an International Baccalaureate school and that has six core subject areas to it. One of them is science, so that’s an upper-level science in addition to the AP. We really want to extend our kids and be able to provide them as much opportunity to be prepared for higher-level sciences in school and beyond. Those are some of the things that have been driving us to take a look at our programs. One of the things we want to do is have all our kids in eighth grade be able to take that Living Environment and get that opportunity to get that Regents [credit] in eighth grade. We think that that’s a course that kids have a natural curiosity about. There’s a lot of hands on in that course. They seem to respond very well. So we get them hooked and excited about science and also experience success. You can see by looking at our results that we have good success. So the fact that kids have that success in science here, then when they move to the high school and get into some of the more challenging sciences, they know they can do it.

–Wayne Administrator

I also try to bring current research and knowledge into the classroom. Showcasing science as an ongoing activity in our culture keeps it interesting. –Jefferson Teacher

When I present new material, I like to try to start at a place that everybody gets. –Oliver Winch Teacher

WHAT IT LOOKS LIKE IN:

# Bolivar-Richburg Middle School Bolivar, NY

Toys, plants, butterflies... all these can be used as tools to pique students' interest and make it more likely for them to engage in science class and want to enroll in upper-level courses. The superintendent of schools declared, "Everything you do on a daily basis probably involves some form of science.... I think it's a teacher's job to get them hooked on science and excited about science, then provide the interesting daily lessons to reinforce that excitement.... I think you tell the teachers, 'Hey, listen, tests aren't the number one thing in the world. I think the student being successful and enjoying the subject is more important.'"

Teachers adhere to this belief. Sparking student interest in science is done through providing 'hands-on' experiences, demonstrating connections to students' lives, and selecting engaging materials, as one teacher conveyed: "We use a lot of interactive materials; we use a lot of technology here. We have the monitors and the projectors in every room, and we use a lot of films." Novel approaches emerge as well. "I also have the students do a lot of the teaching. They just finished five to ten minutes each teaching a part of astronomy. They had a

planet; they had different things in the solar system like black holes or constellations. They had to be the teacher and provide handouts or whatever materials they were going to use."

Teachers are concerned with maintaining the interest of learners at all levels. One teacher stated, "You've got to make it fun. They want to be here. If they're interested, it's amazing. You'll watch what we've coined a 'low-achieving student' become a high-achieving student if they want to become involved. Most of the low-achieving students just haven't been reached; they haven't been touched. They don't care to participate... because they've been deemed as a low-achieving student. The class that you observed this morning, that's my inclusion class. This was my special ed inclusion class, and these guys are one of my top-performing classes. Their study skills, their study habits are good because they've had to work."

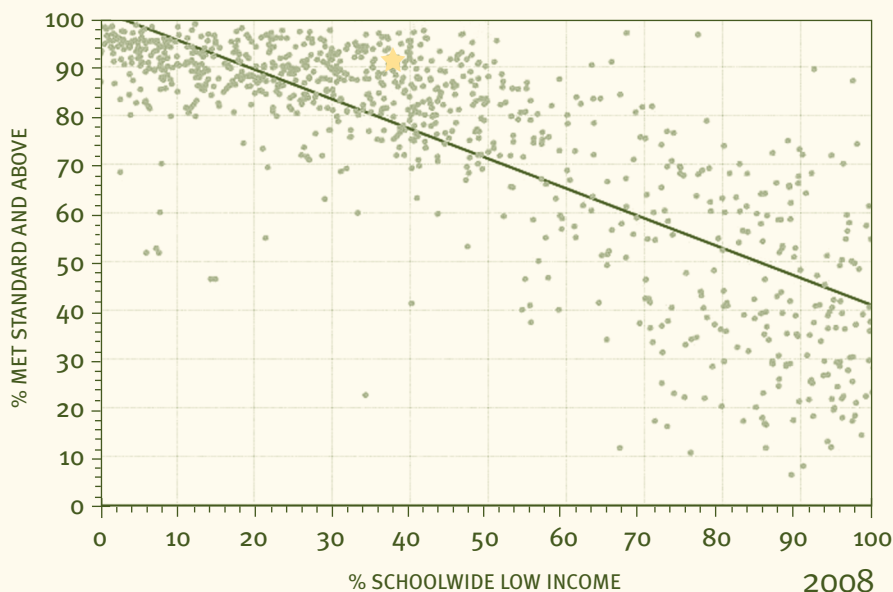
This class focused on the circulatory system. During the 80-minute block, the teacher continually tied learning directly to the students. To illustrate the tremendous work of the heart, he challenged students to flex their arm muscles as often as their heart beats in one day. Finally, students worked in groups to

create questions (e. g., multiple choice, short answer) they considered valuable enough to be placed on an upcoming test.

Special education teachers, most of whom bring their students into the general education classes, concur with their colleagues: it is essential to reach students through their personal interests. "In science we try to make it interesting. In a lot of the experiments he [the science teacher] will try to incorporate sports. We've done friction, and we'll have students pick a sport that they like: 'Where do you see friction? How does the turf on the football field [provide friction?]'"

It's not enough just to prepare interesting lessons. Many teachers consider it essential to vary teaching strategies to address specific needs of learners. Another special education teacher clarified: "As best I can, I gear it to make it relevant to their lives. I assess their learning styles, too. I have one student who does better with hands-on. I might have one student who is a visual learner, one student who is an audio learner. I try to incorporate a little bit of all of their learning styles into a unit so that it becomes relevant for them and easier for them to understand and apply what they've learned." (from Sherwood, 2009a)

Bolivar-Richburg Middle School/High School students consistently outperform students in schools with comparable demographics on the NYS Intermediate-level Science Examination.



● All New York ★ Bolivar-Richburg Middle School

# 2.

## Focus: Driving ‘Aha’ Moments through Data and Dialogue

They have something called T-charts so each teacher can see how the kids do on the test and see what kids are getting wrong. It’s an “Aha” moment. They see how effective it is. Each teacher realizes their place and how effective it can be to other teachers. For example, the kindergarten teachers see how they affect the high school teacher.

–Greene Administrator

Becoming a higher-performing school in science doesn’t just happen because educators in these schools are fair and make science fun. Another important element of best practice is providing focus for efforts that are likely to make the greatest impact on student performance.

The processes by which higher-performing schools create and revise curricula and determine instructional foci (Element 3), employ effective instructional strategies (Element 4), and support these efforts with the right fit of staff (Element 5) are directly linked to the ways they use data and opportunities for dialogue to focus their efforts.

**Focused on Curriculum and Staff Development.** How do higher-performing schools focus their efforts to get the greatest impact on student achievement? One of their answers, in the words of a Jefferson Middle School Administrator, is “to use data... to help us to identify strengths and target weaknesses, particularly, areas in need of staff development and areas in need of curricular attention.”

In higher-performing schools, educators pore over state test score data to inform their work, but they also dialogue continually around impacts of instruction throughout the school year. These dialogues often involve taking close looks at school or district benchmark tests to inform revisions to the curriculum and innovations in instruction and oftentimes include data from elementary and high school.

It is in this work that rich discussions around impacts of instruction and how the curriculum is organized in terms of scope, sequence, and corresponding assessments become directly linked back to professional development. In Geneseo, an administrator voiced a familiar sentiment shared among higher-performing educators about the importance of preserving staff development time for teachers to engage in focused curriculum work:

I think we, as a district, made a conscious decision this year that our four superintendent’s days were going to be utilized for curriculum work, and the principals and superintendents said departments can take curriculum release time—that’s what we call it. But the curriculum release time is very focused. It’s very purposeful. They meet with me ahead of time. They’re often in my office, so I’m able to even just listen to the conversations and then there is always summary. “This is what we accomplished... these are our next steps. This is the direction we are headed in.” –Geneseo Administrator

We have our own teacher center right on campus.... Teachers can write proposals.... We read them, and they must be aligned to our goals and the standards. What evidence do they have it’s needed in their proposal? It’s a state funded center. Teachers can write grant proposals, work on common units, go to other districts to watch others, and go to conferences.

–Johnson City Administrator

K-12 meets in September, January, and then May. The other months change, but we can meet anytime.... Actually we have brought in all the Regents and state tests, so all teachers get to look at them. –Greene Administrator

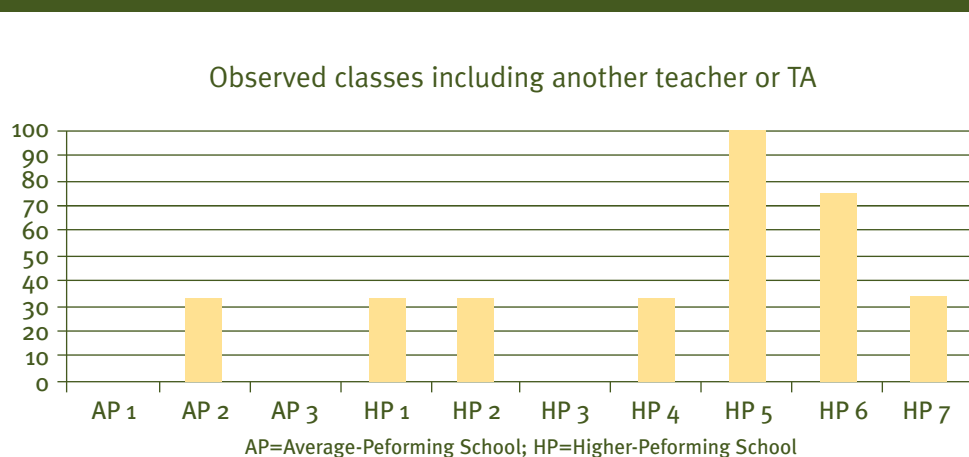
In addition to providing the resource of time to focus on curriculum development and some direction on how to engage in the process, higher-performing schools also show evidence of using teacher expertise to focus their staff development offerings. Through their on-campus teacher center in Johnson City Middle School, for example, teachers submit proposals for staff development based on what they feel is most needed in their school.

**Focused on Instruction and the Future.** In addition to using data and opportunities for dialogue to inform curriculum revision and the use of staff development time, higher-performing educators are also using data to inform some very specific best practices in instruction. Stories of successful integration of instructional models like Bolivar-Richburg’s “Thoughtful Classroom” model are not uncommon and are justified through the results, which can be tracked in the data.

All of these data sources and dialogues around them facilitate another focus shared by higher-performing schools: The future. Educators in these schools are not only concerned about the impacts of their work on student performance this year, but are focused on what they need to do to get even better results in the next two, five, and even ten years. At Oliver Winch, 21st Century Skills complement state standards and assessments in providing a focus for their district, school, and classroom improvement efforts.

Things are changing so fast. As school districts what we’re trying to do is present a platform of knowledge and prepare students for the world of work and post secondary. It’s so rapidly changing that it’s difficult to have that preparation. So we really have to go back to or continue to focus on the problem-solving skills, the higher-order thinking skills, and have those incorporated into lessons. –Oliver Winch Administrator

Right now again, we’re really analyzing data and trying to improve the test-taking abilities and skills of our students. We want to see why... why are students being successful, or unsuccessful for that matter, rather than just because. We want to know why that is. So [we do] data analysis. And there’s been a real strong push within the last two years to think about how we’re providing our instruction to students, the delivery of material and we’re now involved in the Thoughtful Classroom. –Bolivar-Richburg Administrator



Higher-performing schools in our sample showed more frequent use of teaching assistants (TAs) in observed classrooms, with all but one of the schools including at least one TA. Several of these schools note assessment data as providing the impetus for shifting to inclusion models.



# Geneseo Middle School Geneseo, NY

Some teachers have formed educators' study groups. These teacher-initiated and teacher-guided groups investigate areas of interest; a middle school identity group is currently running. Teachers are further involved with their peers during superintendent's conference days, where workshops are often led by Geneseo staff. As the technology director indicated, "I can't really say enough about having it run by teachers and in-house people.... I think that there's a credibility factor that comes into place where sometimes...outside presenters come in... they're disconnected from the classroom... but when you are using it on a day-to-day basis, and you are still working with the students, and you know the impact that it's having, I think that people can sense that right away and connect to it."

Geneseo Middle School teachers and administrators have spent a great deal of time and effort improving and formalizing their science curricula. During the past two years, the middle school and high school teachers have used released time, superintendent's conference days, monthly department meetings, and summer sessions

to coordinate what is taught. As the principal related, "Now the tenth-grade biology teachers will know what the eighth-grade teacher is teaching." The principal further observed that, without the support of the community, the school board, and the superintendent, such extensive work would not be possible because of the cost. Alignment is currently focused on middle school-high school transitions; the plan is to next examine elementary-middle school connections.

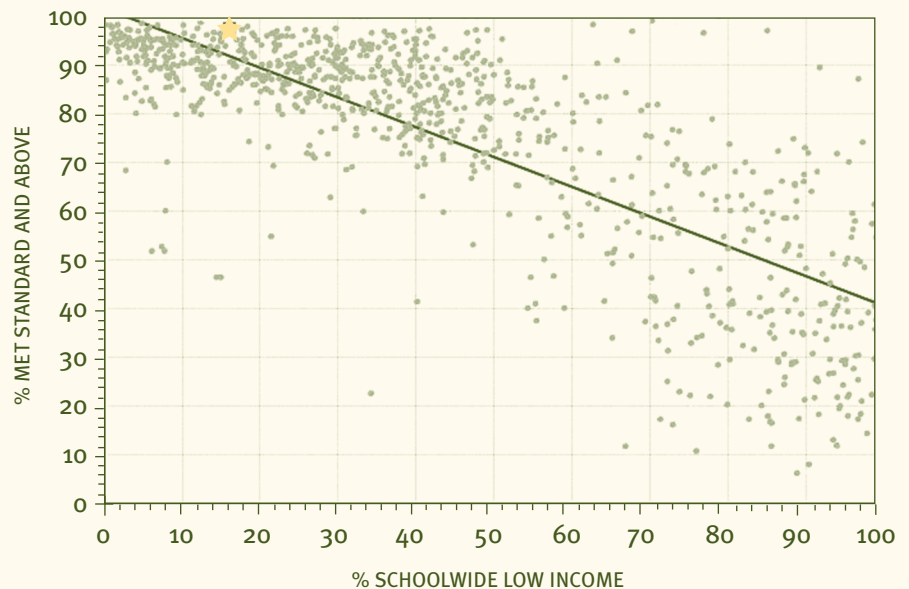
The science curricula at Geneseo do not simply contain the intended content; in addition, the curricular templates include skills, assessments, and resources. One science teacher clarified how they incorporated "the progression of how to use a microscope, from sixth to twelfth grade... research, bibliographies, lab reports.... We meet as a department to talk about... what do you want... to be able to do in terms of Excel, PowerPoint, graphing?"

Others have input into the science curricula. As a special education teacher described, "Here at Geneseo, special ed teachers are generally included... [so we

know] the curriculum, know the changes, know how Geneseo wants to present [the curriculum]... and then they have that special ed perspective to share with those science department members." The principal added to the list of participants; both he and Geneseo's director of learning are involved: "We even extend it throughout [to] our superintendent. He has input to what's going on in classes. Being small it's a luxury we have... if I am in a larger school, I'm not so sure that I'm familiar with each curriculum. Most discussions take place at our team leader meetings, at our administrative meetings, so... the superintendent is aware of what we're doing. And being a former science guy, that helps too."

Geneseo's director of learning, who oversees all curricula work, did not view the science curricula as a project with an end in sight. "We're going to constantly be revisiting and adding... I think what we're really stressing is that it has to be a living, breathing document. It has to be something that we don't just put on a shelf."  
(from Sherwood, 2009b)

Geneseo Middle School students consistently out-perform students in schools with comparable demographics on the NYS Intermediate-level Science Examination.



## On the Continuum to Higher Performing

### Average Performing

Professional development options not necessarily focused on what matters most to increasing student performance in the school's particular context.

Schedule driven rather than student performance driven; interventions, adjustments in schedules, use of TAs, special education, and ESL teachers largely decided by "the way it's always been done."

May be no district- or school-level benchmarks in subject areas. Infrequent use of assessment data (perhaps once a year to evaluate meeting goals and those goals not necessarily followed up on).

Classroom instruction may be as diverse as higher performers but not supported by some of the other best practice elements to gain the maximum effect on student performance.

### Higher Performing

Professional development focused on what is shown in the data to have the greatest impact on student performance. Some offerings specific to science instruction.

Interventions, adjustments in schedules, use of TAs, special education, and ESL teachers flexible and informed by what is likely to have the greatest impact on student performance based on a variety of data.

Processes in place (e.g. benchmark tests) to regularly assess whether achievement goals have been met—and to set new goals.

Variety of classroom instruction techniques encouraged; in some schools particular approaches supported through thorough staff development; effectiveness continually evaluated.



# 3.

## Foundations: Going Deep

I think the goals of middle school science should be to let kids really have the opportunity to go more in depth. —Geneseo Teacher

Educators in higher-performing schools typically see as central to their success creating a solid foundation in science before reaching middle school and deepening that foundation in the middle school years. This is closely linked to the previous elements of best practice in that part of the foundation is about having a fair opportunity to succeed in science and a belief and experiences that science can be fun, but also a focus on what will have the greatest impact on students' learning. It is also related to how literacy-based activities are integrated into science (Element 4) and how the right educators with appropriate backgrounds and interests are connected with middle school students (Element 5).

Going beyond relying on fairness, fun, and focus, educators in higher-performing schools work toward developing a thorough foundation in science content from the beginnings of elementary school and carry these on through middle school. Two dimensions of best practice stand out in contributing to nurturing deep and broad content knowledge: Continual review and, when necessary, revision of the curriculum and the effective use of hands on, differentiated, and inquiry-based instructional practices.



**The Science of Science Education: Scope, Sequence, Assessment.** As explained in Element 2, one component of higher-performing schools' focus is on processes for evaluating and revising the curriculum. Educators in all schools in this study often refer to the state standards and assessments as their guides for what should be taught and learned in science, but they also describe the monumental in-house task of aligning curriculum and organizing activities and materials across grades. In higher-performing schools and districts, a cooperative culture and processes for analyzing assessments to inform curricular revision from kindergarten on are in place to facilitate this work.

I have to say that the reason... for those [state test] scores is because we work collaboratively, professionally from grades 6-8. We have subject area team meetings. We go through that core curriculum and we figure out and make sure that every aspect of that curriculum is being covered in sixth, seventh, or eighth grade. We share materials. We make sure that if something is being taught in eighth grade that maybe in seventh grade we wouldn't go into too much detail; we would give them the basics.... We really share so much. I think that's the reason for the success. I can't say that it's anything that one person does for those scores. It's because we work together. —Oliver Winch Teacher

I think that the biggest thing, is to go a little bit deeper than what the curriculum asks, so that the kids really understand the whole concept. —Wayne Teacher

Identifying what is “fundamental” knowledge to any particular scientific field, whether Earth Science or Biology, is “a good challenge” as one Geneseo administrator explained and something encouraged in higher-performing schools. Educators in these schools think not only about what they are doing in each of their own grades, but about how science content knowledge is distributed over the elementary years and among different scientific fields.

One of the things we always look at is what content should we be teaching at each grade level. We certainly want to make things engaging for our students, but we also want to make sure that students are prepared for Earth Science.... Are we making sure that we hit all of our bases when it comes to what fundamentals students should be leaving our middle level with to enter high school? ... And do our assessments match what we think our intended outcome should be? Are we assessing properly to make sure students, when they leave our middle school, have a foundation in Biology, Earth Science? Do they have all these fundamentals in place so they can be successful at the high school level? –Geneseo Administrator

This is the science of science education: It is disciplined, reflective about results, and iterative. It is supported through collaborative efforts at the grade and school levels.

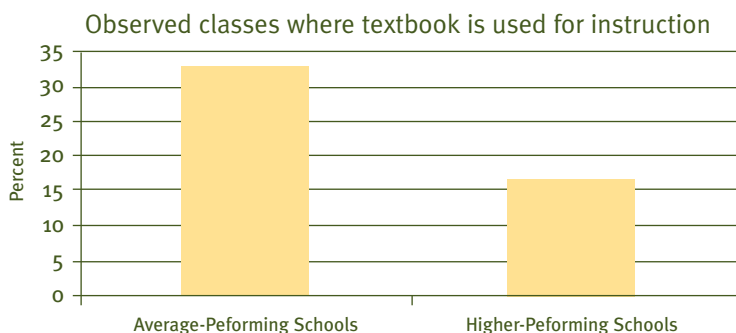
The curriculum is very structured. You can go into one science room and another and you will see the same lesson. All sixth-grade teachers will teach that lesson. Their personalities will be different, but the content [and] the assessment of that lesson, what they want students to know and be able to do as a result of that lesson: Straight as an arrow. I use them as an example because if you can get a department to be that clearly defined in what they need to do by using New York State learning standards, making their curriculum aligned to it, coming up with assessments that measure those performance indicators and you can verify that, you have it made. –Wayne Administrator

Ultimately the impact of this collaborative culture and processes for reviewing the foundational knowledge students should be learning in elementary and middle school affords higher-performing school educators opportunities and a feeling of ease to explore some topics in more depth. They know their curriculum well enough and have enough understanding about where students stand through their assessments that they can adapt their instruction to really make that most essential knowledge stick.

Although going “deep” into particular concepts in middle school science is seen as important, it is still also seen as a luxury among many of the science educators in this study and, therefore, oftentimes deferred to after school or extracurricular events like Science Olympiads, Ecology Club activities and the like.

“Woah” or “wow”... those are some of the best sounds to hear in a classroom. Those “Wow, that’s amazing” or something like that—that’s [what] I strive [for]. I think that comes with making it hands on and making it personal to them. –Geneseo Teacher

A lot of schools don’t have the direct consultant model. A lot of schools have maybe one special ed teacher for three or four grades. But I definitely see that [the direct consultant model] as a plus. I think it has really helped, because a lot of times I would do the daily opener for the science teacher and then he would do some of the lesson and if he’s ever not there, I know the material so I can teach it to the kids. Also being in the class, I can reinforce that during my advisement. –Bolivar-Richburg Teacher



Textbook study pales in comparison to hands-on activities in terms of what teachers point to as most effective in communicating science content. Classes in average-performing schools tended to include slightly higher percentages of time spent using the textbook than in higher-performing schools.



### The Art of Science Education: A Whole Body Experience.

I'm very squirrely by nature. I always have the saying that if your tush goes numb, your brain goes numb. So in these eighty minute blocks, I don't want the students sitting on their tushes for eighty minutes. I want them up, manipulating equipment, thinking, using inquiry, using their own brains. You don't see toddlers bored with learning. Why do you see eighth graders? Because somewhere in there we must have sucked it out and made it not fun to learn anymore. We're trying to put the fun back into learning. We're trying to tap into that natural curiosity that all human beings have. Bring them back to being toddlers. Well why does a ball roll down a ramp? What is this thing called gravity? Why do some things sink when other things float? I think that's part of the big picture. I also think It has a lot to do with teachable moments. –Wayne Teacher

If continual review and revision of the curriculum scope, sequence, and assessments is part of the science of teaching science, then instruction that meets multiple learning styles and needs might be considered part of the art. Among the higher- and average-performing schools, instructional approaches varied widely. A few approaches, however, were identified as being most effective, especially for middle school science students.

**Hands-on.** Hands down, hands on stands out as the most popular approach to teaching middle school science students and is seen as directly connected to reinforcing that science can be fun and relevant to their lives.

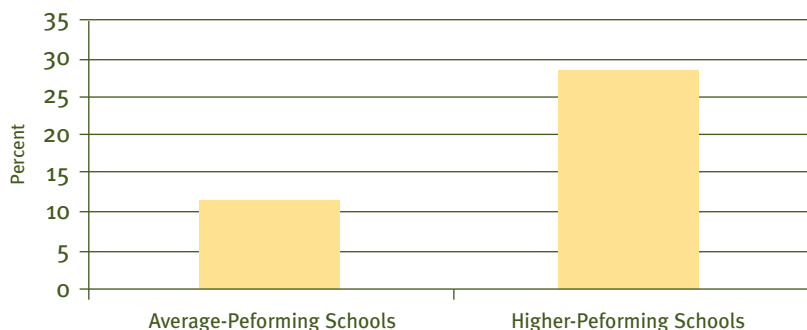
Hands-on activities are viewed as particularly effective for English Language Learners (ELLs) and special needs students in that they provide pathways other than lecture to sometimes abstract ideas.

Balancing lecture with plenty of purposeful hands-on activity in middle school science is a way to both prepare students for more advanced science and still communicate the increasingly complex ideas.

If there's a test coming up, if there's a lab that's particularly difficult, the science department leader drops down to my room a lot and we'll just have a quick little conversation maybe and I share things with [the other teachers], too. I share [my English Language Learners'] reading assessments with them so that other teachers are aware of their reading levels and how that might impact how they read a text book or a newspaper article. –Geneseo Teacher

Science is nice because it's more hands on and so lots of our special needs students prefer [it], or it's their strength. –Johnson City Teacher

Observed class time for small group/student-student interaction



Teacher led class time was approximately the same among higher- and average-performing schools, but the time allotted for student-student interaction including pair and small-group activity was higher in the higher-performing schools.

**Differentiated Instruction.** In addition to a strong emphasis on hands-on strategies for teaching science, educators in higher-performing schools also show evidence of understanding and capability to employ differentiated instructional (DI) techniques. In one Johnson City classroom, a teacher set up three stations, two of each station type (Plant, Mapping, and Matching of Biome with appropriate animals/plants expected to be found in each biome). Activities not only required knowledge of facts but also emphasized patterns, descriptive classifications, and puzzle-like problem solving like matching. The activities in total had various difficulty levels but could appeal to a range of different types of learners. The teacher explained what to do at each station and that two stations had worksheets that were to be placed in their notebooks. Stations were set up at the grouped desks, so students began with the activity set up on the desks where they were already sitting. Explanation of what to do for each activity was given with the instruction that some stations might go faster than others, but to wait patiently for another group at a different station to finish so they could swap space. The teacher moved from group to group asking questions and helping some groups more than others. Much collaborative learning was observed within each group.

Although not all of the classes observed in higher-performing schools showed evidence of differentiation, many did. They tend to be further along with integrating DI than their average-performing peers, use more of their instructional time on new material rather than review, and offer students more opportunities for pair and group work.

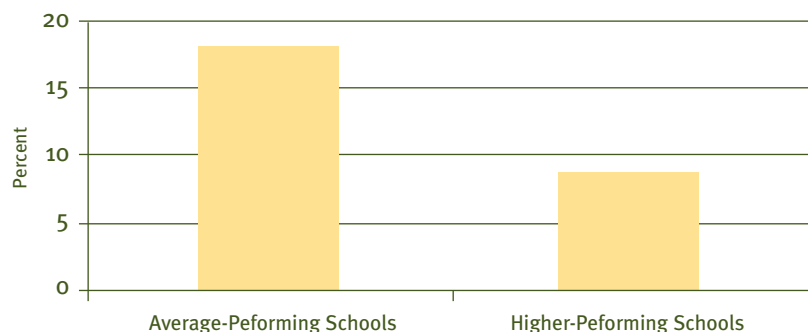
Making a concept like density understandable for adolescents with differing background knowledge, learning styles, and intelligences brings in another of the instructional characteristics common among higher-performing schools: input and support from specialists like English as a Second Language (ESL) and special education teachers.

**Inquiry-Based.** In all schools in our study moving toward “inquiry-based learning” was cited as a goal. How this is defined in different schools and among different teachers and what it is supposed to look like, however, is not so clear. Findings in this study suggest that inquiry may be synonymous with the scientific method to some science educators and only employed unevenly across grades and schools. When asked what contributes to the school’s success in science, a Geneseo administrator touched on foundations of inquiry-based activity: “Creating the classroom environment, where questioning is valued. It’s not like, ‘Put your hand down. We have to keep going.’”

Kids really love the hands on. They eat it up. As soon as I get really crazy with lectures and more of a typical lecture base, which you would see more at the high school level, they fall apart. So I try to keep more of a project-based, hands-on environment. You’ve always got to have a little bit of lecture. They’ve got to experience it. They’re going to see it later on. It’s not going to disappear. If they choose to go to college that’s predominantly what they are going to see, so they have to know their way around that type of classroom. Yet I think the experiences that they have as far as hands on in science will keep them attached. –Bolivar-Richburg Teacher

We’re getting much better at differentiation, changing our lessons in three or four different tiers to teach to the different modalities and the different readiness levels. Especially at this age level, we’ve got kids who are such concrete learners and we’re trying to give them very abstract concepts like density. –Wayne Teacher

Observed class minutes for homework or other review



Although many of the instructional techniques were similar among the higher performers and average performers, average-performing schools in our sample were more likely to spend more time on homework and review than their higher-performing counterparts.

In Jefferson, an administrator points to the importance of “looking at data, making predictions and realizing those ‘ah-ha’ moments.” While in Wayne an administrator attributes Understanding by Design (UBD), a backwards-design instructional approach supported through staff development efforts, to helping teachers conceptualize and use an inquiry-based model in science.

Having kids be real inquiry based. We use a backwards design process... that’s really having them become multifaceted thinkers, so that they can think about whatever it is that they’re studying on many different levels. It has to be taught. It has to be very explicit in the instruction. Those are some of the things that I think have been the priorities and the driving forces behind what we have done. –Wayne Administrator

Working with [the eighth-grade science teacher] and his students before the state exam was big, because we actually got to do some of the hands-on things that we wouldn’t necessarily be able to do if we were contained in this [special education] classroom. We got to participate with the regular ed teacher and have his expertise as a science teacher demonstrating a lot of those activities that the students are asked to do on the test. That helped quite a bit. Giving them the supports and the modifications that they need to understand the curriculum definitely helps them succeed in science. The most important thing is working with regular ed, and making sure I am keeping my curriculum as best as I can aligned with what they’re doing. –Wayne Teacher

## On the Continuum to Higher Performing

### Average Performing

“Covering” the curriculum and getting kids to pass the state test in middle school guides instruction.

Differentiated instruction still in infancy stages among some teachers; talk of improvements to AIS.

“Pull-out” ESL for English language learners; self-contained classrooms for special education.

Curriculum typically mapped K-12, but interpretation of map in light of assessment results then feedback into scope and sequence across K-8 either infrequent or non-existent.

### Higher Performing

Delving deep into content facilitated by continual review of assessments to inform the scope, sequence, and instructional approach.

Differentiated instruction expected and supported; AIS seen as failure for school and teachers.

Inclusion or “integrated” classrooms for special education in process or well-established; “push-in” or “sheltered” ESL.

Curriculum revisited and revised continually based on data feedback loop across K-12.

WHAT IT LOOKS LIKE IN:

# Oliver W. Winch Middle School South Glens Falls, NY

What does it mean to learn science? What is important for students to know and be able to do? Why should students study science? The members of the science department at Oliver W. Winch Middle School seem to share a philosophy that answers these questions.

The teachers believe that students need foundations in science, both in content and skills. One teacher outlined this: “I really see it as a 100 level class. I like to try to touch the surface of what they’re going to see in the high school: content, skills, and labs... so they won’t be shocked when they get there.... We try to really focus on being specific for earth science and being specific for bio, because that’s the next year or two for our students.”

Content is important for all students, in both general and special education, especially in light of the intermediate and high school state assessments. A special

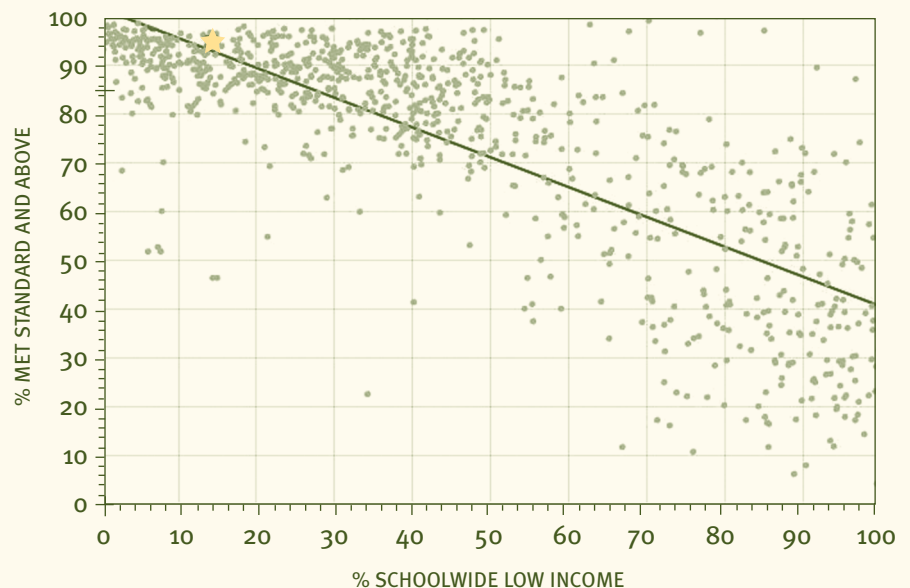
education teacher shared: “I’m really here to make sure that they get the content that they need in order to be successful in the high school. We’re always looking ahead; we’re always looking to the future. We want to prepare them now for what they’re going to encounter with all the high stakes testing.” Teaching this content is not easy; there is a great deal of information to impart to sometimes reluctant students. As one science teacher observed: “They’re at that age where they’re a little immature still, and these new concepts are very challenging for them. So I repeat things, spiraling throughout the course of the year.”

Scientific processes should be just as important as content knowledge, one science teacher declared: “I like to focus on skills and process because that translates beyond whatever class you’re taking next year. Being able to measure and to do some basic math skills and some

basic measurement with balances, microscopes, things like that. If we can get the skills, it sets them up to be successful in the future.”

Providing these fundamentals in science at the middle school level is critical, since science programs in elementary schools can be lacking, the principal noted: “I think the goal should be foundation building. I think it’s the first time. My assistant principal was an elementary school teacher, and he reminds me all the time that science is something that elementary teachers get to when they can in a lot of cases. We teach science every day in sixth grade, seventh grade and eighth grade. So I think it’s our job to establish a foundation for students to have success when they start earning credits towards graduation at the high school level, and, perhaps, go into science careers.” (from Sherwood, 2009c)

Oliver Winch Middle School students consistently out-perform students in schools with comparable demographics on the NYS Intermediate-level Science Examination.





## 4.

## Fluency: Bucking the Poor Step-Sister Syndrome

Not surprisingly, time has been an ongoing concern with math and ELA being so important. In fact, science, unfortunately, has been a victim of time. –Jefferson Administrator

Once upon a time there were two spoiled sisters: Sister “ELA” and Sister “Math.” These two got all the attention while their poor step-sister “Science” sat locked away to do all the work alone. And so the story goes.

Science, as one administrator described it, often acts as the “poor step-sister” to ELA and math partly because, as a teacher noted, “In this educational climate, what gets tested, gets prioritized.” Science often receives less instructional time throughout elementary school, and less professional development specifically for science; generally science is considered “the least of the problems” and therefore, relatively neglected. This is the case in all schools in our study, but with an important difference in how this phenomenon is managed in higher-performing schools. Rather than allowing science to get “squeezed out” by math and ELA initiatives, educators in higher-performing schools make purposeful interdisciplinary connections to highlight science throughout K-8.

The ability to read scientific texts for understanding and to fluently express scientific ideas and concepts is seen as much as a learned art as interpreting poetry or writing an algebraic equation in the eyes of many educators in higher-performing schools. Students in these schools typically have the gift of being surrounded by educators who are keenly aware of the importance of integrating good linguistic and mathematical literacy practices into science to improve students’ fluency in expressing ideas in science. This happens in a few different ways in higher-performing schools and is distinguishable from average-performing schools in the prevalence of literacy-based activities (broadly defined to include a variety of linguistic and mathematical literacies) not only at the middle level but throughout the feeder elementary school(s).

**Everyone Is an ELA Teacher.** Oliver Winch provides an example of how linguistic literacy practice can be integrated into science. Science teachers there are explicit about how they expect language will be used in their classes. They believe that science lends itself to interdisciplinary learning and that this aspect can help make science more relevant to students’ lives. One teacher provided an example of how she tries to pique interest by offering a variety of activities and different ways to explore a topic:

For instance, in this wetland project that we do we acquire the background knowledge we need about wetlands, and then the students choose an animal, insect, or plant to research. Wetlands are endangered, so most of the time, the organism or animal they choose to research is endangered. Then we incorporate reading and language arts because they’re researching the topic; they’re creating a brochure. We sculpt the animal, so they’re also getting their hands in the artistic end of it. We even incorporate phys ed. We take a hike on the bog trail. We use a lot of outside resources. We hold outdoor labs at a pond. Just varied activities so students at all levels can explore the topic and gain an understanding of the key concepts. –Oliver Winch Teacher



We all are teachers of reading, so we always embed reading instruction in our science instruction. –Oliver Winch Teacher

Two of the most oft-cited interdisciplinary connections are reading comprehension and word attack skills. A special education teacher said of a class she co-teaches: “Literacy [has] got to be number one. I mean... if you can read the multiple choice question and understand what it’s really asking you—so much has got to do with literacy.” A co-teacher expanded on the importance of literacy-building activities in middle school science, “It gets back to the vocabulary that we do. It’s so content specific that if they don’t have that basic understanding of the words that we’re speaking, they’re not going to be getting any of it. I’m constantly pushing literacy and, really, the vocabulary aspect.” A Jefferson teacher provides an example of how she tackles vocabulary with her “root of the week” five minute mini-lessons. She explained that she does these to ensure a focus “on vocabulary and etymology, and how it can be used to gain insight into scientific knowledge and tasks.”

In several of the higher-performing schools, specific literacy-building initiatives were supported districtwide with inservice training for all content teachers. In Johnson City, where “4 Square Writing” has been incorporated in all content areas, a teacher reported that “kids get good at it... when [they] go from content to content, they better understand.”

**Everyone Is an Everything Teacher.** Educators in higher-performing schools showed abundant evidence of making connections between ELA and science, but there was also evidence of instruction incorporating almost every other subject: math, social studies, health, art, physical education, and the list goes on.

I just taught a science lesson on the planets—then I included the history of the names of the planets—then I transitioned to the calculation of how old they would be using each planet’s definition of ‘year.’ My goal is to have students not see the content areas and the knowledge thereof as distinct. I want students to be unable to say that they hate math but love history, when really the knowledge is all interrelated. –Jefferson Teacher

As for math connections specifically, as one Johnson City teacher noted, science can make math, a subject some kids “don’t like,” more fun and comprehensible. In Bolivar-Richburg, a teacher noted the importance of basic math skills in being able to “go further in science.”

A lot of the challenges are that my [special ed] students lack a lot of the basic skills needed to go further in science, especially in math. When we’re working with chemistry or physics, where it requires a lot of those basic skills, just basic addition, subtraction, multiplication and division—those are often challenges for us. They require a lot more support and modifications to the curriculum for them to be able to meet those expectations. –Bolivar-Richburg Teacher

Although science is often viewed as “the least of a school’s problems” in light of the accountability structure that emphasizes math and ELA, higher-performing schools do not leave science to take care of itself. Rather, district-level leadership sets goals to incorporate interdisciplinary connections throughout K-8; offers inservice opportunities to help all content area teachers monitor literacy development; and supports field trips and extracurricular activities to bring science to life.

Overall [for] a middle school student, I want them to be able to learn how to read and follow directions, to work on test-taking strategies, to see that the subjects are not independent of each other. I try to draw on as many connections as I can. We’re doing something with calculating, there’s math. We’ve been talking a lot lately about test-taking strategies—that goes for social studies, math and English language arts. –Geneseo Teacher

I took the kids to the creek hike in... Letchworth [State Park nearby], so they can tie in what they are doing in the classroom. That’s why you’ll see today, we’re doing weather but we’re pulling up today’s weather, tomorrow’s weather... because I think that kids are taught too disconnected. They learn to conjugate a verb in English but it doesn’t pertain to math or science. So we do stuff to try and connect.... The kids are handing in a report today that was a joint [one] between science and English, to try and connect together what they are doing. –Geneseo Teacher

## On the Continuum to Higher Performing

### Average Performing

Just beginning the process of focusing on strong literacy links between the subject areas, doing more interdisciplinary work, and supporting all of this instruction with professional development and well-articulated curricula that include mathematical and linguistic literacy in science through middle school.

The focus on ELA and math seen as drawing attention away from science.

Just beginning to see links between literacy in other subjects and science; have not moved toward integration across grades in the curriculum and/or instruction.

### Higher Performing

Purposeful and consistent integration of literacy focus in science and interdisciplinary connections throughout K-8.

Science seen as a naturally motivating subject for middle schoolers and used to develop linguistic and mathematical literacies.

Science curriculum map includes interdisciplinary connections.

If a kid can't read and write, they can't do life. And it's all about literacy. We've really worked very, very hard. This year has been very successful for us: two of our three grade levels are in the nineties on the state assessments [in ELA]; I remember 37%. So that's quite an achievement. I think given what was here, it's a tribute to the staff because they worked so hard, and they believed. I hope they feel good about what they've been able to change, because they've really changed it. –Wayne Administrator

When I first started teaching, we didn't do very much writing in science. –Wayne Teacher

Another remembered the struggle: “How do we get them to approach a paragraph, if they're a poor reader, without panicking? ...Let's slow down, let's underline some key words. ...Let's make an inference like you would in ELA.... Before we even read a question let's make an inference about what the question might be asking if you see this diagram.” –Wayne Teacher

WHAT IT LOOKS LIKE IN:

# Thomas Armstrong Middle School Wayne, NY

A decade ago, literacy was a problem for Wayne. Only about 40% of students were meeting state ELA standards. Dissatisfied, the school began a push for every teacher to be a literacy teacher, and by 2008 twice as many students met the standards. The “literacy movement” spread throughout the school to all classes, from physical education to physical science.

Science teachers have found the new emphasis helpful. As one observed, “The difficulties they were having in science weren’t so much the content in science; they weren’t having the skills to understand the reading and to draw inferences.”

All teachers were not automatically equipped to teach literacy, so professional development was provided. Some of it centered on reading and writing in the content areas; some of it was hard-core ELA review: “We actually...became ELA students again... to show us some basic skills, even just going back and reviewing the basic ELA grammar.”

Once all the teachers committed to the literacy push, they noticed results: “We were all pretty much the same as far as what we accept, what we don’t accept. Because of that, the students are coming out with literacy in science, literacy in

math, literacy in social studies. That helps them to perform well on their tests. It also helps them understand the questions that we ask. When we use our textbooks, and we use our different writing materials, they are able to gain more knowledge because they understand what piece they are actually getting from that.”

Teachers approach literacy in the science classroom in a variety of ways. One teacher spoke of a recent unit: “When we were building circuits, we were underlining key things: how many bulbs, how many batteries, what type of circuit were we building. Whenever I give any written text [other than the textbook], they’re always using strategies, such as finding the answer right in the text and highlighting it. Making sure they’ve got backup for the answer they are putting down.”

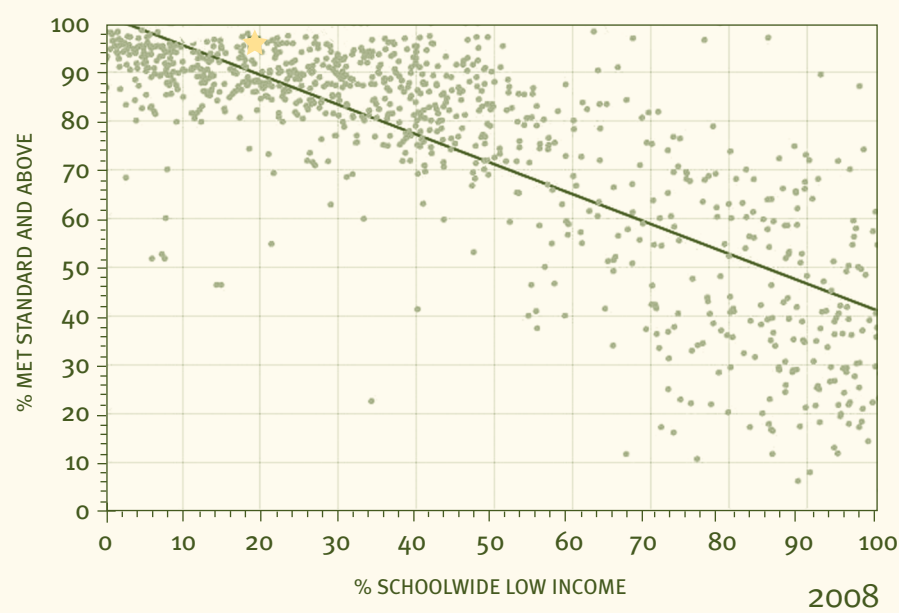
Another teacher compared the current literacy program to earlier efforts, “Over the past few years we’ve increased the writing. On worksheets now [the directions indicate to] restate the question and answer using complete sentences. We do other type of writing activities; we even do some creative writing. Pretend you are a rock; tell your story as you go through the rock cycle.... Some students are going

to pick things up in different ways. Plus, the writing is good practice and a little bit different than they might do in ELA. We also often try to relate things in ELA. If they are doing appositives in ELA... I’ll reinforce that by saying, ‘In this writing, I’d like you to use an appositive in your sentence.’”

In most of the observed classes, students completed tasks that traditionally would be found in an ELA class. For example, in one class, students were asked on the post-assessment to “Make sure you’re re-stating the question, a nice complete sentence.”

Success in literacy has been demonstrated within classes and across classes. The assistant superintendent for instruction stated, “We have found... if they are very literate, they are going to be successful in any area.... We have had an intensive focus on having kids become readers and writers ...[and] to transfer those skills into being mathematicians or scientists, or historians, and using those skills to really... deepen their understanding of those areas.” One science teacher summed it up, “I think without the ELA skills that we teach, the science would just fizzle out.” (from Sherwood, 2009d)

Wayne Middle School students consistently outperform students in schools with comparable demographics on the NYS Intermediate-level Science Examination.



● All New York ★ Wayne Middle School

2008



# 5.

## Fit: Managing Where the Rubber Meets the Road

Surround yourself with good people—that’s where the rubber meets the road. Hire good people. ...Hire excellent teachers and the rest will be taken care of.

–Greene Administrator

Employing all four of the previously described best practice elements is dependent upon one essential final element: Having the right fit of educator to work in middle school science. For higher-performing schools, minimizing potentially destructive friction from teachers or administrators who may not be in line with the school and district’s efforts and central mission begins with a clear idea of what fits.

In most higher performers, qualities that characterize the right fit of educator include the ability and willingness to engage with adolescents in all their oftentimes awkward wonder; knowledge, strong interest, and typically state certification in science; and alignment with the school and district’s educational philosophy, culture, and instructional focus.

**Avoiding the “Stepping Stone Effect”** One of the achievements of higher-performing schools is in avoiding what one educator in this study named the “stepping stone effect.” This is a phenomenon whereby teachers take middle school positions as a “stepping stone” to a high school science job. Higher-performing school administrators share a common concern about ensuring that their middle school science teachers, first and foremost, are willing to teach middle school kids.

I purposely hire people who are kid centered and they have to demonstrate that they’re kid centered. You could tell me that you love kids, but one of my favorite interview questions is, “What makes you worthy to teach my children?” I’ll tell you, you want to see somebody’s eyes roll back in their heads. Some people are very insulted by asking them, “What makes you worthy to teach my kids?” and not what credentials you have please. –Wayne Administrator

Being “kid centered” in middle school may mean dealing with “squirrely” behavior, as one teacher described it. Many of the science educators in this study explained that middle school students are quite savvy at picking up when a teacher doesn’t like them, doesn’t seem to care much about adapting the content to their interests, or doesn’t feel comfortable teaching science. Administrators in higher-performing schools look for teachers who will relate to their students not only in class, but after class, in hallways, through field trips, and in extracurricular club activities.

Administrators and teachers alike see the teaching of middle school science as requiring a unique set of personal qualities, skills, and sensibilities distinct from those of elementary or high school teachers and, therefore, strive to make sure that the stone teachers land on in middle school is the one where they will want to stay.

There’s such a difference between high school, middle school, and elementary school. It’s almost like they’re different professions, really. –Oliver Winch Teacher

We have students who don’t want to leave after school and to me that’s a real good sign, especially [in] our science areas. At 2:30, you can walk by each of our science rooms and find students in each one. It’s part of a dedicated staff because we don’t really have contractual hours. So at 2:30 if teachers want to leave, they can leave, so that is by choice, and it’s about what’s best for students. Our middle-level science teachers certainly model that.

–Geneseo Administrator

**Willing... but Also Ready and Able.** One of the concerns raised in much of the literature around science education relates to what is seen as inadequate science teacher preparation. In this regard, higher-performing schools reveal a few patterns about how they ensure their teachers are ready and able to teach middle school science.

Because state certification in New York is offered at the secondary level (seventh and up) in science and not at the elementary level, there are times when fifth- and sixth-grade teachers, who may be housed within a middle school, come with little background in science and sometimes no background in science pedagogy. For these teachers the science standards are an invaluable guide, as are the curricular documents, inservice trainings, and interdisciplinary collaboration opportunities in their buildings.

In many of the higher-performing schools curriculum coordinators and other teacher leaders were seen as providing guidance in both knowing and “loving” science, but also understanding how to convey that knowledge in effective ways to middle school students.

One of the things is that one of our science teachers currently at the middle-high school is very good in science and in the last few years, he’s been working with the elementary in the areas of science and helping them come up with teaching strategies to help students at the elementary level. He’s been doing this for the last several years. So I think it’s been paying off now. Kids are coming up here now with a good background and a good feeling toward science. I think that has helped us to grow.

—Bolivar-Richburg Administrator

In some cases these instructional leaders come to science teaching from working in the field, in laboratories for private industry and the like, or at least have contacts with private or public research organizations from their college days. They have, as one administrator described a curriculum coordinator in her building, “walked the walk.” Overall, a love or at least a comfortable familiarity with science and science pedagogy were characteristic of teachers in higher-performing schools and supported through teacher leadership.

**Fitting in with Philosophy, Culture, and Instructional Focus.** In addition to a good fit in terms of being willing, ready, and able to teach middle school science, another important dimension of fit is with the school and district focus of instruction and broader philosophy of education.

Alignment to the school’s instructional focus, as one Johnson City teacher asserted, is “huge” and specifically noted in observations. If a teacher couldn’t or didn’t want to adapt to these particular emphases in his or her lessons the friction would be palpable and come with consequences. In Oliver Winch, for example, the focus on hands-on work and differentiated instruction is expected and counts as a measure of a teacher’s success.

The right fit in terms of philosophy and school culture can mean anything from embracing the use of data to inform decision making as in Bolivar-Richburg, or seeing collaboration and teamwork as central to your work as in Geneseo.

You need the right people. I mean in any subject, science, English, you name it. You have to have the right people who are willing to... look at the data and analyze that and be willing to make adjustments to your teaching style based upon that, especially once you see a pattern starting to develop. —Bolivar-Richburg Administrator

The 6th and 7th grade science teachers love science. They have high expectations. The kids see they love what they do, so kids are more into it. They are willing to help them take the time to work after school and they’re working with other staff members. That is a big key to all of it. —Greene Administrator



I think that the role of the standards is partially to help the teacher make sure that they are teaching what they should be teaching. This is especially important because often the elementary teachers do not have a specific concentration in all areas that they are expected to teach. Essentially, it is a good baseline for checking oneself. —Jefferson Teacher

I truly believe our middle level is as strong as it is only because of the teachers. You know what? We have wonderful students. We have a very strong community, but we have outstanding middle-level teachers. The bar is very high. So if you aren't a strong teacher and you enter our middle school, it's going to be noticeable. And when every teacher is communicating on a weekly basis and on a daily basis and when they're communicating with me and with each other and somebody is not doing that, it is brought to my attention real quickly. It's brought to the community's attention because they talk to me. –Geneseo Administrator

## On the Continuum to Higher Performing

### Average Performing

Teachers hired without regard to whether they have interest/desire/background to teach middle school children.

Working toward creating a professional learning community. May be just beginning an effort to do this.

Little inservice and collaborative opportunities for newer and teachers with little science teaching background.

### Higher Performing

Teachers who love middle school kids and have some science education background sought after and hired.

Well-established professional learning community where school and district philosophy, culture, and instructional focus are clear and supported.

Inservice, interdisciplinary collaboration, and well-articulated curriculum support for newer teachers and those with little science teaching background.

At... middle school and on, we've done a lot of inservice and allowed the teachers to go to specific science training.

–Bolivar-Richburg Administrator

WHAT IT LOOKS LIKE IN:

# Jefferson Middle School Jamestown, NY

Much of the success of Jefferson Middle School and the district as a whole is attributed to the previous superintendent, who had a vision of what the district and Jefferson Middle School should be and aggressively sought the funding to bring that vision to fruition. Now, says the director of curriculum, instruction, and assessment, “What is important is what you do with that legacy.” A key position in the district is that of the coordinator of science and technology, formerly a high school physics teacher. He is praised by teachers and administrators alike for his tenacity and assertiveness in seeing that the needs of the science department are met, whatever they are, which in turn allows teachers to meet the needs of the students. He was described as the “go to guy,” the one who will get you what you need—supplies for an experiment or

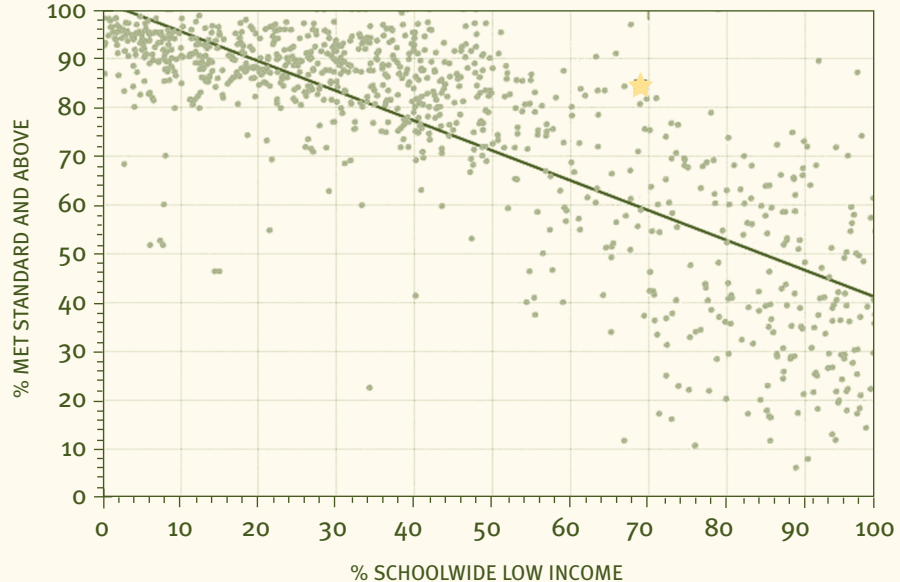
financial support to attend a conference. They praised his attitude, drive, and sense of commitment and wished it could be bottled and distributed to schools throughout the state.

Jefferson recruits teachers from an employment fair held at Edinburg State College in Pennsylvania and Buffalo Regional Recruitment Fairs, as well as through traditional media routes. Because of Jamestown’s close proximity to the State University of New York at Fredonia and St. Bonaventure University, many teachers are graduates of these institutions or they originally hail from the Jamestown area. Teachers are selected in the typical fashion of interviews with the superintendent, principal, and science coordinator. Occasionally, a teacher will join the interview process. Questions cover areas such as how candidates would interact with parents

and how they might deal with disruptive students. In some instances, a candidate may be asked to teach a lesson. The principal described the pools of applicants as “above average” and attributed this, in part, to Jamestown’s reputation as being able to “form a better teacher—to groom a teacher” as well as to the “high level of technology” available for instruction.

Although the district offers no formal process to support teachers to pursue national board certification, professional expectations are high and professional activities support teacher development as much as possible. In addition to district monies for attending conferences, the Jamestown Teachers Association sets aside \$300 per teacher in its budget for professional development. (from Amodeo, 2009)

Jefferson Middle School students consistently out-perform students in schools with comparable demographics on the NYS Intermediate-level Science Examination.





# Conclusion

The problem we have in our schools is that we teach kids that there is right or wrong, but science is about making mistakes.

—Geneseo Teacher

**K**eeping the wonder of science alive for adolescents, as findings from this study suggest, drive to the core of the big questions that have informed how and why any human being attempts to teach another. Do we teach to avoid mistakes? Do we teach from mistakes? Where does personal experience come into play in learning and where does the expert/teacher step in?

In this study of a sample of schools with at least average challenges in terms of socioeconomic backgrounds, findings indicate that higher student performance in middle school science is impacted by a variety of supports resting on attention to the relationships between beliefs about student ability and adolescents' emotional and social needs. In higher-performing schools attention is given to purposefully nurturing a climate of fair opportunity to succeed in more advanced science, supported by keeping science fun and relevant.

Higher-performing schools also show evidence of efficiency in directing efforts to improve science education through the use of data and dialogue in their professional development efforts, curriculum revision work, and instructional approaches.

Strong foundations in science content knowledge, skills, and sensibilities are built through ongoing curricular work and a mixture of instructional practices proven to be highly engaging for students with a variety of learning styles and needs.

A key instructional practice correlated to higher performance in science is the integration of literacy-building approaches to enhance fluency in expressing science knowledge and making connections between science and other subjects.

Enacting all of these practices, as our evidence shows, ultimately lies upon the shoulders of the educators and so,

ensuring a good fit between educators and students' grade level, content area background, and philosophy toward teaching and learning is also a key best practice.

It is important to note that findings from this study are limited to a small sample of schools in one state and observations over two days of site visits. What we can glean from this research is a sense of the state of the art of middle school science education in one state with a, perhaps, raised awareness of how school contexts may differ. We can also draw from these findings an understanding of some of the factors that promote practices that have the greatest impact on student performance, as well as those that don't. In the end, the direction of science education, as these findings imply, is moving toward the breaking down of disciplinary lines and the opening up and exploitation of the human capacity to inquire, nurtured at the earliest stages in a child's learning.

As school administrators and teachers face the challenge of heightened accountability for all students, regardless of ethnic, linguistic, and socioeconomic backgrounds, these findings provide a framework for focusing efforts to improve student achievement in science, not only at the middle level, but across K-12 and beyond.

# Methods

This qualitative study was part of a series of best practices studies and the first to include observations and a closer look at instructional practices (Wilcox & Angelis 2009; Wilcox 2007, 2008; Just for the Kids-NY, 2005). This study sought to investigate how a variety of factors indicated in previous research come into play in promoting exemplary performance in middle school science. Specific questions included the following: How are academic goals and curriculum developed, revised, and utilized to support higher performance in middle school science? What practices related to staff selection, leadership, and capacity building support higher performance in middle school science? What instructional programs and practices support higher performance in middle school science? How are data monitored, analyzed, and used to support higher performance in middle school science? What interventions, recognitions, adjustments are used to support higher performance in middle school science?

Ten schools were included in this study. Seven of these were identified as “higher performing” based on performance in Intermediate-Level Science in 2006, 2007, and 2008. Three of the schools were identified as “average performing” based on the same data. For this sample, study schools were chosen using regression analyses that estimated performance based on a combination of demographic factors that include schoolwide percentage of low-income students, the enrollment of the school, the percentage of students with limited English proficiency, and the ethnic composition of the school population. In addition, per-pupil expenditures in the sample schools cluster near the state average and all have open admissions policies. In 40% of the sample schools, the percentage of students qualifying for free or reduced-price lunch exceed the state average.

Research teams included practicing teachers, researchers, and doctoral students. All received training in conducting research per the University’s Institutional Review Board and specific instruction in the use of interview and observational protocols used in the study.

Data collected included interview transcripts, documentary evidence, and observation. Teachers and administrators in all schools were interviewed over two days by two-person research

teams for approximately 40 minutes each. Interviewees for each school typically included two to four administrators and four to six teachers totaling 83 interviews across all schools. Documentary evidence collected includes: Curriculum maps, pacing guides in science; professional development information/materials; teaching evaluation information/forms; staff selection materials; unit and lesson plans; school schedules; district, school, and classroom assessments; and Academic Intervention Services specific to science. Three to four observations of science classes in each school totaling 34 observations were conducted. Observations were guided by two components: a semi-structured observation protocol that required a narrative account of the observation, and a time x activity chart that recorded numbers of minutes on pre-specified activities (e.g., types of tasks).

Interview, observation, and documentary evidence data were coded inductively using a constant-comparison method utilizing qualitative software (Miles & Huberman, 1994). Individual research teams crafted case studies for each school, and cross-case analyses of all higher-performing and average-performing schools were used to identify “best practices” in middle school science (Yin, 2005).

# About *Just for the Kids—New York*

Since its inception in 2004, one goal of Just for the Kids-NY has been to help schools learn from other schools that are performing well. The project has identified best practices in elementary, middle, and high schools and is currently testing tools to help schools put the findings to use. With this study, it has now identified best practices in middle school science, in which researchers examined schoolwide factors as well as classroom practice in science. Results of both the current and prior studies are available on line at <http://knowyourschoolsny.org> and [www.albany.edu/aire/kids](http://www.albany.edu/aire/kids) and include reports, case studies, best practice frameworks, sample evidence from higher-performing schools, articles, and presentations. Some are also available in print.

**Just for the Kids-NY** is a project of the University at Albany School of Education in collaboration with The Business Council of New York State and the New York State Education Department. Guidance is provided by a statewide Advisory Board. Funding is provided, in part, by the State of New York and the University at Albany. In 2009 the project launched a new initiative, Know Your Schools~for NY Kids, whose website <http://knowyourschoolsny.org>, makes it easy to learn how any school in the state is doing on state assessments and to compare its performance to similar schools.

This report is the result of a study conducted by the University at Albany School of Education.

For more information visit the websites or call 518-442-5171.

What Works in Middle School Science:

Preparing Adolescents to Become the Next Generation of Scientists

Kristen Campbell Wilcox, 2009

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