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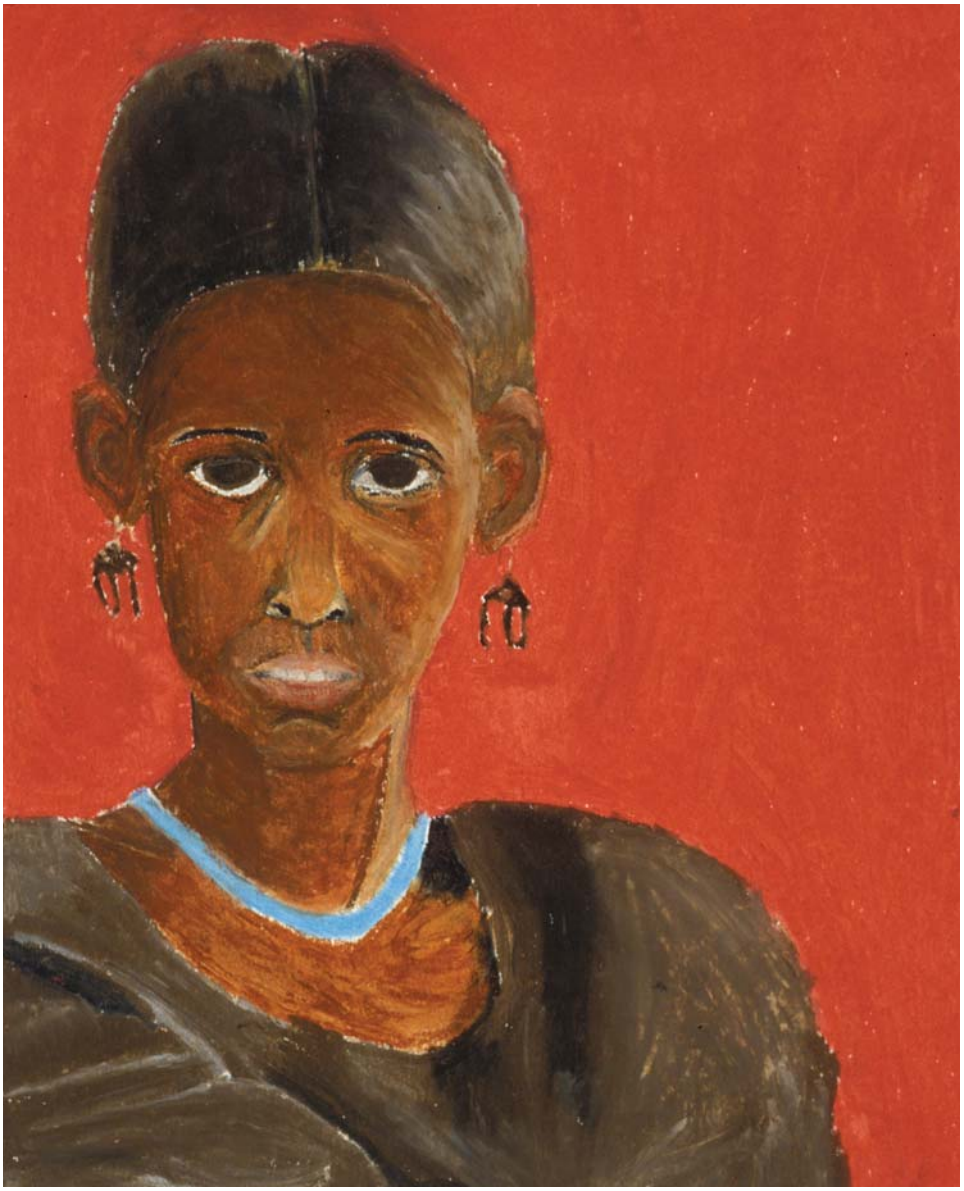
VOLUME 5 NUMBER 1 WINTER 2004

A PUBLICATION OF THE NORTHWEST EISENHOWER REGIONAL CONSORTIUM FOR MATHEMATICS AND SCIENCE

A MATH AND SCIENCE JOURNAL
DEVOTED TO RIGOROUS AND IMAGINATIVE LEARNING



LEARNING ENGLISH IN THE MATH AND SCIENCE CLASSROOM

- From Barriers to Bridges: Diverse Languages in Mathematics and Science
- Growing Language Through Science
- Teaching Across a Spectrum of Languages

Northwest Regional Educational Laboratory

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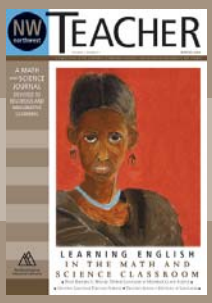

ON THE COVER:
This arresting oil-pastel portrait of a young girl was painted by Adina Menashe, 12, a student at Innerscape Art Center in Portland.

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EDITORS' NOTE

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WHEN HARRY POTTER SPEAKS FEARFULLY of his nemesis as "You-Know-Who" in *Harry Potter and the Sorcerer's Stone*, Professor Dumbledore gently chides him, saying, "Call him Voldemort, Harry. Always use the proper name for things. Fear of a name increases fear of the thing itself."

Indeed, to use the true name of a thing is to have dominion over it, the proverb says. And, like Dumbledore, teachers know that one of their greatest tasks is to impart the power of language to their students. Yet, the specialized languages we use to express ideas in math and science can seem as murky and fearsome as a beast in the shadows to a student who is struggling to master the vocabulary and meanings.

And for the student who isn't a native English speaker, it can be like trying to solve a riddle within a riddle.

Math and science classrooms—especially those rich in inquiry and problem solving—hold special promise and challenge for English language learners. Scientific inquiry and math problem solving are suffused with talk: questioning, describing, explaining, hypothesizing, debating, clarifying, elaborating, and sharing findings. While the language demands are significant, the potential is also strong that students will learn important English-language skills as well as science and math.

In this issue, you'll read about teachers who are fostering their students' English acquisition while taking them boldly into the worlds of math and science. They've resolved that language differences will not hold a single student behind to wait timidly at the edge of knowledge.

The opening article, "From Barriers to Bridges," reviews what researchers and practitioners have learned about English language learners in the math and science classroom. There are rich connections to be made, they say, in the teaching and learning of language, math, and science.

In "Growing Language Through Science," a teacher in the rural town of Royal City, Washington, fires his ESL students' scientific imaginations to the point that they're bursting to communicate the discoveries they've made. They fill their journals and reports with their observations and stand up in class to tell their classmates what they've learned.

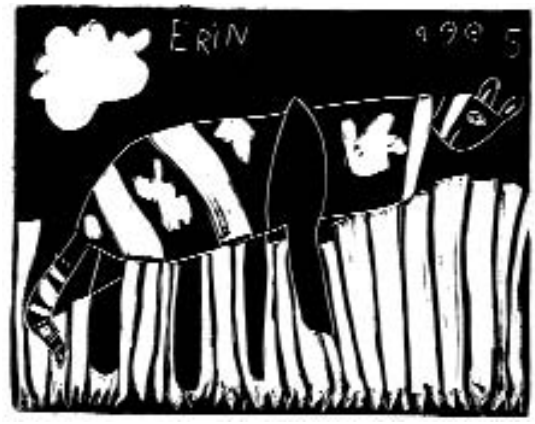
In "Teaching Across a Spectrum of Languages," a third-grade classroom in Woodburn, Oregon, thrums with learning and languages—this is an integrated class of native English-, Spanish-, and Russian-speaking students. Here, the teacher follows an individualized approach to bilingual education in which language acquisition is tightly woven across the district's challenging core curriculum.

Students in these classrooms are learning—in a new language—to wield the magic of words that will reveal secrets of the universe. They, too, must know Harry's thrill when he summons the power of naming to face down his foe and cries triumphantly, "VOLDEMORT!... I've met him, and I'm calling him by his name." NWT

Art is courtesy of Innerscape Art Center.

Our vision is that *Northwest Teacher* will serve as a tool for professional development by actively engaging readers and by speaking to them as imaginative problem solvers, thoughtful inquirers, and lifelong learners. The stories that follow were selected to inspire teachers to reflect on and talk about their own experiences and beliefs.

Professional development providers might use an article to illustrate a concept, providing time for reading and discussion. Teachers might want to share the journal with their colleagues, discussing their responses to the stories, perhaps even collaborating to try a new approach. Administrators might distribute copies to staff members, inviting them to share their reactions and reflections at a meeting or by e-mail exchanges. *Northwest Teacher* can serve as a starting point for group dialogue about issues in mathematics and science teaching, as well as for independent reading and personal reflection.



From Barriers to Bridges:

Diverse Languages in Mathematics and Science

STORY BY Jennifer Stepanek ARTWORK BY STUDENTS OF Innerscape Art Center

TEACHERS DRAW ON DIVERSE LANGUAGES to build a strong foundation for learning mathematics and science.

Learning is a process of developing and negotiating meaning, which is usually achieved through the medium of language (Khisty, 1995). To convey ideas—whether from teacher to student, from student to teacher, or among students as they build meaning together—all must be able to use language.

Because language is the primary means of teaching, students' ability to participate in mathematics and science is dependent on their language ability: talking, listening, reading, and writing (Buxton, 1998; Lee & Fradd, 1998). Both mathematics and science require the ability to understand specialized vocabulary, as well as specialized meanings of common words. Students also need language to express their thinking and communicate what they know.

It is not surprising that studies of the relationship between language skills and mathematics show that language proficiency plays a role in mathematics achievement (Cocking & Chipman, 1988; Secada, 1992). This relationship is not yet clearly understood, however, because there is not conclusive evidence that language ability causes mathematics ability or vice versa. In science, there is less research into this issue, but some evidence indicates that language proficiency is related to science content knowledge (Torres & Zeidler, 2002).

Beth Warren and Ann Rosebery are co-directors of the Chèche Konnen Center and have conducted extensive investigations of English language learners in science. They have developed an understanding of how students' everyday language and sensemaking strategies can contribute to a fuller understanding of science. Rather than moving students away from "nonscientific" ways of sensemaking—such as telling stories, imagining, and arguing—they believe that students' everyday approaches should be encouraged and incorporated into instruction. For example, they describe how one student who was studying ants used a process of imagining himself into the experimental environment to help him identify variables and to design his investigation more precisely (Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

Warren, Rosebery, and their Chèche Konnen colleagues encourage teachers to rethink their approach, using diverse languages as a bridge rather than a barrier to learning and doing mathematics and science. They write that by taking this perspective, "we can begin to envision

pedagogical possibilities that build on diversity as an intellectual resource rather than a problem or tension in science learning" (Warren, et al., 2001). (Chèche Konnen means "search for knowledge" in Haitian Creole. For more information about the Center, visit their Web site at http://chechekonnen.terc.edu.)

Investigating the connection between mathematics and language, Australian educators Mollie MacGregor and Elizabeth Price note the commonalities between language and algebra: "Changes in the order, position, or grouping of symbols affect meaning and the language of algebra has its own set of grammatical rules that are not intuitive but have to be learned and practiced" (1999). Their research, in which they tested for an association between students' algebra learning and their awareness of symbols and syntax, indicates that language ability is associated with algebra learning.

In fact, they found no instances of students scoring high in language and low in algebra. Although far from conclusive, their findings suggest that algebra learning reflects students' awareness of symbol and syntax in ordinary language.

Number words are usually a child's introduction to the language of mathematics. Differences in the ways that various languages construct number words illustrate how language can help or hinder students' understanding of mathematics concepts. In Chinese, Japanese, and Korean, number words are structured to reflect place value, so that the word for 11 in Chinese is *shi-yi*, which means "ten one" and the word for 23 is *er-shi-san*, which means "two ten three."

In English, as well as in other languages, the concept of place value is much less explicit between the numbers 11 and 20: The words "eleven" and "twelve" do not include a reference to 10 and the words for the numbers 13 through 19 are in reverse order, with the 10 ("teen") said after the ones place. This difference in number words may have an impact on children's number sense (National Research Council, 2001). For example, Japanese and Korean elementary students demonstrate a better understanding of place value as well as addition and subtraction with regrouping than U.S. students (Miura & Okamoto, 1999).

finding the right words

Developing knowledge of vocabulary is a touchstone of knowing and doing mathematics and science. As Leslie Garrison and Jill Kerper Mora (1999) explain, "Words are labels for thoughts, ideas, concepts, and thinking." Vocabulary is central to the process of constructing meaning, developing conceptual understanding, and communicating one's thinking.

The languages of mathematics and science are different from the languages that students use socially at home and with their peers, as well as in other subject areas at school. Therefore, all students are likely to benefit from instruction that targets unfamiliar words, expressions, and syntax. "Considering the complexity of the language demands facing all science learners, integrating language and science instruction when working with second language learners is not only a practical alternative, but probably the only alternative," writes Bernard Laplante (1997).

The "mathematics register" is the language used to talk about mathematics. It includes vocabulary that is specific to the discipline, as well as everyday terms that have specific meanings when used in mathematics. Symbols, expressions, and ways of communicating are also included in the register. Mastering discipline-specific vocabulary presents a challenge for all students; everyday words with a different or more precise meaning when used in mathematics and science can be equally challenging (Carlson, 2000; Khisty, 1995). For example, "average" and "divide" have a more precise meaning in

mathematics (Thompson & Rubenstein, 2000), and the concept of "force" is often difficult to understand in science because of its common meaning (Bernhardt, Hirsch, Teemant, & Rodríguez-Muñoz, 1996).

All students need to learn the differences between how words are used in an everyday context and their meanings in mathematics and science. This is not a simple process of translating from one domain or one language to another, but often involves many words and meanings, especially for English language learners. Whenever possible, differences between languages should be explicitly addressed.

Teachers can make sure that students are aware of differences between everyday language and the mathematical register by talking about what a term means in general and its precise meaning in mathematics (Gutiérrez, 2002). Also, asking students for associations they have for technical words and expressions will enable teachers to uncover connections that can enhance or get in the way of understanding (Moschkovich, 2000).

Exploring word origins may help students gain a firm grasp of mathematical and scientific language. When students learn the roots of certain words, it often helps them to understand the mathematical meanings: "Perpendicular comes from a root, *pend*, meaning to hang, because when a weight hangs freely on a string, it forms a perpendicular to the ground. Related English words are pendant and pendulum" (Thompson & Rubenstein, 2000). Another strategy is to have students invent their own words to describe a mathematical concept or come up with an analogy to make sense of a new idea. Teachers can then build on students' invented vocabulary by connecting it to the correct terminology (Rubenstein, 1996).

everyday language

The ability to express themselves in the languages of mathematics and science is a key aspect of learning for both English language learners and native English speakers. Nevertheless, teachers should not overlook everyday language as a learning tool: "Students' everyday experiences and first language can and do serve not only as obstacles but also as resources for constructing mathematical knowledge and communicating mathematically" (Moschkovich, 2000).

Classes that are highly interactive, with frequent discussions and collaborative problem-solving and inquiry activities, are more likely to encourage language development for English language learners. Such classes provide hands-on experiences and meaningful contexts that support students in acquiring language skills simultaneously with knowledge and cognitive skills (Thomas & Collier, 1997). Interactive discussions enable teachers to model and support the use of precise language and technical terms, but also provide opportunities to draw on everyday language. Students learn and practice strategies that they can use to make themselves understood, such as explaining or

describing something in more than one way or using gestures, concrete objects, and pictures to clarify an idea (Gutiérrez, 2002).

Using familiar forms of communication—such as personal narratives, jokes, and stories—provides multiple points of entry for knowing and doing mathematics and science (Ballenger, 1996). Personal narratives offer an interesting context for introducing mathematics and science vocabulary. They also provide students with a familiar situation in which to ground new concepts and terminology. In an activity in which students write or tell a story about a phenomenon they have observed, such as the weather, teachers can begin to make connections between what the students describe and the vocabulary used in science (Simich-Dudgeon & Egbert, 2000).

Native languages are resources for learning because students are more successful when they continue to develop their native language skills rather than focusing exclusively on learning in English (Khisty, 1995; National Research Council, 1997; Samway & McKeon, 1999). Garrison and Mora (1999) suggest that teachers use familiar language to teach an unknown concept or use unfamiliar language when dealing with a known concept. For example, a teacher may encourage her students to draw on their native languages as they begin developing their understanding of a new concept, before she introduces them to English vocabulary.

Bringing diverse languages into mathematics and science does not require that teachers be fluent speakers in their students' native languages. When they encourage students to use their native language to communicate together, teachers demonstrate that they value their students' backgrounds and abilities (Gutiérrez, 2002). They create a learning environment in which students feel more comfortable and have a greater sense of ownership of mathematics and science. Students are able to acquire the practices of mathematics and science while at the same time maintaining their cultural and linguistic identities.

If all students are to become scientifically literate and mathematically powerful, they must learn to use the languages of mathematics and science to pursue their own questions and purposes (Rosebery, Warren, & Conant, 1992). Opening mathematics and science to students with diverse native languages can bring energy to teaching and learning, and meaning to the curriculum. Mathematics teacher Eric Gutstein provides an inspiring model of how to use students' identities and experiences as a resource for learning. He has developed a middle school program centered on using mathematics to analyze social issues. In addition to increasing their understanding of mathematics, Gutstein wanted to help his Latino students develop a sense of how they might use mathematics to understand the world: "Not all students loved mathematics or found it easy. But even among some who did not like it, there was the sense that it was a valuable tool with which to make sense of things that were important to them" (Gutstein, 2003).

Jennifer Stepanek is coeditor of Northwest Teacher.

references

Ballenger, C. (1996). *Science talk in a bilingual classroom* (TERC Working Paper 1–96). Cambridge, MA: TERC.

Bernhardt, E., Hirsch, G., Teemant, A., & Rodríguez-Muñoz, M. (1996). Language diversity and science: Science for limited English proficiency students. *Science Teacher, 63*(2), 24–27.

Buxton, C. (1998). Improving the science education of English language learners: Capitalizing on educational reform. *Journal of Women and Minorities in Science and Engineering, 4*(4), 341–363.

Carlson, C. (2000). Scientific literacy for all: Helping English language learners make sense of academic language. *Science Teacher, 62*(3), 48–52.

Cocking, R., & Chipman, S. (1988). Conceptual issues related to mathematics achievement of language minority children. In R. Cocking & J. Mestre (Eds.), *Linguistic and cultural influences on learning mathematics* (pp. 17–46). Hillsdale, NJ: Lawrence Erlbaum.

Garrison, L., & Mora, J.K. (1999). Adapting mathematics instruction for English-language learners: The language-concept connection. In L. Ortiz-Franco, N.G. Hernandez, & Y. De La Cruz (Eds.), *Changing the faces of mathematics: Perspectives on Latinos* (pp. 35–47). Reston, VA: NCTM.

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GROWING LANGUAGE THROUGH SCIENCE

STORY BY Joyce Riha Linik PHOTOS BY Mario Godoy-Gonzalez

AN ESL TEACHER FINDS INNOVATIVE WAYS to weave science and language arts instruction.

ROYAL CITY, WASHINGTON— In a small town school amid the farms and apple orchards of Central Washington, students are bent over petri dishes with micropipettes in hand, treating bacteria they have cultured on gels with a garlic extract to test the herb's antibacterial properties. In an environmental chamber across the classroom, they are also in the process of growing varieties of basil, chamomile, lavender, and mint which they will harvest and grind to create extracts for further testing. This work is all part of an ethnobotany project through which the students are researching the medicinal use of herbs in various world cultures and testing the validity of these applications.

They will present the findings of their research—involving the processes of chromatography, electrophoresis, and polymerase chain reactions—at a student biotechnology exposition in Bellevue this year.

Their representation at the expo is a notable achievement, not just because they will be the only students attending the event from east of the Cascades (the majority of students represented at the expo come from more affluent communities in Seattle and surrounding King County). Their achievement is especially significant because these particular students are all English language learners in their first two years of high school, many of whom are recent immigrants to the United States who have arrived with little formal education and limited proficiency in English.

Students work on an ethnobotanical project, propagating basil plants that they have grown from seeds.

So how did these students make the cut?

Much of the credit goes to their teacher, Mario Godoy-Gonzalez, and the exceptional English as a Second Language (ESL) program he has developed at Royal High School.

a catalyst for learning

When the Chilean-born teacher arrived in Royal City a decade ago, he was given the charge of developing an ESL program to curb the high dropout rate for Hispanic students. Trained as an English teacher, he says he was prepared to teach language arts. When he learned, after signing the contract, he would also be responsible for teaching history, math, and science, he was a bit intimidated. He wasn't worried about teaching history, he says. "But science? Science was scary."

As he reflected on his own childhood education in Chile, he realized that science had never been one of his favorite subjects, largely because of the approach used by his teachers. "It was just reading and taking tests," he observes. That is, until his senior year in high school when a new teacher came on board, one who

engaged students in lab work in the classroom and even took the students on field trips outside the school to see scientific principles firsthand. It was then, Godoy-Gonzalez says, that his "passion for science was awakened."

As a result of this childhood experience, Godoy-Gonzalez made a decision, he says, "to teach science the way I thought it should be taught. I wanted to give the kids hands-on experience. I wanted the kids to 'discover' science" instead of reading about it in a book.

Further, he resolved that his students' discovery of science would not be hampered by their limited English.

Oftentimes, educators hesitate to introduce complex lessons in other subjects until ESL students have gained some mastery of the English language. "If a student can't read or communicate in English, many people get the idea that they can't do anything," Godoy-Gonzalez observes. He adds emphatically, "That perception is completely wrong."

He knows that just because his students' English language skills may be limited, it doesn't mean that their capability to learn other subject matter is. As a result, Godoy-Gonzalez doesn't hesitate to introduce complex scientific material in his instruction.

In fact, the teacher sees his students' discovery of science as a catalyst for honing language skills. As students experience the thrill of discovery—seeing garlic extracts kill bacteria in a petri dish, for example, or successfully extracting DNA strands from an onion—they are excited to communicate their observations. Godoy-Gonzalez gives them numerous opportunities to share these observations both orally and through such written work as journals and reports, helping them to further develop their language skills.

Students' hands-on experience often proves invaluable in learning new and sometimes complex vocabulary. "First," says Godoy-Gonzalez, "I show kids what we're doing without all the terminology. Then, little by little, I add it." For example, he prompts students to remember a specific experiment they've conducted involving a color reaction and then says, "What you did was 'chromatography.'" To further cement the term, he breaks the word down to its root: "'Chroma' means color." In this way, he says, "practical terminology is grounded in experience."

the poetry of science

Godoy-Gonzalez also finds other innovative ways to weave language arts and science instruction. One project involves writing poetry about environmental science. For many of these students, writing an essay is very difficult because of their limited English vocabulary. They may need to break their train of thought repeatedly to look up scientific terms in the dictionary and, by that time, they may have forgotten how they wanted to use the term in their writing, Godoy-Gonzalez observes. "But you don't need a whole bunch of words to express yourself through poetry."

Poetry allows these students—many whose families are employed in agriculture and who have a keen interest in environmental issues—to share their thoughts and learning more freely. In Godoy-Gonzalez' class, students write about issues of overpopulation, the use of pesticides, and the importance of clean air and water as skillfully and passionately as their American-born peers. Their passion for the subject matter fuels them through further study in language arts as they learn about the many forms of poetry—quatrain versus free verse, for example—and practice revising

A student admires her plants in the environmental chamber.

and editing their work. In small groups, students share their poetry and then offer suggestions for improvement. Along the way, they learn that writing is a process and that there are always opportunities for improving one's work, whether you are a Nobel laureate or a struggling ESL student.

"Research shows it takes about seven years to learn another language," Godoy-Gonzalez notes, "so we can't expect these students to do it after just two or three years."

As a result, journaling is especially important for ESL students, he says, not only to give students practice writing in English, but also to give him crucial feedback about student comprehension. Although the teacher tries to watch students' faces closely for any confusion when he's explaining concepts in English—and add explanation in Spanish if necessary—the journaling gives him more precise feedback on where he may need to focus instruction. "Sometimes kids are shy to raise their hands" to let teachers know they're having trouble with a particular concept, "especially at this age," he says. "I need that constant feedback so I can respond to their needs."

"On evaluations," he says, "I encourage them to answer in English," but then supplement with drawings or Spanish, if necessary. While this approach allows his students to demonstrate their subject knowledge, they are at a disadvantage when it comes to state testing. The WASL is a particular challenge, he notes, because these students' knowledge of other subjects may be more advanced than their grasp of English, but the nature of the test provides little flexibility in this area.

In the lab, students investigate bacterial transformation using green fluorescent protein (GFP).

high-tech discovery

High-tech scientific and technical equipment has been crucial to improving students' knowledge of science. Such tools as gel boxes, grow lights, environmental chambers, and computers have helped transform Godoy-Gonzalez' classroom into a mini-biotech lab, allowing students the opportunity to work on sophisticated projects including DNA extraction and analysis.

Technology is important, he says, "especially for this population" since these are students who otherwise might not have access to this kind of hi-tech equipment. "We're teaching tomorrow's generation, and we can't just go with the book and the board anymore."

Godoy-Gonzalez has been able to obtain such equipment through grants and donations, as well as funds attached to his various teaching awards. He was chosen as the Migrant Teacher of the Year for Washington state in 2000 and has received honors from the National Environmental Education and Training Foundation. More recently, he was the recipient of a $10,000 Toyota Tapestry grant for science and literacy education.

Part of the instructor's award-winning teaching style has included setting a good example for lifelong learning for his students. As Godoy-Gonzalez sought to expand his knowledge base in science in order to teach the subject proficiently, he got hooked on learning about science himself. He started with a summer institute at the University of Washington designed to help elementary school science teachers learn scientific methodology and gain confidence in teaching the subject. Since then, he has continued to seek out opportunities to learn from scientists willing to share their expertise and mentor him. As a result, he has spent every sum-

mer since 1995 studying with or working alongside scientists in cutting-edge research laboratories, among them the Fred Hutchinson Cancer Research Center.

During these experiences, he has kept a lab journal of his own, recording his own discoveries and frustrations. He shares this with his students to let them see that he is "just one more person learning science."

After two years in Godoy-Gonzalez' ESL program, students are mainstreamed in junior year classes. Some are hesitant to leave the stimulating and supportive environment of Godoy-Gonzalez' classroom when their two years are up. "They come and knock on my door asking if they can stay another year," the teacher reports.

But they move on. And many quite successfully.

Several of Godoy-Gonzalez' students have moved directly into advanced biology in their junior year. One of these recently received an award for her expertise in conducting scientific research. And graduation rates for Hispanic students at the school have steadily increased since Godoy-Gonzalez came on board.

Even kids who are not ESL students want in Godoy's program. They've heard about the intriguing science projects being conducted down the hall and want to know how they can participate. "I know English," said one American-born student who approached Godoy-Gonzalez about the possibility of joining his class, "but I don't know science."

Lucky for Royal City's ESL students, they are learning both.

Joyce Riha Linik is a freelance writer based in Richland, Washington.

Students use a UV light to check for glowing bacterial growth in their petri dishes.

Questions To Consider

• How can I make challenging content accessible to English language learners?
Students will benefit from instruction and materials that feature less complex language. However, the complexity of the content or the thinking required should not be reduced. Strategies for reducing the complexity of language include embedding concepts in a familiar or interesting context, using visual representations such as pictures or models, and designing collaborative activities. Providing supplementary materials, such as trade books, written in students' native languages can also support their learning.

• When should I correct students' language mistakes?
When students talk or write in mathematics and science, teachers' comments should focus primarily on the content of students' ideas and only secondarily on their language. In classroom dialogue, teachers should resist the impulse to interrupt students when they make an error in grammar or pronunciation. After a student is done speaking, the teacher can restate what was said using the correct language. Sometimes, students' responses may be difficult to understand. The teacher might try to restate what was said and then ask the student to confirm or rephrase their response. Encouraging students to provide each other with feedback on their writing and oral presentations may help make the process less threatening.

TEACHING ACROSS A SPECTRUM OF **LANGUAGES**

STORY AND PHOTOS BY Bracken Reed

INTENSIVE, CLASSROOM-BASED PROFESSIONAL DEVELOPMENT helps teachers meet the needs of English language learners.

WOODBURN, OREGON—"How do I make this color, again?" asks a student, reaching out for a box of paints.

"How do we get the color brown?" calls out third-grade teacher Sara Duncan, offering the question to the whole class.

"Yellow!" "Blue!" "And red!" comes the enthusiastic response from a chorus of voices.

"That's right," says Duncan, as she navigates around the classroom. "Yellow, blue, and red make brown."

All around her, students are hard at work creating dioramas out of cardboard boxes, paints, and colored papers. As part of her science unit on habitats, each student has chosen an animal and is building a diorama that shows the animal in its appropriate environment: salmon swimming up clear blue streams, bears wandering in dense green forests, bald eagles and red-tailed hawks soaring overhead. Duncan weaves among the tables, asking questions, keeping the students focused, and providing positive feedback.

The project, like many of Duncan's classroom units, is theme-oriented, activity-based, hands-on, and very clearly defined. It's also a lot of fun.

A half hour later, as Duncan counts down the end to the morning's cutting, pasting, and coloring, students plead for more time.

"I know it's hard to stop," she says, "but we've got to. We need to talk about what we've done today." The students reluctantly put away their paints, pens, scissors, glue, and rulers, and settle in for a closer look at their work.

"Julian, you did something interesting, what did you do?" Duncan begins the discussion.

"What did you put in with your bear?"

As Julian points out the fish swimming through his self-made river, Duncan moves to the front of the class and turns on the overhead projector. "Why did you put a fish in your diorama?" she asks him.

"Because bears eat fish," says Julian, which leads to a class-wide discussion about the eating habits of various animals and how students have represented this in their dioramas.

As Duncan writes the terms "carnivore" and "herbivore" on the overhead, she asks, "And what are we? Are we herbivore, carnivore, or something else altogether?"

A student begins one of the many art projects that are integrated into the curriculum.

"Something else altogether," comes the answer.

linking language and content

Sara Duncan's third-grade science class is also something else altogether: an integrated class of native English-, Spanish-, and Russian-speaking students, in which equal emphasis is put on the development of English language skills and the delivery of challenging, standards-level science content.

Teacher Sara Duncan with her third-grade students, whose native languages include Spanish, Russian, and English.

Heritage Elementary School, where Duncan teaches, is an innovative K–5 school located in the heart of Woodburn, a fast-growing community just north of Salem, the state capital, and only a 40-minute drive from the city of Portland. Woodburn, like many other communities in the region, has seen a large influx of both Spanish- and Russian-speaking immigrants during the past decade.

With just over 700 students, Heritage Elementary is bursting at the seams and consistently adding the equivalent of one extra classroom of students each year. A growing percentage of these students are the children of Woodburn's recent immigrants, and are entering the school as English language learners (ELL). But while other schools have staggered under the weight of such challenging demographics, Heritage, and the entire Woodburn School District, have met with a remarkable degree of success.

One key to their success has been a flexible, individualized approach to bilingual education. English Language Development (ELD) is organized differently at each grade level, but a common theme is a balance between integrated time, in which students of mixed English language abilities are grouped together, and ELD time, in which students are grouped with others of a similar ability level. As Duncan says, "It's important for [ELL students] to have both kinds of interaction: time with native English speakers that can provide models for them, as well as opportunities to develop skills at their own level."

These ELD groupings are fluid and flexible, allowing for smooth transitions as new students arrive at the school and others progress to the next ability level.

But a well-structured program model is only a small part of the story. More important is the districtwide focus on developing a curriculum that is challenging, aligned with state standards, consistent within each school and across the district, and attentive to the needs of English language learners, no matter which language is being used to deliver it. ELD time is always linked to the larger curriculum, which allows students to develop cognitive skills and integrate new concepts at a language level with which they are comfortable.

Equally important is the district's emphasis on how and by whom that content is delivered. Teacher quality and professional development are a top priority throughout the district, and it shows.

Sara Duncan is one of a team of five third-grade teachers at Heritage Elementary, including Antonio Ramos, Liliya Zaltsman, Larry Conley, and Mike Ritchey. All five teach integrated classes, while Duncan and Ramos split those sections taught in Spanish, and Zaltsman teaches those in Russian.

lessons from the students' perspectives

When Heritage Elementary received a Comprehensive School Reform grant in 2002, the faculty's first goal was to develop a schoolwide professional learning community. After conducting some research, Principal Kathy Larson and the staff decided to focus much of their time and energy on the innova-

tive professional development model called lesson study.

Originally developed in Japan, lesson study is an ongoing, collaborative process in which teachers create a lesson plan, observe one team member teaching the lesson, and then meet to reflect on and evaluate the lesson. Often this is followed by a further revision and another round of teaching/observing/evaluating.

At Heritage Elementary, lesson study groups were formed by grade level, with each team of teachers using the same basic format, but given the flexibility to develop their own lesson plans, timelines, and evaluation guidelines. Each lesson plan is usually based on the exploration of a single cognitive strategy and an accompanying set of questions that serve to focus the observation and evaluation process.

The third-grade teachers designed a lesson for Duncan's Native-Language (Spanish) Literature block, with a focus on the cognitive strategy of questioning. Using the book *The Three Questions*, by Jon J. Muth (adapted from a story by Leo Tolstoy), the teachers explored ways in which the book could challenge the students to use predicting and questioning skills.

"Lesson study forces you to go deeper into the subject than you might normally and to really examine how the students are making sense of it," says Duncan. "And then you get insight from your peers about how the students were responding. It really helps you see the lesson through the students' eyes."

"It's not just about kids learning," adds Ritchey, "it's about us learning as well. The teacher actually has to think, too."

Lesson study has quickly become part of the culture at Heritage, with current projects focused on language development and cognitive strategies within content area instruction, including Guided Language Acquisition Design (GLAD), an instructional model that provides specific, practical techniques for delivering content to ELL students.

analyzing instruction

Another professional development program that has brought teachers together throughout the district is an annual planning process called teaching for mastery. Each summer teachers work together in grade-level groups to evaluate their curriculum and teaching practices as they relate to a specific area of the state standards, breaking them down horizontally into competencies, concepts, content, and assessments. The process is designed to give teachers a laser-like focus on the objectives of each classroom unit.

"It's really challenging," says Duncan. "It forces you to look at what you're teaching and how you're teaching, and to question every day whether we're reinforcing those major concepts that we want the kids to leave with. It brought us together as a group and it forced us to make the standards our own—to really understand the underlying concepts and competencies."

"Teaching for mastery has potential for everyone," says Ramos. "Looking at the other groups and the work they did, you start to see the similarities—the same ideas and the same philosophy—spreading throughout the district. We all have a common goal, and we share a lot more openly now."

As Ritchey sees it, the process can help remove any complacency teachers may have developed about their teaching practices and their lesson plans. "It's a lot of hard work," he says. "And at first you may wonder why you're doing it. But it works. It's forced us to take a real close look at ourselves. We're not comfortable sometimes, and that's healthy."

It's this refusal to become complacent that has helped Heritage Elementary meet the challenges of its ELL students. Lesson study and teaching for

Duncan's students work on their animal habitat dioramas.

mastery are both ideally suited to teachers working with ELL students. While lesson study focuses on fine-tuning how content is delivered, and understanding the variety of ways students have of making sense of that content, teaching for mastery allows grade-level teams to fine-tune the content itself, constantly reexamining each classroom unit for the maximum student benefit.

Throughout the district, professional development is a major priority and a central strategy in the attempt to address the needs of ELL students. Administrators not only preach the message, they back it up with time and resources.

At Heritage, for example, Principal Kathy Larson uses every available option to find planning and development time for her staff. Early release days allow the third-grade team to meet regularly to review and edit their annual plan and to work on lesson study. Substitutes are provided to free teachers up for lesson study observation, and block scheduling that coordinates the students' "specials" (music, art, and so forth) also provides staff planning time.

Summer professional development classes, such as the teaching for mastery course, are also given full district support: teachers are paid for attending, are given the option of taking them for academic credit, and are led by top-notch instructors.

"Our administration is very supportive and is truly a catalyst for professional development," says Duncan, and in her classroom one can see the positive result of this respect and support for teachers as lifelong learners: a fully engaged, well-trained teacher using every strategy at her disposal to deliver challenging content to her students. In Duncan's class, you see qualities that can't be measured by state standards, but that are the secret to every successful school: the joy of teaching and the joy of learning.

Bracken Reed is assistant editor of Northwest Education, *NWREL's quarterly magazine.*

Questions To Consider

• How can I incorporate language development into mathematics or science lessons?
To ensure success for English language learners (and for all students) language development should be included as a specific objective in all areas of the curriculum. Teachers can identify opportunities for explicitly including language in mathematics and science by designing or adapting activities to reinforce a language-related concept or skill. Opportunities for purposeful communication will also contribute to language development: posing questions, developing theories, interpreting data, and communicating strategies or results. Writing activities in which students create their own mathematics tasks or describe scientific phenomena help students develop conceptual understanding as they practice language skills.

• What evidence can I use to make sure that students understand what they are learning?
Using an interactive approach helps teachers maintain a sense of their students' knowledge and abilities. When students are not proficient with English or with the language of mathematics and science, it is difficult to determine if their mistakes are due to problems with the concepts or problems with communication. Therefore, teachers need alternative ways of checking for understanding, such as attending to facial expressions and expressions of emotion, such as frustration. Teachers can also combine multiple strategies to help students communicate what they know, such as asking students to restate what has been said in their own words, to find a different way of solving a problem, or to apply a concept to a new situation.

Postcript: You'll find more about lesson study in the spring 2001 *Northwest Teacher*, "Lesson Study: Teachers Learning Together," and the spring 2003 edition, "Lesson Study: Crafting Learning Together." Both editions are available online at www.nwrel.org/msec/nwteacher/index.html.

books and materials available from THE CENTER'S LENDING RESOURCE COLLECTION

THE NWREL MATHEMATICS AND SCIENCE EDUCATION CENTER'S RESOURCE COLLECTION is a lending library of teacher-support material. Search the collection and request items from the Web site at www.nwrel.org/msec/resource/ or call (503) 275-9170. Mailing items back is at library rate.

The following titles and resources will be helpful to educators interested in teaching mathematics and science to English language learners.

Changing the Faces of Mathematics National Council of Teachers of Mathematics (1999)

The books in this series, which was developed by an NCTM task force, focus on equity issues involving gender, language, and culture. Each book contains articles that connect research and practice, describing effective strategies as well as reasoned explanations of the underlying principles. Titles in the series include *Perspectives on Multiculturalism and Gender Equity, Perspectives on Asian Americans and Pacific Islanders, and Perspectives on Latinos.*

Talking Their Way Into Science: Hearing Children's Questions and Theories, Responding With Curricula

Karen Gallas (1995)

This book examines how elementary students and teachers think about and talk about science. It provides a window into children's thinking about the world, enabling educators to see how students build complex theories, identify important questions, and begin to enter the world of science, all within the naturalistic setting of the classroom. The author proposes that classroom science be taught as a particular discourse, with its own set of language and thinking practices.

Second Language Learners

Stephen Cary

This book helps K–6 teachers and administrators bring second language learners at all levels of English language proficiency into the core curriculum. The author evaluates common program and instructional models, outlines the basic ideas of how language is best acquired, and provides a wide range of strategies, techniques, and activities for building language and ensuring academic success for these students. The book includes teacher-tested ideas for making instruction concrete, keeping speech understandable, building second language oral and literacy skills, supporting students' primary language, organizing thematic instruction, boosting small-group effectiveness, implementing authentic assessment, increasing family involvement, and using online resources.

Science Learning for All: Celebrating Cultural Diversity

National Science Teachers Association (2001)

This collection of articles from NSTA's journal, *The Science Teacher* addresses inclusive curriculum design, multicultural teaching strategies, and language diversity in science teaching and learning. The articles provide focused teaching techniques, tips on working with English language learners, and practical insights on giving students an appreciation of the contributions that all cultures make to science.

Teaching and Learning Science and Mathematics in Diverse Classrooms: A Resource for Collaboration and Discussion

Gillian M. Puttick, Mary Buchinger Bodwell, & Tracey M. Wright (2000)

This item is a collection of articles that offer various views—backed by research and classroom experience—of science and mathematics teaching and learning. In particular, they explore some combination of the following: science and mathematics as discourse; students' home and culturally based ways of knowing, talking, and valuing; classroom talk and activity; views of learning as inquiry; and teacher research.

Language in Mathematics

Jennie Bickmore-Brand (1990)

This book contains a series of articles from Australian educators describing ways in which mathematics can be integrated with the language arts curriculum. The articles show how teachers are using literature to teach mathematics concepts, and modeling mathematical processing to help teach process-writing techniques. The authors seek to offer constructive ways to maximize the contribution that language can make in generating, comprehending, and expressing mathematical ideas and knowledge.

Integrating Mathematics, Science and Language: An Instructional Program

www.sedl.org/scimath/pasopartners/ (1993)

This two-volume curriculum and resources guide was developed by Paso Partners, a partnership of three public schools, an institution of higher education, and specialists from the Southwest Educational Development Laboratory. It is designed to help elementary school teachers organize their classrooms and instructional activities to increase achievement of Hispanic primary-grade children whose first language is not English. The guide offers a curriculum plan, instructional strategies and activities, suggested teacher and student materials, and assessment procedures.

AMY COYLE is a former teacher who works in NWREL's math and science program.

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Gutiérrez, R. (2002). Beyond essentialism: The complexity of language in teaching mathematics to Latina/o students. *American Educational Research Journal*, 39(4), 1047–1088.

Gutstein, E. (2003). Teaching and learning mathematics for social justice in an urban, Latino school. *Journal for Research in Mathematics Education*, 34(1), 37–73.

Khisty, L.L. (1995). Making inequality: Issues of language and meanings in mathematics teaching with Hispanic students. In W.G. Secada, E. Fennema, & L.B. Adajian (Eds.), *New directions for equity in mathematics education* (pp. 279–297). New York, NY: Cambridge University Press.

Kilpatrick, J., Swafford, J., & Findell, B., (Eds.). (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: National Academy Press.

Laplante, B. (1997). Teaching science to language minority students in elementary classrooms. *NYSABE Journal*, 12, 62–83.

Lee. O., & Fradd, S.H. (1998). Science for all, including students from non-English-language backgrounds. *Educational Researcher*, 27(4), 12–21.

MacGregor, M., & Price, E. (1999). An exploration of aspects of language proficiency and algebra learning. *Journal for Research in Mathematics Education*, 30(4), 449–467.

Moschkovich, J.N. (2000). Learning mathematics in two languages: Moving from obstacles to resources. In W.G. Secada (Ed.), *Changing the faces of mathematics: Perspectives on multicultural and gender equity* (pp. 85–93). Reston, VA: NCTM.

National Research Council, (1997). *Improving schooling for language-minority children: A research agenda*. Washington, DC: National Academy Press.

Miura, I.T., & Okamoto, Y. (1999). Counting in Chinese, Japanese, and Korean: Support for number understanding. In C.A. Edwards (Ed.), *Changing the faces of mathematics: Perspectives on Asian American and Pacific Islanders* (pp. 29–36). Reston, VA: NCTM.

Rosebery, A.S., Warren, B., & Conant, F.R. (1992). Appropriating scientific discourse: Findings from language minority classrooms. *Journal of the Learning Sciences*, 2(1), 61–94.

Rubenstein, R.N. (1996). Strategies to support the learning of the language of mathematics. In P.C. Elliott & M.J. Kenney (Eds.), *Communication in mathematics, K–12 and beyond*. (pp. 214–218). Reston, VA: NCTM.

Samway, K.D., & McKeon, D. (1999). *Myths and realities: Best practices for language minority students*. Portsmouth, NH: Heinemann.

Secada, W.G. (1992). Race, ethnicity, social class, language, and achievement in mathematics. In D.A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 623–660). New York, NY: Macmillan.

Simich-Dudgeon, C., & Egbert, J. (2000). Science as a second language. *Science Teacher*, 62(3), 28–32.

Thomas, W.P., & Collier, V. (1997). *School effectiveness for language minority students*. Washington, DC: National Clearinghouse for Bilingual Education.

Thompson, D.R., & Rubenstein, R.N. (2000). Learning mathematics vocabulary: Potential pitfalls and instructional strategies. *Mathematics Teacher*, 93(7), 568–573.

Torres, H.N., & Zeidler, D.L. (2002). The effects of English language proficiency and scientific reasoning skills on the acquisition of science content knowledge by Hispanic English language learners and native English language speaking students. *Electronic Journal of Science Education*, 6(3) [http://unr.edu/homepage/crowther/ejse/torreszeidler.pdf].

Warren, B., Ballenger, C., Ogonowski, M., Rosebery, A.S., & Hudicourt-Barnes, J. (2001). Rethinking diversity in learning science: The logic of everyday sense-making. *Journal of Research in Science Teaching*, 38(5), 529–552.

A WORD FROM THE DIRECTOR

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THIS ISSUE OF NORTHWEST TEACHER is the latest addition to NWREL's assortment of resources on teaching English language learners.

The Northwest Regional Educational Laboratory continuously strives to assess and address the needs within its region and to provide educators with resources, tools, and services that respond to those needs. This issue of *Northwest Teacher* is one of several publications we've produced over the past few years that focus on helping teachers to provide optimum learning for all students, including those whose native language is not English. I'd like to remind you of some of the previous resources on this topic you may want to revisit or perhaps tap into the first time if you missed them when they were initially published.

For example, you might take a look at *Teaching Mathematics and Science to English-Language Learners* from our It's Just Good Teaching series. This publication offers a summary of the research "linking second-language strategies with content instruction" and explores the use of thematic instruction, cooperative learning, inquiry and problem-solving approaches that can develop students' understanding of mathematics and science content while enhancing their English language proficiency. Classroom stories from schools in Anchorage, Alaska, and Salem, Oregon, illustrate how teachers enable English language learners to participate meaningfully in mathematics and science activities and enhance their language skills. The It's Just Good Teaching series is available in PDF and HTML formats at www.nwrel.org/msec/publications/.

In addition, several previous issues of *Northwest Teacher* complement and expand the ideas presented in this current issue. The Fall 2002 issue on *Math and Science Across the Curriculum* examined the power of integrating

language arts, mathematics and science. In the opening article, Jennifer Stepanek notes that "teachers' skillful use of language arts connections helps students make sense of mathematical and scientific ideas" and can be particularly effective in developing students' English literacy skills. Readers may want to again review the highlighted resources in the Fall 2002 issue and select a few to borrow from the NWREL Mathematics and Science Education Center's lending collection (www.nwrel.org/msec/resource/).

Another possibility is the NWREL quarterly publication series, By Request, that looks at "hot topics" within the region to give practitioners a glimpse of how fellow educators from around the Northwest are addressing issues, overcoming obstacles, and attaining success. *Strategies and Resources for Mainstream Teachers of English Language Learners* can be read and downloaded at www.nwrel.org/request/2003may/. Although not specific to mathematics and science classrooms, this issue of By Request offers an overview of second-language acquisition theory and its application in mainstream classrooms that will be useful to teachers in their mathematics and science instruction.

Finally, watch for a new product currently being developed by the English Language Learners Unit in NWREL's Center for Classroom Teaching and Learning. Expected in early Fall 2004, this publication will provide classroom teachers with a concise look at the research on effective second-language acquisition strategies and consider the implications of these for formative classroom assessment practices.

If you would like more information about any of these resources or need help with other requests, remember to e-mail us at math_and_science@nwrel.org.

This Picasso-esque painting in oil pastel was done by Alison Grewe, a student at Portland's Innerscape Art Center.

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