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AccELLerate!

The quarterly newsletter of the National Clearinghouse for English Language Acquisition

In this issue of *AccELLerate!*

Math and Science Literacy for English Language Learners

Welcome to this issue of *AccELLerate!* dealing with the challenge of educating and assessing English Language Learners (ELLs) in math and science—subjects that have high cognitive and academic language demands, require advanced skills in English reading comprehension, and may have different, culturally bound symbols and algorithms for problem solving.

Judith Wilde opens the issue by analyzing ELL and nonELL students' results from the National Assessment of Educational Progress (NAEP) long-term trend assessment in mathematics for 2004 and 2008. Following this analysis, Rebecca Kopriva discusses the need to create linguistically appropriate math and science tests and describes the ONPAR Science project, an alternative approach to measuring students' content knowledge in a valid and reliable manner. Andrew Powers and Charles Stansfield explore the relationship between scientific inquiry and scientific literacy in the context of ELL instruction. Creators of the award-winning HELP Math Program, Barbara Freeman and Lindy Crawford, explain how the web-based math intervention can meet the needs of ELLs by eliminating language barriers and methodically addressing gaps in skills and language knowledge. Two final contributions suggest new approaches to developing multiple literacies in at-risk immigrant adolescents (Ann Kennedy) and to teaching math concepts to elementary school ELL children (Susan Chilton and Cristina Martin).

As we move into the new school year, this issue highlights the importance of identifying instructional challenges, effective strategies, and reliable assessments for ELLs in the fast-growing fields of mathematics and science. Have a successful year!

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NAEP, the "Nation's Report Card," and ELL Students–Mathematics

Judith Wilde

The National Assessment of Educational Progress (NAEP) is made up of two components, the main assessments of content areas and the long-term trend assessments (LTT). The NAEP LTT has been used to assess 9-, 13-, and 17-year-olds in mathematics every four since 1973.[1] The periodic changes in the assessment generally have not invalidated comparisons across administrations. The only exception was the 2004 addition of accommodations for English language learners (ELLs) and students with disabilities who could not otherwise be assessed in a meaningful manner. Those accommodations make it difficult to compare the 2004 and later results with those from earlier years.

The LTT also began in 2004 when the Institute of Education Sciences (IES) began analyzing students' test scores every four years. The results from the 2008 NAEP LTT, administered to over 26,000 students in each content area, were released by IES in April 2009. These results have been described recently in various newspaper and magazine articles. The articles have focused on:

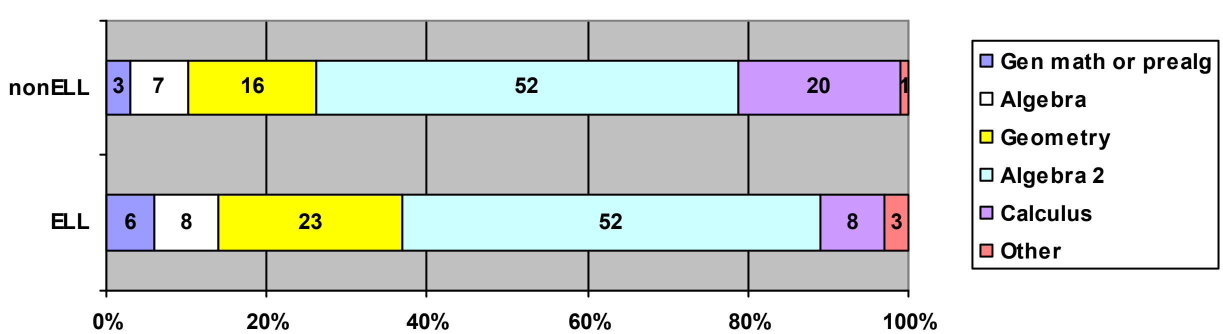
- the improvements seen in mathematics scores for the two younger groups of students;
- the higher mathematics scores of African-American, Hispanic, and White students when compared to NAEP results of the 1970s;
- the narrowing of the achievement gap since the 1970s between White and African-American students and between White and some Hispanic age groups; and
- the increasing numbers of students enrolling in more advanced mathematics classes.

These same newspaper and magazine articles rarely have mentioned ELL students. Having looked at the NAEP reading test results in the Summer 2009 issue of *AccELLerate!*, we focus here on the NAEP LTT mathematics test results.

Student course-taking

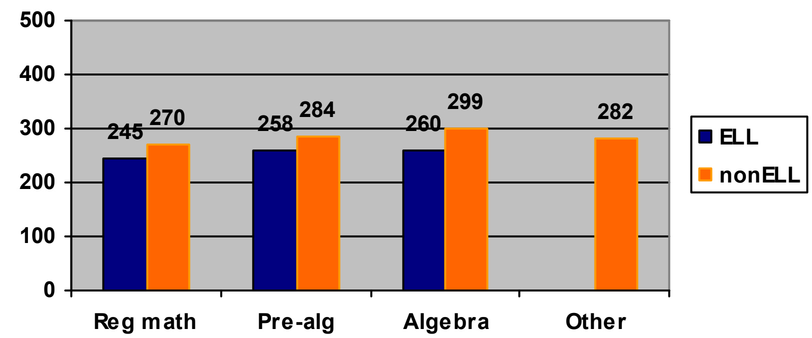
The 17-year-old students were asked to identify all the math courses they had taken, including any course(s) currently being taken. Their choices were general, business, or consumer math; pre-algebra or introduction to algebra; first-year algebra; second-year algebra; geometry; trigonometry; and pre-calculus or calculus. The general trend in course-taking for these 17-year-olds was toward greater percentages of students taking higher-level mathematics courses in 2008 as compared to previous years. We cannot provide such a comparison across years for ELL students, but Figure 1 does provide the information for ELL and nonELL[2] students in 2008. When 17-year-old nonELL and ELL students are compared, over half

Figure 1. Highest level math course taken, for 17-year-old ELL and nonELL students, in 2008



of each group report that Algebra 2 is the highest level math course they have taken; 21 percent of nonELLs, and 11 percent of ELLs, report taking a math course that is a higher level than Algebra 2. There were too few former ELLs identified to include them in the analysis.

Figure 2. Math scale scores for ELL and nonELL 13-year-old students, by class currently taken, 2008



The 13-year-old students were asked to identify any math course they were currently taking. Their options were none, regular math, pre-algebra, algebra, or other. Findings indicate that the math scale scores for ELLs and nonELLs increase based on the level of math course that they report taking in 2008 (the data are not available for 2004). As demonstrated in Figure 2, this trend is clear for nonELLs, but somewhat less so for ELLs because there are too few ELLs taking higher level courses; there were too few former ELLs identified to include them in the analysis. For nonELLs, those enrolled in algebra had higher scores than those enrolled in pre-algebra, who in turn had higher scores than those enrolled in general math. For ELLs, those enrolled in both pre-algebra and algebra had higher scores than those enrolled in general math, but there was little difference between pre-algebra and algebra.

NAEP LTT math test

In the NAEP LTT mathematics assessment, students responded to age appropriate multiple-choice and constructed-response questions. The assessment was designed to measure students' knowledge of basic mathematical facts, ability to carry out computations using paper and pencil, knowledge of basic formulas such as those applied in geometric settings, and ability to apply math to daily-living skills. Each student took parts of the entire assessment, in three 15-minute sections.

National math scale scores, which have a possible range from 0 to 500, are available for groups of 9-, 13-, and 17-year-old students, roughly students in grades 4, 8, and 12, who were tested in 2004 and 2008. In order to understand students' scores more clearly, NAEP has provided some descriptors for specific scale-score groupings:

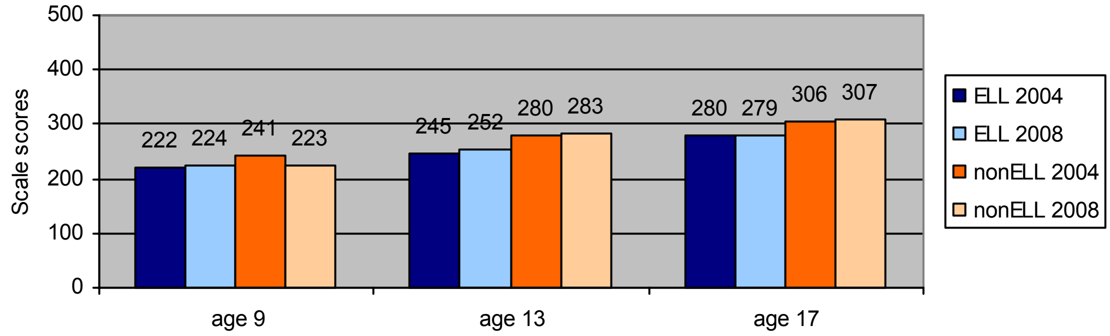
- Level 200 students understand the addition of 2-digit numbers, and know some basic multiplication and division facts, but still need help with subtraction;
- Level 250 students have an initial understanding of the four basic operations and are able to apply whole number skills to one-step word problems and can compare information from graphs and charts; and
- Level 300 students are developing an understanding of number systems and can compute with decimals, simple fractions, and commonly encountered percents; they can identify geometric figures, measure lengths and angles, and calculate areas of rectangles; they are developing the skills to operate with signed numbers, exponents, and square roots.

ELL and nonELL students

For purposes of this article, the scale scores from the LTT math assessment were analyzed for 2004 and 2008, using ELL and nonELL students. Tests administered before 2004 are not equivalent to those administered in 2004 and 2008, thus they could not be included in the analysis.

As a general statement, ELL students at age 9 demonstrated Level 200 math skills; at age 13, the math skills had increased

Figure 3. NAEP math scale scores for ELL and nonELL students, by age, 2004 and 2008

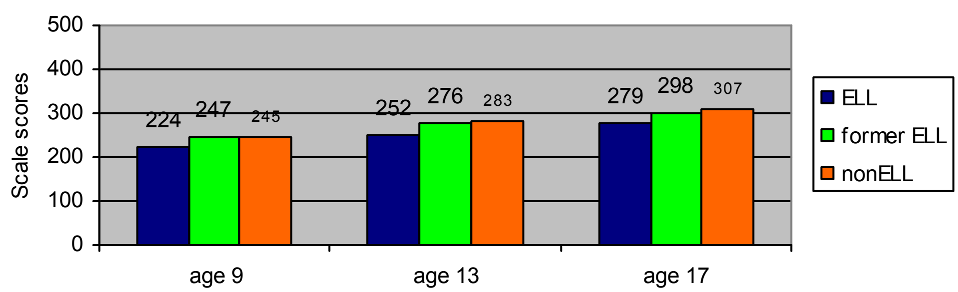


to Level 250; and the 17-year-old group was closer to Level 300 with their math skills. The nonELL students tended to be one level ahead of the ELL students.

Figure 3 provides three pieces of information:
(1) ELL student groups' scores (in blue colors in the figure) are somewhat lower than nonELL students (in the orange colors); but (2) ELL students and nonELL students both are making progress in math; and (3) ELL students gained slightly more than nonELL students at age 13 (7 scale score points *vs* 3). Even though students at age 9 minimally increased their scores from 2004 to 2008, they did more than maintain their math skills while students at age 17, both ELL and nonELL, had scores that were about the same in 2004 and 2008.

In 2008, for the first time, the language subgroup was divided further into ELL, nonELL, and former ELL students. We cannot look at progress for this subgroup, but can provide a "snapshot" of how the students were performing in 2008. Figure 4 shows that, for all three age groups, the former ELL students (green in the figure) have much higher scores than their ELL peers (blue) and score nearer to, or above, their nonELL peers (orange). For age 9, the former ELL students scored 23 scale score points above their ELL peers and 7 scale score points above their nonELL peers. At age 13, the former ELL students again scored 24 points higher than their ELL peers and only 7 points below their nonELL peers. Finally, at age 17, the former ELL students scored 19 points above their ELL peers and only 9 points below their nonELL peers. The scores of the former ELL students and their nonELL peers are very similar, and definitely higher than the scores of the ELL students.

Figure 4. NAEP math scale scores for ELL, former ELL, and nonELL students, by age, 2008

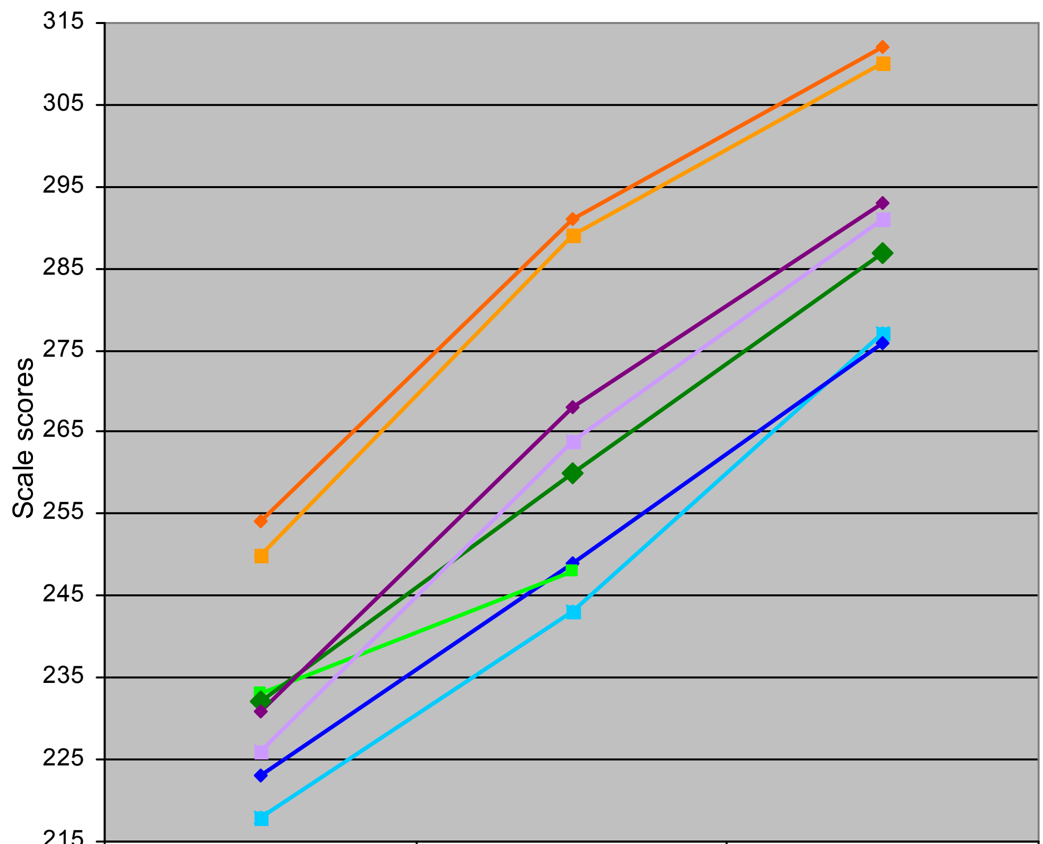


ELLs and students living in poverty

ELL students often are concentrated in schools that serve students living in poverty (as defined by eligibility for free or reduced-price lunches, FRPL). This has led to hypotheses about the effect of poverty on all students and its increased effect on ELL students.

In Figure 5, the 2004 and 2008 NAEP LTT scale scores for ELL students and nonELL students, who are and are not eligible for FRPL programs, are provided. (There were too few 17-year-old ELLs not FRPL-eligible for the analysis.) Except for one instance, the scores of all groups of students increased from 2004 to 2008, and from one age grouping to the next age grouping. However, it might be hypothesized that the scale scores would follow a pattern: nonELL students not living in poverty scoring the highest, and ELL students living in poverty scoring the lowest. The scores of nonELL students living in poverty and ELL students not living in poverty

Figure 5. NAEP reading scores for ELL and nonELL students, living in poverty and not living in poverty (eligible and not eligible for FRPL), by age, 2004 and 2008



	age 9	age 13	age 17
ELL-eligible 2004	218	243	277
ELL-eligible 2008	223	249	276
ELL-not eligible 2004	233	248	(too few students)
ELL-not eligible 2008	232	260	287
nonELL-eligible 2004	226	264	291
nonELL-eligible 2008	231	268	293
nonELL-not eligible 2004	250	289	310
nonELL-not eligible 2008	254	291	312

should be between the two other groups, perhaps with non-ELL students scoring higher than ELL students. For nonELL students not living in poverty (the orange lines in Figure 5), and ELL students living in poverty (the blue lines 5) follow the anticipated pattern. The pattern of scores of the nonELL living in poverty and the ELL not living in poverty is more difficult to discern.

The purple lines represent the scores of nonELL students who live in poverty. In both 2004 and 2008, the scores of the students increased with the age of the student group. These scores also were somewhat lower than the nonELL students not living in poverty, but generally were mixed with the ELL student groups. In 2004, the 9-year-old ELLs not living in poverty scored higher than the nonELLs who were living in poverty and in 2008, the two groups of 9-year-olds scored only 1 scale score point apart.

The green lines represent the scores of ELLs not living in poverty. These students' scores cannot be clearly interpreted, especially in relation to their age-peers. In both 2004 and 2008, the 9-year-old groups of ELLs not living in poverty and, in 2008, the 9-year-old nonELLs living in poverty have virtually the same scores (233, 232, and 231, respectively). In 2008, the ELLs not living in poverty and, in both 2004 and 2008, the groups of nonELLs living in poverty, received fairly similar scores (ranging from 260 to 268 scale score points). For the 17-year-old groups, the outcomes match the hypothesized pattern.

Summary

As a subgroup of students who participate in NAEP LTT testing, often with accommodation to allow their participation in a more meaningful manner, the ELL students' composite math scale scores demonstrate that:

- the scores of all student groups, including ELL students, increase with age;
- the scores of all student groups, including ELLs, were higher in 2008 than in 2004;
- the scores of former ELLs are close to, or above, their nonELL age peers;
- nonELLs who do not live in poverty outscore all other student groups (ELL and nonELL, living in poverty and not living in poverty) at each age level;
- ELLs who live in poverty score lower in math skills than either group of nonELLs as well as ELLs who do not live in poverty; and
- nonELLs who live in poverty, except at age 9, score higher than the other ELL subgroups.

The next time that NAEP will be administered as part of the long-term trend assessment will be in 2012. We look forward to that time and a continuing review of how well ELL, former ELL, and nonELL students are progressing in their math skills.

Notes

1. "The Nation's Report Card™ informs the public about the academic achievement of elementary and secondary students in the United States. Report cards communicate the findings of the National Assessment of Educational Progress (NAEP), a continuing and nationally representative measure of achievement in various subjects over time. ... NAEP is a congressionally authorized project of the National Center for Education Statistics (NCES) within the Institute of Education Sciences of the U.S. Department of Education. The Commissioner of Education Statistics is responsible for carrying out the NAEP project. The National Assessment Governing Board oversees and sets policy for NAEP." Both LTT and main NAEP assess math and reading, with four major differences—the content assessed, the students selected , frequency of test administration, and results reported. These differences mean that results from LTT and main NAEP cannot be compared directly. For further information on NAEP, see *What is The Nation's Report Card?*, NAEP 2008: Trends in Academic Progress (April, 2009). Washington, DC: National Center for Education Statistics, U.S. Department of Education. Accessed on May 5, 2009 from www.nces.ed.gov/nationsreportcard. For further information on LTT see Rampey, B.D., Dion, D.S., and Donahue, P.S. *The Nation's Report Card: Trends in Academic Progress in Reading and Mathematics 2008* (April 2009). Washington, DC: National Center for Education Statistics, U.S. Department of Education. Accessed on May 5, 2009 from http://nces.ed.gov/nationsreportcard/pubs/main2008/2009479.asp#pdflist. All data used for these analyses come from NAEP.
2. We use the term "nonELL" to indicate that this group may include former ELL students, not just monolingual English-literate students.

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NCELA webinars

The NCELA webinars have been on hiatus during the summer. They will return in September. Sign up for the NCELA*list* to receive notification of all topics, dates, and times—as well as updates from the U.S. Department of Education and other entities.

Assessing the Skills and Abilities in Math and Science of ELLs with Low English Proficiency: A Promising New Method

Rebecca Kopriva

How do you reliably assess ELLs' real knowledge and skills in math and science? Accommodations, if properly identified and used (which is still quite a challenge), seem to be effective for ELLs with higher proficiency in English. However, traditional methods for testing students do not work well for ELLs with lower levels of English acquisition. For instance, ELL students with lower proficiency levels do not perform well on:

- multiple-choice items, because the required discriminations between choices demand fine-tuned language skills; or
- constructed-response items, unless scoring procedures are in place to allow for code-switching and greater use of visuals.

Typical scoring is a problem because many ELLs lack the necessary productive language skills. Besides the ELLs' lack of language skills, many tests, particularly large-scale assessments, require cultural and background knowledge outside the experience of lower-English-proficient ELL students and these unfamiliar contexts can confuse, rather than assist, their comprehension.

Two *Obtaining Necessary Parity through Academic Rigor* (ONPAR) grants have been funded through the U.S. Department of Education (USDE) for the purpose of building prototype large-scale items in science and mathematics that would be appropriate for ELLs with little proficiency in English. The computer-based items are being built to be interactive. Multi-semiotic representations, such as animation and simulation, greatly minimize the use of text in presenting the item questions. As response opportunities have been a major stumbling block for these students, the ONPAR items have created novel approaches that allow students to interact with stimuli and demonstrate what they know with almost no language. Native or home language (L1) support and additional visual cues are used to support words or phrases, and to 'act out' action language presented in the remaining text.

The items being developed are particularly impressive because they reflect more cognitively complex maths and science problems. Many recall items can be handled adequately with plain language and static visuals, and do not need many interactive computer capacities. More complex academic items, on the other hand, generally require more complex and abstract language to express the questions suitably and register responses. As such, ONPAR has focused on whether dynamic computer capacities can be used effectively to limit or omit abstract language without changing the complexity of the targeted science or math content.

Research and development questions

To test their viability and effectiveness, ONPAR items are being built from traditional items, with the goal of measuring the same targeted content as the original item. Several steps were involved in developing the ONPAR items. For instance, the construct-relevant and construct-irrelevant components of traditional test items had to be identified (i.e., what portions of an item are necessary to determine a student's skills and knowledge, and what portions of an item are extraneous to the content being tested), so the construct-relevant, or targeted, portions could be translated to the ONPAR versions while the irrelevant components which cause problems could be reduced in the ONPAR items.

Two types of ONPAR items were built in the science study to investigate 'how low could we go' in reducing the language. One version will be used in the mathematics research. The low language (LL) items use simple, sentence-level prompts. If the student so requests, L1 or English audio translations assist student comprehension of the item prompt. The very low language (VL) versions use simple, phrasal-based language prompts and avoid L1 translations. The language on both the ONPAR versions is supported on the computer through rollovers of concepts and sentences that offer pictures and animations to explain meaning. The LL version used a speaker icon that spoke the concept or verb phrase in L1 or English (as chosen previously by the student). A third support was an animated icon that demonstrated how the student should provide a response (e.g., a graph line that moves, showing that the student should anticipate where the graph line should be). The items were analyzed for their behavior with the various ELL groups and were judged by an expert panel for content coverage and for comparability to their traditional item models. Discourse analysis[1] of the traditional and ONPAR items also was undertaken.

Besides building the items, the ONPAR study asked whether the items could be used effectively for low-English-proficient students instead of the traditional statewide tests, and if they could meet the technical standards of the large-scale tests so the scores could be considered comparable to native English students taking the regular test. To complete this portion of ONPAR, a series of cognitive labs were conducted and randomized experimental large-scale studies were scheduled in science and in math at the elementary and middle-school grade levels. The science study was completed in 2008-09; the math study will be conducted this fall. Both investigations are looking at how ELLs at different levels of language acquisition perform compared to nonELLs on both the traditional and ONPAR items. The math project will study how well some other students with language challenges, such as students with learning disabilities in reading, and deaf and hard-of-hearing students, are performing on both sets of items. Expert judgments and statistical analysis of the types performed on large-scale statewide tests are examining the results.

ONPAR item measuring buoyancy

This item determines the relative position of objects in water and the resulting water displacement based on the object's density and volume (go to www.onpar.us/buoyancy.html for more information on this item). Students view an animation showing three balls placed on a platform suspended over beakers; the platform is removed. First (Figure 1), students roll over the balls to determine that the metal balls are solid and the wood ball is hollow. They move the balls up and down to show their relative position in the water when the board is taken away and the balls drop into the water.

Next (Figure 2), students drag the water level to a position reflecting

Figure 1. What will happen to balls in water?

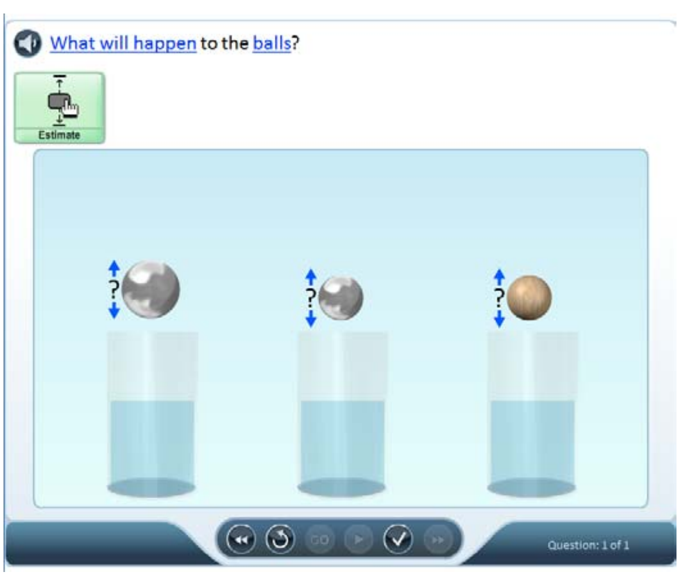
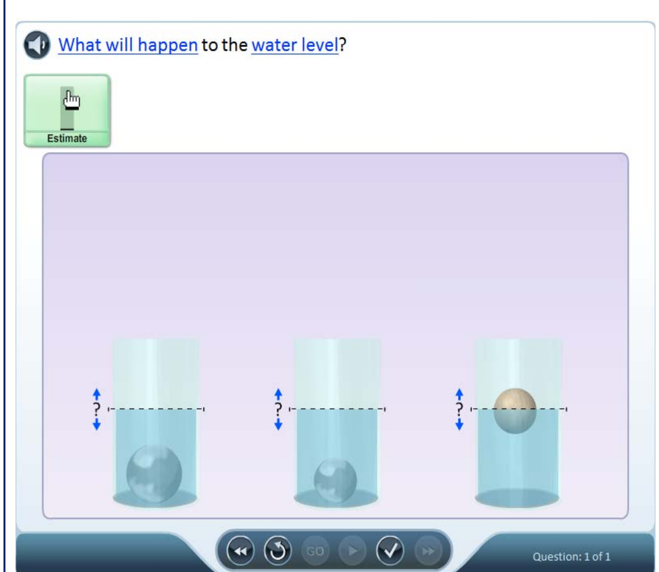


Figure 2. What will happen to the water?



the position of the balls as they placed them in Figure 1.

ONPAR approach: In the first scene, students must compare the properties of each of the balls, determining that density, not size, determines where the balls will go in the water. Students compare wood and metal of the same size and metal of different sizes. In the second scene, students demonstrate knowledge about water displacement. Students' answers from the first scene carry to the second scene to compare relative water displacement.

Traditional item approach: In this item, students are asked to compare two steel balls of different sizes, indicate which water level will be the highest, provide an explanation, then compare a wood ball and steel ball of the same size, indicating which water level would be the highest, and provide an explanation. This item requires extensive language to explain the problem, and it requires students to produce language to respond.

Comparison: The ONPAR item asks students to interact with the screen elements and engage in the experiment, as compared to their more indirect relationship with the content in the traditional item. In ONPAR, the students are *demonstrating* their conceptual mastery, maintaining a depth of knowledge for the subtle comparisons based on several factors and demonstrating knowledge of cause-and-effect relationships. The traditional item asks students to explain but, depending on their meta-cognitive abilities and their proficiency with language, their responses may or may not represent the true sophistication of their knowledge.

Analysis of ONPAR science items

Research on prototype items focused on discourse analysis, cognitive lab results, and the comparability of the computer interactive assessment to a traditional paper-and-pencil test as well as the comparability of specific items on the computer-based assessment to "matching" items on the paper-and-pencil test. The controlled experimental study provides a final look at the "goodness" of the prototype items in measuring the skills and knowledge of 4th and 8th grade students—it provides a first measure of the success of the ONPAR-Science project.

For the science study, three forms of the assessment (traditional, LL ONPAR, and VL ONPAR) were randomized over students. The traditional paper-and-pencil multiple choice and constructed response items were generally from the New England Common Assessment Program (NECAP), the National Assessment of Educational Progress (NAEP), and the Trends in International Math and Science Study (TIMSS). The study was guided by three research questions:

1. When controlled for ability, how does the performance of each group on the LL and VL level test forms compare to their performance on the traditional test form?
2. How does the focal group, the ELLs with low English proficiency, perform relative to nonELLs?
3. What ONPAR item characteristic(s) appear to be effective or not effective?

Approximately 1,000 students from eight districts in three states, grades 4 and 8, participated in the study. ELLs at English proficiency levels 1-3, based on the ACCESS for ELLs™ English Proficiency Test, were the focal group, ELLs with proficiency levels 4 and above were an exploratory group, and nonELLs were the control group.

Most of the ONPAR science items were measuring the same content as the traditional test items from NECAP, NAEP, and TIMSS and the overall cognitive complexity was the same on both the ONPAR prototype items and the traditional assessment items. The students were tested in groups of about 15, with a team of two "testers," and items on a laptop.

For study purposes, the ability of the students was controlled statistically, based on a survey that teachers completed about the science skills of each student. The survey listed each of the concepts measured by the items on the "test" and asked teachers to provide the extent to which the students had demonstrated they understood the concept. Teachers' responses were recorded on a 4-point Likert-type scale.

Results are very promising. While there were significant differences between how LL ELLs and nonELLs performed on the traditional test, there was *no* significant difference between the LL ELLs and the nonELLs on the ONPAR test. Furthermore, the nonELLs did not score significantly differently on the two forms of the test, whereas the ELLs did. All of this suggests that the test scores appear to be comparable for the two groups of students, and that tests which use items such as those used in ONPAR can be used reliably and validly by low ELLs on a statewide test while other groups take the regular test.

Additional findings include (1) the scores of the higher level ELLs tended to be somewhere between both groups on both kinds of tests; (2) on the whole, the VL ONPAR test form did more poorly than the LL test form; and (3) an analysis of item characteristics showed that ONPAR items seem to pick up the science ability of students better than the traditional items do.

Conclusions

The collaboration with and cooperation of both state education agencies and local education agencies has been essential. They have assisted in assuring that the ONPAR items are aligned with state content and language proficiency standards, allowed access to items from the state content assessments, and identified schools and students to participate in the research.

There are both advantages and disadvantages to created assessments such as those being developed by ONPAR. The ONPAR approach has advantages over the traditional approach because it:

- Allows creating more equitable items for ELLs (and perhaps other populations);
- Aligns better with inquiry-based and interactive instructional approaches;
- Is more motivating for test-takers; and
- Offers the possibility of embedding and integrating accommodations for test-takers.

The disadvantages of an ONPAR-type approach include:

- Higher cost of item construction than for traditional items; and
- A technical infrastructure for testing which is still not universally available.

Research on ONPAR prototype items has shown that the ONPAR approach allows ELLs a better opportunity to demonstrate their science ability and thus is a more linguistically appropriate assessment tool for this population of learners. ONPAR-Science is an ongoing project; as more prototype items are developed and field tests of the science items continue, updates will be available at www.onpar.us.

Notes

1.For this study, discourse analysis refers to analyses of test items in order to understand item difficulty and accessibility better—especially for differentiated groups of test takers. The model is designed to predict the ovrall success of individual test items based on the presence or absence of specific discourse components.

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ask*NCELA*'s Inbox

in which we highlight the answers to commonly asked questions that appear in our email inbox.

Q: Where can I find information on ELL students and services in my state?

A: NCELA's newly launched Title III State Information System has a wealth of up-to-date information on ELLs and Title III, by state. You can find information on English language proficiency standards and assessments, standards and assessments in the content areas, demographic information on ELL students, and a list of technical assistance centers tailored to each state. Visit the Title III State Information System often as NCELA adds to the information available: http://www.ncela.gwu.edu/t3sis

askNCELA@gwu.edu is NCELA's email helpline. We are happy to answer questions and to provide technical assistance information upon request.

Developing Science Literacy for ELLs

Andrew Powers and Charles Stansfield

In today's classroom, teachers are faced with an ever-changing academic and cultural climate. In the past, many content-area teachers felt it was not their place to teach language. They did not see the connection between language and their content area. Traditionally, teachers believed that a student had to become literate in English before there was any hope for them to become literate in science. This belief, still ingrained in many seasoned teachers, puts English language learners (ELLs) at a severe disadvantage, since it can take them upwards of seven years to achieve the same level of fluency as a native English speaking student (Collier, 1995).

Defining science literacy. Before steps can be taken to address this challenge, it is important to know what it means to be a scientifically literate person. According to the National Science Education Standards, scientific literacy is the "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (1996, p. 22); whereas "scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the *activities* of students through which they develop knowledge and understanding of scientific ideas" (p. 23).

The purpose of this article is to discuss briefly scientific literacy and scientific inquiry, how these concepts relate to each other, and how they apply to ELLs.

The foundation of science as a discipline is the scientific method. It underlies the process of scientific inquiry and unifies all other aspects of science. The scientific method provides the scaffolding for students to engage the natural world around them by making observations, asking questions, developing tests, collecting data, interpreting those data, drawing conclusions, and disseminating the knowledge to others. Science employs a very methodical, logical, and systematic approach to problem solving and discovery; as such, scientific literacy differs from other forms of academic literacy. It requires a different set of reading, writing, speaking, listening, and thinking skills. This presents a series of challenges to ELLs and to their teachers.

Scientific vocabulary is the most readily identifiable issue in science literacy. Science presents a language that is very distinctive in itself. Words such as *theory, fault, force,* and *wave* take on different meanings from those of everyday English. This can be confusing for a native English speaker, let alone someone who is new to the language. Additionally, processes such as the scientific method involve vocabulary that students must learn in order to partake in the process. Words such as *hypothesis, data,* and *analyze* are central to the scientific method, but may be very uncommon outside of the science classroom. An understanding of this vocabulary, which almost constitutes a language unto itself, is essential to demonstrating scientific literacy through reading, writing, speaking, listening, and thinking.

Students must be instructed on how to read and analyze graphs, charts, and diagrams correctly. Other disciplines utilize graphs, charts, and diagrams, but science has a different, more in-depth way of looking at the information. For example, when reading a graph from an experiment, the students must understand the difference between dependent and independent variables. This is both a vocabulary issue and a new way of thinking for most students, who often do not consider how one variable affects the other or how a variable can be manipulated when examining a graph in social studies. However, it is of fundamental importance in science.

Inquiry-based instruction. In recent years, there has been a strong push towards inquiry-based instruction in the science classroom. Many researchers and educators believe that this method of instruction helps students acquire literacy both in English and in science (Stoddart, et. al, 2002). This method of instruction, initiated through teacher-directed activities transitioning to a more studentdriven process, can be used to address ELLs' need to speak, listen, and think in a scientific way while utilizing English. Traditional methods of textbook and lecture-driven instruction typically only engage listening and reading skills. Textbooks and lectures are not dropped during inquiry; rather they are used to supplement student understanding of the concepts. Students will tend to ask questions of each other that might not necessarily be asked if they had to pose them to the teacher during a lecture. Through small group discussions, students' speaking and listening proficiency, as well as their scientific literacy, is increased.

There can be some limitations to promoting scientific literacy through inquiry-based instruction. If a state's accountability system relies on reading multiple-choice items, this can be a hindrance for students who have become accustomed to working with science through multiple language modalities in the classroom. However, when the assessments involve constructed-response tasks and measure knowledge of process, they support the inquiry-based approach.

In order to develop ELLs' English literacy and science literacy fully, inquiry-based instruction should be used along with traditional textbook instruction. When teaching ELLs, inquiry-based and traditional textbook instruction should be structured carefully. One option is to provide an outline with reading assignments that may precede inquiry-based lessons. These outlines allow students to navigate more easily through dense texts.

Vocabulary building. Many words used in science have Latin roots. If an ELL's native language (L1) is a Romance language, the English word will be a cognate of the word in the student's L1. However, if the student's L1 is not a Romance language, then the vocabulary of science poses a greater problem. It is sometimes necessary to teach the roots of words. Vocabulary exercises, flashcards, and bilingual glossaries can help students to access more fully the terminology that is used in a lesson.

To help ensure that students are able to understand the lesson content and participate in the inquiry process, it is beneficial if the teacher pauses to build students' knowledge of essential vocabulary. One way to do this when introducing new vocabulary, as when introducing anything new in the classroom, is to activate students' prior knowledge. Teachers can ask students what a word means in everyday life or what meanings they associate with a word (Stepanek, 2004; Gutiérrez, 2002; Moschkovich, 2000). This gives teachers a chance to make helpful connections while pointing out important distinctions between a word's general meaning(s) and its meaning within the context of science.

Summary. Teaching science to ELLs is similar to teaching science to general education students. The major differences lie in the need to focus on building the ELL's language skills while imparting science instruction. By focusing on general language development and the language of science while imparting instruction in science, we can develop an ELL's science literacy.

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Math and Science for Dual Language Learners in Preschool: The Right Place to Start

Here are some math and science teaching practices that can meet the needs of preschool Dual Language Learners (DLLs)[1] effectively.

Building on prior knowledge

Choose activities that use previously learned vocabulary— either in the home language or English—to enable your students to spend more time exploring and discovering the math and science concepts at hand. When all the vocabulary for a task is new, the child will be distracted from learning the concepts you want to convey.

Using real items from home and the environment

This allows children to build on their prior knowledge of words and properties of the everyday items they see. With realistic learning activities, DLLs can make connections to real world uses for the concepts they are learning. As an added benefit, asking parents to send things from home can help to build the critical home-school connection. Parents understand more about what their children are learning in preschool as they participate in providing learning materials. The children are more likely to share what they learned if they see the same items at home. Sorting plastic bears may be fun in the short term, but learning to sort socks at school is an activity that can be practiced, discussed, and enjoyed at home too.

Connecting with home and family

The more families understand about the math and science learning goals you have for their children, the more they will be able to reinforce that learning in their home language. Preschool programs often encourage bilingual parents to read to their children in their home language, but we need to see parents given home language math and science explorations to try as well.

Differentiating instruction

Teachers need to keep key math and science goals in mind throughout the day and make opportunities for individualized teaching and learning with each child. Working with individual exploration or small group projects allows teachers to assess what individual children have learned and where they need to go next.

Demonstrating math and science concepts

These subject areas are wonderful for DLLs because they can be demonstrated via body language, exploration, and hands-on activities. Think ahead of key words or concepts that you want to communicate and plan to have pictures, games, and realia to show what these concepts mean.

Extending projects over time

Encouraging dual language learners—and all preschool children—to participate in projects that last a week or more can be a very effective way to scaffold the learning of concepts. Extended learning allows DLLs to acquire new vocabulary, then practice it to develop deeper academic understanding of words and concepts. Projects enable children to build on prior knowledge while they engage in hands-on learning.

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[1] The term *Dual Language Learners* (DLLs) refers to young children who are learning a second language while still acquiring their first.

Embedded Instructional Support in Math Content

Barbara Freeman and Lindy Crawford

Introduction

To be academically successful in school, English language learners (ELLs) must not only learn a new language and integrate with a different culture, but must *concurrently* learn and master a range of academic content including mathematics and science in that new, nonnative language. Navigating through a single day in a different country, leave alone acquiring proficiency in a new task using a foreign language, is a difficult and exhausting undertaking for the most confident and accomplished person. For a young student confronted with this experience on a daily basis, it frequently proves insurmountable. The web-based *Help with English Language Proficiency* (HELP) Math program[1] was created specifically to support ELLs from 3rd grade through high school as they overcome this formidable challenge. HELP scaffolds student learning by embedding research-based sheltered instruction techniques and Sheltered Instruction Observation Protocol (SIOP) principles directly into the web-based curriculum.

Language proficiency and prerequisite knowledge

Students are taught mathematics through the use of language, and must overcome daunting language barriers in order to keep up in class. When students acquire a social grasp of the language, it often is assumed that they are a long way down the road toward comprehension, when in fact they may have barely started their academic journey. To understand content and develop mathematical skills and reasoning—long before comprehension can occur at a symbolic level—students need to be able to read, problem-solve, and communicate using technical and academic English, a specialized language used in the contexts of classroom, textbooks, and standardized assessments. Thus, we must provide ELL students with higher levels of language support to enable grade-level learning in content areas such as math is critical to achievement.

Reading research shows vocabulary knowledge is of the most significant factors affecting students' success . As with reading, math learning, we now understand, is made equally problematic by vocabulary gaps (Blachowicz et al., 2006; Blachowicz & Cobbs, 2007). For example, many math terms are technical and new to learners (e.g., *coefficient, tessellation*), as are the symbols (> *greater than*, $\sum$ *summation*); others are misleadingly familiar (e.g., *scale, table*). Math content typically is taught and tested using grammatical constructions such as *which of the following* or *simplify the equation*, and cause-and-effect language such as *if not x, then y*. Such constructions are problematic not only because of the linguistic impediments that may arise, but also because of the culture-specific aspects of mathematical language. If students cannot understand what is being said in math class, they tend to "switch off," making it difficult to move beyond the language obstacle to master math content and skills—no matter how mathematically able the students actually may be (Freeman & Crawford, 2008).

Students who have gaps in their fundamental understanding of underlying principles, are missing background knowledge, and/or have gaps in prior concept knowledge and prerequisite skills, find it particularly difficult to learn math in a nonnative language (Marzano, 2004). This is especially critical in the field of math in which the content builds and spirals year on year and "prerequisite skills serve as anchors for math ideas" (Sharma, 1989, p.4). For example, students may exhibit gaps in their declarative knowledge and skills (calculating, measuring, arithmetic facts), foundational conceptual knowledge (parts-to-whole, number relationships), procedural knowledge (algorithms, operations, formulas), and problem solving abilities (combining facts and concepts).

Embedded support

HELP embeds specific instructional supports directly into the digital math content to scaffold student learning. It uses sheltered instruction techniques and SIOP principles delivered through technology to make math concepts comprehensible. HELP content is broken down into small, manageable learning chunks, with guided practice to develop math facts, skills, concepts and problem solving. Screens are 'clean' with few distracters, enabling students to maintain focus as they continually interact with manipulatives, games, and real-world scenarios. As shown in Figure 1, for example, HELP adds extra-linguistic cues by synchronizing audio, visual, and text to create a visual connection between words and meaning (e.g., corresponding vocabulary, symbols, or pictures flash in sync with audio). Spanish translation is available on every page for the student who requires extra support in that language.

HELP explicitly teaches technical vocabulary and academic English including a bilingual, pictorial dictionary with contextual hyperlinks on every page (Figure 2). Providing massed practice and cumulative review is essential to the learning process, particularly for students who are missing prerequisite skills or have language needs. Figure 3 shows how feedback loops and hints are embedded into the software, providing interactive practice, unobtrusive assessment, and consistent review.

Figure 1. Visual support

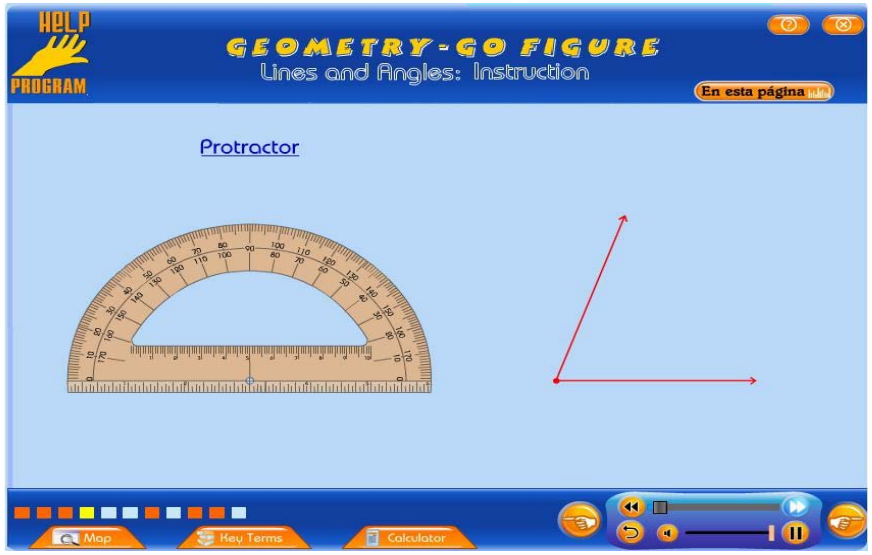
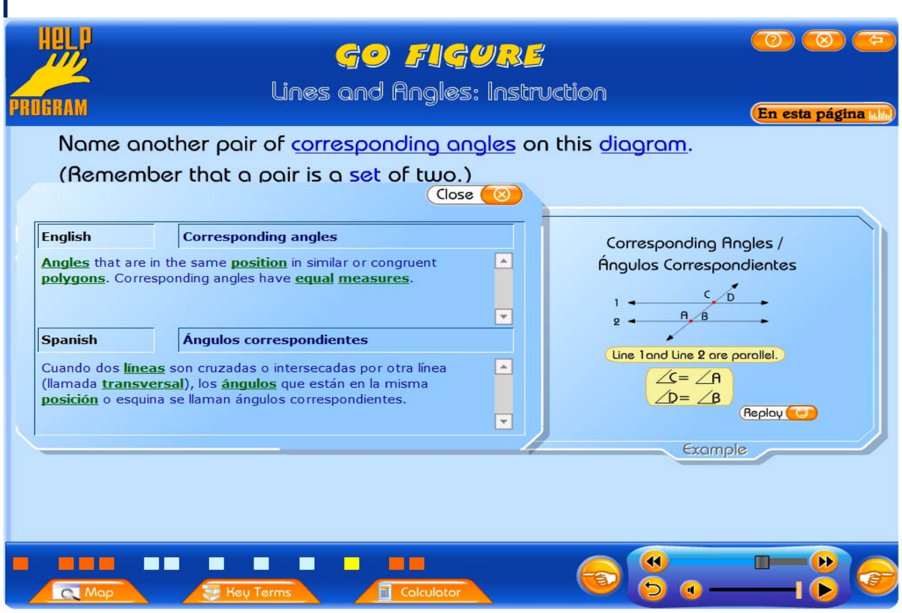


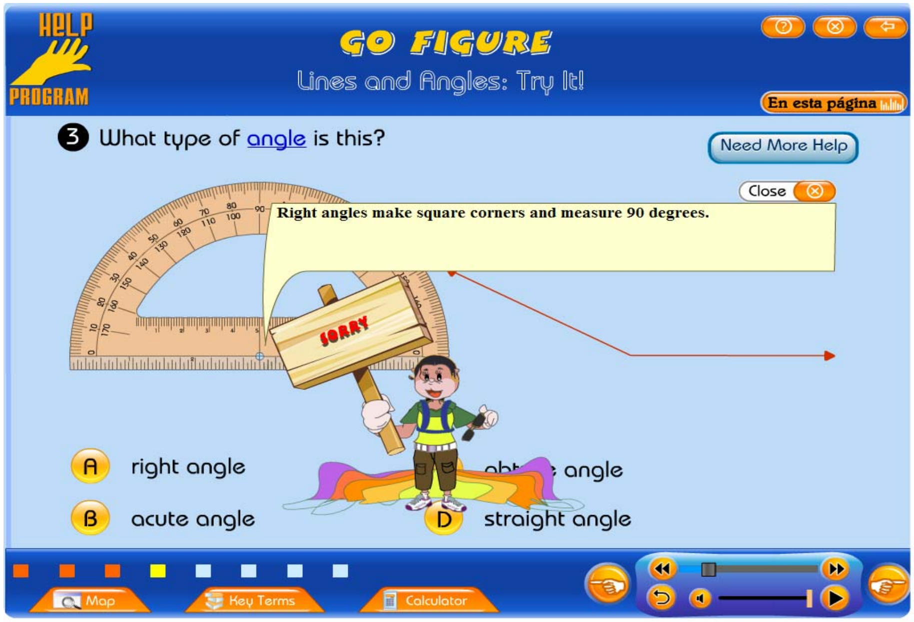
Figure 2. Contextual support of vocabulary



Conclusion

It is imperative to target math interventions to those for whom they are intended, and to make those interventions meaningful to the students. Current technology enables us to embed instructional supports directly into the academic math content in order to eliminate language barriers and methodically address gaps in vocabulary and in prior math knowledge and skills—well-understood needs of ELL students. HELP Math and other specifically developed ELL resources provide students with a genuine opportunity to learn and achieve in math.

Figure 3. Massed practice and review



Notes
1. The Help with English Language Proficiency (HELP) project is partially funded by the U.S. Department of Education; 46% of this project is funded by the U.S. Department of Education through a *Ready to Teach* grant.

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Upcoming Conferences

1. Improving Outcomes for ELLs: Oral Literacy Learning Across the Curriculum
   Location: Austin, Texas TX. Organized by the National Center for Research on the Educational Achievement and Teaching of English Language Learners (CREATE)
   Dates: October 5-6, 2009
   Website: www.cal.org/create/events/CREATE2009/index.html

2. Language Learning in Computer Mediated Communities (LLCMC) Conference
   Location: University of Hawai'i at Manoa; Honolulu, HI
   Dates: October 11-13, 2009
   Website: http://nflrc.hawaii.edu/llcmc

3. National Council of Teachers of English (NCTE) Annual Convention
   Location: Philadelphia, PA
   Dates: November 19-22, 2009
   Website: www.ncte.org/annual

4. The American Council on the Teaching of Foreign Languages (ACTFL) Annual Convention and World Languages Expo
   Location: San Diego, CA
   Dates: November 20-22, 2009 (Pre-convention workshops November 19)
   Website: www.actfl.org

Using Open Source Software to Connect Science, Technology, English and Math for English Language Learners

Ann A. Kennedy

The administration of our at-risk alternative high school was encouraging the teaching staff to incorporate the concepts of STEM (Science, Technology, Engineering, and Math) into our practices, and an ESL/Reading Specialist teaching Science Concepts and a Computer Scientist teaching Information Technology (IT) Fundamentals seized the opportunity to investigate how our collaboration might benefit the students that we shared. Tacitly, we substituted *English* for *Engineering* in the STEM acronym and plunged into a new world, combining TESOL standards and Career Technical Education standards with an eye toward action research. This article offers a description and anecdotal outcomes of our year-long pilot study that fostered a community of inquiry and support among *all* participants—teachers and students—by giving students a double dose of Science Concepts and IT, twice each day! Our goal is to ascertain if "depth over breadth" results in deeper understanding.

Of our ten students, aged 17-20 years, nine were newly arrived from Central or South America with little formal education; one student, from Thailand, had had an uninterrupted education, but no English proficiency and was not familiar with the English alphabet. The students scored as Level 1, "Entering," on the ACCESS for ELLs™ English language proficiency test. The academic year started with the students taking one period of IT and one period of Science Concepts. Each class was taught independently, and we were serendipitously available (during our "prep periods") for visits or consultations. As the year progressed, we found ourselves in each other's classrooms, losing "prep time" but gaining perspective and insights.

As a reading specialist, I approach the collaboration as a way to test much of the research regarding adolescent literacy, including specific factors such as motivation, use of technology, encouraging social interaction, and acknowledging multiliteracies[1]. The computer science teacher is interested in collaboration as a way of making interdisciplinary connections and sees the fusion of our classwork and assignments as an effective way to reinforce learning and to increase relevancy[2]. As a thoughtful educator, he enhances our learning community by modeling the working relationships among all of us and strengthening accountability equally among us—teachers and students.

The combined lessons

The topics in Science Concepts included *Animals and their Habitats*, *Magnets and Electricity*, *Insects*, the *Solar System*, and *Health*. The assignments in Informational Technology Fundamentals were all based on open source (free access) software. After a combined needs assessment, we decided to focus on three sites:

- *Wiktionary* (www.wiktionary.org),
- *Audacity* (www.audacity.sourceforge.net), and
- *Scratch* (www.scratch.mit.edu).

Wiktionary was chosen because it is more than a standard dictionary; it is a multilingual wiki-based open content dictionary. When students search a focal vocabulary item, they see a translation, an academic definition, as well as multiple meanings (Figure 1).

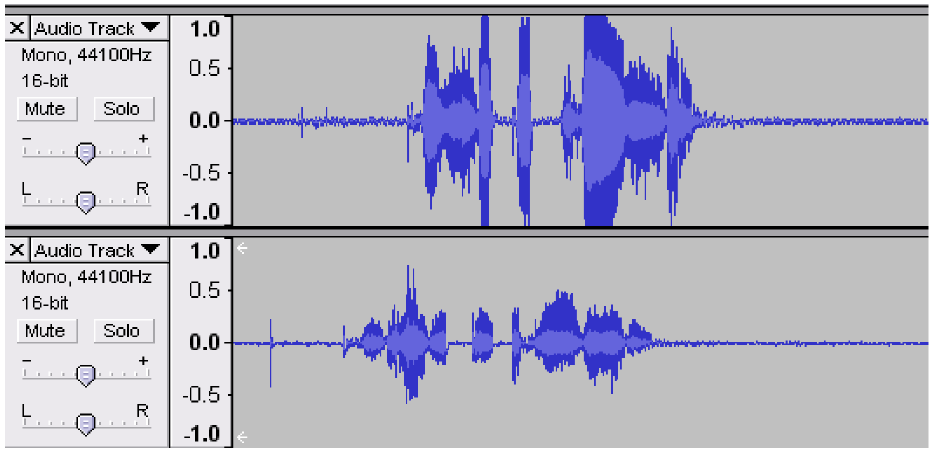
Figure 1. *Wiktionary* entry for *precipitation*

Pronunciation: (US, UK) IPA:

prɪ.sɪ.pɪ'teɪ.ʃən/

Noun (countable and uncountable; plural: precipitations)
1. A hurried headlong fall.
2. (countable, chemistry) A reaction that leads to the formation of a heavier solid in a lighter liquid; the precipitate so formed at the bottom of the container.
3. (weather) Any or all of the forms of water particles, whether liquid or solid, that fall from the atmosphere (e.g., rain, hail, snow or sleet). It is a major class of hydrometeor, but it is distinguished from cloud, fog, dew, rime, frost, etc., in that it must fall. It is distinguished from cloud and virga in that it must reach the ground.
4. (figurative) Unwise or rash rapidity; sudden haste: *had acted with some precipitation and had probably started out upon a wild-goose chase – Dorothy Sayers*

Figure 2. A spectrogram of teacher (top) and student (bottom) pronunciation of *precipitation*

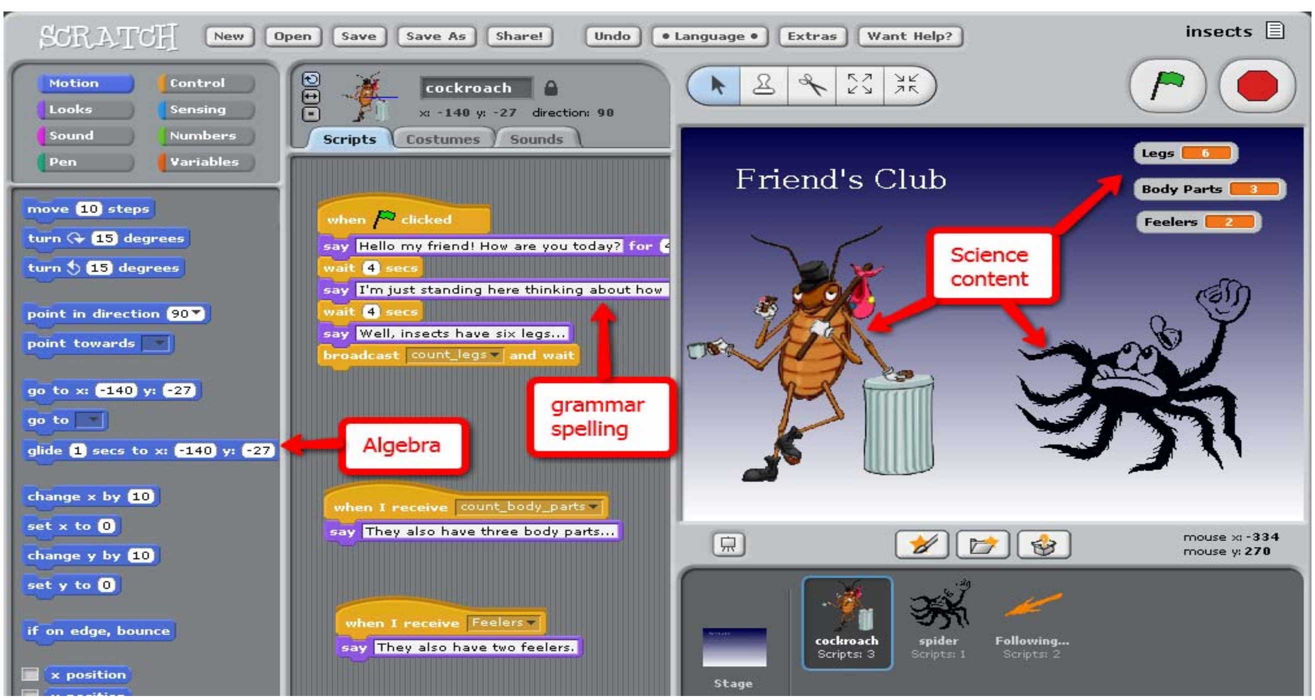


The information most relevant to our project is the ability to "capture" the audio files of key vocabulary for each lesson. Students import each audio file into *Audacity*.

Audacity was chosen because it is an easy, free, and powerful tool for improving listening and pronunciation. Using a spectrogram included in *Audacity*, students can see concretely the sound waves of the modeled pronunciation. Then, they record their own pronunciation, which also is translated into sound waves on a spectrogram, and practice the pronunciations repeatedly, in the "private world" of their own headsets and microphones, until they are satisfied. Students improve pronunciation greatly as they are able to compare the spectrograms, as seen in Figure 2. Their confidence in using the words in class discussions as well as spelling in written work also has been noted.

After reading and discussing chapters in adopted texts for the Science Concepts class, students use the programming software, *Scratch*, to extend and expand their learning. Working with *Scratch*, students see three areas on the screen (Figure 3). They manipulate commands, from the left column, to work with timing and to create, place, and move elements into a script, in the middle column. The language in these steps includes such math-related content as *degrees*, *change x by [number]*, *set x to [number]*. In this script, students practice grammar,

Figure 3. Creating a story in *Scratch*



spelling, and meaning as they create their conversations. The third column in *Scratch* allows the students instant gratification for their creation. They can test their scripts and work alone or with others to solve problems. *Scratch* allows these at-risk adolescents to apply math and algebra skills, utilize story elements, practice grammar and spelling, use logic and problem solving, and reinforce comprehension as they program animated stories with sound. Figure 3 illustrates one student's step in creating a story about insects. As students learn particular commands and "tricks," they are encouraged to share, either by showing (for those whose English language skills are developing) or by telling (to strengthen oral skills). For Level 1, "Entering" ELL students, the need to communicate in English—whether to ask for help or to give help, and while using Science vocabulary and content—seems to be natural and powerful. This verbalization offers them a natural redundancy that helps their English language acquisition. Observations show that multiple opportunities to read, write, listen to, and talk about the topics for authentic purposes are accelerating acquisition and aiding confidence in all language domains.

Scratch stories are uploaded on the Internet; this step offers students an authentic audience for their efforts, and motivates them to create a polished, creative product. Classroom assessments are based on rubrics that attempt to cover desired outcomes and acceptable evidence for *both* ELP and CTE standards.

As ESL teachers grapple with the realities of preparing at-risk immigrant adolescents for increasingly cognitively-demanding content standards, we are excited by the possibilities of our collaboration. We are establishing an environment that supports their reading, writing, visual, and technological literacies. We are giving our students an opportunity to utilize a variety of materials in order to make critical interdisciplinary connections. As we continue to improve on our collaboration in the approaching new academic year, we hope our new community of learners will develop their multiple literacies into a blueprint for lifelong learning.

Notes

1. For instance, Beers et al., 2007; Biancarosa & Snow, 2003; Ivey & Fisher, 2007; Sturtevant et al., 2006.

2. For example, Alvermann, 2007; Wilhelm & Smith, 2007.

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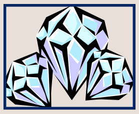
Did you know?

- Of postsecondary students who spoke a language other than English as a child, 34% entered STEM (science, technology, engineering, mathematics) fields between 1995 and 2001.
- Of monolingual English speaking students, only 22% entered STEM fields over the same years.

Source: U.S. Department of Education, National Center for Education Statistics (2009). *Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education*. Washington, DC: Author. Available from
http://nces.ed.gov/pubs2009/2009161.pdf



Learning Content with Listening, Speaking, Reading and Writing Strategies

To help my students think, speak, read, and write about science, I design my lessons following a set template.

Tap into prior knowledge

Using a graphic organizer, I ask groups of students to come up with facts they think they know about the topic at hand. Then each group completes a K-W-L graphic organizer (*What we know, What we want to know, What we learned*), and we organize this information in a K-W-L chart on the board.

Contextualize the lesson

I search the web and the media center for the best pictures and charts that enlighten the current topic and make laminated posters for the classroom bulletin board for EVERY chapter.

Guide text comprehension

- I create a Cornell-style Power Point slide for each chapter and a set of Cornell-style notes that mirror the slides' questions. In an *Ask-Answer-Discuss* activity, students answer the questions and write a summary statement for each slide.
- Pre-reading, reading, and post-reading strategies help students navigate textbook chapters.
    - ◊ Students complete a scavenger hunt by looking at the pictures, legends, subtitles, and graphs to predict what the chapter is about.
    - ◊ As students read, they create two summary statements for each subheading.
    - ◊ At the end of each chapter, students discuss possible answers to higher-order thinking questions (following Bloom's taxonomy) and collaboratively complete a skeleton graphic organizer of the chapter.

Teach study skills

The Cornell-style note taking, Ask-Answer-Discuss activity, scavenger hunts, graphic organizers, and higher-order thinking assignments teach students valuable study skills that can be used in other classes.

Keep a positive affective domain

ELLs are doing double duty learning a new language and subject matter in that language. So, to relieve the stress, I use review games that lighten the atmosphere and provide opportunities for extra credit points.

- *$25,000 Pyramid* is a fun way to review vocabulary. One student has their back to the board while the other gives clues. They reverse roles, and points are accumulated.
- *Who Wants To Be a Millionaire*, or *Cellopoly*, modeled after *Monopoly*, give students an opportunity to review topics.
- Rummy-style card games are a great review for linear topics like scientific method, food chains, and chemical reactions.
- *Concentration* cards for terms and definitions are also useful for vocabulary or topic review.

Use performance assessments

Students do activities where they can apply their knowledge and practice before multiple-choice tests.

- An overhead projection of the Krebs Cycle is moved back to allow a large tracing of it to be done on butcher paper. After five classes complete this 'art' project, there are five large charts for the bulletin board. Groups of students assemble before each chart and discuss the answers to 12 questions from the Power Point screen.
- Portions of the Krebs Cycle reaction are created and placed on the white board magnetically as the teacher reviews its stepwise progression. The pieces are taken down and handed to each student. As the teacher recites the reaction progression again, students place pieces on the board. Finally, students put the pieces on the board with no prompting.
- Students create cell models from 'junk drawer' materials. An accompanying chart has students explain why they chose each material to represent the cell part.
- As an in-depth way to review human body systems, students are given a teacher-created summary with pictures. The class is divided into seven groups, and each has to create a poster for their system. The next day, there are five posters for each of the seven systems. The same group goes to each 'area', reads the summary of that system again, and discusses what the poster creators left out, or stated incorrectly.

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"Equals" is the Point:
A Perspective on Math Instruction for English Language Learners

Susan Chilton and Cristina Martin

Introduction

Our observations of many primary classrooms suggest that much introductory math time is dedicated to teaching the language of math and algorithms of early arithmetics. We contend that it is more effective to use math time to guide the students toward seeing operations as related tools for comparing quantities, discovering numeric or geometric relationships, and understanding how the repeated application of a mathematical function to a quantity produces a predictable pattern of outcomes.

This philosophy underlies math instruction by teachers in the Dual Proficiency program (DP), a site-developed, teacher-driven, two-language K-4 academic sequence taught at Magnolia Avenue Elementary School in central Los Angeles. It is a content-based program developed through collaboration among members of a vertical team of bilingual teachers who have worked together for over twenty years (cohort teachers). The team includes two retired-but-active members, four current DP teachers, the ELL coordinator, and several cooperating teachers.

Virtually all of the cohort students are ELLs whose home language is Spanish and/or an indigenous language of Mexico or Central America, and who score in the lowest level of beginning English proficiency upon entrance to Magnolia. Approximately 90 percent enter this parent-choice program in kindergarten and remain in the program through fourth grade.

Three years of test results show promising gains in math for ELL students in DP classes (see Table 1). We believe these gains are related to the significantly different approach to the subject by DP teachers. During the last two years, a research team from a nearby university and from the district research office has been leading efforts to document the key features of the program.[1]

Since DP students are native speakers of a Romance language, the linguistic aspect of DP instruction regularly incorporates the highly useful Latin roots, often tied to common Spanish words, of most academic vocabulary, including the mathematical register, that the children need to learn (Bravo et al., 2005). The children's knowledge of Spanish is utilized explicitly by the DP vertical team as a major asset, a "fund of knowledge" for the learning of mathematics and other academic subjects (González et al., 2005). A few examples of frequently used cognates would include: *comparar-compare, partes-parts, patrones-patterns, movimiento-movement, sistema-system, diferencia-difference, cantidad-quantity,* and *operaciones-operations*. While this strong Spanish-to-academic-English link is primarily available to teachers in bilingual classes, other DP strategies are applicable to math instruction for ELLs in any instructional program. The defining math strategy can be summarized as a commitment to *teaching the system rather than*

Table 1. Percentage of students scoring proficient or advanced in math in cohort classes and school as a whole

Grade / Score basis		School Year		
		2006-07	2007-08	2008-09
2nd	Cohort students	75.0%	85.7%	95.0%
	School average	41.0%	43.5%	54.6%
3rd	Cohort students	89.5%	79.0%	63.7%*
	School average	36.2%	37.0%	44.5%
4th	Cohort students	—	47.1%*	86.4%
	School average	23.5%	31.5%	42.6%
5th	Cohort students	—	—	78.6%*
	School average	—	—	33.3%

* Class taught by non-cohort teacher.

focusing on the algorithms. A few examples are outlined in the following sections.

Focus on a key principle: Equals

The symbolic focus of DP instruction is the = sign. Other mathematical signs are tools to arrive at equality. "Equals" first appears in kindergarten and continues through graduate-level math courses where mathematical symbols stretch across whiteboards, still with an = somewhere up there. Equals is the point; "equals" represents the intention to understand and define a relationship.

In primary grades, children interpret the sign for "equals" based on their experiences in early math instruction. These experiences with pages of addition and subtraction lead them to the conclusion that "=" means "perform the indicated operation." This interpretation is logical based on the teacher's constant exhortation to "Look at the sign!" However, the emphasis on the procedural sign rather than on the *intention to define a relationship* by arriving at the *same value* on two sides of the equality sign leads students down the path of mechanical algorithms rather than leading them to an understanding of age-appropriate mathematics.

Presenting math problems in which the known and unknown quantities are reversed from the standard order uncovers misconceptions about the concept of "equals." The number sentence *6 = __ + 4* gets a frequent response of *10*. End-of-year exams have problems similar to *8+2+4 = __ +4*, for which the often-selected answer choices include *14* and *18* rather than *10*. To put it in "kid" jargon, "The sign rules!" They are not talking about the = sign; they mean the plus or minus sign.

Down to specifics

Until the concept of "equality" is better understood by students, DP teachers substitute the term "vale lo mismo que..." (is the same amount as) during math lessons. Instruction and follow-up materials are designed to illuminate the relationship between numbers in the Base 10 system, to clarify how digit order relates to number value, and to emphasize the fact that operations in the system are related movements. The focus is always on making equal quantities for the purpose of understanding mathematical relationships.

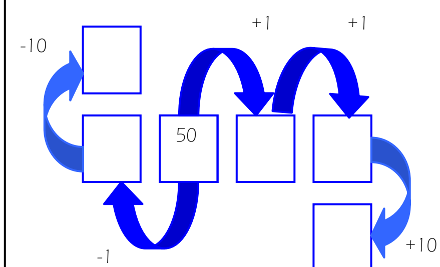
Essential principles

The following principles characterize key aspects of the approach embedded in the DP program. Applicable to all of the following examples are: (a) the consistent introduction of new concepts in the children's dominant language, (b) the explicit identification and charting of the Spanish/Latin key terminology and the related English/Latin mathematical vocabulary, and (c) the subsequent use of both Spanish and English, depending upon teacher monitoring of both student comprehension and student progress toward balanced use of two languages.

1. *The teacher team believes it is essential to emphasize relationships between numbers while teaching an understanding of the relative value of numbers in kindergarten and first grade.*

To depict these relationships, numbers are often presented in squares corresponding to the arrangement of the standard classroom hundreds chart with arrows representing movement in the system. The value of the indicated movement is indicated by the arrows (see Activity 1).

Activity 1

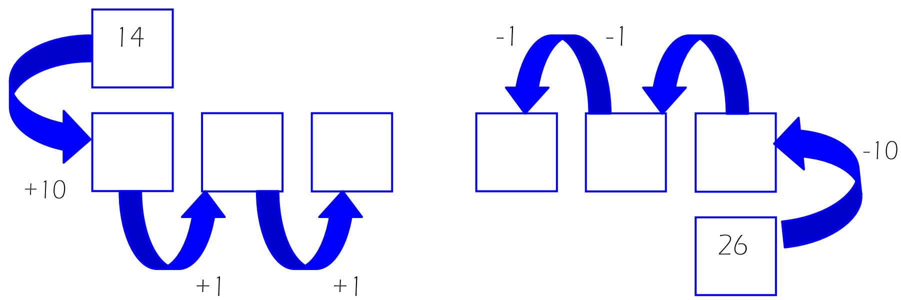


One less (fewer) than 50 is ____.
Ten less than 49 is____.
Two more (greater) than 50 is ____.
Ten more than 52 is ___.

Interpretation questions, like those that follow the illustration, teach the children to see the relationship between the directional moves and the change in value, to associate the mathematical terms with the change, and to begin to recognize the patterns present in the Base 10 system.

2. The DP team believes it is more effective to approach operations from the perspective of getting from one numerical location to another in Base 10. First, it becomes clearer to the students that the distance between the two *locations is the same regardless of the direction of the measurement.* The illustrations and questions in Activity 2 work to teach the children to see "*more than*" and "*less than*" as distance questions. In this way the linguistic traps these terms can pose, especially for ELLs, are reduced (Celedon-Pattichis, 2003).

Activity 2.



a) Your house is at #14. You need to get to #26. How far is it?

Going there:	Going home again:
b) 14 + __ = 26	26 - __ = 14

c) To go home from #26 to #14, how far will you go?

____

Distance: (12) = ___ + 1 + 1
26 - (distance) __ = 14
26 = 14 + __

3. Emphasis is placed on the concept that the system is logical and the children can discover and apply that logic with teacher guidance.

After working in kindergarten and first grade to develop a beginning understanding of the logical and systematic relationship of numbers in the Base 10 system, teachers move to the more complex representations of the place value of numbers and to a focus on the relationship among second grade math operations. Borrowing and carrying are merely extensions of the distance question and can be represented accurately by the children long before the standard algorithms are mastered. Fractions, multiplication, and division are presented not as separate "procedures" but rather as parts of a process analogous to taking apart a number puzzle and putting it back together again (see Activity 3).

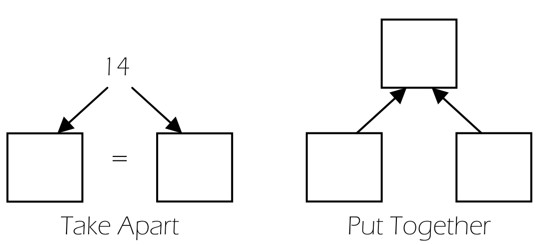
Conclusion

By focusing on making equal quantities, on determining the distance between numbers, and on seeing the relationship of operations in the Base 10 system, Dual Proficiency teachers support the ELL students' confidence in their ability to uncover the logic of the system while providing ample opportunity to master required standards-based procedures. We hypothesize that redirecting the children's attention from procedural signs to the "making of equal quantities" can contribute to the

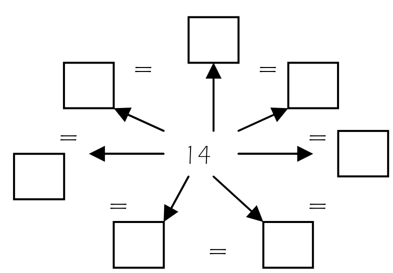
Activity 3.

14 = ☐ + 7

14 ÷ by 2 = ☐



½ (one of the two equal parts) of 14 is _______
2/2 (two of the 2 equal parts of 14 is _________



There are __ equal parts. If one part is 2, the others are __
How many times do you count by 2 to get to 14? __

development of deeper understanding of age-appropriate mathematical concepts and that the resulting higher achievement will increase student motivation and assure for continued math learning for our ELL, dual proficiency, students.

Notes

1. Observational research on our instructional program took place in the 2007-2008 school year under the direction of Professor Robert Rueda, USC, Rossier School of Education and Dr. Katherine Hayes, Program Evaluation and Research Branch of the Los Angeles Unified School District, and funded by a grant from the Haynes Foundation.

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Web Resources: Math and Science for ELLs

Cory Geraths, NCELA Intern, summer 2009

National Clearinghouse for English Language Acquisition
Excerpts from NCELA's 2008 report *Educating English Language Learners: Building Teacher Capacity* suggest strategies for professional development practices for mainstream teachers of ELLs, including teachers of mathematics (www.ncela.gwu.edu/files/uploads/3/mathforELLs.pdf) and science (www.ncela.gwu.edu/files/uploads/3/scienceforELLs.pdf).

National Council of Teachers of Mathematics
NCTM provides resources for teaching ELLs, including games and activities for students, which can be located using the search function. Some content requires membership to access.
www.nctm.org

National Science Teachers Association
NSTA has a number of resources for ELL students that can be located using the search function. Games for students and an assortment of resources for teachers can be accessed, and publications ESL strategies are available for purchase.
www.nsta.org/

Texas State University System's Mathematics for English Language Learners (TSUSMELL)
This research project develops instructional materials for ELLs in math. Available from the Web site are a lesson bank, teachers' guides and professional development products, information on preservice education, and research results.
www.tsusmell.org/

Pacific Resources for Education and Learning
With a strong focus on culturally appropriate materials, PREL's Web site provides resources for teachers of ESL students of mathematics and science through a listing of workshops and links to various programs, as well as a listing of relevant articles on teaching and learning strategies.
www.prel.org/services/science–mathematics-education.aspx

REL-Northeast and Islands Issues and Answers Report (January 2009). *New Measures of English Language Proficiency and Their Relationship to Performance on Large-Scale Content Assessments*
The report examines the relationship between ELLs' scores on state assessments of math, reading, and writing and compares these to results on a new English language proficiency test. The report touches on ELL and ESL strategies for mathematics and science, and examines ways in which further progress can me made in both fields.
http://ies.ed.gov/ncee/edlabs/projects/project.asp?projectID=172&productID=125