

Noorchaya Yahya, Florida Atlantic University
Joseph M. Furner, Florida Atlantic University

U.S. MATH PROBLEM SOLVING: CONSIDERATIONS FOR TEACHERS OF ENGLISH LEARNERS

This paper addresses the importance of quality math instruction for English learners. ESOL adaptations to math lessons and problem solving are important so that all students will be able to compete in our high-tech world in the 21st Century. Three objectives need to be considered when teaching math: language, content, and learning strategies. This paper demonstrates how the Cognitive Academic Language Learning Approach (CALLA) is applied in a sample math lesson and shows the benefits of process and problem solving using language, content, and learning strategies. This paper challenges all K-12 mathematics teachers to maintain a partnership with English teachers to further language skills when tackling math problems.

Introduction

K-12 Schools in Florida, as well as other states, are faced with similar situations where teachers feel inadequately prepared to work with students who are native speakers of languages other than English. Many states, schools, and colleges of education are addressing this very concern by looking at research on teaching English to speakers of other languages, also referred to as Teaching English to Speakers of Other Languages (TESOL).

Since the inception of the META Consent Decree in 1990, Florida elementary and secondary school teachers are required to receive training in TESOL

that is commensurate with the content and grade level they teach. At a minimum, this training must involve three university credit hours (or sixty inservice points). The secondary content area teachers (e.g., mathematics or science) are required to take a three credit hour course or fulfill 60 inservice points. The state-approved TESOL Endorsement program in Florida consists of fifteen credit hours in TESOL methods, evaluation, and multicultural education. (Ariza, Morales-Jones, Yahya, & Zainuddin, 2002). About two years ago, an amendment to the Consent Decree on Section IV, Personnel, was implemented. As a result of this change, teachers who pass the

TESOL test will be required to take only six credit hours instead of fifteen to be TESOL endorsed. With the increase of English language learners (ELLs) in Florida, K-12 math teachers need to be well trained to teach effectively so that all students are skilled and confident in their ability to do mathematics.

According to the most recent Census Brief, Hispanics and Asians will account for 61 percent of the population growth from 1995 to 2025, that is, 44 percent will be Hispanics and 17 percent will be Asians. California will gain 12 million Hispanics. The Asian population is expected to increase from 3.6 million in 1995 to 9.1 million in 2025. Other projections show that Texas, Florida, Georgia, and California will gain more second language learners. The diversity of the U.S. population will continue to impact ESOL program enrollments (U.S. Census Bureau, n.d.).

In today's high-tech world, it is important that all our young people, including the large ESOL population in the U.S., grow to become confident in their ability to do mathematics in a globally competitive world. The task of teaching ELs can be daunting, especially for secondary mathematics teachers. Often, the challenge of meeting the needs of these students is so overwhelming that teachers unintentionally end up letting ELs fall through the cracks of a system that cannot cope with the needs of the English learner. Sometimes, content area teachers are of the opinion that it is not their job to teach the English learner the English language and that it is the job of the English teacher. As language is a vehicle for content delivery, it is unrealistic to separate the teaching of language proficiency skills and content area skills. Second language learners attain a higher achievement in learning a second language when they learn it in meaningful ways.

The Importance of Mathematics in the 21st Century

A changing economically competitive world has necessitated reform in mathematics education. Dawson (Internet n.d) has found that Americans often are not qualified for many high-tech jobs and that companies seek employees outside the U.S., requiring

special H1-B Visas. Dawson (Internet, n.d.) contends that our K-12 educational system is not preparing students for future studies in math and science. Lane (1999) emphasizes the critical importance of mathematics and science education for our young people and the contribution they will make to our nation's economy and overall well-being. Lane asserts that we must support high quality mathematics and science education in every way we can so that we are ensured an adequately trained talent pool for our country. Much of the research conducted by the Board of Directors of the National Council of Teachers of Mathematics (NCTM) in the mid-1980s indicated that the mathematics curricula for elementary and secondary schools in the United States could be more effective. NCTM's response to the need for change was the publication of *Curriculum and Evaluation Standards for School Mathematics* (Standards) in 1989. The NCTM suggested that standards would improve nationwide test scores in the area of mathematics. Most often, current teaching practices in mathematics classrooms do not provide sufficient critical thought needed to compete in an ever advancing technological age. In its revised version of standards for teaching mathematics, NCTM (2000) included "Equity" as one of its six principles for teaching mathematics so that there are high expectations for ALL students, including the ESOL population. Steen (1999) points out that national and international studies show that many U.S. students leave high school with far below even minimum expectations for mathematical and quantitative literacy.

Neunzert (2000) believes we have to understand ourselves as MINT-professionals, where MINT is M=mathematics, I=informatics, N=natural sciences, T=technology. Neunzert feels that mathematics is critical for people living in the 21st Century to be successful. In the book, *Descartes' dream: The world according to mathematics* (Davis & Hersch, 1990), the authors discuss how computers have made mathematics the most important discipline to study. They take an incisive look at how math is applied in the real world today, particularly the influence of computers on mathematics, science, and society. Davis and Hersch (1990) believe we are drowning

in digits and depend constantly on math for our high-tech lifestyle. They purport the idea that math is everywhere, in business, in warfare, and is a propaganda tool in social sciences. Dawson (Internet, n.d.) cites that fewer Americans are studying math, science, and technology fields, yet the demand for these fields with technology skills is growing. It is estimated that by 2008, the top three areas of employment growth will be in technology fields: computer engineering, 108%, computer support specialist, 102%, and systems analysts, 94%. If the U.S. cannot produce and attract sufficient workers from the U.S. in the areas of math, science, and technology fields, the country is left with the alternative to seek outside the U.S. for qualified workers. The U.S. has led the world in the *Information Age*. This success can only continue if we can solve some of the technology labor shortages and start preparing our children better for the digital world by allowing them to see math as a human endeavor that will encompass a large part of their future. Having said this, our ESOL population may need some special accommodations to reach this level.

A Look at Mathematics Problem Solving

Regardless of their length of stay in the U.S., (e.g. they could have been in the U.S. for only two days) ELs in grades 5, 8 and 10, are expected to take the Florida Comprehensive Achievement Test (FCAT). Florida requires all of its public school students to pass this high stakes test to be promoted to a higher grade level or to graduate from high school.

Examine the following mathematics question on the 5th Grade FCAT Test:

Herb bought a candy bar for \$0.75 and a package of gum for \$0.50. What else do you need to know to find out how much change Herb should receive?

- A. How many sticks of gum were in the package
- B. Where he bought the gum
- C. The size of the candy bar
- D. How much money he gave the clerk

This type of question may not test the content knowledge of the students, even if the students have the mathematical knowledge to answer correctly. The structure of the question is extremely complex, involving multiple cases of what linguists call *long-distance wh- extraction*. This type of linguistic structure poses a special burden on cognitive resources devoted to language processing (Stabler, 1994), which introduces a particular processing difficulty for second language learners (Juffs & Harrington, 1995, 1996; Myles, 1996).

How is it possible for content area teachers not to address the language objectives in their lessons? It is inevitable that content area teachers must weave language goals into their lessons so that their ELs can be successful in their learning of the content areas such as mathematics and science.

Key Points for Teaching Math to ELs

Key questions that mathematics teachers should raise in teaching their lessons to ELs are:

- a) What is my ELs' English language proficiency level?
- b) How much math knowledge do my ELs have in their previous schooling?
- c) Are there differences in the presentations of the math concepts in their country?
- d) With a theme in mind, what kinds of cultural and interdisciplinary connections can I make within these lessons?
- e) How can I successfully incorporate the teaching of English language skills and learning strategies in my math lessons and problem solving?
- f) Which ESOL strategies should I select that are appropriate to my ELs' needs and will truly yield the best results?

The CALLA approach (Cognitive Academic Language Learning Approach) advocated by Chamot and O'Malley (1994) is one approach that will incorporate all of the above considerations. CALLA considers these three main components in teaching any concepts: the concept itself, the language appropriate

within the context of the concept, and the strategies that can help the ELs learn the concept. According to Chamot and O'Malley (1994), ELs learn mathematics using CALLA based on these four key ideas: a) link language of math word problems and solutions; b) have mentally active students; c) verbalize the steps to problem solving in mathematics; and d) incorporate learning strategies and math problem solution steps.

Analyze a sample mathematics lesson plan with problem solving that accounts for all of the above concerns using CALLA:

Grade level: 3rd

Math Standards: MA. B.3.2.1

The student estimates measurements in real-world problem situations.

Language Standards: LA. B.1.2.1

The student prepares for writing by recording thoughts, focusing on a central idea, grouping related ideas, and identifying the purpose for writing.

Math and language objectives:

- A. Students will estimate or predict what the measurement of the object is.
- B. Students will learn and correctly use vocabulary related to a metric system.
- C. Students will measure with metric rulers to determine the length of objects.

Pre-teaching of concepts through language arts:

In meeting the language objectives, use a reading passage, song, or poem that meets the grade and language proficiency levels of students. Students' interest will be tapped and their schema will be activated by reading to them the metric poem. Use realia (real objects), a bilingual dictionary, or TPR (Total Physical Response) for action words to explain words students do not understand. Brainstorm using a mapping strategy. Look for answers related to items measured in the metric system, tools used in measuring metric, and units

used to express metric measurement.

1. Name some things you can measure in the classroom.
2. Name tools with which you can measure.
3. Name some units of measurement.

Experiencing the learning of the concept through hands-on activities:

Group students according to ability/language proficiency levels and set up two math centers. More math centers with varying tasks can be used.

Math Center #1

In this center, students are shown real objects to be estimated and measured (e.g., a pencil, a book, a glass of water, a table, and their own height and weight) and tools to measure the objects.

Have students record in their journal their estimates of the measurement of these objects.

Allow students to use construction paper 1-centimeter squares to place across the objects to determine the actual measurement.

Math Center #2

In this center, students work in pairs to write word problems using the experience they had in center one. Students will use vocabulary they have learned from the reading passage or poem at the beginning of the lesson. Students will be shown models of the finished product.

Reviewing and assessing the learning of the concept.

Students will write/draw about the concept they learned in their journal and will solve the word problems generated by different groups in center two.

Using CALLA to teach math concepts not only benefits ELs, but also assists mainstream learners as the method attends to the teaching of content, language and strategies simultaneously.

In the example of the math lesson above, a teacher addresses the concepts (metric measurements),

language (vocabulary and word problems in learning the metric system through a reading passage or a poem) and strategies. Strategies involve these domains: **metacognitive**, **cognitive**, and **social affective**. Metacognitive strategies include: a preview of vocabulary in reading passage /poem/song; grouping of items measured, elaboration and transfer; relating new information to what is already known, e.g., types of measurements used in ELs' home country, (some may have already been familiar with the metric system); imagery: and visual images that are mental or actual to understand and remember new information (for example, mnemonics). **Social affective techniques include:** cooperation, working together with peers to solve math problems, gathering information, checking a learning task, or getting feedback on oral or written performance; self-talk, using mental techniques to boost one's own confidence and reduce anxiety when completing task, (for example, verbalizing the thought process of solving a math problem). This social affective strategy is easily utilized by the teacher when math centers such as the above example are arranged. Setting up these centers enables teachers to meet the individual needs of the ELs, especially those who are at the lower language proficiency levels. This construct frees the teachers from whole class instruction and allows them to give the ELs some individual attention. Teachers need to remember that immigrants, refugee students, English learners in general are individuals with their own unique perspectives on problem-solving, and will not approach problems in the same manner. We must listen to and understand each student's approach to solving problems. Educators must remember that the depth and clarity of a teacher's multicultural lens can make or break a students' ability to learn (Kilman, 2005). As educators, it is our primary obligation to reach all students in our classrooms.

Assessment and Problem Solving

Assessment is an important component of a lesson and students can be assessed using the CALLA approach as well. Keeping a math journal and completing a simple project are excellent ways for practical application of introduced concepts. Projects

can be: finding objects at home to measure using the metric system; researching about the countries in the world that use the metric system (a multicultural element within the lessons) and solving peer generated word problems. These projects are good examples of alternative assessments, which are a more meaningful measure of students' capabilities and comprehension of concepts than the standardized test format. However, this is not to imply that students should not be exposed to samples of high stake tests, such as FCAT, that they will eventually take. Observations and evaluations of students' performance can be made by using a rubric.

Currently in math instruction, the primary focus is on process and problem solving, as opposed to single answers and computation. Teachers can incorporate more problem solving approaches to instruction as well as rubrics that grade based on the process rather than just providing the correct answers only. Reys (2004) and NCTM (2000, 1995 & 1989) suggest that teachers need to see that methods and tasks for assessing students' learning should be aligned with the curriculum's goals, math content, instructional approaches and activities, including the use of calculators and manipulatives. Reys (2004) and NCTM (2000, 1995 & 1989) feel that assessment should allow for multiple sources of information with tasks that show different kinds of math thinking, in addition to presenting the same math concept or procedure in different contexts, formats, and problem situations. Also, appropriate assessment methods and uses need to be taken into consideration based on the type of information sought, how the information will be used, and the degree of developmental level and maturity of each student. Teachers need to employ alternative forms of assessment in math classes, as suggested by Reys (2004), such as observations, questioning, interviews, performance tasks, self-assessments of students, work samples, portfolios, writing samples, paper and pencil tests, and standardized tests. Schools need to shift toward assessing students' full mathematical power by giving students multiple opportunities to demonstrate their full mathematical understanding, aligning assessment with curriculum and instruction,

and regarding assessment as continual and recursive (NCTM, 1995). With less of an emphasis on right or wrong and more of an emphasis on process, teachers can help to create a population of students who can show competence in mathematics.

Summary

In conclusion, teachers should be tireless in exploring the best means of reaching all their students and to do this is to experiment with new approaches. We recommend that math teachers explore many approaches that exist, but especially CALLA. Although CALLA is an approach that is popular in the language teaching and learning field, its benefits extend to teaching in other content areas, such as in mathematics instruction. Many factors inside and outside of school influence students' level of achievement; the quality of classroom teaching is key to improving students' learning (National Commission on Mathematics and Science Teaching for the 21st Century, 2000). Much of mathematics is taught through working on mathematics problems (TIMSS Video Mathematics Research Group, 2003). Math teachers need to take ESOL issues into consideration when planning effective instruction.

In light of current concerns for all students, including the ESOL population, to achieve at a level consistent with or above national and international scores on math assessment tests, educators may need to take a more proactive role in encouraging students to become excited about math. When students see themselves as successful and confident, they are more likely to become mathematical problem solvers. In this technological era, all students require much knowledge related to mathematics and problem solving. As mathematics teachers, we need to be diligent in preparing our ESOL population so they may possess mathematical expertise in our high-tech globally competitive world.

References

- Ariza, E, Morales-Jones, C., Yahya, N., Zainuddin, H. (2002). *Why TESOL? Theories and issues in teaching English as a second language for K-12 teachers*. (2nd Edition). Dubuque, Iowa: Kendall/ Hunt Publishing Company.
- Chamot, A. U. and O' Malley, J.M. (1994). *The CALLA Handbook: Implementing the cognitive academic language learning approach*. Reading, MA: Addison-Wesley.
- Dawson, R. (n.d.). *Setting the record straight on H1 visa legislation*. An Opinion Piece by the Information Technology Industry Council. Retrieved February 24, 2004, from http://www.itic.org/policy/h1b_000628.html.
- Davis, P. J., & Hersch, R. (1990). *Descartes' dream: The world according to mathematics*. London, England: Penguin Publishing Group.
- Juffs, A., & Harrington, M. (1995). Parsing effects in second language sentence processing: Subject and object asymmetries in wh-extraction. *Studies in Second Language Acquisition*, 17(4), 483-516.
- Juffs, A., & Harrington, M. (1996). Garden path sentences and error data in language sentence processing. *Language Learning*, 46(2), 283-326.
- Kilman, C. (2005). *Crossing borders border crossings*. *Teaching Tolerance*, 28(1), p. 26-31.
- Lane, N. (1999). *International mathematical olympiad 2001 USA*. Paper presented at the Secretary's Conference Room of the U.S. Department of Education. Retrieved September 27, 1999, from http://www.ostp.gov/html/0022_3.html.
- Myles, F. (1996). The acquisition of interrogatives by English learners of French: The role played by structural distance. *Jyvaskyla Cross Language Studies*, 17, 208.

National Commission on Mathematics and Science Teaching for the 21st Century. (2000). *Before It's Too Late*. Washington, D.C.: U.S. Department of Education.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1995). *Professional assessment standards for teaching mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics*. NCTM: Reston, VA.

Neunzert, H. (2000). *Will Mathematics and the mathematicians be able to contribute essentially in shaping the future?* Paper presentation at the 3ECM Conference Round Table Discussion on Shaping the 21st Century, Barcelona, Spain, July 11-14, 2000.

Reys, R.E., Suydam, M. N., Lindquist, M. N., & Smith, N. L. (2004). *Helping children learn mathematics*. (7th Edition) Boston, MA: Allyn and Bacon.

Stabler, E. & P. Jr. (1994). The finite connectivity of linguistic structure. In C. L. Frazier, & K. Rayner (Eds.), *Perspectives on sentence processing*. New York: Erlbaum.

Steen, L.A. (1999). Numeracy: The new literacy for a data-drenched society. *Educational Leadership*, October, 8-13.

TIMSS Video Mathematics Research Group. (2003). Understanding and improving mathematics teaching: Highlights from the TIMSS 1999 video study. *Phi Delta Kappan*, 84(10), 768-779.

U.S. Census Bureau (n.d.) U.S. Census brief. Retrieved May 24, 2005, from <http://www.census.gov/population>.

The Authors

Noorchaya Yahya, Ph.D. is an Associate Professor of TESOL Education at Florida Atlantic University in Port Saint Lucie, Florida. She trains South Florida pre-service and in-service teachers in all areas of TESOL education: Methodology, Curriculum and Instruction, Language Assessment, and Applied Linguistics for K-12 teachers. Her main research interests are ESL writing, ESL in the content area teaching, and teachers' reflections of their teaching process. She has published several articles in her research areas and co-authored two books, *Why TESOL?: Theories and Issues in Teaching English as a Second Language for K-12 teachers*, and *Fundamentals of Teaching English to Speakers of Other Languages in K-12 Mainstream Classrooms*. Her email address is: nyahya@fau.edu.

Joseph M. Furner, Ph.D. is an Associate Professor of Mathematics Education at Florida Atlantic University in Jupiter, Florida. His research interests are related to math anxiety, the implementation of the NCTM Standards, TESOL issues as they relate to math instruction, the use of technology in mathematics instruction, math manipulatives, and children's literature in the teaching of mathematics. Dr. Furner has worked as an educator in New York, Florida, Mexico, and Colombia.