# THE ALGORITHM COLLECTION PROJECT (ACP)[1]: THE ETHNOMATHEMATICS OF BASIC NUMBER SENSE ACQUISITION ACROSS CULTURES

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***Abstract***

*This discussion focuses on the interactions this writer studies that occur between culture, the language(s) spoken, and the particular algorithms used by recently arrived high school immigrant students attending an inner-city high school in Northern California. This activity allows students to develop an understanding between the relationships of an individual's language and their algorithms. This work is based on a Brazilian research paradigm employing strategies of ethnomathematics and mathematical modeling.*

***Abstrato***

*Esta discussão focaliza as interações, que o escritor estuda, e que ocorrem entre cultura, língua falada, e a peculiaridade dos algoritmos que são utilizados por alunos imigrantes, recém-chegados aos Estados Unidos, e que freqüentam uma escola secundária no norte da Califórnia. Esta atividade permite aos alunos desenvolverem a capacidade de compreender o relacionamento entre a língua falada e os algorítmos por eles utilizados. Este trabalho tem como base um paradigma brasileiro de pesquisa que utiliza etnomatemática e a modelagem matemática como estratégias de ensino.*

## Theoretical Foundations

A large number of students experience mathematics negatively. Many of these same students have difficulty in performing basic arithmetic operations that may ultimately exclude them from participation in society. Comparable populations across the world have fewer problems with mathematics than do students in the United States (TIMSS, 1997). Facility with the algorithm one uses, including its unique history and cultural significance, certainly contributes to one's success or failure in mathematics.

[1] *http://www.csus.edu/indiv/o/oreyd/Alg.html*

A fundamental aspect of this project respects the importance of the interaction between languages spoken and algorithms used that combine to form individual abilities or disabilities in mathematics. Success during early attainment of arithmetic operations forms the basis for how successfully one learns advanced mathematics. Work with mathematics learners in other countries (Orey, 2000, 1999, 1998) suggests that true reform should not exclude an ethnomathematical perspective. An in-depth study of the type of algorithms used by many immigrants to California has important international significance as well, and represents a clear case for studying "what works" across cultures in relation to number sense acquisition.

## Project Design

This writer studies these interactions from an ethnomathematics perspective by using techniques as learned as a Fulbright Scholar in Ethnomathematics at the Pontifícia Universidade Católica de Campinas in Brazil. The design of this project encompasses a three-step process:

Collection: The ACP uses a Brazilian interview protocol (Orey & Rosa, 2002) that is used to conduct interviews with recently arrived immigrants in relation to their mathematics. Cohorts of graduate and student teachers were trained to interview recently arrived immigrant students in relation to their attainment and use of the four basic arithmetic operations. As part of course assignments, students make interviews in relation to how immigrants learned and use addition, subtraction, multiplication, and division algorithms in their country of origin. The data taken from these interviews have assisted in the development of a vocabulary collection of over 21 languages currently spoken in the researcher's immediate community.

Analysis: Each semester, the principle investigator trains groups of preservice teachers to contact and interview immigrants to our region. The samples are analyzed for diverse protocols, and error patterns distinctive to each algorithm. During the pilot study, 16 groups were represented; it has grown to over 35 in the Sacramento region, some of which are shared on the ACP Website. The initial pilot study uncovered four patterns for long division being used by the high school students (see appendix).

Dissemination: ACP study data has been used to construct a new course objective for mathematics methods students at California State University, Sacramento. Students are asked to interview a newly arrived immigrant along the same lines as outlined above, and descriptions written by the students are posted on the ACP website. Data gleaned from this work has been used to develop curriculum strategies for teacher educators in both California and Brazil through numerous seminars and workshops given by this writer. As well, the findings have been shared in the United States, Costa Rica and in Brazil, as well as Capital Public Radio, the California Mathematics

Council Asilomar Meeting, NCTM, and CERME3 and though The International Study Group on Ethnomathematics network. The ACP website has generated a great deal of interest from researchers in Europe, North and South America. Recently the Algorithm Collection Project was awarded a Pedagogy Enhancement Award from the Center for Teaching and Learning at California State University, Sacramento to further develop the data and upgrade the website.

## Research Question and Significance

Do algorithms we use have cognitive, as well as pedagogical significance for their users? What is the consequence for language attainment (multi-bilingualism) and a specific algorithm? Recent research suggests that one's mother tongue affects one's personal form of cognitive processing (Holtz, 2001; Devlin, 2000). It appears that some language groups have significantly more incidences of dyslexia, most notably native monolingual speakers of American English. This interaction of language and written language, suggests that monolingual children in California possess equal difficulty with the standard algorithm as taught here, and may be influenced by factors related to the unique linguistic interactions between American Standard English and the algorithms taught in the United States. Educators in many countries are surprised to find that common day-to-day algorithms differ by culture and by national origin.

For example, there are at least five major patterns used for long division, four of which are used by immigrants to this part of the world. For purposes of this study, they are called: North American; Franco-Brazilian; Indo-Pakistani; and Russo-Soviet. A fifth, represented by a colleagues Norway, has not been found in the samples gathered from this part of the world as of this writing.

## Context and Background to the Study

Early colonization enabled, for better or worse, the exchange of alternative ways of thinking and learning between diverse groups in North and South America. The ongoing processes of immigration and urbanization have brought together members of diverse cultures; Northern California is part of this phenomenon, where people of all cultures and languages interact with some frequency. Sacramento, the state capital (metro area population of 2 million) has over 80 languages and cultures represented. The Sacramento region is one of the fastest growing metropolitan regions the United States, suggesting as the population and urban area expands, schools here will have to adapt to the increased migration and diversity.

The pilot study uncovered relationships between mono, bi and multilingualism; the algorithms used; and student ability and confidence. For example, some language groups use the comma (,) for the decimal, which can cause for some confusion for scientists, business people, students and educators. Mistakes, often deadly, in translation between standard and metric measurements are legendary in this country. Thus, a strong case can be made for studying "what works" across cultures in relation to number sense acquisition and language. A surprise to many educators is the successful methods for learning, memorizing, calculating and communicating answers often differ across cultures.

Much of what has been studied in both ethnomathematical and multicultural contexts has often been related to the ancient ways of doing algorithms. For example, it is not uncommon for textbooks in many countries to introduce Roman and Babylonian number systems, medieval-Russian peasant addition, Napier's bones and other such activities as historical curiosities. It is also quite common to study certain aspects of Aztec-Mayan math.

A Brazilian graduate student, Milton Rosa, serving as a visiting foreign exchange teacher in mathematics, was having difficulty in using and explaining the standard North American algorithm to his students as prescribed by the curriculum, and realized that his method also differed from that of a number of his students (see examples from Brazil and Kazakhstan). He asked his students to demonstrate how they learned to do long division in their former schools.

**What is Ethnomathematics?**

Ethnomathematics forms the intersection between mathematics and cultural anthropology. It was introduced by Ubiratan D'Ambrosio (2001) who explained that ethnomathematics is the "art or technique of explaining reality within a proper cultural context", and describes all the ingredients that form the cultural identity of a group: language, codes, values, jargon, beliefs, food and dress, habits, and physical traits. Ethnomathematics defines a broad view of mathematics, and includes ciphering, arithmetic, classifying, ordering, inferring, and modeling. In this context, "ethno" and "mathematics" are understood in the broadest possible sense. *Ethno* refers to a broad concept of cultural groups, and not an anachronistic concept related to race or exotic groups of people; *mathematics* is to be seen as a set of activities such as *calculating, measuring, classifying, ordering, inferring, and modeling*. The traditional curriculum in the United States has encouraged "only one way to solve a problem," the ethnomathematical perspective as adopted by the Algorithm Collection Project enables this researcher to use the diversity in California classrooms as a resource.

## Mathematical Modeling

The construction of mathematical concepts incorporates the reality of each individual. It begins by placing new situations and problems in front of a child for them to master within their own context and experiential reality. It is on this basis that math concepts are learned. It is with a focus on the understanding and resolution of problems, that we "do" mathematics. Students must be given experiences that enable them to learn how to mathematically: break a problem situation into manageable parts, create a hypothesis; test the hypothesis, correct the hypothesis; and make transference and generalizations to their own reality. Activities involving mathematics should enable opportunities for open-ended exploration, appropriate project work, group and individual assignments, discussion and practice using a variety of mathematical methods, tools, and techniques. It is no longer acceptable that the intellectual activity of a child is exclusively based on memorization and testing, or for that matter only with the application of archaic knowledge, which serves only to increase math avoidance. Using an ethnomathematics based pedagogy, a teacher can introduce their students to new tools and techniques directly connected to the real life of the learner, help them to practice becoming proficient in their use, and guide them towards sophisticated mathematical applications. It is through "context" that the teacher creates additional explanations and ways to work within a "mathematically based reality". This work within a mathematics reality is related to the "transforming action" (Freire, 1997) that looks to reduce its degree of complexity through the choice of a model where representations of this reality are derived by enabling the exploration, explanation, and increased comprehension of the concept.

A cross-cultural study of basic algorithms allows us to reflect on the inherent possibilities of each context and for these same possibilities to become the object of critical analysis by the students. The process in which we consider, analyze and make ongoing reflections on different algorithms is called *modeling* and is an important element in uncovering ethnomathematics in general. The way to introduce students to mathematical modeling is to expose them to a diversity of problems and models that include mathematical interpretations of problems, which in turn, are representations of models under study. When we analyze a given situation for its mathematical perspective, the teaching and learning process becomes more than an over emphasis on rote memorization of basic facts. An excellent place to begin this study is in the way that people have learned to personally compute or calculate thought a study of the algorithms used on a day-to-day basis. Mathematical questions are used to explain and to forecast phenomena in the real world. What is interesting from an ethnomathematical point of view is that many of these explanations are unique from one culture to another, and of course this works for algorithms that people use to make basic day-to-day calculations. Many of these perspectives are used in representing situations for the study of alternative techniques used to make calculations.

By bringing the alternative strategies and algorithms found in our community together, teachers and students can learn to flexibly solve problems, use alternatives when one strategy does not work, and look at "best practices" from a global view.

## Reflections

A number of interesting things happened as an outgrowth from this activity. A few preservice students were extremely nervous about contacting someone to interview, "I do not know any one from another country" was heard a number of times. Together as a class, we brainstormed a number of possibilities which included, going to the Student Union, sitting and listening, and politely introducing yourself and asking if the person speaking another language was a foreign student, and if they would be interested in being interviewed; contacting a church or other religious community, contacting the University Multicultural Center, and contacting the Department of Foreign Languages.

Interestingly enough, students who expressed the most reluctance stated that they enjoyed the activity the most. All interviewees in the sample mentioned how happy they were that Americans were interested in knowing something about their culture and ways of doing something as basic as arithmetic. The classes developed lists of vocabulary words, mathematical terms, numbers from 0-10 etc. , and wrote the words on index cards that were placed in the classroom to compare each language.

Additions to this activity often include: conversion formulas — standard to metric, time zones, etc.; vocabulary lists in languages not represented by this study; the four basic operations, and square roots; tricks for resolving problems; and a discussion of how the participants memorized the basic facts. Almost all students who have participated in this activity have come away with a greater appreciation of “more than one way to solve a problem” a greater appreciation for cultural diversity, a new understanding for how hard it is for newly arrived students to adapt to life in a new country.

## Bibliography

D’Ambrosio, U. (2001). “What is ethnomathematics, and how can it help children in schools?" In: Teaching Children Mathematics, 7(6). Reston, VA: NCTM.

_____________. (1985). “Ethnomathematics and its place in the history and pedagogy of mathematics. ” For the Learning of Mathematics. 5(1): 44-48.

Devlin, K. (2000). The Math Gene: How mathematical thinking evolved and why numbers are like gossip. Basic Books.

Freire, P. (1997). Pedagogia da Autonomia: Saberes Necessários à Prática Educativa (Pedagogy that Gives Autonomy: Necessary understandings towards a practical education). São Paulo: Editora Paz e Terra.

Holtz, R. L. (2001, March 16). "Study: Some written languages intensify dyslexia. ” Sacramento Bee, p. A20.

International Study Group on Ethnomathematics (ISGEm) Website: http://www.rpi.edu/~eglash/isgem.htm

NCTM. (1999). Every child Statement. Reston, VA: National Council of Teachers of Mathematics (www. nctm. org).

Orey, D. & Rosa, M. (2002). *Vinho e Queijo: Etnomatemática e Modelagem*. Submited to: Boletim de Educação Matemática. Unversidaded Estadual Paulista – Rio Claro, Brasil.

Orey, D. (2000). "Etnomatemática como Ação Pedagógica: Algumas Reflexões sobre a Aplicação da Etnomatemática entre São Paulo e Califórnia in Proceedings of the Primeiro Congresso Brasileiro de Etnomatématica — CBEm1. Universidade de São Paulo, São Paulo, Brazil.

______. (1999). "Fulbright Ethnomathematics in Brazil. ” International Study Group on Ethnomathematics Newsletter. Las Cruces: ISGEm, 14 (1).

______. (1998). "Mathematics for the 21st Century. ” In: Teaching Children Mathematics, Reston, VA: National Council of Teachers of Mathematics.

______. (1989). "Ethnomathematical perspectives on the NCTM Standards. ” International Study Group on Ethnomathematics Newsletter. 5(1): 5-7.

______. (1984). "Logo goes Guatemalan: an ethnographic study. ” The Computing Teacher, 12(1): 46-47.

*TIMSS. (1997). Third International Mathematics and Science Survey.*

# Appendix I.
## Examples of Long Division Algorithms