# The Borrowers: Using Transportation, Addresses, and Paralelepípedos to Prompt Creativity using Ethnomodeling

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**Abstract:** *It is our pleasure to share with readers a bit about our journey and our developing perspective in relation to the creative potential we have encountered in California, New Mexico, Nepal, Guatemala, and Brasil in relation to ethnomathematics and mathematical modeling and distance education. We conclude this discussion with a few brief examples of how ethnomodeling works in Brasil.*

## INTRODUCTION

The starting point of this discussion is related to the question, what does it take to make a mathematical mind? By answering this question, it is necessary to outline factors regarding: a) Number sense; b) Numerical ability; c) Algorithmic ability; d) Ability to handle abstraction; e) A sense of cause and effect; f) Ability to construct and follow a causal chain of facts or events; g) Logical reasoning ability; h) Relational reasoning ability; i) Spatial reasoning ability (Devlin, 2000).

We have encountered these abilities in a diversity of cultural manifestations. For example, as a teacher in Guatemala in the early 80's, Professor Orey first encountered mathematics in the context of culture. While purchasing an item in a highland Maya market, he bartered with a woman who took a hand-held calculator from inside her huipil[1]. Neither of them could speak the other's language, so she quickly punched in the price she wanted and handed it back to him. Shaking his head, he then entered a new price and handed it back to her. This process continued until both were met with satisfaction. It was not until a few hours later while returning home on the bus that Orey asked himself: *What just happened?*

Over the years he has become increasingly interested in how diverse people incorporate new ideas and technologies; in novel and creative ways, and how these interactions, often enabled by technologies, are increasingly affecting all of our thinking and learning processes. In this regard, we need to take special effort to open our eyes to the dynamic histories and technological sophistication of indigenous cultures (Eglash et. al, 2006).

Mathematical thinking is influenced by the diversity of human environments and their elements such as language, religion, mores, economics, and social-political activities. These same forces influence and encourage creativity. Historically, human beings have developed logical processes related to quantification, measurement, and modeling in order to understand and explain their socio-cultural-historical contexts (Rosa & Orey, 2010). These processes allow each cultural group to develop its own way to *mathematize*[2] their own realities.

According to this perspective, the purpose of this paper is to provide a discussion on ethnomodeling, which aims to show through a series of examples how mathematics can be understood and used as way of translating mathematical practices in diverse cultural contexts.

However, before discussing our work in Ouro Preto, a brief discussion of *ethnomathematics* and *ethnomodeling* is necessary in order to assist in contextualizing aspects of mathematical creativity, which may be described as a multifaceted construct involving both "divergent and convergent thinking, problem finding and problem solving, self-expression, intrinsic motivation, a questioning attitude, and self-confidence" (Runco, 1993, p. ix). In this direction, students need to see how mathematics is developed and realize that creative individuals help the evolution of mathematical knowledge.

## ETHNOMATHEMATICS

Ethnomathematics is the application of mathematical ideas and practices to problems that confronted people in the past or are encountered in present day culture (D'Ambrosio, 2001). Much of what we call *modern mathematics* came about as diverse cultural groups sought to resolve unique problems such as commerce, art, religion, exploration, colonization and communications, along with the construction of railroads, census data, space travel, and other problems-solving techniques that arose from particular communities. For example, the Mayans invented the number zero and the positional value that are often attributed to the Hindus around the 9$^{th}$ century. These concepts were transmitted to the Arabs from the Hindus by means of exchanges of commercial activities (Rosa & Orey, 2005).

Cultural variables have strongly influenced how students how came to understand their world and interpret their own and others experiences (D'Ambrosio, 1990). In attempting to create and integrate mathematical materials related to different cultures and that draw on students' own experiences in an instructional mathematics curriculum, it is possible to apply ethnomathematical strategies in teaching and learning mathematics. These strategies include, but are not limited to the historical development of mathematics in different cultures, which means that:

> (…) people in different cultures which use mathematics (e.g. an African-American biologist, an Asian-American athlete). Mathematical applications can be made in cultural contexts (e.g. using fractions in food

> recipes from different cultures). Social issues can be addressed via mathematics applications (e.g. use statistics to analyze demographic data) (Scott, 1992, p. 3-4).

The challenge that many communities face today is in determining how to shape a modernized, national culture, which integrates selected aspects and where its diverse ideas coexist in an often delicate balance with those of westernized science. Increased cultural, ethnic, and racial diversity while not homogenizing the whole, providing both opportunities for, as well as challenges to, societies and institutions, with many questions related to schooling forming an integral part of this question. Indeed the most creative dynamic and productive societies do this well (Florida, 2004).

## ETHNOMATHEMATICS AS A PROGRAM

The inclusion of moral consequences into mathematical-scientific thinking, mathematical ideas, procedures, and experiences from different cultures around the world is vital. The acknowledgment of contributions that individuals from diverse cultural groups make to mathematical understanding, the recognition and identification of diverse practices of a mathematical nature in varied cultural procedural contexts, and the link between academic mathematics and student experiences should all become central ingredients to a complete study of mathematics.

This is one of the most important objectives of an ethnomathematics perspective in mathematics curriculum development. Within this context, ethnomathematics can be described as:

> The prefix *ethno* is today accepted as a very broad term that refers to the sociocultural context, and therefore includes language, jargon, and codes of behavior, myths, and symbols. The derivation of *mathema* is difficult, but tends to mean to explain, to know, to understand, and to do activities such as ciphering, measuring, classifying, ordering, inferring, and modeling. The suffix *tics* is derived from *techné*, and has the same root as art and technique. In this case, *ethno* refers to groups that are identified by cultural traditions, codes, symbols, myths and specific ways used to reason and to infer (D'Ambrosio, 1990, p. 81).

In this regard, ethnomathematics forms the intersection between cultural anthropology and institutional mathematics that uses mathematical modeling to solve real-world problems in order to translate them into modern mathematical language systems. In so doing, mathematical modeling is a creative tool, which provides a translation from indigenous knowledge systems to Western mathematics. This perspective is crucial in giving minority students a sense of cultural ownership of mathematics, rather than a mere gesture toward inclusiveness (Eglash et. al, 2006).

An essential aspect of the program includes an ongoing critical analysis of the generation and production of mathematical knowledge as well as the intellectual processes of this production (Rosa & Orey, 2010). This program seeks to explain, understand, and comprehend mathematical procedures, techniques and abilities through a deeper investigation and critical analyses of students' own customs and cultures. In Brasil, the use of Bakairi body painting in Bakairi schools facilitates the comprehension of spatial relations such as form, texture, and symmetry; which are excellent for the construction and the systematization of geometrical knowledge by allowing students to experience academic mathematical language through a cultural lens (Rosa, 2005).

In this context, the use of artifacts from cultural groups in educational settings that can raise students' self-confidence, enhance and stimulate their creativity, and promote their cultural dignity (D'Ambrosio, 2001). The use of ethnomathematics as pedagogical action restores a sense of enjoyment or engagement and can enhance creativity in doing of mathematics.

## ETHNOMODELING

Studies conducted by Urton (1997) and Orey (2000) have shown us "sophisticated mathematical ideas and practices that include geometric principles in craft work, architectural concepts, and practices in the activities and artifacts of many indigenous, local, and vernacular cultures" (Eglash et. al, 2006, p. 347). Mathematical concepts related to a variety of mathematical procedures and cultural artifacts form part of the numeric relations found in universal actions of measuring, calculation, games, divination, navigation, astronomy, and modeling (Eglash et. al, 2006).

The term *translation* is used here to describe the process of modeling local cultural systems, which may have a Western academic mathematical representation (Eglash et. al, 2006; Orey & Rosa, 2006). Indigenous designs may be simply analysed as forms and the applications of symmetrical classifications from crystallography to indigenous textile patterns (Eglash et. al, 2006). On the other hand, ethnomathematics uses modeling to establish the relations found between local conceptual frameworks and mathematical ideas embedded in numerous designs. We define this relationship as *ethnomodeling* because "the act of translation is more like mathematical modeling" (Eglash et. al, 2006, p. 348).

In some cases, translation into Western-academic mathematics is "direct and simple such as that found in counting systems and calendars" (Eglash et. al, 2006, p. 347). For example, the mathematical knowledge that lace makers in the northeast of Brasil use to make geometric lace patterns, (Figure 1) have mathematical concepts that are not associated with traditional geometrical principles, which may be modeled through the techniques of ethnomodeling.

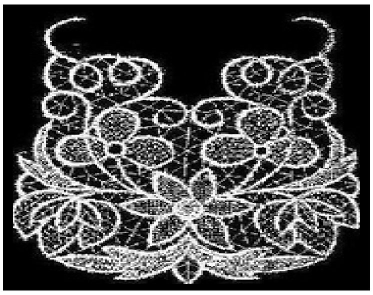

**Figure 1: Geometric lace patterns**

Ethnomodeling takes into consideration diverse processes that help in the construction and development of scientific and mathematical knowledge, which includes collectivity, and overall sense of and value for creative invention. It may be considered as the intersection region of cultural anthropology, ethnomathematics, and mathematical modeling (Figure 2).

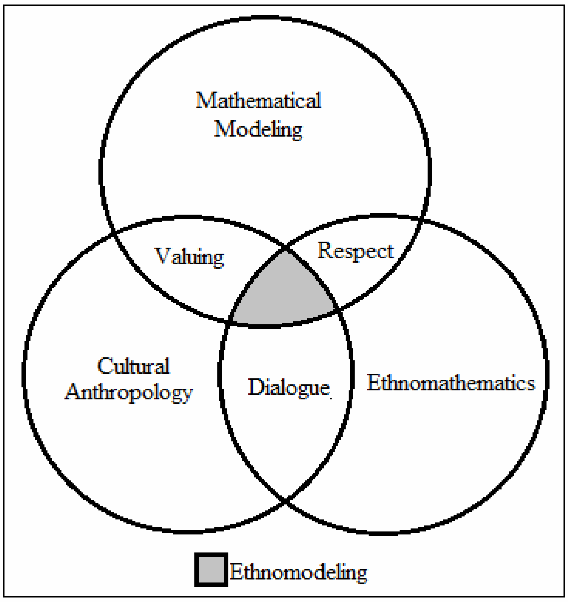


**Figure 2: Ethnomodeling as the intersection region of three knowledge fields**

The processes and production of scientific and mathematical ideas, procedures, and practices operate as a register of the interpretative singularities that regard possibilities for symbolic constructions of the knowledge in different cultural groups. In this context, mathematics is not a universal language after all, because its principles, concepts, and foundations are not always the same around the world. By using ethnomodeling as a tool towards pedagogical action of the ethnomathematics program, students can be shown to learn how to find and work with authentic situations and real-life problems (Rosa & Orey, 2010, p. 60).

## GENERAL ASSERTION

Ethnomathematics is a contemporary pedagogical trend in education (Scientific American-Brasil, 2005). The world's economy is globalized, yet, traditional mathematics curricula neglects, indeed often rejects contributions made by non-dominant cultures. An ethnomathematical perspective offers new and expanded definitions of a given society's particular scientific contributions.

Pedagogically, ethnomathematics allows school mathematics to be seen "as the process of inducting young people into mathematical aspects of their culture" (Gilmer, 1990, p. 4). An ethnomathematics perspective reshapes cultural identity in a positive way by requiring the inclusion of a greater representation of practices and problems of a student's own community (D'Ambrosio, 1995).

Ethnomathematics helps both educators and students alike to understand mathematics in the context of ideas, procedures, and practices used in their day-to-day life. It further encourages an understanding of professional practitioners, workers, and academic or school mathematics. Such depth is accomplished by taking into account historical evolution and the recognition of natural, social and cultural factors that shape human development (D'Ambrosio, 2001).

## SOME PRACTICAL IDEAS AND EXAMPLES

So, how to go about doing this? How does this relate to creativity and mathematics? Toliver (2008) has for years offered an interesting tool she named a *Math Trail* by which we considered connecting our thinking to the mathematics found in the cultural context of a neighborhood school. She has said that in this activity, she saw a way to get her students working with each other, in a way to have them become active learners, and to increase their respect for their own community. Together with mathematical modeling we have used this perspective in Nepal, Guatemala, United States, and Brasil. We have shared here examples that engendered a great deal of creativity in groups of learners.

### An exploration of Addresses in Ouro Preto

In 2005, Prof. Orey was invited to participate as a visiting professor with the mathematics education group at UFOP. During that time he began working with a group of elementary school children attending one of the municipal schools in Ouro Preto, Minas Gerais, Brazil. That *pilot study* became the basis for the Ouro Preto Math Trail[3]. Prof. Orey visited the school and worked with the kids over a period of 8 months.

**Fig. 3: Students doing research in front of the school in Ouro Preto**

When a group of nine year old students were asked why the first house number on Rua Alvarenga began with a number 7 (Figure 3), automatically, the responses were “it is 7 meters from the bridge”. Upon exploration and discussion we found that it was not 7 meters.

**Fig. 4: Number 7on Rua Alvarenga**

After some research we found that measurements in the historic center of Ouro Preto were once based on the old imperial units such as *barras*[4]. We took the distance from the end of the bridge to the door divided it by seven and found it closely resembled the *barra unit* and then realized that all the address were showing distances along the street. For example, my apartment building was at 130 Rua Alvarenga (130 barras from the beginning of the street).

Kids from a rural aldeia[5] *Coelhos*[6], after visiting the *Ouro Preto Math Trail*, studied their own street and presented a plan to the mayor’s office. The result was that the houses in aldeia were renumbered! This approach allowed kids the opportunity to learn and use mathematics in order to make either a transformation or contribution to the community. The idea that learning mathematics and giving back to one’s community at the same time is motivating because it gives all us reason for hope.

**How many Paralelepípedos [7] are on the Rua Alvarenga?**

This was just one of a few activities that students developed in Ouro Preto. The activities gave a sense of importance and value to Ouro Preto, a *World*

*Cultural Heritage* site that did not exist among the students of their university town.

College students in the specialization program in Prof. Orey's mathematical modeling class at the Universidade Federal de Ouro Preto were enlisted to create final projects related to Rua Alvarenga. The students divided themselves into a number of groups and asked to develop and solve problems related to Rua Alvarenga. One group developed a number of models that estimated the number of paralelepípedos (Figure 5).

**Fig. 5: Paralelepípedos on the Rua Alvarenga**

## Transportation[8], Modeling, and Moodle[9]

In June of 2013, millions of Brazilians went to the streets to protest corruption; the movement was spurred on by tremendous amounts of money spent on stadiums for the FIFA World Cup in 2014 while social services, health care, and education have suffered. The straw that broke the camel's back so to speak was brought on by a sudden rise in transportation (mostly bus fares) across the country (Langlois, 2013; Orey, 2013).

During this same time, Prof. Orey was teaching his online course entitled *Seminar in Mathematical Modeling* with 110 students enrolled across 2 states in 10 very diverse educational centers named *polos*[10]. Normally, a good portion of the course is devoted to forming groups and having the students find their own themes, but this semester everyone was encouraged to select *transportation* as a theme. Groups of students in all polos produced models regarding to the proposed theme. Both students and professor was to be courageous to use the moment and not be afraid of taking aspects of day to day events found in our daily lives and use these opportunities to teach, learn, and communicate mathematical findings.

Because this seminar is a long-distance offering, each group recorded a 10 minute video and placed it on YouTube and shared the link on the class forum. A PowerPoint and a short paper used in the presentation describing their findings were shared with the class, professor and tutors.

Each presentation shared a brief introduction on the development of the submitted work; information they gained through interviews with citizens and public transport users in their respective cities; questions related to the situations presented in the interviews; mathematical models built upon the data researched; possible solutions to the problems outlined, and conclusions and reflections.

## FINAL CONSIDERATIONS, THOUGHTS AND QUESTIONS

If one borrows something from someone, then one is less than interested in truly incorporating it (D'Ambrosio, personal communication, email, January 23, 2008). Borrowing suggests that one wants to borrow it to do something, as in collecting something *exotic* to place in a museum shelf, or like a selection of food at any shopping mall. The act of borrowing is only important for a particular moment and does not serve for the present when diverse elements collide, live, and create new foods, music, science and of course mathematics as is happening in numerous locations in the Americas.

When we *borrow*, we are acquiring objects or ideas with less thought or any sense of mindfulness to where they come from or how they came to be. Borrowing is often less interested in *knowing* the culture of the other. In a communication, D'Ambrosio (personal communication, email, January 23, 2008) shared with me that if culture A meets culture B, then three things may happen:

a) Culture A eliminates culture B.
b) Culture A is absorbed by culture B.
c) Culture A assimilates culture B and produces culture C, that is, A + B = C.

What D'Ambrosio (personal communication, email, January 23, 2008) was speaking about is also related to work done by Walker and Quong (2000) in which it is necessary to confront the limits of uniformity. Who equate *borrowing* with *sameness*? Instead of finding models that encourage diversity, many of our social and educational institutions have grown to force *sameness*, often as an outgrowth of the trend towards globalization, which has, in turn:

> (…) promoted the phenomenon of sameness, or what can be labeled "cultural borrowing". (…) Questions naturally arise about the relevance, applicability, validity, and appropriateness of theories, perspectives and policies which are transferred to, or borrowed, adopted by education systems whose cultures and situational conditions are quite dissimilar from those in which they were conceived (Walker & Quong, 2000, p. 73-74).

According to this context, one of the goals of any educational system should be fostering creative students. Creativity is a dynamic property of the human mind that can be enhanced and should be valued. Therefore, it is important to study creativity and determine its characteristics. Nature of mathematics through ethnomathematics provides a suitable platform for developing creativity.

On the other hand, ethnomathematics is closely aligned with the types of encounters in what D'Ambrosio (personal communication, email, January 23, 2008) calls *cultural integration*. It seems to us that *cultural borrowing*, a process of sameness and by which the *good* and the *accepted* has already been defined from the outside, cannot fit within the aforementioned dynamics.

In closing, we are left with a number of questions from our research that we look forward to looking into:

1. What happens when *non-represented* or *non-majority* cultures begin a process of *borrowing*? What does this borrowing infer, especially when technology gives them access to new mathematical ideas and vice versa? Is there a *sharing* between both parties, and just a *taking* of one by the other?
2. Can a reverse sense of *cultural borrowing* also happen? Especially in places with great cultural diversity such as Nepal, Brasil or California? Or is it a reverse colonization? Or can technology be mindfully used to what D'Ambrosio (2001) calls true *cultural integration*?
3. By using *ethnomodeling*, more traditional ideas are studied, categorized, and incorporated, how might this be reflected in and create new forms of mathematics?
4. How does technology influence borrowing? Does it accelerate the process, especially in rich environments such as long distance education, mobile learning, smart phones, and internet?
5. How might we use new technologies to create a dialogue by which all mathematical ideas contribute to the good of all humanity?

## NOTES

[1] A huipil (from the Nahuatl *uipilli*, meaning *blouse*) is a form of Maya textile tunic or blouse worn by indigenous Maya women in southern México, Guatemala, Belize, El Salvador, western Honduras, and in the northern part of Central America.

[2] Mathematization is a process in which members from distinct cultural groups develop different mathematical tools that can help them to organize, analyze, comprehend, understand, and solve specific problems located in the context of their real-life situations.

[3] Retrieved from: https://sites.google.com/site/trilhadeouorpreto/projeto-piloto-escola-municipal-alfredo-baeta.

[4] The older standard linear measure that originated from measurements of area and volume was conceived in Egypt around 3000 BC. This measure was once called a cubit or bar, based on the length of the arm to the tip of the middle finger. Colonial Brazil, in the time of e Portuguese-Brazilian Empire, used a system that was often confusing and diverse in its measures because length was often measured in *barras*, and this pattern could vary from person to person, and region to region in Brasil and did not allow for a high precision in its measurements.

[5] Village.

[6] Rabbits.

[7] Cobblestones.

[8]https://sites.google.com/site/meuetnomate/home/modelagem-matematica-mathematical-modeling

[9] Courses in long-distance education as part of Universidade Aberta do Brasil offered through the Centro de Educação Aberta e a Distância at the Universidade Federal de Ouro Preto use moodle as the platform.

[10] Some of the polos are located in small towns in the interior of Brasil and others in urban centers.

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