The field of research in ethnomodeling: emic, ethic and dialectical approaches

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Abstract

In this article, we offer an alternative concept of research through the acquisition of emic and etic knowledge for implementing ethnomodeling, which aims to connect the cultural aspects of mathematics with its academic aspects. From this perspective, the use of emic and etic approaches facilitates the translation of problem situations present in the systems, extracted from the reality of distinct cultural groups, into academic mathematics. Emic knowledge is essential to the intuitive and empathic understanding of the mathematical practices developed by a particular cultural group, while etic knowledge is essential for comparing these practices. We also discuss the dialectical approach to research on ethnomodeling, which uses both emic and etic knowledge through a dialogic process, aiding a fuller understanding of the knowledge of the mathematical practices developed by members of different cultural groups. In this sense, emic knowledge is a valuable source of inspiration for the development of etic hypotheses. In such a dialectical context, a mathematics curriculum based on the ethnomodeling perspective favors the generation of mathematical knowledge to ensure the balanced integration of the effective mastery of educational objectives, which are essential for the recognition and use of students' emic knowledge.

Keywords

Ethnomodeling – Ethnomodels – Emic approach – Etic approach – Dialectical approach

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O campo de pesquisa em etnomodelagem: as abordagens êmica, ética e dialética

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Resumo

Neste artigo, oferecemos um conceito alternativo de pesquisa por meio da aquisição dos conhecimentos êmico e ético para a implementação da etnomodelagem, que tem o objetivo de conectar os aspectos culturais da matemática com os seus aspectos acadêmicos. Nessa perspectiva, a utilização das abordagens êmica e ética facilita a tradução de situações-problema presentes nos sistemas, retirados da realidade de grupos culturais distintos, para a matemática acadêmica. O conhecimento êmico é essencial para a compreensão intuitiva e empática das práticas matemáticas desenvolvidas por determinado grupo cultural, enquanto o conhecimento ético é essencial para a comparação entre essas práticas. Discutimos também a abordagem dialética para a pesquisa em etnomodelagem, que utiliza ambos os conhecimentos êmico e ético por meio de um processo dialógico, auxiliando uma compreensão mais completa sobre o conhecimento das práticas matemáticas desenvolvidas pelos membros de distintos grupos culturais. Nesse sentido, o conhecimento êmico é uma valiosa fonte de inspiração para a elaboração de hipóteses éticas. Em tal contexto dialético, um currículo matemático baseado na perspectiva da etnomodelagem favorece o desenvolvimento da geração do conhecimento matemático para garantir a integração equilibrada do domínio efetivo dos objetivos educacionais, que são essenciais para o reconhecimento e a utilização do conhecimento êmico dos alunos.

Palavras-chave

Etnomodelagem – Etnomodelos – Abordagem êmica – Abordagem ética – Abordagem dialética.

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When investigating the knowledge developed by members of different cultural groups, researchers and investigators can find original mathematical practices, which may be considered ethnomathematics. However, the capturing the knowledge developed by these groups requires a constant effort to understand scientific phenomena using native references and categories, so that a mathematical practice can also be expressed in the academic system. So we should be careful not to run the risk of transmitting them based on facts and phenomena judged with our own vision and our cultural profile.

In this context, researchers and investigators' understanding of the cultural traits of a particular group is an interpretation that often emphasizes the surface characteristics of the culture analyzed, generating a misinterpretation of the knowledge developed by the members of that cultural group. One challenge that arises from this approach is how mathematical practices, which are culturally rooted, can be drawn or understood without allowing the culture of researchers and investigators to interfere in the culture of the members of the cultural group under study. However, this can occur because members of cultural groups have their own interpretation of their culture, called *emic* approach, as opposed to the interpretation of the researchers and investigators, called *etic* approach.

The terms *emic* and *etic* are also used as an analogy between *inside observers*, called insiders and outside observers, called outsiders (CAMPOS, 2002). The etic approach concerns an interpretation of aspects of another culture using the categories of those who observe it, that is, of the researchers and investigators themselves. On the other hand, the emic approach seeks to understand a particular culture based on its own references. In other words, the etic approach is the external view, of observers and researchers who are looking from the outside, with a transcultural, comparative and descriptive perspective, while the emic approach is the internal view, of the observed who are looking from within, with a particular, unique and analytical attitude. So, the etic approach corresponds to the vision of the self toward the other, while the emic approach corresponds to the vision of the self toward ours.

In our view, the etic approach is inevitable and necessary. However, it is extremely important that a given culture is first observed with the emic approach, which seeks to understand how the members of such cultural group understand their own cultural expressions. However, unlike the etic approach, the emic one is not automatic, inevitable and implicit. Rather, we must strive to use it, because it is equivalent to seeing the world through the eyes of others. Table 1 shows the differences between the emic and etic approaches.

Table 1 – Differences between emic and etic approaches

Emic approach	Etic approach
Perspective of the natives (internal)	Perspective of the observers (external)
Local vision (internal)	Global vision (external)
Prescriptive translation	Descriptive translation
Cultural	Analytical
Mental structures	Behavioral structures
Cultural transcription	Academic transcription

With regard to scientific knowledge, the lack of understanding of a certain mathematical phenomenon from an emic perspective favors the determination of conceptualizations based only on traditional mathematics. In this sense, the presentation of mathematical practices is relevant only if etic conclusions are reached after we acquire a relevant emic understanding of such practices.

In this perspective, researchers, investigators and educators who take an emic approach believe that factors such as cultural and linguistic background, social values, morals and lifestyles influence the development of mathematical knowledge which is triggered in the cultural context itself. Thus, Rosa (2010) states that different cultural groups have developed different ways of *doing* mathematics so that they could understand and comprehend the cultural, social, political, economic and natural environments in which they live. Furthermore, each culture group has developed unique and distinct ways to mathematize their own reality (D'AMBROSIO, 1990).

In this context, mathematization is the process through which members of different cultural groups use distinct mathematical tools which can help them organize, analyze, comprehend, understand, model and solve specific problem situations that are faced in everyday life (ROSA ; OREY, 2006). These tools allow the identification and description of mathematical practices which are specific to a cultural context and which are intended to help cultural group members discover relationships and regularities, schematize, formulate and visualize problem situations in different ways, transferring them from the real world to academic mathematical concepts through mathematization.

Therefore, it is extremely important to search for an alternative methodological approach that aims to record the mathematical practices present in different cultural contexts. According to Rosa & Orey (2010a), this methodological approach is called *ethnomodeling* because it can be considered a practical application of ethnomathematics, which adds a cultural perspective to the concepts of modeling.

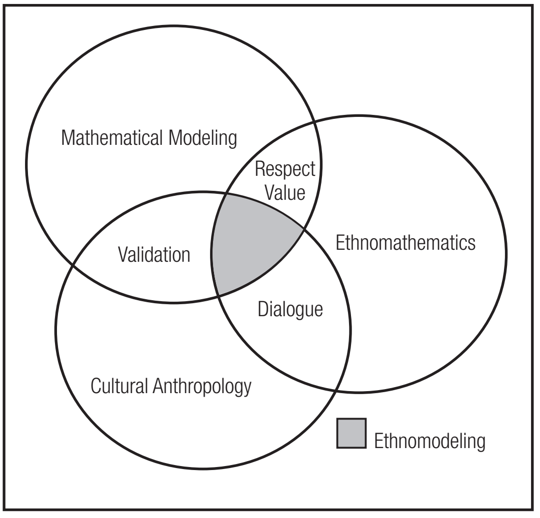
Ethnomodeling

Studies conducted by Ascher (2002), Gerdes (1991), Orey (2000), Rosa & Orey (2009) and Urton (1997) reveal sophisticated mathematical practices that include geometric principles in crafts, architectural concepts and practices developed in the activities of production of artifacts by members of different cultural groups. Eglash et al. (2006) argue that these procedures are related to the numerical relations found in calculation, measurement, in games, navigation, astronomy and modeling.

From this perspective, Rosa & Orey (2010a) argue that ethnomodeling can be considered the study of the mathematical practices developed by members of distinct cultural groups through modeling. So, the procedures of ethnomodeling involve mathematical practices developed and used in several problem situations faced by the members of these groups in their daily lives. According to Caldeira (2007), ethnomodeling considers the knowledge gained from the mathematical practices used in the cultural group or in the community. In this sense, there is a need to understand that the mathematical knowledge originates in social practices, which are rooted in cultural relations. D'Ambrosio (1993) and Rosa & Orey (2003) argue that this viewpoint allows the exploration of different mathematical practices through the appreciation and respect for the knowledge acquired when individuals interact with their own environment.

According to Rosa & Orey (2010a), ethnomodeling can be considered the region of intersection between cultural anthropology, ethnomathematics and mathematical modeling. Figure 1 shows ethnomodeling as the intersection between these three fields of research.

Figure 1 – Ethnomodeling as the intersection between these three fields of research



Therefore, in ethnomathematics, the emic consists of logical-empirical systems considered appropriate for the members of cultural groups. In modeling, the etic consists of tools that are used to obtain data on the local mathematical practices observed. Eglash et al. (2006) state that "cultural anthropology has always depended on acts of 'translation' between emic and etic perspectives" (p. 347). Thus, the interrelationship between these three areas of research triggers the ethnomodeling development process. However, this process is positive only when the knowledge systems of cultural groups are idealized by the view of researchers, investigators and educators, and only if students are free from antiquated modes and dominant ways of thinking mathematically.

When an ethnomathematical system is actively used in the present as a system based on a theory that can solve problems drawn from reality, this process can be described as ethnomodeling (ROSA; OREY, 2010b). In this context, ethnomathematics emphasizes the knowledge acquired in communities (emic), while ethnomodeling tends to connect academic mathematics (etic) to this context. Such perspective evidences that mathematics is a cultural enterprise rooted in tradition because each cultural group has developed a system of techniques to understand and deal with reality mathematically through measurement, quantification, comparison, classification, inference and modeling. These techniques can be regarded as the basic tools used by ethnomodeling for the translation between emic and etic approaches.

However, according to Eglash et al. (2006) we should be cautious, since indigenous designs are often analyzed simply from a Western view (etic); for example, the application of crystallography symmetrical classifications to textile patterns of indigenous fabrics. The authors also argue that, in some cases, the translation of a local mathematical practice into symbolic mathematical language is direct and simple; for example, the modeling of counting systems and calendars.

On the other hand, there are cases in which the procedures used in local mathematical practices are incorporated emically, such as the iteration used in craft work with beads in some African regions and the Eulerian paths used in Sona sand drawings in Angola and Mozambique (EGLASH et al., 2006). Accordingly, we believe that the act of translation used in these mathematical practices stems from emic knowledge and not from etic knowledge.

Thus, it is impossible to imprison mathematical concepts in records of a single name of reality, because there are different systems which use multiple representations of such reality (CRAIG, 1998). Therefore, mathematics has not been designed as a universal language because its principles, concepts, and fundamentals have been developed in different ways by members of distinct cultural groups (ROSA, 2010). We agree with Rosa & Orey (2006), who argue that the procedures used in mathematical practices are developed according to the register of interpretive singularities of the possibilities of a symbolic construction of mathematical knowledge, which is necessary for the resolution of problem situations faced in the daily lives of different cultural groups.

Ethnomodels

Generally, a model can be considered a representation of an idea, concept, object or phenomenon (BASSANEZI, 2002). Ethnomodels can be understood as cultural artifacts, which are pedagogical tools used to facilitate the understanding and comprehension of systems taken from the reality of distinct cultural groups (ROSA; OREY, 2009). In this sense, ethnomodels are accurate external representations consistent with scientific knowledge, which is socially constructed and shared by the members of specific cultural groups. According to this perspective, the primary objective for developing ethnomodels is to translate the procedures involved in the mathematical practices present in the systems drawn from reality, which are symbolic systems organized by the internal logic of the members of these cultural groups.

However, Eglash et al. (2006) and Rosa & Orey (2010b) argue that the models that are constructed without a meaning for the reality to be modeled should be viewed with suspicion. So, there is a need for researchers, investigators and educators not be deceived by their own ideology, so that they can understand the different points of view of the knowledge of mathematical practices of the system being modeled. Therefore, it is highly important to avoid the allusion to the emic to impose our etic model on a given mathematical practice. Thus, it is important that researchers, investigators and educators are able to inform *outsiders* (etic) about what really matters to *insiders* (emic).

The emic and etic constructs of ethnomodeling

In the perspective of ethnomodeling, emic constructs are descriptions and analyses expressed in terms of conceptual schemes that are meaningful and which have been appropriated by members of the cultural group under study (LETT, 1996). Thus, an emic construct is consistent with the perceptions and understandings deemed appropriate by the culture of the internal observers (*insiders*). The validation of emic knowledge is related to the consensus of the local population, who should agree that these constructs coincide with the common perception and depict the characteristics of the group's culture (LETT, 1996). In other words, the emic approach investigates mathematical phenomena, their structures and interrelationships through the understanding of the development of knowledge about the mathematical practices acquired by the members of a particular cultural group. According to Viertler (2002), emic data, representing the views of those surveyed, can be obtained by techniques such as interviews, participant observation and life history. Lett (1996) states that the emic knowledge of mathematical practices can be obtained through elucidation or observation, since it is possible that external observers can infer mathematical perceptions used in these practices.

On the other hand, Lett (1996) argues that etic constructs are regarded as descriptions and analyses of mathematical practices expressed in terms of conceptual schemes and categories considered meaningful and appropriate to the community of scientific observers, researchers and investigators. An etic construct is precise, logical, comprehensive, repeatable, falsifiable and independent of researchers and observers. The validation of etic knowledge is obtained by means of logical and empirical analysis. For Viertler (2002), etic data, which evidence the concepts and theories of researchers and investigators, are often obtained through questionnaires. According to Lett (1996), etic knowledge can also be obtained by elucidation and observation, because it is possible that members of a particular cultural group have scientifically valid knowledge. In this sense, D'Ambrosio (1990) states that investigators must recognize that local people develop scientific knowledge used in mathematical practices which is validated in their own socio-cultural practices.

The emic-etic dilemma in ethnomodeling

Emic and etic approaches were first introduced by linguist Pike (1954), who was inspired by an analogy between two linguistic approaches:

> 1) *Phonemic*: system of organization of sounds used in a given language and which are locally significant. The study of the phonemic approach involves examining the sound used in a particular language.
>
> 2) *Phonetic*: general aspects of all possible sounds produced in a given language. The phonetic approach aims to generalize considering phonemic studies of a specific language, trying to develop a universal science that encompasses the sounds produced in all languages.

Such concepts have reached the anthropological academy, becoming key elements for the cultural analysis of the data collected in research and investigations.

In this context, we have made an analogy regarding ethnomodeling on which it is possible to assert that its emic approach studies the internally developed and locally significant mathematical practices. We also argue that *emic ethnomodels* are based on features that are important for the systems taken from the reality of individuals belonging to distinct cultural groups. On the other hand, there are *etic ethnomodels*, developed in accordance with the view of outside observers of the systems drawn from the reality of the individuals whose mathematical practices are being modeled.

Etic ethnomodels represent the way modelers imagine that the systems taken from this reality work, whereas emic ethnomodels represent how individuals who live in these cultural groups perceive the use of these systems in their own reality. Importantly, the etic approach plays an important role in research on ethnomodeling but the emic approach should also be considered in this process. From this perspective, the focus of the analysis is etic if the mathematical practices can be compared between cultural groups with the use of common procedures and definitions. On the other hand, the focus of the analysis is emic if mathematical practices are developed exclusively by the members of a certain cultural group, because this way such practices will be rooted in the different ways in which they can be performed in a specific cultural environment. So, the logic of the emic-etic dilemma is grounded on the argument that the understanding of the complexity of the mathematical phenomena can only be established in the context of the cultural group in which these phenomena occur.

The dialectical approach to ethnomodeling

Currently, the debate between the emic and etic aspects is one of the most intriguing research themes in ethnomodeling, because it is important to deal with issues such as:

> 1) Are there mathematical patterns that are identifiable and / or similar in different cultural groups?
> 2) Is it better to concentrate on mathematical patterns that derive from the cultural groups under investigation?

While the etic and emic approaches are often considered in a conflicting dichotomy, Berry (1999) emphasizes that Pike (1954) originally conceived them as complementary viewpoints. According to this reasoning, instead of representing a dilemma, the use of both approaches deepens our understanding of important issues in scientific research and ethnomodeling research. Berry (1990) suggests that, to deal with such dilemma, it is necessary to use a combination of emic and etic approaches, and not just use the emic or etic dimension of the knowledge of mathematical practices present in cultural groups. However, the combination of both approaches first requires researchers and investigators to perceive the emic knowledge of the cultural groups studied. According to Berry (1990), this allows these professionals to give up their own prejudices and become familiar with the cultural differences that are relevant to each cultural group.

In research on ethnomodeling, the emic analysis focuses on a single culture, employing qualitative and prescriptive methods for the study of a mathematical practice of etic concern. Thus, the focus of this action is to study the internal context of the cultural group, in which researchers and investigators develop the research criteria in relation to the internal characteristics and logic of the knowledge system developed by the group. From this perspective, meaning is acquired in relation to the context and, therefore, it is not easily transferable to other cultural contextualizations.

For example, researchers do not intend to compare the mathematical patterns observed in a certain environment with standards developed in other cultural environments. This means that the primary purpose of an emic approach is a descriptive and idiographic orientation of mathematical phenomena, because it emphasizes the uniqueness of each mathematical practice developed in these groups. Thus, if researchers wish to highlight the meanings of these generalizations in an emic way, there is a need to refer more precisely to more specific mathematical events. In contrast, a comparative analysis is etic when, in the examination of distinct cultural mathematical practices, standard methods of research are used (LETT, 1996). In this sense, the etic approach seeks to identify the relationships and causal explanations that are valid in different cultural contexts. Thus, if researchers and investigators wish to develop statements about the universal or etic aspects of mathematical knowledge, these statements must be written in an abstract manner.

On the other hand, Pike (1954) states that the etic approach can be a way for us to reach the emic approach of the mathematical practices developed in cultural groups. Thus, the etic approach can be useful for us to penetrate, discover and elucidate the emic systems developed in these groups. Then, given that the traditional concepts of emic and etic approaches are important for us to understand and comprehend the cultural influences on mathematical models, we propose a differentiated approach to research on ethnomathematics and modeling through ethnomodeling. Martin and Nakayama (2007) call this approach *dialectical*. According to Alvarez-Pereyre and Arom (1993), Pike (1954) originally worked with a dialectic relation in which the interdependencies, intercrossing and complementarities between these two approaches could be evidenced, because in that case the emic is part of the etic and the etic is part of the emic.

In this approach, the etic claims of mathematical practices developed in any cultural group do not take precedence over their emic claims. According to this view, Eglash et al. (2006) argue that it is necessary to depend upon the “acts of ‘translation’ between the emic and etic approaches” (p. 347). In other words, cultural specificity can be better understood if grounded in the communality and universality of theories and methods, because to achieve a scientific character the procedures used in mathematical practices must be verified or refuted according to methods which are independent of the subjectivity of researchers and investigators. So, it is important to analyze the perceptions that have been acquired through subjective and culturally contextualized methods. In the dialectical approach, researchers may be both domestic observers (*insiders*) and outside observers (*outsiders*) of a particular cultural context.

The dialectical ethnomodel of the Sioux Tipi hut

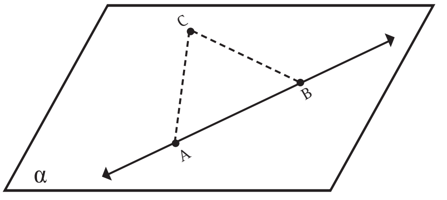
Orey (2000) states that the "[flat and] spatial geometry is inherent in the format of Tipi[1], which was used to symbolize the universe in which the peoples from the plains lived" (p. 241). Figure 2 shows the Tipi huts.

Figure 2 - Watercolour on paper of the Sioux Tipi hut, painted by Karl Bodmer in 1833 during his trip in the United States (1832-1834)

As stated by this author, for the natives of the Sioux nation to stand the harsh reality of life on the plains, they needed to use a tripod foundation to build the Tipi hut, because it offers more resistance to the base than a quadripedal foundation. Laubin and Laubin (1989) claim that most residents of Tipi huts were able to realize that the tripod foundation is the best defense against the strong winds prevalent in the open prairies of North America. According to these authors, there is historical evidence that the tripod foundation is the most common one in areas that have fewer natural obstacles and are thus more prone to wind action. Furthermore, for the Tipi hut to have better stability, the tripod foundation needs to have the approximate shape of an equilateral triangle.

In this context, an etic ethnomodel may explain why a tripod foundation is more flexible and resilient than a quadripedal foundation. Thus, let us consider three non-collinear points called *A*, *B* and *C*. There is an infinite number of planes passing through the points A and B and containing the line *AB*. However, only one of these plans also passes through point C. Therefore, we can say that three collinear points determine a plan and that a plan can also be determined by a straight line and a point outside this line. Figure 3 illustrates the case described.

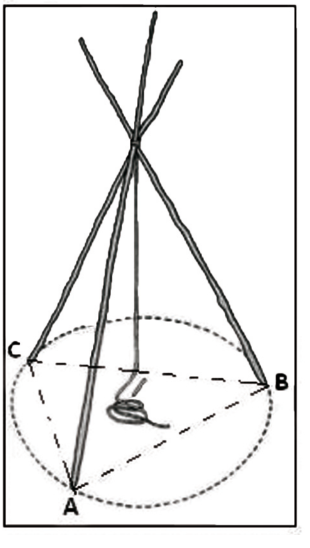
Figure 3 – Determination of a plan



Geometrically, this fact can be explained using the plane assumption, which states that, given any three non-collinear points, there is a single plane on which those three points are located.

Regarding the construction of the Tipi hut, this information can be determined mathematically. Figure 4 shows the construction of the Tipi hut.

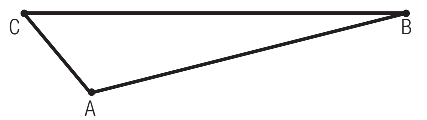
Figure 4 – Construction of theTipi hut



1- According to Orey (2000), in the Sioux language, the word Tipi refers to a conical tent used by the indigenous peoples of the open prairies of North America.

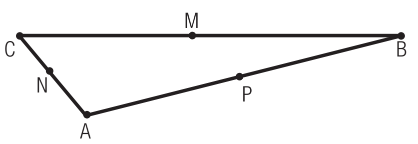
The base of the Tipi hut is formed by the tripod foundation determined by triangle *ABC*. Figure 5 shows the tripod base of the Tipi hut.

Figure 5 - Tripod base determined by the triangle *ABC*



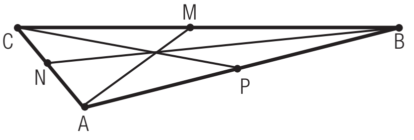
The midpoints of the sides of the triangle *ABC* are the points *M*, *N* and *P*. Figure 6 shows the midpoints of the sides of the triangle *ABC*.

Figure 6 – Midpoints of the sides of triangle *ABC*



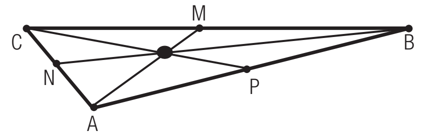
It is possible to connect each vertex of the triangle *ABC* to the midpoint of each of its opposite sides to obtain the line segments *AM*, *BN* and *CP*. These line segments form the three medians of the triangle *ABC*, which are the line segments that connect the midpoint of each side of the triangle to its opposite vertex. Figure 7 shows the three medians of triangle *ABC*.

Figure 7 – Three medians of triangle *ABC*



The medians meet at a point called *centroid* (OREY, 2000). Archimedes showed that the medians of a triangle are located in their balance point or center of gravity called *barycenter* of the triangle. Figure 8 shows the centroid or the barycenter of triangle *ABC*.

Figure 8 – Centroid or barycenter of triangle *ABC*



It is important to emphasize that the Sioux use this place, *centroid*, to kindle the fire to heat the interior of the hut and to cook. At that place, they also build a sacred altar to burn incense during prayers. In this sense, Orey (2000) argues that the "center of Tipi holds an ultimate and sanctified power" (p. 246). So the Sioux also determine the center of the Tipi base hut due to its holiness, and not just for reasons of necessity or aesthetics.

On the other hand, an emic ethnomodel can explain this problem situation. Throughout history, the nomadic peoples of the prairies have observed that the tripod foundation of the Tipi hut seems to be perfectly adapted to the harsh environment where the Sioux live (OREY, 2000). Thus, if we understand the distinction between the use of the tripod and the quadripedal base or foundation in this hut, we realize that these Indians have an understanding of geometry basic concepts, such as features and geometrical properties of the triangle, which shows the development of emic mathematical knowledge[2]. So we can infer that the Sioux Indians use the tripod base rather than a quadripedal base because this kind of base provides greater stability to its foundation.

Given this perspective, a quadripedal base will probably have only three of its legs supported, while the fourth leg can move a

2 - The term *emic mathematical knowledge* used in this text does not mean that we are calling the know-how of the Sioux according to the perspective of the researchers who are not immersed in the sociocultural context of this group. In our view, these indigenous use emic techniques and procedures that demonstrate mathematical practices shared and accepted by the cultural group. However, with the etic view that we have, we can argue that such techniques and procedures can be explained from the perspective of *outsiders* with respect to the academic knowledge called *mathematics*.

little above the ground. When this structure is tilted to the side of the leg that does not touch the ground, the other legs of the foundation can also arise and thus destabilize the Tipi hut. So the quadripedal foundation tends to sway or move while the Sioux are trying to protect themselves from the harsh weather conditions and high winds of the plains. This aspect makes the quadripedal foundation unfit for the stabilization of this hut. In such a context, the tripod base of the Tipi hut has the advantage of providing a stable structure for housing so that the Sioux can live peacefully in hostile environments.

The implicit procedures (emic knowledge) used in this mathematical practice have been transmitted to the members of the Sioux people through generations by the women in this cultural group, who are responsible for the construction and maintenance of housing. In this sense, D'Ambrosio (1993) states that mathematical practices are socially learned and historically transmitted from generation to generation between the members of cultural groups.

In this example, in the dialectical approach, the emic observation seeks to understand the mathematical practice to build the Tipi hut from the perspective of the internal cultural dynamics and relations of the Sioux people with the environment in which they live. On the other hand, the etic approach provides a cross-cultural contrast, employing comparative perspectives with the use of academic mathematical concepts. This approach aims to translate the procedures used in this mathematical practice for the understanding of those who have different cultural backgrounds, so that they can understand and explain the practice from the perspective of outside observers, that is, of *outsiders*. In our view, the emic approach may help clarify the intrinsic distinctions of cultural procedures, while the etic approach seeks to show the objectivity of external observations on these procedures.

Therefore, the etic approach concerns the characteristics of academic mathematics regardless of the culture studied, whereas the emic approach may be considered an attempt to discover and describe a system of emic knowledge of a particular culture in its own terms, identifying the units and structural classes of such culture. Ultimately, it is important that an emic description identifies the etic characters that are locally meaningful, because the more we know about the etic knowledge of a particular cultural group, the easier will its emic analysis be. In other words, it is necessary that the emic description, which is locally significant, should identify the academy's etic features because the etic knowledge can be considered an interpretation of the knowledge of a particular culture, and not an interpretation of the culture itself.

We agree with Pike's viewpoint (1996) according to which both approaches are essential for a better understanding of human behaviors, especially those related to the development of mathematical knowledge, because the dialectical approach is related to the stability of the relations between the emic and etic approaches.

The dialectical approach to the mathematics curriculum from the ethnomodeling perspective

The conjunction of mathematical knowledge of the members of cultural groups with the western system of mathematical knowledge can result in a dialectical approach to mathematical education. In a curriculum grounded in the perspective of ethnomodeling, the emic analysis of a mathematical phenomenon is based on the internal structural elements of the knowledge of a particular cultural group, whereas the etic analysis is based on certain general concepts that are external to the knowledge developed by the members of this cultural group (LOVELACE, 1984). The emic perspective provides internal perceptions and conceptions about mathematical practices, whereas the etic perspective provides a theoretical framework to determine the effects of culture on the development of these practices. In this perspective, the acquisition of mathematical knowledge may be based on the applications of a mathematics curriculum, which can be evaluated using various teaching methodologies developed in distinct cultural groups.

A dialectical approach to the school curriculum includes the recognition of other epistemologies and of the holistic and integrated nature of the mathematical knowledge of the members of the various cultural groups found in many schools. A curriculum based on the ethnomodeling perspective provides an ideological foundation for learning that uses the diverse cultural and linguistic elements of the members of different cultural groups in the pedagogical action for teaching mathematics (ROSA; OREY, 2010a). In this type of mathematics curriculum, it is essential to understand that an etic construction is a theoretical mathematical concept used in the academy and supposedly applied to all cultural groups. On the other hand, the emic construction is the one that is applied only to the members of specific cultural groups. This fact may signal the existence of a concern with cultural prejudices, likely to materialize if researchers assume that an emic construction is actually etic (EGLASH et al., 2006). In this sense, an academic mathematical practice is mistakenly imposed on the members of these cultural groups.

A school mathematics curriculum based on the ethnomathematics perspective combines local knowledge key elements with those of the academy in a dialectical approach, allowing students not only to manage the production of knowledge production and of systems of information drawn from reality itself, but also to apply that knowledge creatively in other situations. There is a need to opt for an integrative approach to the curriculum which, besides considering the emic approach, recognizes that we must also consider the etic data, since we commit to seeking a comprehensive and holistic understanding of cultural information (MARQUES, 2001). We believe it is necessary to reconcile the cognitivist emphasis with the adaptationist one, because they are able to combine the essential aspects of research on ethnomodeling into a single perspective in order to establish the connection between *corpus* and *praxis*.

In our view, ethnomodeling can be understood as part of critical mathematics education, because it is a learning process in which teachers encourage a critical analysis of multiple sources of knowledge in many different learning styles. In this approach, the knowledge gained is centered, located, oriented and based on the cultural profile of the students, since it aims to equip them to be productive citizens locally and globally. According to Rosa and Orey (2010b), ethnomodeling is the pedagogical approach required to achieve this goal.

Final thoughts

Currently, several systems of traditions and mathematical knowledge of different groups are at risk of extinction due to the rapid change in natural and cultural environments, and due to the rapid pace of economic, social, environmental and political changes on a global scale. Thus, many local mathematical practices may disappear because of the substitution of emic knowledge for the etic one, the invasion and the imposition of foreign technologies on the basis of globalized development concepts that promise short-term gains, or the proposition of solutions to problems faced by a certain cultural group regardless of their emic knowledge to solve such situations.

In this article, we offer an alternative research concept, which is the acquisition of emic and etic knowledge for implementing ethnomodeling. Emic knowledge is essential for an intuitive and empathic understanding of mathematical practices of a particular cultural group, and it is important to conduct ethnographic research, whereas etic knowledge is essential to compare cultural groups and it demands categories and standard units, which are the essential components of ethnology. We also offer a dialectical approach to research on ethnomodeling, which uses emic and etic knowledge through dialogical processes. Therefore, when we conduct research based on both approaches, we gain a more complete understanding of the knowledge of the mathematical practices developed by members of cultural groups. In this sense, emic knowledge is a valuable source of inspiration for the development of etic hypotheses.

Given this dialectical context, the mathematics curriculum based on the perspective of ethnomodeling provides an underlying philosophy for the generation of knowledge with and between subsystems of education in mathematics in order to ensure the balanced integration of the affective domain of educational objectives, which are essential for the recognition and for the use of pupils' emic knowledge. So, it is important to reinterpret the world, replan experimental situations, and see empathetically the individuals from diverse cultures to understand better their different viewpoints and to produce internal descriptions of mathematical knowledge. In summary, our goal is to absorb the viewpoint of *insiders* in order to understand their worldview.

Finally, we define ethnomodeling as the study of the mathematical phenomena that occur in a particular cultural group through modeling, because mathematical practices are socially constructed and culturally rooted.

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