DOI: doi.org/10.37781/vidya.v43i2.4606 VIDYA, v. 43, n. 2, p. 113-132, jul./dez., 2023 - Santa Maria, 2023. **ISSN** 2176-4603

INTERACTIONS BETWEEN SOCIOCULTURAL PERSPECTIVES OF MATHEMATICAL MODELLING AND ETHNOMATHEMATICS IN AN ETHNOMODELLING APPROACH[1]

INTERAÇÕES ENTRE AS PERSPECTIVAS SOCIOCULTURAIS DA MODELAGEM MATEMÁTICA E DA ETNOMATEMÁTICA EM UMA ABORDAGEM DE ETNOMODELAGEM

INTERACCIONES ENTRE LAS PERSPECTIVAS SOCIOCULTURALES DE LA MODELACIÓN MATEMÁTICA Y LAS ETNOMATEMÁTICAS EN UN ENFOQUE DE LA ETNOMADELACIÓN

MILTON ROSA[2]
DANIEL CLARK OREY[3]

ABSTRACT

Local (emic) knowledge interrelationships related to assorted school/academic knowledge areas are important to enable a more precise understanding about a particular field of study in relation to diverse forms of mathematics. These interrelations are addressed, especially wherever one needs to understand specific concepts acquired in school/academic knowledge broadly-based on mathematics, which may be supported by ethnomodelling. The main goal of this theoretical article is to further advance the development of important theoretical basis for ethnomodelling, which considers the polysemic interactions between sociocultural perspectives of mathematical modelling and ethnomathematics in an ethnomodelling approach. Thus, when students are encouraged to examine mathematical activities in their own sociocultural contexts, they can realize that mathematics procedure and practice are not trivial as they see them connected to their daily lives. The main contribution of this article is to develop awareness among students regarding analyzing the connection between both traditional and non-traditional learning settings through ethnomodelling.

Keywords: Ethnomathematics. Ethnomodelling. Interactions. Sociocultural Perspectives. Mathematical Modelling.

RESUMO

As inter-relações de saberes locais (êmicos) relacionadas com os diversos conhecimentos escolares/acadêmicos são importantes para possibilitar uma compreensão mais precisa sobre um determinado campo de estudo em relação às diversas formas de Matemática. Essas inter-relações são abordadas, principalmente, sempre que é necessário compreender os conceitos específicos adquiridos em conhecimentos escolares/acadêmicos amplamente fundamentados na Matemática, que podem ser apoiados pela Etnomodelagem. O principal objetivo deste artigo teórico é avançar no desenvolvimento de importantes bases teóricas para a Etnomodelagem, que considera as interações polissêmicas entre as perspectivas socioculturais de Modelagem Matemática e da Etnomatemática em uma abordagem de Etnomodelagem. Assim, quando os alunos são encorajados a examinar as atividades matemáticas em seus próprios contextos socioculturais, eles podem perceber que o procedimento e a prática matemática não são triviais, pois os veem conectados à sua vida diária. A principal contribuição deste artigo é conscientizar os alunos sobre a análise da conexão entre os ambientes de aprendizagem tradicionais e não tradicionais por meio da etnomodelagem.

Palavras-chave: *Etnomatemática. Etnomodelagem. Interações. Perspectivas Socioculturais. Modelagem Matemática.*

1 This article is based on investigations previously conducted by the authors on ethnomodelling, which is a new research field that has been developed beginning in Brazil and currently expanding internationally, in the area of mathematics education. Consequently, the similarity of this text with other academic productions published by the authors, as well as the self-citations in this manuscript, are justified by the lack of investigations in this field of study. Yet, this article contains innovative ideas, procedures, and techniques related to interactions between the cultural aspects of mathematics (ethnomathematics), the sociocultural perspective of mathematical modelling, and ethnomodelling.

2 Doutor em Educação, Liderança Educacional, pela California State University, Sacramento (CSUS). Professor da Universidade Federal de Ouro Preto. E-mail: milton.rosa@ufop.edu. Orcid: https://orcid.org/0000-0002-5190-3862.

3 Doutor em Educação, Currículo e Instrução na Formação Multicultural de Professores, University of New Mexico (UNM). Professor da Universidade Federal de Ouro Preto. E-mail: oreydc@ufop.edu. Orcid: https:// https://orcid.org/0000-0002-8567-034X.

RESUMEN

Las interrelaciones de los saberes locales (émicos) relacionados con los diversos conocimientos escolares/académicos son importantes para permitir una comprensión más precisa de un dado campo de estudio en relación con las diversas formas de Matemáticas. Estas interrelaciones se abordan, principalmente, siempre que sea necesario comprender los conceptos específicos adquiridos en conocimientos escolares/académicos basados en gran medida en las Matemáticas, que pueden ser apoyados por la Etnomodelación. El objetivo principal de este artículo teórico es avanzar en el desarrollo de bases teóricas importantes para la Etnomodelación, que considera las interacciones polisémicas entre las perspectivas socioculturales de la Modelación Matemática y de las Etnomatemáticas en un enfoque de la Etnomodelación. Por lo tanto, cuando se anima a los estudiantes a examinaren las actividades matemáticas en sus propios contextos socioculturales, ellos pueden darse cuenta de que el procedimiento y la práctica matemática no son triviales, ya que los ven conectados con su vida diaria. La principal contribución de este artículo es desarrollar una conciencia entre los estudiantes sobre el análisis de la conexión entre los entornos de aprendizaje tradicionales y no tradicionales a través de la etnomodelación.

Palabras-clave: *Etnomatemáticas. Etnomodelación. Interacciones. Perspectivas socioculturales. Modelación Matematica.*

INITIAL CONSIDERATIONS

There are hundreds of reasons for the teaching and learning of mathematics in the schools. One of the most relevant reasons involves the consideration of mathematics as an overall expression of human development and culture. In this regard, mathematics may be considered as an integral part of the greater cultural heritage of humankind. What this heritage consists of is equally dependent upon time, contexts, and places (D'AMBROSIO, 1990).

For all these reasons, members of distinct cultural groups have developed their own way to mathematize their own realities. Western scientific arrogance often exhibits an overt disrespect of and outright refusal to acknowledge cultural identities by some researchers, scientists, and mathematicians (ROSA, 2010). This approach puts all processes of understanding and comprehension of many non-Western cultural systems at risk of losing their own cultural identity and/or disappearing (D'AMBROSIO, 1985).

According to D'Ambrosio (1993), the use of modelling as an educational measure for an ethnomathematics program provides earlier values knowledge and traditions, developing students' ability to judge and translate mathematical processes for developing models in diverse contexts. Therefore, it is necessary to start with the social context, reality, and interests of the students rather than informing several mathematical curriculum activities and values with no context or meaning to the students.

This holistic environment helps to analyze reality as a whole that allows students to engage in modelling processes that allow for a study of *systems*[4] present in their own reality in which there is an equal effort to create an understanding of all aspects and components of the studied system - This may as well include interrelationships among them (D'AMBROSIO, 1990).

Contexts such as these reveal sophisticated mathematical ideas and procedures that include, for instance, the geometric principles in craftwork, architectural designs, and the traditional (mathematical) practices encountered in activities and artifacts developed by members of distinct cultures (EGLASH, BENNETT, O'DONNELL, JENNINGS; CINTORINO, 2006).

4 D'Ambrosio (1993) defined a system as a part of reality, which is considered integrally because students can analyze a given problem or phenomenon in order to take a position and make decision regarding to their sociocultural, political, environmental, and economical in relation to the system under study.

Hence, ethnomodelling is considered as the pedagogical approach that respects a diversity of cultural forms of mathematics, which is a process of *translation*[5] and elaboration of problems and questions that are part of the reality of members of distinct cultural groups (ROSA; OREY, 2017). Similarly, Desai and Safi (2023) affirm that ethnomodelling respects individual and collective community experiences and offers educational experiences that acknowledge and celebrate the multidimensional aspects related to the identity of members of distinct cultures.

In this context, Bassanezi (2002) introduced the term *ethno/modelling* by arguing that mathematical ideas, procedures, and practices used in the daily life offers alternative interpretations of reality. This kind of cultural perspective is used in problem solving methods, numerous conceptual categories, structures and models that are developed and used to represent and manipulate data to translate forms of cultural mathematical practices, specifically, related to the modelling process.

Ethnomodelling is the process of elaboration of problems and questions that grew out of practical contexts and form an image or sense of idealized versions of *mathema*, which are composed of actions that helps to explain and understand daily phenomena so that members of distinct cultural groups to survive and transcend (ROSA; OREY, 2010).

The focus of this perspective constitutes a critical analysis of knowledge generation and production (creativity), which enables the development of discussions related to the social mechanisms of the institutionalization of knowledge (academics) and its diffusion through generations, as well as its transmission in educational systems (education) (ROSA; OREY, 2010).

The process of ethnomodelling is a valuable pedagogical approach suitable for an ethnomathematics program because it contextualizes mathematical knowledge developed locally. Thus, ethnomodelling is the study of the mathematical phenomena that occurs in diverse cultural contexts. These phenomena form socially-rooted constructs that include cultural aspects of mathematical knowledge in the modelling process (ROSA; OREY, 2013).

It also presents a set of educational opportunities developed through the modelling process conducted in sociocultural contexts. Such contexts allow for critical exploration of local mathematical knowledge by appreciating and respecting cultural values developed by members of distinct cultural groups. This stance indicates that mathematical knowledge is inherent to the reality of these members. This knowledge establishes itself as a tool for decision-making processes regarding their unique perspective and reality (ROSA; OREY, 2013).

Interactions between sociocultural perspectives of modelling and ethnomathematics in an ethnomodelling approach may help students to remove and/or reduce a sense of social apathy towards mathematics by working with curricular activities based on sociocultural contexts. Thus, it is necessary that teachers and educators be supported to include sociocultural aspects of mathematics in order to value and respect students' learning and cultural diversity as a guide to improve their mathematical knowledge through a sense of dialogue.

In this context, the main goal of this theoretical article is to further advance the development of an important theoretical basis for ethnomodelling, which considers the polysemic interactions between sociocultural perspectives of mathematical modelling and ethnomathematics in a dialogical approach. Thus, when students are encouraged to examine mathematical activities in their own

5 Rosa and Orey (2017) use the term translation to describe the process of modelling local (emic) cultural systems, which may have connections to other mathematical knowledge systems, such as school (etic) mathematical representations. These translations are addressed in order for the members of distinct cultural groups to understand specific concepts acquired in the school through the disciplines of ethnobiology, ethnoecology, ethnomedicine and, especially, ethnomathematics and mathematical modelling trough ethnomodelling.

sociocultural contexts, they realize that mathematical ideas, procedures, techniques, and practices are not trivial as they see them connected to their daily lives.

ETHNOMATHEMATICS AS THE CULTURAL ASPECTS OF MATHEMATICS

Ethnomathematics was introduced by the Brazilian educator and mathematician Ubiratan D' Ambrosio in the 1970s. Ethnomathematics uses the etymology of three Greek roots: *ethno*, *mathema*, and *tics* (ROSA; OREY, 2014). It is a program that incorporates mathematical ideas and procedures practiced by the members of distinct cultural groups, which are identified not only as indigenous societies but as groups of workers, professional classes, and groups of children of a certain age as well (AMBROSIO, 1985).

In other words, *ethno* refers to members of a specific group within a cultural environment identified by their cultural traditions, codes, symbols, behaviors, myths, and specific ways used to reason and to infer. *Mathema* means to explain and understand the world to transcend, manage, and cope with reality so that members of the cultural groups can survive and thrive in their daily endeavors and *tics* refers to techniques, procedures, and strategies such as counting, ordering, sorting, measuring, weighing, ciphering, classifying, inferring, and modelling (D'AMBROSIO, 1999).

Ethnomathematics researchers investigate ways in which members of distinct cultural groups comprehend, articulate, and apply ideas, procedures, and techniques identified as mathematical practices. In this regard, Rosa and Orey (2008) affirmed that ethnomathematics uses cultural experiences as vehicles to enable learning to become more meaningful and to provide students with insight in relation to mathematical knowledge as embedded in their social and cultural environments.

Ethnomathematics empowers students intellectually, socially, emotionally, and politically. It does this by using sociocultural and historical contexts to convey knowledge, impart academic skills, which can change student attitudes towards academic instruction (ROSA; OREY, 2011).

According to Barton (1996), ethnomathematics embraces the mathematical ideas, thoughts, concepts, procedures, and practices as developed by the members of all cultures. From this perspective, a body of anthropological research has come to focus on both the intuitive mathematical thinking and the cognitive processes largely developed in distinct cultural groups.

Following the above definition, Ethnomathematics may also be considered as a program that seeks to study how people have come to understand, comprehend, articulate, process, and ultimately use mathematical ideas, concepts, procedures, and practices used to solve problems related to their daily activities. The ethnomathematics program and its pedagogical action of teaching and learning mathematics is built on student *tacit knowledge*[6], background, the role his environment plays in terms of content, methods, and his past and present experience of his immediate environment (ROSA, 2010).

The arguments often given for using ethnomathematics-based examples in classrooms are: (a) to show students of underrepresented cultures that their own cultures do contribute to mathematical thinking and (b) to expose students of majority cultures in diverse cultures from around the world, building respect for others and generally contributing to global education. These are certainly laudable goals, occasionally, however, ethnomathematicians have expressed concern that too

6Tacit knowledge is the unwritten, unspoken, and hidden knowledge held by members of distinct cultural groups, which is based on their emotions, experiences, insights, intuition, observations, and internalized information developed through the resolution of phenomena they face in their daily life. It is integral to the development of the consciousness of these members because it is acquired through association with members of other cultural groups and requires joint or shared activities to be imparted from one to another. It constitutes a set of informally developed knowledge and forms the underlying framework that makes explicit knowledge possible (POLANYI, 1966).

often Western field research tends to seek the *others* to the extent of exploiting indigenous cultures (ROSA; OREY, 2016).

In this context, Gavarrete (2014) states that one possible way to avoid this problem and, notably, bring the goals of ethnomathematics even more directly to students, is to encourage students to develop ethnomathematical studies of their own individual cultures, heritage, and personal interests. Therefore, in accordance with Shirley (2015), if students make presentations to each other, they can learn something about the other cultures represented in their classrooms.

In this context, when mathematical knowledge is perceived as an aspect of an ethnomathematics perspective, teachers build from informal forms of mathematics and direct the lesson toward their own culture and experiences while developing critical thinking skills. This environment enables us to reflect on the nature of mathematics, culture, education, and society and the relationships among them to include pedagogical practices in the teaching and learning of mathematics that address deeper notions of equality and equity (GAVARRETE, 2014).

Examples can come from family traditions, hobbies, religions, and occupations; geography-based activities; celebrations of holidays and life events; personal interests such as sports, music, art, dance, or crafts; and even child-related activities, from playground games to computer games to skateboarding, jumping rope, and birthday parties. All bring the students' attention to culture and alternative ways of doing and can show applications of mathematics in context (GAVARRETE, 2014).

It is necessary that teachers emphasize connections between mathematics and other curricular disciplines and consider students' cultural backgrounds in designing and selecting mathematical activities. Students learn in ways characterized by a diversity of social and affective approaches, in harmony with the community, holistic perspectives, field dependence, expressive creativity, and non-verbal communication (ROSA, 2010).

This context enables the evolution of ethnomathematics as a research field in which one of the main goals is to link local (emic) knowledge to mathematics curriculum (global, etic) by applying innovative approaches to mathematics through dialogue (glocal, cultural dynamism) (ROSA; OREY, 2017).

The interrelated innovative approaches in ethnomathematics programs, such as their relation to social justice, civil rights, indigenous education, professional contexts, game playing, urban and rural contexts, ethnotransdisciplinarity, ethnopedology, ethnomethodology, ethnomodelling, ethnocomputing, and the sociocultural perspective of modelling (ROSA; OREY, 2017) all form important aspects worthy of discussion and exploration.

It is important to emphasize that investigations conducted in ethnomathematics pedagogy study supply cultural congruence between the backgrounds of students, communities, and schools, which in turn form one of the main principles of an ethnomathematics program (HART, 2003). An important characteristic of ethnomathematics is the transformational power it helps in rethinking the nature of mathematics.

This means that one possible purpose for ethnomathematical studies and their innovative approaches could be to foster the development or transformation of mathematics (D'AMBROSIO, 1993). Therefore, mathematical instruction needs to accommodate continuous and ongoing changes in students' demographics in mathematics classrooms around the world. Since ethnomathematics proposes that educators contextualize their mathematics teaching and learning by relating mathematical content to the sociocultural experiences of their students (ROSA, 2010).

Hence, the integration of the sociocultural perspective of modelling and ethnomathematics into existing teacher education programs. In this perspective, students succeed in mathematics when their understanding of it is linked to real and meaningful cultural referents and when instruction assumes that all students are capable of mastering mathematics (LADSON-BILLINGS, 1995).

Ethnomathematics presents possibilities for educational initiatives and new curriculum objectives based on pedagogical action in ethnomathematics. However, one dilemma regarding this issue is how to both prepare and support educators to create activities based on ethnomathematics (GREER, 2013). One important approach is to solve this dilemma and to focus on the promotion and dissemination aspects of local (emic), cultural, and mathematical knowledge that helps students to strengthen their own cultural identities in school environments (GAVARRETE, 2014).

In this regard, Rosa and Orey (2008) affirmed that ethnomathematics uses cultural experiences as vehicles to make mathematics learning more meaningful and to provide students with the insights of mathematical knowledge as embedded in their social and cultural environments.

In accordance with D'Ambrosio (2001), it enhances creativity, reinforces cultural self-respect, and offers a broader view of mankind. In everyday life, it is a system of knowledge that offers the possibility of more favorable and harmonious relations between humanity and nature. In this approach, ethnomathematics aims at drawing from cultural experiences and practices of the individual learners, the communities, and the society at large.

Ethnomathematics uses cultural experiences as vehicles to make mathematics learning more meaningful and to provide students with the insight of mathematical knowledge as embedded in their social and cultural environments (ROSA; OREY, 2011). It presents mathematical concepts found in the school curriculum in such a way that is related to students' cultural and daily experiences, whereby enhancing meaningful connections and deepening understanding in mathematics and how it connects to outside of academic environments.

Ethnomathematics, in contrast to colonialized forms of academic-western sciences, helps to develop learner's intellectual, social, emotional, and political learning by using their own unique cultural reference to impart the learning process. Mathematics as part of the school curriculum must reinforce and value the cultural knowledge of students rather than ignore or negate it. Every culture has its own way of mathematizing concepts which are part of its inheritance and the result of the struggle for its survival (D'AMBROSIO, 1990).

Consequently, the overall goal of this curriculum is to empower students through learning activities that help them develop literacy, numeracy, with a diversity of technological, social, and political skills for them to be active participants in a democratic society. One way to construct links between ethnomathematics and the experiences of learners and educators is through the development of a sociocultural perspective of mathematical modelling.

SOCIOCULTURAL PERSPECTIVE OF MATHEMATICAL MODELLING

Mathematical modelling constitutes one of the most important research trends for the development of teaching and learning processes in mathematics. In this regard, it is important to point out that this pedagogical action is directed to the resolution of everyday problems and situations, with the energy focused on observing and documenting how diverse peoples do this. With the use of modelling, can begin to understand the connection between mathematics and the daily experiences lived by members of distinct cultural groups (ROSA, 2000).

In this context, Bassanezi (2002) states that mathematical modelling is the art of transforming reality problems into mathematical problems and solving them by interpreting their solutions in the language of the real world. In this regard, Rosa (2010) affirms that modelling techniques can provide opportunities for the contextualization of academic school/mathematics.

According to Rosa and Orey (2017) state that modelling does this by providing the necessary conditions for the development of pedagogical actions through the elaboration of mathematical models that people construct about their own reality. This is so that the members of diverse cultural groups can act satisfactorily in a *glocalized society*[7] and avoid any overt acts of colonialization.

According to this assertion, mathematical modelling presupposes the use of multidisciplinary approaches. This occurs when the modelers share how they do and use the mathematics and demonstrate confluences with other trends in mathematics education. Ethnomathematics, supports the removal of boundaries between the various areas of research (BASSANEZI, 2002).

Thus, there is a need to consider mathematics education as a scientific field directed towards the teaching and learning process in mathematics through its resignification, which enables, through the voice of those who share their own understanding and perceptions in the development of this pedagogical action (ROSA, 2010).

Similarly, ethnomodelling relates the concepts of ethnomathematics with mathematical modelling (ROSA; OREY, 2010). For example, Caldeira (2007) explains that it is important to apply the assumptions of mathematical modelling as a means to achieve the proposed objectives for the conduction of this pedagogical action through its complementarity with ethnomathematics, which is necessary to consider mathematics constructed and signified in the cultural practices developed by the members of local communities, as well as the influences of these meanings in the pedagogical process.

Historically, models originating in the reality of members of distinct cultural groups can be considered as pedagogical tools that are used for the abstraction of mathematical concepts, because member of distinct cultural groups develop its own set of ideas and mathematical concepts, among which some basic tools that are used in the development of the modelling process stand (ROSA; OREY, 2017).

These tools can be understood as the ways that members of distinct cultural groups develop procedures, techniques, and strategies to deal with their own realities to mathematize and model their world through sharing how they might use forms of measurement, comparison, quantification, classification, and inference, to understand phenome present in their realities (ROSA; OREY, 2021).

According to this context, it is important to challenge and strengthen existing theoretical models by critically looking at both assumptions of mathematical universality and their claims of descriptive, predictive, and explanatory adequacy. For example, Stillman and Brown (2019) state that:

> Mathematical modelling plays an important role within social-critical research of mathematics education as a result of the relationship to the real world. The socio-critical perspective accounts for all participants' situations and backgrounds and aims to position learners as independent decision-makers and critical users of information (p. 237).

From the perspective of Cortes (2017), this context allows for the exploration of ideas, procedures, techniques, and local mathematical practices, which aim towards developing a sense of value

7 Glocalized societies enable the development of active, interactional, and dialogical processes in which requires an ongoing negotiation between the local and the global mathematical, scientific, technological, and engineering knowledge through a cultural dynamism. The complexities of a glocalized society require members of distinct cultural groups to be equipped with a new set of core knowledge and abilities that enables them to solve problems as well to gather and evaluate evidence that empowers them to make sense of information gained and accumulated from diverse media sources in order to develop decision making processes (OREY; ROSA, 2021, p. 212).

and respect of the diverse *cultural traits*[8] and the knowledge acquired by students through their own experiences in society.

Therefore, modelling is an important tool to help students to explain to others as the come to understand, comprehend, analyze, and reflect on their own sociocultural context. Being proficient in the use of modelling is of fundamental importance so that educators and learners, through their own actions, modify their own reality so that they can be included in the process of social transformation in a critical and reflective way (ROSA; OREY, 2014).

For example, Rosa and Orey (2008) state that, through the sociocultural perspective of modelling, it is possible to show how key aspects of this process is to help students realize their mathematical potential through the recognition of the importance of culture for the appreciation of their own identity because this aspect influences the way they think, learn, reflect, infer, and takes informed decisions. Thus, Rosa and Orey (2012) state that mathematical modelling is a learning environment that facilitates the construction and transfer of knowledge through the use of their mathematical knowledge: a) explicit[9] and tacit, which interact in this environment.

These sociocultural mathematical modelling activities empower members of distinct cultural groups because it provides them with tools, rights, and responsibility to investigate critically and reflectively, as well as to discuss mathematical arguments to enable them to judge applications of mathematics they use to analyze phenomena that occur in their daily life (Mukhopadhyay & Greer, 2001).

In this context, members of distinct cultural groups have developed and are developing diverse and different ways of doing mathematics. Thus, D'Ambrosio (1990) states that members of these groups have developed, throughout history, distinct ways to mathematize their own reality by using elements of the modelling process.

Thus, it is important to see mathematization as a process through which members of distinct groups to use different mathematical tools to help them organize, analyze, understand, understand, model and solve the problems faced in their daily lives (ROSA; OREY, 2006). These tools enable the identification of ideas in order to describe procedures and mathematical practices specific to a cultural context, which aims to help these members to discover relationships and regularities.

Hence, Rosa and Orey (2003) highlight that this cultural approach to modelling allows these members to schematize, formulate, and visualize problems and situations in different ways, which help them transcend the solution of real-world phenomena to mathematical conceptualization through the mathematization process.

In this direction, Rosa and Orey (2017) state that a sociocultural perspective of mathematical modelling encompasses the study of mathematical ideas, procedures, and practices found in different cultural contexts so that they can be used in their pedagogical action in classrooms through the elaboration of ethnomodels.

Thus, mathematical modelling procedures can be employed using ethnomathematics to assist members of distinct cultural groups in the development of solving everyday problems related to social, cultural, economic, political, and environmental contexts (ROSA; OREY, 2010).

8 Cultural traits can be considered as a system of beliefs, values, traditions, symbols, and meanings that members of a given cultural group acquire throughout history. They can be considered as producers of knowledge, practices, experiences, actions, cosmovisions, artifacts, attitudes, hierarchies, religions, notions of time, spatial and temporal relations, as well as how the concepts of the universe and the diverse visions of the world they develop from generation to generation that are spread through their collective efforts (ROSA, 2010).

9 Explicit knowledge is related to a concrete fact, which can be disseminated by teachers through the use of textbooks, academic knowledge about the subject, knowledge of pedagogical instructional practices, and any other method of using materials and technological instruments that can to help them to absorb, internalize and, consequently, transfer and diffuse the applicability of this knowledge to other areas of human knowledge (ROSA; OREY, 2012).

For Rosa and Orey (2014), these techniques are considered as the basic tools used by ethnomodelling that help teachers and researchers in carrying out the translation between the emic and etic approaches. Ethnomodelling is a tool that aims to mediate cultural forms of mathematics with the school curricula used to facilitate the development of diverse teaching and learning processes. Thus, sociocultural perspectives of modelling forms a teaching trend that aims to develop critical and reflective students who are aware of the different problems occurring in their everyday lives.

However, for this objective to be achieved, there is a need for learning environments that encourages the use of mathematical knowledge acquired both at school and tacitly in their own community. This approach will help students to contextualize curricular activities in the daily life of the students (ROSA; OREY, 2007).

Modelling techniques provide the links and contextualization of school/academic mathematics by providing the necessary conditions through the elaboration of mathematical models, so that members of distinct cultural groups can act in the glocalized world. This contextualization is an important concept for the development of citizens students, as it offers a great opportunity for the teaching of sociocritical efficiency[10] (ROSA; OREY, 2007).

In this regard, teachers should be given the support and responsibility to favor the establishment of relationships between school/academic mathematics and students' tacit knowledge, to explore with their students and colleagues the presence of mathematics they experience daily. Thus, it is necessary that, in classrooms, due to the nature of most schools, teachers are forced to discard traditional transmissive pedagogical models and favor the transformative pedagogical models (ROSA; OREY, 2009).

According to Rosa and Orey (2012), the traditional teaching methods predominant in most educational systems tend to focus on the traditional objectives of learning for the transmission of mathematical knowledge. Modelling as a learning environment is presented, where both educators and students are responsible for the development of mathematical knowledge and for the conversion between both tacit and explicit dimensions, arising from situations, preferably, from their own realities.

The conception of the role of students in this approach is that of creating active collaborators in the learning process, which is a more stimulating task than the one related to the simple reception of mathematical knowledge and practices (ROSA; OREY, 2007). Hence, in the sociocultural perspective of modelling, students can be considered as creators of their own mathematical knowledge. This process provides conditions for them to get involved with mathematics, so that they can critique it, challenge it, understand it, and interpret it by making it into a product of human creation.

As well, learning can be triggered according to students' purpose, as it develops differentiated capabilities so that they can act, react, reflect, and change the environment in which they live in by transforming it, strategically. Thus, this environment influences the development of students' cognitive process in different ways, as it is related to their sociocultural context (CORTES, 2017).

Therefore, the sociocultural perspective of modelling has as background the sociocultural and social knowledge theories, which are related to the emancipatory perspective and transformative learning that apply the philosophical ideals of the critical thinking theory. Therefore, sociocultural theory is related to learning processes triggered through socialization, as knowledge is better constructed when students interact to socialize learning (ROSA; OREY, 2007).

10 The fundamental characteristic of sociocritical efficiency is the emphasis on students' critical analysis of society's power structures. Another important feature is the students' personal reflection on the social elements that underpin the globalized world. Thus, the critical perspective of students in relation to the social conditions that affect their own experiences can help them to identify common problems and, collectively, develop different strategies to solve them (ROSA; OREY, 2007).

Thus, when ethnomodelling, students act cooperatively and collaboratively in order to support and encourage each other, so that they can reflect on the resolution of complex problems rooted in authentic situations they choose. As in the mathematical modelling process, it is important that students actively participate in the construction of their mathematical knowledge by connecting it with other areas of knowledge in an interdisciplinary fashion (ROSA; OREY, 2017).

In the sociocultural theory, Rosa and Orey (2007) affirm that the joint work between teachers and students makes learning more effective when cultural tools, such as artifacts, language, traditions, behaviors, and institutions are shared. The meaning of learning is constructed in context, as members of different cultural groups learn collaboratively through integrated experiences.

According to the *National Curricular Parameters of Mathematics* (BRASIL, 1998), it is necessary for students to develop their ability to solve problems, make decisions, work in teams, and communicate effectively, all of which are important characteristics. of sociocritical mathematical modelling. For example, Bassanezi (2002) states that the analysis of data through statistics and the interpretation of the results determined in studies have contributed to direct the use of active strategies in commercial, social, environmental and political environments.

Consequently, Kaiser and Sriraman (2006) and Rosa and Orey (2007) argue for the need to apply an emancipatory approach to mathematical modelling, whose educational objectives address issues of a sociopolitical nature and their consequences in the pedagogical practices used in school systems. For example, this emancipatory approach is based on the sociocritical and cultural competences of members of distinct cultural groups in which its main objective is to help students to face and solve challenges imposed on them by a glocalized society.

Accordingly, sociocritical and cultural perspectives of mathematical modelling aim at the study of problems and phenomena that privilege critical and reflective understanding of the world, as well as the role of members of distinct cultures in society to expand their possibilities of actions and interactions in their communities (KAISER; SRIRAMAN, 2006). In this regard, these perspectives focus on exploring societal problems and phenomena with mathematics as critical and reflective tools to deal with controversial real-world situations by dialogically reflecting on alternative solutions (JUNG; WICKSTROM, 2023).

This approach must be encouraged to transform students into flexible, adaptable, reflective, critical, and creative citizens. This can be done through the use of alternative pedagogical methodologies, one of which is ethnomodelling, which aims to value and record ideas, procedures, and mathematical practices that are developed in distinct cultural contexts (OREY; ROSA, 2021).

The sociocultural perspective of modelling is based on the expansion of students' autonomy, as it aims to provide a critical and reflective reading of their worldview, as well as for the development of their autonomous thinking, which aims to contribute to the full exercise of their citizenship.

AN ETHNOMODELLING APPROACH

Many studies have shown that sophisticated mathematical ideas and practices that include geometric principles that appear in craftwork, architectural concepts, activities, and artifacts of many local and *vernacular*[11] cultures (CORTES, 2017, EGLASH *et al.*, 2006, KNIJNIK, 1993, ROSA; OREY, 2013, SHOCKEY; MITCHELL, 2017, ZASLAVSKY, 1996).

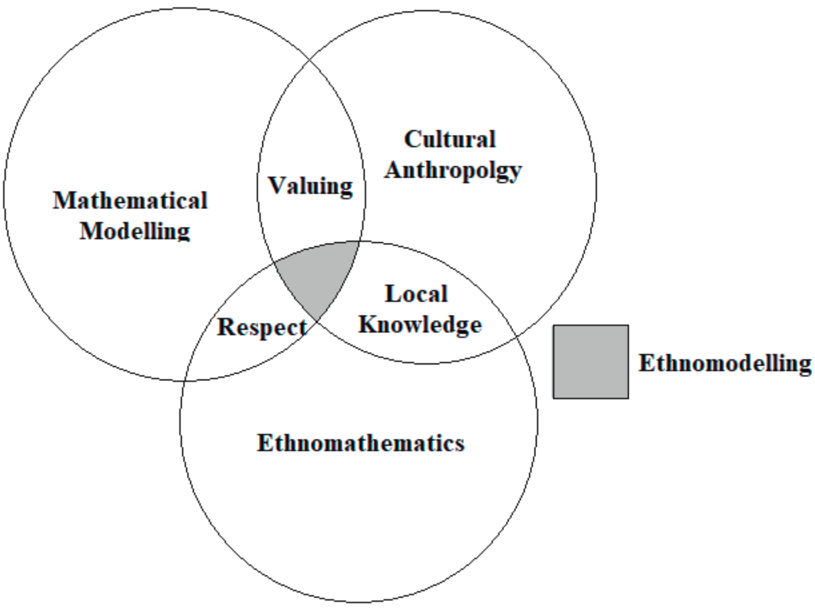
11 Vernacular cultures are composed of a wide range of diverse everyday practices, which is also related to the development of local mathematical ideas, procedures, and practices. The term vernacular means the ways in which everyday creativity is practiced by the members of distinct cultural groups inside of their own cultures. This approach creates cultural value systems that help these members to holistically understand their own realities (ROSA, 2010).

In this context, the mathematical concepts related to a variety of mathematical procedures and cultural artifacts are part of the numeric relations found in Bishop's (1988) six universal activities of counting, playing (games), designing, measuring, locating, and explaining. Similarly, Eglash *et al.* (2006) stated that the development of mathematical concepts are related to a variety, or a combination of mathematical procedures and cultural artifacts registered in numeric relations found in universal actions of divination, navigation, astronomy, inferring, and modelling.

According to Rosa and Orey (2010), ethnomodelling investigations consider the many diverse processes that help members of distinct cultural groups in the construction and development of scientific and mathematical knowledge that includes collectivity, and the overall sense of, and the many unique and distinct cultural values and practices for, creative and new inventions and ideas through the sociocultural perspective of modelling.

In relation to this context, Rosa and Orey (2010) consider ethnomodelling as the intersection of three research fields: cultural anthropology, ethnomathematics, and mathematical modelling, which can be used "as a tool towards pedagogical action of an ethnomathematics program, students have been shown to learn how to find and work with authentic situations and real-life problems" (p. 60). Figure 01 shows ethnomodelling as the intersection of 3 (three) research fields: cultural anthropology, ethnomathematics, and mathematical modelling.

Figure 1 - Ethnomodelling as the intersection of three research fields.



Source: Adapted from Rosa and Orey (2010, p. 60).

Cultural anthropology is the study of distinct cultures and how their members shape the world around them by studying similarities and differences regarding the development of mathematical procedures and techniques. The goal for education is to learn how to collect data on how political, economic, social, environmental, and cultural practices to understand how mathematics is influenced by the cultures that are studied.

In the context of ethnomodelling research, Rosa and Orey (2017) affirm that the prefix *ethno* indicates the specific mathematical knowledge is developed by the members of distinct cultural groups in which modelling seeks to establish relations between the local conceptual framework and the mathematics embedded in relation to local designs and other mathematical knowledge systems.

This means that studies using ethnomathematics produce through the use of the modelling can approach a more complete comprehension of mathematical ideas, procedures, and practices developed by the members of distinct cultural groups than just exploring diverse mathematical forms of learning based on the cultural aspects of the students' own reality (ROSA; OREY, 2016).

This is especially true when the diverse voices of those who do mathematics, who are the insiders (emic), do the research and demonstrate and share to outsiders (etic) how they develop their own ways of doing. Consequently, in the ethnomodelling approach, the use of ethnomathematics assumptions along with the application of tools and techniques of mathematical modelling, encourages members of distinct cultures to share their often holistic experience which gives an insight into the ways mathematics is performed in a broader way (ROSA; OREY, 2010).

Ethnomodelling plays a role in creating and implementing didactic situations in shaping pedagogical tools in the process of teaching and learning mathematics by promoting, valuing, and respecting the cultural aspects of distinct communities. It is an approach that plays a relevant role in solving problems and understanding alternative mathematical knowledge systems. It also helps students to understand the vital role that mathematics plays in society (ROSA; OREY, 2017).

For example, ethnomodelling presents a set of educational opportunities developed through the modelling process conducted in sociocultural contexts, which allow for the critical exploration of local mathematical knowledge by appreciating and respecting cultural values developed by members of distinct cultures. This stance indicates that mathematical knowledge is inherent to the reality of all peoples, which establishes itself as a tool for the development of a decision-making processes regarding their own unique needs, perspectives, and realities.

Ethnomodelling continues to improve ethnomathematics research, especially in relation to the cultural aspects related to the main characteristics of the mathematical modelling process through a *glocal/dialogical*[12] approach that provides communication between *etic (local)*[13] and *emic (global)*[14] approaches. In this regard, ethnomathematics adds cultural perspectives to the modelling process. It actively allows for the decolonialization of the aspects of modern mathematics and science to be countered by the valorization of myriad diverse local, historical, and unique ways of applying problem-solving.

According to Ikeda (2013), this process elevates and promotes the diversity of mathematical models based on the cultural aspects of school mathematics. This approach is closely related to the elaboration of modelling activities contextualized in the students' sociocultural context in which the learning process is related to the achievement of the mathematical construction knowledge.

Therefore, ethnomodelling is based on the capacity to model and find solutions to situations that actively serves members of distinct cultural groups to understand daily activities. This happens in order to build new knowledge or reconstruct know/how these members have acquired through

12 Dialogical (glocal) approach uses both emic and etic mathematical knowledge to understanding the development of mathematical ideas, procedures, and practices through the processes of dialogue (ROSA; OREY, 2010).

13 Etic approach is developed when external observers reinterpret local mathematical ideas, procedures, and practices according to the conceptual network of mathematical concepts used in their own cultural backgrounds (ROSA; OREY, 2010).

14 Emic (local) approach is developed when members of cultural groups have their own interpretation of their culture. It is also essential for an intuitive and empathic understanding of mathematical ideas developed inside of distinct cultures (ROSA; OREY, 2010).

experiences lived in their own sociocultural contexts using the experience and voices of those who do mathematics (ROSA; OREY, 2017).

In considering ethnomodelling as a tool to uncover and study ethnomathematics, according to Freire (1998), teaching is much more than the transference of knowledge because it becomes an activity that introduces its creation. This approach in mathematics education is the antithesis of turning students into containers to be filled with information.

In this Dambrosian perspective, it is necessary for school mathematics curriculum to translate the interpretations and contributions of ethnomathematical knowledge into systemized mathematics because students need to be able to analyze the connection between both traditional and non-traditional learning settings through ethnomodelling (ROSA; OREY, 2010).

For example, a study conducted to find the volume of a wine barrel, which is similar to a truncated cone, can be motivated by the application of techniques learned by the ancestors of Mr. Joaquim, a wine producer in Ijuí, in the state of Rio Grande do Sul, in Brazil (BASSANEZI, 2002). In accordance with D'Ambrosio (2002), this is a beautiful example of an ethnomathematical practice and its natural encounter with mathematical modelling.

Also, the use of the practices of *squaring the land*[15] and *cubing the tree trunk*[16] content calculation (cubação and cubagem) and the mathematization of Tipi from the indigenous nation Sioux as a pedagogical proposal to elaborate activities for the teaching and learning of mathematics, which show the importance of the contextualization of problems in the learning environment through the connection of ethnomathematics and modelling (ROSA; OREY, 2021).

It is important to state here that ethnomodelling related investigations previously explored include a study with a farmer seller (Cortes, 2017), coffee culture (Ruggiero, 2020), peripheral communities (Mesquita, 2020), and ethnomathematics trails (Rodrigues, 2021), and other research developed by connecting the sociocultural perspective of mathematical modelling and ethnomathematics.

Thus, Rosa and Orey (2013) affirm that ethnomodelling promotes the development of ideas, techniques, procedures, and practices developed by members of distinct cultures that enables the attainment of mathematical knowledge. For Bassanezi (2002), when researchers and educators investigate mathematical knowledge developed by these members they are able to study unique mathematical ideas and characteristics that can be considered as ethnomathematical practices.

ETHNOMODELS

Culture is a lens that shapes reality, as well as it is blueprint that specifies a plan of action or expectations. At the same time, there are aspects of a culture that are unique to the members of distinct cultural groups, who together have grown, learned, and act daily in diverse contexts, such as economic, social, cultural, political, and environmental in which they live (ROSA; OREY, 2015).

Thus, Rosa and Orey (2010) affirm that research in ethnomodelling is linked to mathematical practices developed by members of different cultural groups that tend to be of benefit to the presentation and organization of mathematical ideas and procedures that enable the development of communication, diffusion, and further transmission through generations (emic knowledge). The representative

15 The demarcation of land activity is about the method of cubação (squaring) of the land, which is a traditional mathematical practice applied by the members of distinct cultural groups in Brazilian rural areas. The term cubação of the land is considered as the solution of problems of the measurement of land with diverse and irregular shapes (ROSA; OREY, 2017).

16 The wood cubing method involves the calculation of the volume of a tree trunk; thus, *cubing* means to determine the volume of a given object by measuring it in cubic units. Performing calculations for wood cubing involves popular and scientific methods (ROSA; OREY, 2021, p. 456).

idea of this approach gives room to the development of mathematical knowledge through scientific methods that help researchers and educators to build and understand the world (etic knowledge) by using small units of information called *ethnomodels* that make up the set of these representations.

Accordingly, Rosa and Orey (2012) state that ethnomodels are powerful examples of cultural artifacts. This happens when one of the main objectives of their elaboration is to comprehend or share the way of thinking of between modelers, as well as to understand how the ideas are organized and modeled by using their own mathematical perspectives, ideas, and procedures. On the other hand, a model built without a first-hand sense for the world being modeled should be viewed with suspicion.

Researchers and educators, if not hindered by prior ideology, paradigms, cosmologies, and worldviews, should come with an informed sense of, and appreciation for effective distinctions emerging from the point of view of the mathematical knowledge of the worldview being modeled. In so doing, they should be able to inform the outsiders (etic/global) what matters to the insiders (emic/local) (ROSA; OREY, 2017). This forms a powerful counterbalance to colonialist aspects of modern mathematics and science imposed on many diverse communities worldwide.

Ethnomodelling emphasizes the organization and presentation of mathematical ideas and procedures developed by members of distinct cultural groups in order to facilitate communication and transmission across generations, through the addition of cultural aspects to the modelling process. In this regard, *ethnomodelers* construct models of their own mathematical practices found in their own contexts and sociocultural systems, and which link their voices and cultural heritage with the development of the greater human mathematical practices (ROSA; OREY, 2017).

This approach supports the organization of pedagogical action in classrooms by using emic (local) and etic (global) aspects of mathematical knowledge through the development and elaboration of ethnomodels, which are described as cultural artifacts that are pedagogical tools used to enable the understanding of systems taken from the reality of the members of distinct cultural groups (ROSA; OREY, 2013).

In this regard, ethnomodels may be considered as representations that are precise and consistent with the scientific and mathematical knowledge. This is especially true when they are socially constructed, developed, and shared by members of specific cultural groups. The main objective for the elaboration of these ethnomodels is to translate emic constructs such as mathematical ideas, procedures, and practices in order to establish relations between local conceptual knowledge and the mathematics embedded in these constructs through dialogical relations (ROSA; OREY, 2017).

Thus, ethnomodels help to link the development of mathematical practices to the cultural heritage of the members of distinct cultural groups, who detain necessary information to solve problems and situations described in systems taken from their own reality. The emphasis of ethnomodelling research considers the processes that help the construction and development of local mathematical knowledge systems, which include collectivity, creativity, and inventively through the elaboration of ethnomodels (OREY; ROSA, 2021).

According to this approach, it is impossible to imprison mathematical ideas, procedures, and practices in registers of univocal designation of reality because there are distinct systems that provide unambiguous representations of reality as well as universal explanations (CRAIG, 1998). This means that mathematics cannot necessarily be conceived as a universal language because its principles are not always the same everywhere around the world (ROSA; OREY, 2007). In accordance with this context, the production process of mathematical ideas, procedures, and practices operates within the register of interpretative singularities regarding possibilities for symbolic construction of local mathematical knowledge (ROSA; OREY, 2013).

It is important to state again that ethnomodelling studies local mathematical processes developed by the members of distinct sociocultural groups. Many interesting ethnomodels have been formulated by using data obtained from studies related to ethnomathematics, and which propose a rediscovery of knowledge systems adopted by the members of diverse groups (BASSANEZI, 2002, BABBITT, LILES; EGLASH, 2012; ROSA; OREY, 2011). When this knowledge applies mathematical ideas and procedures through the elaboration of ethnomodels, members of distinct cultures can understand the origin of mathematical practices more efficiently.

In ethnomodelling research, emic constructs represent the accounts, descriptions, and analyses of mathematical ideas, procedures, and practices expressed in terms of conceptual schemes and categories that are regarded as meaningful and appropriate by members of the cultural group under study. This means that emic constructs are in accordance with the perceptions and understandings deemed appropriate by the insider's culture. The validation of these constructs comes with a matter of consensus from those who do the mathematics under study, in which local people who must agree that emic constructs match shared perceptions, behaviors, and knowledge that portray characteristics of their culture (LETT, 1996).

Emic mathematical knowledge can be obtained through elicitation and observation because observers infer local perceptions. In emic approaches, researchers and educators must put aside their own bias, prior theories, and assumptions to let those who do the activity under study to explain, in their own their own ways of doing and allow for better understanding of mathematical themes, patterns, and concepts that have emerged over time and locally. Some of its beauty and strength lies in its appreciation of the uniqueness of the context being studied and in its respect for local viewpoints, and the potential to uncover unexpected mathematical findings (ROSA; OREY, 2015).

For example, Lett (1990) states that "etic constructs are accounts, descriptions, and analyses of mathematical ideas, procedures, and practices expressed in terms of conceptual schemes and categories that are regarded as meaningful and appropriate by the community of scientific observers" (p. 130). An etic approach uses these concepts as starting point theories, hypothesis, perspectives, and concepts from outside of the cultural setting being studied, which are developed by researchers and educators.

Etic constructs are precise, logical, comprehensive, replicable, and observer-researcher independent (ROSA; OREY, 2017). The validation of etic knowledge becomes a matter of logical and empirical analysis the logical analysis of whether the construct meets standards of comprehensiveness and logical consistency of concepts (LETT, 1990).

It is important to emphasize that the research techniques that are used in the acquisition of scientific and mathematical knowledge have no bearing on the nature of that knowledge. Etic knowledge may be obtained at times through either or both elicitation, as well as observation. One of the strengths of the etic approach is that it allows for comparison across contexts and populations, and the development of more general cross-cultural concepts (LETT, 1990).

On the other hand, Rosa and Orey (2012) state that etic ethnomodels are the mathematical representations elaborated through descriptive and external observations. Thus, the representation of local mathematical knowledge is developed when the members of different cultural groups have their own interpretation of their culture (emic) as opposed to the researchers' interpretation and researchers who develop representations of mathematical knowledge place from the perspective of their own conceptions (etic).

FINAL CONSIDERATIONS

Ethnomathematics is a program that incorporates mathematical ideas, techniques, and procedures practiced by the members of distinct cultural groups, identified by D'Ambrosio (1985) not only as indigenous societies but as groups of workers, professional classes, and groups of children of a certain age group as well. In this context, the ethnomodelling approach is the use of ethnomathematical assumptions and the application of techniques of the sociocultural perspective of mathematical modelling that allow us to perceive reality by using different lenses, which gives us insight into mathematics performed in a holistic way (ROSA; OREY, 2013).

These approaches are socially rooted constructs that include the cultural aspects of mathematical knowledge in the modelling process, which acknowledge the importance of the sociocultural perspective in this process. In this regard, *ethnomodelling*[17] approaches are intended to make school mathematics more relevant and meaningful to learners and to increase the overall quality of education and assert more culturally relevant views of mathematics (CORTES, 2017). This pedagogical approach is achieved through important *dialogue* when community members, teachers, educators, and students discuss mathematical themes that help them to work on problems that are directly relevant to their own community.

Thus, there is a need to promote a synergy between the knowledge developed locally with those used in the school/academy so that, through this cultural dynamism, ethnomodelers develop a dialogical relation and exchange of experiences and perspectives. Consequently, its necessary to discuss ways to encourage the development of possibilities for an interaction between different tendencies in mathematics education, which involve the breaking of some disciplinary boundaries and *epistemological cages*[18] between mathematical modelling and ethnomathematics through ethnomodelling.

In this context, in the sociocultural perspective of mathematical modelling, students investigate conceptions, traditions, and mathematical practices developed by members of distinct cultural groups, and to incorporate them into the greater mathematics curriculum. When students are encouraged to examine mathematical activities in their own sociocultural contexts, they realize that mathematics procedure and practice are not trivial as they see them connected to their daily lives.

In closing, innovative procedures and techniques can be generated while conducting pedagogical actions found in ethnomodelling processes that value and respect mathematical knowledge developed by the members of distinct cultures. Therefore, one of the most important characteristics of ethnomodelling is the engagement in the glocal dialogue between global (etic) and local (emic) approaches where diverse forms of mathematical knowledge intersect. This also necessitates humility and a great deal of listening and observing.

Attending to unique mathematical interpretations developed by members of distinct cultural groups challenges the fundamental goals of Western academic mathematics, thus, theoretical ad-

17 If you would like to obtain more information about ethnomodelling, ethnomodels, and activities related to ethnomathematics (cultural perspectives of mathematics) and the sociocultural perspective of mathematical modelling, please, access the link: https://ppgedmat.ufop.br/dissertações, and research for investigations under the supervision of professors Daniel Clark Orey and Milton Rosa.

18 Traditional mathematics education contains theories and techniques developed, often hundreds of years ago, and accumulated in academic environments, in epistemological cages. Even so, in traditional teaching and learning contexts, it is possible to organize classes looking for shortcuts and new organizations and applications of techniques and theories, especially, with the wide resources offered with new information, communication, and technologies. However, it is necessary to state here that it is not about destroying epistemological cages because the organization of disciplines leads to the necessary advancement of specialized knowledge. But, metaphorically, the cage doors must be left open to leave and return with new ideas apprehended from the outside world. In this context, teachers can contextualize the contents through problems formulated regarding real-world and everyday life experiences (D'AMBROSIO, 2018).

vances in ethnomodelling investigations show that its main objective is to build its theoretical basis that describes the development of local mathematical practices diffused through generations.

REFERENCES

BABBITT, B., LYLES, D.; EGLASH, R. From ethnomathematics to ethnocomputing: indigenous algorithms in traditional context and contemporary simulation. In: MUKHOPADHYAY, S.; ROTH, W. M. (Eds.). **Alternative forms of knowing in mathematics**: celebrations of diversity of mathematical practices. Rotterdam, The Netherlands: Sense Publishers, 2012. p. 205-220.

BARTON, B. Making sense of ethnomathematics: Ethnomathematics is making sense. **Educational Studies in Mathematics**, v. 31, n. 1-2, p. 201-33, 1996.

BASSANEZI, R. C. **Ensino-aprendizagem com modelagem matemática.** São Paulo, SP: Editora Contexto, 2000.

BISHOP, A. J. **Mathematical enculturation**: a cultural perspective on mathematics education. Dordrecht, The Netherlands: Kluwer Academic Publishers,1988.

BRASIL. **Parâmetros curriculares nacionais**: matemática. Brasília, DF: MEC/SEF, 1998.

CALDEIRA, A. D. Etnomodelagem e suas relações com a educação matemática na infância. In: BARBOSA, J. C., CALDEIRA, A. D.; ARAÚJO, J. L. (Orgs.). **Modelagem matemática na educação matemática brasileira**: pesquisas e práticas educacionais. Coleção Biblioteca do Educador Matemático. Volume 3. Recife, PE: SBEM, 2007. p. 81-97.

CORTES, D. P. O. **Re-significando os conceitos de função**: um estudo misto para entender as contribuições da abordagem dialógica da etnomodelagem. Dissertação de Mestrado Profissional em Educação Matemática. Departamento de Educação Matemática. Ouro Preto, MG: Universidade Federal de Ouro Preto, 2017.

CRAIG, E. **Routledge encyclopedia of philosophy**: questions to sociobiology. New York, NY: Routledge, 1998.

D'AMBROSIO, U. Ethnomathematics and its place in the history and pedagogy of mathematics. **For the Learning of Mathematics,** v. 5, n, 1, p. 44-48, 1985.

D'AMBROSIO, U. **Etnomatemática**: arte ou técnica de explicar e conhecer. São Paulo, SP: Editora Ática, 1990.

D'AMBROSIO, U. Etnomatemática: um programa. **A Educação Matemática em Revista***,* v. 1, n. 1, p. 5-11, 1993.

D'AMBROSIO, U. Literacy, matheracy, and technoracy: a trivium for today. **For the Learning of Mathematics**, v. 1, n. 2, p. 131-153, 1999.

D'AMBROSIO, U. General remarks on ethnomathematics. **ZDM- Mathematics Education**, v. 33, n. 3, p. 67-69, 2001.

D'AMBROSIO, U. Etnomatemática, justiça social e sustentabilidade. **Estudos Avançados**, v. 32, n. 94, p. 189-204, 2018.

DESAI, S.; SAFI, F. Model it! Building and sustaining cultural traditions with ethnomodeling. **Mathematics Teacher: Learning and Teaching PK-12**, v. 116, n. 10, p. 782-787, 2023.

EGLASH, R., BENNETT, A., O'DONNELL, C., JENNINGS, S.; CINTORINO, M. Culturally situated designed tools: ethnocomputing from field site to classroom. **American Anthropologist**, v. 108, n. 2, p. 347-36, 2006.

FREIRE, P. **Pedagogy of freedom**: ethics, democracy, and civic courage. New York, NY: Rowman and Litttlefield, 1998.

GAVARRETE, M. E. Elementos del conocimiento matemático cultural en la tradición indígena de Costa Rica. **Journal of Mathematics and Culture**, v. 8, n. 1, p. 25-27, 2014.

GREER, B. Teaching through ethnomathematics: possibilities and dilemmas. In: M. BERGER, K. BRODIE, V. FRITH; LEROUX, K. (Eds.). **Proceedings of the 7th International Mathematics Education and Society Conference.** Capetown, South Africa: MES7, 2013. p. 282-290.

HART, L. E. Some directions for research on equity and justice in mathematics education. In: BURTON, L. (Ed.). **Which way social justice in mathematics education?** International perspectives on mathematics education. Westport, CT: Praeger Publisher, 2003. p. 25-50.

IKEDA, T. Pedagogical reflections on the role of modelling in mathematics instruction. In: Stillman, G. A.; BROWN, J. (Eds.). **Teaching mathematical modelling**: connecting to research and practice. Dordrecht, The Netherlands. Springer, 2013. p. 255-275.

JUNG, H.; WICKSTROM, M. H. Teachers creating mathematical models to fairly distribute school funding**. The Journal of Mathematical Behavior**, v. 70, n. June, p. 1-18, 2023.

KAISER, G.; SRIRAMAN, B. A global survey of international perspectives on modelling in mathematics education. **The International Journal on Mathematics Education**, v. 38, n. 3, 2006. p. 302-310.

KNIJNIK, G. Ethno-mathematical approach in mathematical education: a matter of political power. **For the Learning of Mathematics**, v. 13, n 2, p. 23-25, 1993.

LADSON-BILLINGS, G. Toward a theory of culturally relevant pedagogy. **American Educational Research Journal**, v. 32, n. 3, p. 465-491, 1995.

LETT, J. Emic/etic distinctions. In: LEVINSON, D.; EMBER, M. (Eds.). **Encyclopedia of cultural anthropology**. New York, NY: Henry Holt and Company, 1996. p.382-383.

MESQUITA, A. P. S. S. **Uma ação pedagógica para o desenvolvimento de conteúdos matemáticos em uma comunidade periférica.** Dissertação de Mestrado em Educação Matemática. Departamento de Educação Matemática. Ouro Preto, MG: Universidade Federal de Ouro Preto - UFOP, 2020.

MUKHOPADHYAY, S.; GREER, B. Modeling with purpose: mathematics as a critical tool. In: Atweh, B., Forgasz, H., & Nebres, B. (Eds.). **Sociocultural research on mathematics education**. Mahwah, NJ: Erlbaum, 2001. p. 295-312

OREY, D. C.; ROSA, M. Applying ethnomodelling to explore glocal mathematical knowledge systems. **Acta Scientiae**, v. 23, n. 1, p. 199-232, 2021.

POLANYI, M. **The tacit dimension.** London, England: Routledge & Kegan Paul, 1966.

RODRIGUES, J. **Explorando a perspectiva de pesquisadores e participantes de trilhas de matemática sobre a (re) descoberta do conhecimento matemático fora da escola**: um estudo qualitativo em etnomodelagem. Dissertação de Mestrado em Educação Matemática. Departamento de Educação Matemática. Ouro Preto, MG: Universidade Federal de Ouro Preto - UFOP, 2021.

ROSA, M. **From reality to mathematical modelling**: a proposal for using ethnomathematical knowledge. Master degree thesis in Mathematics Education. College of Education. Sacramento, CA: California State University, Sacramento (CSUS), 2000.

ROSA, M. **A mixed-methods study to understand the perceptions of high school leaders about English language learners (ELL) students**: the case of mathematics. Doctorate dissertation in Education. Doctorate in Educational Leadership Program. College of Education. Sacramento, CA: California State University, Sacramento (CSUS), 2010.

ROSA, M.; OREY, D. C. Vinho e queijo: etnomatemática e modelagem! **BOLEMA**, v. 16, n. 20, p. 1-16, 2003.

ROSA, M.; OREY, D. C. Abordagens atuais do programa etnomatemática: delinenando-se um caminho para a ação pedagógica. **BOLEMA**, v. 19, n. 26, p. 19-48, 2006.

ROSA, M.; OREY, D. C. Cultural assertions and challenges towards pedagogical action of an ethnomathematics program. *F***or the Learning of Mathematics**, v. 27, n. 1, p. 10-16, 2007.

ROSA, M.; OREY, D. C. Ethnomathematics and cultural representations: teaching in highly diverse contexts. **Acta Scientiae**, v. 10, n. 1, p. 27-46, 2008.

ROSA, M.; OREY, D. C. Ethnomodeling: a pedagogical action for uncovering ethnomathematical practices. **Journal of Mathematical Modelling and Application**, v. 1, n. 3, p. 58-67, 2010.

ROSA, M; OREY, D. C. Ethnomathematics: the cultural aspects of mathematics. **Revista Latinoamericana de Etnomatemática**, v. 4, n. 2, p. 32-54, 2011.

ROSA, M; OREY, D. C. O campo de pesquisa em etnomodelagem: as abordagens êmica, ética e dialética. **Educação e Pesquisa**, v. 38, n. 4, p. 865-879, 2012.

ROSA, M.; OREY, D. C. Ethnomodelling as a methodology for ethnomathematics. In: STILLMAN, G. A.; BROWN, J. (Eds.). *Tea***ching mathematical modelling**: connecting to research and practice. International perspectives on the teaching and learning of mathematical modelling. Dordrecht, The Netherlands: Springer, 2013. p. 77-88.

ROSA, M. OREY, D. Fragmentos históricos do programa etnomatemática**. Anais/Actas do 6o Encontro Luso-Brasileiro de História da Matemática**. Natal, RN: SBHMat, 2014. p. 535-558.

ROSA, M.; OREY, D. C. A trivium curriculum for mathematics based on literacy, matheracy, and technoracy: An ethnomathematics perspective. **ZDM-Mathematics Education**, v. 47, n. 4, p. 587-598, 2015.

ROSA, M.; OREY, D. C. Humanizing mathematics through ethnomodelling. **Journal of Humanistic Mathematics**, v. 6, n. 2, p. 3-22, 2016.

ROSA, M.; OREY, D. C. **Etnomodelagem**: a arte de traduzir práticas matemáticas locais. São Paulo, SP: Editora Livraria da Física, 2017.

ROSA, M,; OREY, D. C. Ethnomodelling as a glocalization process of mathematical practices through cultural dynamism. **The Mathematics Enthusiast**, v. 3, n. 3, p. 438-468, 2021.

RUGGIERO, E. D. D. **Etnomodelagem e café**: propondo uma ação pedagógica para a sala de aula. Dissertação de Mestrado em Educação Matemática. Departamento de Educação Matemática. Ouro Preto, MG: Universidade Federal de Ouro Preto - UFOP, 2020.

SHIRLEY, L. Mathematics of students' culture: a goal of localized ethnomathematics. **Revista Latino americana de Etnomatemática**, v. 8, n. 2, p. 316-325, 2015.

SHOCKEY, T.; MITCHELL, J. B. An ethnomodel of a Penobscot lodge. In: ROSA, M., SHIRLEY, L., GAVARRETE, M. E.; ALANGUI, W. V. **Ethnomathematics and its diverse approaches for mathematics education**. Cham, Switzerland: Springer, 2017. p. 257-281.

STILLMAN, G. A.; BROWN, J. **Lines of inquiry in mathematical modelling research in education.** Cham, Switzerland: SpringerOpen, 2019.

ZASLAVSKY, C. **The multicultural math classroom**: bringing in the world. Portsmouth, ME: Heinemann, 1996.

RECEBIDO EM: 26 jun. 2023
CONCLUÍDO EM: 06 nov. 2023