COMPETENCIES AS RESOURCES FOR RESPONSIBLE SUBVERSIVE MATHEMATICS TEACHERS PROGRAMS

COMPETÊNCIAS COMO RECURSOS PARA PROGRAMAS DE PROFESSORES DE MATEMÁTICA SUBVERSIVAMENTE RESPONSÁVEIS

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ABSTRACT
The main objective of this theoretical essay is to present suggestions for competencies that should be cultivated by mathematics teachers. We present a possibility of creative insubordination and responsible subversive pedagogical action, which can be critical in the development of teachers, in both teacher education programs[1] and professional development courses[2]. We also introduce the definitions that will help to understand how teachers can act, do it differently and, hopefully, make a difference. We also present aspects of responsible subversion in mathematics teacher education programs rooted in ethnomathematical perspectives. Our theoretical references are Ubiratan D'Ambrosio, Beatriz D'Ambrosio, Celi Espasandin Lopes, Philippe Perrenoud e Paulo Freire.

Key words: Competencies, Creative Insubordination, Responsible Subversion, Ethnomathematics.

[1]Teacher education programs are higher education courses that prepare students to become teachers of basic education. In Brazil, these programs qualify future professionals in their respective areas, such as mathematics, by enabling them to become teachers in elementary, middle, high, and technical schools.
[2]Professional development courses relate to processes towards ongoing learning opportunities that are available to teachers through schools and universities and encourage personal growth. Specifically, these are courses that offer certificates or specializations used in reference to a wide variety of training, formal education, or advanced content and learning intended to help teachers improve their professional practice, knowledge, competences, skills, and effectiveness.

RESUMO

O objetivo principal deste ensaio teórico é apresentar sugestões de competências que devem ser cultivadas pelos professores de matemática. Apresentamos uma possibilidade de Insubordinação Criativa e Ação Pedagógica Subversiva Responsável, que pode ser crítica no desenvolvimento dos professores, nos cursos de formação ou de desenvolvimento profissional. Também intoduzimos as definições que nos auxiliarão a entender como os professores podem agir de forma diferente e, esperançosamente, fazer a diferença. Apresentamos também os Aspectos de Subversão Responsável em Programas de Educação de Professores de Matemática arraigados em perspectivas etnomatemáticas. Nossos referenciais teóricos são Ubiratan D'Ambrosio, Beatriz D'Ambrosio, Celi Espasandin Lopes, Philippe Perrenoud, and Paulo Freire.

Palavras-chave: Competências, Insubordinação Criativa, Subversão Responsável, Etnomatemática.

1. Introduction

This is a theoretical essay that invites educators to both think and practice mathematics education that is not based on *hierarchies of excellence* as defined by Perrenoud (1999), which excludes students and only serves to people who understand school mathematics. In this regard, the authors seek the inclusion of all students in the process of learning mathematics.

We understand that this process occurs as teachers develop competencies in regard to ethnomathematical scenarios in which students problematize themes connected with their own sociocultural realities. Teacher education in Brazil must adapt to this approach because it is not addressing the disconnection between pedagogical and mathematical content found in university teacher education programs and the reality prospective teachers experience in their classrooms.

In this context, Machado (2017) argues that insufficient teacher education development coupled with inadequate working conditions and low pay constitutes an impediment to the initial and continuous preparation of teachers. These facts do not attract students to become mathematics teachers. Therefore, there is a "need for permanent preparation is absolutely consensual: we are sweetly condemned to study and always improve" (p. 38).

In agreement with this author, we argue that an ongoing improvement of this scenario is related to the development of stronger teacher education programs and continuing education courses that help educators to strengthen their competencies to act in complex contexts as pointed out by Morin (1986). The complexity of the cultural richness of Brazilian schools is the main characteristic of our educational system.

However, there are issues that emerge in the mathematics classrooms. These include: lack of interest, violence, dropouts and a boring and disconnected curricula that is not linked to students' reality. The production of mathematical knowledge connected to school realities may be improved if teacher education programs add aspects of cultural diversity present in communities and schools through the development of projects involving ethnomathematics.

An ethnomathematical perspective establishes that all people have created and developed techniques such as counting, ordering, sorting, measuring, weighing, ciphering, classifying, inferring, and modeling (*tics*) to explain, understand, know, and learn to respond to the needs of survival and transcendence (*mathema*) in the most diverse natural, social, and cultural environments (*ethno*) (D'Ambrosio, 1990).

As well, the theoretical background of this essay is based on the competences formulated by Perrenoud (1999) and the possibilities of putting them into action in ethnomathematical scenarios in which educators acquire competencies in order to become both insubordinate and creative and to be subversive and responsible as proposed by Lopes and D'Ambrosio (2015a).

The main epistemological and theoretical concepts discussed in this essay justify its importance for the development of teacher education programs that need to become aware of the complexity of their profession, and to support them to develop competencies related to practices linked to procedures developed in distinct cultural contexts.

This approach seeks to develop a sense of creative insubordination that promotes learning based on an ethnomathematical perspective that generates the development of social justice as emphasized by Freire (1993) and Skovsmose (2000), wherein it is necessary to empower students by teaching them about real-world issues and instills in them a desire to seek out and work towards this goal. In this regard, D'Ambrosio (1990) states that individuals who do not believe in, or value, their own cultural roots can easily assimilate dominant cultural values without critically reflecting on the values of the new culture.

The main objective of this essay is to present competencies cultivated by mathematics teachers that help them promote the development of mathematics education in connection to the students' own culture through ethnomathematics. These competencies promote the development of insubordinate and creative teachers that encourage the progress of responsible and subversive actions in the school community. In this context, teacher education programs and professional development courses must develop prospective teachers' sense of social renewal, inclusion, and equity.

Teacher education is a strategic area that should be conducted with passion and responsibility to the community, both at initial and/or continuing stages. This area provides the genesis of teachers as mediators of content knowledge students need to learn in order to help them to become autonomous citizens. In this regard, Meirieu (1989) suggests a roadmap for teaching that requires competencies that are developed and cultivated to promote a meaningful professional life. In this scenario, a teachers' role is decisive for students to become active, competent, ethical, and sympathetic promoters of equity and social justice.

For Perrenoud (1999), there is a scenario for professional development represented by the environment in which teachers deal with a certain amount of uncertainty. To this end, established actions are no longer sufficient for classroom management, or to produce knowledge that provides a sense of emancipation, reflection and autonomy (Freire, 1993). If what has been done before needs to be revised, teachers may put in

place competencies that help them to become critical, reflective, insubordinate, questioning, and effective mediators of the learning process.

Twenty-first century teachers should be leaders who lead students to learn mathematics in connection to their own sociocultural contexts that help them to act in a dynamic, complex, and challenging contemporary society. For example, Rosa (2010) argues that teachers must acknowledge daily experiences and value *tacit knowledge* [3] in mathematics classrooms.

It is well-known that mathematics teachers should master the content they teach, which equips professionals with competencies that enable them to transform new forms of information into knowledge. As such, it is important to clarify which competencies are required for mathematics teachers so that new information becomes new mathematical knowledge. In the process of the construction of mathematical knowledge, this possibility is often ignored, yet it helps us to rethink our own practices as teachers and reflect on and incorporate the rich historical and cultural diversity that permeates our classrooms and communities.

2. Competencies for Teachers' Action

In this section, we introduce definitions that help us understand how to develop teacher education programs and professional development courses that both operate differently and make a difference in the development of pedagogical action. We define our theoretical conceptions supported by researchers who have been working with creative insubordination and developing responsible subversive actions. Most importantly, such definitions and theoretical discussions have helped us to perceive how practices based on ethnomathematics constitute an innovative educational paradigm for school curricula.

In accordance to Perrenoud (1999), such practices are dynamic and occur when teachers leave their comfort zone and experience uncertainty. Competencies developed in teacher education programs should cultivate in prospective teachers aspects of insubordinate, creative, subversive, and responsible actions and practices because they have "suffered from the prejudice of a dominant paradigm that excludes work that deviates from what is taken as the norm" (D'Ambrosio & Lopes, 2015a, p. 31).

Perrenoud (1999) emphasized that the "notion of competence shall designate an ability to mobilize several cognitive resources to face a kind of situation" (p. 15). Hence, in order to mobilize these competencies, teachers need to put into action resources obtained through their knowledge, methodological experiences, perceptions, and beliefs.

For example, currently, most teachers learn complex and everyday procedures from their peers and students. In this regard, they need to involve resources available in the local school community that promote scenarios that help in the problematization of

[3] This type of knowledge is embedded in personal experience, is subjective, contextualized, and analogous. It is acquired and accumulated by experiences and involves intangible factors such as beliefs, perspectives, perceptions, value systems, ideas, emotions, norms, presentiments, and intuitions (Rosa & Orey, 2012).

mathematical content. Thus, it is necessary to mobilize cognitive resources for the development of problem solving techniques and reading contexts. It is necessary that teachers cultivate an interest in students to *learn how to learn* and to learn new information from people with different backgrounds (Perrenoud, 1999).

Obstacles in many teacher education programs include heavy top-down set of directives disconnected from local reality, with a need for a mobilization of cognitive resources that support teachers in focusing on their classroom performance. In order to promote emancipatory actions, teachers need to overcome difficulties and problems they observe in the mathematics curriculum that insists on the compartmentalization of mathematical knowledge. Standardized tests and competitions with low expectations for creativity and the artificialization of mathematical knowledge in classrooms create unstable and disconnected development of competencies of the teachers.

Resilience constitutes itself as the first competency that should be cultivated in teaching practices. It often happens both in teacher education programs and in professional development courses that deal with the development of pedagogical practices in the mathematics classrooms. In many cases, mathematics teachers want to attempt and try new scenarios and methodologies, but they are limited by community-school contexts and standardized examinations. Hence, it is important that teachers resist bureaucratic difficulties imposed by the academic school system.

A second group of competencies refers to the process of *learning mathematics*, including the ability to mobilize resources for educators to overcome obstacles that often overwhelm performance by the school context. Teachers must be supported and encouraged to be attentive to, and learn from, their peers and colleagues about the development of the learning process of their students.

Perrenoud (1999) establishes four actions or responsibilities of teachers in the context of learning: (i) to organize and direct learning situations, (ii) manage a progression of learning, (iii) develop and advance heterogeneity, and (iv) develop in the learners an interest to learn. Such competencies refer to the attention that should be given in the teacher education programs and in professional development courses so that learning is always the main focus of the teachers.

Of these competencies, it is best if teachers mobilize their resources to teach and learn about diverse ways of presenting content, highlighting and sharing new representations to their colleagues, and seeking to problematize errors and obstacles that arise throughout the learning process. Thus, teachers organize new scenarios that enable the occurrence of different learning situations presented in many textbooks. For example, Rosa and Orey (2015a) state that regarding

> (…) ethnomathematics as pedagogical action for the school curriculum, there is a need to propose an approach by which the investigation of concepts, tradition, and mathematical practices by the members of a particular cultural group are incorporated into the mathematics curriculum (p. 137).

This approach allows didactical experimentation with new sequences that promote the involvement of students and teachers in research activities and projects that develop

significant mathematical learning as well the awareness that every cultural and social group produces ethnomathematics (Rosa, 2010).

Teachers must organize diverse learning actions when standardization streamlines teaching and assessment practices ignore the historical, social, and cultural heterogeneity of the students (Perrenoud, 1999). Teachers also must be supported and encouraged to question standardized examinations that often produces problems for teacher education programs and ongoing professional development.

In this regard, Rosa and Orey (2015a) argue that it is important to support the development of alternative and diverse forms of mathematics in curriculum design to access the information of dominant mathematical discourse that provide critical reflections regarding the application of mathematics curriculum.

It is necessary to mobilize resources that enable teachers to manage learning progressions so that they become aware of the need to both discuss and share classroom experiences. According to Perrenoud (1999), by adjusting the teaching process to the reality of their peers and students, teachers come to understand the goals, comprehend the actions, and conduct research that supported practices developed in distinct learning environments.

However, it becomes a challenge for resilient teachers to assess and evaluate themselves and to observe how their proposals are accepted and promoted. For example, Perrenoud (1999) called this process a creation of educational settings that promote the occurrence of significant and dynamic learning processes.

From the organization and administration of learning progressions, a third action arises, which is related to the teachers' experiences, where teachers mobilize student cognitive resources, new competencies, and conduct research in order to understand a growing diversity of the acquisition of students' mathematical knowledge.

From an ethnomathematical perspective, mathematics curriculum design must be conceived as a development of mathematical ideas, procedures, and practices originating in the sociocultural background and the interests of students and develop connections to academic mathematics.

This proposed curriculum method can be considered as a position of resistance, that is, subversive but responsible, and insubordinate but creative. These professionals develop a sense of flexibility between institutionalized teaching practices and the real context of everyday life by applying mathematical activities based on the ethnomathematics program (Rosa & Orey, 2015a)

In this context, Rosa (2010) states that unlike traditional educational settings, diversity is ever-present and cannot be forgotten or ignored. This competency regarding the acknowledgement of diversity in classrooms is crucial in teacher development because it is the action in which they sought to promote inclusion, provide integrated support to work with student with learning difficulties, and manage the heterogeneity in their classrooms.

On the other hand, Perrenoud (1999) suggests that through the mobilization of the cognitive processes, teachers develop cooperation between students and teaching methodologies in-regards to the use of innovative teaching and educational resources. Rosa (2010) argues that one of the innovative approaches in mathematics education is ethnomathematics as a program, which helps to develop a sense of autonomy for teachers that enable them to comprehend different learning styles acquired in distinct sociocultural realities.

The promotion of autonomy is challenging because teachers regularly teach, assess, certify, and take decisions in relation to the mandated curriculum, while students act as secondary actors in this process. For example, it is necessary to denounce and criticize this educational process, known as *banking education*, in which students are at the mercy of the content of curricular subjects, dominated by standardized school practices that are devoid of the diversity and true reality of the students. In relation to *banking education* (Freire, 1996), students are involved in repeated didactic acts established by their educators, and making use of limited competencies that result in perpetuated passivity, and a lack of autonomy and creativity.

Competencies that promote a banking education are divergent from the ones we are sharing in this essay. Here, we encourage the development of competencies that seek the development of creative and insubordinate mathematics curriculum that question pedagogical practices developed in teacher education programs in order to value and stimulate the use of diverse mathematical knowledge.

For example, Rosa and Orey (2015a) argue that this "process of choice is also creative when professionals oppose the selection of a particular pedagogical action that enables the maintenance of a social *status quo* through the development of curricular activities that prevent the development of student reflection and criticality" (p. 138).

A third group of competencies essential to the performance of teachers relates to: (i) promoting teamwork; (ii) participating in academic and school contexts; and (iii) use of new technologies (Perrenoud, 1999). In this context, practices that promote individualization, separation, stigmatization, and exclusion of groups of students who think differently should be reconsidered and replaced with pedagogical methodologies that share diverse forms of mathematical knowledge (Rosa, 2010).

This approach includes learning how to negotiate rules about learning with *others*, learning how to work in teams, and promoting students' togetherness and solidarity so that they are able to construct their own mathematical knowledge (Moffitt & Peppet, 2004). This also includes learning how to work with students from different backgrounds and beliefs and how to incorporate processes using negotiations between students involved in the learning process (Rosa, 2010).

The competences needed to work in teams includes respecting the student's point of view and introduces possibilities for the development of actions necessary in promoting changes in teacher education programs. In this regard, the mediation of technological resources and distance technologies become essential in the development of the ability to learn mathematics from *others*.

Hence, Perrenoud (1999) argues that it becomes relevant and possible to communicate with colleagues through programs that increase the educational possibilities of the curricular content with the use of multimedia tools in the teaching and learning process. Similarly, Rosa and Orey (2013a) state that the

> (…) proposition for Ethnomathematics as part of an ongoing training for future teachers is in line with current trends in mathematics education. Prospective teachers can foster skills to investigate mathematical ideas and practices that occur outside the school in order to develop them pedagogically through contextualized activities, matured under an ethnomathematics perspective (p. 60).

Rosa (2010) asserts that the use of technology in classrooms and different sociocultural contexts, such as social media, constitute a broad challenge to educators. In social media and gaming, the members of a group learn and share new ideas from each other, which provoke the development of a sense of cultural dynamism in the use of technologies and innovations that challenge the pace of questioning learned in the schools.

For example, D'Ambrosio and D'Ambrosio (2013) discuss the concept of *technoracy*, which is the ability students must use to combine different technological instruments that help them solve problems they encounter in everyday activities. Rosa and Orey (2015b) argue that from an ethnomathematical perspective, technoracy is as an important feature of mathematical knowledge as well its reification as technological artifacts. It can manifest itself in technological tools that translate ways of dealing with natural, social, cultural, political, and economic environments.

A fourth group of competencies that should be developed in teacher education programs and professional development contexts correspond to: (i) discussing the duties, ethical dilemmas, and challenges of the teaching profession; (ii) developing a professional sensitivity to recognize the other person's cultural wealth, and (iii) provide professional reflections about the importance of rethinking practices and the ability to review epistemological conceptions and act towards the development of teaching practices in the classrooms (Perrenoud, 1999).

Such competencies seek to provide inclusive mathematical practices that focus on the inclusion of students who require different educational needs in order to value diversity in the classrooms. It is important to point out that major challenges for teachers include developing an awareness of diverse approaches to mathematical content as well the ethical aspects and dilemmas related to the inclusion, racial, and gender issues. For example, Rosa and Orey (2015a) state that "there is a need to recognize mathematical knowledge originated from practice that stems from the cultural relationships and problem solving in diverse contexts" (p. 142).

In accordance to this context, four groups of competencies that we have established are essential for the teaching and learning process in order to encourage teachers to become both creative and responsible to developing insubordinate and subversive pedagogical actions that promote new learning and new scenarios in which teachers teach and learn along with their students by experimenting with alternative methodologies used to cultivate questioning, inquiries, and investigate issues raised by the students.

The development of this theoretical discussion enabled us to propose the following questions:

- How can teachers become insubordinate and creative, yet cultivate a sense of responsible subversion?
- How can teachers incorporate an ethnomathematical perspective in their teaching practices?

In the next section, we present a brief description to show how teachers may become insubordinate and creative in a responsible subversion posture in schools. In order to do so, it is necessary to explore the concepts of creative insubordination and responsible subversion in teacher education programs and in professional development course because, in accordance to D'Ambrosio (2014), the

> (…) teachers are prepared to follow orders and to fulfill, in a broad sense, what they were taught (…) they should teach a predetermined content, using a traditional methodology, having as a main objective the students passing standardized tests. Teachers receive in their training courses, contents and methodologies decided by distant authorities for the classrooms in which these teachers will serve in. Each classroom is different from another, students have different motivations, and teachers should have a lot of creativity to deal with situations that are new, many times not even imagined, and for which they were not prepared. They should be very creative, even if it means insubordinate, when it means not following the content and methodologies that have been taught in their graduate courses. They should be creatively insubordinate (p. 11).

Consequently, a question emerges from this assertion: How can creatively insubordinate teachers in distinct educations systems using mandated curricula act as subversive and responsible teachers? In order to answer this question, D'Ambrosio and Lopes (2015b) clarify that creative insubordination can be considered as an

> (…) act of opposition and, generally, to challenge established authority when it contrasts with the good of the other, even if not intentional, through inconsistent determinations, are exclusive and/or discriminatory. Creative insubordination has been aware about when, how and why to act against established procedures or guidelines. Being subversively responsible requires an assumption as unfinished and taking curiosity as the bedrock of knowledge production and makes this unfinished and a permanent movement (p. 19).

A challenge is imposed upon teachers in teacher education programs and in professional development courses that often limits development of their ability to experiment and act creativity. It is important that teachers use educational competencies against a bureaucracy that curtails innovative and experimental pedagogical practices. For example, Freire (1967) warns about the loss of creativity created by a mass education that results in settled and passive students who become adjusted to the system.

D'Ambrosio and Lopes (2014) argue that for teachers to transcend this classification system, it is necessary to perform acts of insubordination so that they are able to become creative professionals who have an understanding of the environmental, social, cultural, economic, and political contexts that influence the construction of

mathematical knowledge that, sometimes, promotes individualism and competition. Consequently, teachers must question, challenge, and change the current educational system.

We stress that for teachers to become creatively insubordinate in developing acts of responsible and subversive changes in their schools, they need to evolve competencies such as: (i) recognizing when significant learning occurs; (ii) investigate the apprentice skills so that they can promote the best use; (iii) cause the socialization of knowledge, stimulating epistemological curiosity; (iv) promoting the development of cognitive skills, including a sharpening sensitivity for collaborative practices, and finally; (v) seek to promote learning scenarios based on ethical values and actions of citizenship, giving voice to the subjects involved in the educational process (D'Ambrosio & Lopes, 2014).

This context enables teachers to understand and analyze teaching practices, competencies that allow them to review their pedagogical actions. For example, the results of a study conducted by Pinheiro (2017) showed the importance of teachers' collaboration that enabled them to promote the development of academic and professional skills that assisted in the inclusion of deaf students in a productive life and in the full exercise of citizenship. Thus, the main objective was to propose an innovative methodology in the teaching and learning mathematics for deaf students based on the assumptions of an ethnomathematics program related to the development of financial education content for this student population.

Hence, teachers need to continually evaluate themselves in regard to their teaching methodologies and develop formative evaluation systems. Collaborative work also makes a significant contribution in the development of creative teachers, because they are able to share valuable experiences obtained through failures and successes in their teaching practices in classrooms. But, how to become creatively insubordinate teachers in order to develop acts of subversion that eventually change educational systems established in traditional practices that exclude students from the minority groups?

In order to answer many of the questions posed in this essay, it is crucial that teacher education programs and professional development courses develop competencies that cultivate and propose learning scenarios related to the social and cultural contexts of the students. The possibility for the progress of this educational shift, which is insubordinate and creative as well subversive and responsible, is presented in the following sections in regards to the ethnomathematics as a program.

2. Ethnomathematics as a responsible subversive pedagogical action in mathematics teacher education programs

Ethnomathematics as a research paradigm arose in opposition to a dominant Eurocentric discourse in mathematics education, which emphasizes the school curricula developed and imposed on local communities during the process of colonization. This traditional view of mathematics curriculum is also highly valued in mathematics teacher education programs worldwide. In this context, ethnomathematicians challenge the view that members of distinct cultural groups that only develop simplistic techniques for solving problems they face.

The emergence of an ethnomathematics program can be interpreted to some extent as a reaction to this *cultural imperialism*[4] that spread around the world along with the expansion of great navigations in the fifteenth century (D'Ambrosio, 1985), and can be connected to concepts of *responsible subversion* (Hutchinson, 1990). In this context, and to achieve the welfare of members of distinct cultural groups, ethnomathematics relates to the flexibility of rules and regulations in mathematics teacher education programs.

In the field of mathematics education, according to D'Ambrosio and Lopes (2015a), *subversion* refers to teachers' practices that in an insubordinate way, but with discernment, are opposed to prescriptions with no pedagogical sense, of the educational bureaucracy and of public policy. This concept refers as well to actions that are assumed in relation to the norms and institutional rules, which aim at a better commitment to the needs of the school population.

This forms the central objective of mathematics teacher education programs related to helping prospective teachers to become responsible, yet subversive teachers. In these programs, the

> collaborative nature of the course [ethnomathematics], along with the reflection on practice, the group deliberations about implementing alternative teaching strategies, and the documentation of student learning, provided teachers with the confidence and self-efficacy necessary to defend the multiple dimensions of their practice and their acts of *creative insubordination*[5] (Lopes & D'Ambrosio, 2016).

In this sense, it is of great importance that educators put their competencies into practice and promote learning scenarios that seeks to develop in students actions of critical insubordination and responsible subversion. This approach in education is the antithesis of the development of

> most models of mathematics teacher education that aim to develop effective teachers of marginalized students (e.g., low performers, (...), students of color, working class students), rely on strategies that underscore the need for a mainly white, middleclass female population to understand the schooling experiences of *others* (Gutiérrez, 2012, p. 32).

Thus, educators can be considered responsible subversives if they design creative alternatives that can achieve better results for the common good of the community constituted by their colleagues, students and parents. This action is an opposition and generally a challenge to established authority when it opposes the good of others, even if it is unintentionally excluding and/or using discriminatory policies.

Responsible subversion means that people gain awareness about when, how, and why to act against established procedures or unjust guidelines, or do not positively serve their population. Being *subversively responsible* requires assuming oneself as an unfinished

[4]Cultural imperialism can be considered as the economic, technological, and cultural hegemony of developed nations that has come to determine the direction of both economic and social progress, many cultural values and standardizes civilization and cultural environment throughout the world (Sandbacka, 1977).

[5]In this essay, the concepts of *creative insubordination*[5] (Crowson & Morris, 1982) and *responsible subversion* (Hutchinson, 1990) are equivalent.

being that makes use of curiosity as the foundation of knowledge production and makes it a permanent search tool (D'Ambrosio & Lopes, 2015a).

According to this context, ethnomathematics can be considered both a subversive and responsive program because it often causes a disruption in the existing order in academic mathematics by encouraging and developing the study of local ideas, procedures and unique mathematical practices found in various, specific, and diverse cultural contexts, which are in accordance to the emic perceptions of its members (Orey & Rosa, 2014). In this regard, this theoretical program breaks the rules and bureaucratic expectations of academic mathematics in order to recognize divergent ways that values diverse modes of the mathematics produced in other cultures.

Because it has initiated a certain amount of disturbance that has caused a review of both traditional and western academic mathematical knowledge systems, the subversion triggered by this program is *responsible*. In this regard, responsible subversion contributes to the confrontation of taboos suggesting mathematics as a universal field of study without traditions and cultural roots (Rosa & Orey, 2015a).

A related challenge faced in mathematics education in dealing with the development of methodological procedures that helps prospective teachers to understand culturally bound mathematical ideas, procedures, and practices developed by members of distinct cultural groups without letting their own culture interference with the cultural background of others.

Furthermore, Presmeg (1998) argues that an "important step in using cultural practices in the affirmation of diversity in mathematics classrooms is that teachers and prospective teachers become aware of these issues through courses, such as the one described, in teacher education programs" (p. 336). These programs enable the development of active, critical, reflective, and responsible teachers, willing to collaborate with their peers in order to collectively seek solutions to the educational problems that emerge in their pedagogical practices (D'Ambrosio & Lopes, 2015b).

Consequently, teacher education programs in mathematics need to provide opportunities to prospective teachers to develop your competencies and to

> 1) broaden and add complexity to their understandings about teaching, learning, mathematics, and marginalized youth; 2) notice and develop multiple interpretations on situations they would not normally see (e.g., about mathematics, about students, about issues of social justice, about the profession of teaching); 3) develop an advocacy stance on teaching, learning, mathematics, and marginalized students; and 4) become adept at creatively responding to subtractive discourses that position marginalized students as incompetent and/or narrowly define mathematics as a predetermined knowledge base to learn, (i.e., be able to use creative insubordination) (Gutiérrez, 2015, p. 6).

According to this assertion, it is necessary, in these programs, to deconstruct the notion that mathematical ideas, procedures, and practices are uniquely *modern* or *European* in origin as they are based on certain philosophical assumptions and values that are strongly endorsed by western civilization. On the one side there are the beliefs that mathematical procedures are unique and that the sociocultural units of operation are

individual; on the other side there are beliefs that mathematical practices are the same and that its goals and techniques are equally applicable across all cultural groups.

An important goal is to challenge and strengthen existing theoretical models, including both their assumptions of mathematical universality and their claims of descriptive, predictive and explanatory adequacies. A second goal is to understand and explain existing and historical variations of mathematical ideas, procedures, and practices that vary across time, culture of origin, race, ethnicity, gender, sexual orientation, and other sociocultural characteristics. In this regard, it is recommended that mathematics teacher education programs are

> (...) concerned with interrogating oppression or promoting more social justice focus on teaching and curriculum — in particular, the ways in which teacher beliefs, teacher practices, and school policies like tracking can be viewed as forms of racism. At a practical classroom level, it is important for teachers and teacher candidates to recognize how popular educational reforms in mathematics can have different affects on students who historically have been marginalized (Gutiérrez, 2015, p. 13).

Therefore, when working with ethnomathematics in mathematics teacher education programs, it is possible to identify three approaches that assist us in investigating, studying, and coming to understand the mathematical ideas, procedures, and practices developed by the members of any given cultural group:

1. *Global* (*etic-outsider*) is the outsiders' view on beliefs, customs, and scientific and mathematical knowledge of the members of distinct cultural groups. Globalization has reinforced the utilitarian approach to school mathematics and the Western bias in the prevailing mathematics curricula, as well as helped to globalize pervasive mathematical ideologies.
   In particular, school mathematics is criticized as a cultural homogenizing force, a critical filter for status, a perpetuator of mistaken illusions of certainty, and an instrument of power.
   The mathematics curriculum is central to cultivating values as well as fostering *conscientization* in learners. In this approach, *comparativist* teachers attempt to describe differences among cultures. These individuals are *culturally universal* (Sue & Sue, 2003).

2. *Local* (*emic-insider*) is the insiders' view on their own cultural practices, customs, religion, sexuality, beliefs, and scientific and mathematical knowledge. Local knowledge is important because it has been tested and validated within the local context. Local knowledge creates a framework from which members of distinct cultural groups are able to understand and interpret the world around them.
   Currently, there is a recognition of the importance of the unique local perspectives and contributions to the development of scientific and mathematical knowledge. In this approach, the members of distinct cultural groups describe their culture in its own terms. These individuals are *culturally specific* (Sue & Sue, 2003).

3. *Glocalization* (*emic-etic*) represents a continuous interaction between globalization and localization, which offers a perspective that both approaches are elements of the same phenomenon (Kloos, 2000). It involves blending, mixing, and adapting two processes in which one component must address the local culture, system of values and practices (Khondker, 2004).
   In a *glocalized* society, members of distinct cultural groups must be "empowered to act globally in its local environment (D'Ambrosio, 2006, p. 76). In this context, it is "necessary to work with different cultural environments and, acting as ethnographers, to describe mathematical ideas and practices of other peoples. It is fundamental to give meaning to these findings" (D'Ambrosio, 2006, p. 79).

Through focusing on local knowledge first and then integrating global influences can create individuals and collective groups that are rooted in local cultural traditions and contexts but are also equipped with a global knowledge creating a sort of *localized globalization* (Cheng, 2005). Learners build an environment for mathematics when it stands on a context they understand from their own reality.

Accordingly, a question arose: *Should teachers tacitly agree with the imposed cultural universality (global) of mathematical knowledge or take on techniques, procedures, and practices of its cultural relativism?* In this regard, teachers seeking to link universal (global) and community specific (local) approaches face the classic dilemma of scientific goals conflicting with investigations in ethnomathematics.

3. Aspects of responsible subversion in mathematics teacher education programs rooted in ethnomathematical perspectives

Both the local and global approaches are often perceived as incommensurable paradigms. While they are thought of as creating a conflicting dichotomy, instead, we believe that they can be considered as complementary viewpoints, rather than posing a dilemma, the use of both approaches deepens and can clarify understanding of important issues in scientific investigations about ethnomathematics (Rosa & Orey, 2013b).

Since these two approaches are complementary, it is possible to delineate forms of synergy between the local and global aspects of mathematical knowledge. A suggestion is to use a combined local-global approach rather than simply applying one dimension. This combined local-global approach requires teachers to first attain local knowledge developed by the members of distinct cultural groups. This approach allows us become even better familiar with relevant cultural differences in diverse sociocultural settings (Rosa & Orey, 2015a).

For example, the results of the study conducted by Cortes (2017) revealed that ethnomathematics provides an integrative approach to the school mathematics curriculum that considers both etic and emic mathematical knowledge origins, so that teachers and students come to understand, in a more realistic, holistic and comprehensive way, the mathematics developed by the members of the different cultural groups that make up diverse student populations.

Ongoing debates regarding the importance of cultural diversity in the mathematics curriculum has also renewed the classic global-local debate. This discussion demonstrates why we need to better comprehend how to build scientific generalizations while, at the same time, try to understand and make use of sociocultural diversity. Yet, attending to unique mathematical interpretations developed in each cultural group can challenge the traditional goals of mathematics in which the main objective is to build theories that describe the development of mathematical practices in academia.

Local observers seek to understand mathematics and culture from the perspective of the internal dynamics and relationships as influenced within a group. A global approach often takes on a *cross-cultural* contrast or comparative perspective, which seeks to comprehend or explain different cultures from the outside worldview. Local worldviews clarify intrinsic cultural distinctions while the global worldview seeks objectivity as an outside observer across cultures (Anderson, 2007). These approaches are complementary.

This local approach seeks to examine the principles of classification and conceptualization from within the group. When the distinctions made by members of a particular culture are emphasized, a local analysis can be culturally specific in the context of the insider's beliefs, thoughts and attitudes. Local knowledge and interpretations are essential to an emic analysis, it says, *this is how we do this*. It is the viewpoint of the participant that conveys messages about mental and behavioral dimensions for the understanding of cultural contexts. Therefore, it is important to highlight that "what is emphasized in this approach is human self-determination and self-reflection" (Helfrich, 1999, p. 133).

A global analysis gives us a cross-cultural approach. Etic-oriented researchers examine the question from a more cross-cultural perception so that their observations are taken according to externally derived criteria. This context allows for the comparison of multiple cultures where "both the objects and the standards of comparison must be equivalent across cultures" (Helfrich, 1999, p. 132). Accordingly, in the conduction of ethnomathematics research, cultural, gender, social, linguistic, political, religious, and ethnic affiliations are researched and integrated into a unified holistic solution. In this manner, the intended mathematical practice is given a stake in the overall process and not just the mere ending result.

Ethnomathematics-based investigations in regards to teacher education programs have revealed the cultural influence in the evolution of world-wide mathematical knowledge through the study of historical accounts, which helped the analyses of ideas, procedures and mathematical practices developed locally, which aimed to deconstruct dominant mathematical discourse by offering innovative views about the nature of this knowledge (Ascher 2002; Orey 2000). In this sense, responsible subversion was used in this process when the norms and rules used in academic mathematics in these programs are inconsistent with the mathematical knowledge developed in terms of the local reality of the students.

It is necessary to emphasize how pedagogical action developed in many mathematics teacher education programs ignores this important connection between academic knowledge and the practices developed by community members. Thus, to reduce the gap between theoretical and practical knowledge in mathematics teacher education

programs, there is a need for prospective teachers to query possible connections between the mathematical knowledge developed in local, community contexts and that which are practiced and supported by the academy.

In this context, it is important to emphasize how the pedagogical action in an ethnomathematics-based program allows for comprehensive analysis of the school context because pedagogical practices transcend its physical environment in order to welcome knowledge and practices present in the sociocultural contexts of the students (Chieus, 2004).

In this approach, the pedagogical proposal of teacher education programs and professional development courses help transform mathematics into what learners come to see as *living* knowledge that includes real situations (Rosa, 2010). Thus, it is in the school community that educators may find didactic elements of the mathematical content necessary for the development of mathematics curriculum (Damazio 2004).

François (2010) argued that there has to be a translation to mathematics education where the teacher is challenged to introduce the cultural diversity of pupil's mathematical practices in the curriculum since pupils also use mathematical practices in their everyday life" (p. 1518). It is also important that the results of these investigations show that mathematical knowledge developed locally is worthy of recognition and appreciation by the members of the academic community (Rosa & Orey, 2015b). Similarly, it is recommended that

> Teacher education programs have incorporated study of multicultural classrooms into the pre-service preparation of teachers. Teachers must learn special instructional skills to accommodate different backgrounds and different learning strategies. It has now been recognized that culture can determine the student's feeling toward participation in class discussion, initiating questions, acceptance of authority, memorization of facts, seeking innovative ways of understanding, and many other aspects of classroom education. Misreading the cultural signs can cause teachers to misunderstand the student's learning process or even mistake a natural response for unwillingness to learn (Shirley, 2001, p. 86).

Responsible subversive teacher education programs using ethnomathematics recognizes both the uniqueness and can incorporate perspectives of the community as well as members of distinct cultural groups by emphasizing emic knowledge systems. Showing these perspectives in a dynamic way, and valuing them on their own terms and contexts (Rosa & Orey, 2016) allows learners to see a context for the mathematics they are learning.

It is important that ongoing investigations in ethnomathematics for mathematics teacher education programs describe and achieve ideas and procedures implicit in mathematical practices locally developed by community groups. In this sense, the research on these practices can be regarded as a form of resistance towards the imposition of academic mathematical knowledge as they may suggest actions in search of creative and innovative solutions to these challenges (Lloyd, 2011).

For example, a study conducted in Brazil investigated the specificity of mathematical ideas, procedures, and practices produced by adolescent and adult construction workers who were also students in an evening adult education course. The results showed that mathematical knowledge produced, developed, and transmitted in construction sites had important curricular implications. It also studied the connections of the local knowledge with academic knowledge legitimized by the school in order to determine curricular modifications (Duarte, 2004). The researchers found that these connections had positive results in the development of a more positive and relevant mathematics curriculum.

Responsibly subversive teacher education programs use ethnomathematics and contribute to the generation to a respect for diverse forms of mathematical knowledge and assists in resolving ethical dilemmas involved in investigations in this area of study. During investigations seeking to understand and comprehend local mathematical knowledge, teachers may be faced with a set of specific characteristics related to ideas, procedures, and mathematical practices different from those studied in the academy (Rosa & Orey, 2013b).

The above discussion demonstrates a need for educators to reconsider the greater western-Eurocentric perspective of mathematical knowledge (Anderson, 1997) and add local knowledge and experience to it. Hence, mathematical knowledge must be interpreted in the broader sense given that the term *ethno* is associated with members of identifiable cultural groups, such as national and tribal societies, working groups, children of a given age, individuals belonging to distinct professional classes, and marginalized and minority cultural groups (D'Ambrosio, 1985).

This approach may assist this ongoing reconstruction process, which seeks to relate academic (top-down) mathematics with sociocultural activities through the use of:

- Artifacts as observational objects created and developed by the members of distinct cultural groups. These instruments provide clues and information about its creators and users.
- Mentifacts as analytical tools such as thoughts, reflections, concepts and theories that represent the ideas and beliefs of the members of a particular cultural group, for example, religion, language, and laws.
- Sociofacts that represent the social structure of distinct cultural groups such as family and tribal structures. They can be considered as the patterns of interpersonal relations expected and accepted among the members of these groups.

This perspective aims to reduce the prejudice, inequity, and harm due to the disconnections between knowledge as practiced in the academy (etic) and its practical use in everyday life (emic) (Rosa & Orey, 2016).

Responsible subversion in mathematics teacher education programs can be seen as a responsible form of subversion that uses the theoretical and methodological apparatus of these investigations to reveal and combat the privilege and the authority that was granted to the academic mathematical discourse. This approach enables the development of understanding and comprehension of how privilege and authority, stemming from colonization, have influenced the distribution of power in modern society (Fitzsimons, 2003).

This context allows for the analogous use of responsible subversion to conduct research in ethnomathematics in order to start a changing process in mathematics education. However, it is necessary that professionals are willing to take the risks associated with that decision. This decision-making process is one of the most important components of responsible subversion, which can be understood as a fight against dehumanizing effects of bureaucratic authority (Haynes & Licata, 1995) that may occur during the conductions of investigations related to the ethnomathematics program.

It is necessary to outline ongoing research related to cultural perspectives in ethnomathematics in mathematics teacher education programs. Chiefly, this work acknowledges that contemporary academic mathematics is predominantly Eurocentric. Eurocentrism has its positive elements in relation to dramatic scientific accomplishments over the last 500 years. Yet, at the same time, it has hindered local mathematics ideas, specifically those once practiced by vanquished societies.

For example, the results of the study conducted by Rosa (2010) showed that traditional mathematics education aims at transmitting a certain techniques and uses them in artificial situations, which are presented to students as problems. These problems are artificially formulated in such a way that they only help the memorization of skills and techniques, which are usually boring, uninteresting, obsolete, and unrelated to reality or the modern world.

It has supported by a scientific paradigm that has allowed us to develop destructive military power and created financial chaos and environmental ruin for the planet. Many procedures and practices coming from local traditions have been lost, many are considered inferior, and therefore unimportant. There is growing evidence that current academic paradigm needs to consider the moral implications of its uses. Thus, the main objective of teacher education programs is to situate educational activity in the real life and experiences of individuals in their own socio-cultural-economical contexts. According to Freire (1993), this methodological approach opens up a series of possibilities for the way many teachers can approach educational practices.

Since a systematic ethnomathematics-based study, as called for here, aims at developing skills to observe phenomena rooted in distinct cultural settings. The results will lead to new viewpoints into mathematics education in order to improve cultural sensitivity in the teaching of mathematics. Ethnomathematics is defined as the study of mathematical phenomena within a culture, thus, it differs from traditional conceptions that consider mathematics as western-academic forms of mathematics as the sole foundation of science. Therefore, in an ethnomathematics process, mathematics is a social construction and is often culturally bound and is diverse.

Mathematics teacher education programs based on an ethnomathematics perspective emphasize the importance of community to school It is necessary that the school curriculum is designed to value and promote local knowledge (emic) and practices developed by members of communities who integrate school contexts. So, this perspective provides a necessary balance to school curriculum because the integration of these components in the mathematics curriculum enables the conception of ethnomathematics as a program that aims at the humanization of mathematics through contextualized approaches to curriculum development.

Because pedagogical practices often transcend physical environments in order to welcome knowledge and practices present in diverse sociocultural contexts, it is important to emphasize that these pedagogical actions in the context of mathematics teacher education programs allows for comprehensive analysis of the school context (Rosa & Orey, 2015a).

In this approach, one important pedagogical proposal that can be offered by a teacher education program is to develop mathematics knowledge in future teachers that allows them to freely transform mathematics into living knowledge and integrates real situations through questionings, analysis, and critical reflection of phenomena that occur in everyday life. Thus, it is in the school community itself that teachers find the didactic elements of the mathematical content necessary in the development of mathematics curriculum (D'Ambrosio, 2006).

Hence, there is a need to diversify teaching strategies used in the mathematics curriculum. In this case, an ethnomathematics perspective supports this. It must be acknowledged here that, like in literature, art or cooking, there is no single recipe that will help prospective teachers everywhere to acquire all the necessary pedagogical tools for improving the performance of students in mathematics. In this sense, educators need to be supported in developing innovative educational pedagogies that help students and communities reach their potential.

Responsible subversion, especially in regards to ethnomathematics in mathematics teacher education programs, can be considered as a tool to combat against dehumanizing effects of curricular bureaucratic authority and as a tool for peace. According to this context, Haynes and Licata (1995) argue that the objective of this subversion is to ensure that curricular bureaucracies do not disservice students because, often, public policies and institutional procedures have no real connections with the school community, which means

> (...) helping teachers develop not just knowledge of mathematics, pedagogy, and learners, but also the political knowledge and experiences necessary to negotiate the system (e.g., learning how to use creative insubordination to buffer themselves from mandates that are not in the best interest of their students) and develop working networks with other educators who share their emancipatory visions (Gutiérrez, 2013, p. 62).

According to this assertion, responsible subversion is necessary to the development of teacher education programs in order to assist prospective teachers to serve students' learning. This should be the main concern of any educational system in order for teachers to address student's cognitive and pedagogical needs. Surely, this demonstrates the need for a new perspective in the mathematics teacher education programs.

4. Final Considerations

In this essay, the authors identify creative insubordination as an essential element in the pedagogical action of ethnomathematics in teacher education programs and professional development courses because it seeks to connect school mathematics to the

mathematical ideas, procedures, and practices developed locally. In this regard, the authors hope that this essay enables readers to reflect about questions of why these programs and courses should consider creative insubordination in reinterpreting the mathematical competencies of the teachers.

Thus, it is necessary that teacher development programs and professional development courses are designed to value and promote local knowledge and practices developed by the members of the communities that integrate community contexts into the mathematics curriculum, which enables the humanization of mathematics through contextualized activities in the mathematics curriculum.

Consequently, there is a need for the teacher education programs and professional development courses to help prospective teachers to diversify teaching strategies used in the classrooms, because there is no single recipe for improving the performance of students in mathematics in a insubordinate and creative way by being committed to innovative educational practices in order to help students to reach their mathematical potential. This type of creative insubordination can be considered as combat against the dehumanizing effects of curricular bureaucratic authority.

Both teacher education programs and professional development courses opportunities constitute strategic areas for the promotion of equity and social justice in understanding contemporary society. In order for this to occur, the work of mathematics educators must be provided with competencies that encourage insubordinate and creative acts of responsible subversion into the mathematics curriculum. It becomes urgent and indispensable for students to learn mathematical content in connection to their sociocultural contexts to show that the development of mathematical knowledge is not formatted on in a Eurocentric perspective.

The ethnomathematics program as conceived by Ubiratan D'Ambrosio assists teachers and illuminates their epistemological and pedagogical paths. What is established is a possibility for action in teacher education programs and professional development courses is the inclusive, insubordinate, subversive, yet creative and responsible approaches to mathematics education that promotes the inclusion of students with different ways of thinking and learning styles in order to construct mathematical knowledge.

Moreover, an ethnomathematics program is constituted as a way in which teachers can discuss and share their experiences and expand their competencies in order to value and respect diverse modes of doing mathematics that are not in accordance to the mathematical thinking practiced in the classrooms.

Finally, it is urgent that an important transformation in mathematics education takes place in order to accommodate changes in teacher education programs and professional development courses. Therefore, the main goal of teachers should be to accomplish equality among students by incorporating ethnomathematics into the school curricula. In this regard, mathematics has to be made equal for all students.

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