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Teacher training for a mathematics education in and for diversity

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Abstract

The purpose of this article is to present a research based on a process of training teachers in mathematics education who work with populations with cognitive deficit (Down syndrome), auditory limitation or low vision, and deafness or hearing loss. Teacher training is theoretically assumed from the onto-semiotic approach (Godino, Batanero and Font, 2007); the trajectories of learning (Clements, and Sarama, 2009 and Simon, 1995); the registers of semiotic representation (Duval, 2004); the didactic situations (Brousseau, 2004), and the didactic knowledge of the mathematical content of populations in cultural contexts (Shulman, 1986). The methodology is qualitative interpretative, (Medina and Castillo, 2003), because it is a method to observe behavior of teachers and students. This study was conducted with a group of 25 professionals and support teachers, through an action research process, for which a plan, action, observation and reflection of the research was designed. The results show, on the one hand, the degree of motivation generated in the professionals who serve these populations; and on the other hand, they offer those teachers tools so that they can facilitate learning for these students, and thus achieve a mathematical education in and for diversity, as a gateway towards an inclusive education.

Keywords: Diversity, mathematics education, teacher training.

Introduction

The purpose of this research is to develop a training process with professionals and support teachers who have not necessarily graduated in mathematics, and who therefore require an update and improvement in mathematics didactics. The purpose is that they acquire some knowledge instruments, so that they can attend populations who requiere inclusive education (Ministerio Educación Nacional, MEN, 2017); focused on the particular case of people with differentiated abilities such as: Cognitive deficit (Down Syndrome), auditory and/or low vision limitation, and deafnes and/or hearing problems, in order to elaborate a didactic environment favorable for these populations, as a learning potential for mathematics; and the technological resources as necessary instruments to offer multiplicity of forms of exploration with mathematics to these populations on the apprehension of numerical, geometric, metric, variational and random phenomena.

In this sense, the educational process builds an enabling environment: "which should be the one that fits and adapts to the particularities of everyone, identifying and working on the barriers that exist for learning and participation (MEN, 2017, p.5)." It is about carrying out a process of teacher training and updating, linked to the sociocultural aspects of mathematics education, in order to offer children, youth and adolescents a better quality education and equal opportunities, through institutional policies for the 21st century.

In the last decades, as a product of the analysis and reflection on the importance of the role of teachers in the processes of transformation of conceptions, practices and attitudes that directly affect education, there have been generated educational reforms in several countries of Latin America, which demonstrate that this has not been enough and that it is necessary to change the traditional training of teachers, focused on the disciplinary, especially when it is necessary to train mathematics teachers who recognize the diversity of contexts, technological advances, the learning rhythms of the students, the economic, social, and political situations of the students and the communities where the educational system is developed, so that the teachers can act on the aforementioned recognition and (thus) facilitate access to mathematical knowledge.

One of the tensions occurs between educational systems and educational policy at the global, regional and local levels; it is to promote the implementation of different strategies and the creation of educational environments. So, in what way do proposals for updating and training mathematics teachers in practice incorporate these particularities, make them visible and work with them? With what kind of curriculum do future teachers of mathematics face, so that they can respond to one of the greatest challenges teachers face in the 21st century, making it possible for

the right to education to become a reality for all? Which is equivalent to say that, in spite of the diversity of genres, cultures, learning rhythms, economic conditions, life stories, disabilities, languages and many others, there can be generated social, affective and academic conditions in order to learn mathematics.

The challenge is for any educational system that intends to build future teachers of mathematics and to promote in the current teachers, with the purpose of overcoming the social and cultural need of transforming educational practices by which (it is possible to) access mathematical knowledge, which cause that the area of mathematics be considered the one that creates the most complications for students and teachers, since it has the highest rates of academic failure in students and people in general, rejection, discouragement and lack of motivation for learning.

In view of the above, the action proposal is performing a research, framed in the training of mathematics teachers for performing in intercultural education. Therefore, this research proposes to make visible the needs, possibilities and potentialities of the populations that are in conditions of sensory and cognitive diversity, starting from the following question: What didactic aspects should be taken into account for the didactic training process of professors who attend populations in conditions of intellectual disability (Down syndrome), auditory limitation (deafness and difficulties for hearing) and visual impairment (low vision and blind), of formal and non-formal education institutions in Armenia - Colombia?

Theoretical framework

First, (the expression) *inclusive education* in the context of this article is assumed according to the (definition given by) MEN (2017, p. 4 - 5), as:

A permanent process that recognizes, values and responds in a relevant manner to the diversity of characteristics, needs, interests, possibilities and expectations of all children, adolescents, youth and adults, with peers of the same age, through practices, policies and cultures that eliminate barriers to learning and participation; guaranteeing changes in the content, approaches, structures and strategies in the framework of human rights (MEN, 2017, pages 4 - 5).

In the MEN document: "Inclusive education approach in the pedagogical update of Educators" (2017), six basic principles of inclusive education are explained. According to the experience lived in the training program with the participating teachers, it was made an adaptation of the figure, where there are incorporated other relevant elements that come into play to teach people with sensory and/or cognitive limitations, in order to facilitate learning to these populations, and to achieve true inclusion.

Graph 1: Basic Principles of Inclusive Education

Source: Adaptation of "principles in their sections, most of them were literally taken from the Policy Guidelines for Inclusive Higher Education, MEN (2017).

In relation to teacher training, it is considered as the set of curricular references in contexts of diversity, from the onto-semiotic approach (Godino, Batanero, and Font, 2007); Learning Trajectories (Clements, and Sarama, 2009 and Simon, 1995); registers of semiotic representation (Duval, 2004); didactic situations (Brousseau, 2004), in the approaches of Shulman (1986), propose that knowledge to perform the practice of teaching mathematics should incorporate knowledge of the cultural environment of the classroom and the conditions of their populations in their context. In this regard, Bruno and Noda (2010, pp. 146-147) say that: "Teachers who attend special students have a strong background in psychological and pedagogical aspects, but they have not received training in didactic contents of curricular areas, which leads them to have insecurities in the treatment of the different contents."

The study in the cognitive social (Vygostki, 1979) argues that, in fact, the individual functioning is determined exclusively by social functioning; and that the structure of the mental processes of an individual reflects the social environment from which he/she comes from; in the manifestations of cognitive and cultural competence of people with cognitive limitations (López Melero, 1999). In particular, (Ruiz, 2013) states that it is not enough that students with cognitive deficit (SD) attend school, because they should be given opportunities to make the most of the school space, and that this is achieved when they get the necessary attention, a favorable attitude and an adequate formation of the educators; the deaf connect with the world through vision, and the use of a sign language confers them traits of their own identity; and in people with low vision, education has to get in tune and use the advantages that cybernetic systems and artificial intelligence can provide them (Blázquez / Lucero, 2002).

Materials and methods

The methodology on which this research is based is qualitative interpretative (Medina & Castillo, 2003), because it uses an appropriate method to look at the nuances of behavior of teachers and students; it (also) generates affirmations and reflective questions based on evidence from of the analysis and the objectives of the investigation. Through the communities of practice, the aim is to obtain didactic sequences mediated by technological incorporation for the initial mathematical development of the populations who are the object of this study.

Based on the analysis and the results obtained from the research, it is expected to validate the theoretical and methodological reference framework, networking and thinking about the training of teachers; and the technological, pedagogical and didactic materials that offer teachers the tools necessary to teach people with sensory and/or cognitive limitations; therefore facilitating learning to these populations, according to their needs and expectations, and in this way achieve a true inclusion in the conventional education system.

The focus has been on a research-action methodology guided by the (following) phases: 1. Identification of the target populations of the research and of natural teaching environments. 2. Preparation and application of a diagnosis, in order to meet the needs and expectations of teachers. 3. Development of didactic laboratories for the epistemological approach towards the three fronts of interest, on the mathematical objects of study, the theoretical and methodological framework of the research. 4. Design of didactic situations, which relate the numerical thoughts, spatial-metric, variational and random, in particular, the understanding/ construction of basic mathematical concepts in populations with cognitive deficit, deafness, and blindness. 5. Teacher updating through practices during the seminar on didactic sequences in the three populations, taking real objects as articulatory axis, in order to generate motivation in teachers for mathematics and its teaching. 6. Application of the theory and practice of teachers with their students in natural environments of teaching and learning. 7. Validation of the didactic sequences elaborated by the same professionals and support teachers, in order to share the results obtained with the academic community through the presentation of a product, as a result of the updating and improvement of the teaching staff.

Results and Discussion

With the purpose of configuring the general objective of this research in the training of professors who serve populations with differentiated capacities at the levels of: cognitive deficit (SD), auditory limitation (deafness and difficulties for hearing) and visual limitation (low vision and blindness) of institutions educational, it was performed the

analysis of a twenty-question diagnostic instrument, of qualitative and quantitative type. with open answers that provide personal appreciation on the strengths and weaknesses of supporting teachers who teach mathematics to disabled students.

In relation to professional training, according to this variable, it is observed that the vast majority of teachers do not adequately handle the mathematical area in terms of conceptualization processes; for this reason, there can be generated shortcomings in the teaching of basic concepts in the diverse populations of diversity; likewise, learners may present insecurity when facing the mathematical context, or the development of learning itself.

On the other hand, they acknowledge not having a good experience during their training process regarding the form of teaching and learning of mathematics that they had to learn by themselves and consider, because they do not have the disciplinary knowledge to develop mathematical thinking in these three populations to which reference is made throughout this document.

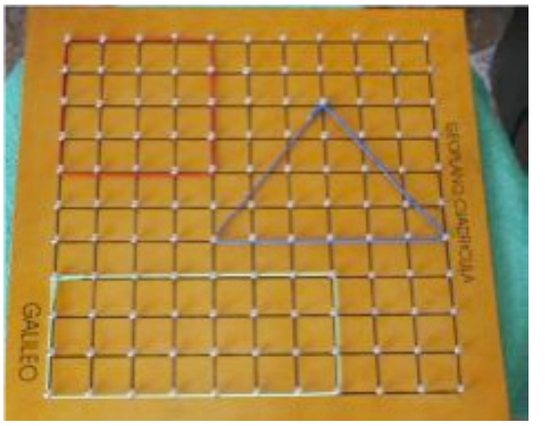
They recognize the training and updating in general aspects of the training of a support professional and support teacher, but they do not know updating elements regarding the knowledge of the disciplines; and in particular, of mathematics, the results allowed to identify conditions and needs of the teachers for teaching in contexts of diversity and recognize resources (cognitive, physical, communicative, emotional, social) from the difficulties of communication, representation and problem solving at the time of teaching mathematical concepts in the classroom.

From the diagnosis made in the consecutive phases of the process, different didactic sequences were designed from different theoretical approaches. Here are some examples:

Didactic sequence 1: counting

Objective: Through the *Geoplano* (2). The student will be able to explore geometric objects, in order to recognize the shape and size, and to perform association processes, correspondence and object counting.

Graph 2. Concrete material set MathGalileo



Source: the authors

Didactic variable. Counting (one-to-one relation, one-to-many relation, many-to-one relation)

Class management

A geoplane is handed out (to the students). This material allows to build a geometric place from a minimum unit, until the grouping thereof, for which they need to add wool, string or elastic bands, in order to make the association nail, unit, grouping of units and shape. The above allows to request the participants to carry out the activity.

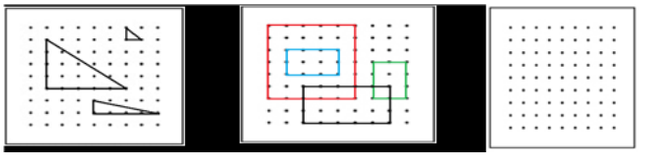
Procedure

1. The Geoplane board is presented to the children for a process of sensitization with the support material [Touching - Feeling - Observing] and

2. Build different shapes (forms) using the Geoplane and the elastic bands, oriented by the facilitator. (See Graph 3.)

Graph 3. Geometric figures built with the bands

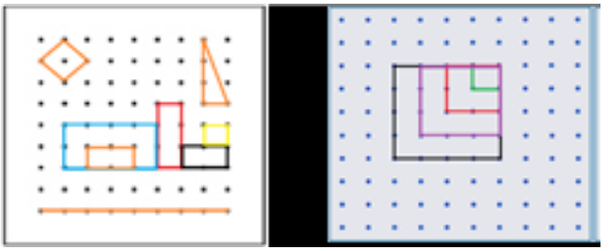
3. The facilitator asks contextual association questions to the students, such as: What do I draw? What does it mean? In order to determine the concept of closed figure or open figure.



Source: the authors

4. Now the students are asked to do the following with the Geoplane and the elastic bands. (See Graph 4.)

Graph 4. Other geometric figures that were built



Source: the authors

The above allows us to ask questions in the following way: What is the name of the flat figure that you drew? Are they of the same size? Are they equal (in size)? Which one is bigger? This spatial description of the object allows us to ask: How many points are enclosed? Respectively, how many points were covered with the elastic band? As a directional challenge, the student may be asked to draw the figures again, but in such a way that (see illustration) allows to ask questions such as: What is the color of the smallest "square"? The larger one? Is the red square inside or outside? Is it possible to fill the black figure with green figures? (Correspondences - Inclusion).

Sequence analysis

The participants were able to transfer, without difficulty, the figures of the photocopy to the Geoplane; and at the moment in which the facilitator asked questions like the number of nails present inside, they responded correctly, which made us feel that they recognized characteristics such as "interior of a figure" or "outside of a figure." In addition, they built some figures considering elements such as the number of sides, the interior or the exterior region of the construction made.

Didactic sequence 2: identification of the forms in the environment

Objective: To recognize shapes, sizes, colors, properties, relationships and representations of some geometric concepts, from the observation and manipulation of objects of the environment surrounding the students.

Resources: Students' environment, paper, and colors, domino tiles of geometric figures.

Didactic variable: shapes, sizes, colors of some geometric figures

Management of the class:

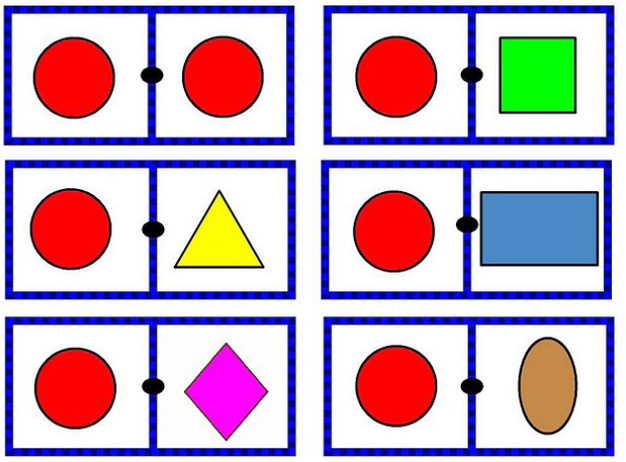
Children's space is surrounded by geometric elements with concrete meanings: doors, windows, floors, boards, desks. In their everyday environment, at home, city, school and parks, they learn to organize mentally and orient themselves in space. This is the appropriate context to develop the geometric teachings, in a meaningful way.

From these situations and through manipulation and visualization of objects, there can be encouraged the development of geometric concepts.

Procedure:

- The teacher seeks that students find different forms in the environment, and that they establish a relationship between geometry and the real environment, where these geometric elements take on meaning.
- Based on stories, (the teacher) guides students to observe these elements in a real physical environment.
- Through questions, it is intended that students establish a relationship between geometry and the real environment, where these geometric elements take on meaning.
- Through the previous instruction, students are asked to make representations of the different geometric objects that they consider (that are) present in the observed environment.
- To strengthen the representations of some geometric figures, the game of domino tiles is proposed for couples. This game works with all the populations, making modifications for each of them. For the case of a blind or low vision population, each figure of each domino tile, with a slice, is embossed, so that the blind student can identify each one. (See Graph 5.)

Figure 5. Domino tiles



Source: Recovered from: http://miescueladivertida.blogspot.com.co/2011/09/juego-de-domino-figuras-geometricas.html

Sequence analysis

The participants were able to identify, without difficulty, the figures of the domino tiles, associating each one with their respective names; and recognizing the similarities and differences among them. Finally, they played the game in pairs. (See Graph 6.)

Graph 6. Polygon model

Source: the authors

Didactic sequence 3: polygons and polyhedrons with didactic material (with multiple die cut edges)

Objective: To identify the characteristics of different polyhedrons with their flat and spatial form.

Didactic variable: polygons and polyhedrons

Class management

Through this activity, it was intended that the students were able to recognize the number of faces and the classes of polygons that form a polyhedron. In addition, there were built polyhedrons with didactic materials; and the names and mathematical formulas were determined, in order to find the lateral and total areas, and the volume of the regular polyhedrons.

Procedure

1. Present (to the students) the classes of polygons in didactic materials.
2. Write down on the board the names of the polyhedrons that can be assembled with the polygons.
3. Hand out, by groups, sets of different polygons: squares, rectangles, equilateral and isosceles triangles, pentagons, hexagons.
4. Build prisms and pyramids of different bases, recognizing characteristics and properties of each one.
5. Assemble the regular polyhedron: tetrahedron, octahedron, dodecahedron, and icosahedron. Recognize the characteristics of each one.

Sequence analysis

It was possible to demonstrate the polyhedron that caused the students more difficulty to build. Through a test in three columns, students related the name of the polyhedron with its flat and spatial form. In addition, students proposed different procedures to find the lateral, total and volume area of prisms, pyramids, and regular polyhedrons.

Didactic sequence 4: mobile (devices) digital contents

Objective: To recognize different mobile applications as support tools in mathematics.

Didactic variable: digital environments

Class management

Through this activity the students are expected to recognize apps (short for "mobile applications" in English) designed to be executed on smartphones, tablets and other mobile devices, which allow a specific task, at professional and educational level, and access to services.

Procedure

Developed activities:

1. Definition of mobile application.
2. Distribution: Android (Google Play), Windows and Apple.
3. Team work: the students are organized in groups of 3 people, each group is given a tablet with the following environment to work on a guide for the recognition of digital tools and some applications for education in Android. (See Graph 7.)

Graph 7. Mobile applications for the construction of geometric figures and development of mathematical operations.

Source: the authors

Sequence analysis

It was evident in the students that the use of digital environments, as a support tool, favors the learning of the initial mathematics and is a determining element to recognize properties of mathematical concepts.

The sequences designed and worked contribute to the development of mathematical thinking, in some mathematical notions that are part of the types of numerical, spatial, metric, random and variational thinking, which were developed with the teachers participating in the training program in such a way that they could be taken to the classroom, where teachers had the opportunity to use both manipulable material and digital environments.

Conclusions

The problems that supporting professionals have with these populations are: absence of representation of mathematical concepts, difficulty in establishing relationships between forms of representation of a concept, poor applicability of mathematical concepts, lack of ability to propose problem-solving strategies, lacks in Braille management, absence of specialized material and conflict to solve problems that involve logic, sign language difficulties, communication barriers that hinder interaction with their peers, lack of understanding, and application of concepts, and absence of meanings of mathematical concepts.

The majority of supporting teachers who participated in the mathematics education training program, who attend populations with cognitive deficit (Down syndrome), auditory or low vision limitation, and deafness or hearing loss (hypoacusis), are not professionals in the area of mathematics; however, they showed great interest in the appropriation of the different theoretical and methodological frameworks worked on, in order to incorporate them in their classrooms and to propitiate spaces that lead to the fulfillment of the proposed objectives of inclusive education.

The epistemological framing made with the teachers allowed them to recognize some theories in order

to partly mediate the difficulties that were evident, and to recognize the didactics of mathematics as a scientific discipline and not with a solely instrumentalist vision. The degree of motivation reached by professionals and supporting teachers exceeded expectations and was demonstrated by the reflections they shared and the field work with other teachers and students from their own natural scenarios of teaching and learning mathematics.

The journey through the didactic from the different thoughts, the use and implementation of resources as a means for the didactic transposition for the teaching of mathematics generated in the participating teachers greater interest in mathematics, as well as a different position at the time of transferring to the students the mathematical notions addressed in the different didactic sequences.

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