Application of mathematical modeling in the construction of the ecological house and the teachers' perspectives in this teaching trend

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ABSTRACT
The investigation was carried out in a public school in the Federal District, located in the Structural Administrative Region, in the period of one year, to verify the perspectives of the teaching trend Modeling and a reflection of mathematics interacting with an environmental conscience. The article intends to disseminate the results of the research carried out on Mathematical Modeling and promoted with the incentive of the Scientific Initiation Program (PIBIC) of the Federal Institute of Education, Science and Technology of Brasília – structural campus. The investigation aimed to identify the methodology most used by mathematics teachers and how the discipline was approached, as well as to carry out the creation of an ecological model. The methodology was bibliographic reviews, questionnaires for teachers, intervention through the production of a model and reinforcement strategies for students in mathematics content, aiming to promote a different perspective on how to solve the proposed activities and introduce the basic concepts of geometry , with the vision of applying several objects with different geometric shapes for the construction of the model. Regarding the teaching trend of Mathematical Modeling, the teachers who answered the questionnaire stated that they did not know this methodology, at least with this name. Furthermore, it was identified that most of the classes were transmitted in the traditional way, that the teachers did not feel comfortable using new methodologies and/or methods, so that the meetings and the production of the model collaborated effectively for the student and teacher learning in the contents related to the recycling of sustainable materials, in order to innovate activities proposed in the classroom.

Keywords: Geometry, Mathematical Education, Mathematical Modeling.

1 INTRODUCTION

The project was based on outlining the process of teacher education in relation to trends in the teaching of mathematics making use of mathematical modeling, given that modeling allows the application of activities and research that develop the creative thinking of students, giving room for criticism and the expansion of the understanding of mathematics for the daily life of students.

It is widely recognized that the role played by teachers is strategic in any curricular proposal, as they are the ones who organize, decide and orchestrate classroom activities. "It is known that teachers interpret and implement new proposals in the light of their knowledge and conceptions." (THOMPSON, 1992).

It is then up to the teacher to stimulate through this thought the learning of his students showing how teaching can be different from repetitive and similar formulas and exercises, because for Almeida and Dias (2004, p. 2), "taking into account that it is also up to school education to prepare critical, conscious and integrated subjects to society, teaching should take place in environments where learning happens in a significant way". Above all, in the context of mathematics, learning must make connections with actions so that the student has the "opportunity to experiment, model, analyze situations and develop a critical spirit about the solutions found."

The creation of the model then stimulates the students' learning, promoting the idea of the formation of future conscious citizens, bringing them not only the opportunity to build, but to understand the world around them and to which their contribution belongs.

According to CASTROGIOVANNI (2000, p. 74), "The model is a three-dimensional example of space, works as a laboratory, promotes the social interactions experienced by students and teachers on a daily basis, are perceived in the context and produces a systematic activity in geographical representations."

The project was outlined on the process of teacher education in relation to the Trend of Teaching Mathematical Modeling that adds significant learning. Modeling allows the application of creative activities through models, formulas, images, visual processes that activate learning, to quantify through visual learning.

The research had its direction in two questions **:** – What is the level of knowledge in relation to the Mathematical Modeling of the Mathematics Teachers of Basic Education and the performance of the transversal themes? How many teachers know about this teaching trend?

Teaching and learning have gone through several historical moments with many pertinent contributions that have made a relevance in learning. But, currently, it is still reported facts in which teachers can not elaborate association of the content to what is already known. This process is defined by AUSUBEL (1982) "as mechanical learning, without interaction with important concepts inserted in cognition, promoting learning through memorizing formulas or mechanical processes".

For AUSUBEL (1982), the significant learning is related to the content directed in a synthetic way, promoting the interaction of a certain aspect of the previous cognitive structure, being the conceptual antagonistic the mechanical or repetitive learning.

This learning process connects the mathematical contents with a construction model to make the connection of what is learned in contextualized situations. Thus, meaningful learning presents enrichment in the cognitive structure of the student through previous and new knowledge.

In addition, the Mathematical Modeling provides this learning, especially in the situation of the project, directed to the creation of the **model -** ecological house **-** promoting a contextualization, because the model is known by all.

In this sense, "mathematical knowledge must go beyond the simple resolutions of mathematical questions, often without any meaning for the student, and lead him to acquire a better understanding of both the theory and the nature of the problem to be modeled." (BIEMBENGUT; HEIN, 2000, p. 18).

Thus, the creation of the model promotes the interaction of the previous cognitive structure with the mathematical contents. Emphasizing one of the competencies present in the current BNCC for elementary education "Use mathematical processes and tools, including available digital technologies, to model and solve everyday problems, social and other areas of knowledge, validating strategies and results."

Thus, Mathematical Modeling creates situations that model the transmission of knowledge, facilitating the teaching and learning process and promoting a teaching capable of involving current situations and close to our conviviality in the models presented and suggested for the assimilation of what is learned. Defined by Biembengut and Hein (Apud SANTOS; OLIVE TREE; ALVES, 2013, p. 6):

> The idea of modeling evokes the image of a sculptor working with clay, producing an object. This object is a model. The sculptor armed with material – clay, technique, intuition and creativity – makes his model, which in the right represents something, whether real or imaginary.

The model becomes the learning model with the transmission of teaching and learning through various perceptions, involving learning by cognitions. Because when approaches are promoted with different subjects, introducing motivating aspects such as games, models and others, they create situations that involve the student to arouse interest in the content and the conception of the reality of a whole, especially their own role in this reality.

Therefore, the project outlined a study on the knowledge of teachers in relation to the trend of teaching Mathematics, focusing on Mathematical Modeling through the model to verify the use of teaching trends in the teaching and learning process. The result served as an indicator of how the

procedure of future graduates should be in relation to the trends in the teaching of Mathematics in professional performance, elucidating the dynamics of teaching and learning in the discipline of Mathematics, since the research was developed by the Scientific Initiation Program.

The development of this research and results contributed to the Center for Research in Mathematics, Education and Society **— IFB/CNPQ** and NEPECS — IFG/CNPQ .

The investigation had as general objective to identify if the teachers of the discipline of Mathematics of the basic education of the school located in the Structural know the trend of Teaching of Mathematics, Mathematical Modeling and if they use interdisciplinary.

In order to achieve the general objective, the respective specific objectives were directed:

1. To question the professors of the discipline of Mathematics about the Mathematical Modeling and its application with transversal themes;
2. Present the model, ecological house, with recyclable materials;
3. Evaluate the comparative results before and after the presentation of the model.

In addition, the model through the intervention research promoted new conceptions regarding the mathematical and environmental contents and presented a contribution to future studies in relation to the students' conception of the environment. It indicated the possibility of directing an improvement in the quality of teaching in relation to the environment, in an interdisciplinary and transdisciplinary way, according to the results presented.

2 METHOD

The research made a bibliographic review of qualitative and quantitative application, as well as an intervention, because the bibliographic methodology based the intervention and the conception of the model with recyclable materials. (MARCONI; LAKATOS, 2003).

The quantitative processes were delineated through the results in relation to the numbers of teachers who know the trend of teaching Mathematical Modeling and its application in the interaction of teaching and learning significantly. As for the qualitative data, questions of conceptions of Mathematical Modeling were applied to teachers and students.

Initially, the intervention was proposed only at the time of presentation of the model to students and teachers, because the mathematical modeling in the form of a model in the presentation of an ecological house fosters conceptions about environmental education, mathematics education, meaningful learning and other questions during the process. For the intervention provides, according to MOREIRA (2008), "the consideration of social and everyday realities and the ethical and political commitment of the production of innovative practices".

The intervention was carried out in an educational institution in Estrutural, in the context researched, triggered by the question and cooperating in the solution of problems. The scholarship

holder acted as a mediator who articulated, organized meetings, provided opportunities for the interaction of knowledge, old and new knowledge, fruit of the subjects involved in the research, valuing the daily knowledge and practices of the collective, systematized, admitting discoveries and methodological theoretical elaborations.

There was a proposal that the scholarship holder offer the intervention in the opposite shift to better help the content, however, the vast majority of students chose not to attend because there was no obligation. Then the intervention and all the activities related to research were done with the students that the teacher made available, either for the good performance, or for the need for content review.

Thus, the intervention did not occur only in the presentation of the model, but also at other times, especially on Thursdays and Fridays, almost every week, with the exception of holidays, recesses. And when the teachers responsible for the classes needed the time directed to the intervention, during the period of one school year, starting in March with a duration of 6 hours available per week.

In this process, several moments of interventions were applied with mathematical activities that included actions with concrete materials, kits of flat figures, various manipulable geometric shapes, such as: *tangram*, pyramids with triangular and square bases, cylinders, quadrangular prism, triangular prism and rectangular prism. The mentioned kits (wood material) were purchased because the school did not have them. But, it is suggested to make the planned objects with EVA material (Ethyl Vinyl Acetate).

At other times of the intervention, the mathematical activities applied to the students were through drawings with various formats, so that they could create the geometric shapes and identify each shape of the drawing, with A4 sheets, colored pencils, colored pens, pencils, erasers, scissors and others.

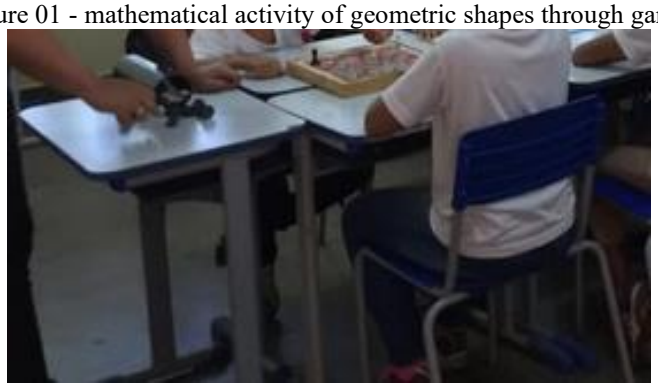
In addition to these activities, the scholarship holder used objects in some interventions for students to identify and relate to the geometric shapes in the proposed activities. Example: Rubik's Cube, binoculars, ball, milk carton, oil can, among others.

In addition, the students were asked to identify some objects at home and to be able to recognize which geometric shapes were present.

Two types of games were also provided, because the games present geometric shapes through the board itself and the pieces, such as chess and lady, and in some moments, the sweets were the prizes.

At first, the intervention would occur only in the presentation of the model, and the mathematics teachers were perceiving the actions of the research, thus, they asked the scholarship holder to provide other activities with diversified resources, as shown in Figures 01 and 02.

Figure 01 - mathematical activity of geometric shapes through games



Source: Author.

Figure 02 - mathematical activity of geometric shapes through technological resources

Source: Author.

We also used the application designed by the scholarship holder himself in partnership with a researcher and undergraduate student of the Mathematics Degree Course of IFB – Structural Campus. The application is called *GEAR*, being developed for the learning of mathematics, in which one can visualize objects in 3 dimensions (3D), which uses augmented reality for the visualization and study of polyhedra, and construction of geometric figures using the basic concepts of plane and spatial geometry.

Above all, for the creation of the model was made with recyclable materials used at home and with some purchased materials, such as: cardboard boxes, colored cardboard sheets, recyclable plastics, barbecue sticks, caps of pet bottles, pencils, pens, liquid glue and stick, adhesive tape, colored papers (sulfite paper, wax paper) and newspaper and / or brochures (ads).

It is concluded that the model provided new conceptions in the relationship of teaching and learning and achieved the objectives expected in the research carried out. According to the perception in the results of the questioning and participation of the students, it promoted an environmental awareness, practices that should be recurrent in school units, with the intention of producing a broad and diversified knowledge only with a teaching resource, through mathematical modeling.

2.1 THE PROCEDURES ESTABLISHED IN THE INVESTIGATION

In this section, the results of the research applied to the Mathematics teachers who were teaching the discipline in the analyzed years of the study will be presented. Mathematics teachers of the sixth and seventh grades of elementary school in which there was contact with a scholarship holder, from the morning shift.

Chart 1 presents the questions asked to the teachers.

Table 01 - questions and answers in relation to teacher training

	Questions directed to teachers
1.	What year did you graduate?
2.	What is the predominant methodology that you use most in your teaching praxis?
3.	In your training (Degree in Mathematics) was presented the Trends in Teaching Mathematics?
4.	Do you know some of the Trends in Mathematics Teaching?

Organization: Author.

The teachers used the traditional teaching model and did not have or do not remember that there was an approach of different methodologies in teaching being presented in their graduation. According to Caldeira (2009, p. 45): "What Mathematical Modeling, as a teaching-learning method does, supported by subject-object epistemology, is to give quantitative understanding to problems of the student's reality, seeking meanings in everyday experiences."

Just like all other markets, education also undergoes some changes over time. So there is an importance in updating the methodologies that teachers should use in the classroom, because to attract the attention of students. Currently, it is necessary to change the dynamics of the traditional classroom and put them at the center of the process, as a way to involve them and still showing the importance of future teachers to be prepared to use such methodologies and new technologies to aid the teaching of mathematics.

One should also consider the great demand for research on school subjects of students with doubts, individuals who are looking to acquire new knowledge and how much the level of knowledge, which can be found through online.

Young people are increasingly using and mastering technologies such as mobile phones, computers, games and other media. "Thus, an opportunity arises for education professionals to understand such technologies and use games to instigate and channel students' attention to educational games." (GHENSEV, 2010).

The incredible amount of platforms and applications developed for learning and the diversity of choices brings a wide variety of didactics, enabling a choice of user preference.

It is **speculated** that in the initial training of some teachers this methodology is approached superficially, leading to graduates more as information through readings and punctual texts.

It was noted that the trend of teaching Mathematical Modeling was not applied. Above all, regardless of the time in which they graduated, in relation to the teachers interviewed. The approach of updated methodologies based on teachers in their way of working the students' knowledge through activities in which they could develop theories, using the knowledge of these elements of daily life or any type of activity, was not effective.

Thus, a more detailed investigation would be important, only directed to this perspective of Mathematical Modeling, to verify if in fact it is usual, or is usual and its denomination is unknown.

> The presence of these trends in the classroom is only a prescription of official documents, since there seems to be no effective work with them, even when it comes to a policy of continuing education [...]. There is only an initial discourse about the adoption of them in the classroom, without there being with the teachers a work that seeks to provide a more in-depth knowledge, both with regard to theory and pedagogical practice. (TAMBARUSSI; KLUBER, 2017, p. 857).

Therefore, stimulating research that analyzes teaching trends in school environments is necessary, because there will be a parameter for these trends to be usual, or just a pretension in school environments.

2.2 THE CREATION OF THE MODEL

The first day was used to make all the elaboration of the model, which stated: what would be the type of construction to be done? What would be the necessary and ecologically sustainable materials to be used and also easy to handle?

The type of model was the construction of an ecological city with shapes. Above all, using basic notions of plane and spatial geometry in order to recognize, compare and name polygons and polyhedra, consider vertices, faces and sides of the figures presented, and then all the knowledge used during the proposed activities to make the model.

The assembly of the model was on a thick cardboard plate with measures of 30×30 cm, built gradually, once a week, in each meeting with students of the sixth grade classes on **Fridays**. Because there were more classes that day and they were students who did not have much difficulty with the subject and who absorbed better the content taught by the professors and the interventions of the scholarship holder. Three students from each class were chosen to carry out the confection.

In the weeks following the beginning of the making of the model, the following were made:

- Trees with popsicle sticks and monolucent paper;
- Houses with tea boxes and matchboxes;
- Small buildings with paper packaging;
- Water tank with cardboard roll;
- Simulated solar panels with popsicle sticks glued to cardboard surface;

- Walls and fences made with toothpicks;
- Simulated terrain with coconut fiber.

The preparation took place at each meeting after the end of the reinforcement and revision activities, but initially it was necessary to present the geometry content to the students, according to the previous interventions.

The geometry contents addressed were:

- Basic geometric figures;
- What are vertices, sides and faces;
- Calculating areas and volumes;
- Related Issues.

With the help of the figures of the *tangram and the* polyhedra obtained with the project, the absorption of the content by the exposed students took place quickly and intuitively.

The main idea was to teach students to recognize geometric shapes and their particularities in their daily lives and relate to the construction of the model, promoting the idea of sustainability and recycling and developing mathematical reasoning in relation to the space and materials used in the making of the work.

For Barbosa (2001), "Modeling contributes to the understanding of mathematical concepts, develops research and experimentation skills, takes into account the sociocultural context and, finally, enables interdisciplinarity".

During the meetings, while the students were making the items used in the model, they were constantly asked about the shapes of the objects that were being used and how their areas and volumes could be calculated, because at that moment the process of how to calculate the figures questioned by the scholarship holder began.

Initially there was great difficulty, because although the students identified some figures, knowing how to calculate through them required more than one operation, and even among the students with greater ease, there was difficulty in identifying and differentiating the flat figures and polyhedra in the application of the activities.

In the weeks that followed, there was an improvement in the answers related to the areas of the figures, because the operations used were the same as those used by the students in the classroom. However, there was still great difficulty in remembering which operation was used in each of them. What helped them was the recollection of previous activities with manipulation of polyhedra and *tangrans*. The moment the students could see and manipulate the figures, instead of just seeing them drawn on the board or on worksheets, it was identified that it contributed to the improvement of learning.

After completion of the model and, even near the end of its completion, there was a significant improvement both in the students' knowledge about the activities performed in the classroom, referring

to basic mathematical operations (addition, subtraction, multiplication and division) and logical reasoning problems, as well as the geometry content.

3 RESULTS AND DISCUSSIONS

What was initially proposed were ways of relating the construction of the ecological model with the teaching of mathematics. The great challenge was to develop the project with children who lived in a region of low HDI and who in many cases sought school as a refuge. An important observation of the teachers of the classes where the scholarship holder had contact was that the difficulty resided, even in advanced years, in learning the initial operations.

Many materials for use by the students were used, initially with the help of the school, but some were replaced with the feasibility of the PIBIC Program funding, it is perceived the importance of these financial aids, but other materials could not be replaced due to the budget being limited.

It was noticed that without the participation of the school this research could not be carried out successfully, because the institution contributed with excellence in the demands of the research project.

Using geometry was the best way because there was constant work with shapes seen and used in the construction of the model and use of basic operations.

There was great difficulty in several aspects such as time, availability of students and even in learning, because students were not used to questioning. If an activity was passed, they tried to do it, but depending on the degree of difficulty, some gave up or were easily distracted.

The fact that the number of students was adequate per class, facilitated the possibility of controlling, assisting and observing each one better, and it was noticeable that the students did not have much confidence, so they were insecure when answering each question, even having performed similar procedures in previous activities.

Through the concepts adopted**,** interdisciplinarity and transversality can be worked on, showing the student how mathematics/geometry is directly related and how it can be useful in their lives, in the school environment and outside it, and how it interacts with other areas of knowledge.

The interest of the students in general was ratified, a good part was attentive to the explanations and the performance in the activities that were proposed to them and, according to the reports of the mathematics teachers of the classes involved, there was an improvement in their performance in the discipline.

Keeping in mind that governing a group of students who need more thorough assistance requires a lot and, being aware that students are learning the subject is the greatest prestige to have achieved. For the same is the main goal to keep in mind when working in the classroom.

Therefore, there is no doubt about the use of the teaching trend Mathematical Modeling that actually produces learning, however, in some situations more financial resources, more classes and

time available from the teacher for planning are needed, perhaps it is for this reason that this methodology is little used. In a way, these observations stand as suggestions for future research.

Given the above, investments are needed in the training of qualified teachers to enable an adequacy of the use of methodologies and the financial resources that many of them demand.

4 CONCLUSIONS

The investigation produced results that there was no application of the trend of teaching Mathematical Modeling in the classes taught and evidenced the lack of knowledge of it in the teaching and learning process, at least with this denomination.

It was concluded that the use of the model led to mathematical knowledge and an ecological and sustainable awareness, as well as an interaction of the students and the scholarship holder. But, it was considered that the use of the trend of teaching Mathematical Modeling as a methodology requires a much greater logistics than a traditional class, because it requires financial resources and more hours of planning to be applied.

It was noted that the trend of teaching Mathematical Modeling that, applied also through the design methodology, can create manipulable objects that can contribute to the production of a written material for visually impaired students and sighted. This result was presented at the *XII Summer Workshop in Mathematics* 2020.

Above all, for contribution in the area of knowledge, it was evidenced that the trend of teaching Mathematical Modeling produces a more consistent learning, because it is not only an abstraction, in the case of models, and it was confirmed that a certain financial aid was necessary for the action to occur.

It was found that the two teachers who were teaching the discipline of Mathematics in the years that were part of the investigation, did not use in the classroom the contents through mathematical modeling, being perceived that they do not know the methodology, as previously mentioned, at least with this denomination.

Above all, mathematical modeling provides the opportunity to create materials for visually impaired students and also for sighted students. It was realized that several models can be created and that the design methodology can be applied to the creation of mathematical models, being a methodology in the teaching of mathematics, by enabling a concrete learning, in this case, in the creation of objects such as a model. There is importance in verifying the methodologies used and the perceptions of teachers in relation to the new teaching methodologies, because in the school in question it was verified that there were resources such as computer room and functional computers for all students, but it was little used.

In addition, it is suggested to apply this research to other public educational institutions in the Federal District, preferably in schools with less financial resources and in a way that can build materials for the teaching and learning process for visually impaired students and also sighted.

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