ISSN: 2525-6599
REVISTA UNIFEV: Ciência & Tecnologia

STUDY OF THE IMPACT OF DIFFERENT INTERDISCIPLINARY THEMATIC APPROACHES THROUGH MATHEMATICAL MODELLING: THE CASE OF NANOSCIENCE AND NANOTECHNOLOGY

SANTOS, Driely Gomes[1]

SANCHES, Carmem Silvia Rodrigues Paschoal[2]

RAMOS, Milena Aparecida Batelo[3]

MELO, Michael de[4]

ABSTRACT

This work has a great and substantial importance in the framework that the country is engaged when the issue is concerned about basic education system. Analyze distinct perceptions due different interdisciplinary thematic approaches in classrooms of basic education might result in different results in the teaching and learning process using mathematical modelling. Nanoscience and nanotechnology has been chosen as a theme with a wide interdisciplinarity, constituting one of the most important themes to generate discussion in classroom. This study will present the effects of the student perceptions and its relatable mathematical modelling results for different two education levels: Fundamental II and High School. One believes that interdisciplinary is a main methodological tool to defragment the knowledge, contributing with mathematical concept learning. Nevertheless, it is widely accepted that the way an interdisciplinary theme is presented in a classroom can significantly alter the efficiency of the employability of interdisciplinary methods and, consequently result in teaching learning process failures.

Keywords: Interdisciplinary learning. Mathematical Modelling. Nanoscience and Nanotechnology.

[1] Discente – Unifev – Centro Universitário de Votuporanga – SP, e-mail: drielygomes56@gmail.com
[2] Mestre em Matemática. Docente – Unifev – Centro Universitário de Votuporanga – SP, e-mail: casirop@gmail.com
[3] Mestre em Matemática. Docente – Unifev – Centro Universitário de Votuporanga – SP, e-mail: mibatelo@hotmail.com
[4] Doutor em Ciência dos Materiais. Docente – Unifev – Centro Universitário de Votuporanga – SP, e-mail: michaeldemelo@hotmail.com

INTRODUCTION

Except the physical sciences, the factual sciences, in which the truth is based on a logical structure (LAKATOS, 1970), constantly used a more common language to report natural phenomena. The application of mathematics in these sciences has significantly contributed to the achievement of a better understanding in their particular empirical investigations.

Given its importance to science, mathematical modelling also is essential as a tool for developing the teaching-learning process. In the educational sector, for instance, mathematical modelling provides a blend of math ludic aspects with its potential applications, allowing a more precise and objective learning.

Over the last few years, the interest in promotion of interdisciplinary and transversal themes in the teaching planes has remarkably increased. Nowadays, one of the main objectives of Ministry of Education and Culture (MEC) of Brazil is to encourage the application of interdisciplinary themes in the basic educational system to improve the perception of the importance of science and enable better learning.

Analyzing from this perspective, this work has a very clear objective: provides a classroom experience about the efficacy of interdisciplinarity method applications. It is difficult to measure precisely the different perceptions resulted from the different approaches. Quantitatively, it is possible to parameterize some indicators that could be compared statistically with other approach techniques of interdisciplinary themes. However, it is important to stress that the perception will be tested in two different classes and a quantitative description is out of the question. Therefore, a qualitative investigation concerning the perception results can be done within the posture of an educator researcher.

An educational activity about mathematical modelling has been developed involving the nanoscience and nanotechnology as an interdisciplinary theme applied to this investigation. Here, the behavior of the teacher in the classroom was that of an educator researcher, capturing student’s perceptions about mathematical modelling using different techniques of the proposed interdisciplinary theme.

1 AN INTRODUCTION TO MATHEMATICAL MODELLING

Mathematical modelling is the process of translating between the real world experience and mathematics propagated in both directions (BLUM & FERRI, 2009). In a general view, the modelling process can be twofold: a theoretical and an object model. Models, in the theoretical view, are defined as interpretations or a realization of a theory about a specific phenomenon. For example, mathematical objects, such as triangles and cubes, are theoretical models resulted from the Euclidian geometry (FRIGG, 2006). On the other hand, an object model is the representation of an object, in which its representation can be pictorial, such as a scheme, a drawn, a map, etc., or symbolic, using mathematical expressions (BASSANEZI, 1994).

A modelling process is simply an action to produce a model. Within the different types of models, we will highlight the scientific model. This specific model is a result from the process of an abstract representation to analyze, describe, explain, simulate, and predict phenomena and processes. Modelling process can be applied to several situations and problems, in which the real world can be described as closest as possible (SODRÉ, 2007).

The concept of mathematical modelling is a dynamic process that seeks appropriate models in several areas. Apparently, mathematics and reality are disjoint, and the modelling process is a path to integrate them. Mathematical modelling is an area of the knowledge the study the simulation of real systems, showing distinct features depending on the field that are applied, such as mathematics, economy, physics, chemistry, biology, psychology, astronomy, engineering, etc. Regardless the field, the approach will be always the same (BASSANEZI, 1994).

The mathematical modelling can be taken both for the scientific method and for the teaching-learning process. Therefore, in the educational sector the learning through mathematical modelling provides application of ludic mathematical features, arising as a methodological tool in education (SILVA, FERREIRA, & MOREIRA, 2010). Its use for the teaching of mathematics allows develop both creativity and critical thinking in students. As it is widely known that one of the main objectives in math education is to learn how to solve different types of problems. In view of this, mathematical modelling is conspicuous to deal with real situations culminating in an effective solution of real problems (D'AMBRÓSIO, 1986).

2 MATHEMATICAL MODELLING AND INTERDISCIPLINARITY

The interdisciplinarity concept is has begun to be addressed in Brazil from the Law of Guidelines and Basis (LDB) Nº 5,692/71. Since then, its presence in the educational system has become much more evident, either in legislation or curricular proposals (CHAVES, 2015).

Besides the revealed importance of the interdisciplinarity as an excellent instrument to conduct the learning process, investigations have been disclosed that interdisciplinarity is not well known, mainly in the schools, despite being one of the presented proposals by the National Curricular Parameters (PCN's)* (CHAVES, 2015). The interaction between subjects has enabled the formulation of a critical thinking, which should be enriched in the teaching-learning process. Only employing interdisciplinary we can overcome subject fragmentation, providing a dialogue and a better understanding.

The learning process depends on the student interaction, teachers, contents, and especially of the educational context itself. The educator has the explicit role to intervene and to evoke progress that would not be accomplished spontaneously (FRISON, 2012). The interdisciplinarity can happen naturally, however its practice and systematization requires the didactical work of one or more educators. Generally, reasons such lack of time, interest, and others, educators can neglect other subject interfaces, limiting the knowledge that would be conveyed to the student.

One of the many challenges that educators face is how to engage students in authentic problem solving involving complex systems within an interdisciplinary context. To establish a real connexion between mathematical modelling and interdisciplinarity it is necessary elaborate a scholar activity, addressing facts that relate to different situations (ENGLISH, 2009).

The proposal of this work is mainly to contribute with the understanding of the interdisciplinarity complexity involved in learning process using mathematical modelling. The thematic applied to this work was about nanoscience and nanotechnology due to its wide interdisciplinarity application in several fields, increasing the student knowledge and the connexions between different sciences.

* PCN's are references for the elementary and High School of whole country. The objective of the PCN's is to ensure to each Brazilian student, even in economically disadvantage place conditions, the right to enjoy a set of recognized knowledge as essential for the exercise of citizenship (Brasil, 2013).

The application of an interdisciplinary subject does not necessarily bring an efficiency in the learning process, but the way educators use to motivate and evoke new concepts in mathematical modelling that is most essential for the mathematics education in problem solving.

3 MATERIALS AND METHODS

Before application of the interdisciplinary theme for students, the educator needed to get involved about the theme and, consequently, investigating deeply all concepts, importance, characteristics and all points that should be presented in a particular class. Topics such: what is nanoscience; who were the most important scientists that have predicted this new wide investigative field; what nanotechnology is; the importance of the nanotechnology for the country economy and the social progress; daily uses of nanotechnology in food, health, security, mobility, military, and other; etc.

Two different activities related to the application of interdisciplinarity in mathematical modelling were performed in two different classes from elementary and high school in Votuporanga, countryside of São Paulo state, in Brazil. These classes had approximately 26 students each. In order to stablish the connexion between mathematical modelling and the interdisciplinary theme, an activity involving geometric solids would be very appropriate, since both classes had already worked such subject in the classroom. Geometry subject can easily be used in mathematical modelling, being correlated to the main characteristics obtained from nanoscience and nanotechnology theme, such as surface and volume of nanoparticles.

In Elementary School, a brief discussion about calculation of surface and volume of most known geometric solids was performed. Due to its simplicity, the cube was chosen as the geometric solid for the mathematical modelling activity. This activity comprised some questions and calculations about surface and volume calculations. The questions used were:

- Given a cube with side length of 15 centimetres, calculate both area and volume.
- In case of splitting this cube in other cubes with 5 centimetres, answer:

  - How many cubes with 5 centimetres do we need to fill the cube with 15 centimetres?
  - What is its total area considering all the cubes?
  - What is its total volume?
- What happens when we decrease the side length of the small cubes?

A 3D cube projection made of foam with the dimensions discussed right above was constructed in order to facilitate and get a better visualization of the proposed activity, relating the theoretical model used in the mathematical modelling.

In High School, the previous knowledge of physics and chemistry enabled the students to deepen into the problem of size reduction until reaching the nanometre scale taking advantage of a more elaborated presentation concerning to the nanoscience and nanotechnology, illustrating concepts, application, researches and the importance to the students.

Nanoscale is the scale of "nano" that means in the International System of Units one-billionth, or 10^{-9}, i.e., one nanometer is a one-billionth of a meter. Some examples of how small is the nanoscale can be thought when we compare a sheet of paper has 100,000 nanometers thick, a strand of human DNA possess 2.5 nanometers in diameter, and a human hair is approximately 80,000-100,000 nanometers wide (NATIONAL NANOTECHNOLOGY INITIATIVE, 2017). Using this scale, surfaces and interfaces play a very important role in materials properties and interactions. Nanoscale materials have far larger surface areas than similar masses of larger-scale materials. As the surface area per mass of a specific material increases, a greater amount of the material can come into contact with surrounding materials, becoming more reactive. So, using this very important concept about size particle and increment of surface area in nanoscience and nanotechnology can be quite helpful for mathematical educators to connect interdisciplinary themes with mathematics by means of mathematical modelling.

4 RESULTS AND DISCUSSION

Though it is hard to compare the perceptions of different interdisciplinary approaches using mathematical modelling in two different class from different levels, it is possible to perceive the positive effects caused in the students through strategies that motivate more a specific subject.

In elementary school, there was a retaken of mathematics concepts and formulas necessary to solve the problems of surface and volume calculation of geometric solids. The activity was developed presenting some geometric calculations and the resolutions, always being provoked by the educator to solve the questions proposed. As the students from elementary school did not have a previous knowledge about nanometre scale and the importance of the size effects in nanoscience and nanotechnology, they did not show much interest in the scale properties. For them, it was only a matter of abstraction used by the educator to understand better the problem of mathematical modelling. The size reduction of the cubes and its relationship with nanoscience and nanotechnology was barely provoked by the educator and, consequently, the interesting in this interdisciplinary theme was not so exploited as it should be.

However, in High School, the activity was very similar to that applied in Elementary School, except by a deeper presentation concerning the fundaments of nanoscience and nanotechnology and its importance in several fields. After the education presentation about the theme, the same activity applied in the elementary school was done in the High school. During the presentation, many doubts have been arisen due to the interdisciplinary theme, in which most of the students never heard about it.

With more motivation to better understand the most important properties of nanomaterials and its wide range of applicability, the students has noticed the subject had a great correlation with mathematics and they became more interest to use the mathematical modelling. In fact, we observed that when the problem is not focused only in the solution mathematically, but seeking to highlight other important aspects involved, the interdisciplinarity becomes a more effective tool for mathematical modelling in the teaching-learning process.

CONCLUSION

This work has showed the importance of two different approaches used in the application of an interdisciplinary theme in mathematical modelling in two different classes from Elementary and High School. For students from the Elementary School the lack of some concepts in natural sciences has decreased the efficiency of the application of the interdisciplinary theme chosen for mathematical modelling. Nevertheless, we observed a higher degree of interaction about the interdisciplinary theme with the educator in the High School. Perhaps, due to the previous knowledge of natural sciences, such as Biology, Chemistry, Physics, and others, has significantly contributed to increase the student's interest about nanoscience and nanotechnology. The role of the theme applied to solve mathematical modelling are essentially different in each class. While it has been considered more a tool of assistance to the problem solving in elementary school in an abstract way, the interdisciplinary theme has helped to increase the motivation in other science subjects, contributing to the perception of the knowledge inter-connexion, and supporting in the development of the mathematics education. The main role of an educator in mathematics education is constantly to provoke the student interests in several parts of the knowledge, helping the students to find the needed motivation in order to obtain a higher efficiency in the learning process through the application of the mathematical modelling.

REFERENCES

BASSANEZI, **R**. (1994). Modelagem matemática: uma disciplina emergente nos programas de formação de professores. In R. Bassanezi, *Modelagem matemática: uma disciplina emergente nos programas de formação de professores.* Blumenau: Dymanis.

BLUM, W., & FERRI, R. B. (2009). Mathematical modelling: Can it be taught and learnt? *Journal of Mathematical Modelling and Application, 1*(1), pp. 45-58.

BRASIL. (2013). *MEC*. Retrieved apr 04, 2016, from Portal MEC: http://portal.mec.gov.br/pnld/195-secretarias-112877938/seb-educacao-basica-2007048997/12640-parametros-curriculares-nacionais-1o-a-4o-series

CHAVES, A. (2015). Master Dissertation. *O ensino da matemática e os tipos de contextos*. São Paulo, Brazil: Pontifície Universidade Católica de São Paulo.

D'AMBRÓSIO, U. (1986). *Da realidade à ação: reflexões sobre a educação matemática.* (5ª ed.). Sao Paulo: Summus.

ENGLISH, L. (2009). Promoting interdisciplinarity through mathematical modelling. *ZDM Mathematics Education, 41*, pp. 161-181.

FRIGG, R. (2006). Scientific Representation and the Semantic View of Theories. *Theoria, 55*, pp. 49-65.

FRISON, M. D. (2012). Interdisciplinaridade no âmbito escolar. *Seminário de Pesquisa em Educação da Região Sul - IX ANPED.*

LAKATOS, I. (1970). Hystory of Science and its rational reconstructions. *Boston studies in the Philosophy of Science*, 91-136.

NATIONAL NANOTECHNOLOGY INITIATIVE. (2017, 05 20). *Nano.gov*. Retrieved from National Nanotechonolgy Initiative: https://www.nano.gov/nanotech-101/what/nano-size

SILVA, L., FERREIRA, L., & MOREIRA, F. (2010). *Modelagem matemática: reflexões teóricas e aplicações.* Retrieved may 14, 2016, from http://www.ufjf.br: http://www.ufjf.br/emem/files/2015/10/MODELAGEM-MATEM%C3%81TICA-REFLEX%C3%95ES-TE%C3%93RICAS-E-APLICA%C3%87%C3%95ES.pdf

SODRÉ, U. (2007). Class notes (Mathematics) - UEL. *Modelos matemáticos*. Londrina, PR.