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HISTORICAL RESEARCH IN THE CLASSROOM: A EXERCISE OF CREATIVITY FOR SCHOOL MATHEMATICS

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ABSTRACT

In this paper I discuss the importance of research in the history of Mathematics for the training of mathematics teachers and argue that it is possible to see historical research in a pedagogical light as a creativity exercise which provokes the mathematical creative process, in mathematics' classes. I mention examples of mathematicians who gathered a set of cognitive skills to reinvent mathematical principles in the explanation of challenging themes in mathematics. It is about seeking in the history of mathematical practices and elaborations, in its experimental and formal levels, aspects that define the outline of the challenges which lead to the production of mathematical knowledge currently addressed in Middle, High and Upper Education. I present two historical examples in order to show how the creative spirit is of fundamental importance in the mathematical training of students of basic education as well as that of the mathematical teacher.

INTRODUCTION

During twenty years of trials, errors, successes and ideas about the use of history in mathematics education, I evaluate the studies and research the organization and evaluation of experiences in initial and continuing teacher, advocate the use of a historical and investigatory in mathematics classes as a pedagogical alternative for achieving a meaningful teaching math, problem-solving situations that rescue that lead students to construct their mathematical learning through historical data that cover these situations. In this article I discuss the possibilities of use of historical research as an exercise in creativity for the learning of school mathematics taking as a guiding principle. Accordingly, I have relied on studies in initial and continuing training of mathematics teachers, whose guideline focused on the use of the historical development of mathematics and its relations with the epistemological and teaching of school mathematics. From these studies have produced educational materials for teaching basic mathematics in order to overcome some difficulties encountered by teachers in their mathematics classes.

Creativity, society, culture and education

To start any reflection on creativity is important to keep in mind that one cannot think that creativity is a skill originated from a human phenomenon or purely individual act, but as a systemic process in which social interaction is crucial, as Csikszentmihalyi argues (1996). This means therefore that to be creative is necessary to make use of creative or divergent thinking and thinking creatively, but in order to establish connections consistent with the context in which ideas are being put, ie, society, culture and process validation of the ideas produced.

It is able to be provocative, paradoxical, metaphorical, playful with his own thoughts, thus exercising their flexibility in being able to always find the best options and the best ways for any situation in life, both personal and professional. From this perspective, think creatively is to engineer alternatives, face challenges, find solutions, that is, knowing how to use various resources that enable us to go further than we thought possible (cf. Araújo, 2009, p. 52-53).

If we consider that there are some systemic models of creativity, investment theory of creativity is seen as the convergence of six distinct factors and inter-related intelligence, the intellectual styles, knowledge, personality and motivation, thus emerge this thread factors, an environmental context in which the creative process can occur in varying degrees. However, the characteristic of a social context conducive to creativity is evident in that context that contribute

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to creativity in order to involve not only the individual, but also affect their social environment and the people who live in it. If those who surround the individual does not value creativity, not provide the supportive environment necessary not accept creative work when it is presented, then it is possible that the creative efforts of individuals are insurmountable obstacles (Stein, 1974, p. 12) .

A question often established in educational settings and contexts of the academies of sciences and arts refers to the act of creation, taking creativity as a skill inherent to human beings in the process of knowing, explain and understand. Such speculative restlessness refers to two questions: why and what for? In this regard, many scholars in the subject ensure that creativity is an essential human skill to be developed because it is fundamental to developing the potential of those who study, learn and produce knowledge and essential to human autonomy and may develop divergent thinking / creative, as an essential skill to conduct ourselves in life, since it becomes possible to develop an emancipatory educational process for the production of new knowledge and to enrich the educational process, which could favor the growth of those who produce knowledge; taking a view that the process of learning and cognitive production always be pleasurable and that innovation never allow the rigidity of concepts and practices, instead, there is a constant interest in the renewal of ideas and aeration.

The search for answers to these two questions suggest reflections on creation and its relationship with the tree of knowledge proposed by Maturana and Varela (2001), ensure that

(...) The knowledge of knowledge compels us to assume an attitude of permanent vigilance against the temptation of certainty, to recognize that our certainties are not evidence of the truth, as if the world was that everyone sees the world and not a world we build with others. It forces us to learn because we know we cannot deny that we know (MATURANA; VARELA, 2001, p. 267).

Is this watch mentioned by the authors that enable us to ask ourselves constantly about knowledge in order to include new looks, thoughts, concepts and new searches for new reflections on the conclusions already established earlier to set up so the creation process, which makes knowledge production a movement of action-reflection-action in which 99% consisted of perspiration and 1% creativity. This numerically small portion that is evident in the production of knowledge, means an addition steeped in tradition, innovation and renewal, as suggested by Raquel Gonçalves-Maia (2011), as well as through the trance of art and creativity as mentions Teresa Vergani (2009), noting that the prohibition of trance gentrification and commercialization of art and creativity left just as the possibility of giving the world the opportunity to experience knowing.

The tree of knowledge that underlies the discourse of the method proposed by René Descartes makes us reflect on the process of creativity in finding solutions to problems of explanation of natural phenomena and their relation to the establishment of secondary general questions and to solve a problem. Over the years, in the scientific context, the problems were taken without regard to the trunk of the tree, following only the branches and, finally, only the leaves, until specifically focusing on the flowers or the fruits.

A new look for the tree of the knowledge given by Maturana and Varela (2001) reflect on the need to look through the whole brain and in the greatest number of possible approaches, since interconnected in order to make sense of broader and deeper over object under construction. Meanwhile, Michel Serres (2008) states that the new branches originating from the tree of knowledge refer directly to the portion of that 1% creativity, to which I referred earlier. For Serres (2008, p. 81), "the branch does not kill the stem, but it rests, although for him to depart. However, it is necessary that such departure did not mean disconnection". The author also claims that the connectivities of information originating from virtual networks of communication and practice informationism, very common today due to virtual research may lead to the inhibition of the branches on the tree of knowledge.

Examples of creation and creativity in mathematics history

The classical Greek tradition referred to the term as learning math or science. Over time this meaning was extended to special fields of learning, generating several definitions for math. Its disadvantage, however, was to ignore intuition, mathematical practices and non-standard methods that have arisen throughout history. Such methods and practices advanced by stimulating the creation of symbols and patterns of formal representation for certain mathematical concepts, representing a process of creativity and, consequently, the creation of new mathematics.

The conclusions reached by the use of new patterns and symbols began to impose certain laws that supported combinations of mathematical writing, leading scholars of the subject to search the literature to adapt to multiple conditions and symbolic representation of mathematical ideas and practices offered by them, making emerge several modes of representation of mathematical thinking and practices.

Throughout the history of mathematical ideas and practices, attempting to correct possible errors in perceived work already announced in academia or even aas related mathematical practices in technical contexts, cultural and technological developments have led scientists as Fermat, Descartes, Newton, Leibniz and others to develop their creativity in trying to solve the perceived wrongs. Creativity attributed to that moment meant research, rewriting, interpretation and development of new mathematical explanations.

Continuing investigations, inquiries and revisions made to mathematical knowledge in different periods of history constituted an extremely enriching. The beauty and insight provided by the new results and statements were critical to understanding how a mathematical curiosity can influence the process of invention and discovery math. For this, often the investigation of errors in the work of mathematicians were the basis for creativity in the history of mathematics knowledge.

The discussion of errors in geometry, for example, stimulated by the work of Ptolemy and Proclus and others, causing a mathematical production decisive in the seventeenth century, with the work of René Descartes discourse on method and solution to the problem of Pappus originating a new branch in Mathematics: problem solving geometry supported in solving

equations, which currently characterizes the studies in analytic geometry. This seems to be a unique example of creativity and mathematical creation.

The geometry of Descartes can be considered an example of creativity in mathematics. For Jullien (1996), Geometry of Descartes considered what was unreadable, because it was not an easy approach to the reader of the seventeenth century, as today, almost four centuries later. For both Descartes mentioned that "it is impossible to represent a figure devoid of any length," ie, to know the body, its length, figures and movements, it is then possible to meet the unique understanding, but much better understanding helped the imagination (Rule XII).

The rows of the Cartesian geometry are not therefore separated from the object material. This does not in any way imply that doing reflection on them, should be embracing all the determinations of the bodies because he can turn his attention on a specific mode of the thing, on one (or two) of its dimensions, making abstraction from the rest of its determinations (see Rule XIV). From these observations, it is clear that understanding in the course of their investigations geometric, booking a place to the imagination, which is really helping here indispensable. It is, however, require certain characters this imagination, required for the production of geometric knowledge. If it were just a reproductive imagination, too realistic, it would quickly bearer of confusion. It is this conception of imagination that Descartes accused the former option and tried to imagine another explanation for the problem.

Another unique example of creativity shown by Lewis Carroll in his literary or mathematical densely populated of ideas, principles, and mathematical mentifacts, whose logic is based on the ideas of provocation, in apparent disorder and confusion. Such logic is called logical nonsense (French non-sens) used to denote something meaningless or unreal, that is outside the normal parameters, ie, devoid of reason. The logic of nonsense, characteristic of mathematical logic of Carroll defines your personality and your creativity mathematics, whose appeal to the curiosity and imagination shown at all times, as strong allies of his invention mathematical approach to their teaching.
An example of this creativity is in Carroll's book titled Euclid and his Modern Rivals Euclid and his modern rivals. This work gives Carroll a sample of his creativity in the production of mathematical knowledge to the classroom. Published in 1879, the book itself is a work that addresses the theoretical positions of a number of contemporary mathematicians, demonstrating how each turn, or is less than or functionally identical to Euclid. To achieve its objectives the author uses to support the instructional book "Geometry", in The Elements of Euclid, with a view to doing a review on the relationship as the geometry book that should exist in schools, against modern books of geometry were replaced.

Carroll made several reformulations of content and form in mathematical textbooks, considering it necessary to include some aspects that provoke curiosity and creativity of students in learning some mathematical topics taught by him during the second half of the nineteenth century. These changes were justified by their concern for teaching and he doubted some aspects addressed in works that came into his hands, in the form of translation of the original Greek and Latin. Therefore, simplified versions of Euclid's Elements found in order to correct the weak points in these translations and in order to clarify, add definitions and approaches to develop clearer statements of the theorems.

A didactic model focused on historical research

In a didactic model of historical research that can be used in school mathematics, activities should guide a dialogue between the conjunctive mathematical ideas developed and organized historically and investigative perspective that characterizes the construction of knowledge. Is this integrative alliance that investigative activities may print more meaning to mathematics education, based on an active-reflective process given to research as a means of building mathematics.

Accordingly, students should participate in the construction of their own knowledge in a more active, reflective and critical as possible, listing each knowledge built with the needs historical, social and cultural conditions prevailing in it. In this process effective, it is necessary that the teacher assumes the position of supervisor of activities to enable a dialogic interaction in which students construct their knowledge by investigating the mathematical processes present in the historical development of mathematics, transposing them to the current situation daily construction their knowledge and socializing hypotheses, results and conclusions about their experiences.

The instructional procedure adopted for this cognitive exercise should prioritize practical experience and / or theoretical experienced by students and guided by the teacher, to formulate concepts and / or properties and interpret these formulations in order to apply them in solving practical problems as well require. It is important to provide an action-centered didactic direct experience with situations arising from natural or historical content, for the creation presupposes the mathematical principles learned acting job in new situations, since the knowledge base is centered on knowledge already constructed by the learner and the process learning is determined by the conditions in which it learns.

The way I propose to historical research in the classroom gradually emerges as a decisive contribution to the exercise of reflective practice in mathematics education. Such didactic exercise is effective as the constructive principle is explored in the provocation of curiosity expressed in the historical context of mathematics. It is this movement that the activities are sources of motivation and generation of school mathematics.

My conception of historical research assumes that the experiences manipulative or visual learner contribute to manifest them first impressions of the knowledge acquired during the subject-object interaction experienced in the production of knowledge (know-how). These first impressions are to be communicated in the form of verbalization, ie, by speaking student in the classroom, through discussions among colleagues, a process of socialization of ideas seized. This movement of deep self-reflection implies the need for representation of learning through symbolization (formal representation through systematic algorithms, formulas, etc..), Since it shows the degree of abstraction in which the student is found with respect to knowledge built during the activity (level of representation: intuitive - algorithmic - formal).

These levels of representation refers to the concepts of Fischbein (1987), according to which there are three key components for the development of a mathematical activity:

- Intuitive, in which mathematics is not released from their human roots, although it has extremely sophisticated processes of abstraction. Thus, it is important to discuss the imaginative character of mathematical reasoning, and visualization of all human experiences, as well as the biological character of learning;
- The algorithmic, allowing adaptation of thought to the procedures proposed problematic in practice, systematic training to which the student is subjected. Thus favoring mechanization (memorization) of knowledge. It depends on a previous construction over the concept of contextualization and seized (problematic situation) learned of the matter;
- The formal, in which mathematical concepts are expressed by means of propositions that we consider adaptable to all circumstances - in this very traditional textbooks, which is considered an advanced form of knowledge, becoming a way of teaching math. There is a need for contextualizing the formal component is meaningful to the knowing subject.

You must often clarify the objectives, implementation procedures, discussions to be held and provided oral and written reports on each of the activities, so that each student can orient yourself. Also, try these suggestions lead directively research of mathematics, in this historical information, so that students reconstruct the conceptual aspects relevant this math, significantly advancing the conceptual organization of the content provided by the teacher.

The creativity of the teacher is very important for the proposed theme for the activity arouses students' imaginations, motivating them throughout the learning process envisaged. The language used in the preparation of activity should be clear and concise so as not to cause doubts in students during execution.

The historical content should be provocative element of research and generator of mathematics to be explored in discussions of the whole class, because it is a factor of enlightening whys as mathematicians questioned by students at all levels of education. It is this information that the teacher can address the aspects everyday school math and science among students, since the questions and guidelines are well explored and developed by the teacher. This is where one should emphasize the facts and issues, throughout the history of mankind, provoked the inquiry and human endeavor aiming at the systematic organization and its dissemination to the current model. This part will support the development of the activity and may lead students to an interactive dialogue with the transversal aspects of mathematics investigated.

The ability to organize into steps for solving a problem can develop in students since the teacher is the main craftsman of this action, because it is their exploration of all the possibilities of improvisation and bricolage that can minimize the difficulties existing school. It is imperative that the teacher be bold and creative, because that is how you can create in the classroom, an investigative environment that favors the development of imagination and creativity of mathematics students.

Regarding procedures mentoring students, historical research should be directed in steps that lead students to design and testing of hypotheses, formulating explanations and demonstrations relating to the content investigated historically. It is important to use simple language and straightforward, thus it will be possible to give students the freedom to explore challenging situations proposals and test them, seeking the knowledge provided in each activity.

As for the challenges posed in the activities, they should be very attractive and challenging in order to provoke the curiosity of students. These characteristics certainly stimulate learning if they are richly explored during the preparation of each challenge. These challenges are usually present in historical texts original or secondary sources such as the history of mathematics books, old textbooks, textbooks and those who are in the form of novels like the work of mathematical Malba Tahan, Amir O. Aczel, Leonard Mlodinow, Eli Maor, Gilles Gaston Granger, Bulent Atalay, Mario Livio, David Leavitt, among others.

The exercise of formalization and systematization of knowledge generated during the historical research, the teacher should guide the students to organize their continuous sequence of actions that lead to the formalization of mathematical ideas developed throughout the investigative process. The teacher should realize the most appropriate time for this exercise of formalization and systematization of knowledge, since the intuitive handling of components, algorithmic and formal, present research, nurture the process of mathematical abstraction of students and enables the assessment of levels of abstraction in students. I admit this because they express their mental representation through these three components that make up the symbolic expression of mathematical thinking.

It is wise to think of these activities, considering the possibility of using the more creative aspects of mathematics textbooks in order to give the student the pleasure of exercising this formalization with enough significance. This will occur if we combine the manipulative experiences and challenges and problems of history rescued, power of generalization that the formal exercises can have. It will be possible to establish a link between the concrete and formal through these activities.

In terms of other activities, I argue that they are complementary and constitute work that should be guided by the teacher, which can be generated from own activities in the classroom. Often configure themselves as individual projects or groups that imply the culmination of the whole learning process occurred in class. It is these activities that students can exercise fully their ability to achieve a plural understanding that enables them to see and experience mathematics in everyday aspects, educational and scientific. Also, have the opportunity to develop investigative skills whose educational principle is to make them independent to pursue their own experience, their own understanding and explaining the world, seeking dialogue with what was presented to him by history.

Another modality to be developed in the classroom, also considered as a complementary activity is the exploitation of existing problems and exercises in textbooks former, current

and in some textbooks. It is located in these books, number of exercises or problems that emerge from different historical situations of mathematics, although they are often coated with a language more current. These problems are still present in current textbooks, only with a language reformulated.

These exercises and problems are taken as axes generating a plural understanding to be achieved by students during math classes. Most often consist factors for contextualizing a reality in which students can possibly support to overcome some difficulties in understanding objectified by the teacher during the introductory classes of the subject.

It is through these problems that teachers can take their students to a level of symbolic representation of mathematical ideas seized on direct experience and discussions with colleagues, and to promote the establishment of mathematical knowledge built during the development of previous activities. The holdings of these problems and exercises will emphasize concepts and their meanings, because exercises classics no longer make sense to students if they are not coated with historical and social relations (culture, science and technology) that are of great importance in understanding and explanation of reality constructed by the students.

Contributions to mathematics lessons

Historical research in mathematics classes can help students become familiar with the use of references as an agent of understanding of the historical development of mathematics, epistemological, and gain autonomy to work independently to build their own learning, develop the spirit and investigative skills to organize, analyze and present the results of their research projects through the exercise oral communication of their ideas, writing and visual presentation.

Deepening students' math can also be checked in the course of historical research, certainly expanding their knowledge of the topics investigated and the events related to construction math, which favors the learning of mathematics through its historical development, providing opportunities for them transversalizante an approximation of Mathematics in its connections to other disciplines. In preparing the investigative project on the history of mathematics in the classroom, students can develop their creativity and sense of ownership, so that everyone will tend to take an active role in their own learning, engaging deeply in the formulation of mathematical ideas surveyed, starting to feel like the creators of each topic investigated.

Besides the benefits already mentioned, students will develop their confidence and increasingly mature, especially in moments of research and socialization of their experiences with other colleagues involved in the investigative process in the classroom. This will involve training students in more creative and able to encourage the demonstration of mathematical principles discovered during historical research. This certainly will reveal the nature of mathematics alive and globalizing included in research and connected to other academic disciplines that can provide connections between the external environment and the classroom.

The use of historical research in mathematics classes involves both the exercise and expression of subjectivity and objectivity of those who practice it. These two aspects will be evident more broadly or not, according to the criteria used by the person who develops and evaluates. Soon, the teacher conduct guidelines that all students start to identify both the subjective and objective aspects of the investigation in order to establish quantitative parameters and qualitative validation of the results at each stage of exercise in investigative history of mathematics.

Another way to take the path of research, especially with more mature students, are the thematic investigations. The teacher can lead them pursue the reconstruction of historical-epistemological mathematical topics you want to teach their students. This type of historical research can contribute to the development of skills for research, organization, analysis and presentation of oral and written academic papers, plus the ability to learn to learn.

A exercise of creative in the research historical in the classroom

So you can work creatively historical research in mathematics classes, the teacher must initially choose some mathematical topics of interest to their teaching and do a small survey of bibliographical material on this subject. Then it is important to search for the life and work of the mathematicians involved, his philosophies and beliefs, paying particular attention to the discoveries, creations and their mathematical contributions to the development of the theme selected. For it must use all materials available in libraries, on the Internet, in newspapers and magazines, among other sources.

The teacher should explain that historical research can show the main contributions of mathematicians and about the people who were involved in the construction and evolution of mathematics. Additionally, it provides ample opportunity to build a learning process in which the independent student explores, discovers, investigates and learns about math, society and human culture. Thus, it may be possible to the student to make connections between mathematics and other disciplines.
There is, however, a wide range of issues that may arise during the course of historical research in the classroom. The teacher must be careful to realize some possibilities to exploit the creativity of students, even if, in certain times it is necessary to reformulate some of the issues presented by them. For this practice to be possible, you need to use up the most diverse forms of historical inquiry in the classroom such as:

- Activities manipulative extracted directly from the history of mathematics;
- Activities manipulative adapted the history of mathematics;
- Development of thematic research projects;
- Investigation of historical problems;
- Studies of historical texts adapted from primary sources;
- Studies of historical texts drawn from primary sources;
- Development and use of video-based lessons in historical texts of primary or secondary sources.

Each type of historical research addressed in mathematics classes requires the teacher a little knowledge of the level of maturity of their students, the degree of depth to give the issue being addressed in the classroom and the level of autonomy of students with respect to search their own learning. Furthermore, it is necessary to make a preliminary survey of the material to

be used in investigations location of research sources or, if appropriate, selecting activities to be applied next to each class, according to the topic learning mathematics taken as a reference for the development of historical research.

We can conclude, then, that research on the history of mathematics develop the insight and knowledge of the student on several mathematical areas. Furthermore, the study of various mathematical topics offers multiple opportunities to learn about other areas of knowledge as important to mathematics and that are not always discussed by the school, especially in traditional math classes.

Assure, therefore, that the historical research of mathematics in the classroom can assume a structuring role in student learning since the activities are not transformed into mere hobbies illustrative of the issue being addressed, but are rather linked to everyday issues, school Math and science, society and culture. This link should be consolidated from the introductory classes to the proposition and problem solving and fixing the content. That does not mean breaking with the proposal of most textbooks, because this is not our goal. What I propose is a reorganization of the information contained in these books, with reference to the historical aspects implicit in the proposed exercises and problems.

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