POSTER SESSIONS

A HERMENEUTIC APPROACH TO HISTORY AND EPISTEMOLOGY IN MATHEMATICS EDUCATION: THE CASE OF PROBABILITY

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The paper presents a theoretical framework for a hermeneutic approach based on the interpretative line proposed by Bagni (2009). Our purpose is to show how this approach may serve as the basis of work with historical sources in teachers education. Its advantage is that it enables to present also teachers positions incommensurate with current mathematical discourse, thus relaxing the need for coherence imposed by an epistemological approach to learning. As an example of the approach, we look at the history of probability.

In his work *Interpretazione e didattica della matematica: una prospettiva ermeneutica* (Bagni, 2009), the Author suggests a shift from epistemology to hermeneutics in mathematics education. Indeed, contrasting Jahnke's hermeneutic approach (Jahnke et al., 2000) - which is Gadamer inspired and needs to see hermeneutics having an episodic character in the epistemological "stream" - Bagni's approach is Rorty inspired and allows to see hermeneutics in antithesis to epistemology. This approach authorizes to propose a radical pragmatic-hermeneutical approach to mathematics education. Although we use here historical sources to explain the research of interpretation tools, the subject works to each kind of text.

As investigative tool Bagni proposes an adaptation of Peirce's semiotics. At the basis of this semiotic approach we find the semiotic triangle but, from a global point of view Peirce's semiosis is a potentially unlimited process leading to the progressive construction of the meaning of a dynamic object. Bagni shows how the initial sign, which allows to start the semiotic chain, is comparable to an initial attitude (habit), and what Peirce calls "the final logical interpretant", can be seen as a mental "effect" (habit change) (Bagni, 2009, p. 212). We can explain this in the following matter. Facing the historical source, the subject is obligate to investigate the beliefs that induced the Author to formulate the sentences. She/he will do this according to her/his current beliefs and this may produce an awareness of the absence of an adequate knowledge, necessary for the interpretation; this allows to start the semiotic chain of meaning construction. The "habit change" would be a new, more meaningful attitude to face the text. The semiotic chain can be repeated using other sources until the subject judges the new attitude adequate to face a didactical processing of problems which treats the matter. This explains why the approach is able to produce and interpret changes in teachers' beliefs (Goldsmith et al., 2014) about mathematics, even when those changes involve radical reorganization of their system of reference: the reorganization is interpreted and measured by the acquired ability and don't' refer to real, objective values.

Probability is a meaningful example in this sense; its history has experienced at least two major epistemological ruptures, which teachers don't always seem to be aware of. The first, with Buffon (1777), involves a shift in focus from discrete situations common in classical treatments to continuous ones with a concomitant shift in operational tools, namely, from arithmetic to geometric tools. The second, with Kolmogorov (1933) and his axiomatization, which completely changes point of view and leaves so aside the question of the nature of probability. Furthermore, the asking of an answer of the last question, which can be accomplished starting from irreconcilable philosophical and epistemological assumptions (Cera, 1990), was an obstacle for the construction of mathematical theory of probability and can be seen as an epistemological obstacle (Bachelard, 1938). We suppose also that the history of probability provides a good example of epistemological ruptures arising from a cultural substrate and we are convinced that teachers' difficulties with probability, beyond those arising from an inadequate mathematical background (Stohl, 2005), may be ascribed to obstacles in the interpretation of probability concepts. Our treatment may thus contribute to the debate concerning the theory of epistemological obstacles as it appears in the work of Guy Brouseau (Perrin-Glorian, 1994) and in Luis Radford's Cultural Semiotics (D'Amore, Radford & Bagni, 2006).

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THE CONTRIBUTIONS OF FUNDS OF KNOWLEDGE AND CULTURALLY RELEVANT PEDAGOGY AS METHODOLOGIES FOR THE DEVELOPMENT OF SOCIOCULTURAL PERSPECTIVE OF HISTORY OF MATHEMATICS IN MATHEMATICS CLASSROOMS

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This study is grounded in the Sociocultural Perspective of History of Mathematics, Funds of Knowledge (FoK), and Culturally Relevant Pedagogy (CRP) theories. It was conducted with the purpose of seeking contributions to activities based on gaining insight into parts of students' culture, specifically, their FoK. The other purpose is to understand the role of History of Mathematics (HM) that can help teachers to comprehend students' questioning and reasoning about mathematics. The population was composed of 72 students from two classes in a first year of a technical course in a public technical high school in Ouro Preto in the state of Minas Gerais, Brazil. The researcher collected information that could answer the research question: What are some of possible contributions that activities based on students' funds of knowledge and anchored in sociocultural perspective of History of Mathematics can bring to teaching and learning functions through the use of Culturally Relevant Pedagogy approach? Two questionnaires, two focus groups, field notes, interviews and informal conversations with participants, and three documental records containing mathematics activities related to functions content were used. HM was applied in both implicit and explicit ways, which served as an orientation guide so that the researcher-teacher could develop the proposed activities by applying the FoK of participants, which helped in the analyses of the students way of represent and/or write functions concepts. We highlight the use of History of Mathematics in high school context in explicit and implicit ways. The implicit way let the teacher-researcher guide some activities and understand some of students' answers. On the other hand, the explicit way was used as problems taken from history to be worked out by the students.It was found that the acquisition of mathematical knowledge and algebraic symbolic language in the classroom is related to students' cultural experiences. This approach allowed us to use some propositions of CRP, which is defined as a critical pedagogy that is committed to collectivity and is based on a tripod composed by critical awareness, cultural competence, and academic success. For data collection, analysis, and interpretation of qualitative and quantitative data, a mixed methods study QUAN + QUAL and content analysis were used. Data were collected and analyzed concurrently in all phases of the study. Thereafter, the results were analyzed, discussed, and interpreted in order to be addressed as part of the research. The interpretation of the results showed that the majority of participants

learned and improved their knowledge in relation to symbolic algebraic notation by highlighting the importance of rhetoric stage of algebra in order to understand symbolism and academic development of symbolic algebraic language. Besides that, we drew attention to the fact that History of Mathematics used in explicit way cannot be applied as a teaching methodology for high school teachers in all mathematical content. However, it can be used in an implicit way to help teachers to understand students' reasoning even though the sociocultural context is very important in this understanding.

Poster Session – Theme 1

DESIGN RESEARCH ON INTEGRATING THE HISTORY OF MATHEMATICS INTO TEACHING AND APPLICATION

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INTRODUCTION

One common phenomenon: "High Evaluation, Low Application", always appears in mathematics teachers' comments and reflections on (IHT) (Wang,X. &Zhang,X., 2005) Therefore, this paper proposes a model of design research on IHT that may be useful in the conduction of HPM research, and show an example of application of design research on IHT.

WHAT IS DESIGN RESEARCH ON IHT?

Based on studies about design research (Bannan-Ritland 2003; Brown, 1992; Cobb, 2001; Yishay, 2010), the author proposes a model of design research on IHT (as shown in Figure 1). Using design research of IHT circularly processes five steps: Investigation & Preparation, Development & Design, Implementation & Operation, Analysis & Evaluation, Popularization & Application to produce reliable IHT instruction design, and to promote the development of theory and practice on IHT.

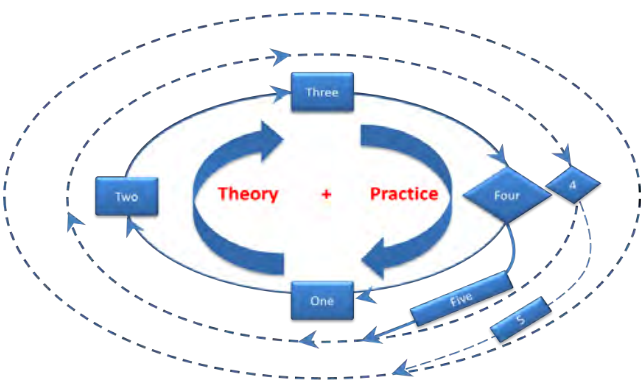

Figure 1: The five steps of HPM's design research

EXAMPLE ON USING IHT DESIGN RESEARCH

Many teachers complained that it was very difficult to teach mathematical induction (MI) and students cannot understanding the two steps meaning. Therefore, teachers will use teaching strategy of IHT by using design research on IHT. Based on the five steps of Figure 1, I will show how to use design research on IHT in the following.

Preparation & Investigation: the researchers started to search some materials on MI as many as possible when they received SOS from the teachers. Researchers will cooperate with historian of mathematics to obtain the original materials about MI, and receive some suggestions. Then, researchers well know that development of MI in history: a) Inductive reasoning in the period of Rhetoric Algebra; b) Recursive reasoning in the period of Abbreviated Algebra; c) Recursive reasoning in the period of Symbolic Algebra; d) Formalization after the Peano axioms (Katz, 2008). Finally, researchers discussed with the teachers, and decided that they would use the reconstruction to integrate the historical materials into the design of lesson.

Design & Development: Based on the preliminary design framework, the researchers and teachers develop the framework into the figure 2. At that time, they would choose some historical materials or problems to design the detailed lesson plan. The problems in Figure 2 includes towers of Hanoi, wrong pattern on natural numbers and Fermat's wrong conjecture, L-shaped tiles, Domino cards, and exercise problems on MI.

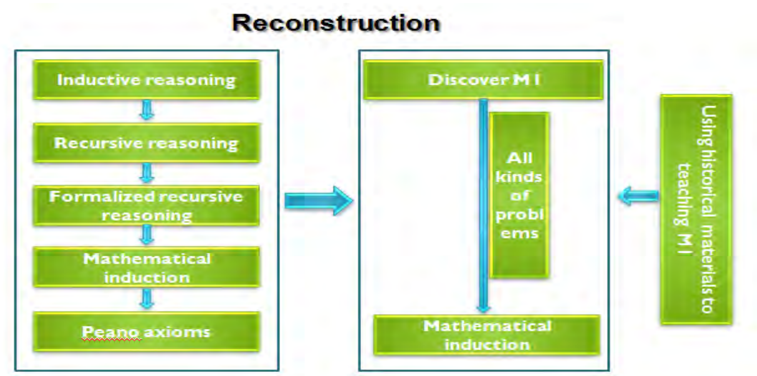

Figure 2: The framework of instruction design of mathematical induction

Operation & implement: Researchers and teachers work together to implement the design. During the process of teaching, Researchers cared about how to modify the historical materials to be adaptable for the students' cognition. The purpose of this way is to improve the quality of teaching.

Analysis & Evaluation: After the discussion and analysis the effect of teaching, researcher found some problems- wasting time in explaining the reasoning, the design cannot adequately use the historical materials. L-shaped tile problem is too difficult for students. Meanwhile, they thought about how to solve the

Application & Promotion: After repeating the four same steps, the design had been modified to the Figure 3. Most importantly, teachers and researchers agreed that the design can be recommended to other instructors for their checking after completing the analysis and evaluation. Of course, the new instructor will process the same procedures when they use and text the design. Therefore, the whole process can provide some evidence to support the theories of integrating history of mathematics into teaching practice, and promote the development of theories and practices on IHT.

In general, this example is to illustrate the application of IMT design research although the process is succinctly introduced, and much detailed information will be shown in another paper.

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Poster Session – Theme 2

PROGRESSIONS AND SERIES IN ANCIENT CHINA

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In this poster we present a brief chronology of the series numerical progressions and Chinese mathematics. The arithmetic and geometric progressions appear in China in a book called 九章算術 or Jiuzhang suanshu (Chu Chang Suan Shu) or Nine Chapters on the Mathematical Art, written approximately around 200 BC (Some historians assigned a date between 100 BC and 50 a. C.), and which over time mathematicians were adding various comments. In Chapter 3, named Cui fen or Distribution by Proportion, there are problems whose solution involves the use of arithmetic and geometric progressions.

Zhang Qiujian (also known as Chang Ch'iu-Chin or Chang Ch'iu-chien) wrote a book called Zhang Qiujian suanjing (Zhang Qiujian’s Mathematical Manual) between 468 d. C. and 486 d. C. (Some historians date Zhang Qiujian 100 years before) consisting of 98 problems divided into three chapters. In this work solves and computes the sum of arithmetic progressions. Zhu Shijie also known as Chu Shih-Chieh was born around 1260 near Beijing, China. It is known that he wrote two works considered as surprising. The first named Suan xue qi meng (Introduction to mathematical studies) published in 1299 and came to be used as a textbook of mathematics in Japan (printed in 1658) and Korea (printed in 1660) deals with polynomial equations and polynomial algebra, areas, volumes, rule of three and a method equivalent to Gaussian elimination. The second book published in 1303 is Siyuan yujian (True Reflections of the Four Unknowns) and it includes the famous Pascal's Triangle to the eighth power. He solves polynomials with 1, 2, 3 and 4 unknowns. It also features 288 problems divided into three volumes with 24 chapters. He presented formulas of sums of integers like

$$1+4+10+20+\ldots+\frac{n(n+1)(n+2)}{6}=\frac{n(n+1)(n+2)(n+3)}{24}$$

among others, and also provided the sum of series of the kind $1+4+9+16+25+36+\ldots$, $1+5+14+30+55+91+\ldots$

Yang Hui was born in 1238 in Qiantang (present Hangzhou, China). In 1261 Yang wrote the Xiangjie jiuzhang suanfa (Detailed analysis of the mathematical rules in the Nine Chapters and Their reclassifications). Yang also gave the Pascal Triangle's scheme to the sixth row and also gave formulas for the sum of series like

$$1+3+6+10+...+\frac{n(n+1)}{2}=\frac{n(n+1)(n+2)}{6}$$

and the sum of the squares of the natural numbers between m^2 and $(m + n)^2$.

POSTER SESSION – THEME 2

GENETIC APPROACH TO TEACHING DERIVATIVE: A TEACHING EXPERIMENT ON THE GEOMETRIC INTERPRETATION OF DERIVATIVE IN SENIOR HIGH SCHOOL

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Abstract: The problem of the tangent line is one of the most important problems which lead to the birth of calculus. Through a questionnaire survey conducted to 201 students, we concluded that there are historical parallelism between the students' understanding and that of the ancient Greek mathematicians. On the base of historical and epistemological analysis of the concepts of derivative, we design a teaching instruction by integrating history of the birth of calculus, such as problems of light reflection, curve movement. Based on the reconstructed history, The Cyclotomic Rule by Liuhui is introduced to construct a bridge connecting the static and dynamic concept of the tangent, enabling students to pass from the finity to infinity naturally and successfully. It is revealed through interview and a questionnaire survey that the genetic approach to teaching derivative in conducible to better understanding of the concepts of derivative.

INTRODUCTION

Calculus is the main mathematical subject taught in both senior high school and university. However, the teaching of the concept of calculus is universally difficult. In In high school, the derivative is taught in the twelfth grade. Three aspects are emphasized: 1) the concept of the derivative itself and how it is calculated; 2) its geometric representation; 3) applications. Students often know how to compute the derivative, but know nothing about its meaning in nature. Geometrically, the derivative may be interpreted as the slope of a curve at a point. The problem of the tangent line is one of the most important problems which lead to the birth of calculus. This teaching experiment is a part of action research on derivative, focusing on the teaching of the geometric interpretation of derivative from the HPM perspective.

RESEARCH QUESTION

The research questions are: 1) How do senior high school students understand the concept of tangent? 2) Can the integration of mathematics history contribute to the learning of the concept of tangent? 3) Can the integration of mathematics history improve students' understanding of the mathematical idea of replacing curves by straight lines?

RESEARCH METHOD

A historical and epistemological analysis of calculus is a way to reveal some possible sources of students’ difficulties as well as an inspiration in the design of activities for students. Otto Toeplitz first summarized and elucidated calculus in terms of an organic evolution of ideas beginning with the discoveries of Greek scholars and developing through the centuries in his book< The Calculus: A Genetic Approach>. The genetic approach to teaching and learning is that a subject is studied only after one has been motivated enough to do so, and learned only at the right time in one’s mental development.

Historical analysis and epistemological analysis

Many mathematicians have done a lot of work to descript the tangent. Greek mathematician Euclid speaked of a line that touches the curve at a point on it and is such that no other line can be drawn from the point and between the curve and the original line, that is, it will cut the curve. Apollonius and Archimedes used the same definition that the tangent is a line which touches a conic section or spiral at just one point. Fermat developed a general technique for determining the tangents of a curve by using his method of adequality in the 1630s. Torricelli and Roberval developed a method for finding the tangent by using instantaneous velocity. Leibniz defined the tangent line as the line through a pair of infinitely close points on the curve. L’hospital defined the tangent as an extension line of one side of a inscribed polygon. We can conclude that in ancient mathematics, the tangent touches the curve at one point, lies entirely on one side of the curve without crossing it and in modern mathematics, the tangent line to a curve is a straight line representing the limiting position of the secants.

To grasp the starting points of students’ understanding about the concept of tangent line, we carried out a questionnaire survey by using these two questions.

Question 1: Is the straight line y=1 the tangent line of the curve $y = \sin x$? why?

Question2: Is the straight line y=0 the tangent line of the curve $y = x^3$? why?

	Response	Number	Reason
Q1	Yes	117	the curve lies on one side of the straight line
	No or no response	84	there are more than 1 common points
Q2	Yes	48	there is only 1 common point
	No or no response	153	the curve doesn’t lie on one side of the straight line

Table 1: results of the questionnaire survey

Through the questionnaire survey, we can conclude that there are historical parallelism between the students’ understanding and that of the ancient Greek mathematicians. We should help students to understand that whether the tangent lies on one side of the curve is not the criterion, to motivate them to seek the new definition of tangent line.

Teaching experiment

The question of finding the tangent line to a graph was one of the central questions leading to the development of calculus in the 17th century. Three questions from real life, namely, light reflection, instantaneous speed, the slope of an arch bridge, have motivated the research of tangent problems in 17th century. We ask students to think about the definition of the tangent of a circle and a conic section, then to explore the new definition of tangent.

The teaching project of the geometric representation of derivative has a distinctive feature that it deeply connects to the Cyclotomic Method, to calculus the area of a circl presented in the famous Chinese book of mathematics *The Nine Chapters on the Mathematical Art.* "*Multiply one side of a hexagon by the radius (of its circumcircle), then multiply this by three, to yield the area of a dodecagon; if we cut a hexagon into a dodecagon, multiply its side by its radius, then again multiply by six, we get the area of a 24-gon; the finer we cut, the smaller the loss with respect to the area of circle, thus with further cut after cut, the area of the resulting polygon will coincide and become one with the circle; there will be no loss*". Two examples can motivate students to explore the connection between tangent and derivative and understand the transition from the algebraic representation to the geometric representation. In the case of the ellipse, the construction of the tangent rested on the theorem that the tangent at the point of tangency forms equal angels with the two focal radii drawn from the point of tangency. After we magnifies the ellipse 100 diameters, students can find the curve and the straight line is overlapped, which is the mathematical thinking of replacing curves by straight lines.

RESULTS AND REFLECTIONS

We conducted interviews with 8 students and carried out a questionnaire survey in two 12-grade classes comprising 105 students. They all think the class was interesting. There were no difficulties in understanding the concept of tangent and the mathematical idea of replacing curves by straight lines. Almost all students agreed that the integration of the Cyclotomic Method can help them understand the concept of tangent and the process of magnify the ellipse can improve their comprehension on the mathematical thinking of replacing curves by straight lines.

We think the genetic approach to teaching and learning is that a subject studied only after one has been motivated enough and learned only at the right time in one’s mental development. The historical and epistemological analysis can help us recognize the starting point of the students’ comprehension of the concepts of tangent. The integration of mathematical history should reconstruct the natural way of developing a concept from realistic problem situation.

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Poster Session – Theme 5

PLIMPTON 322: A VIDEO DOCUMENTARY TO MOTIVATE STUDENTS TO STUDY MATHEMATICS

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I shall provide an introduction to the 33-minute film Plimpton 322: The Ancient Roots of Modern Mathematics, which was produced to motivate college and high school students – especially minority students – to pursue mathematics. The mathematics that drives our modern world owes its origins to ancient cultures in the Middle East, Asia and Africa. Set against a backdrop of today's New York City, the film explores the extent of our debt to this tradition. Along the way we meet up close some precious and revealing ancient artefacts that now have their homes in New York, most of all a controversial cuneiform tablet from Mesopotamia known as Plimpton 322. We witness ancient mathematical ideas still playing crucial roles in 21st century society and technology.

This film celebrates the diversity underlying our mathematical culture. Teaching at a large, urban, multiethnic university, I have found it useful in encouraging students in courses ranging from mathematics for liberal arts students to history of mathematics. The film incorporates brief introductions to two mathematical topics, positional number notation and Pythagorean triples, which can be developed in the classroom. The purpose of my presentation is to bring this freely available resource to the attention of educators and to discuss with anyone interested its use in the classroom. As well as a poster, I shall display a trailer and excerpt from the film on a laptop computer or tablet.

The film is at http://faculty.baruch.cuny.edu/lkirby .

Poster Session – Theme 6

MATHEMATICS, EDUCATION AND WAR

Júlio Corrêa

Roskilde University & Universidade Estadual de Campinas

In this work we present some ideas related to a PhD project started in 2011 where we try to problematize some relations between mathematics, education and war. More precisely we have been trying to understand the modifications in the field of mathematics education in the context of Cold War. Here we try to problematize the enigmatic phrase of Jean Dieudonné: “Euclid must go!”. For a long period in the history of mankind the Euclidian geometry played an important role not only in the warfare, but at the schools and in science in general. So, why, in a context where the “Western” headed by United States seemed to be losing the conflict capitalism versus communism, Euclid must go? Tracing some relations between the development of disciplines as Operational Research, Game Theory, Linear Programing, the emergence of computer sciences and the structuralist mathematics proposed by the Bourbaki group, we shall enlighten the so called “modern mathematics movement” and its relation with the Cold War. Apparently there is no explanation available for the demise of Euclidian geometry and the predominance of “New Math” solely in terms of mathematics neither in terms of society neither of mathematics education, then we need to look for fields of human activities and its relations to explain this event. Based on a post-structuralist theoretical approach, mainly on the works of the “second” Wittgenstein, Jacques Derrida and Michel Foucault, we try to develop a grammatical deconstructive therapy of mathematics, education and war in the specified context. We believe that such kind of historic-philosophical problematization could help teachers to understand the relations between the field of mathematics and other fields of human activity which may help them to show to students the role of mathematics in different contexts of socio-cultural practices.