

Math & The City - Learning to apply mathematics outside the school. Documentation of the joint online research seminar

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▶ **To cite this version:**

Nils Buchholtz, Daniel Clark Orey, Milton Rosa. Math & The City - Learning to apply mathematics outside the school. Documentation of the joint online research seminar. 2020. hal-02961977

HAL Id: hal-02961977
https://hal.science/hal-02961977

Preprint submitted on 8 Oct 2020

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Institutt for lærerutdanning og skoleforskning

Math & The City –

Learning to apply mathematics outside the school

Documentation of the joint online research seminar

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https://www.uv.uio.no/ils/forskning/prosjekter/math-and-the-city/index.html

The project Math & The City is a cooperation project between the University of Oslo and the Federal Unversity of Ouro Preto. The project is funded by the Norwegian Agency for International Cooperation and Quality Enhancement in Higher Education (Diku), project UTF-2018-two-year/10051

University of Oslo, October 2020

Diku Direktoratet for internasjonalisering og kvalitetsutvikling i høyere utdanning

Preparation of the joint online research seminar

Due to the worldwide Covid-19 pandemic in 2020, the exchange between the student teachers of the University of Oslo and the Federal University of Ouro Preto could not go as planned in March or respectively September. Brazil is one of the countries hardest hit by the virus and at the moment (October 2020) it is not foreseeable if and in what form an exchange between student teachers can be planned. For this reason, we have decided to allow a digital exchange in the form of a joint online research seminar, in order to ensure the scientific exchange. The seminar was designed as a two-day research seminar, in which student teachers had the opportunity to present their research projects and discuss them with the project team as part of a scientific presentation. As envisaged in the project "Math & The City - Learning to apply mathematics outside the school", the student teachers' presentations focused on the topics of outdoor mathematics, use of digital media in educational mathematics trails as well as ethnomathematics and mathematical modelling. The student teachers' presentations were framed by two workshops by the project team, one on the topic of using digital media in math trails and the other on the topic of ethnomathematics and mathematical modelling. In this documentation, the presentations of the student teachers are documented in the form of short summaries. The seminar was held on 18 and 19 September 2020 for 4 hours each (see Fig. 1). In addition to the project team, Prof. Pauline Vos – an expert in mathematical modelling for teaching purposes – from the mathematics education group of the University of Agder in Kristiansand as well as one of her student teachers could participate on one of the days of the seminar as further collaboration partners.



Fig. 1: Participants in the online research seminar

Sched

ule of the joint online research seminar

Friday, 18.09.: Joint seminar day 1

Brazil	Norway	
12:00- 12:15	17:00- 17:15	Meet and greet, Introduction Nils Buchholtz
12:15 – 14:00	17:15- 19:00	Workshop Using the Actionbound app to create outdoor mathematics trails Nils Buchholtz
14:00- 14:30	19:00- 19:30	Break
14:30- 15:30	19:30- 20:30	Participants research presentations and discussion Jéssica Rodrigues Diego Pereira de Oliveira Cortes Roberto Arlindo Pinto

Saturday, 19.09.: Joint seminar day 2

09:00- 11:00	14:00- 16:00	Workshop Ethnomathematics, environment and mathematical modelling Daniel Clark Orey & Milton Rosa
11:00- 11:30	16:00- 16:30	Break
11:30- 12:30	16:30- 17:30	Participants research presentations and discussion Ticiano Azevedo Bastos Erika Dagnoni Ruggiero Dutra Ana Paula Santos de Souza Mesquita
12:30- 13:00	17:30- 18:00	Joint discussion: Looking ahead and Planning of further collaboration

A MATH TRAIL AND THE (RE) DISCOVERY OF MATHEMATICAL KNOWLEDGE OUTSIDE SCHOOL

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ABSTRACT

The author's master's research entitled: *A Mathematical Trail and the (Re) discovery of Mathematical Knowledge outside school* seeks contributions from the ethnomathematics program and its connection with mathematical modelling in its sociocultural perspective through ethnomodelling in the context of the Math Trails. In this sense, D'Ambrosio (1990) has stated that ethnomathematics is a program that aims at discovering and analyzing the processes of origin, transmission, diffusion and institutionalization of mathematical knowledge from different cultural groups.

Thus, Rosa (2010) states that this approach enables the promotion of a teaching and learning process in Mathematics that is humanized and that respects the values and knowledge of members of different cultural groups, which are brought to the classroom. For Burak (1992), mathematical modelling "is a set of procedures whose objective is to build a parallel to try to explain, mathematically, the phenomena present in the human being's daily life, helping him to make predictions and take decisions" (p. 62).

According to these assertions, Rosa and Orey (2017) argue that ethnomodelling can be used when ethnomathematics is actively used as a system based on a theoretical basis that can solve everyday problems related to the contexts: social, cultural, economic, political and environmental through the mathematical modelling procedures, as it considers the knowledge acquired from cultural practices developed in the communities with the use of locally developed procedures and techniques.

Math Trails can be considered a form of pedagogical action, as it consists of a sequence of designated stop places or stations along a planned route for each path, in which students stop to explore the mathematical content contextualized in everyday situations (Cross, 1997; Richardson, 2004). In this context, the project seeks to identify the local mathematical and geometric concepts relevant to the development of awareness and appreciation of mathematical

procedures and practices that emerge from different socio-cultural contexts through the mathematical trails.

Because of Covid19, the present research and data collection, is still in progress, but has as its main objective to follow *different paths* for the development of the teaching and learning processes in mathematics. Thus, this approach may enable a deeper interaction of students with the world itself through the development of an educational product, in the form of a book of suggestions, which aims to provide educational opportunities that aim to make students critical, reflective and aware of the social, environmental, economic, political and cultural problems present in their own realities.

Keywords: Ethnomathematics, Mathematical Modelling, Ethnomodelling, Sociocultural Perspective, Math Trails.

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RE-SIGNIFYING THE CONCEPTS OF FUNCTION: A MIXED-METHODS STUDY TO UNDERSTAND THE CONTRIBUTIONS OF THE DIALOGIC APPROACH TO ETHNOMODELLING

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ABSTRACT

This research was conducted in a public school located in the metropolitan region of Belo Horizonte, Minas Gerais and a local farmers market[1]. The main objective of this study is to show how the dialogical approach of ethnomodeling contributes to the process of resignification of function concepts. The data from this study involved 38 students in the second year of high school during their interaction with a farmer and his labor practices. Complementing the overall objective of this study, the specific objectives were: a) to describe the connection between ethnomathematics and mathematical modelling, b) to create an understanding of the importance of cultural concepts for the development of mathematical ethnomodels extracted from daily practices found in the sociocultural context of the students in this study, c) describe how both emic and etic approaches and the subsequent dialogical approach of the ethnomodeling process were found in interactions and the meetings between the student group and the farmer, and d) verify how the mathematical practices of the farmer might be adapted and used in the classroom in the development of educational actions in relation to ethnomodeling. Thus, supported by these objectives, and by the theoretical frameworks found in ethnomathematics, modelling, and ethnomodelling developed by D'Ambrosio (2001) and Rosa and Orey (2012), the following research question was outlined: *What are the possible contributions that ethnomodeling can offer to the process and re-signification of the concept of function to second year students of a high school in a public school in the metropolitan area of Belo Horizonte through a dialogical approach?* Three blocks of activities, two questionnaires, one initial and one final, a semi-structured interview with the farmer, a seminar with the students and the farmer, and the field

[1]The local farmers market in which this research was carried out sells horticultural products, clothing, food products, and handicrafts. However, in this investigation, only the labor practices of a marketer in relation to the commercialization of horticultural products were studied.

notes of the researcher teacher, as well as transcriptions of audio and video recordings were used for as data collection in this study. Both quantitative and qualitative data were collected and analyzed by using the methodology of a Mixed Methods Study (PLANO CLARK; CROSSWEL, 2007) by applying the *QUAN+QUAL* design. After this analysis, qualitative data were quantified. This enabled interpretation of the results through the elaboration of three categories and 11 subcategories that allowed the research question to be answered. One of the main results of this study is that ethnomodeling provides an integrative approach to the school mathematics curriculum that considers both etic and emic (OREY; ROSA, 2015) mathematical knowledge origins, so that teachers and students come to understand, in a more realistic, holistic and comprehensive way, the mathematics developed by the members of the different cultural groups that make up diverse student populations, such as found in this study. As a result of this study, an educational product was elaborated in the format of a notebook of suggestions for implementing ethnomodeling in classrooms.

Keywords: Ethnomodeling. Etic Approach. Emic Approach. Dialogical Approach. Functions Re-signification.

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THE HISTORICAL PATRIMONY OF ITABIRITO UNDER THE VIEW OF MATHEMATICAL MODELLING

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ABSTRACT

Mathematics is often seen as a difficult discipline, however, important we can see it. In this sense, this project was aimed, according to Orey (2011), to encourage in students a sense of awareness and importance towards the conservation and preservation of cultural heritage and identify the presence and importance of mathematics and mathematical modelling in the same cultural-historical heritage of their city. The study was carried out with twenty-nine students of the seventh grade in a municipal school in Itabirito, Minas Gerais, Brazil. A study was made from the mathematical point of view of elements of historical heritage, based on increasing awareness and sensitivity of students to this theme. The record was made through photographs taken by the students and notes and operations carried out in their field notebook. During the fieldwork, the students were able to observe various geometric patterns, in the lines of houses and churches, which drew attention for their high degree of complexity. It can be concluded that the work provided the students to know a little more about their history and the architectural importance of the city by showing the existing geometric richness found in their walks. This was only the first stage of building a mathematics trail in the city of Itabirito, and after Covid-19, we hope to increase more work in this area.

Keywords: Historical Heritage, Geometry, Mathematics. Mathematical Modelling.

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MODELLING IN MATHEMATICS EDUCATION FOR THE DEVELOPMENT OF COMBINATORIAL ANALYSIS CONCEPTS IN A PRIVATE SCHOOL IN VALE DO RIO DOCE IN MINAS GERAIS

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ABSTRACT

This masters research was conducted at a private school located in the Vale do Rio Doce, in the eastern region of Minas Gerais. It was developed with 17 sophomores high school students and a physical education teacher from a regional university. The main objective of this study is associated with the identification and analysis of contributions offered by mathematical modelling through sociocritical perspectives. Other objectives guided this study such as: the identification of everyday problems and situations in out-of-school gymnasiums. These involve concepts of combinatorial analysis that can be solved through mathematical modelling so that students can better understand this curricular content. From this the following research question was defined: *How can the socio-critical perspective of mathematical modelling contribute to the development of combinatorial analysis concepts for sophomore high school students in the Vale do Rio Doce region?* The theoretical foundation was based on mathematical modelling (ROSA; OREY, 2003), its sociocritical perspective, critical and reflexive dimensions, and the processes of teaching and learning of combinatorial analysis (ROSA; OREY, 2007). For data collection, two questionnaires were used, one initial and one final; notes from the professor-researcher's field diary, four blocks of activities related to the concepts of combinatorial analysis and their connections with the processes of preparation of prescription forms for training sheets in the gyms, and also a semi-structured interview with the teacher of physical education participant in this study. The collected data were analyzed, and results were interpreted according to the theoretical framework adopted in this study and the assumptions of grounded theory (STRAUSS; CORBIN, 1990). Data were coded by using open and axial coding for the elaboration of the conceptual categories that allowed the interpretation of the results obtained in this study. The results of this investigation show that the sociocritical perspective of mathematical modelling contributed to the development of combinatorial analysis concepts in the participants in this study. This occurred because modeling practices in which they used allowed them to analyze and elaborate training prescription models, thus providing the development of criticality and reflection on the practices adopted in the gyms regarding the

management of training and the quality of care offered by instructors, as well in relation to the role of mathematics in other knowledge fields. Therefore, from the involvement of participants in the activities proposed in this investigation, explicit or implicit counting strategies were identified, involving combinatorial reasoning and mathematization in the elaboration to training prescription forms. Thus, participating students presented the proposal of working circuit in the gyms at the time of the prescription of the training to minimize the problem of congestion in the machines during the bodybuilding work. These results also show that the Sociocritical Perspective of Mathematical Modelling has contributed to the establishment of connections between school mathematics and the problem-situations implicitly present in the daily lives of these participants, such as the elaboration of training forms prescriptions. The establishment of a pleasant and attractive climate motivated these participants in the development of the proposed activities in the documentary record blocks, enabling the learning of the concepts of combinatorial analysis. The Sociocritical perspective of Mathematical Modelling also contributed to the promotion of more dynamic classes through teacher-researcher interaction with the participants of this study through the use of everyday situations in the teaching and learning process of the concepts of Combinatorial Analysis and, also, with the development of a critical view on the practices adopted in the gyms. Finally, an educational product was elaborated in the format of a suggestion book that presents proposals for activities conducted in this study, and guide teachers and readers interested in this area to work with the concepts of combinatorial analysis in the sociocritical perspective of mathematical modelling. The educational product, which is a book of suggestions originating from this dissertation, was designed to guide teachers, educators, and those interested in this subject, who wish to innovate their teaching practices related to the concepts of combinatorial analysis. Thus, this book of suggestions was designed to bring readers closer to the mathematical practices that were developed in this study through the use of dialogical boxes named: Observations, Suggestions, Tips, and Reminders, which aim to guide readers in the development of the proposed activities in this educational product.

Keywords: Mathematical Modelling. Combinatorial Analysis. Sociocritical Perspective. Prescription Forms for Training. Grounded Theory.

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ETHNOMODELLING AND COFFEE: PROPOSING A PEDAGOGICAL ACTION FOR THE CLASSROOM

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ABSTRACT

This research was developed in a private school, located near Manhuaçu, Minas Gerais, with 35 students from the 2nd year of high school. One of the main objectives of this study was to assist members of different cultural groups in obtaining emic and etic mathematical knowledge, in a dialogical approach to mathematical curriculum based on ethnomodelling (ROSA; OREY, 2017) using blocks of curricular mathematical activities, and proposals for the classrooms. In addition, this study also enabled a sociocultural appreciation of the members of different cultural groups (coffee and school cultures) by students through cultural dynamism. In this sense, emic mathematical knowledge was used as a starting point for the development and formulation of etic curricular mathematical activities, in a dialogical manner, in a holistic way, which enabled the understanding of mathematical processes developed by members inserted in the coffee culture. The following research question was defined: How does an application of ethnomathematics, together with modelling tools, contribute to the development of a broader understanding of mathematical and geometric contents for students of the 2nd year of high school, through a pedagogical action based on ethnomodelling, relating to coffee culture of a city near of Manhuaçu, in Minas Gerais? To support this research, the theoretical bases of ethnomodelling, mathematical modelling, and ethnomathematics were used. Data collection was carried out by using two questionnaires, an initial and a final one, four blocks of activities, a seminar, notes in the teacher-researcher's field diary, and three semi-structured interviews. The analysis of the collected raw data was carried out according to the methodological design adapted from grounded theory (GASQUE, 2007) through the open and axial codings, which provided, respectively, the development of preliminary codes and the conceptual categories. The results of this research showed that the students participating in this study developed the necessary mathematical tools that could influence their own reality, transform it, aiming at achieving a collective good, as well as improving the quality of life of their community, such as, for example, when designing a vehicle prototype to assist coffee harvesting processes in a mountainous terrain. Finally, an educational product was prepared, in the form of a suggestion

book, which in addition to proposing the development of pedagogical activities for teachers, also sought to present the possibility of using daily practices developed by members of a certain cultural group (coffee culture), in the teaching and learning process in mathematics through ethnomodelling.

Keywords: Coffee, Ethnomathematics, Ethnomodelling, Mathematical Modelling, Grounded Theory.

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A SOCIOCRITICAL ANALYSIS OF ETHNOMODELLING AS A PEDAGOGICAL ACTION FOR THE DEVELOPMENT OF MATHEMATICAL CONTENT IN A PERIPHERAL COMMUNITY

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ABSTRACT

The research that forms this master´s thesis was conducted in a public state school, located in a peripheral community in the metropolitan region of Belo Horizonte, Minas Gerais, Brazil. Data that forms this research originated with the participation of thirteen students in the eighth grade of Middle School and a collector of recycled materials. One objective of this study was related to conducting a sociocritical analysis of ethnomodelling as a pedagogical action in the development of mathematical content in a peripheral community. As well, other objectives were necessary to conduct this study, including, for example, discussing and problematizing of the relations between mathematical modelling and ethnomathematics, culminating in the concept of ethnomodelling; identify main cultural characteristics of peripheral communities and investigating the practice of ethnomodelling in the classroom. The following research question was elaborated: How can ethnomodeling as a pedagogical action constitute a critical environment for the development of mathematical content of 8th grade students in a peripheral community in the metropolitan region of Belo Horizonte? The theoretically base of this study, the concepts of ethnomathematics (D'AMBROSIO, 2001), mathematical modelling (BIEMBEGUT, 2009) and its sociocritical perspective, ethnomodelling (ROSA; OREY, 2017) and peripheral communities (LANA, 2016) were used. As instruments of data collection, three blocks of activities were used, based on ethnomodelling, mathematical modelling, emic, etic, and dialogical approaches; two questionnaires, one initial and one final; the field diary of the teacher-researcher and a semi-structured interview conducted with a recycled material collector. The data were collected, analyzed and coded according to the assumptions of the Grounded Theory (GLASER; STRAUSS, 1967). For the data analysis, both open and axial codifications were used, which allowed for the elaboration of conceptual categories, providing the interpretation of results obtained in this study. The results show that ethnomodelling contributed to the development of mathematical content of the participants in this study, who are residents of a peripheral community based on the study, which lack of adequate basic

sanitation that make up the daily lives of members of that community. The results of this study also show that ethnomodelling provided the participants with the development of a critical reflection in relation to the space itself, in addition to reflecting about multicultural and interdisciplinary experiences from the development and presentation of the project: *Projeto Wall*-e: repensando a produção de lixo em comunidades periféricas por meio da Matemática (*Wall-e File*: rethinking production of garbage in peripheral communities through mathematics), at the 3rd Minas Gerais Scientific Initiation Fair - FEMIC, which culminated with a 1st place in the category of Exact and Earth Sciences and the accreditation for the 18th Brazilian Fair of Sciences and Engineering - FEBRACE. At the end of this investigation, an educational product was prepared in the form of a book of suggestions, whose objective is to present proposals for activities that were related to basic sanitation, which aims to guide teachers and those interested in this theme in the development of tasks that involve sociocultural aspects of mathematics and its students in their own communities.

Keywords: Ethnomodelling. Ethnomathematics. Mathemtical Modelling. Peripheral Community. Grounded Theory.

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Overview of the Norwegian master's theses at the University of Oslo, which are part of the project.

MATH TRAILS AND MODELLING - A QUALITATIVE ANALYSIS OF STUDENTS' WORK WITH MODELLING ACTIVITIES IN AN OUTDOOR LEARNING ENVIRONMENT CALLED MATH TRAILS

Juliane Singstad (Master's thesis Spring 2020)

ABSTRACT

The qualitative study examines students' modelling work in an outdoor, object-related learning arrangement. Modelling is about linking reality and mathematics together by describing a real problem in a mathematical way, and then interpreting the mathematical solution in light of reality. The school today is changing to make the subject of mathematics more relevant and close to reality, and can benefit greatly from the teaching of modelling precisely for that reason. When modelling also becomes a relatively important part of “Fagfornyelsen” (a curriculum reform in Norway), it becomes all the more important to follow with the development in the classrooms. So far, there are relatively few prepared examples for teachers to integrate mathematical modelling in Norwegian mathematics teaching. Blackboard teaching is most widespread, despite the fact that it is not necessarily the best form of teaching. The master's thesis is based on a learning environment that is to be an alternative to blackboard teaching. By examining how students work with the "Math Trails", I want to investigate which modelling processes the students go through as well as how the teaching plan affects the modelling work in different ways. The research question is as follows: What characterizes students' work with modelling in the learning environment “Math Trails”? To be able to answer that question, there were nine mathematics students in 1P (11^{th} grade) filmed while working with the learning environment. The students collaborated in groups, and solved three tasks with modelling activities. The video material was later analyzed with a deductive and an inductive approach to nuance when addressing the research question. The results show a difference between the students' choice of modelling routes, as well as how much time they spent per subprocess in the modelling cycle. The results also show that using the mobile phone can be helpful where students understand the procedure and have an idea about the outcome, but can be an obstacle in the cases the students encounter, for example conceptual barriers or lack of aids competence. The purpose of this study is to contribute with empirical research in a research gap that means

that there is a lot research on what modelling is, but little research both on how students work with an outdoor learning environment and how it can best be implemented in teaching.

EXAMINATION OF PROFESSIONAL TEACHER COMPETENCE FOR TASK DEVELOPMENT AND IMPLEMENTATION OF OUTDOOR MATHEMATICS TEACHING

Issat-Erke Trosten (Master's thesis Spring 2021)

ABSTRACT

In the master's thesis, the competence development of four mathematics teacher students is examined, who participate in a workshop on the subject of outdoor mathematics and independently develop outdoor mathematics tasks. The workshop includes the mediation of professional teaching knowledge for outdoor teaching as well as knowledge of the quality of mathematics assignments and tasks. In the master's thesis, the quality of the developed tasks is examined, as well as the beliefs of the teacher students of the apprenticeship to carry out mathematics lessons outdoors.

INVESTIGATION OF SOLUTIONS, STRATEGIES AND MISCONCEPTIONS ON THE CONCEPT OF PROPORTIONALITY TO STUDENTS WHO PERFORM A MATH TRAIL

Elin Sletten (Master's thesis Spring 2021)

ABSTRACT

In the master's thesis, written student solutions of a math trail are examined in order to reconstruct their basic ideas and misconceptions about the concept of proportionality. The aim of the work is to find out to what extent the tasks used on a math trail can activate corresponding ideas, support the solution of tasks and encourage the students to explain mathematical thoughts and arguments. Subject-didactic task analyses are coupled with an empirical study. Through a pre- and post-test, the student's pre-knowledge of the concept of proportionality is surveyed.

EXAMINATION OF THE DIAGNOSTIC KNOWLEDGE OF TEACHERS IN THE FRAMEWORK OF OUTDOOR MATHEMATICS LEARNING

Anette Skovly (Master's thesis Spring 2021)

ABSTRACT

The master's thesis examines the diagnostic knowledge of teachers who are confronted with different situations when conducting math trails. In a video-based evaluation format, teachers can view snippets of student work on outdoor mathematics tasks to which they must make a statement. The short video clips focus on the difficulties of the students in completing the tasks, misconceptions when measuring and determining sizes as well as problems in group work. In a qualitative analysis procedure, the diagnostic knowledge of the teachers is reconstructed. The evaluation furthermore asks them about their attitudes to outdoor teaching in order to identify possible connections here.