Mathematical modeling in a long distance course: accessing higher education in Brazil

Milton **Rosa**
Centro de Educação Aberta e a Distância (CEAD)
Universidade Federal de Ouro Preto (UFOP)
Brasil
milton@cead.ufop.br
Daniel Clark **Orey**
Centro de Educação Aberta e a Distância (CEAD)
Universidade Federal de Ouro Preto (UFOP)
Brasil
oreydc@cead.ufop.br

Abstract

The authors led a group of diverse students by using long distance technologies to write mathematical models in relation to their experience with the nationwide protests related to a sudden and steep climb in transportation costs during June 2013. In this article the authors outline theories and work related to critical mathematical modeling, distance interaction, and transactional distance by using long-distance technologies in Brazil. Mathematical modeling became a teaching methodology that focuses on the development of a critical and reflexive efficacy that engages students in a contextualized teaching-learning process that allows them to become involved in the construction of solutions of social significance. This critical dimension of mathematical modeling is based on the comprehension and understanding of reality, in which students learn to reflect, analyze and take action on their reality. This approach coupled with long distance education allows students to access higher education in Brazil.

Keywords: Critical Reflexive Mathematical modeling, Higher education, Long Distance Education, Virtual Learning Environment.

Introduction

In recent years, Brazil has experienced an accelerated social and economic growth and accompanying social changes. The country is now the 7th largest economy in the world. It sponsored the 2014 World Cup and it is sponsoring the Olympics in Rio de Janeiro in 2016, and is suffering a tremendous amount of modernization in relation to infrastructure, including that of health and education. Nation-wide a process of upgrading teacher competencies and the training of new teachers on a massive scale is making a difference in school and community quality of life. The most expedient, economical, indeed reasonable method to do this is by integrating the use of long distance and multimedia technologies. To increase access to a wider audience, the use of Moodle as the platform and freeware is used; which has enabled the Universidade Aberta do Brazil (UAB) system to the democratize the access of higher education. In this context, the study of new educational and methodological proposals become relevant as a result of social changes resulting from contemporary scientific and technological development. The need to update and upgrade professional development for teachers raises new institutional methods and resources in order to meet the demand for specialized teacher education programs such as in mathematics as imposed by technological developments.

The Long Distance Learning program in Brazil offers teacher education programs to prospective teachers in places and in contexts that have had extremely limited access to higher education, if at all. This was developed because face to face teacher education programs cannot currently meet the needs or allow people the time required by traditional face to face instruction to earn degrees. Instruction is performed by using a variety of technologies as well as special organizational and administrative arrangements (Moore & Kearsley, 2007). Several actions of the Brazilian Federal Government were developed for teaching and learning in a long distance modality and forms part of the Ministry of Education's plan representing the intention of the current government to invest in distance learning and a new digital era of informational and communicational technologies that support teaching practices and professional development (Brazil, 2005). This program aims at meeting the demands of the 21st century in which this program is mediated by emerging technologies and methodologies in order to cover all educational levels and social classes. According to the Brazilian Law No. 5622 promulgated in December, 19th 2005, Long Distance Education is characterized as an educational modality in which its didactical and pedagogical mediation is facilitated in the teaching and learning processes and occurs through the use of a variety of informational and communicational technologies. In this process, students and teachers develop educational activities in diverse and distinct local and times (Brazil, 2005). However, it is necessary to work beyond the concepts of this law in order to understand the didactical and pedagogical action plan for this educational modality, which has direct influence to the quality of education offered to students and communities.

It is important to emphasize the relevance of the preparation of a long distance course where it is necessary to know the learning needs of diverse groups of students and their unique conditions in which they live. However, it is not enough to enhance access to this kind of education without changing and adapting processes and methods of teaching and learning regarding available technological resources. This means that in order to establish processes and methods for a distance learning mathematics courses such as modeling, it is relevant to know its potentialities and possibilities that meets the expectations and aspirations of the institutions and people involved in this process. In this regard, it is necessary to establish a system of long distance learning process and methods based on existing theories regarding to these research fields and then analyze this model that was applied in a *Seminar in Mathematical Modeling* in a

long distance mathematics undergraduate course in a federal university in Brazil. This course is offered entirely in a distance environment mediated through technology and internet. The development of the activities is conducted through the use of Moodle Platform that possesses interactional tools among teachers, tutors, and students. According to this context, the Centro de Educação Aberta e a Distância (CEAD) at the Universidade Federal de Ouro Preto (UFOP) have come to integrate instruction, technology, content and pedagogical methods in order to reach a diversity of students. In just this university alone, there are over 4500 students enrolled in four undergraduate majors (Mathematics, Geography, Pedagogy, and Public Administration), which represents 41% of UFOP students from three states (Bahia, Minas Gerais, and São Paulo) and access courseware and instruction via 31 *polos* (long distance learning centers). UFOP that is one of the oldest public institutions of higher education provides one of the largest distance education programs in Brazil.

Outlining Theories Related to Distance Learning and Critical Mathematical Modeling

In Brazil, push back in regards to long distance education is evident, especially in regards to its implementation in higher education, and amongst the attitudes of traditional face-to face faculty and colleagues. Despite these concerns, and in order to expand higher education in Brazil, UAB was developed. It has the mission of providing access to higher education to a population of prospective learners who has not had access. Paulo Freire's ideas related to literacy; primarily, his idea that links social justice, access and community development to literacy has made a great impact, and has influenced this initiative; as well, ethnomathematics has for years said that we should do the same in the context of mathematics education. According to the Brazilian National Curriculum for Mathematics (Brazil, 1998), students need to develop their own autonomous ability to solve problems, make decisions, work collaboratively, and communicate effectively. This approach is based on abilities, which help students to face challenges posed by society by turning them into flexible, adaptive, reflexive, critical, and creative citizens. This perspective is also related to the critical dimension of mathematics, which is closely associated with the ethnomathematics as program (D'Ambrosio, 1990). This aspect emphasizes the role of mathematics in society by highlighting the necessity to analyze the role of critical thinking in relation to the nature of mathematical models as well as the function of modeling that solves everyday challenges.

So, when Brazil suddenly erupted, it seemed the perfect opportunity to look at the question of transportation that people were concerned with. Having a number of diverse polos (educational centers) with a diversity of costs, populations and social contexts seemed a rich opportunity, not to be missed. This approach allows us to determine the main goals for schools that relate to the development of creativity and criticality to help students apply different tools to solve problems faced in their daily lives as well as competencies, abilities, and skills to help them to live in society. This context also allows for the development of a critical mathematical modeling, which enabled students to develop mathematical models related to the proposed theme of transportation. Unfortunately, in most cases, these goals are established in school curricula without the participation of community input. This curricular aspect contributes to an authoritarian education which unmotivates and promotes passivity in the teachers and students. The focus of education must be to prepare both teachers and students to be active, critical, and reflexive participants in society. However, in order to reach this objective, it is necessary that the community supports teaching and learning processes that help students to develop their social-critical efficacy. This means that teachers should be encouraged and supported to adopt

pedagogical practices that allow their students to critically analyze problems that surround them in order to promote social justice.

Critical Mathematical Modeling

In the last three decades, critical mathematical modeling as a method for teaching and learning mathematics has been a central theme in mathematics education in Brazil; in teacher education programs this is a way to rebuild or restore part of fragmented knowledge students acquired during their previous mathematics learning experiences. Critical Mathematical modeling has become one of the most important lines of research for processes of teaching and learning of mathematics in Brazil. This work points out some reasons for teaching and learning of mathematics aimed at solving real world problems that makes use of critical mathematical modeling as a methodology that values and enables the connection between mathematics and reality. However, this aspect is not commonly reflected in the teaching practices of mathematics teachers. Much of the literature related to mathematical modeling and its critical perspective contributes to the formation of both critical and reflexive teachers and presents us with opportunities for the meaningful learning of mathematical concepts by students in virtual environments. As a methodology in a virtual learning environment in undergraduate courses for prospective mathematics teachers, it allows for the exploration of issues related to the context and interest of students and thus provides meaning for mathematical content under study.

By using this critical mathematical modeling perspective we encourage the examination of ways in which students develop and use certain mathematical procedures so that they learn to identify and propose solutions to problems faced in everyday life (Skovsmose, 1990). This process is crucial to the development of an informed, active, and critical citizenship. One of the necessary pedagogical practices for transforming the nature of mathematical teaching is the deployment and implementation of this perspective in long distance mathematics undergraduate courses, using the Moodle platform and a variety of freeware. This approach helps prospective teachers to examine, interpret and understand phenomena that affect our daily lives. The interpretation and understanding of these phenomena are due to the power provided by critical mathematical modeling, which occurs through the critical analysis of the applications of mathematical concepts during the development of mathematical models in a virtual learning environment. Thus, the process of developing mathematical models is not a neutral activity because the solution of a modeling a problem situation includes an understanding of how ideas and mathematical concepts are designed in the preparation, analysis, and resolution of these models. Thus, it is important that the mathematical results obtained in this process are linked to the reality of students (Barbosa, 2006).

During the process of constructing the model, it is necessary to describe, analyze, and interpret phenomena present in reality in order to generate critical and reflective discussions about the different processes of resolution of the models, which are prepared by students. These discussions occur through reflective argumentation about the influence needed to build models as well as comparisons between the different models that are built by students (Barbosa, 2006) criteria. Thus, it is important to enable true reflections on the reality, which becomes a transformative action that allows students to practice explanations, sharing their understandings, develop abilities to organize, manage, and find solutions to problems that present themselves (Rosa & Orey, 2007). This both critical and reflexive discussion triggers a cycle of construction of mathematical knowledge from the reality through the process of critical mathematical modeling. In this process, students develop skills that help them to process information and

define essential strategies to perform actions that aim to modification and transformation of reality (Rosa & Orey, 2007). This kind of discussion provokes in students the ability to comprehend and debate about the implications of the mathematical results, which flow from the resolution of a particular problem situation. In this regard, critical mathematical modeling can be considered an artistic, indeed poetic process because in the process of elaboration of a model, the modeler needs to possess mathematical knowledge as well as develop a certain a sense of intuition or creativity that enables this interpretation (Biembengut and Hein, 2000).

This is akin to writing a poem. In so doing, students need to work in a motivating virtual learning environment (VLE) so that they are able to develop and exercise creativity and criticality through analysis and the generation and production of knowledge. According to this point of view, critical mathematical modeling may be considered a learning environment in which students are invited to inquire and investigate problems that come from other areas of reality. In this environment, students work with real problems and use mathematics as a language for understanding, simplifying, and solving these situations in an interdisciplinary fashion (Bassanezi, 2002). In other words, critical mathematical modeling is a method using applied mathematics that was transposed to the field of teaching and learning as one of the ways to use and connect reality in the mathematics curriculum (Barbosa, 2006).

In the context of critical mathematical modeling process, students communicate by using hermeneutics (written, verbal, and non-verbal communication) to verify if social actions and norms are modified by communication, which can be developed through the virtual learning environment (VLE). It is in this kind of knowledge that meaning and interpretation of communicative patterns interact to construct and elaborate the community understanding that serves to outline the legal agreement for the social performance. In this learning environment students control and manipulate technological tool, which is gained through empirical investigations and governed by technical rules in the (VLE). In the mathematical modeling process, students apply this instrumental action when they observe the attributes of specific phenomena, verify if a specific outcome can be produced and reproduced, and know how to use rules to select different and efficient variables to manipulate and elaborate mathematical models.

Long Distance Learning

Over the past few decades, and in many diverse locations, distance education has grown quickly. Beginning initially with the use of mail-order course, it transitioned to include radio and television. Once associated with mailed printed materials, it facilitated the dissemination and democratization of access and has now moved to the internet and MOOCS. It has become a key element in the democratization for many countries and now allows access to education and professional development opportunities once only given in face to face and elite members of society. In Brazil, as mentioned earlier, it has allowed a portion of the population that traditionally has had difficulty in accessing public education to advance. The basic idea of distance education is very simple: students and teachers are in different locations during all or most of the time in which they either learn or teach (Moore & Kearsley, 2007).

Although this type of education might in some ways hinder traditional teacher-student relationships, strangely enough it also allows students who had never had access to professors or teachers to gain contact. Distance educational technologies answer the need of a population who deserve initial or continuing education opportunities. Distance education allows for educators and learners to break barriers related to time and space, and allows for interactivity and

information dissemination. Distance education environments are open systems that are composed of "flexible mechanisms for participation and decentralization, with control rules discussed by the community and decisions taken by interdisciplinary groups" (Moraes, 1997, p. 68). This approach also allows interactions between teachers who prepare instructional materials and strategies, with tutors, who in our case in Brazil provide hands-on face to face assistance at polos. In Brazil, tutors are tasked to assist students in their activities and tasks, guiding them in their doubts, helping them learn to use search tools, libraries, and offer help in writing and basic math skills. These interactions are triggered by lessons on “platforms” that are virtual learning environments (VLE) in Brazil and enables the use of technology and the teaching and learning of specific content. These features have enabled the development of large variety of educational methodologies that utilize web interaction channels and aim to provide needed support in the achievement of VLE curricular activities.

Theory of Distance Interaction

Interactional distance learning tools (Moore & Kearsley, 2007) seek to eliminate the gap in respect to the understanding and communication established between teachers, tutors and learners because by either time or geographic distance. Distance is considered an important feature or element of this form of education and is often supplanted by differentiating procedures, instructional and pedagogical tools that facilitate interactions. In this sense, distance education may need to be redefined because it cannot be considered only as the geographical separation between teachers, students and tutors, but as a different pedagogical concept for teaching and learning.

According to this theory, there is a real need for distance education students to exercise interactions in virtual learning environments that facilitate understanding and the comprehension of new content and activities. This interaction allows students the opportunity to make or answer questions and in most subjects also allows for the expression of opinions (Moore, 2007, p. 128). This theory considers that the time and space distances found between teachers, students and tutors needs to be overcome with the inclusion of differentiating elements in the process of teaching and learning (Moore & Kearsley, 2007). Many studies involving the research and investigation of distance education environments focus on communication media. In this sense, new learning tools are adapted for use in classrooms such as the use of mathematical modeling in mathematics courses.

We have learned to emphasize the need to introduce new methodologies based on changing pedagogical contexts; that is available technologies that students in diverse distance modalities can learn mathematical content through a diversity technological and methodological procedures, including access to computers, laptops, tablets or even the use of smartphones, that help them in breaking the barrier provided by the distance separating them from tutors and teachers (Neto, 2008). It is important to note here that new teaching methods in Brazil include the use of mostly freeware tools available in Moodle platforms, in addition to forums, posts, wikis, youtube and questions and responses, which can be performed in real time in live video and web conferences.

Theory of Transactional Distance

Before the development of the concept of the Theory of Transactional Distance (Moore, 1993) definitions of distance education were related to the physical separation of teachers and students. Transactional distance differs from the physical or temporal distance as it refers to the psychological and communicative space that separates teachers from teaching students of

transactions triggered in an educational system in distance modality, and can occur in planned structured virtual learning environments (Moore, 1993).

Consistent with this perspective, this theory is preoccupied with pedagogical aspects of teaching and learning than with the geographical aspects of the students. In the greater educational process, this theory requires the presence of "students, teachers, [tutors] and a channel of communication" (Martindale, 2002, p. 4) in order to resolve situations of teaching and learning that involve different transactional distances and require different techniques or even specialized forms of instruction. The use of this theory is an invaluable contribution that guides complex practices of processes of teaching and distance learning (Garrison, 2000)

Transactional Distance Theory describes relationships and interactions that exist between teachers, students and tutors and were often established when these individuals were separated by time and space. However, for this interaction to satisfactorily take place there is a need to discuss the extension of the length of a particular transactional education program, which depends on a set of three distinct qualitative variables: dialogue, program structure and the range of autonomous possibilities for students. That is, students might work in groups, or individually. It is also emphasized that these many variables are not always technological, as they relate to the interaction between teaching and learning itself (Moore, 1993).

This theory seeks to utilize information, technology, and the inherent communication found in structuring coursework, which prioritizes an interactive educational process centered on learners. In this educational process, transactional distance is considered as a pedagogical phenomenon and not just a geographical issue. This means that it investigates its influence on distance teaching and learning of the disciplines of the curriculum, the organization and management educational program, and curriculum development (Moore & Kearsley, 2007). This theory also focuses on “the universe of teacher-learner relationships that exist when learners and instructor are separated by space and/or time” (Moore, 1993, p. 22). In general, it describes the interrelationship between three categories named dialogue, structure and learner autonomy as well as how the interactions of these elements influence the intensity and the quality of the transactional distance.

The theories presented here utilize information technology and communication in structuring coursework, which prioritizes interactive and collaborative educational process centered with learners. In this educational process, transactional distance is considered a pedagogical phenomenon and not just as a geographical issue, which seeks to investigate the influence that this has in distance teaching and learning, the curriculum, curriculum development and in the organization and management educational programs (Moore & Kearsley, 2007). This includes critical mathematical modeling.

Critical Mathematical Modeling Process in the VLE

In literacy and language learning environments learners very quickly learn to communicate through oral and or written forms of language. Early on, learners see the importance of written narratives, prose, and poetry that allow them to quickly see the beauty and power of language, and to incorporate that beauty into their lives. Contrast this to the learning of mathematics, where in the vast number of mathematics classes, learners are subjected to endless rote memorization of algorithms and grammar and pages of exercises, often without context to the learners’ lives, experiences, values or communities. Rarely do they see a direct connection to what they are learning and how they actually will use mathematics.

Mathematics is often referred to as a language, but it seems that it has become a language that is taught without giving leaners the opportunity to communicate mathematically, or to even write the rudimentary forms of mathematical prose or poetry. It is not until learners reach advanced mathematics that the few that survive this process, are afforded the opportunity to engage in communicating and creating new ideas using the beauty and power found in the language of mathematics. It is why, no wonder, that most people detest mathematics, to them mathematics is stuck in endless boring drills in the use of mechanical and mathematical grammar without being able to write or communicate in this synthetic but powerful language.

To those of us who are privileged to understand the beauty and elegance of mathematics, this is deeply sad. In Brazil a strong culture of inquiry has developed in the mathematics education community by using critical mathematical modeling, and is influenced by the philosophies and work of Paulo Freire (2005) and Ubiratan D'Ambrosio (1986). In preparation for rigorous university entry exams, Brazilian students are encouraged to reflect upon, engage in, debate, and dialogue to resolve problems they find in their own contexts, neighborhoods and environments. These opportunities often use mathematical modeling and ethnomathematics and become the first opportunity that mathematics learners have to write, a mathematical poem, as it were (Rosa & Orey, 2011).

For example, data gleaned from a study about transportation conducted by Orey and Rosa (2014) in 2013 in a course offered to mathematics majors in mathematical modeling showed that students acquired information through interviews with citizens and public transport users in their respective towns. In this regard; questions related to the situations presented in the interviews served as starting point to the elaboration of mathematical models. According to this context; students determined different solutions to the problems outlined, and reflected regarding to the conclusions obtained in this process. In this study, 110 students in 10 *polos* in two states (Minas Gerais and São Paulo) made use of an historic event, the nation-wide 2013 demonstrations, to develop competency in mathematical modeling and how studied this raise in bus fares in their communities in Brazil and shared their findings with fellow students, faculty, and tutors.

As mentioned above, in June 2013, early in the Seminar on Mathematical Modeling, the country erupted in mass demonstrations against the growing problem of corruption and over spending in relation to preparation for the 2014 World Cup tournament. Just in the small college town of Ouro Preto, 10,000 people marched from the university campus to the main square of the city. What sparked this national mass movement was a sudden spike in transportation fares in urban transportation systems. What may seem to those who do not use mass transit as something minor (20 cent rise) created a difficult problem for many who live in the large megalopolises of São Paulo, Rio, and Brasilia. Some long daily commutes became R$30 (about U$14) roundtrips five or six times a week and for many became untenable.

Normally a week or so is devoted to bringing consensus with students and generating a number of themes, and to make use of this particular historic circumstance the instructor consulted with the tutors and students and together we agreed that transportation would be the theme. Eight polos were participating in the seminar. The instructor asked the tutors at each polo to organize the students into smaller working groups of 4 or 5 students. Over a period of 5 weeks students were led through the steps, and groups were required to post evidence of their work on line.

Synchronous virtual classes were held. Critical mathematical modeling lessons were transmitted through video conference. Lessons were organized and activities and projects were posted in the Moodle Platform. Discussion forums were also developed in order to prepare students for the modeling process. By the end of 16 weeks course there were 4 synchronous/virtual meetings in which the development of the mathematical models of each group of students was discussed. The course calendar that contained the description of the course, the terms of the proposed activities, and the dates and times of synchronous was published in the VLE. Approximately, every two weeks there were activities and questions to be worked on by the students and sent to the tutors and the professor through specific links in the Moodle Platform.

During the development of the course, the professor and the tutors, although geographically distant from the students used virtually tools to be connected with them. Pedagogical and didactic strategies were used to promote professor and tutors interactions with the students in order to contribute to the process of teaching and learning critical mathematical modeling. The resources used for this purpose were the discussion forums and videoconference. Through these tools it was possible to promote dialogues between all participants in the VLE. In addition to promoting interaction, the professor took care that the preparation of teaching materials, such as the structure and policies of the activities available on the VLE. Thus, due to perceived needs of the students during this course, the professor created supplemental materials and short video-lessons in order to lead students step by step in the modeling process, so they were able to improve their performance in carrying out the modeling proposed activities.

It is important to highlight here the design of the use of digital communication technologies in the development of this course such as videoconferences and virtual learning environments guided the selection of procedures and techniques:

a) Videoconferences enabled the integration of students, tutors and the professor for socialization and clarification of questionings; which allowed for a collaborative environment for sharing experiences on the proposed themes and promoted students attendance in the polos to develop their modeling projects. The use of videoconference proved to be very effective because it has sufficient teaching resources for conducting synchronous classes. In this perspective, knowledge is translated in a dialogical way so these technological tools can be used as instruments to help students to critically think about problems they face daily.

b) The Virtual Learning Environment (VLE) allowed for continuous updates of the course content; the development of discussion forums concerning teaching practices in the critical mathematical modeling process and the elaboration of questions about the pedagogical and technical aspects of this process. VLE also allowed for the integration of students, tutors, and the professor through the tools to deliver messages; the provision of summaries of contents the course; the conduction of pedagogical monitoring such as sending messages to all participants and participation in the discussion forums; and technical support such students and tutors access reports in the VLE.

In this virtual environment, the learning occurred through socialization because knowledge was better constructed when the students worked in groups and act cooperatively in order to support and encourage each other. This approach allows students to reflect on complex problems embedded in real situations that help to construct knowledge by connecting it to other knowledge

areas in an interdisciplinary way. According to this perspective, students' engagement with a sociocultural environment helps them to be involved in meaningful and complex activities. It is through social interaction (Vygotsky, 1986) among teachers and students from distinct cultural groups that learning is initiated and established.

Accessing the Virtual Learning Environment (VLE)

In the mathematical modeling process, the social environment also influences cognition in ways that are related to cultural context. In this context, collaborative work through Moodle Platform between groups of teachers, tutors, and students makes learning more effective as it generates levels of mathematical thinking through the use of socially and culturally relevant activities Thus context allows the use of a *dialectical constructivism* because the source of knowledge is based on social interactions between students and environments in which cognition is the result of cultural artifacts in these interactions (Rosa & Orey, 2007).

Critical mathematical modeling provides concrete opportunities for students to discuss the role of mathematics as well as the nature of their models as they study systems taken from reality through the use of technological tools in the VLE. In accordance to this point of view, critical mathematical modeling may be understood as a language to study, understand, and comprehend problems faced community (Bassanezi, 2002). For example, mathematical modeling is used to analyze, simplify, and solve daily phenomena in order to predict results or modify the characteristics of these phenomena. In this process, the purpose of critical mathematical modeling becomes the ability to develop critical skills that enable teachers and students to analyze and interpret data, to formulate and test hypotheses, and to develop and verify the effectiveness of mathematical models. In so doing, the reflections become a transforming action, seeking to reduce the degree of complexity through the choice of a system that can represent it (Rosa & Orey, 2007).

By developing strategies through technological tools provided by the Moodle Platform encourage students to explain, understand, manage, analyze, and reflect on all parts of this system, the process optimizes pedagogical conditions for teaching and learning so that students understand a particular phenomenon in order to act effectively and transform phenomenon according to the needs the community. In order to lead students towards the understanding of its social-critical dimension is to expose them to a wide variety of problems or themes. As part of this process, questionings are used to explain or make predictions about the phenomena under study through the elaboration of models that represent these situations (Rosa & Orey, 2007).

Recommendations

Based on the experience of the development of Critical Mathematical Modeling in a long distance environment this course transformed into a simple, yet elegant, pedagogical and didactical methodology. However, in a new edition of this course, it is possible to take into account adjustments that needed to be made in order to correct technical difficulties that occurred in the students' virtual learning environment. Thus, new challenges and needs arose when upgrading methodological and pedagogical processes according to the new context of long distance learning. According to this context, some recommendations related to this experience and implemented in future course offerings are:

Professors and tutors

There is a need to intensify the help given to the students by answering their questions and grading activities according to the schedule posted in the Moodle Platform, improve orientations and instructions regarding to the development of critical mathematical modeling steps as well as clarifying the description of policies and activities. It is also important to avoid too many changes in the schedule of the proposed synchronous classes as well as the delivery of the activities in the VLE; make more effective use of the forums for interaction and discussion of the proposed activities, enhance the use of virtual environments in order to provide the means for monitoring on the participation of students, including forums and synchronous activities such as seminars by videoconference presentation of the proposed activities.

Students

It goes with saying, and this is a difficult problem for us in Brazil but it is necessary that students have enough time to study and participate in the proposed activities in the VLE. Many students are working or do not have access to the internet or computers in their homes and must travel to the polos to do some or all coursework, which presents them with various logistical problems. On one occasion, a student needed to leave the polo in time to make her bus ride because her horse was tied to the bus stop and she need to ride home yet another hour by horse! As well we need to intensify the elaborations and use teaching resources and materials found closer to home and explore pedagogical support in order to clarify questioning and inquiries; and better organize groups to prepare their answer to activities regarding the elaboration of mathematical models. It is also recommended that it is important to use Freirean-Dambrosian perspectives in order to use this opportunity to teach prospective teachers to use real life contexts to engage learners. As well it allows us to gain the tools and experience to make useful arguments for what can be emotional topics. In so doing, modelers learn to create data, and thoughtfully engage in debate and dialogue in relation to the data, which enable them to take an active role in the process of the transformation of society.

Final Considerations

The study of new educational methodological proposals becomes relevant because it originates with ideas regarding social changes resulting from ongoing continuous contemporary scientific and technological developments. In order to enable teaching methods using structured learning materials and existing technological resources, it was developed the long distance learning, which refers to planned learning that normally occurs outside of school (Moore & Kearsley, 2007). On the other hand, in the last three decades, critical mathematical modeling as a teaching and learning methodology has been one of the central themes in mathematics education in Brazil and has come to offer a way to rebuild or restore what has become for many, a fragmented and meaningless mathematical knowledge. This approach appears to encourage them to develop more informed and research-based opinions in their real life.

In this context, mathematical modeling soon becomes a teaching methodology that focuses on the development of a critical and reflexive efficacy that engages students in a contextualized teaching-learning process that allows them to become involved in the construction of solutions of social significance (Rosa & Orey, 2007). This critical dimension of mathematical modeling is based on the comprehension and understanding of reality, in which students learn to reflect, analyze and take action on their own reality. When we explore examples and problems from their reality, students begin to study the symbolic, systematic, analytical, and critically contexts to their work through the use of technological tools provided in a virtual learning environment. In

so doing, long distance learning modalities contribute and can assist students to overcome difficulties regarding the adoption of critical mathematical modeling courses because technological tools offered by the platforms such as Moodle are simple and funcional. Through the use of discussion forums and videoconferences, professors and tutors are able to and can better analyze interactions enabled by these tools, which contributed to development of the elaboration of mathematical models in the virtual learning environment.

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