Strategies for the use of Technological Resources in a Discipline of a Distance-Learning Mathematics Teaching Degree Program

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Abstract

This paper presents some strategies that teams of research professors and advisors used in developing the content and activities of the Distance-Learning Mathematics Teaching Degree program at the Pontifical Catholic University of São Paulo, in a virtual learning environment, in this case Moodle. With our participation, as coordinator, in the activities that enabled the process of making the course viable and in constructing the proposals for teaching and learning the different disciplines, the issues that emerged and triggered debates between the faculty members could be identified. Among these issues, we can cite the one underlying this paper: which strategies were used by teams of teachers in preparing the material for their respective disciplines, to promote the students' learning and to facilitate the use of mathematical language in a virtual environment? To try to answer this question, we focus on the work of the team in the Functions and Limits discipline.

Keywords

Distance Learning, Mathematical Language, WIRIS, GeoGebra, Cabri.

1 Introduction

This article presents some strategies used in elaborating the content and activities for the use of mathematical language, both for teachers and for students, in developing the Distance-Learning Mathematics Teaching Degree program[1], in a virtual learning environment, in this case, Moodle. The course was developed, in 2009, at the Mathematics Department of the Pontifical Catholic University of São Paulo – PUC/SP.

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1 The Distance-Learning Mathematics Teaching Degree Program was authorized by the Ministry of Education (MEC) - Decree n°. 98 of August 5, 2008. It began in March 2009.

One of the motivations for creating this course was that students who may not have access to the university could conduct their studies with a quality level that is compatible with the requirements of the Brazilian education system and that they could do it according to the standards of excellence that are sought from a classroom course.

The interactivity of the course offered through the Internet and using the Moodle environment was enabled through the use of new virtual spaces for teaching and learning, which assume the redefinition of the roles of sender, recipient, and message. The environment provided for a rich fabric of possibilities, in order to stimulate open creativity using hypertext and multimedia resources. With this new paradigm, the challenge of creating strategies for the mutual impregnation of natural language and mathematical language arose.

2 The problem and the emerging question

The activities that enabled the process for making the course viable allowed for the identification of issues that arose and triggered debates between the team members. Among them, we can cite the one on which this article is based:

Which strategies were used by the teams of research professors and advisors in preparing the content of their respective disciplines to promote student learning and to facilitate the use of mathematical language in a virtual environment?

Granger (1974, p. 141) states that: "every mathematician uses mathematical language in symbiosis with natural language;" that is, it is through the teacher's lecture in the classroom that communication is established with the students, in order for them to understand the symbolic, encoded, and formalized writing of mathematical language.

In accordance with this author, Machado (2001, p. 10) states that:

> a mutually dependent relationship exists between Mathematics and the mother tongue. In considering these two issues as curricular components, this impregnation is revealed through a parallelism in the functions that have complementary goals that pursue the overlap in the basic questions regarding the teaching of both. It is necessary to know the essence of this impregnation and to have it as a basis for proposing actions that aim to overcome the difficulties in teaching Mathematics.

In line with the authors, we consider that the difficulties in teaching and learning Mathematics in the classroom environment can be minimized if the mutual impregnation between the natural language and mathematical language, experienced through the teacher's lecture, is taken into consideration.

In the transposition of the environment to a virtual one, the same difficulties may arise, although the students have already experienced, in the primary and secondary school classroom, the mathematics teacher's lectures. However, a more sophisticated mathematics was now being presented and the teacher did not provide oral lectures during all the moments of learning. Thus, strategies to overcome these limitations of this future teacher should be considered and created in the course design.

3 The planning and production of materials require a joint collaborative effort

Over the last few years, the faculty of the Post-Graduate Program Studies in Mathematics Education at PUC/SP has developed various teaching, research, and knowledge production activities in the area of using information and communication technologies in education, in support mode for classroom learning or for distance learning. A large part of the faculty is involved in different projects, acting as advisors or research professors.

Given the need to elaborate content and activities for the course, an action plan was developed based not only on the profiles of the teachers with their specificities, but also on the available technological resources that could comply with the course proposal and the institutional structure for implementing its offering. These teachers, in their respective areas of research, had the challenge of leveraging the work of their teams in elaborating content and activities. Each team organized its work schedule, and in the follow-ups of some of the meetings, we identified which questions arose with the greatest frequency. In general, and in the beginning of the work, the teams shared clarifications about the elaboration of content, the possibilities of including it in the virtual environment, and the methods for enabling interaction with the students.

4 Experiences and research aid in the creation of content and activities

One distinctive aspect in the production of content and activities for the disciplines was the work resulting from the research that had already been performed by the teachers, ensuring its quality. This was one of the concerns of everyone involved: the course should have a differential that would reveal the incontestable quality of the teachers and the name of the responsible institution.

> From the beginning, the experiences and the diagnostic evaluations that originate in the presence-learning course will feed the distance-learning course. As the distance-learning course continues to be developed, the learning that occurs can serve as support for the inclusion of changes in the classroom course, in particular for the use of new technologies. (Course Project, p. 7)

Even with an environment that is favorable to the development of content and specific activities for the course, the proposal was challenging and the knowledge of the virtual environment and the technological resources should be studied and analyzed with strict standards to meet the objectives presented by the project:

> To integrate the training of Mathematics teachers in the processes of changing, innovating, and developing the curriculum with the support of technology. Teacher training should be analyzed in relation with the development of the curriculum and should be conceived as a strategy to facilitate the improvement of teaching and to understand the contributions of technologies to learning Mathematics. The training, the change, and the use of technologies must also be considered in parallel. Today, it is difficult to defend a vision of change for the improvement of education that is not, in itself, enabling, that does not stimulate

> new learning, and that does not make use of the distinct languages and forms of representation of the knowledge offered by media and technologies; in summary, that is not educational for the agents who have to develop the reforms in practice. The training should preferably be aimed at change, activating relearning in the subjects and in their teaching practices, which should be, in turn, facilitators of the student's teaching and learning processes. (Course project, p. 24)

According to the quality references for distance-learning programs, presented by the Ministry of Education (MEC) on April 2, 2003 (p. 5)

> The use of new information and communication technologies can make it easier and more effective to overcome the distances, make the teacher-student interaction more intense and effective, make the teaching-learning process more educational, and make the student's conquest of autonomy faster and more real.

It is in the search for this quality that the importance of training teams of specialist teachers was considered, with the collection of results from research that has been performed and the experience gained from each one's teaching practices.

The roles of the teachers were expanded in this new context and, according to Authier (1998), the teachers "are producers, when they elaborate their course proposals; they are advisors, when they accompany the students; and they are partners, when they construct innovative approaches to learning with the technology specialists."

In each of these roles, and, at each moment, a subject of mathematical knowledge was transformed by the activities of the researcher-teacher, of the producer-teacher, and of the trainer-teacher.

5 The role of technological tools in the creation of content and activities

The goal of using technological tools, included in the virtual environment of the course, was to provide the conditions that would be favorable the students in the teaching and learning process and in the construction of knowledge.

The question that was initially posed, regarding the creation of strategies for using mathematical language in a virtual environment, was reconsidered, based on what was available in the virtual environment and what could be included in it, so as to allow the teacher's "lecture" and the mutual impregnation of natural language and mathematical language.

Balacheff (1994, p. 4) considers that:

> The creation of teaching objects is the result of a complex process of adapting the knowledge to the teaching and learning limitations that are specific to the didactic systems. This process, didactic transposition (Chevallard, 1985), leads to the creation of objects originated by their own characteristics and operation. The development of information technology, its introduction in the schools and educational centers, is accompanied by new phenomena of the same order as those of the didactic transposition. The limitations of didactic transposition are added to,

> or better yet, combined with the limitations of the model creation and the software implementation: limitations of the "computational modeling," limitations of software, and limitations of the digital support material for the realization.

In mathematics, it is not only the proper transcription into its symbology that is important, but also the visualization naturally used for the graphical representation of functions, for drawing geometric figures, and for displaying rationales about the shape of the inference graphs.

Thus, the challenge was to overcome the technological limitations that might impede the use of mathematical language, as observed in Borba *et al.* (2007, p. 40):

> In the context of Mathematics Education, these difficulties are broadly related to the nature of mathematical language itself, which has particularities that often hinder the discussion. For example, if we have a certain problem, whose statement would be given by $\int_2^4 (\frac{1}{x^2} + x)dx$, we would have to write "the definite integral
>
> over the interval from two to four of the function one over x squared plus x" or the "integral from 2 to 4 of 1 over x squared + x dx", and, upon writing the sentence, regardless of the chosen method, in addition to taking more of the participant's time to interpret it and translate it into mathematical symbology, it can also cause misunderstanding, since we know that, when we type in chats we often abbreviate words and write in an informal manner, in an attempt to save time.

In this way, other technological resources specific to mathematical language and visualization should have a significant presence in the virtual environment, in the course content and activities, observing that the mathematical language does not consist merely of equations or expressions, but also of graphs and geometric objects.

6 The technological tools used for mathematical language and visualization in the Functions and Limits discipline

To try to overcome the difficulties mentioned above, the tools used were those of the Moodle environment itself, and others installed by the administrator, with their respective plug-ins to allow access.

The resources used were either available in the Moodle platform, such as WIRIS, or freely accessible by teachers and students, such as the GeoGebra software. The Cabri and program, although not freely accessible, allowed for proposed activities with the use of plug-ins.

The strategies and technological resources indicated the difficulties with mathematical language and symbols for distance learning; on the other hand, however, they also provided a context in which these difficulties in teaching and learning Mathematics in an online environment could be minimized, to allow the mutual impregnation between natural and mathematical language.

6.1 The WIRIS tool in Moodle

One of the resources used, called WIRIS[2], allowed mathematical expressions to be written with its editor, in addition to the resource of a Computer Algebra System (CAS). Easy to use, both are available on the Internet and comply with the special and particular needs of mathematical language in the environment, without resulting in difficulties for the teachers and students.

In the example previously cited by Borba *et al*. (2007), the WIRIS tool easily allows for the symbolic representation of the proposed expression in its formula editor or for its solution through its Computer Algebra System (CAS), as we can see in Figure 1 below

$$\int_2^4 \left(\frac{1}{x^2} + x\right) dx \qquad\qquad \int_2^4 \left(\frac{1}{x^2} + x\right) dx \;\; \mapsto \;\; \frac{25}{4}$$

Figure 1 – Expressions obtained in Moodle with the use of WIRIS

One example of the use of the WIRIS resource in the Moodle environment can be observed in Figure 2 below, included in the questionnaire tool. The student can respond not only to the proposed question, but can also modify the given expressions and verify the effect in the graphics window.

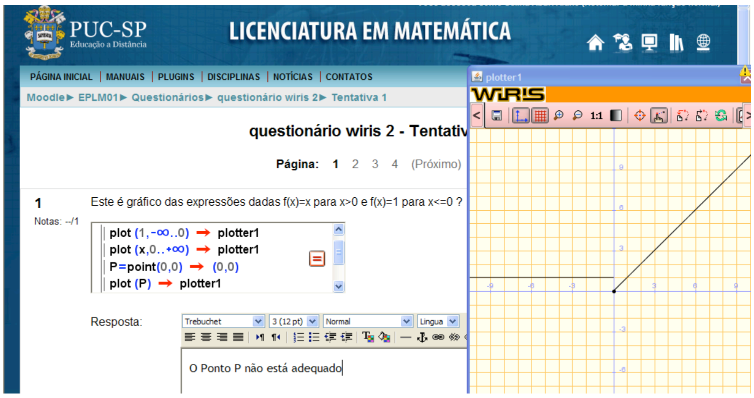

Figure 2 – Example of the use of WIRIS in Moodle

The technological tools are improved every day and thus, over a short span of time, they allow the teaching and learning strategies to be redefined.

[2] As described on the website http://www.wiris.com, WIRIS is a "software family of products dedicated to mathematical calculation and formula designing, mostly used as education tools for learning mathematics."

6.2 GeoGebra: a tool in Moodle

GeoGebra[3] was another resource used. It is mathematics software for studying Geometry, Algebra, and Calculus. With the GeoGebra tool, it was possible to simulate situations in which, for example, the student's use of "graph paper" was necessary.

The figures 3 and 4 below are examples of activities resolved by students using files constructed in GeoGebra and opened with the click of the mouse. After completing the activities, the students saved them and sent them to the teacher using the task tool of the Moodle virtual environment.

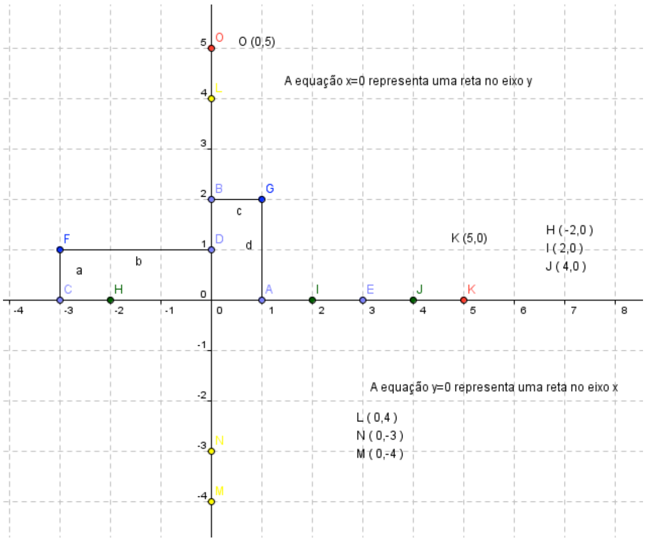

Figure 1 - Figure of an activity sent by a student

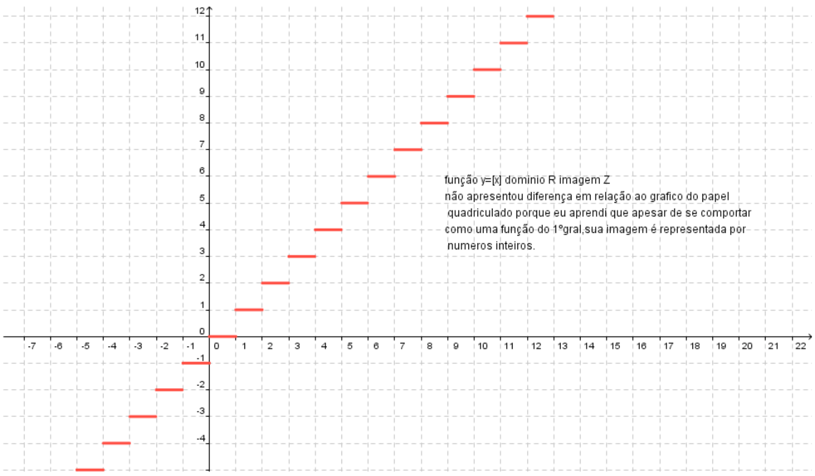

Figure 4 - Figure of an activity sent by a student

[3] GeoGebra is free software developed by Markus Hohenwarter, available in Portuguese, at the Internet address http://www.geogebra.org/.

Another proposed activity asked students to begin a geometric construction in a GeoGebra file and to make it available in the Moodle Portfolio, sharing it with another student, who was supposed to continue the construction. This proposal allowed the formation of study groups, encouraging collaboration and interactivity.

As the content and activities of the disciplines were elaborated and discussed in the teams, other needs were made evident, such as the use of Cabri, which allowed the movement of constructions, as in the example Figure 5 below.

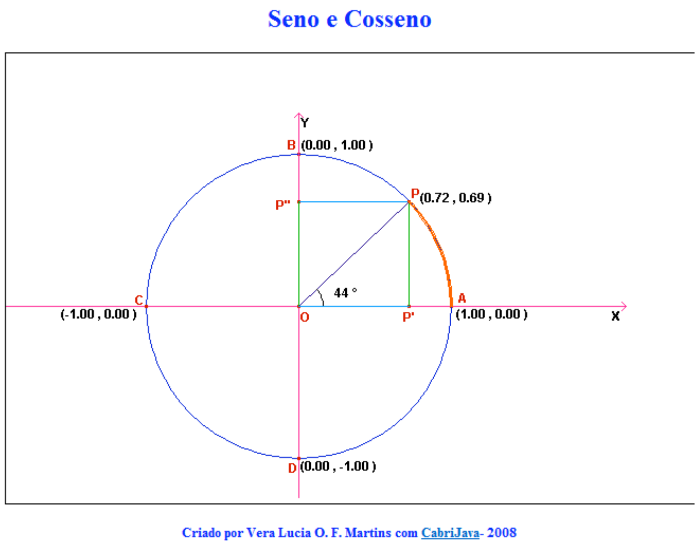

Figure 5 - Figure of an applet created with Cabri

Videos of the course presentation, of the presentations of the discipline, of the trainers, and other specifics were elaborated and edited by TV PUC and included in the Moodle virtual platform.

7 Final Considerations

Through records produced by the students, it was possible to ascertain that the available resources allowed for the mutual impregnation between natural language and mathematical language. The signification of the mathematical language occurs in the experience that the subject has with the object and, from this experience, the significant data that lead the student to abstraction and understanding are be extracted.

We conclude that although they had difficulties using technology in Mathematics Education, some teams sought to use the differentiated technological resources that could comply with the teaching and learning proposals of the respective disciplines.

The appropriate use of technological resources in the virtual environment can allow teachers in training to use them in the future with their students, in a course with new technologies.

The pedagogical proposals can be updated with the advances made in technological resources and education can be responsibly integrated with this world, without losing sight of the consistent training of a future teacher who is prepared to teach and who is always ready to learn on his/her teaching path.

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