ELECTRONIC AND ONLINE RPG IN THE MATHEMATICS EDUCATION CONTEXT[1]

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ABSTRACT

This paper introduces two Mathematics Education experiments based on Role-Playing Games (RPG). In the first study, we investigated how the construction and application of Electronic RPGs can contribute to teaching and learning Whole Numbers; in the second one, we used Online RPGs in Distance Education to analyze how the construction of online identities is applicable to the teaching and learning of Definite Integrals. We describe both research studies, their participants, procedures, theoretical references, future trends and final results. For the first investigation, we present the results on multiplication of Negative Whole Numbers and their relationship to everyday life; the results related to the second experiment relate to the virtual presence of online identities created and their relationship to the learning process. We demonstrate the playful aspect inherent in the construction and application of computer games as a powerful tool in learning mathematics.

Keywords: Mathematics Education. Electronic and Online Games. Playfulness.

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INTRODUCTION

This paper focuses on the use of Role-Playing Game (RPG) in Mathematics Education from two distinct experiments: the first one, through Electronic RPGs to learn Whole Numbers and the second, through Online RPGs, exploiting the concept of Definite Integral (subject of Differentiation and Integral Calculus). Thus, this paper briefly explains both investigations, describing the objectives, subjects and some results obtained in each one. In doing so, we highlight particular aspects of the mathematics learning process in a playful environment afforded by the use of RPG in Mathematics Education. To review all results from these investigations, see Rosa (2004; 2008).

Both research studies were guided by a qualitative research methodology (Bogdan & Biklen, 2002), as we aimed to understand the processes involved (and not only the results or products) while interacting with the students. In the first experiment, we interacted with them from May to October, collecting data using a tape recorder, a camcorder and daily recordings. In the second one we started to talk to the students in March and ended data collection in July, using communication tools like chats, forums and e-mails. As such, a large amount of data was collected and analyzed through triangulation (Lincoln & Guba, 1985). In this paper, we will present only a few sets of exemplary quotes to demonstrate the contribution of RPGs to Mathematics Education.

An RPG is a sort of game that is based on its participants' interpretation and imagination; or, better still, it is a game with players and the master (the person in charge of constructing not only the scenery, plot, and the environment of the game, but also the one who leads its story, being capable of role-playing other characters). It can be played in presence, which is called Tabletop RPG, at distance through the Internet, Online RPG (also known as Virtual RPG), or on the computer, which is called Electronic RPG.

The investigation of the use of Electronic RPGs in Mathematics Education is based on Seymour Papert's constructionist ideas (Papert, 1985), as we explain in the following sections. We created an environment in which some groups of students would gather to construct and play (test) their games with other students based on

the research, dialogue and thinking about contents and work strategies. These interactions were guided by a researcher-professor and with the help of extra resources such as books, the Internet and some software[3]. Those students, age group 12, used to have weekly extra class meetings with their researcher-professor to work directly on the concept of Whole Numbers (content which had not been formally studied); it was during this time that they planned and constructed their games using the RPG Maker software. All students came from a non-privileged socio-economic class – in fact, only a few had a computer at home – and they were all from a state school on the outskirts of town.

In this context, the research focus was to use mathematics through educational Electronic RPGs to identify possible contributions that the construction and application of this sort of game could bring to the mathematics learning process (specifically related to Whole Numbers). Some contributions were clearly identified; among them, the relationship between mathematical content and everyday life; in other words, a creative way of representing arithmetic operations with Negative Whole Numbers and the learning actions found in Constructionism and perceived in both processes: Electronic RPG construction and test.

The idea to use Online RPG in the study of mathematical concepts emerged from our experience with Electronic RPG and from the possibilities shown by Online Distance Education, in which space and time are clearly different from face-to-face education. But besides space and time, we observed the identity as a different aspect that was present in textual interactions found in environments like the ones used on Distance Education courses. From this point and, based on some theoretical support mainly from Sherry Turkle's (1997; 1989) studies, we developed a course named *"Constructing the Concept of Integral through Virtual Role-Playing Games",* whose main objective was to work on the concept on Definite Integral through Online RPGs. It was also a useful tool to investigate the relations between the construction of online identities and the teaching and learning of the mathematical subjects studied. In this manner, the game became a learning and teaching environment of the concept of Definite Integral backed by playful and at distance approach.

3 At the end of this process they spent some hours with their classmates observing them playing in order to improve their games. In this paper, this phase will not be considered.

Eight graduates in Mathematics aged from 18 to 30 and from several regions of Brazil participated in this course. Six were from public Universities and two from a private one. Brazil is bigger in area than the continental U.S.A., so these students had different cultural backgrounds in accordance with the region they live.

These students first read something on RPG and then constructed their characters (keeping in mind the adventure proposed in the course, which we detail ahead). Then they were inserted in the teaching and learning virtual environment used in the Online RPG. In this way, their real identities were hidden.

None of the students had taken a corresponding subject that focused on Definite Integral at their institution. This choice was made in a way so that the participants would not be "contaminated" with previous concepts of Definite Integral. None, for instance, had experience with *epsilons* and *deltas*, a specific form of academic mathematics. The course used in this study was a 40-hour Distance Education course; it included synchronal and assynchronal activities such as chats, forums, e-mails and the elaboration of a final project (further details at http://www.rc.unesp.br/igce/demac/maltempi/cursos/curso2/ – Portuguese only).

Throughout the course it was possible to observe that one of the relations – or views – of how the construction of online identities is involved in the teaching and learning of the concept of Definite Integral in Online RPGs is strictly linked to the action of imagining, creating and representing the game itself – which can be seen as a virtual presence.

In this paper we show that the virtual being that learns mathematics consists of a multiplicity of online identities that have their own lives in a different time/space. This "collective" being constructs itself while acting, living and reflecting. What is more, experiencing cyberspace makes imagination, creation, organization, and re-organization of ideas about the physical world possible, contrary to the physical one in which sometimes is impossible. Online RPG makes the teaching and learning of mathematical concepts potentially feasible and in this game we do not find obstacles concerning the representation of the concepts in question. These processes, therefore, depend on "who" learns and this subject ("who") is collective and shows itself in a multiple way, in a multiplying movement.

MATHEMATICS EDUCATION AND COMPUTER GAMES: MEANINGFUL ASPECTS

Several authors justify the importance of games in education. Among them, there are Macedo and Petty (2000) who state that games "[...] make the production of a meaningful experiment for children possible not only in terms of school contents but also developing their competencies and abilities" (p. 6) and Almeida (1984) highlights the benefits games can bring into an educational context concerning physical, intellectual, social and didactic views. In this manner, they emphasize the didactic benefits and the production of knowledge through the use of games in educational situations.

Whenever a game is linked to knowledge it becomes important for teaching and learning. It also allows us to consider it a tool of great value in an educational approach. In the same way, the aspect related to this tool in education is also extended to Mathematics Education as stated by Moura (2001):

The analysis of new elements included in Mathematics Education cannot put aside the advances of the discussions referring to education and the factors that contribute to […] learning. The game, then, appears in a large context that attempts to represent education, in particular Mathematics Education, whose basis is becoming more scientific. We believe this context should be our safe harbor […]. (pp. 76-77)

Valente (1999) questions the scenery in which the apprentice is inserted. He claims that while playing he (the apprentice) only uses concepts and strategies mechanically and he cannot notice their meanings and the way they are used. Many times he may be wrongly using these concepts and strategies and, consequently, there would be no real gains in terms of education. Although we agree with Macedo and Petty and Almeida we firmly believe that the question raised by Valente is important. However, we think it can be clarified if we consider using games in education as a process that depends on other elements. These elements are beyond the game itself and the action of education which is often understood as "a mechanical transmission of information".

In our view, in Mathematics Education, the playful involvement of students as well as the teacher in educational experiments that involves actions and construction of games is extremely important. This involvement can also turn the educational environment into a specific context in which actions of learning mathematics can happen in a pleasing way, increasing learning possibilities. Nevertheless, we cannot forget that Mathematics Education has also to be seen as a field that studies, investigates and works on aspects that involve educating through mathematics as well as educating mathematically. This field is based on emotional aspects concerning what a person is like and some linguistic and socio-cultural components. All of them are aimed at the individual and collective development of cultural groups (families, tribes, societies, civilizations) in order to keep their status or to move forward to fulfill the need of survival and transcendence (D'Ambrosio, 2003) as understood as a human project.

Also taking as a base this scientific view in which Mathematics Education is established, our approach to this contextualization includes the game as an environment of research on learning mathematics as well. So, we consider RPG (being a game) as "an actor" of extreme importance in this scenery.

Besides that, we refer to RPG considering, as a part of it, all characteristics identified in a general game in terms of its use in a classroom. So it makes feasible the relationship between the learning that the game and its constructing establish with Mathematics Education. In this perspective, we took as a starting point the view of Moura (2001): "The game in Mathematics Education becomes a means of [...] providing students with learning activities. The child, exposed to playful situations, learns the logical structure of the game and then learns the mathematical structure present as well" (p. 80).

In this way, actions of creating, imagining and representing that are present in a scenic atmosphere and computer games (electronic and virtual) (Murray, 1997; Carrol, Anderson & Cameron, 2006), for instance, they make the playful involvement happen in an educational environment. It broadens, many times, some didactic and epistemological possibilities and it justifies the use of this sort of game in an educational process.

From this perspective, mathematics is not seen through laws and formulae but in a context emerging from situations that are created and represented and, many times, imagined by students themselves. Such situations happen since the game to be constructed or played in a virtual environment makes the up-to-date of these educational situations either possible or not.

Behrens (2000) states that computer games "[...] are offered as a means of leisure. They may be used for an educational purpose if they are connected with other activities suggested by the teacher" (p. 98). However, we see that they can also be educational whenever being constructed and used with this purpose.

Then, concerning the construction of educational games, we support what was stated by Kafai (1994) when presenting the results of her research: "Designing games for learning offered a rich learning environment for children to become engaged in a variety of issues and to learn about many more aspects that I was able to pursue in detail in the context of this thesis" (p. 310).

In this way, the author expresses relevant actions in the construction of electronic games as well:

Definitely, the parts that students enjoyed most in making their games were designing the graphics, creating the characters and story, and programming the animation and manipulations for the player. Many these choices were guided by personal preferences in the same way that playing video games resonates with personal preferences. Students were having "hard fun" […] (Kafai, 1994, p. 290).

The game, then, can be capable of having the role of making learning fun using its playful aspect as a creative source of knowledge. It can also provide the educational environment with a pleasing image contrary to boredom see through yawns, quick naps or even indiscipline in the classroom, which are often teachers' complaints. In the same way, the construction of electronic games also assume these premises as characteristics of this process. In this matter, Kafai (1994) states that "My initial assumption was that children's interest in playing games could be a motivation for making them. During the project, it became clear that students were strongly engaged in accomplishing their designs" (p. 288).

There are many interests in constructing games. One of them is linked to the fact there must be an interest in playing them. So the construction itself through the actions of projecting, creating characters and stories, strategies and actions can be characterized as a game of choices. The construction and the application of a game do not make them be considered a game “on their own” in which there are interactions, dialogues and actions that are justified for themselves; as we know, in any game it is necessary to have an objective and reach it.

Either playing or constructing games we find a playful aspect that is part of a context of a specific mathematics knowledge production. This context makes several relations with learning mathematics in terms of mathematics objects as well as educational actions involving this production possible. According to Macedo and Petty (2000)

We can analyze the application of knowledge acquired in a context of games and the contributions of playing under different perspectives. It is known that certain attitudes (Coll, 1987), like being attentive, organized and able to co-ordinate certain points of view are fundamental to obtain a good performance when playing and it can also bring advantages at the same time that the child becomes more participating, co-operative and a better observer. Besides that, the act of playing demands, for instance, interpreting, classifying and operating information – aspects which are related to the demands regarding school situations. (p. 14)

Such aspects also have a direct relation to the logical-mathematical thinking. It backs the argument for the use and construction of games in Mathematics Education. In this way, the analysis of the action of construction and the application of either an electronic or a virtual game can show us traces of the knowledge acquired by the participants during these processes, as the students explicit their knowledge while creating and talking about the creation (of the game). Then, our research studies show the contributions that constructing electronic games and the participation in a virtual one, both RPGs, brought to the mathematics learning process, co-related to other knowledge fields.

In this view and according to Severino (2001), games can contribute to a conceptual design that shows creativity as a student’s potential quality. So we can

realize as Electronic RPGs construction by students from Elementary School as playing Online RPG by graduates are processes that identify an increase in the possibilities of constructing mathematical knowledge in educational environments.

After reviewing some topics on the importance of game construction and the application of them in Mathematics Education we found a particular game among many others; this one has a singular symbolism that caught our attention. Such a game, as previously mentioned, is an RPG and so, we are showing our experiment with the construction of Electronic RPGs and the execution of Online RPGs in different educational situations, which are linked to mathematics as a main point of our investigation.

RPG AND MATHEMATICS EDUCATION: THEORIES, PRACTICES AND RESULTS

RPG is a game that can be useful in environments of face-to-face and distance teaching and learning. In our first experiment with this game in Mathematics Education we aimed to investigate the following issue: *How can the construction and the application of Electronic RPGs contribute to mathematics learning in terms of Whole Numbers?*

The direction shown by this question is the result of our interest in using playful technology in teaching and learning environments in mathematics and, mainly, in our convictions on constructionist ideas. Constructionism is an educational theory developed by the mathematician Seymour Papert. Assuming that knowledge is actively built by people, Papert (1985) claims that educating consists of creating situations so that apprentices can be engaged in activities which feed this constructive process.

Moreover, Constructionism states that learning occurs especially whenever the apprentice is engaged in building a *product* which has a personal meaning (for instance, a poem, a model or a game) that can be shown to other people. Therefore, referring to the concept that we learn better through practice, we added: we learn far better whenever we like, think of and talk about what we do.

From this point, while working according to constructionist concepts, two sorts of constructions occur, and they mutually reinforce each other for the apprentice, when creating a product together with the world is, simultaneously, creating knowledge. This new knowledge makes the creation of more sophisticated products possible, which lead him to more new knowledge and so on. In this context, technology, especially the computer, becomes a tool that provides learning environments, where Constructionism can be largely exploited.

So we attempted to exploit them in an environment in which Electronic RPG, by means of RPG Maker software[4], were used to work on the concept of Whole Numbers. Such action resulted in the Master's dissertation "Electronic Role Playing Game: some playful technology in order to learn and teach Mathematics" (Rosa, 2004), concluded at UNESP, Rio Claro.

The subjects of this paper were eight students (two men and six women) from the sixth grade of a public Elementary School in Brazil (São Paulo state). These students were divided into two groups under the supervision of a researcher-professor. The content chosen to be developed in Electronic RPG construction has many topics; among them, Multiplication. As a particularity, Whole Numbers have a characteristic which leads to a dichotomy between signs: calculating means working with *operatorial* signs, or, better still, those which indicate the action, and *predicative* signs, which qualify a positive or a negative condition, representing the same signs. Sometimes such circumstances establish some confusion whenever the apprentice, operating with Whole Numbers, cannot distinguish operatorial signs from predicative ones; however, it can also make easy to a student whenever he builds the meaning of a positive number as the opposite of a negative one in everyday situations.

According to Teixeira (1992),

> *Mathematics operations are brought from actions linked to everyday experiences; however, whenever these operations are linked to each other, they exceed empirical reality, anticipating and dominating it through symbolic level operations. Consequently, it is highlighted the greatness of mathematical thinking seen as a creation*

4 The construction of electronic RPGs is possible through a simple visual program. It is a piece of freeware software available to download at http://superdownloads.uol.com.br/download/56/rpg-maker-2000/

> *in which not only makes constructions beyond real world (physical) possible but can also be applicable to it at the same time. (p. 62)*

We, therefore, identify the role of mathematics as being responsible for conjectures that explain not only concrete everyday relations but also their link to abstract for the purpose of finding solutions that are beyond those relationships. However, even being capable of developing the thinking of questions that are beyond common reality (imaginary world), abstraction is coupled with everyday actions establishing a meaningful bridge with them.

So working on the content chosen, the participants began to put into practice actions that could make them plan conjectures that join concrete and abstract to understand more clearly how the manipulation of Whole Numbers in formal operations happen; and, as a result, they can relate such procedures to the most common operational questions. Concerning multiplication with Whole Numbers, what makes its understanding difficult is when it is used with Negative Numbers. The most common question is associated with the possibility of multiplying Negatives quantities, or, better yet, how can we multiply by *n* negative times? How can we connect multiplication of Negative Numbers with our everyday life without creating "monsters" which can prevent students from understanding such operation?

Formally, from Piaget's ideas, Glaeser (1985), as cited in Teixeira (1992) makes some conjectures about this process:

> *[...]* ***+a -a = 0****, so, multiplying* ***+a -a*** *by any quantity, the product must be* ***0****; if I multiply by* ***n****, the first term is* ***+na****, thus the second one is* ***-na****, for it is necessary that two terms "destroy" each other. Therefore different signs result* ***(-)*** *in the product. If I multiply* ***+a -a*** *by* ***-n****, in accordance with the previous case, I will obtain* ***-na*** *as a first term; consequently, the second is* ***+na*** *for it is always necessary that the two of them "destroy" each other. So* ***(-)*** *multiplied by* ***(-)*** *results* ***(+)*** *in the product. (p. 51)*

Despite using zero as an auxiliary tool and words which are not so common in mathematics such as "destroy", Glaeser does not make an analysis of an everyday situation to show how to Multiply Whole Numbers with negative signs (a largely polemical issue). In other cases in which Whole Numbers are used, contrary to the one that involves two Negative Numbers, make understanding easier, seeing that the use of everyday situations as a positive multiplying becomes concrete.

We firmly believe that the answer to the question related to why multiplying Negative Numbers results a positive one, meaning an everyday representation for such questions, is an important fact while teaching Whole Numbers. Nevertheless, after analyzing some didactic books we could not find any significant information which could fulfill our expectations for rules and technical procedures to solve that operation (multiplication) are the ones generally found.

Such statement valorizes more the experiment we made, according to the excerpt below, which is a result of the interaction of the researcher-professor with the students while constructing those games using RPG Maker software.

> **Teacher**: Let's think! What did we have there? *[the researcher-professor is referring to a situation created in the game by the participants to represent the multiplication of a negative number by a positive one; which is (-4) □ (+3)]*
>
> **Rônei:** I owed four, four Reais *[Brazilian currency]* to three people! *[Rodrigo asks permission to ask a question]*
>
> **Rodrigo:** In this situation I owed four Reais to three people, these three people are still alive. *[the student represents the situation of those three ones who are alive using a positive sign; so three people still alive means +3]*
>
> **Teacher:** Three people alive?
>
> **Rodrigo:** So there, now, I owed four Reais to three people; three people died and I got more twelve. *[the student is referring, once more, to the situation of those people. In this moment, according to the student's representation, those people are dead. So the student understands that the debt which existed was forgiven from the physical situation of the person (dead) and, concludes, realising that, in that moment, he owns 12 positive for he owed four (-4) to three dead people (-3); as a result, he keeps the money, making the operation: (-4) □ (-3)]*
>
> **Teacher:** That's it! It happened because you don't need to pay anybody any longer! Did you understand, Rodrigo? Cool! Did you understand what he meant, Rônei?

From that moment, it can be said that such an event represents the meaning that the apprentice attaches to what he is constructing; in this case, multiplication of Negative Numbers. It also makes the identification of a way of representing that operation with emphasis in an everyday situation possible, which does not happen whenever rules of multiplication are shown in most didactic books. That situation

portrays the constitution of some relations that, sometimes, are beyond what the teacher is expecting. At the moment that Rodrigo represents the idea of living people through a positive sign and, when they die, through a negative one, he elaborates a meaning to Multiplying Negative Numbers; such findings are not usually expected by teachers.

In the same way, when a student refers to debts which he had and, in the next moment, he does not have them any longer due to the creditor's death, and then ending up having a positive result to the debtor (represented by the student himself in his example) who keeps the money meant for paying the debt, can indicate the constitution of the meaning that two Negative Numbers result in a positive one by the student himself.

We know that in both representations made by the student, the elements which are identified are not found in the same group for they represent different ones, or, better yet, a debt means neither the same as a dead person nor is part of a set of similar elements. So we can say that if we consider the operation made by Rodrigo, this would not be valid in terms of formal academic mathematics. However, we believe that, even not building a formal meaning, the participant while constructing this situation, as an example to his Electronic RPG, makes a meaning closer to his reality feasible and coherent, to multiply by *n* negative times and using this concept in his life. In our view, this finding is enough to allow 6^{th} grade students from Elementary School to understand how to multiply Negative Numbers, even not being aware of the fact that the representation of that operation is not formally accepted.

As previously mentioned, Rodrigo creates a situation presented as an example to show the operation in the electronic game he was constructing but it does not mean this student would not come up with the same idea in another moment, in another situation apart from that one. However, the construction of Electronic RPGs made this conjecture possible to be accomplished by the participant in the moment he had the task of construction an Electronic RPG.

The participant elaborates conjectures based on the information obtained by him, even not being through investigative work. It confirms what Maltempi (2004) states, while mentioning that Constructionism engages students in a way that they become active participants, making their sharing the control and responsibility for

their learning process possible. It turns into an extremely important fact and it contributes, in our view, to students' mathematics learning as well. In this way, over the past years we have been teaching teachers and universities students (future teachers) using as an approach the experience described in this research study through Electronic RPGs.

THE ONLINE RPG STUDY

The second experiment with RPG in Mathematics Education was made by using its online version and it makes part of ongoing research, whose development is based on qualitative methodology, which investigates the question *How the construction of online identities in a distance course, whose educational environment is an Online RPG, shown in the teaching and learning process of the concept of Definite Integral?*

Virtual presence is an element of how the construction of online identities is shown. It is in the cyberworld along with online identities that occurs their own construction, similarly to what occurs with the teaching and learning of mathematics concepts that are determined from a microworld particularly established.

Identities built in specific contexts (scenery, microworlds) are found in RPGs regarding this research, to assure greater possibilities of imagination by the participants. Online RPGs were used due to the fact they are largely played on the Web and promote the need of a high level of creativity encouraged for the participant's anonymity, which is connected with its essence and playful aspect of this game – aspects that are thought to be essential in an environment of study.

The action of constructing each online identity by means of objects that promote thinking (computers), or evocative (Turkle, 1997; 1989), turns into a presence. This occurs throughout the game and in Maria Bicudo's (2003, italics by the author) view, "There must be considered that the *pre-sence*[5] *is always spread in*

5 It is here "[...] understood as the human being who is always in the world, temporally. The temporality of this being, always opened at random or to his a-round [...]" (Bicudo, 2003, p. 75).

the world. It means it is always a *pro-ject*[6] having its own responsibility for renewing itself by its powerful force that brings life, which has to be careful so that it can keep all its vigor, sustaining itself" (p. 76). The life that occurs in a virtual world also happens in Online RPG owing its particularities. Among them, there is the mathematics perception of concepts which emerge from experiencing and, consequently, from the presence in a virtual microworld.

Regarding Online RPG Turkle (1997) points out that the person will be present by using a chat which will make the word processing, the communication software and the simulation built considering that for each one of them a window is opened and, then, each identity on the computer will be in these spread ones.

This leads us to state that "being related to" promotes different experience aspects. In a distance course, whose teaching and learning environment is an Online RPG, many of these experiences are emotional and cognitive in a way that the human being who participates "out of the computer" has his intentionality that entangles the educational question whenever constructing his online identity through these and other sorts of experiences Then, the construction of mathematics knowledge is feasible in these experiences when, being the others, at the same time he remains, for instance, as a mathematics student (multiple identities). The same happens in the group that is present in a microworld especially created to discuss some ideas of everyday situations that carry with them some sub-adjacent mathematical concepts.

So as to the microworld could be constructed, TelEduc platform (http://teleduc.nied.unicamp.br) was used as an investigative tool to make us capable of identifying the interaction of each student with other participants as well as the context used in the game during the constitution of mathematical knowledge.

All meetings were recorded in TelEduc, which let us make – in full – the analysis of all chats for this platform that automatically backs up each meeting. From those recordings, we show an excerpt that implies some reflection/discussion on the

6 "Pro-ject is mentioned by Heidegger referring to being forward, what is ahead, towards future" (Bicudo, 2003, p. 76).

calculus of a plantation[7] area taken from the adventure of RPG developed. In this manner, we realized the presence of online identities in the rural area inserted in the adventure context. This fact justifies the construction of online identities, whose presence promotes the articulation of all actions of learning that are evidenced as contributing tools to learning the concept of Definite Integral.

JUNE 07, 2005 – 2ND MEETING (06:50:06 – 10:00:52 PM)[8]

[The group thought of how to calculate the plantation area of the property, located among the house, the granary and the barn so that they could know the quantity of seeds to be planted and, as a result, to help Ana with the plantation execution From the views of the rural property (Figures 1 and 2), available at TelEduc, the group made some mathematical hypothesis due to the fact that the plantation area was not a geometric figure pattern. The area was upper limited by a bend (the river) and it caused a problem-situation to all participants.]

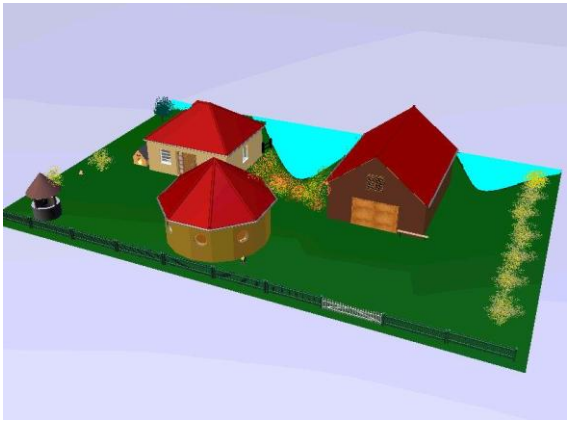

Figure 1: General view of the farm.

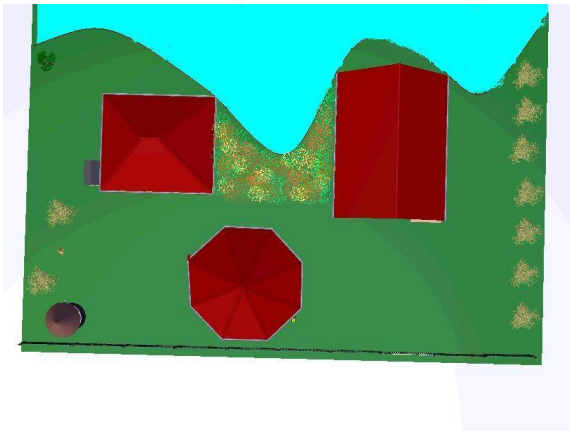

Figure 2: Vertical view of the farm.

7 The adventure proposed in the course had the scenery the rural property of the Farias Dutra. So, the objective inserted in the story was to help its owner, Mrs. Ana, to plan in a limited area, whose localisation was down a curve (the bend of the river).

8 As the objective of the paper is not to analyse the language used in the chat, we eliminated all spelling and typing mistakes. However, we kept the way the online identities expressed their thoughts; also consider that the Master was the researcher-teacher.

(07:38:19) **João Dutra** talks to **Master**: with a significant small base, at the moment of calculating the area, the area itself could not exist as if we were calculating the area of a line [...]

(07:39:55) **Vanessa** talks to **All**: I agree with João but I would like to know the opinion of my classmates.

(07:40:02) **Mariosvaldo** talks to **All**: using triangles, only the hypotenuse (the river) modifies; in winter all other measures would remain the same.

(07:40:22) **Master** talks to **All**: Ana talks: Does everybody agree with the idea of the non-existence of this area? What would it be? Similar to what? Could someone explain it to me?

(07:42:07) **Master** talks to **Mariosvaldo**: Ana talks: but the river changes completely. Sometimes, instead of only one bend (like the one shown on this map), there are two, three, like if it were a worm in a grey background. And so? Would they be triangles? What if there are only two, could they not be one on the other?

(07:42:09) **Chiquinho** talks to **Master**: I don't agree for it is not necessary the existence of such a narrow base to get the thickness of a line!

(07:42:35) **João Dutra** talks to **Chiquinho**: It is complicated... to obtain accuracy the base has to be quite small...

(07:42:52) **Sol** talks to **All**: Do you think we are going to use triangles? No?

(07:43:00) **Mariosvaldo** talks to **All**: In this situation we should not consider the area which is closer to water for the soy cannot grow in a humid place.

(07:43:47) **Master** talks to **Chiquinho**: Ana talks: But Chico, imagine the upper vertex of the rectangle, would it not be down or up the bend of the river? Or, better yet, of each rectangle?

(07:44:40) **Mariosvaldo** talks to **All**: The best thing we can do is to use the part we know that it is not possible to have a flood and so, plant the soy before missing the suitable phase of the moon.

(07:45:21) **Chiquinho** talks to **Master**: It depends. They could be down or upper. It would be better if, in a real situation, they were down so that we do not have to measure inside the river.

(07:45:52) **Master** talks to **Mariosvaldo**: [Ana:] For a while I do not want to plant but to know, as accurately as possible, which my area of plantation is and if the area

> goes till the edge of the river, independently on planting there or not. These things I would like to know so that some years from now I can calculate it with no stress at all.

The construction of each online identity tends to converge on a presence. It can be realized when Ana, addressing to Mariosvaldo, argues *"[...] the river changes completely. Sometimes, instead of one only bend (like the one shown on this map[9]), there are two, three as if it were a worm in a grey background [...]"*, which is clearly shown that her identity is being constructed from the past in that rural area. This past reveals the presence of Ana in that environment, since she realizes (through her memories) changes of the flow of the river during the seasons of year.

Moreover, Ana foresees the alterations of the river bend on the farm. She attempts to see ahead as a person who needs to know how to manage her own agricultural land. In Bicudo's (2003) opinion, the *pre-sence* is always spread in the world, which means it is always a *pro-ject* having its own responsibility for renewing itself by its powerful force. The project brings Ana to life, making her interested in living and being lively. Life, in this case, occurs in online, with its characteristics – thinking of how to calculate the area in a zone limited by an upper curve since there was the need to calculate the number of seeds which should be grown in that zone as well.

Likewise, the presence is also perceived when Mariosvaldo claims that "*[...] we should not consider the area which is closer to water for the soy cannot be grown in a humid place*", confirming his knowledge on agricultural field, as much as he reveals a certain routine in that land, in which has a river that cuts the area of the plantation.

In this manner, both Ana and Mariosvaldo's presence exposes a process of reflection/discussion on the accuracy of using certain known geometric figures so as to make sections in the area of the plantation. This discussion and the presence are confirmed by Chiquinho when he argues that "*it depends, [the rectangles] could be upper or down, [from the river bend]. It would be better if, in practice, they would be*

9 As it happens in adventure RPG, there are other present elements so that the actions can happen. In this case, there was a map of the rural property with an air view of it, showing the area of the plantation as a limited area limited by an upper curve.

down so that we do not have to measure inside the river [get into the river to measure]". Chiquinho knows the land and let it be known, having a practical attitude regarding the problem. This allows us to assert that each identity is "[...] in a "turning into" process. It [the identity] is 'happening'. Its life is a flow in which, regarding the specific circumstances that are introduced, changes itself and changes reality in which lives" (Bicudo, 1978, p. 3). Such fact made each student of mathematics who played Online RPG live the mathematics situation of dividing the area investigated into known geometric figures, in a way which is closer to the idea of Riemann Sum, which is a process that leads a student to the concept of Definite Integral. However, this "experiencing" happened in other person's shoes, with another identity – in this case, online – remaining, at the same time, a student of mathematics.

Then, the presence in cyberspace makes the experiencing in that one possible. According to one Ana's sentence, *"I do not want to plant, I want to know, as accurate as possible, what the available area of plantation is, and if this area goes till the edge of the river, independently on planting there or not. These things I would like to know so that in the next years I can calculate with no stress at all"* reveals her presence on the farm, place from where she is talking, for she states: independently on planting "there"; in other words: in the place she is. From this perspective, we conceive that there is a reflection/discussion on how to calculate the available area for the plantation or, better yet, which geometric figure would give more accuracy regarding the space to be calculated, generating a relation of experiencing online identities with the concept which is being constructed. According to Papert (1994), the study of the human being and the study of what s/he learn and thinks are inseparable. Perhaps, paradoxically to some of them, the research of this nature of this inseparable relationship has been progressing through this study of computers and the knowledge of what the role they can play. The author also argue that studying the structure of knowledge is not only important to understanding the process of knowledge itself but also a means of understanding the human being; as a result, understanding who produces knowledge and the knowledge produced by it. This "[...] can be interpreted as being, that neither the person nor knowledge – including mathematics – can be reached in isolation [...]" (Papert, 1985, p. 196).

So we understand that this social construction may playfully happen in cyberspace through the Online RPG. The game makes possible that all those actions of social practice occur in and with the constituted microworld, which was constituted in and for the game. Interests, conflicts, political influences and many others situations can be experienced in Online RPGs. So we believe that production of mathematical knowledge can be inside the action itself of imagining which happens along with each start through chats. This action can establish some relations with everyday life like plays, movies or soap operas. The plot of the game requires actions which are pictured and include in their meta-plot[10] mathematical ideas. These ones can help understand the situation at the same time they are understood from it (meta-plot). Respectively, concepts and living actions are made through the flux between microworld and the online identities – both of them constituted in the game.

This process may characterises what Lave and Wenger (1990), Winbourne and Watson (1998), Cobb and Bowers (1999), among other authors define “situated learning”. In this perspective, learning usually occurs according to an activity, a context and culture in which it is inserted. Many times, it is opposed to the activities developed in a classroom which take abstract knowledge out of a context.

The understanding of how the calculus of an area over a river bend would be possible (the area of available for the plantation) occurred within a process which happened as far as the experiencing in the place was happening. Such experiences were only possible due to the presence of online identities in the microworld (in this situation, the virtual rural property). In this way, the virtual presence attempts to reach the imaginary and, in other aspects, the perception of geographic localization in which we make part, the place where we are present. Although it is a virtual space, we are there and visualize, dialogue, reflect and discuss about questions of the calculus of an area, which implies the idea of Riemann Sum (a significant factor in terms of understanding the concept of Definite Integral), having as a starting point specific views, for instance, like a tractor driver’s one. It is only feasible through the action of playing by the offline identity that is “in front of” the computer. Such action is

10 Meta-plot is composed of underlying ideas (in this study, mathematical) to the ones which have to be taken by the characters (for instance, to calculate the region for plantation) and it makes possible that some concepts be experienced through the actions in a game.

portrayed by others related to the construction of mathematical knowledge, which is identified as creating, representing and imagining.

Hence, it is in the presence of online identities in this time/virtual space (Online RPG) that appears relations of each identity with many others, both on and offline. This represents a multiplicity of "beings" and relations. Cybernetic and cognitive beings that multiply themselves and multiply relations of dialogue, reflection and discussion with others and with their own world in a way they become, in this study, the teaching and learning processes of the concept of Definite Integral, which was the reason of the identities existence. So the presence in the virtual world, the story of the existence of these identities as an aspect of constructing themselves, starting a relation with others and with the world within this space are actions that express how the whole process of constructing is shown to teaching and learning of the subject matter and, then making known the broadening of possibilities in terms of constructing mathematical knowledge.

FUTURE TRENDS

From the investigations reported in this paper, it can be stated there are two large trends in regard to the construction and application of virtual and electronic games. The fist one is the constitution and maintenance of communities of practice (Wenger, 1999) that can be found in virtual environments and whose common interests is the discussion linked to computer games; and, the second, the elaboration and execution of those games with a greater power of immersion since the advances of computing technology. Such future trends open a wider range of possibilities in terms of Mathematics Education and researches with regard to the issues analyzed in the studies presented.

Concerning communities of practice, many of them are the ones that are created in cyberspace. Their interests are attached to computer games and the leisure they may bring. Likewise, we understand that such communities become virtual communities of learning due to electronic and virtual games since,

> *Now, playing with simulations encourages people to develop their abilities in an easy and more informal form, since it is extremely easy to create alternative scenery (like "What if I did that?) [...] and*

> *manipulate the results in a process of trial and error. Instead of being restricted to follow a set of rules previously established, the users of computers are encouraged to try out in all simulated micro cosmos. Then, they learn how things work while interacting with them. (Turkle, 1997, pp. 76-77)*

Interaction in cyberspace makes feasible, then, new ways of fun and entertainment in which use simulation empowered by the computer as a source of endless learning, for it demonstrates the experience the virtual world itself. Learning through direct actions makes playful meanings found in virtual communities, whose interests lies in electronic and virtual games, present some forms of interaction as playful-virtual and reflexive-virtual among their participants. This situation brings out not only an interaction related to the game itself but also contributes to an exchange experience net that feeds the pleasure of playing. In this regard, it is established a circle of beginners who comment on their moves, exchange “tips”, read professional books and magazines to be updated and better their performance in a collaborative form.

The interests found in virtual communities can also be presented as topics by which such communities frame their interactive communication with a view to planning some guidelines on thematic that created them. From this perspective, mathematics seen under the context of a game, from actions performed and/or developed for it, becomes an interest of discussion in communities of practice as well.

We conceive that while discussing the actions to be experienced in a game, since they take mathematics as a base of reflection and action, the participants of future communities of virtual practice, will empower their process of learning inasmuch as they will broaden mathematical discussions in a natural way. We believe that such thematic leads to newer dimensions while pondered under the view of Mathematics Education. We also consider as true that establishing personal and informal interactions on everyday life linked to mathematics promotes its learning in a natural way as argued by Papert (1994) with respect to a mother-tongue learning process.

Thus, we assert that the constitution and maintenance of communities of practice as well as the research on such communities whose common interest is the

game, will make new and important perspectives be framed concerning mathematics – its teaching and learning process. This assertion is based on the premise of collaboration and co-operation connected to those communities as well as on learning through practice also present in them (Wenger, 1999).

As for the construction and application of computer games, we would like to highlight the possibility of more immersive environments than the current ones. In this manner, we perceive new forms of interaction and construction of mathematics knowledge regarding that, and we also think about the relations involving "being" and "learning" that begins to be produced and understood in a different way in those virtual environments. Such facts happen since "The investigators of Artificial Intelligence study minds to develop programs and use programs to reflect on the mind. Along their profession investigators have used questions on the human intelligence and *human essence* as their leading subject" (Turkle, 1989, p. 20 – our quotation). This makes projects on human essence be developed; projects in which are inserted in a virtual world into a Virtual Reality (VR) that, "[...] emphasizes characteristics such as multi-sensorial devices, navigation on tri-dimensional space, immersion in the context of application, simulation of environments and interaction in real time" (Pasqualotti & Freitas, 2001, p. 81).

However, this VR neither excludes itself nor gets out of mundane reality (Bicudo & Rosa, 2007). Although there is a specific meaning in the term, VR is linked to reality and it is reality itself being experienced in a context that is made in this reality. Nevertheless, the immortality of the cybernetic being, as it does not have a "physical body", is a fact that expresses and provokes human actions more specific, not only related to this cybernetic being that can become "perfect" but also related to the action of learning from it.

This idea causes polemical questions with respect to VR. It can be observed in Turkle's (1989) view that states that many people believe that living in a virtual world can cause a pathological influence on real world relations. Yet, likely pathologies created by this inventive system of VR are not to be questioned here,

> *[...] whenever we talk about information sources and artificial realities that derive from them, the important issue consists of knowing not if machines of information can be create inventive*

> *systems but if they are capable of provoking in the interface with the user other forms of knowing and thinking (Lopes, 2005, p. 109)*

VR in accordance with Mathematics Education can, then, bring new ways of knowing and thinking. Nowadays, we realize that whenever we use immersive VR environments, or, better yet, systems that include the perception and sensation of being inside an environment (Pasqualotti & Freitas, 2001), we have already produced distinct ways of constructing knowledge. Despite that, we believe that in a near future, when we are able to create immersive environments more powerful with the use of special helmets and *datagloves*[11], we can reach other ways of thinking. According to Turkle (1997) "Even the "AI engineering" [artificial intelligence] is greater than a purely technical subject. Its objects as well as its theories are open to our eyes like a mirror to contemplate the nature of human identity" (p. 184). Thus, the nature of human identity within this space will be more discussed not only in a philosophical aspect but an educational one as well. We think we will be immersed in a virtual world using all the necessary devices and we will visualize in a virtual mirror the physical image of the identity we created to be there. We will also see other virtual identities that will interact with us in a classroom, for instance. Those will be different students, teachers, etc., in a way we will inquiry *Who is learning in this environment? In which way is the "being" learning? What are the influences of this being-in-a-virtual-world?*

Bittencourt and Girafa (2003) already guarantee that the great advantage of VR is the possibility of exploiting environments, processes and/or objects by means of virtual manipulation and analysis of the own question studied. From this perspective, mathematics will be presented with multiple interactions among cybernetic beings, virtual graphics, sounds, images and movements that will imprint the process of knowing, learning and teaching. The intensity of the experience may be similar to the processes of exploiting mundane and broadened reality concerning them. So, we consider as true that "If, in our future experiences, a simulated reality has a more casual impact in our life experience and real behaviour than a non-simulated one, then, in a pragmatic meaning, it will be more real" (Weberman, 2003,

11 Gloves that enable the manipulation of virtual objects so that the explorer sees and feels that the image of his hands in a virtual world (virtual hand) is led by the movements of his own hands.

p. 258). This statement raises several questions that have to be investigated in a philosophical and educational aspect not only in mathematics but also in other areas linked to human knowledge.

CONCLUSION

In this paper, we explained the way we have been using RPG in Mathematics Education, presenting some results of our experiments with Electronic RPG in Elementary School and Online RPG at University. Thus, we presented our motivation to use games in education, especially the ones that involves representing characters, and also, discussed the theoretical referential adopted in each case whose ideas based on the constructionist theory and multiple identities. We also indicated as future trends the use of RPG in education the constitution and maintenance of communities of practice and the elaboration and execution of games in highly immersive environments by means of techniques of artificial intelligence and virtual reality as significant factors to forthcoming studies.

Moreover, we identified electronic and virtual games as enriching sources of knowledge. We also perceived the “learning” through playing as a process in which the collaboration and the new view of the world contribute in a way that playful forms can be highlighted in the context itself. Concerning RPG, which arouses imagination and creativity, we realize that the actions of constructing and playing games engage students in a process that associates pleasure and reflective work and, in this process, we observed some evidence of effective learning of the content chosen. To do so, we were based on constructionist ideas that make feasible a regular description, execution, reflection and debugging of the ideas of those involved in the teaching and learning environment and on the relations of these actions with situations of mundane reality.

In addition to it, even not being the focus of this study, we consider relevant pointing out that the teacher had a fundamental role in both studies, being in charge of all preparation of the environment, conducting the experiments and being a mediator between them and the mathematics content studied.

To sum up, we do hope to have contributed to researchers and teachers interested in using RPG in education. Our researches and practices are to indicate that playful activities and technology can create a sort of inspiring synergy to the teaching and learning process.

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