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JOURNAL OF INFORMATION SYSTEMS APPLIED RESEARCH

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Do Experiments using Immersive and Interactive 3D Structures Improve Memorization?

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Abstract

The paper focuses on the experiment of human computer interaction in an immersive and interactive 3D structure by students during their courses**.** We want this article to examine the real effect of the New Technologies on the students and in particular how virtual reality could improve education, specifically in the ease of reception of knowledge. We study in particular the effects of virtual reality (3D, vision headset, total immersion) on the long-term memory of the students and the different form of communication that the specific type of media imposes. In our study, we compared the case of different form of courses from a traditional course (an oral media-based course/ a media-based course in PowerPoint without taking notes/ and with note taking) to a media-based course in virtual imagery (3D, vision headset, total immersion). We analyse the type of communication with the use of an immersive, interactive structure, giving the sensation of presence. Our experiment entails a 3D device in the setting of media-based, educational communication (Peraya, 1998; 2000) in scholarship.

Keywords: human computer interaction, 3D Head Mounted Display, virtual image, levels of communication.

1. INTRODUCTION AND POSITION OF PROBLEMS

Much research has shown that technology could improve education. For example, Kulesza, Dehondt, and Nezlek (2011) wrote that "educational institutions use the appeal of technology to attract students, academicians advocate technology as a means of engaging students in learning material rather than simply presenting it, and research suggests that students are more engaged with classroom material when it is accompanied by technology." In this paper, we examine the real effect of the New Technologies and in particular how virtual reality could improve education, specifically in the case of reception of knowledge. We will study the effects of virtual reality on the long term memory of the students and the different form of communication that the specific type of media imposes. In this paper, we want to show that the human computer interaction is a complex process.

In our study, we compare the case of different form of courses from a traditional course (an oral media-based course/ a media-based course in PowerPoint without taking notes/ and with note taking) to a media-based course in virtual imagery (3D, vision headset, total immersion). We analyze the type of communication with the use of an immersive, interactive structure, giving the sensation of presence. Our experiment entails a 3D device in the setting of media-

based, educational communication (Peraya, 1998; 2000) in scholarship.

We created five homogeneous groups of students (18 students per group in the second year of initial training, DUT (Diplôme Universitaire Technologique) of TC (Techniques de Commercialisation, IUT (Institut Universitaire Technologique.) at the IUT of Université du Sud, in the setting of our courses in the Psycho-sociology of Organizations, ninety students were tested. The content of this course was the same in the five groups:

1. An oral, media-based course: the course was dictated but the students did not take notes.
2. A media-based course in PowerPoint alone but without note taking. The images and the diagrams were the same as those that were used in the course in synthetic images.
3. A media-based course in PowerPoint, with note taking. The images and the diagrams were the same as those that were used in the course in synthetic images.
4. A media-based course in virtual imagery and synthetic images (3D, vision headset, total immersion).
5. A control group course, the pre-test and the post-test only.

We compared the five courses on:
- -The cognitive and memorial aspects (long-term explicit memory)
- -Identifying the different types of communications

We ventured two hypotheses:

H1: A course in virtual images allows a better memorization compared with other types of media-based presentations (auditory, PowerPoint without notes, PowerPoint with notes);

H2: the type of media-based presentation acts on the communication of course content and the students experienced the four types of media-based presentation differently.

Our initial hypothesis was calling upon an increasing number of sensory modes which have made simultaneously possible the increasing performance of the long-term explicit memory of the information delivered by the didactic content (Paivio, double coding theory, 1971, 1986, 1991; Paivio and Caspo 1969). As far as our experiment is concerned, we have tested long-term / explicit memory. In fact, that is the form of memory at work when memorizing a course, even if learning brings several forms of memory into play. The result of our study showed that students did not have better memory performances in 3D virtual image course with HMD. It is the reason why we thought that these results could be explained by students' resistance to change.

Our approach combined:
1. A quantitative analysis based on hypothetical-deductive reasoning (first hypothesis) in order to analyse if an immersive 3D structure in the framework of our courses would have effects on memorization and to test the sensation of presence in the course presented by means of virtual images
2. A qualitative analysis (second hypothesis) a) in order to understand how the students experienced the different communications situations across the four types of media-based presentation; and b) to study the different types of reluctance face to change and the ambivalence of this concept.

For our first hypothesis, the differences in results obtained by the courses were calculated by variance analysis (Anova). We used a t-test to examine the sensation of presence in the virtual environment. The results of the Anova and the t-tests are exposed in this article.

For our second hypothesis, we interviewed 18 students in the course in virtual images with HMD. The results of these qualitative interviews are presented in this article. First, we present our case study.

2. CASE STUDY: an immersive and interactive structure, giving the sensation of presence

We can describe the structure of our experiment as 1) immersive, 2) interactive structure and 3) giving the sensation of presence.

A total immersive structure

Many authors have likened this term to a technical notion, which might act on the user's senses. Cadoz (1994) asserts that immersion is "a technology, an interface technique between man and machine and does not involve the psychological state of the subject". The physical immersion of a subject in a virtual environment is performed by sensory information (sight, hearing, etc.) alone.

For Pimentel and Texeiria (1993), immersion is "the state of a participant when one or more of his senses ... is isolated from the exterior world and he no longer registers any information that does not come from the computer".

According to Seipels (2003), a virtual environment is considered in total immersion when the totality of the user's senses is called upon on the one hand, while on the other hand there is total immersion of each sense (even if this total immersion is seldom attained in practice).

According to Slater and al. (2001), in an immersive environment, the users have an egocentric view of the virtual world, that is, a view from the inside of the environment or of the phenomenon, as opposed to an exocentric view from the inside of the environment, where the user does not directly take part in the virtual word. For systems of these types, immersive technologies are used: data loves, CAVE o HMD headsets, etc. Technologies of this kind allow visual immersion of the user in a virtual environment. Our structure was a total immersive structure because the students had a 360 degrees vision and an egocentric view of the virtual world.

An Interactive Structure

In virtual environments, the user's interactions are said to be subordinated to four tasks, according to Fuchs et al. (2001), as regards functional interaction. The user's four tasks are to:

1) Observe the virtual world
2) Navigate in the virtual world
3) Act upon the virtual world
4) Communicate

Observing the virtual world is a stage that allows us to prepare ourselves for other actions and that is necessary for understanding the virtual world.
Navigating, acting and communicating presume an action on the user's part. The structure of our experiment can thus be considered as interactive in the sense that it allows the user to perform these four actions.

A Structure Giving the Sensation of Presence in a Virtual Environment

The feeling of being present in a virtual environment is sometimes combined with that of immersion, but it forms the psychological aspect, while the notion of immersion refers more to the technological aspect. The notion of "presence" in a **virtual** world is "the psychological feeling of being there in the environment, of which immersion is the technological basis" (Slater and al., 2001).

For our experiment, the students were equipped with:

A HMD (Head Mounted Display, that is, a Sony Glasstron LDI-D100B ruggedized vision headset (LCD screen, Resolution 800x600, non-stereoscopic, visual field 26° Horizontal, 19.6° vertical, headphones with stereophonic sound - see Figure 1).
A Tracker (movement detector) Intersense intertrax² (3 degrees of freedom, angular resolution: 0.02°, latency time 4 ms: internal refresh rate of 256Hz), mouse buttons as navigation tools.
Software used: Unreal 2004, 3D Studio max, Actor X, and PowerPoint.

The students were in total immersion, in an interactive structure giving the sensation of presence.

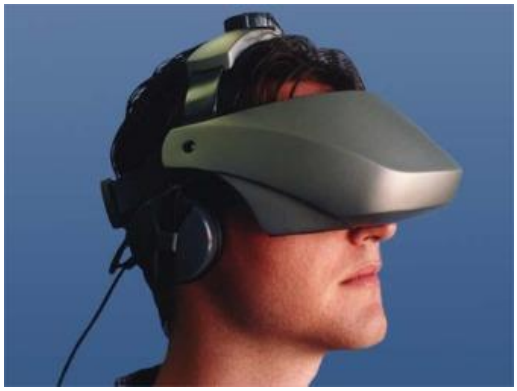

Figure 1 Head Mounted Display

The People Involved in the Project

Doctor Eric Malbos, physician and neuro-psychologist, who has elaborated a system conceived within a virtual environment in order to treat patients suffering from phobias by successive habituations. He created the storyboard of the course in virtual imagery, the animations and the course in virtual imagery.
A professor of Psycho-Sociology of organization who prepared a doctorate thesis (Lombardo, 2007) was the project leader.

A media engineering student from the University of Toulon and the South (Wallid), a specialist in synthetic images, has created, in the framework of a proficiency grant, the 3D images for the course in virtual imagery.

Experiment, Report, The Courses
Group 1: An oral, media-based course: the course was dictated; the students did not take notes.

Group 2: A media-based course in PowerPoint alone but without taking notes. The images and the diagrams were the same as those that were used in the course in synthetic images.

Group 3: A media-based course in PowerPoint, with note taking. The images and the diagrams were the same as those that were used in the course in synthetic images.

Group 4: A media-based course in virtual imagery and synthetic images (3D, vision headset, total immersion).
Group 5: A control group course, the pre-test and the post-test only.

An example of virtual environment: the students had to get into the university and cross 23 classrooms (Figure 2)

Figure 2 An example of the virtual environment seen by students

3. METHODOLOGY H1

A way of verifying hypothesis H1 was to construct a quasi-experimental system that allowed us to vary the different dimensions of the Independent Variable (IV) and to create teaching structures each one of them corresponded to a mode of the IV that we wanted to test, that is the structure of the media-based presentation.

4. DATA PROCESSING H1

The IV has several modes: course 1 auditory, course 2 PowerPoint without note taking, course 3 PowerPoint with note taking, course 4 by means of virtual images in immersive 3D.

The differences in results obtained by the courses were calculated by variance analysis (Anova), and by a test T. of the Student.

5. ANOVA RESULTS H1

Group 3 (PowerPoint with note taking) is the one that had the clearest significant improvement in performance.

By decreasing order of performance, group 2 came next (PowerPoint without note taking), then group 4 (virtual images), then group 1 (auditory) and last came group 5 (the control group).

6. RESULTS OF THE TEST OF PRESENCE H1

The results show that the students had a feeling of presence within the virtual environment of the course in immersive 3D.

7. RESULTS OF THE QUALITATIVE TREATMENT H2

The recurrent themes in the 4 groups (auditory, PowerPoint with note taking, without note taking, and by virtual images) were the following:

Theme 1: emotional
1) Positive emotional dimension: original universe/ environment; innovation/social network; funny.
2) Negative emotional dimension: unreal; "small lab rats".

Theme 2: physical
1) Positive physical dimension: sensation of presence in virtual environment
2) Negative physical dimension: discomfort/sick; headache

Theme 3: cognitive
Positive cognitive dimension: simulation as help in learning; simulation as help in understanding the reality; experiment as a source of motivation

Negative cognitive dimension: no human aspect: learning boundaries

Theme 4: intentional
Positive intentional dimension: emulation to take the course in virtual image

Negative intentional dimension: technical aspects of virtual device

Emotional Dimension: The Device (Structure) in Virtual Images: an Original and Pleasant "Universe" for Students
In our case study, we notice that students have positive or negative responses.

Positive Emotional dimension: original universe / environment
The course in virtual image has emerged as "a universe" (student 5V), a world", "virtual world" (Student 2V), "and thus we entered directly into a virtual world. It was a world that we were not used to being into "(Student 3V)," then I walked into this world "(Student 3V). The characteristics of environment played a positive role (positive emotional dimension) in the perception of change recipients (students).

Positive Emotional / innovation / social network
Many students noticed the novelty of the device, particularly highlighting the fact that it was new for them, the surprising aspect of the device appeared to them as positive: "It was a first" (Student 1V), "So we were expecting something really innovative, that's why we were surprised because it's true that it has changed us, it was innovative" (Student 3V). The innovative aspect of the device is also linked to the idea (and fantasy) of a future where education will go through the virtual "yes we realized that it might be the future of an educational standpoint, this would happen, and it is true that compared to whatever is happening to video games, the virtual world, it seems to be a fairly logical way for the future "(Student 3V). (The structure in virtual image as an Innovative changed the patterning of Students' actions in the social network).

Positive Emotional / funny
The lighter side of the device is often linked to the playful aspect of the device: "First of all, the playfulness" (Student 3V) "I found it really interesting, the virtual world, to recreate a building, I thought it was really nice after I find that to learn the course, it's true that it's more fun yes, it is a fun side in the course "(Student 2V)," it is true that the 'playfulness that I really appreciated "(Student 3V)," and I took it as something fun "(Student 5V).

We noted that the communication is a complex mixture of context, attitudes and processes. The characteristics of environment played a positive role (positive emotional dimension) in the perception of students. The structure in virtual image as an innovation changed the patterning of Students' actions in the social network.

Negative Emotional dimension: unreal - "small lab rats"
Psychological immersion is not felt with the feeling of being truly present, but as a "game" that does not correspond to "real life" by some students, "The problem is that I was a little troubled by the virtual world. I, too, never felt like myself. ... It's not real. Even if the atmosphere was nice, it is not real life, but it's well done, but after what I told you ... it's something else, it's a game for me"(Student 2V). This is consistent with the idea of being in a "universe" that has been identified by many students as we have seen.

The course is seen as an experimental laboratory study, "I said, ah, my psychology teacher, she wants to brainwash me for her thesis!" (Student 2PSN).

The course in virtual images caused an excitement and a kind of fantasy so that the students saw it as an imaginary being, a science fiction world, "Because it was different. Because we were not in a lecture hall, 90, listening to someone speak. It's different. And I remember with one of my colleagues, we said we will have a helmet, we will believe in "Back to the Future" in fact it was not like this story helmet, we had a good laugh about it" (Student 1PSN).

Some students felt they were "small lab rats" and they thought it was rather funny: "we amused ourselves by saying we were small laboratory rats, but it was fun, it was quite lively"(Student 3PAN)"As I told you, when we went to the course, we said we will play small laboratory rats, but it was so good-it was not negative, that we knew very well that we were used (in quotes) for an experiment but it amused us all that ... So we did not have to say, no we will not go, we will be used, we didn't think that at all "(Student 2PAN).

PHYSICAL DIMENSIONS: The real body, to test the technical and informational device in the virtual images

Positive Physical
The physical immersion was felt by many students in the course virtual images, "I said through the headset and looking directly at the video, we felt really "in", like almost in the character. There was someone who was driving, which met after the questions, we were in the character, the main character, and it is true that I was fully integrated in this virtual world, I had returned"(Student 3V)"The sensation of moving the head, that was interesting" (Student 1V).

Negative Physical dimension: discomfort / Sick; headache
Regarding the binding aspects of the device, they are of several types: first the physical discomfort caused by the device "for the first time, it is not too comfortable, what I felt, I was not well, I remember, I was really sick "(Student 1V)

The evil of heart (to feel sick) and headache (headache) were also often mentioned, but it seemed to appear to students as a problem of adaptation to the device "I think it gave a little bit of heartache anyway ... it's true, then we must get used to "(Student 2V)

It was also noticed that physical tiredness often went through the eyes: "The eye fatigue. The sound is not annoying, but after a while I think it can be tiring" (Student 5V). The "eye tiredness" seems to cause disorientation. Another student talked about a total loss of direction due to the HMD, "Headaches, disorientation and loss of landmarks"

The helmet was part of the technical (technical constraint) often noticed, "It hurts to the forehead, I remember now, finally, after a while, it is a little better.

We have the feeling of bearing the course, "and also all that is helmet and all, it seems we are passive and we are imposed that mode of education, of instruction, we are here and we suffer a bit with the helmet and the video "(Student 3V), the device appeared in some less interactive than a traditional course:" Not necessarily because there is an interaction, we "suffered" in quotes "(Student 5V).

COGNITIVE DIMENSION

Positive cognitive dimension: **simulation as a help in learning; simulation as a help in understanding the reality; a source of motivation**
The simulation appears to be necessary in learning when describing situations that cannot be simulated in real life; it helps the understanding of a phenomenon (the student evokes a course in 3D simulation he followed during his training): "I remember everything from Art History, the representation, so we were told this, you have such a perspective, something like that, and then they showed us a 3D simulation that really gave it so we understood really well" (Student 2V) "I do not know there was an experience, we had imagined drawing reflections of mirrors with all that, and, actually, they really showed us the mechanism inside with different views, it's true that if the teacher wants to explain it like this, it would be difficult. Here it is true that we understood better" (Student 2V).

The simulation is therefore necessary to simulate case studies that in reality cannot be, "Here, they are real case studies" (Student 2V).
A memory aid student think the course in virtual imaging allows better remembering: "By not taking notes after the PowerPoint, I don't think it was a good method, I think the virtual image can help ... after I do not know what it is exactly but I think that I would have preferred virtual imaging "(Student 3PAN).

Having lived an experimental course was seen as a source of motivation, "Well first, it's true that experimentation had motivated me more than usual, knowing that it was an experiment, I went in class, but it's true that I was more motivated, I was more careful when I filled out the questionnaire, when I experienced, I ' was really more focused than usually "(Student 3V).

The fact that this is an experiment that had motivated students because they wanted to be useful and please the teacher: "We were a bit more involved, because we knew it very well ... There was a desire (in quotes) to help you, since you've done all the researches "(Student 3PAN). Therefore, they were more attentive, "Bluntly, we listened a little more because we always knew the teacher had to find some benefits from the experiment. So perhaps we were a little more attentive" (Student 3PAN). In addition, they showed more motivation, "Yes, because I

know very well that there is an experience" (Student 3PAN).

Negative cognitive dimension: no human aspect: learning boundaries
The fact that there is no teacher also appeared to be a constraint for the human and relational aspect, "So, yes, what really bothered me, was that, well first it's true that there was no teacher, no human aspect, and I found it a bit annoying "(student 3V).

Also the absence of teacher seemed to lead to a lack of motivation "and also, I may leave the classroom for a short moment without anyone to notice as "the teacher" is a computer, the contrary, it's true that nothing can replace the human side, we are more attentive" (Student 3V). The teacher appears as a person to the student, who will be boosted and motivated, "So I really prefer education with a teacher, a real person, who can touch us, motivate us, whereas with this virtual version, it's true that there, we cannot do anything, it cannot motivate us, tell us what to do, so it's really ... a cold means of instruction. So I really prefer having a teacher" (Student 3V).

The role of the Professor is very important in breaching of agreements and restoring trust in students.

Intentional Dimension
In the Intentional dimension, we show that change recipients (students) propose improvements for the virtual device.

Positive Intentional dimension
There was indeed some emulation to take a course in virtual imaging, and thus, in the end, a certain disappointment to those who had not followed (randomization): "I believed that I was, I know, in the dark, with glasses, we saw things, I imagined the big thing, and I wasn't picked, it was a shame" (Student 5A).
Having had such an experience seemed to have been a source of motivation, so that the whole course seemed to tend towards that goal: "During my first year of psychology, we had not really done that kind of experiment, which was so interesting and useful. So I might get more invested next year "(Student 5A).

Negative Intentional dimension
Some students were disappointed not to live the experiment in virtual images, "Honestly, in the beginning we were a little disappointed because we were told it would be us who would do the virtual images course, we heard about it, so we wanted to discover it, because, the PowerPoint, taking notes ... this is a usual course"(Student 3PAN).

Technical improvements doubled the inclusion of an interactive character
The improvement of the device appeared necessary for some students, particularly in the technical aspects: "It is true that we thought it was more impressive than that usual experiment, it was fairly new and I think it especially needed some serious change".

We can say it was really a "prototype""(Student 3V).
The attenuation of the monotony could go through the distinction of classrooms: "Well, I think that if all the rooms were different, it would be a plus" (Student 5V).

The notion of feedback also seemed to be a source of improvement, if it would include an interactive character: "If we were told the course by a character, that would be a plus"(Student 5V) "But I think that it was fun enough, even if, instead of being read, the text should be told by a character, it would be a nice change, it would vary a little"

Taking notes also appeared as a possible improvement of the device "because it has not been possible to take two or three notes"(Student 4V).

Remove the text and use the virtual image alone, appears also as an opportunity for improvement, "But to return to the information, it is true that read, hear, move, it was perhaps too much and if we had simply done it as a video game, or simply controlling virtual elements by removing the text, perhaps I should have paid more attention to the sound, without rereading, etc.. So that, it might be added to the next experiment"(Student 3V).

Depending on their personal experience
A student was afraid and wondered a lot about the course; he was older than the others and was working, he was following the course in a continuing education course: "I was a little tired, stressed; I was doing odd jobs, so I was afraid but I took and finish this course, fingers in the nose"(Student 4PSN)"

Some students wondered how the experiment would take place, particularly in relation to the medical question sheet, "Yes, they wondered what was going to be experimented, you had to follow attentively through the course, because you had a questionnaire and that it might cause minor problems, so they were wondering how it would happen" (Student 4PSN).

8. THE LIMITS OF OUR STUDY

We assume that the average score of students in the group 'virtual images' could be explained by:

1. The cognitive load theory: in fact, sometimes students were embarrassed by the HMD, they experienced headaches or heartaches, indeed, the hardware could cause mental or cognitive overload. Mayer (1997, 2003) or Schnotz, and Böckheler Grzondziel (1999) took into account in their models the notion of mental activity associated with multimedia learning, Sweller, Paas and Van Merrienboer (1998) defined the concept of cognitive load by placing it in the problems of multimedia learning. These authors define cognitive load as the mental workload that the execution of a task imposes on the cognitive system. Varies depending on the quantity and quality of information presented in a multimedia educational product, the cognitive load is assumed to depend on storage capacity and processing information in working memory learners. The theory of cognitive load may partly explain the poor performance of students in memory if the current 3D immersive virtual images;

2. The effect of habituation may be too long (we had planned to let students get used to the device for a quarter of an hour, but this time perhaps it has not been sufficient. So, another experiment might be lead by allowing students to have time to get used the device for a much longer time.

9. CONCLUSION: HUMAN/COMPUTER COMMUNICATION IS A COMPLEX PROCESS

In this paper, we wanted to show that the human/computer interaction is a complex process. First, we showed that a course in virtual reality hadn't improved the long-term memory. Secondly, we showed that the students felt as if they were present in the virtual world. Thirdly, we showed that communication in virtual reality course had taken four dimensions:

The emotional dimension is an important factor in communication between students and teacher because the virtual images could be symbolized like a cyber-fear or a cyber-utopia (the 3D device is in the same time symbol of modernity like an innovative device and symbol of an inhuman world where the students felt quite alone)

The physical dimension is to take into account because the bodies of the students are involved in the process (the structure gave them headaches for example)

The cognitive dimension is important too, because the results of our study show that the virtual images did not allow a better memorization.

Intentional dimension shows that the course in virtual images gave them a real emulation.

These four dimensions are complex because they could take a positive or negative meaning. For example, the emotional dimension is both positive and negative. All the speech about the virtual images and a cyber-world created an emulation for the students and they felt like participating into this sort of course, however, most of them were disappointed by this course because it was not enough interactive.

The complexity of the communication is also present in the role of the teacher and the students. The teacher is in participative observation; she is a part of the experiment and participates in the resistance to change. As a teacher, she has authority and influences the beliefs of the students. Simply saying that she would do an experiment influenced the students. They felt they were little "lab-rats". Also, the environment had an influence on the students and the teacher's beliefs. The speech around the virtual world was spooky (self-fulfilling prophecies and Pygmalion effect) but also showed a positive image (virtual images as a symbol of modernity and multiplicity of realities) or a negative one (the world where one feels alone, abandoned). These beliefs were transcribed in the interviews of students (verbatim).

Students who followed the course in virtual imaging were enthusiastic to participate in this experience because the teacher has passed on her enthusiasm (theory, experiment never done before), a doctor in medicine was involved in the

experiment (control of the health of students before the experiment) he was a figure of "authority". The relationship between the teacher and students were based on trust, she prepared the students to the course with sense-making.

So, we think the role of the perception of people in the process of communication is a very important part in the process of human /computer interaction. After this study, we can assume that some new patterns of the "good" teacher, who would like to drive a course with computer interactions, are emerging.

First, the teacher who wants to drive this sort of course has to consider the importance of the global design of this kind of courses. Second, the dynamism of the teacher has a preponderant role in the good implementation of this course and the management and participative democracy (student were volunteers) has to be taken into account. Third, the teacher has to be iconic and charismatic. Fourth, the tools used during the courses have to be analyzed: (the speech around the technology was very important in our study): the course must be an extraordinary activity and not a common activity. Last, the teacher must take into account the ambivalence of communication mediated by computer (not all negative / not all positive for example).

To conclude, we can say that students are not the only actors in the process, and there is a co-construction of meaning made by teachers and students. The human/computer interaction and communication are complex processes and the teacher has to take into account all the dimensions of this type of communication (emotional, physical, cognitive and intentional, reluctance to change).

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