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## Use of Telepresence and Holographic Projection Mobile Device for College Degree Level

Eduardo Luévano<sup>\*</sup>; Eduardo López de Lara<sup>†</sup> Juan Edward Castro.<sup>‡</sup>

Tecnologico de Monterrey, Av. Pedro Coronel No. 16, Zacatecas, Zac, 98600, Mexico

### Abstract

The evolution of technological tools has allowed for the increased quality of telepresence in the classroom. The experience using a telepresence robot and holographic projection is reported in official college level classes taught at the Tec de Monterrey in the period 2013-2015. This combination allows students to “feel” the presence of the professor in the classroom through a human scale holographic image, bi-directional audio and video and autonomous movements of the remotely controlled robot. The individual and combined use of these telepresence devices is reported. The results founds show that we are on the correct path. This work has echoed in the Latin-American community, mainly in Uruguay, Colombia, Argentina and Chile. Our work is shown as a way of disseminating this information and as an invitation for other researchers in the world to collaborate, thereby accumulating experience, formality and scientific rigor.

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### 1. Introduction

Videotelephony technology had its first breakthrough in 1964. 50 years ago AT&T presented the Tele-image service for the first time in the New York World Fair. Surprisingly, this video-phone invention didn't have the

\* Luevano, E. Tel.: +52-492-56820-1603.

*E-mail address:* [luevano@itesm.mx](mailto:luevano@itesm.mx).

† Lopez de Lara, E. Tel.: 52-492-56820-1603

*E-mail address:* [elopez@itesm.mx](mailto:elopez@itesm.mx).

‡ Castro, J. Tel.: +52-492-56820-1611.

*E-mail address:* [juanedward@itesm.mx](mailto:juanedward@itesm.mx).

expected success, it was concluded that, elevated costs, bad quality image and consumer unwillingness to interact with cameras stopped it's development. This is recognized as the first documented tele-presence event [1].

A quarter century needed to pass until, in the early 1980's, the digital net made long distance compressed video and audio signals possible. Since then videotelephony has grown in two branches: personal and entrepreneurial, amongst which we can find the distance education field.

Long distance education has gone through three stages of development. First stage (printed) when our ancestors hired education, this came via mail to their addresses, they studied it and once they had covered all the material, they would send their written evaluation, to then receive a diploma and the access to the next level. Second stage (analogical) including; open TV, cable TV, video sending and radio programs, etc. Third stage (digital) the Internet is used.

Tec de Monterrey's history on distance education started on April 26th, 1989 when the foundations of an innovative education system are established. (back then) it promoted the use of satellite technology with two main objectives: upgrade the teacher's academic level and extend the impact of teacher's achievements in all campuses. It was then when the SEIS operations started (Interactive Satellite Education System). With its first historical transmission. "How to export to the U.S." From then on, the first master, professional and continuous education systems started.

Subsequently in 1996 the Virtual University is born, incorporating various technological resources without precedent (until then) in the educational field, such a satellite transmissions, e-mail, multimedia, videos, manual and websites.

The evolution of this model continued from 1998 to 2001, years in which the Virtual University transforms it's educational model to include in its programs a major online component, with the objective if taking high quality education to a larger amount of people in different geographic locations. [9].

From 2002 to 2009, is when the Tec de Monterrey Virtual University, is established as the biggest Spanish speaking online University in Latin America.

In the year 2007 the use of new technological resources is introduced, amongst which: digital interactive boards, mobile and interactive devices for evaluation and collaborative team work, interactive videoconferences and video conference telepresence in videoconferences. [9].

In the XXI century the teaching-learning techniques are transforming at an accelerated rate. Digital tele-education is now an important complement, but not a substitute of face to face teaching.

Telepresence in its initial stage has been applied using larger than 1 meter screens, with high definition and in which the image of the person appears in real size. This model works relatively well in a work meeting with entrepreneurial profile, in which, even, a meeting room is set up so that the screen uses one of the seats in the meeting. In College education our experience says that, the result of telepresence has not been satisfactory, the fixed screen traditionally used for this, makes the average student get distracted easily.

It is held into account that Edex, the biggest educational purpose internet connection supplier in the U.K. presented in London, as part of the BETT2000 show, a holographic teacher inside a classroom. This holographic teacher could see and speak with his students as if he was in the classroom. This technological package didn't have the success expected, two reasons for this were found, in the first place, its high band width exclusively dedicated to more than 20 megabytes per second and, more important, its high estimated cost, which ascended to 215,000 dlls in the year 2000 for this technological package. [4].

Secondly, recent research on holography presents the following outlook: the University of Arizona has shown that the development of computer capacities will allow the construction of a three-dimensional presence by the year 2018 [2]. It is expected that it will be possible to view a 3D prototype before it is constructed [3]. Research sponsored by the National Science Foundation allow for a 3D and 360 videoconference to be established with a 2 seconds refresh interval [7].

The use of photorefractive polymers is one of the best prospects to scale the 3D holographic projection.

After the webinars and videoconferencing, now coming “live” to meetings and conventions: holograms [10].

Is in this new technological resources evolution context, in this new digital world of constant transformations, where we find the frame for the innovative educational experience described in this scientific dissemination article.

## 2. Previous Experience

This holographic live projection with telepresence robot included, is the result of a long history of experience, observation and learning that through 9 years, professor Eduardo Luevano acquired. As collaborator in the Tec de Monterrey Virtual University, after 15 years of experience as an Accounting and Finance teacher and after almost a decade as enabler in subjects imparted in the virtual model; professor Luevano concludes: It is difficult to retain the attention of the group, because, in a certain way, the screen is something static that can be easily ignored. The professor doesn't have visual access to the whole classroom and it becomes easy for the student to evade the professor. It's not possible to give real time feedback on the personal performance of each of the students. In the actual virtual model, classes with high quantitative content don't allow the professor to give the proper attention to the progress of the student during the session.

Looking for solution alternatives for this problem, professor Luevano built a team with professor Eduardo López de Lara, full time professor for 25 years. Professor Luevano has witnessed the evolution of the educational model of the Tec de Monterrey, he has been able to closely witness its project's success and failures. His constant interaction with students has allowed him to listen and get firsthand information on their interests, needs and the complaints on the educational model and its evolution throughout time.

Five years ago, Professor Luevano has been doing research and working on making the long distance education process more efficient. His research is centered in the telepresence concept. Some time ago, he acquired, with his own financial resources, a telepresence robot. This little robot had limited capabilities, but still allows the telepresence experience. This robot was used for pilot proofs and allowed to demonstrate the potential viability of a larger project oriented on long distance formal teaching.

During the August-December 2011 semester, professor Luevano, was invited as emerging teacher in Campus Aguascalientes to teach the Cost Analysis subject, this course had been going on for a month, when, for special causes, the course was left out without teacher. Additional video conferences were required from Campus Zacatecas, with the objective of covering the program established for this subject and not leave any student behind. This experience a head teacher in a long distance course allowed him to explore and at the same time, take the most of the benefits of videoconferences and the use of Blackboard. It was possible too, to confirm the previous limitations of long distance classes through this model. One of the most important limitations, if not the most important one, is the impersonal the class becomes, because, logically, it's not the same to have the teacher in a TV screen, than it is to have him in front of the classroom, to be able to ask him anything, or ask for an immediate revision.

The NO presence of a teacher, causes some students not to express their doubts in front of a camera. Mostly because they don't want to do it in public and sometimes facing the mockery of the rest of the audience, which originates some students to go home with questions and doubts, therefore not taking advantage of the class at a 100% as it would be in an on-site class.

On the other hand, missing the immediate peripheral vision of the classroom, some students located outside the sight length of the camera, lost interest and where somewhere else but in the class, this caused the other students that were on camera sight to lose the concentration on the teacher for moments.

Based on many years of experience in long distance education in which we proposed the use of a telepresence robot denominated “Avatar Professor”, with the idea of trying to reduce the present limitations of the known videoconference model. But, what is a telepresence robot? It is the professor using an android, which is a robot that gives him physical autonomous presence in the classroom, transmitting audio and video on both directions; allowing him mobility to interact and personal intercommunication, one to one, on real time. It's not only an automat, it can be said, that the professor is in the classroom, represented by a robot.

With the purpose of innovating and the interest to solve this problem, our research team, acquired, a telepresence robot, called “Avatar Professor”, this experience took place in the Tec de Monterrey, Campus Zacatecas, from September 2012 to May 2013.

According to our research, we haven’t found official evidence on the use of a telepresence robot for teaching formal classes at a University Degree before this one. This technology has been previously used in the medical field for consultations and as patient companions. In the Asian Southeast, it has been used for language classes for elementary school kids. It has also been used for students that due to illness, cannot attend the classroom, here, the robot takes their place in the classroom.

Being world pioneers in the use of a telepresence robot for formal University education was one of the most relevant points of this educational innovative project.

The robot allows the professor with physical presence, two direction video and voice, as well as distance control autonomous movement.

In no time, when this technology matures, the telepresence robot will allow the professor to give his lectures, even if he cannot be physically present, without the interference of distance, weather conditions, time zones, etc.

This technology will also allow important savings in costs, because thanks to this robot assistance, in various occasions, it will no longer be necessary to move to other cities to give a lecture, conference, meetings or to perform any type of inspection that requires real time audio and video. Besides, this also eliminates absences due to out of control situations, such as; weather contingency, insecurity, traffic, cancelled flights, illness, etc. Because, even from the professor’s home or office, or any other place. He will have access to the assistant robot, in an immediate way.

### 3. Avatar Professor Academic. Use Experience

The 2015 mission of the Tec de Monterrey through its academic programs, establishes: “To contribute to the sustainable development of the community, with innovative models and systems to improve it academically,...” [6]. For the achievement of this mission, there have been outlined 10 strategies, the first one says: “Assure the academic quality and enrichment of the academic model” [6]. Framed on the Mission and Strategies 2015 we propose this Innovative Educational Model.

Being the first in technology and educational innovation in Mexico, is something that has always distinguished the Tec de Monterrey. With this project it is desired to continue contributing to this leadership.

In the Tec de Monterrey, we work hard to form internationally competitive people, for this, it is necessary that our students get familiar with the new forms of education and distance interaction, nowadays, this is new, but a few years from now, it will be something natural.

This project of a robotic assistant inside the classroom, allowed a total panoramic vision of the classroom, a major interaction with students, moving the robot through the classroom halls. This allowed a more direct contact with students, offering more personalized attention. With this robot, the students could express their doubts in a personal way, through the robot’s bidirectional audio and video. Besides, the teacher could check notes of each one of the students individually and instantly through the Avatar Professor IP camera.

This form of interaction with technology will undoubtedly be an important part of our future professionals, personally and professionally.

The research project proposed to give 8 class sessions in the Accounting and Costs subject. This plan was not performed exactly as planned, it had some modifications. The long distance work sessions were as follows:

1. Guatemala - Zacatecas (1 session)
2. Zacatecas – Zacatecas (4 sessions)
3. San Luis Potosí – Zacatecas (1 session)
4. Zacatecas-Aguascalientes (1 session)
5. Monterrey-Monterrey (1 session)
6. Guatemala-Zacatecas (1 session)

There were 48 students that took one or more classes with the “Avatar Professor”.

Some situations that represented delays were: our personal computer didn’t have enough RAM memory, nor

integrated camera, we had to acquire more equipment. The technical requirements for the robot are considerable. Besides, it was necessary to ask authorization to open some net ports for the robot to have the correct transmission quality.

The band width of Campus Zacatecas is insufficient for the correct functioning of the Robot; the audio is sometimes inconsistent and has a little delay. The image is accurate.

The robot is designed to work in a G4 net, in rush hours it demands band width and present some connection failures. In Campus Aguascalientes (with wider band width) the robot performed perfectly-



Fig. 1. Telepresence Robot. "Avatar Professor"

This is an infrastructure issue of the Campus, in a way, we had an advanced technological product, designed for the U.S. standards. The responsibility did not depend on any of the participants, so we had to wait until this technological advance took place.

After the band width augmented from 34 Mbps to a 100 Mbps, another round of sessions took place, during the August-December 2013 semester. After 6 sessions, of the Cost and Accounting Class; given to 25 students. This included 2 transmissions from the Universidad Rafael Landivar in Guatemala. The following information was gathered:

1. 72% of the students felt the presence of the teacher when the robot approaches them, looks and talks to them directly.
2. 68% considers acceptable the use of a robot that complements the use of TV screens for video transmissions.
3. 88% considers acceptable the use of a robot when the teacher is absent for work trips, illness, etc.
4. 24% would enroll in a semester course that only used the robot.
5. 80% considers that the maximum time they can pay attention to the robot is 60 minutes.
6. 40% of the students that attended more than three sessions with the robot said they gradually lost attention to it, meaning, it stops being a novelty.
7. 12% think that any subject can be imparted with the robot assistance. Which means it might not be useful for all subjects.
8. 36% think they achieve the same learning working with the robot than with the on-site professor.
9. 80% considers necessary the presence of an auxiliary in the classroom.
10. 28% consider viable the use of a robot in highly quantitative subjects.

As it is evident, increasing the band width of the net and also with the acquired practice in the use of this technology, the reported results for students improved substantially in comparison with the previous measurement.

With the proper band width, the robot has functioned perfectly.



Fig. 2. Avatar Professor supported class.

#### 4. Telepresence, holographic projection and robot.

Searching to improve the telepresence sensation given by the professor, we propose to integrate an additional complement to long distance education, which is holographic projection. We believe that integrating the existing technologies: Videoconference, telepresence robot and holographic projection, we can assemble a technological package that will allow supplying, but never to replace, the temporary physical absence of the teacher in the classroom. There are enough elements that predict the use of intense telepresence technology. We want to be the first ones in the world in experimenting and achieving successful results in formal classes at a University Level.

Now we will describe the experience that we have had using a combination of technological resources.

A 90% transparent holographic projection foil was acquired to build the screen. This foil was adhered on a 12mm glass, anchored to a metallic stable base; supported on wheels to make it easier to move. This screen allows it to visualize 3D images without distortion. This product is imported, comes in roll and is presented in different lengths, in a standard 1.52m width. The cost for this material is \$3,250 mexican pesos per lineal meter. We built two screens with a 1.80m height.

Three classes were given with these screens in the International Finance subject during August-December 2014. Figure 3.



Fig. 3. Holographic projection supported class.

As it can be observed, in figure 3, when doing the projection on the transparent screen, the foil retains the projection photons and then, the image of the professor appears as if he was floating, which is, telepresence, “he is there, but he’s not there”. It’s important to notice the transparency, because you can see the furniture and the white screen behind the transparent screen, giving it a very real sensation. With the intention of improving the perception of telepresence amongst students, we integrated: the holographic screen, the robot and the software to control long distance projection.

The experiment was divided into two stages; the first one consisted of three sessions given in the August-December 2014 period. These were normal classes in official hours. They didn’t last the 90 minutes, because there were some interruptions and adjustments. 22 students attended the International Finance class. The transmission was in Campus Zacatecas, using Skype as the communication system, holographic screen and Avatar Professor. Subsequently, the second stage; with 21 students from the Economic Environment and Costs Accounting during the August-September 2015 term. They participated in five formal classes sessions, using only the holographic screen. There were some incidents, we solved them little by little and each class was improving its performance. The student’s opinion is reported in Section 5; Findings.

Additionally, we built a portable cabinet, figure 4, to reproduce holographic prerecorded segments with academic topics related to the International Finance subject. With this device, the students could study playing the previously recorded segments as many times as required.

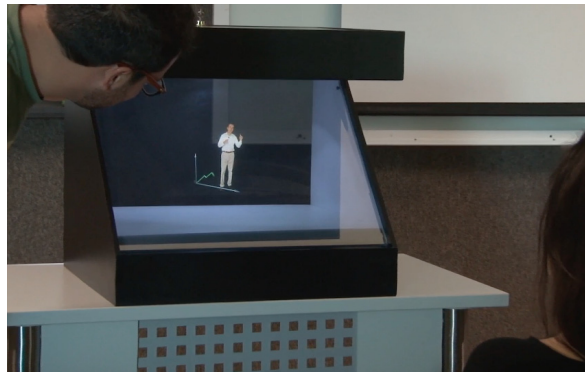


Fig. 4. Portable cabinet for holographic pre-recorded segments.

This cabinet will be permanently in our audiovisual classroom in the Campus Library, to start creating a video library with different didactic material. This way our students can see and listen their professors in a tridimensional way. There were also performed some other proofs, integrating the use of the telepresence robot, with the holographic reproduction cabinet, with the intention of clarifying doubts, listening to comments and interacting in real time with the students.



Fig. 5. Portable cabinet for holographic reproductions and telepresence robot.

The studies we have been developing, for more than two years now, in telepresence, focused on University Degree level have grabbed attention from the academic community, inside and outside our institution. We were contacted by government people from Uruguay, as well as by Civil Organizations in Colombia, both interested in our work and its different uses.

Taking advantage of our South American trip we decided to make a stop in Santiago de Chile. Our objective was to visit the Universidad Pontificia Católica de Chile, ranked No. 1 among Latin-American Universities [8]. There we met with Professor Don Rodrigo Cevallos, Assistant Director of University Research. He became acquainted with the project, we shared our experience in telepresence and we left open the possibility that in the near future a Chilean professor may be able to give a talk using the telepresence tools that we provide him with.

## **5. Findings**

The students who participated in the study were 22, belonging to the International Finance subject, August-December 2014 and 21 students from the Economic Environment and Costs' Accounting, in the August-September 2015 term.

The instruments used to collect data, gave us mainly, qualitative information, using the anecdote registration system that allowed us, to collect spontaneous behavior in the students. We also used the Likert attitude scale, semantic differential scales and appreciation scale.

The results are not considered statistically significant, we didn't have a pilot group, it was not possible to control the variables of the experiment, nevertheless, we consider the following findings very valuable.

1. 72% of students "feel" the presence of the teacher when the robot approaches them, talks and looks at them directly. 81% feel the presence of the professor when the professor listens to, looks at and talks to him or her, through the holographic projection.
2. The vast majority, 93% of students, say to "feel" the presence of the professor, through any of the used technologies; videoconference, robot or holographic projection, meaning, telepresence works.
3. 98% of students participating in the study consider the class to be more interesting and with a higher percentage of attention from them, when the robot and holographic screen are being used simultaneously, than when used separately.
4. 95% of students consider acceptable the use of this technology, even though it is not accepted as a permanent substitute of the teacher, but it highly welcomed when the teacher is absent for travel, disease or any other out of his control cause.
5. 65% of students recognize they pay more attention when the professor appears on the holographic screen, than when he is only present using the telepresence robot.
6. It requires technical training and support to use the robot, specialized software and holographic screen, projector and real time connections simultaneously. There must be technical support in the classroom.
7. 58% of the students that attended more than 5 classes start losing interest, saying it stops being a novelty.
8. 42% of students consider that they achieve the same level of learning using these technologies than having the physical presence of the teacher.
9. The holographic image that we achieved to project has a very good quality, but we still believe it can improve.
10. There is interest in the Ibero-American academic community on our project. We have established contact with professors in Uruguay, Argentina and Chile. All of them have interest in working collaboratively.

## **6. Conclusions**

The intense use of technology in education is, in the XXI century, an indispensable element. We recognize and believe important to outline that technology is not a substitute, but a complement. The evolution of long distance education has taken us to the use of the Avatar Professor, for the first time, in a University level. Our work hasn't stopped there, with the intention of making them "feel" the telepresence, the most real way possible, we added the



3D holographic experience. The findings show we are on the right path. The work here shown, is only a first attempt to applying these technologies in the classroom. The authors are conscious that there is a long way to go from here and that this report is presented only for dissemination. We expect other researchers in the world to continue with what we have started, giving it proper formality and scientific strength. And that with this accumulation of experience and knowledge, we could learn as a great community the best and wider use of the telepresence robot and the holographic projection as an excellent auxiliary for superior teaching.

We know that near future education will be like this and we want to be the first ones in the world to experiment and achieve successful results.

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