

## Virtual Learning Environments: Proposals for Authoring and Visualization of Educational Content

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### ABSTRACT

Heated debates involving reforms in the educational system are becoming more and more frequent in recent years. This is due to the increasingly evident shortcomings in the educational system and its difficulties to evolve at the same pace as technological development. The aim of this work is to present an analysis of the current engineering educational context and propose an interactive content authoring system as well as a virtual professor in an attempt to make learning experience richer and more motivating to students.

### KEYWORDS

Flipped Classroom; Virtual Learning Environment; Avatar; E-Learning; Content Authoring.

### 1 INTRODUCTION

The advent of new technologies in recent years has been transforming human lifestyle at a breathtaking speed. Education, as an exception, is one of the social structures most resistant to adopting the technological tools available today. Educators, in general, do not truly believe that the lack of interest and low student performance can be directly associated with the traditional and restricted way of learning. This has motivated the interest of researchers in the search for methodologies and processes in an attempt to make an educational reform based on Digital Information and Communication Technologies [1].

In applied sciences, for instance, there is a growing disaffection of high school students for

courses in the STEM areas (Science, Mathematics, Engineering and Technology). Students do not consider these fields creative or even innovative enough. This lack of interest is often due to misconceptions on the role and responsibility of professionals working in these areas. The consequences of this scenario will certainly have profound impact on industry development, especially in emerging countries. In Brazil, for instance, there is currently a shortage of 150,000 qualified engineers, according to the Brazilian National Industry Confederation - CNI. The proportion in the country is 6 engineers per 1,000 economically active people. In developed countries, such as U.S. and Japan, the proportion is 25 engineers per 1,000 workers [2].

The current generation of students has grown interacting with computers, video-games and other technological devices. This makes the paradigm of “learning-by-doing” even more important today. As a crucial complement to traditional methods, this paradigm should not be overlooked in new proposals for youth training. Everyone seems to agree that the best way to learn is by putting into practice the acquired knowledge in everyday needs [3].

In this context, researchers have been proposing methodologies and tools to overcome the problems described above in an attempt to make school more attractive for younger generations. Marasco and Behjat [4], for instance, have proposed a multidisciplinary framework for electronic and electricity teaching in Electrical Engineering courses. Their aim was also to integrate the disciplines of English, Physics, Sociology and Arts in the traditional curriculum. This framework is based on the CDIO paradigm (Conceive, Design, Implement and Operate) and

PBL (Problem-Based Learning). Other proposals refer to the intensive use of WebLabs, Virtual Labs and Simulation Tools, either at home or in the classroom [5, 6, 7, 8, 9]. However, these new methods of education will require: (1) improved classroom acoustic and environments; (2) high-quality audio and video; (3) use of smart computers; (4) use of Flipped Classroom methodology and (5) proposition of real-life challenges.

Currently, with the help of Internet, millions of students can be simultaneously attended in online courses offered in different areas of knowledge. Universities like Harvard, MIT and Stanford have already adopted distance learning and achieved good results with their MOOCs (Massive Online Open Courses) offered through Coursera and edX platforms.

In addition to distance learning, the concept of Flipped Classroom [10] seems to be an efficient solution to make classes more dynamic and attractive. Reversing a classroom means to change the pedagogical model of teaching concerning the traditional oral exposition of concepts and homework assignment. In this new model, students are encouraged to study and learn by themselves, reading books and articles, watching videos and solving especial homeworks. The classroom environment is then redirected to focus on projects, activities and discussions. Technology and new media are invaluable tools for the success of this concept. Briefly, the value of this inversion is the transformation of disciplines into workshops, where students can test their knowledge in the application of concepts and interact with each other in practical activities [10]. In other words, “learn at home and practice in the classroom”.

According to [10], in traditional classes students try to understand what is being said, which often makes them lose important points of the speech. They also cannot think about the speech often because they are trying to transcribe the words of their instructors. The use of movie and other technological resources places them under control of the content presentation execution flow. It is worth mentioning that there is also the possibility to include people with special needs through the use of subtitles and other interesting

features. By delegating instructional time to these resources, professors are able to concentrate on subtle aspects of learning, such as students' inherent difficulties, misconceptions in reasoning and interpretation, etc.

There is not a well-defined model when it comes to Flipped Classrooms. However, it usually contains pre-class contents being offered to students in order to transform classes in discussions, projects and activity solving. According to [10] and [11], a simple and traditional style to be applied consists of students watching pre-class movie lessons up to 20 minutes, followed by quizzes and online activities to measure how much they learned, which allows them to have immediate feedback. In the classroom, instructors are advised to stimulate discussion groups or even turn the classroom into practical laboratory for students to practice what they have learned.

The use of Flipped Classrooms has become recurrent in recent years, especially due to its proven benefits [11, 12, 13, 14, 15]. Although recent, to the extent that the concept becomes popular, new proposals for its adaptation to make use of new technological resources are created. Particularly, with the emergence of smartphones, tablets and laptops the access to this type of education becomes ubiquitous and therefore can be accessed from anywhere. It is also worth emphasizing the need for Universities and Institutions to be adapted to accommodate this new format of pedagogy [10]. Among the main benefits found by researchers we can list:

- More content could be taught by professors;
- Student's performance was better compared to traditional tests and exams at the end of the course;
- Although students felt uncomfortable at first, they were able to quickly adapt themselves to this format in order to consider it satisfactory and effective.

Economides [16] included Flipped Classrooms in his state-of-art analysis of the most valuable educational technologies current being used these days:

- Massive Online Open Courses (MOOCs);

- Flipped Classrooms;
- Online video broadcasting (YouTube);
- Learning Management Systems (LMS);
- Real-time communication;
- Increased use of technological devices (smartphones, mobile phones, tablets, etc.);
- Broadband Internet.

According to Economides [16], the term “Collaborative Education” should be used instead of “Distance Education”, considered by him surpassed.

Although simple and promising, the reverse classroom paradigm can be easily misunderstood. This occurs mainly because of the careful preparation of contents that are needed. Moreover, lesson recording requires great dedication and effort, and activities need to be carefully integrated with content taught. In addition, instructors may need to learn new skills to put into practice lessons’ recording, which introduces a learning curve for the model. Well-structured and well-prepared lessons contribute to students’ motivation [10]. Not to mention the cost of recording equipment and the difficulties of updating or editing recorded content. Our proposal tries to deal with these trade-offs and will be further discussed soon.

Peer Instruction [17] has also been used in a similar way. Proposed by Eric Mazur, it involves students completing simple and direct learning tasks at home and discussing content in classes assisted by their instructors. This technique was first used in introductory physics courses at Harvard University and quickly spread to other disciplines and institutions due to its efficiency and flexibility compared to traditional teaching methods based on oral presentation [18, 19, 20]. Watkins and Mazur [21] have found a significant increase of retention among STEM students that used this technique in an introductory physics course. Giving students the chance to think, respond and actively interact in the classroom can significantly contribute to retention in courses in these areas [21].

The Peer Instruction technique consists of:

1. Professor proposes a pre-class activity that might be a reading, movie, etc., as homework;

2. In class, professor proposes questions based on student's feedback to pre-class readings;
3. Students think about them in peers;
4. Students commit to a consensus;
5. Professor review answers given;
6. Students discuss new ideas and answers with their peers;
7. Again, students commit to a consensus;
8. Again, professor reviews the answers and decides where more explanation is needed before changing to a new concept for the cycle to be repeated.

In the 90s, Professor Eric Mazur [17] suggested what would be the teaching paradigms of current days, mainly transformed by the use of computers and technological devices in the learning process:

“I believe that we are just seeing the beginning of the process and the computer will soon become an integral part of education. Computers will not replace teachers, but will surely provide dynamic tools to improve the quality of education.”

Along with Flipped Classrooms, Peer Instruction and Simulation Tools, Avatar-based proposals for teaching students have also been published in recent years [22, 23, 24, 25]. It has been recognized that one of the main problems faced by these methodologies is the lack of interest of students in spending time at home to learn by themselves [8]. Our group is currently working on attractive ways to present content to students to be used along with these new proposals. We are building two platforms: one in which the instructor can build especial educational contents and another in which students can watch contents being presented by virtual instructors.

## 1.1 Related Work

The use of virtual tutors within computer aided learning has become recurrent in research agendas nowadays [22, 23, 24, 25, 26, 27].

Virtual tutors are characters able to entertain his interlocutors while they learn. The work of Grujic et al. [22] proposes a virtual tutor to be used in a virtual educational system. The avatar is

integrated into an e-learning system and is able to interact with users sympathetically. Its goal is not actually to teach students, but demonstrate emotional reactions according to actions taken by them, with the use of gestures and facial expressions.

According to Wang et al. [23], it is important to make students to feel good during the learning process. In this context, in their work is proposed an approach to build an environment for empathic learning. Users can express their emotions while they learn. A virtual human was also created for proactively reacting to users' actions.

Other proposals of virtual professors were made by Hu and Zao [24] and Sharma et al. [25]. In their work is proposed a 3D virtual teaching environment where students can connect and interact remotely with each other and with their professors, and attend classes, all of them represented by avatars. The virtual professor is suggested to be affective and intelligent when interacting with students according to them.

## 1.2 Challenges for Contemporary Educators

Currently, we spend much of the day interacting directly or indirectly with technological devices. All this involvement can be used for educational purposes. Through this interaction, we have easy access to a large number of information, what was difficult to access in the past.

With all this advancement, and considering that most students have access to technological devices, we can think about a methodology that enhances teaching based on the conceptualization of knowledge rather than just memorization.

However, in order to take advantage of the benefits provided by technology, we must have a teaching environment that makes it possible to apply new methodologies. Hence, this involves creating computational tools to improve education and motivating student's interaction with professors, monitors, and classmates.

To accommodate all technological capability it is necessary to adapt classrooms, so that all available resources can be better used. This means providing classrooms with high definition projectors, high quality sound systems, digital whiteboards, tablets, notebooks, access to

broadband network, and so on. In addition to encouraging students to use technology as a means of study, providing means for everyone to have their own equipment is also very important.

It is also important to encourage teachers to create new methodologies that use all technological resources available for classroom improvement, besides creating teams of professionals composed of experienced and beginning teachers and monitors of various levels (masters, doctoral and postdoctoral). These heterogeneous teams are able to more effectively provide theoretical and practical instructions together in the same classroom, as well as to provide efficient use of simulation tools for visualization and interaction.

Massive amounts of information are freely available today on the Internet. From simple images to extensive free encyclopedias, the content is immeasurable and invaluable. With the simple click of a mouse and a few search keywords, a great number of priceless information content is presented. In this context, making use of this giant supply of information is of a great value for teachers.

Encouraging students to look for content on the Internet, as well as teaching them techniques for positive content filtering, contributes significantly with the learning process by exposing students to other universes beyond the textbooks and handouts.

Motivating students to carry out individual and team projects, as well as presenting them to their classmates, allows them to actively and effectively interact with the context of the discipline. In this way, learners are encouraged to look for content outside the class to understand the problem, and often develop and work their own solutions, which makes them feel the nice experience of being an "expert" in the subject. Also, the presentation and discussion of projects makes them familiar with actual pedagogical situations, where they are forced to play the role of tutors in front of the room, even as if for a short period of time.

The simple stimulus for learning foreign languages and methods of technical and scientific wording considerably expands the horizon of students' experience. This means they can be familiar with information available in other

languages rather than just in their mother tongue. In addition, students learn valuable techniques for writing and reading academic papers.

## 2 PROPOSAL OF AVATAR-BASED TEACHING

The purpose of this work is mainly based on the creation of virtual classes taught by avatars in e-learning environments. Here we propose an environment where a human professor works by creating classes that are taught by avatars and watched by students.

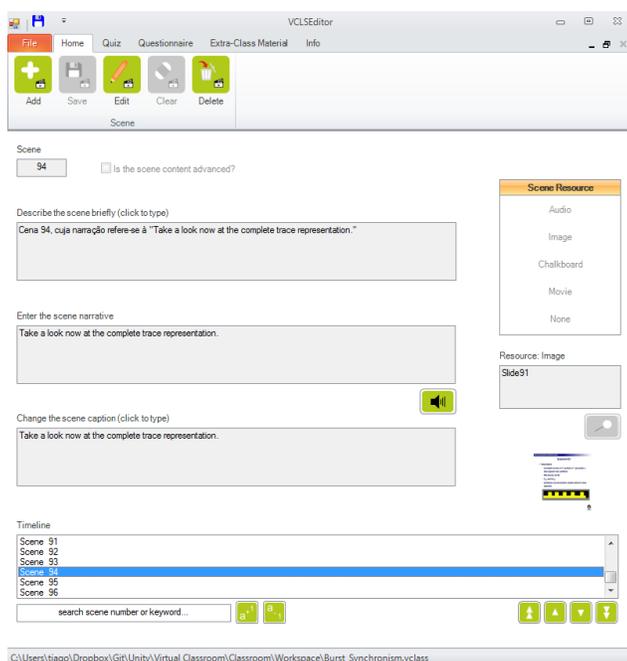


Figure 1. Virtual Class Editor.

Currently, work is being done on two distinct platforms: an editor of virtual classes and a player for them. The Virtual Class Editor in Figure 1 is intended to support professors designing virtual classes in a friendly and simplified format. The class authoring is made through timeline paradigm, based on execution of temporal scenes. Rich media can be inserted in scenes such as movies, images, audios, documents, URLs, etc. All the actions and gestures performed by the virtual professor are controlled by the human professor in this editor.

The Virtual Classroom, presented in Figure 2, is intended to support the execution of classes

modeled by the Editor. In this platform we have two avatars acting as virtual professors, a male and a female. Briefly, the Player is composed of chalkboards, projection screens, computers, desks and books. It simulates a real classroom in which the avatar interacts with the environment.



Figure 2. Virtual Classroom.

In addition to the content used for traditional exposure, the Virtual Class Editor also allows the modelling of interactive activities such as quizzes, questionnaires and reference materials for students.

Some of the main benefits of the Editor compared to traditional movies involve:

- Little expertise is required from professors to create content;
- A wide variety of content can be included in virtual classes;
- Professors can edit and re-edit classes at any time with relatively little effort. Traditional movies usually require the content to be recorded over and over;
- There is no need to worry about codec conversions or resolution issues to adjust content for the Player. The Editor takes care of these processes;
- Low cost is required to create virtual classes. Movies usually require expensive recording instruments and people to support it;
- Students feel motivated to use our approach (as we will show soon);
- It represents a good alternative to be used in conjunction with Flipped Classroom or Peer Instruction methodology, since

students seem more motivated to study at home.

## 2.1 Virtual Class Editor

The Virtual Class Editor was designed to support the work of professors in the creation of instructional content presented within the Virtual Classroom. Professors can model scenes which are presented by avatars, create interactive activities for students, insert reference materials, etc.

The tool has structured its development on the .NET platform, using C# coding language. Besides the flexibility provided by this framework, it can be said that its adoption occurred because Virtual Classroom has been coded in Unity3D, also developed using .NET. No DBMS (Database Management System) was used for the storage of data, only notations for file serialization. The editor also made use of a multimedia encoder (ffmpeg2theora) in order to allow the work with the most common media formats currently available on the market.

Some of the main components built to create the editor were:

- Language Parsers: the tool uses XML to serialize class content as well as language description. Therefore, in order to an application be able to read and write XML, some parsers are necessary;
- TTS System: this is necessary to allow the creation of synthetic voice based on text for the avatars. The tool does not make use of voice recording;
- Multimedia Player: the multimedia player, as shown in Figure 3, is intended to allow professors previewing multimedia content when modeling classes. It works with image, audio and movie files;
- Multimedia Codec: this is necessary to process a wide variety of media files as input. These files are adjusted and encoded to fit VClass Projects requirements as we will see soon.
- Process Builder: this component was built to provide multi-threading support for the tool. Several threads are used to optimize processing of multimedia files;

- Language Module: this element allows the system language to be easily translated throughout the translation of some language files;
- Cryptography Module: component responsible for adding cryptography to content created by the editor in order to avoid unauthorized access to XML. A 256 bits security key was used along with the Rijndael symmetric algorithm.

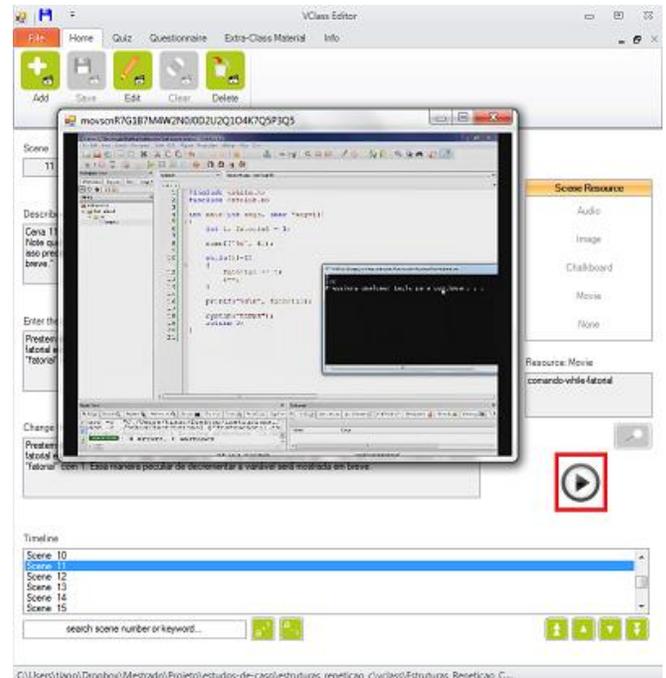
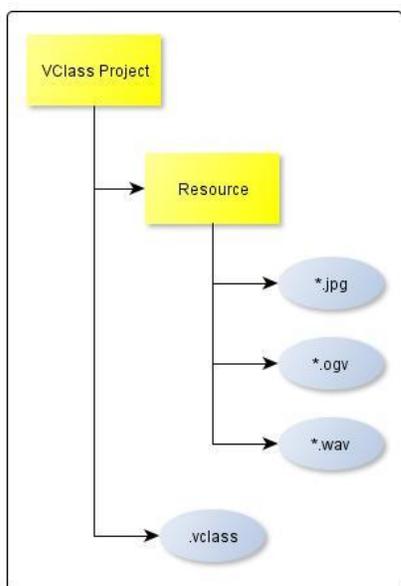


Figure 3. Virtual Class Editor Multimedia Player.

VClass Projects are structures for storing virtual classes generated by the Virtual Class Editor. It can be said that they correspond to a well-defined organization hierarchy, composed of files and folders used to organize content. We can have as example the illustration in Figure 4. VClass Projects have a nested directory named Resource and a .vclass file. The Resource container is the hub of resources, in other words, it stores voice files, movies, pictures, audios, etc. The .vclass file contains the virtual class description language, specified using XML.



**Figure 4.** VClass Projects.

The eXtensible Markup Language (XML) is a recommendation created by the World Wide Web Consortium (W3C), an international consortium of companies and organizations created to develop standards for processing of distributed Web content. The use of XML allows the creation of customizable markup languages to meet a special need. Therefore, it can be said that the platform has used this technique to describe its Virtual Class Markup Language, also known as VCML.

Also according to the diagram shown in Figure 4, we can see some multimedia file formats such as JPG, WAV and OGV. In a nutshell, they are the formats adopted by the tool for recording and viewing content. Images are stored in JPG and movies in the open format OGV. Audios and voice files are encoded to WAV.

At this point it is worth saying that for the correct operation of both platforms, this hierarchy must be maintained: VClass Projects that do not follow this standardization are unable to be edited by the editor or even be watched by students in the Virtual Classroom.

Non-functional requirements of a system are composed of restrictions relating to its services and functions. They include performance constraints, standards, database, security, etc. These requirements are usually associated with the system as a whole and not with some functionality

in particular. Therefore, we can say that some of the non-functional requirements that guided the development of this environment were:

- Usability: to create friendly user interfaces to assist professors and students;
- Performance: to avoid excessive waiting in multimedia processing;
- Security: to prevent unauthorized access to content of VClass Projects;
- Integration: to allow Virtual Class Editor to be integrated to any TTS (Text-to-Speech) system built using SAPI 5 framework from Microsoft;
- Internationalization: to allow the editor to be easily translated to any language throughout the use of XML.

## 2.2 Virtual Classroom

The Virtual Classroom was designed to support students when viewing content created by the Virtual Class Editor.

This tool made use of .NET development platform, also using C# coding language. MonoDevelop was used as the integrated development environment (IDE). This application is a suite of free compilers created as an alternative to Visual Studio, supplied by Microsoft. The C# language was a slightly adapted version for programming in script mode. This development paradigm is used in most 3D model programming environments available today. This platform also made use of Unity3D as rendering engine for graphics processing.

Due to the characteristics of APIs and frameworks adopted for the development of tools of this work, it can be said that both are restricted to Windows operating system and cannot be considered cross-platforms.

The Virtual Classroom also used software for modeling and graphical animation to work with 3D models of objects and avatars such as Autodesk Maya and MotionBuilder, and Blender.

In 3D interactive virtual environments it's common to have the concept of HUDs (Head-Up Displays). This concept refers to a graphical interface that remains active in the screen during the whole time that the application is executed.

Therefore, a HUD was modeled for the Virtual Classroom in order to allow students to have access to all the tools offered by virtual classes, as shown in Figure 5. Regarding this picture, we can also see several numbers indicating some specific regions of this component:

1. Button that give us access to the playlist of scenes;
2. Scenes control area. When any option of this area is accessed, scenes can be forwarded, rewind, paused, etc.;
3. Button that give us the ability to move to a specific scene in the playlist;
4. When the student wants to access the interactive quiz, this button can be used. Quizzes may or may not be present, since it depends on the professor to model them;
5. Button to access the class questionnaire;
6. Button that give us access to extra-class resource materials. A wide range of items can be added to classes as resource materials to support students that want to have further information about the topics covered;
7. Button that provides access to the got question interface. When the student clicks on it, the class execution flow is interrupted so he or she can write its doubt. After this doubt is transmitted, the flow is resumed;
8. Option that allows returning to the Virtual Classroom main menu, composed mainly of classes contained in the Workspace directory;
9. The ability to show subtitles was coded in the tool in order to support students when hearing synthetic voices or even for internationalization purposes. Subtitles can be activated by this button;
10. The immediate interruption of any song played by the tool can be made through this option at any time;
11. And finally, the click on button 11 turns off the execution of classes, as well as the tool closed.

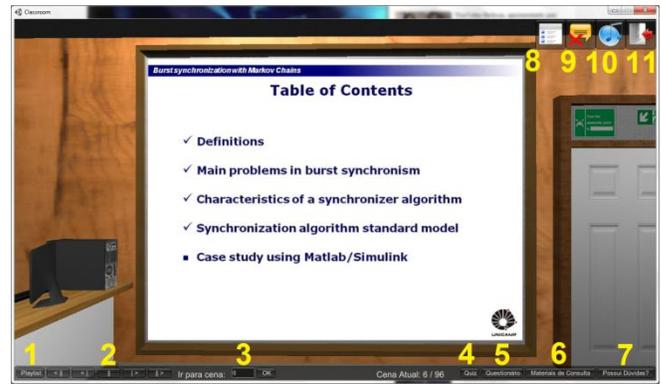


Figure 5. Virtual Classroom Head-Up Display.

According to Figure 5, it's possible to see a multimedia content being presented by the projector in the class projection screen, in this case a slide. We can also see that the avatar does not participate in this moment. This strategy tries to reduce the burden of visual elements shown simultaneously to the student, in other words, in order not to cause any distraction to the explanation, only the relevant content is shown. Therefore, the student hears only the voice of the avatar on projected images, movies and audios.

The main menu interface is shown in Figure 2. The content of this component is populated with information from VClass Projects contained in the Workspace folder. Projects outside this directory are not displayed correctly and therefore cannot be watched by students. This strategy eases the distribution of classes by professors to their students by the concentration of content in only one place.

Also according to Figure 2, we can see the avatars modeled to be presenters of content. For animating these avatars models, human movements were captured using Kinect, from Microsoft. These movements could then be segmented and populated in a base of gestures, which served to support the creation of a Markov chain to control the flow of execution of movements.

In the interface shown in Figure 2 we can also see some required fields that are asked to be filled before the execution of virtual classes (for instance, name, email and student id). This is necessary for reporting purposes of students' scores in interactive activities, since these fields

do not constitute an access control system. Also according to this picture, you may also notice an option to display or omit scenes containing content considered advanced. Marking content as complex depends on the professors when they are modeling scenes. This functionality was implemented to meet a requirement generated during evaluations, when students reported that they were not willing to see content that did not match their cognitive load. Therefore, now it is possible to accommodate a wide diversity of students' profiles.

When the Virtual Classroom is started, some checkup operations are executed in order to validate the consistency of the tool and projects contained in the Workspace directory. If there are any unwanted issues, the environment interrupts its execution and notifies the user the problem occurred.



**Figure 6.** Virtual Class Exhibition.

Figure 6 shows the presentation of a scene being made by the female avatar. This presentation is made by the movements commented in previous paragraphs. In this picture we can also see the use of subtitles synchronized to the audio narration, besides the male avatar that does not participate in scene waiting next to the printer. For this case, there isn't effective use of the chalkboard environment. The other items that compose the classroom scenario (for instance, books, computers, tables, etc.) are also there; however, they do not represent interactive elements for the avatar.

### 3 EVALUATION METHODOLOGY

In order to evaluate the attributes of the Virtual 3D Learning Environment, we have selected especial classes of graduate students in the School of Electrical and Computer Engineering, University of Campinas - UNICAMP, and in the Salesian University of São Paulo – UNISAL, both in the city of Campinas, SP, Brazil.

A survey was carried out during the month of November of 2013, where 73 individuals had the opportunity to interact with classes presented by avatars in our Learning Environment. At the end of each presentation the students were asked to answer an especial questionnaire.

The nature of the survey was based on mixed-methods. Data were collected in questionnaires containing 12 Likert items [28], which are based on a scale of levels of agreement or disagreement to specific questions: (1) Completely Disagree, (2) Disagree, (3) Indifferent, (4) Agree, (5) Strongly Agree; and three open items.

The questionnaires were based on a proposal by Knay and Knaack [29], which was developed mainly to measure user satisfaction of students when interacting with learning objects. We have adapted their proposal for our study by adding three open items. The original proposal divides the instrument into 3 dimensions to group and collect data:

#### Learning

1. The platform helped me learn.
2. Feedback resources (i.e., email) can be useful in learning.
3. Graphical resources and animations helped me learn.
4. The platform helped me learn a new concept.
5. Overall, the learning platform helped me learn.

#### Quality

6. Help features can be useful in learning.
7. Instructions appear to be easy to follow.
8. The platform appears to be easy to be used.
9. The platform appears to be organized.

#### Motivation

10. I liked the theme presented.
11. I consider the learning environment motivating.

12. I would like to use the platform again.

Open Items

1. What did you like most in the platform?
2. What did you most dislike in the platform?
3. What would you change in the platform?

The questionnaire reliability analysis was performed in accordance with the principles of Cronbach's alpha coefficient [29], which ended up showing that the questionnaire was reliable to be applied in the study. Part of the instrument was already validated in previous studies and presented good results [30].

Cronbach's alpha coefficient can be estimated according to

$$\alpha = \frac{k}{k-1} \left( 1 - \frac{\sum_{i=1}^k \sigma_i^2}{\sigma^2} \right) \quad (1)$$

where  $\alpha$  is the coefficient,  $k$  is the amount of items,  $\sigma_i^2$  is the variance of each item and  $\sigma^2$  is the variance of all items.

Values greater than 0.7 for the coefficient are said to be good and satisfactory. Values below this limit are said to be poor and therefore can be discarded [29].

For the analysis of quantitative data, parametric studies concerning descriptive statistics were chosen (average calculation, standard deviation, etc.). For qualitative data, students' comments were categorized and scored in order to enable their representation and visualization in usual graphical forms [30]. The realization of a pilot study to fit the standard deviation of the sample was also contemplated.

All evaluation sessions were carried out in groups, with the projection of virtual classes in a multimedia projector for a classroom of students. The purpose of the study as well as the main features and capabilities of the environment were also explained. At the end of the exposition participants were asked to answer the questionnaire. High quality loudspeakers were used to improve sound quality, given the large number of participants in each class.

In the next section we discuss the pilot study carried out to obtain a reliable estimate for the sample size of the population.

### 3.1 Pilot Study

Working with the entire population in a scientific study is often impractical. Therefore, we have to choose a representative sample of this population, consisting of a typical subset of individuals.

The determination of the population sample size is an issue of extreme importance, mainly for two reasons:

- Small sample sizes tend to lead to inaccurate results, which makes the extraction of reliable results impractical;
- Large sample sizes tend to lead to waste of resources and time employed in the survey.

It is possible to obtain a reliable estimate of the population sample size by using

$$n = \left( \frac{\sigma Z_{\alpha/2}}{E} \right)^2 \quad (2)$$

where,

$n$  = the number of individuals;

$Z_{\alpha/2}$  = the confidence interval (CI) [31];

$\sigma$  = standard deviation of the sample;

$E$  = the error rate.

For a first approach of calculus, standard deviation is usually not known. Therefore, many authors suggest a pilot study with the largest number of participants. After carrying out this study, standard deviation can be extracted and analyzed to estimate the sample size.

For this work we decided to carry out the pilot study with the largest number of individuals. Therefore, 47 graduate and undergraduate students were chosen initially. Worst case was always considered to estimate the size of our sample. For this initial study, standard deviations were similar, taking the mean as reference. Normalizing, the standard deviation was about 20% for all items. Therefore, for CI = 90% the sample size would be 44, for CI = 95% would be 62 and for CI = 99% would be 106 people. For all these confidence intervals a 5% survey error rate was considered. Therefore, we have chosen to work with a reliability of 95% since the number of individuals selected for the final study was 73.

### 3.2 Sample Characteristics

A high percentage of individuals were enrolled in an undergraduate course (89.04%, N = 66) while others were involved with a graduate course (9.59%, N = 7)

Except for one course, the others had somewhat similar numbers of participants in this study: 35.62% students were enrolled in Bachelors in Mechanic Engineering (N = 26), 27.4% were attending Industrial Automation (N = 20), 26.03% were in Bachelors in Computer Engineering (N = 19) and, finally, 9.59% were enrolled in an Electrical Engineering graduate course (N = 7).

Sample was mainly composed of young people: 32.84% of respondents reported to be between 21 and 25 years old (N = 22), 26.87% of them said they were between 15 and 20 years old (N = 18), 13.43% were between 26 and 30 (N = 9), and, finally, the rest of them declared to be in age groups with smaller percentages.

The vast majority of respondents declared to be males (91.67%, N = 66) while there were only 8.33% females for this study (N = 6).

## 4 RESULTS

As a case study, we have modeled some virtual classes to be presented to students. Due to our sample characteristics (most of them were enrolled in an engineering course), we decided to create some introductory classes concerning the use of Matlab applied to Calculus. We tried to enrich the platform as much as possible, using almost all features and characteristics developed. Students had the opportunity to watch content, ask questions to our avatars, solve interactive quizzes, access complimentary resources such as documents and websites, etc. Special attention was given to the TTS (Text-To-Speech) system in order to produce voices for avatars as close as possible to human voices, reducing pronunciation errors or misspellings.

According to the statistical parameters of our results, presented in Table 1, the mean was similar for all items, as well as the standard deviations. Mode and median parameters were also identical.

**Table 1.** Statistical Parameters of the Study.

Item	1	2	3	4	5	6
Me	4	4	4	4	4	4
Mo	4	4	4	4	4	4
$\alpha$	3.7	4.0	3.8	3.7	3.8	4.1
$\sigma^2$	0.4	0.2	0.4	0.4	0.3	0.3
$\sigma$	0.6	0.5	0.6	0.6	0.5	0.5
Item	7	8	9	10	11	12
Me	4	4	4	4	4	4
Mo	4	4	4	4	4	4
$\alpha$	4.0	4.1	4.1	4.0	3.8	3.8
$\sigma^2$	0.5	0.5	0.4	0.4	0.4	0.3
$\sigma$	0.7	0.7	0.6	0.6	0.7	0.5

Data from Cronbach's alpha coefficient analysis in Table 2 confirmed that the questionnaire was reliable to be used in our study. All dimensions of the instrument achieved values greater than 0.70, which corresponds to satisfactory results [29].

**Table 2.** Description of the Questionnaire.

Scale	Items	Possible Range	Internal Reliability
LOES-S	12	12-60	0.82
Learning	5	5-25	0.78
Quality	4	4-20	0.73
Motivation	3	3-15	0.77

Overall, analyzing the results of the three dimensions originally proposed by the questionnaire, all of them obtained satisfactory results.

Our platform has achieved good results concerning learning dimension according to students' opinions, as shown in Figure 7. Although most of them agreed that they were able to learn new concepts when watching virtual classes, a considerable number of students rated to be indifferent. In item 4, for instance, more than 30% neither agreed, nor disagreed. For this scenario, it is worth emphasizing the need for further studies to measure how much they actually learned. Since this evaluation was based mainly on summative aspects concerning user satisfaction, it would be interesting to carry out formative evaluations to identify real knowledge retention.

Quality items of our questionnaire were those that achieved the highest scores, as shown in Figure 8. All items scored higher than 80%.

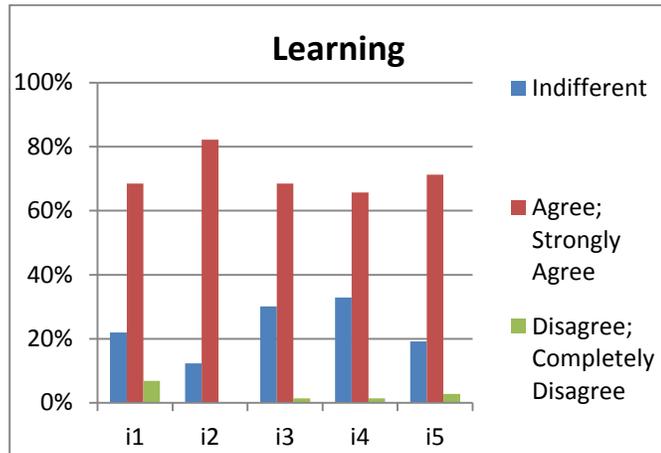


Figure 7. Learning Results Chart.

Although named quality, items in this dimensions related mainly to help features or the ease of use of the platform. These results reflect mainly our initial requirements concerning usability and functionality. Both platforms always kept in mind to be as simple as possible in order to be used by anyone.

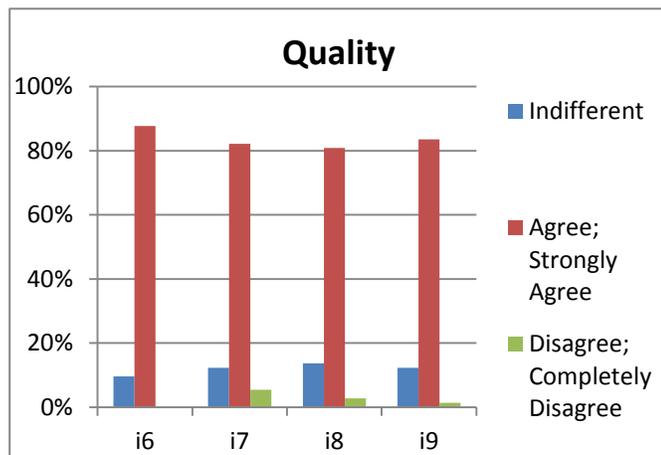


Figure 8. Quality Results Chart.

The results of motivation dimension of the questionnaire, as in Figure 9, show that students felt motivated when they had the opportunity to watch our classes. About 80% of them liked the overall theme presented, focused on an introduction to Calculus using Matlab. More than

70% of students considered the learning environment motivating and almost 78% agreed that they would watch virtual classes again if they had the opportunity to do so. It is worth emphasizing that the quality of virtual classes depends mainly on the content created in the Editor. Well-designed classes tend to contribute to motivation, while poorly-designed ones lead to students' rejection. It became clear that well-prepared classes were successful in trying to make learning more attractive to students.

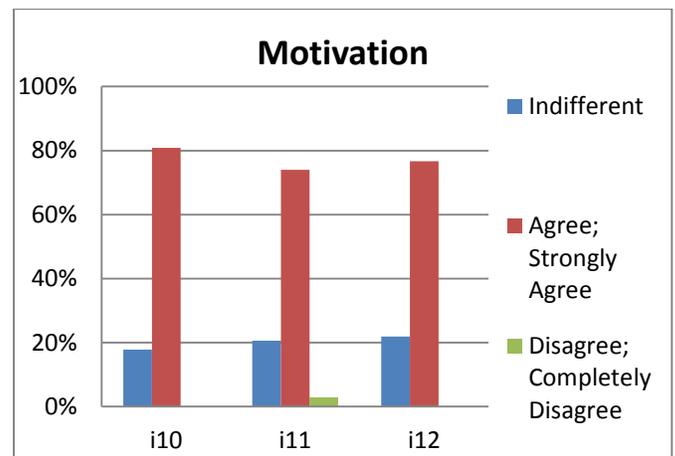


Figure 9. Motivation Results Chart.

For qualitative data, students' comments from open items were grouped in some thematic groups: theme, audio, ease of use, interaction, animations, graphs, comparison to other methods, motivation, technology, visual, challenge and learning. After this grouping, each comment was rated individually in a scale spanning -2 (very negative), -1 (negative), 0 (neutral), 1 (positive) and 2 (very positive). This grouping and scoring allowed us to analyze qualitative data through descriptive analysis.

Among main pros pointed out by students we can list:

- Similarity with a real classroom;
- The motivation provided by the platform, which is not based only on readings and enables the interaction with a virtual tutor;
- The fact that the environment is fun and versatile.

As points of improvements, the suggestions concerned fixing some visual aspects, such as

image resolution and fonts, and reducing speech speed in order to improve understanding of what was being spoken by the virtual tutors.

## 5 CONCLUSIONS

Throughout this work we presented in-progress studies of an attempt to create an environment to help professors designing content-rich interactive virtual classes, as well as virtual instructors. Efforts have been made in the design of robust and easy-to-use platforms for use in educational contexts in order to enable the creation of motivating and friendly classes. Our platform has already achieved the first results. Summative evaluations were carried out with success, resulting in good feedback from users' satisfaction. On the other hand, we intend to carry out formative evaluations to measure the extent to which students have really learned from content presentation. Moreover, there are several recent developments with great potential for important contributions to education. Big Data algorithms and Artificial Intelligence, for instance, are among the applications that are likely to foster the advancement of these educational tools, especially for Massive Online Open Courses.

## 6 ACKNOWLEDGEMENTS

The authors would like to thank São Paulo Research Foundation - FAPESP, Padtec S.A. (Proc. 2007/56018-4), CAPES and CNPq for the financial support.

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