Chapter 4.9
Online Multimedia Educational Application for Teaching Multimedia Contents:
An Experiment with Students in Higher Education

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ABSTRACT

This chapter describes an experiment undertaken with higher education level students, which consists of utilizing an online multimedia educational application as an aid in teaching organizational multimedia. This course is taught to fourth year students at the Escola Superior de Ciências Empresariais (Higher School of Management Sciences, Setúbal, Portugal), where the first author teaches. This chapter also describes the educational software model used for the planning, development and evaluation of the above-mentioned application. This model is the result of the integration of the model presented in the first author's Master's thesis with methods, methodologies and guidelines proposed by others. As for the resulting application, the manner in which it was applied and its evaluation are also presented in this document. The results obtained are then interpreted and future developments proposed.

INTRODUCTION

The use of information technology currently plays an important part in the day-to-day of the majority of public and private institutions. The traditional educational system also has had to adapt to this new way of doing things (Chambel et al., 1998) and has benefited significantly from the contribution of these types of technological applications (Azevedo, 1997; Hartley, 1999; McCarthy, 1995). Likewise, the reigning "professional philosophy"

has also evolved towards the notion of life-long learning (Ryan et al., 2000). Professional careers are becoming increasingly demanding, implying a rapid adaptation to new circumstances and constant acceleration in education, preferably without dismissing employees (Abbey, 2000; Chute et al., 1999). All this leads us to e-learning: a teaching method which utilizes Internet technologies to supply, at a distance, a range of solutions for the acquisition and/or updating of knowledge (Machado, 2001; Rosenberg, 2001; Ryan et al., 2000).

The main reason for the growing popularity of this teaching method is the fact that it combines the advantages of using information technology in education (Azevedo, 1997) with the advantages of distance learning (Machado, 2001; Rosenberg, 2001), namely, access to information using the new instructional model "anytime, anyplace and anybody" (Aggarwal, 2000). This was, therefore, the main reason for choosing to develop and use an Online Multimedia Educational Application (OMEA) to serve as an aid in the teaching of *Organizational Multimedia,* a course taken by fourth year students at the Higher School of Management Sciences. As this is a compulsory course, the classes tended to be very heterogeneous, bringing together students from five different academic areas. Given that the students had different schedules and study constraints, this naturally implied a few difficulties when teaching the course. So, with OMEA, the main goal was to solve this problem, and render access to information easier for anybody, anytime and anyplace. At the same time, we were expecting to benefit from the advantages of using information technology (namely Web-based technology) as a teaching support inside and outside classroom and, finally, to contribute to the modernization of study methods used by students. Other goals were to acquire more experience in planning, developing and evaluating online educational applications and to research the critical process of developing real educational, multimedia and interactive online applications. Unfortunately, in spite of all the advantages associated with the use of information technology (namely Web-based technology) as teaching support, we still have a long way to go in the planning and development of real educational, multimedia and interactive online applications. As a recent and supposedly lucrative phenomenon, e-learning is now concentrating all the efforts of the majority of teaching institutions (Palloff et al., 2001). However, this effort is mainly concentrated on the search for the "ideal" platform, instead of the "ideal" content. So, it is usual to find technologically strong platforms supporting very poor content. In a study to evaluate the online educational applications delivered by some university e-learning platforms (Prata et al., 2003a), we saw that the majority:

- Are not interactive
- Are mainly text-based
- Are not planned and developed by following adequate educational software models and educational and pedagogical rules
- Are made available, at least initially, without being properly tested, namely by getting some feedback from the target population

In the development process of the OMEA, which was supposed to serve as an aid in the teaching of the *Organizational Multimedia* course, we tried to overcome the problems mentioned above, namely by creating an online application:

- That could act as a substitute for the face to face classes that the students could not attend
- That would allow the students to achieve the same results they would achieve by attending the face to face classes
- That would correspond to the target population's expectations and needs
- That would be motivating
- As well as interactive
- And pedagogically adequate

- Which would include different types of media components, namely, text, image, graphics, sound, animation and video
- Which would follow an adequate educational software model for its planning, development and evaluation
- That would be appropriately tested
- That could be integrated as an help/support tool in the classroom
- That could be used by the students as a regular tool/support to their study
- That could be available on the Web on a short-term basis, and later easily adapted to the school-specific intranet and e-learning platforms
- That could be adapted to any standardized e-learning platform (LMS)

In the following sections of this chapter we will justify in more detail the need for this kind of study and its contribution to the resulting OMEA. We will also explain the characteristics of the OMEA developed, present the educational software model used for the planning, development and evaluation of this OMEA and explain the evaluation method used to assess it. Finally, the results obtained will be presented and interpreted, and future developments will be proposed.

BACKGROUND

In recent years information technology has become more commonplace in many areas partly due to government initiatives such as society digitalization, and due to the general public's growing awareness of the Internet as a privileged vehicle for obtaining information. The utilization of these technologies (online and off-line multimedia contents) is presently part of the day-to-day of the vast majority of public and private institutions. Traditional education systems also felt the need to adapt to this new society (Chambel et al., 1998) and have benefited significantly from the contributions of these types of contents (Azevedo, 1997; Hartley, 1999; McCarthy, 1995). Some studies made in order to evaluate the impact, in general terms, of using computers and multimedia in teaching, demonstrate that these types of environments promote creative rationalization, problem solving approaches, strategy formulation, and persistence in the pursuit of goals. Since they promote the use of different sensorial channels, they also represent substantial gains in terms of learning, retention and understanding of issues (Azevedo, 1997; McCarthy, 1995). In other words, they are a more stimulating and involving study method than traditional materials since they imply increased adaptability to different styles of learning, greater involvement of students in the learning process and, also, offer equal advantages for students with or without previous knowledge of information technology. In short, computers and multimedia are a consistent teaching method and, on a worldwide scale, a new learning model (Könyves-Tóth et al., 1995).

Another issue widely discussed nowadays, although not a recent phenomenon, is Long Distance Learning (LDL), which is characterized as an educational event where learning is undertaken by a physical separation (geographical and/or temporal) between students and teachers (Santos, 2000). LDL has emerged as a way of bringing flexibility to educational resources and of leaving less mobile populations the option of continuing their studies/further education. Increasingly, with time, that less mobile population has grown. The "professional philosophy" has also evolved towards a notion of life-long learning (Ryan et al., 2000), and professional careers in most institutions are becoming increasingly demanding, requiring rapid adaptation to new circumstances and constant education, preferably without employee absence to achieve these objectives (Abbey, 2000; Chute et al., 1999). LDL has become the only alternative for many. This teaching method has also evolved with time. What first started as an educational project by means of the post, or tele-school in the

1960s (classes broadcast over the traditional TV network) and CD-ROM based media in the 90s, is now often based on e-learning systems (which have been continuously refined since the Internet's appearance about 10 years ago) (Machado, 2001). E-learning can be defined as a teaching method which utilizes Internet technology to supply a set of solutions at a distance (Online Multimedia Educational Applications) for the acquisition and/or updating of knowledge, and there are many authors involved in its refinement (Machado, 2001; Rosenberg, 2001; Ryan et al., 2000).

According to Elliot Masie, one of the most respected and recognized specialists in this area, the excitement and commitment with which some countries, such as Portugal, embrace e-learning will make them progress at the speed of light (Machado, 2001). Steve Ryan believes that the development of e-learning, which is occurring in all types and at all levels of educational organizations (public and private), all around the world, is highly significant (Ryan et al., 2000). Whereas Marc Rosenberg considers that nowadays, almost all traditional American institutions for higher education are developing e-learning systems (Rosenberg, 2001), such systems are not limited only to higher education because, according to LeBaron, Laurel Springs High School was the first of its kind to implement all of its courses online (LeBaron, 2001).

The main reason for the growing popularity of this teaching method is the fact that it combines the advantages of using information technology in education (Azevedo, 1997) with the advantages of distance learning (Machado, 2001; Rosenberg, 2001); namely, access to information using the new instructional model "anytime, anyplace and anybody" (Aggarwal, 2000). These advantages, in relation to traditional study methods, are on the level of accessibility. Information:

- Is accessible to anybody at any time, anywhere (Aggarwall, 2000; Machado, 2001; Rosenberg, 2001)
- Is accessible through multimedia contents (Machado, 2001)
- Is ready to evolve at the student's individual rate (Machado, 2001)
- Uses hypertext (Machado, 2001)
- Focuses on the student – who is an active participant (Machado, 2001)
- Is available in module form (Machado, 2001)
- Relies on a flexible electronic infrastructure (Machado, 2001)
- Allows for simple and rapid updating (Machado, 2001; Rosenberg, 2001)
- Allows for a great diversity of operators (Machado, 2001)
- Works on individual programs (Machado, 2001)

The general advantages also pointed out are:

- Low cost (Machado, 2001; Rosenberg, 2001)
- Efficient proximity to an unlimited number of people (Aggarwall, 2000; Machado, 2001; Rosenberg, 2001)
- Feasibility of personalization (Machado, 2001; Rosenberg, 2001)
- Permanent availability (Machado, 2001)
- Ease of use. Does not require too much previous knowledge (Machado, 2001; Rosenberg, 2001)
- Universality, since it is based on Internet protocols which operate under standard protocols (Machado, 2001; Rosenberg, 2001)
- Promotion of the emergence of communities with common interests, functioning as a motivating factor (Machado, 2001; Rosenberg, 2001)
- Scalability, as it always allows inclusion of another person (Machado, 2001; Rosenberg, 2001)
- Promotion of a better collaborative environment (Machado, 2001)

- Justification and maximization of investments in intranet and Internet networks (Rosenberg, 2001)

In short, summarizing all that has been mentioned previously, and considering:

- All the advantages of utilizing multimedia and information technology in teaching
- The increasing importance of courses delivered through LDL
- The specific advantages of using e-learning systems
- The testimony of a wide range of known authors

... we can easily conclude that e-learning is here to stay and that it constitutes, on a worldwide scale, a new way of teaching that is redefining the concept of learning as we know it. That is, we are in the presence of an issue that offers great research prospects.

However, it is important to understand that technology is a tool and not a means in itself. It is absolutely vital that, in conjunction with technological investments, efforts be made to find methodologies, rules, guidelines and educational principles that are appropriate to the planning, development and evaluation of contents of this new way of teaching. The non-observance of this basic rule may lead to the development of systems that are technologically perfect but unable to fulfill their role from an educational point of view. This situation, for example, occurred in Portugal, when in the mid-nineties, companies concerned only with filling market niches started mass producing CD-ROMs, many of which were of low quality from a pedagogical point of view (Prata, 2000). In relation to e-learning, that imbalance is visible. It is noticeable that, with the majority of institutions (companies and schools, public and private) that have begun developing or are currently using e-learning solutions, the dominant concern has been essentially technological. That is, they have focused on developing the ideal platform in detriment of the educational slope, which should always be considered first when planning and developing contents for education.

One of the largest difficulties, despite more than four decades of research in human-computer interface areas, is that multimedia system architectures are still missing essential rules and guidelines for the association of different multimedia components. The use of contents with several types of multimedia components, such as text, graphics, image, sound, animation and video, is normally very attractive to users and helps retain their attention and interest during long periods of time. However, this is not the fundamental issue. What truly matters is to understand the real impact, in terms of efficiency and efficacy, these contents will have at the level of information processing and in the acquisition of knowledge. To achieve the desired efficiency and efficacy it is necessary, whilst developing the content, to consider the following factors:

- The way human beings learn
- The personal and cultural characteristics of the target population. Personal, amongst other things, in terms of age, education, previous knowledge, desires and expectations. Cultural, in terms of "certain cultural and policy cross-border peculiarities" (LeBaron, 2000)
- The specific characteristics of each component used (which, obviously, impedes to group or associate components randomly) (Chambel et al., 1998)
- The advantages and disadvantages of each component (for instance, video is, amongst all components, the most powerful in generating attitudes and emotions) (Guimarães et al., 2001)
- The specific characteristics inherent in the issues being presented (e.g., not appropriate to use the same methodology to explain such

different issues as literature and information technologies)

- The need to accommodate several different styles of learning (Chambel et al., 1998)
- The importance of interactivity and of active participation by the user (Chambel et al., 1998)
- The need for a virtual environment (learning environment) which facilitates the learning process. A learning environment is an active environment that infuses the user with a sense of mission that leads him or her to participate actively and to do things. It is an interactive environment (Abbey, 2000; Chambel et al., 1998).
- The learning process is a continuous one and not a set of sporadic and disconnected events (Machado, 2001).

In recent years, due to the growing success of the Internet, some authors have developed studies of generic rules/guidelines for the development of educational multimedia contents for the Web. Several universities have multimedia laboratories where these studies are made. Some of the most important are: the laboratories of the University of Alberta in Canada (Driedger, 1999), the University of Toronto (Drenner, 1998), Yale University (Lynch et al., 1999), the British Open University (OU) in England (Santos, 2000) and Universidad Nacional de Educación a Distancia (UNED) in Spain (Santos, 2000). However, the rules/guidelines defined by these institutions for the development of multimedia environments are few, generic, highly varied and constantly changing. From a study to compare different Web style guides it was possible to conclude that "sometimes they make quite similar recommendations for developing a web site, sometimes they disagree, and sometimes they emphasize different design considerations" (Berk, 1996). Specific rules which are defined and accepted world-wide do not even exist yet (DISA, 1995), which means that some empirical research is needed in order to determine/identify which design criteria will facilitate different online tasks.

This considerably aggravates some considerations/concerns previously pointed out as fundamental to the efficiency and efficacy of content development. These regard the selection of multimedia components to be used but more importantly the manner in which these components can be combined in user-friendly graphical interfaces and, simultaneously, be efficient from an educational point of view. The size and the implications of this deficit allow us to conclude that this is an area where a lot of development is needed and where any advance will be heartily welcome.

With the development of the OMEA our main goal was to facilitate access to information for anybody at anytime and anyplace; that is, to solve the students' problems in attending the face to face classes. Simultaneously, we were expecting to benefit from the advantages of using Web-based technologies as a teaching support inside and outside the classroom and to contribute to the modernization of the study methods used by students. Another goal was to acquire more experience in planning, developing and evaluating online educational applications. Taking into account the above-mentioned difficulties, we also committed to doing some research into the complex process of developing real educational, multimedia and interactive online applications.

ONLINE MULTIMEDIA EDUCATIONAL APPLICATION (OMEA)

As mentioned before, the OMEA main goal is to solve the students' problems in attending the face to face classes by facilitating access to information for anybody at anytime and anyplace. Thus, students who could not attend the *Organizational Multimedia* face to face classes were considered to be the target group for the OMEA and the most

important factor was to develop an OMEA that could best compensate for a student's absence. However, and since we also intended to use the application as a study support inside and outside the classroom, the application was developed so that the general student population could also use it.

All classes in the course are laboratory-based and last three hours. The first hour and a half is dedicated to theory (theory-based) and the remainder to practice (practice-based), that is, to the presentation of practical cases. Given that the educational software model used for the planning, development and evaluation of the OMEA relies on the initial development of a prototype (which, if proven efficient, will serve as the basis for the subsequent development of the final educational application), the OMEA will be, from this point forward, designated as a prototype.

However, the extension/diversity of the course content, which comprises classes covering six different themes, namely text, graphics, image, sound, animation and video, also had to be considered. There are lots of theories and experiments about learning at a distance, especially if we consider research conducted by the British Open University over the last 30 years (Santos, 2000). However, there are some difficulties inherent to the development of this type of OMEA. A universal "formula" capable of guaranteeing the success of applications does not exist and, in order to be properly presented, each theme has its own specifications and methodologies, especially with regards to practice-based classes where the differences appear the greatest. These were the reasons that led us to opt for the development of more than one prototype. As the approach to some of the above mentioned themes was similar, the decision was taken to implement four prototypes in the following order: the first with a practice-based class on image (Prata, 2003), the second with a practice-based class on sound (Prata et al., 2003b), the third with a practice-based class on animation (Prata et al., 2003d) and the fourth with a practice-based class on video (Prata et al., 2003c).

The prototypes were not developed simultaneously because:

- We wanted to learn from the different experiments; therefore a new prototype only began to be developed after the previous one had been concluded and tested
- From a technological point of view, the prototypes include components with different levels of complexity. In terms of manipulation, representation, storage, and types of resources needed, components may be classified in the following ascending level of complexity: image, sound, animation and video. Therefore, we decided to implement the prototype with a class on image first, and the prototype with a class on video last. This way we could count on some experience gained from our previous work. It is important to say that this last prototype was doubly challenging given that video is the most complex component, and although a great deal has been achieved in terms of improving compression algorithms and increasing bandwidth/access speeds to the Internet, we are still far from achieving the ideal
- We wanted to include as many groups of students as possible in the evaluation process. In fact, each prototype was evaluated by a different group of students. We paid particular attention to this question because we did not always want to bother the same students and we wanted each prototype to be evaluated by a new group that had never seen the previous prototypes. All the prototypes were evaluated by students taking the *Organizational Multimedia* course during the 2002/2003 academic year, both semesters.

Each of the four prototypes comprises three different sections: one section with the content of a practice-based class about a specific theme (image, sound, animation or video), the Frequently Asked Questions section (FAQs) and the exercise section (which includes solutions).

In conclusion, it is important to realize that the main goal of our work is to develop a final OMEA, which will include all the classes on the *Organizational Multimedia* course. However, as supported by the model we have used, we must start by developing and testing a prototype. As mentioned before, the content of the *Organizational Multimedia* course comprises six different chapters and our first thought was to develop a prototype for each chapter. Yet, after a detailed analysis we came to realize that some chapters included components with similar characteristics, so the final decision was to develop four prototypes: a first prototype with a practice-based class on image (Prata, 2003), a second one with a practice-based class on sound (Prata et al., 2003b), a third one with a practice-based class on animation (Prata et al., 2003d), and finally, a fourth one with a practice-based class on video (Prata et al., 2003c).

As part of a major project, the educational software model used for the planning, development and evaluation of the prototypes as well as the evaluation method used were the same in all four prototypes. Both the educational software model and the evaluation method used will be described in the next sections.

EDUCATIONAL SOFTWARE MODEL

Origins of this Model

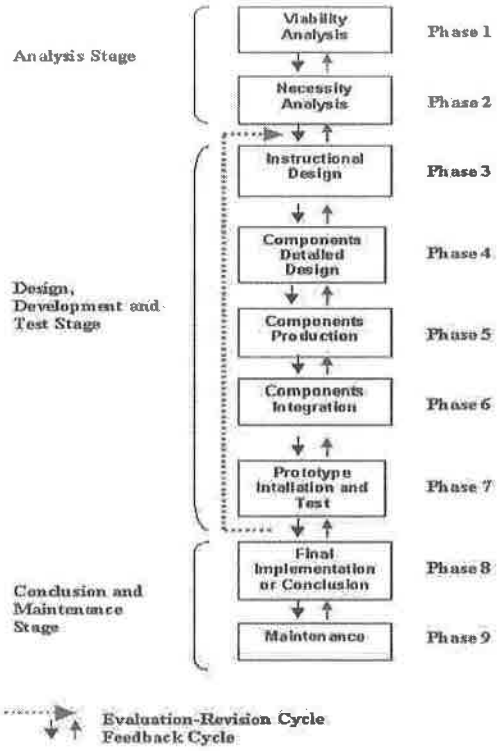
The model used for the planning, development and evaluation of the OMEA was a result of the integration of the model presented in the first author's Masters thesis (Prata, 2000; Prata et al., 2002) with methods (Sutcliffe, 1999), methodologies and guidelines proposed by other authors (Drenner, 1998; Driedger, 1999; Fernandez, 2000; Lynch et al., 1999; McGloughlin, 2001; Nielsen, 2000; Olsina et al., 1999; Salmon, 2000; Tsai, 2000; Vaughan, 1998; Vrasidas, 2000). The final model is composed of nine phases grouped in three different stages and, in very general terms, marks the initial development of a prototype, which, if proven efficient, will serve as the basis for the subsequent development of the final OMEA.

Structure of the Model

The final model, which can be seen in more detail in Figure 1, is composed of nine phases grouped in three different stages, namely: the analysis stage (phases of viability and necessity analysis), the design, development and test stage (instructional design, components detailed design, components production, components integration and prototype installation and test phases) and, finally, the conclusion and maintenance stage (final implementation or conclusion, and maintenance phases).

In general terms, the model marks the initial development of a prototype, which, if proven efficient, will serve as the basis for subsequent development of the final educational application. The software evolves according to an organized sequence of phases, in which the output of a given phase constitutes the input of the following phase. Each of these phases is composed of a varying number of tasks, which should be totally completed before moving onto the next phase. In an ideal situation the software would be developed following all phases of the model, in the exact order presented, and an efficient prototype would probably be obtained on the first trial. Unfortunately, things do not usually work out this well in practical terms. In reality, what happens is that it is frequently necessary to return to previous phases. These situations are also foreseen in the model, namely through the presence of feedback cycles in all phases. The tests or evaluations occur during

Figure 1. Detailed structure of the model



all phases and constitute the so-called formative evaluation. The final tests or summative evaluation only occur at the end of phase 7 and are meant to test the efficiency of the developed prototype. If the prototype is confirmed as efficient, then the remaining models are implemented following the same process. If the prototype is not efficient then we return to phase 3 of the model, or rather, we enter a evaluation-revision cycle.

It was noted that in all analyzed development models (lifecycle models and models for the development of educational multimedia software) there are phases and tasks, which, though bearing different designations, are common to most of the models. After analyzing each of these phases, their relevance to this work and the order in which they should be included in relation to the other phases, we reached the following final result:

1. Phase 1 – Viability Analysis
   - **Goal:** Analyze the viability of the project.
   - **Input:** Students' needs.
   - **Tasks:** Define without going into great detail:
     - The goals; the target population; the subject or domain; the choice of medium; tasks, resources, constraints and costs; alternative implementation strategies
   - **Output:** A viability report considering the alternatives.
2. Phase 2 – Necessity Analysis
   - **Goal:** Description of the situation and of the learning goals.
   - **Input:** Initial needs identified in the viability report.
   - **Tasks:** Detailed defining:
     - The make-up of the working and executive groups; a survey of field conditions; target population descriptions (knowledge, motivation, capacities, objectives and exceptions) and the choice of evaluation groups; learning necessities analysis and a hierarchy of learning objectives; subject analysis, problem description, objective and generic selection of components; selection of development environment (educational software model); analysis and multimedia tools selection.
   - **Output:** Needs specification; contents learning/educational structure (learning model).
3. Phase 3 – Instructional Design
   - **Goal:** Conceptual instructional design.
   - **Input:** Specific needs and learning model.

- **Tasks:** Instructional design (navigation, colors, background and feedback among others); contents structuring (division into hierarchical levels and prototypical schemes); instructional events identification and sequence (navigation maps, for instance).
- **Output:** General schemes of content structure and sequence of instructional events.

4. Phase 4 – Components Detailed Design
   - **Goal:** Detailed design the several structures.
   - **Input:** General schemes of content structure and sequence of instructional events.
   - **Tasks:** Creation of a detailed design of the several structures (general base layouts); also, creation of a detailed design of instructional events (base layouts for instructional events).
   - **Output:** Functional specification (detailed design of the base interface).
5. Phase 5 – Components Production
   - **Goal:** Collect all the components that are to be used.
   - **Input:** Functional specification.
   - **Tasks:** Distribute contents through base layouts; identification and detailed study of said components (general design of the prototype's interface); collect and/or produce the different components (editorial work) and script (detailed design of prototype's interface); proceed to final selection of the authoring system.
   - **Output:** All multimedia components that are to be used, alternatives, and script (detailed design of the prototype's interface).
6. Phase 6 – Components Integration
   - **Goal:** Conclude the prototype.
   - **Input:** Functional specification script and all multimedia components that are to be used.
   - **Tasks:** The integration of all collected and/or produced components.
   - **Output:** Concluded prototype.
7. Phase 7 – Prototype Installation and Test
   - **Goal:** To install the prototype, evaluate its efficiency and identify weak points.
   - **Input:** Concluded prototype.
   - **Tasks:** Prototype installation; prototype evaluation (to detect errors and evaluate its efficiency).
   - **Output:** The results of the prototype evaluation.
     - **NOTE:** If the prototype is not efficient, it is necessary to go back to the instructional design phase in order to proceed to its adjustment. This process is called the evaluation-revision cycle and it does not imply that all phases have to be repeated with the same degree of detail. Depending on the types of weak points and/or faults identified during the evaluation it is necessary to ascertain which phases need revision.
8. Phase 8 – Final Implementation or Conclusion
   - **Goal:** Conclude the educational application.
   - **Input:** Documents resulting from all previous phases, as well as the prototype.
   - **Tasks:** The correction of faults detected during the prototype's evaluation; the incorporation of any remaining modules in the prototype.
   - **Output:** Final educational application.

9. Phase 9 – Maintenance
   - Regular maintenance of the educational contents of the application is necessary in order to keep it up to date.

As a working philosophy, we decided to adopt an inherent characteristic of the Carrie Heeter model, that is, letting creativity decide the course of the software's design (Scarlatos, 1997).

The evaluation referred to in phase seven concerns the final tests to be conducted on the prototype. However, and even though this is not schematically represented in the model, intermediate tests should be carried out for all phases.

EVALUATION METHOD

Each one of the four developed prototypes underwent two kinds of evaluation:

- Formative Evaluation – which was based on the tests conducted during the entire development process (intermediate tests). This kind of evaluation was carried out by a team of two people from the work team, 10 people belonging to the target population, and four people belonging to a potential target population, that is, students from another Higher School, who also take multimedia classes. The goal of this kind of evaluation was to identify and correct problems during a preliminary phase and at the same time, to understand the students' expectations and preferences;
- Final Evaluation – which consisted of a final test or experiment and also of the handing out of a questionnaire, as will be described in the next subsections.

Final Test or Experiment

Students from the target population participated in this experiment, the goal of which was to evaluate the efficiency of the prototype as a substitute for the *Organizational Multimedia* face to face classes. The experiment is described below:

- As mentioned in previous sections, the *Organizational Multimedia* classes are laboratory-based and last three hours: one and a half hours are dedicated to theory and the other hour and a half is set aside for practice. Thus, to begin with, all students participated in a one and a half hour theory-based face to face class on the theme covered by the prototype.
- After that, there was an attempt to place the students in four categories: students with experience using the Internet (and with experience using the multimedia components used on the prototype), students with experience using the Internet (and with no experience using the multimedia components used on the prototype), students with no experience using the Internet (and with experience using the multimedia components used on the prototype) and students with no experience using the Internet (and with no experience using the multimedia components used on the prototype).
- After being placed in categories, the students were then distributed into two groups. Each group comprised the same number of students from different categories and occupied a separate classroom.
- One of the groups was submitted to the other hour and a half face to face class, which corresponded to the practice-based class (practical part of the laboratory-based class). Meanwhile, in the other group, each student for an hour and a half had access to the prototype which was meant to act as the substitute for the practice-based face to face class being attended by the others. This group of students used the prototype under the supervision of a teacher in order to guarantee obedience to the established rules.

During the practice-based face to face class we tried not to convey more essential information than was covered by the prototype. Thus, the students who used the prototype did not access less essential information than those who attended the practice-based face to face class did. What they did have, however, was access to a different teaching method with different characteristics.

- The prototype was installed on a public server and each user achieved speeds similar to those of a 56Kb-modem connection (the most frequent type of connection speed amongst the student population).
- Afterwards, all students were submitted to the same individual practical exercises.
- The next step was the analysis of results.

The students chosen were considered natural because they were in the last year of their degrees and, at the time, all of them were taking the *Organizational Multimedia* course.

By separating the student population into two groups and submitting each group to a specific situation (one of the groups having only studied using the prototype and the other group having attended the practice-based face to face class), we used an experimental methodology of the *between-groups* type, which seemed to most appropriate (Santos et al., 1999).

However, with the goal of improving the experiment, we considered the possibility of performing it in two different phases:

A first phase would be exactly what is described above and a second phase would involve changing groups: having the group that initially studied with the prototype now attend the practice-based face to face class, and having the group that initially attended the practice-based face to face class now study with the prototype. The studied contents could be:

- The same in both phases of the experiment, but in this case, it would not be the first time that the students were exposed to the subject matter, which would therefore carry a learning situation from the first phase of the experiment to the second. To solve this type of situation, what we could do would be to carry out the second part of the experiment after some time. However, that solution would have been impossible in this case as the students, who were in the last year of their courses, were about to finish school and obviously were not very committed to coming back later to participate in a new experiment. However, even if the experiment were possible, the experience of these students in using the Internet would not be the same, because the majority of them have easy access to these technologies and strong motivation to use them.
- Different in two phases of the experiment – if the contents used on the second phase of the experiment were different from the ones used in the first phase, then the second phase of the experiment could be conducted immediately after the first one. However, as the complexity level of the contents varies from theme to theme, and as the multimedia structure of the different themes is also different, the result will not be reliable. Another possibility would be to consider the population as an individual group and submit them to both situations: all students would be supposed to attend the practice-based face to face class and after that use the prototype, or vice versa. This methodology, of the "inside-groups" type, did not seem to be very appropriate because, from one situation to another, we will have situations of learning.

We can therefore conclude that the options referred to above work as a new experiment, similar to the first one, but not as a complement to it.

Questionnaire

The second part of the final evaluation was the use of a questionnaire. We were expecting to capture the students' reactions to the prototype, find out their opinions about it, detect technical failures, and collect some suggestions in order to improve it. As we wanted to include all the students in this evaluation, we had to partially repeat the final test or experiment. That is to say, after finishing the practical exercises, the groups were switched around. The group that had initially studied with the prototype attended a practice-based face to face class, and the group that had initially attended the practice-based face to face class studied with the prototype. After that, they were all able to voice an opinion about the prototype's characteristics and fill out the questionnaire.

We asked them to give their opinion freely (in writing and anonymously) concerning all details that they particularly liked and disliked. The students were encouraged to navigate around all the prototype's paths. No information was given (not even a manual or any previous tips) about using the prototype. While the students were using the prototype, they were observed in a passive manner. This gave us the opportunity to collect information about their reactions, expressions and behaviors.

RESULTS OBTAINED

Prototype with a Class on Image

In the final evaluation of the prototype, which focused on a practice-based class about image, 54 students participated (38 of whom with previous experience in using the Internet and 16 with no experience using the Internet). All the students experienced in using the Internet also had experience using image files). After the experiment and the submission of the questionnaire, the results were analyzed as follows:

Experiment Results

In relation to the experiment, in general terms, all students solved the exercises easily. However, the results obtained were different, as presented in Table 1.

In both situations (students with experience and students with no experience using the Internet) we tried to verify if the variables of grade obtained in the exercises and method of study used were or not co-related (dependent). As the sample size was considered small, we used Fisher's Test (Everitt, 1997) and we verified that the variables were not independent. That is to say that, in both situations, the grade obtained in the exercises was not independent of the study method used.

The experiment showed us that the majority of the students feel quite enthusiastic about using this type of online application and that its use may

Table 1. Average grades obtained by the students

	Students who initially used the **prototype**	Students who initially attended the **practice-based class**
With experience using the Internet and image files (**38** students)	**14**	13
With no experience using the Internet (**16** students)	13	13

have better results than previously expected. In fact, as this application is meant to be a substitute for attending classes, the main goal is to achieve the same results that we achieve with the classes, and this happened in the group of students with no experience in using the Internet. However, the results obtained in the group experienced in using the Internet were a little better amongst students who initially only used the prototype than the results obtained amongst those who initially attended the practice-based class (at an average of 14 against an average of 13). This probably happened because the class was about image, which is simple to represent and did not occupy too much space, when compared with more complex media such as sound, animation or video. In fact, the prototype, which was very easy to use and relatively fast, worked very well in terms of motivation. These results prove the efficiency of the prototype and are a good incentive to continue this work.

Questionnaire Results

As for the questionnaire, the direct answers are summarized as presented in Table 2.

It was noted, as expected, that the 38 students with experience in using the Internet were more demanding and, in fact, they are amongst the ones who classified the prototype as slow. Another factor was that although all students considered this type of prototype to be a good (51 out of 54) or medium (three out of 54) substitute for attending classes, only 45 out of 54 considered the studied prototype good enough to replace the class entirely. This probably indicates that there are still

Table 2. Answers obtained on the questionnaire

About the prototype:	Very	More Or Less	A Little	Very Little
1. Has an attractive design	42	11	1	0
2. The information is well organized	45	7	2	0
3. Navigation is simple and intuitive	37	10	7	0
4. The subject is clearly presented	49	5	0	0
5. Easy to use	44	10	0	0
6. Motivating	50	4	0	0
	Good	Medium	Weak	Poor
7. Number of examples presented	51	3	0	0
8. Number of exercises presented	41	10	3	0
9. FAQs section	53	3	8	0
10. Speed	29	16	9	0
11. Constitutes good method of replacing attended class	51	3	0	0
12. Global evaluation	40	11	3	0
	Yes		No	
13. A good enough substitute for the attended class?	45		9	

some improvements to be made to the prototype. In relation to the open-ended questions, students were asked to identify the strong points, the weak points and to suggest ways of improving the prototype. The strong points mentioned were that it helped students who could not attend classes (50 out of 54), that it was accessible from anywhere (51 out of 54), that it was motivating (49 out of 54), enjoyable (32 out of 54) and different from other study methods (43 out of 54). The weak points mentioned were average navigational structure (16 out of 54) and slowness (23 out of 54).

The majority of students considered that the prototype had an attractive design, that the information was well organized, that navigation was simple and intuitive, that subjects were clearly presented, that it was easy to use and motivating, that it presented an adequate number of examples and exercises and that it was a good substitute for attending classes. In fact, the only problems pointed out were a degree of slowness in downloading the prototype and an average navigational structure.

Prototype with a Class on Sound

In the final evaluation of the prototype, which included a practice-based class on sound, we had the participation of 82 students (16 students experienced at using Internet and sound files, 40 students experienced at using the Internet but with no experience of using sound files and 26 students with no experience of using Internet or sound files). After conducting the experiment and applying the questionnaire, the results were analyzed as follows.

Experiment Results

As for the experiment, in general terms, all students solved the exercises easily. However, the results obtained were different, as presented in Table 3.

With Fisher's test (Everitt, 1997) we verified that the variables (grade obtained in the exercises and study method used) were indeed co-related (not independent). That is to say that the grade obtained in the exercises did relate to the study method used.

As for the results obtained by students who initially attended the practical class and results obtained by students who initially used the prototype, there were some differences, namely:

- The results obtained among students with no previous experience of using the Internet

Table 3. Average grades obtained by the students

	Students who initially used the **prototype**	Students who initially attended the **practice-based class**
With experience using the Internet and sound files (**16** students)	14	16
With experience using the Internet but with no experience using sound files (**40** students)	13	13
With no experience using Internet and with no experience using sound files (**26** students)	12	12

or sound files (26 out of 82) and the results obtained among students with experience of using the Internet but with no experience of using sound files (40 out of 82) were more or less the same for both groups.

- The results obtained among students experienced in using the Internet and sound files (16 out of 82) were very good and even better among those who attended the class (an average of 16 against an average of 14). These students already had previous knowledge of sound subject matter and, as it was probably an interesting subject for them participated quite actively in class by asking several questions and expressing doubts, which were immediately clarified. Those who used the prototype may also have had their doubts but as they were not immediately clarified (they had to resort to the FAQ Section), their results were slightly worse.

These results were encouraging because in both groups (the group that attended the practice-based class and the group that only used the prototype) the majority of students achieved similar scores. The only category of students to achieve better averages in the group that attended the class (as compared to the average obtained by the group that only used the prototype) was the one with previous experience using the Internet and sound files (16 out of 82). However, these higher averages were the result of the personality and attitude of these particular students, who prefer asking the professor direct questions and obtaining rapid answers, rather than browsing

Table 4. Answers obtained on the questionnaire.

About the prototype:	Very	More Or Less	A Little	Very Little
1. Has an attractive design	58	18	6	0
2. The information is well organized	63	16	3	0
3. Navigation is simple and intuitive	68	12	2	0
4. The subject is clearly presented	69	13	0	0
5. Easy to use	67	13	2	0
6. Motivating	79	3	0	0
	Good	Medium	Weak	Poor
7. Number of examples presented	75	7	0	0
8. Number of exercises presented	50	22	10	0
9. FAQs section	72	5	5	0
10. Speed	4	34	36	8
11. Constitutes good method of replacing attended class	78	4	0	0
12. Global evaluation	51	30	1	0
	Yes		No	
13. A good enough substitute for the attended class?	68		14	

around the prototype looking for the answer. We consider that this problem can be solved with a more friendly and personalized FAQ Section.

Questionnaire Results

The answers are summarized in Table 4.

As we can see from Table 4, some attention needs to be paid to the results relating to the prototype lack of speed. It was noted, as expected, that the 56 students experienced in using the Internet were more demanding and, in fact, were among those who classified the prototype as slow. Another discovery was that although all students considered this type of prototype to be a "good" (78 out of 82) or "average" (four out of 82) substitute for attended classes, only 68 out of 82 considered the studied prototype good enough to replace the class. This indicates that there are still some improvements to be made to the prototype in order to make it more efficient and comparable to the attended classes.

In relation to the open-ended questions, students were asked to identify the strong points and weak points of the prototype and to suggest ways of improving it. The strong points mentioned were: the fact that it helps students who cannot attend classes (80 out of 82); it is accessible from anywhere (75 out of 82); it is motivating (79 out of 82) and it is a novel and original study method (73 out of 82). The only weak point mentioned was slowness (44 out of 82).

We saw that the students believed the prototype gave them autonomy (80 out of 82), flexibility (75 out of 82) in regard to their studies, and classified it as a motivating (79 out of 82) and novel (73 out of 82) teaching/learning process.

Prototype with a Class on Animation

In the final evaluation of the prototype, which included a practice-based class on animation, 68 students participated (16 students with Internet and animation file experience, 34 students with Internet experience but with no experience in using animation files and 18 students with no experience of using the Internet or animation files). After conducting the experiment and applying the questionnaire, the results were analyzed as follows:

Experiment Results

As for the experiment, in general terms, all students solved the exercises easily. However, the results obtained were different, as presented in Table 5.

With Fisher's test (Everitt, 1997), we saw that the variables (grade obtained on the exercises and study method used) were indeed co-related

Table 5. Average grades obtained by the students.

	Students who initially used the **prototype**	Students who initially attended the **practice-based class**
With Internet and animation file experience (**16** students)	14	15
With Internet experience but with no experience using animation files (**34** students)	13	13
With no experience of the Internet or animation files (**18** students)	11	11

(dependent). That is to say that the grade obtained on the exercises did relate to the study method used.

As for the results obtained by students who initially attended the practice-based class and results obtained by students who initially only used the prototype, there were some differences, namely:

- The results obtained by students with no Internet experience (18 out of 68) were the same in both groups.
- The results obtained by students with Internet experience but with no previous knowledge of animation (34 out of 68) were more or less the same for both groups.
- The results obtained by students with Internet experience and previous knowledge of animation (16 out of 68) were very good, and better among those who sat through the attended class. These students already had previous knowledge of animation and participated quite actively in class by asking questions and expressing doubts, which were immediately clarified. Those who used the prototype may also have had questions but as these were not immediately clarified (they had to use the FAQs section) the result was a slightly worse score.

These results were optimistic because in both groups (the one that attended the practical class and the one that only used the prototype) the majority of students achieved similar scores. The only category of students to achieve a better average in the group that attended the class, when

Table 6. Answers obtained on the questionnaire

About the prototype:	Very	More Or Less	A Little	Very Little
1. Has an attractive design	47	18	3	0
2. The information is well organized	60	7	1	0
3. Navigation is simple and intuitive	58	8	2	0
4. The subject is clearly presented	61	7	0	0
5. Easy to use	56	10	0	0
6. Motivating	63	5	0	0
	Good	Medium	Weak	Poor
7. Number of examples presented	60	7	1	0
8. Number of exercises presented	19	36	13	0
9. FAQs section	57	6	5	0
10. Speed	0	21	37	10
11. Constitutes good method of replacing attended class	59	9	0	0
12. Global evaluation	44	15	9	0
	Yes		No	
13. A good enough substitute for the attended class?	49		19	

compared with the average obtained by the group that only used the prototype, was the one with previous Internet and animation file experience (16 out of 68). As with the prototype with the class on sound, we believe that this higher average was the result of the personality and attitude of these particular students, who prefer asking the professor direct questions and thus obtaining rapid answers, rather than browsing around the prototype looking for answers. Probably, this problem will be solved with a more friendly and personalized FAQ Section.

Questionnaire Results

The answers are summarized in Table 6.

As we can see from Table 6, the majority of students considered the prototype "good" in general terms. However, some attention needs to be paid to the results relating to the prototype lack of speed. As with the previous prototypes, we also noted that although all students considered this type of prototype to be a "good" (59 out of 68) or "average" (nine out of 68) substitute for attending classes, only 49 out of 68 considered it good enough to replace the class. This indicates that there are still some improvements to be made to the prototype in order to make it more efficient and comparable to attending class.

In relation to the open-ended questions, students were asked to identify the strong points and the weak points of the prototype and to suggest ways of improving it. The strong points mentioned were the fact that it helped students who could not attend classes (58 out of 68), that access was possible from anywhere at any time (61 out of 68), that it was motivating (62 out of 68) and that it was a novel and original study method (36). The only weak point mentioned was slowness (47out of 68).

Prototype with a Class on Video

In the final evaluation of the prototype, which involved a practice-based class on video, 32 students participated (14 students with Internet experience and 18 students with no Internet experience). None of them had any previous experience of video files. As the size of the sample population was very small (because we were at the end of the semester), the results should be considered no more than a mere indicator, useful essentially for improving the prototype.

After conducting the experiment and applying the questionnaire, the results were analyzed as follows:

Experiment Results

As for the experiment, in general terms, all students solved the exercises easily. However, the results obtained were different, as presented in Table 7.

With Fisher's test (Everitt, 1997) we saw that the variables (grade obtained in the exercises and study method used) were indeed co-related

Table 7. Average grades obtained by the students

	Students who initially used the **prototype**	Students who initially attended the **practice-based class**
With Internet experience (**14** students)	12	13
With no Internet experience (**18** students)	10	12

(dependent). That is to say that the grade obtained on the exercises did relate to the study method used.

In general terms, both groups solved the exercises easily. However, in both groups, the results obtained among students who initially only used the prototype were worse than the results obtained among those who initially attended the practice-based class. These inferior results were especially noticeable among the students with no Internet experience. It was noted, as expected, that the 14 students with Internet experience were more demanding. However, they were much more tolerant of slowness while downloading the prototype components than the students with no Internet experience.

Questionnaire Results

The answers are summarized in Table 8.

As we can see from Table 8, the majority of students considered that the prototype had an attractive design, that information was well organized, navigation was simple and intuitive, that subjects were clearly presented, that it was motivating, that it presented a sufficient number of examples and exercises, and that it was a good substitute for attending classes. However, although all students considered this kind of prototype to be a "good" (27 out of 32) or "average" (five out of 32) substitute for attending classes, only 13 out of 32 considered the studied prototype good enough to substitute for the class. This indicates that there

Table 8. Answers obtained on the questionnaire

About the prototype:	Very	More Or Less	A Little	Very Little
1. Has an attractive design	25	4	3	0
2. The information is well organized	16	10	6	0
3. Navigation is simple and intuitive	11	17	4	0
4. The subject is clearly presented	23	9	0	0
5. Easy to use	3	11	18	0
6. Motivating	21	10	1	0
	Good	Medium	Weak	Poor
7. Number of examples presented	28	4	0	0
8. Number of exercises presented	26	6	0	0
9. FAQs section	24	6	2	0
10. Speed	0	9	17	6
11. Constitutes good method of replacing attended class	27	5	0	0
12. Global evaluation	3	16	13	0
	Yes		No	
13. A good enough substitute for the attended class?	13		19	

are still serious improvements to be made to this prototype in order to make it more efficient.

As for the open-ended questions, students were asked to identify strong and weak points and to suggest ways of improving the prototype. Strong points mentioned were the fact that it helped students who could not attend classes (20 out of 32), that it could be accessed from anywhere (26 out of 32), that it was motivating (17 out of 32) and that it was a novel study method (27 out of 32). The weak points mentioned were difficulties in using the prototype (25 out of 32), average navigational structure (15 out of 32) but, especially, slowness (24 out of 32).

From observing the students directly, we were able to see a great deal of enthusiasm when they started using the prototype. However, after some time they lost part of their enthusiasm and showed some impatience with the prototype's slowness.

For the first time in the course of these experiments, the results obtained among students (of all categories) who initially used the prototype were worse than the results obtained among those who initially attended the practice-based class. This probably happened because the class was about video, which is very difficult to represent/implement and resulted in a slow prototype. In this particular case, with all categories of students, the face to face class was more effective than the application.

FUTURE TRENDS

Regarding future work, we expect to conclude the implementation of the final OMEA with all the classes of the *Organizational Multimedia* course. This final OMEA, which is currently being implemented, as mentioned before is meant to substitute, in the best possible way, the face to face classes students could not attend. During the first phase the OMEA will be made available on the Internet, meaning it can be accessed by anyone, anywhere and at anytime (as an example, please check MIT's open courses, available at *http://ocw.mit.edu/index.html*). As the OMEA's main goal is to be an efficient substitute for the face to face classes, its contents are very complete and detailed, as to exactly reproduce the subjects delivered in those classes. The only thing that is different is the way in which the information is presented, because, obviously, it is adapted to be displayed in an online educational application. With this application, the student will be able to access from anyplace at anytime the content corresponding to classes that he or she missed. Creating this OMEA was the quickest and most efficient solution found to solve problems/difficulties inherent to student absences.

The Higher School of Management Sciences currently has several projects in place, namely, the implementation of an intranet and an e-learning system. Thus, and considering the OMEA's future integration in both systems, its contents are being developed in a modular fashion. This kind of development will allow the OMEA's integration with both projects' platforms and will also permit different ways to associate the contents/modules considering the required level of difficulty in each case.

Concluding, the goal is that in the future the OMEA is to be integrated and made available, in the following order, through the following systems:

- The Internet (which will help us to provide an educational environment that we classified as "online anytime, anyplace, anybody" model).
- The school's intranet (which will help us to provide an educational environment that we classified as "online in the studyplace" model).
- The school's e-learning system, and in that case it will have to be adapted to the teaching model being used (blended or exclusively online).

- Other standardized e-learning systems (LMS). In order to achieve this goal, the modules will have to be portable (multi-platform), interoperable and reusable, which is, according to Elliot Masie from the Masie Center, the present market tendency (Masie, 2004). However, and as this standardization process is already in a early stage and far from achieve universal and wide-world accepted standards (Holley, 2003), the integration of our application with other standardized systems will be the last part of the entire work.

The following describes the way in which the OMEA is supposed to be used:

1. **As a complete online substitute for the face to face classes students could not attend.** Pedagogically speaking, this is a learning model where students are at the center of the model, and we can call it online "anytime, anyplace, anybody". Some functionalities are currently being studied as to be implemented on a later stage of this work. Those functionalities include: "virtual post-its" that allow students to add their own comments and notes on the contents, exercise sections including exercises with answers and others only with the final result (solution), evaluation tests section, which will be automatically corrected by the system's application, FAQs section and personalized classes. These personalized classes will be manually or automatically generated using modules in which the student has shown most weakness with. Manually – through information obtained directly from students via an online form, where he or she notes the modules found to be the hardest; or automatically – generated by the application that analyzes results obtained on exercises and evaluation tests sections. Obviously, this last solution will only be available after obtaining some input on the student through the resolution of exercises and/or evaluation tests.
2. **As a tool to help/support the face to face classes.** In this learning model, which we can call "online in a classroom," the professor will be in control and is the center of the model. In fact this is like a traditional face to face class where the online educational application is made available not only as a background material but is integrated with classroom instruction as a classroom tool. Apart from the motivation associated with this learning model, one of the biggest advantages is that students learn with the professor how to use the application and thus need not do it on their own.
   The application will be used in the classroom to support the following tasks:
   - Examples demonstration – through the use of the application the students will, more rapidly, easily and efficiently understand the theoretical concepts. In our OMEA, and considering that the course classes are on multimedia, with a simple click students will, for instance, hear, see and compare sound and video files recorded using different quality parameters; see and compare the visual differences obtained after resizing images and after resizing graphics; compare the quality of an image recorded with different color palettes and compression algorithms; and so on.
   - Exercises resolution – through the use of the exercises section.
   - Evaluation tests – through the use of the evaluation tests section.
3. **In students' evaluation processes.** Through the evaluation tests section, and similarly to what can be achieved with the WebCT, once all students are connected, the application will allow them to solve the same test.

However, and in order to avoid any cheating, the questions will be presented in a different order to every one of them. The tests will be automatically corrected by the system's application, which brings some obvious advantages: the results will be quickly known and the professor will have more time to spend with more important tasks such as supporting and helping students with their learning process.

4. **As a regular study tool/support.** Which will be very useful for students because the application includes an exercise section, evaluation tests section and a FAQ's section.

   Another advantage may be what we have decided to call the "dejá vu learning advantage": the application's contents are made available in the exact same order and level of complexity as the contents presented at the face to face classes, thereby making it easier to remember and memorize these when studying.

CONCLUSIONS

Mainly in order to make information easier for students to access at any time from any place, we decided to develop an Online Multimedia Educational Application (OMEA) to aid in the teaching of the *Organizational Multimedia* course. Others goals were to benefit from the advantages of using information technologies (namely Web-based technologies) as a teaching support inside and outside the classroom, to contribute to the modernization of study methods used by students and, finally, to acquire more experience in planning, developing and evaluating OMEA. The *Organizational Multimedia* course is taught to students in their fourth year at the Higher School of Management Sciences, where the first author teaches. In order to plan, develop and evaluate this type of application, the use of adequate models is highly recommended. The model followed and described in this chapter involves the initial development of a prototype, which, if proven efficient, will serve as the basis for subsequent development of the final application. As the *Organizational Multimedia* course is made up of six different chapters: text, image, graphics, sound, animation and video, our first thought was to develop a prototype for each chapter. However, after more detailed analysis, we noticed that some chapters include components with similar characteristics. Thus, the final decision was to develop four prototypes in the following order: a first prototype with a practice-based class on image, a second one with a practice-based class on sound, a third one with a practice-based class on animation, and finally, a fourth one with a practice-based class on video.

As part of a major project, the model used to plan, develop and evaluate the prototypes as well as the evaluation method used were the same in all four prototypes. Both the model and the evaluation method used have been described in this chapter.

The final evaluation of the prototypes was made up of two parts: an experiment and a questionnaire, both requiring the participation of different categories of students. However, as the sample size was considered medium or small in all four experiments, the results achieved should be considered merely indicative, and useful for improving the prototypes.

In general terms, the experiments (four: one for each prototype) showed us that the majority of students felt quite enthusiastic about using this type of application and that it may have better results than expected. In fact, as this application is meant to be a substitute for attending classes, the main goal is to achieve the same results we achieve with face to face classes, and that happened with the majority of the prototypes and categories of students, as we can see in Table 9.

As we can see from Table 9, in general terms, the prototypes were efficient with 70% (54.5% +

Table 9. Results obtained for all four prototypes.

	Number of students whose results with the prototype were worse than results achieved with the face to face class	Number of students whose results with the prototype and the face to face class were the same	Number of students whose results with the prototype were better than results achieved in face to face class
Prototype with a class on image: (tested by 54 students)	0 (0%)	**16 (29.6%)**	**38 (70.4%)**
Prototype with a class on sound: (tested by 82 students)	16 (19,5%)	**66 (80.5%)**	0 (0%)
Prototype with a class on animation: (tested by 68 students)	16 (23,5%)	**52 (76.5%)**	0 (0%)
Prototype with a class on video: (tested by 32 students)	**32 (100%)**	0 (0%)	0 (0%)
Total (246):	**64 (26%)**	**134 (54.5%)**	**38 (15.5%)**

15.5%) of the students. However, when we consider each prototype separately, we can see that:

- The prototype with a class on image worked even better than expected. In fact, 70.4% of the students achieved better results with the prototype than by attending face to face class.
- The prototype with a class on sound needs to be improved. There is a particular category of students (those with Internet and sound file experience – 19.5%) who achieved better results by attending the face to face class than with the prototype. As this category of students is more demanding and dependent upon direct student-teacher interaction, one solution may be the improvement of the FAQ section.
- The prototype with a class on animation needs to be improved. There is a particular category of students (the ones with Internet and animation file experience – 23.5%) who achieved better results by attending the face to face class than with the prototype. As this category of students is more demanding and dependent upon direct student-teacher interaction, one solution may be the improvement of the FAQ section.
- The prototype for a class on video needs to be completely reformulated because 100% of the students obtained worse results with the prototype than by attending the face to face class.

It was possible to note from the questionnaires that the majority of students considered the prototypes to have an attractive design, to contain well organized information, to feature simple and intuitive navigation, to present subjects clearly, to be easy and motivating, to contain a sufficient number of examples and exercises, and to be a good substitute for attending classes. As for weak points, it was also possible to obtain enough feedback to improve the prototypes. In fact, the only problems consistently reported were slowness (in all the prototypes) and only average navigational structure in two prototypes (the prototype with a class on image and the prototype with a class on

video). In the prototypes with classes on sound and animation we felt that the FAQs sections had to be improved in order to become more user-friendly and personalized for a particular category of more demanding students, and those more dependent on traditional student-teacher interaction.

The results obtained were very encouraging and showed us that the production of this type of online applications should be encouraged. The enthusiasm and the results achieved by using the prototypes justify further development work, and at present the prototypes that were already perfected are being now used in the implementation of the final OMEA. As the Higher School of Management Sciences has currently several projects in place, namely, the implementation of an intranet and an e-learning system, the final OMEA contents are being developed in a modular fashion in order to be easily integrated with both systems. So, the goal is that in the future, the final OMEA may be integrated and made available, in the following order, through the following systems: the Internet, the school's intranet, the school's e-learning system and, when possible, in other standardized e-learning systems (LMS). As to the way in which the OMEA is going to be used: as a complete online substitute for the face to face classes students could not attend, as a tool to help/support the face to face classes (in the following tasks: examples demonstration, exercises resolution and evaluation tests), in students' evaluation processes and as a regular study tool/support.

Concluding, in a general way the use of these types of OMEA, inside or outside the classroom, brings considerable benefits to its users (students and professors), namely:

- Students who cannot attend the classes have access to the exact same contents presented at those classes without depending on others for help.
- Contents are available to anybody at any time from any place.
- Students easily understand theoretical concepts when associated with practical demonstrations via multimedia files with images, sounds, animation and video.
- Students in face to face classes do not need to be constantly concerned on taking notes all the time and may therefore instead pay more attention, dedication and immerse themselves in the learning process itself, by analyzing practical cases, solving exercises or simply discussing the subjects with the professor and colleagues.
- Professors have more time and feel more free to attend to students' solicitations and doubts;
- Students feel more motivated not only because they are using information technologies inside and/or outside the classroom but also because they are using real online multimedia educational applications and because their study methods are being modernized.

In conclusion, this was a worthwhile project since the goals were achieved. Considering that the development of this type of application is a complex process, the results obtained with the prototypes of the OMEA were very good, indeed better than expected. This project also allowed us to see that students are enthusiastic about learning through this type of applications and are prepared to use them.

A fundamental contribution to the prototype's success was the use of the educational software model described in this document, which for its simplicity of use and intuitive design we consider important to recommend.

Finally, with this work we contributed to the modernization of the study methods used by students and we have acquired more experience in planning, developing and evaluating Online Multimedia Educational Applications.

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