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A Multimedia-Based Course To Learn Basic Acoustics Through The Internet: Description And Evaluation

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Abstract
A course on Basic Acoustics has been implemented as an Internet site with multimedia resources such as Flash animations, video clips, etc. Multimedia resources are particularly suitable for acoustics, due to the special role played by sound. The constructivistic model of learning within the EHEA framework was taken as the most suitable approach. The students' overall evaluation has been positive, especially as regards the embedded multimedia resources. Furthermore, many comments taken from their evaluations and assignments have helped to correct deficiencies and to improve the course.

1. Introduction
The goal of our contribution to the MPTL14 is the presentation of (a) how we organized a course on basic acoustics accessible as an Internet site (Pejuan 2009), and (b) it how has been assessed by its addressees, the engineering students in our technical college.

2. Organization of the course for the Internet
The bases for the first part of our goal (organization of the course for the Internet) were the following: (1) Constructivistic model of learning, (2) EHEA format, and (3) Use of multimedia resources. (Of course, these bases are not of absolutely different nature, but rather on the contrary, there are cross-implications between each other!)

2.1. Constructivistic model of learning
As for the basis of the course, the constructivistic model was taken as the most suitable approach, especially taking the students' prior ideas about sound into account, which are far from being the scientifically accepted ones and also far from being consistent with a given mental model of sound.
The main prior ideas about the microscopic nature of sound which are not scientifically acceptable are, in short (Periago 2009):

a) Sound consists of air particles or molecules travelling from the sound source among the other particles or molecules of the transmitting medium.
b) Sound consists of "sound particles" (different from air molecules) travelling among the particles or molecules of the transmitting medium.

Therefore, the wave nature of sound had to be emphasized, also at microscopic level. It is most important that students internalize the wave model, because many other misconceptions about sound would change if students would have really internalized and assimilated this model and would apply it in a consistent way to the different properties of sound. Two examples of these "derivative" misconceptions are a presumed dependence between sound intensity and speed of sound and between sound frequency and propagation medium.

2.2. EHEA format
The course is the basis for an elective subject on acoustics for distance-learning, given yearly since autumn 2006. (Before, a similar elective subject had been already given since autumn 1997, but as a presential subject and with only few multimedia resources).
The main learning goals are: to describe sound mathematically as an oscillatory phenomenon and as a wave, to solve related situations numerically, to identify the sound features and the respective parameters, to know the theoretical background of the performances of musical instruments, and to acquire the basic concepts of architectural acoustics and digital sound processing, both at qualitative and quantitative level.
The EHEA (European High Education Area) format is clearly the desired framework for the future teaching and learning, at least in Europe. Therefore, we took this EHEA format for the mentioned

new elective subject. This was here easier, because there was already a previous subject on Basic Optics, which already followed this format (Novell 2009).
As a result, the course includes:

a) Theory, with a distribution as granulated as possible in web pages. As a result, these web pages were held as short as possible, usually with no need of scrolling down.
b) Problems to solve, each problem opening in a pop-up window. Each problem has a link to a second pop-up window with its solution and, if necessary, also hints to solve the problem.
c) Multiple-choice questions, each question opening in a pop-up window. Each one of the possible answers is linked to a respective pop-up window telling if the answer was right or, if not, why it was not right. In this way, the course provides self-evaluation means to the user.
d) Three "lab practices" with the own PC at home, with headphones and microphone. Each practice has detailed instructions for carrying it out and for composing the lab report. They are real practices, since the student has to analyze real sounds, taken with his own microphone or pre-recorded and downloaded as MP3 files.
e) Collaborative work: The students are distributed in working groups; each group has to choose an appropriate topic on acoustics by mutual agreement (otherwise the topic is chosen by the lecturer), in order to compose a paper as the result of the contributions of the group members. For control and assessment purposes, all the discussions on the topic, individual contributions, etc. of a given group have to take place (or to have their reflection) in a given Internet forum, which was created before in our Virtual Campus and to which only the group members and the lecturer have access.

2.3. Use of multimedia resources

Multimedia resources are especially suitable for a course on acoustics, since they can combine image and sound most conveniently, and sound actually plays the leading role in acoustics.
For their design, we accounted again for the students' previous ideas on the nature of sound and the pitfalls reported in the literature for visual learning materials (Leite 2001), as well as possible ways to avoid them (e.g. Treagust 2001), especially the use of "blended representations" as bridging analogies according to Podolefsky (2007) (see Fig. 1). There are also research results about multimedia material which were incorporated in the multimedia resources used (Altherr 2004, Gerjets 2009, Guan 2009, Hennessy 2007, Trindade 2002, Watkins 1997).
The multimedia resources used in the implementation of the course as an Internet site are Flash animations, sound, video clips and external applets. All of them fulfill the basic requirement to be always under the user's full control. In the following we are giving some examples of each resource.

a) Flash animations:

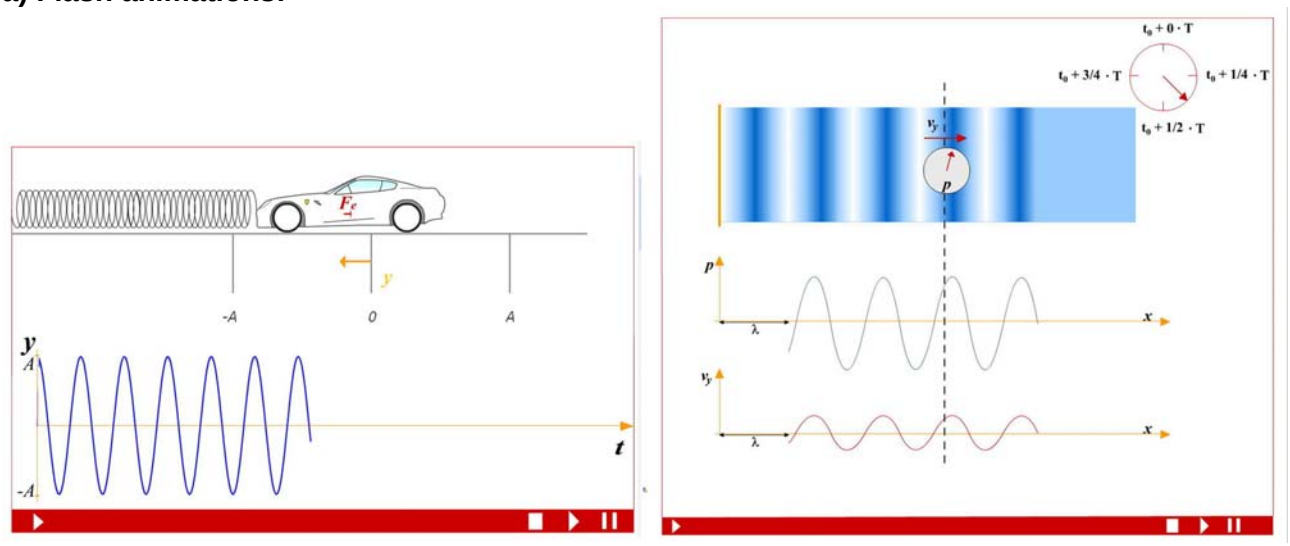

Figure 1: Descriptions of simple harmonic motion (left) and a sound wave in terms of mean particle velocity and acoustic pressure (right). Both descriptions are in the form of "blended representations".

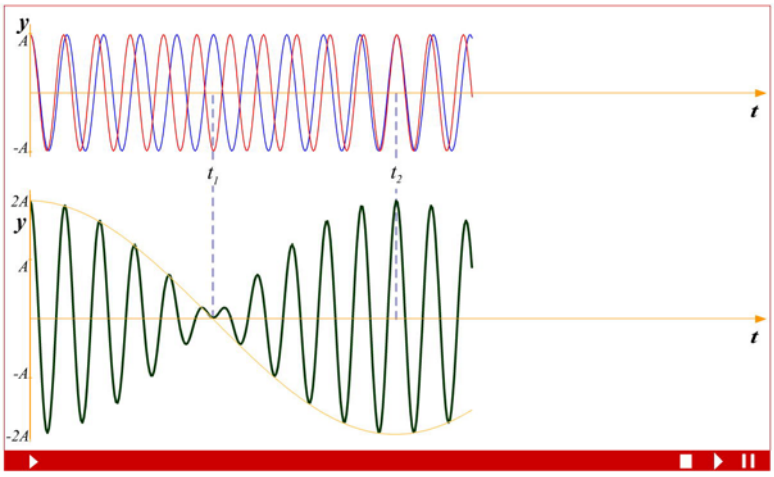

Figure 2: Animated illustration of the beat phenomenon.

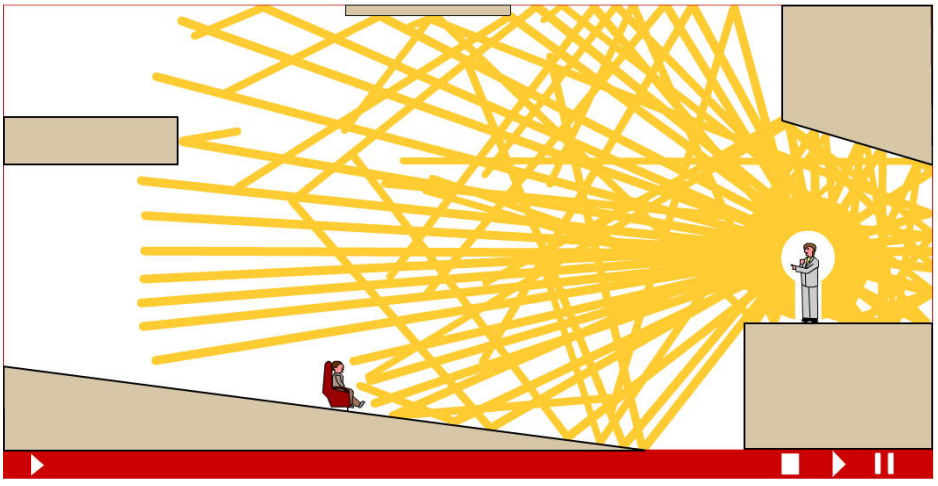

Figure 3: Animated illustration of the basic (Sabine) model for sound behaviour in closed spaces.

b) Sound (in two ways of embedding)**:**

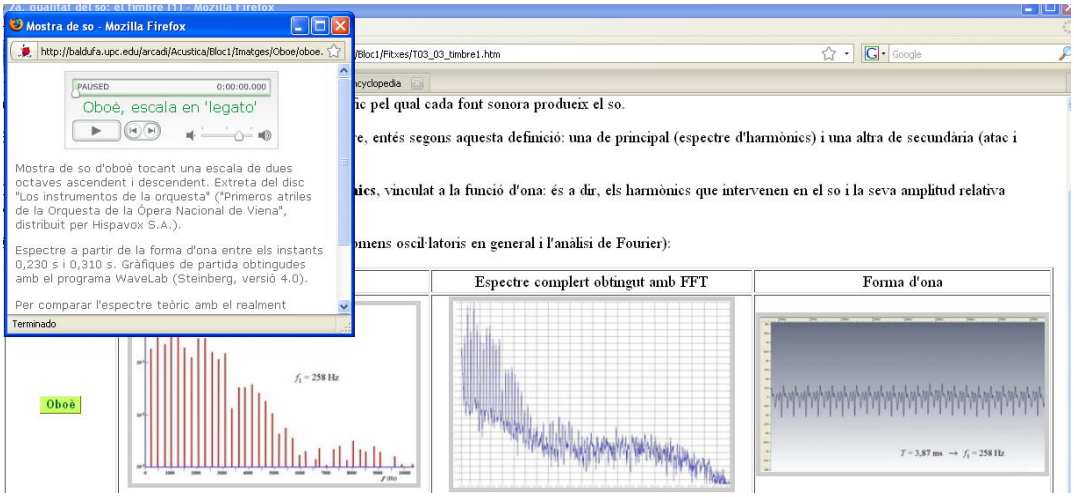

Figure 4: Sound samples for the explanations in the web page text.

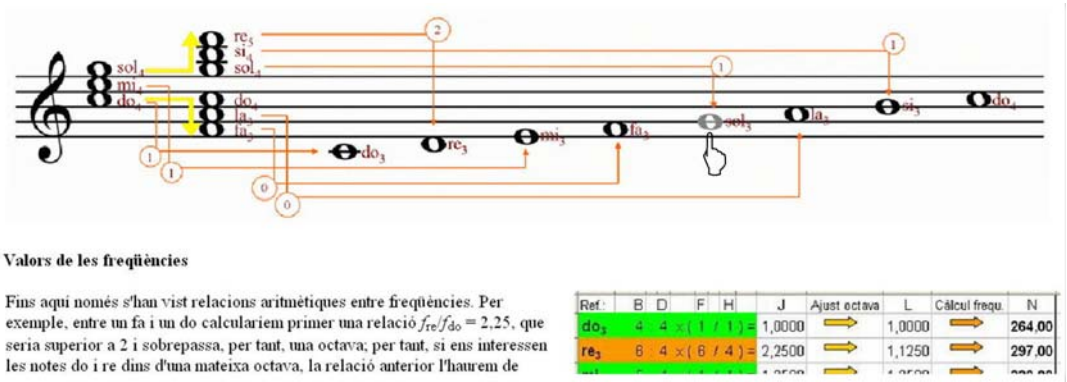

Figure 5: Sounds as a response to mouse clicks on images (musical notes) or text (frequency values in the table).

c) Video clips:

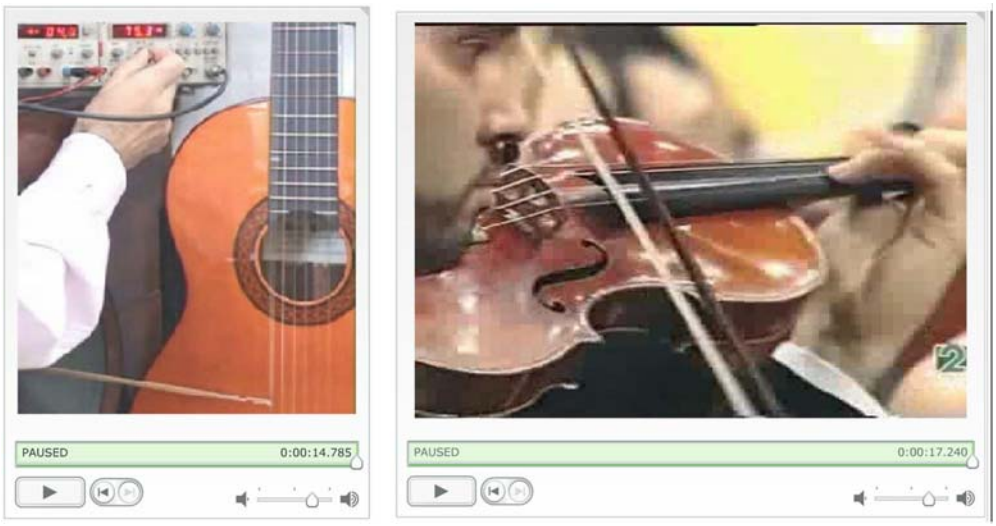

Figure 6: Recorded (own) experiment about the resonance phenomenon (left), and external video clip about the relationship between string length and frequency (right).

d) External applets:

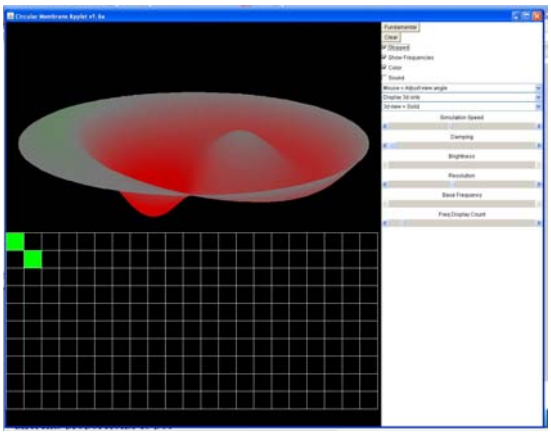

Figure 7: Applet on vibrational modes in a circular membrane, by Falstad (2009).

3. Assessment by students

Every year, students have been asked to assess the course features. In the last three years, 38 students have expressed their opinion in a questionnaire at the end of the course, after receiving their marks for the different parts of the course (homework assignments, lab practices, etc.);

answering the questionnaire provided just a small bonus, of course independently of the answers given. The questionnaire was presented with the aim of improving the course in the future. It contained questions with a numerical grading of different aspects of the course, as well as questions that had to be answered in free text (comments). The latter questions are more interesting here. For example:

- Compared to a text book or class notes, which advantages have you found in the course web site used as “theory notes” and collection of problems and multiple-choice questions?
- Which deficiencies or drawbacks have you found in the mentioned web site?

Their overall evaluation has been positive, especially as regards the embedded multimedia resources. Just two examples in their own words (only translated into English):

- “The theory is good, it is understandable and I like a lot the part of videos, sound samples and examples which are used to exemplify some parts. […]” (student of 3rd year of Telecommunication Engineering).
- “It is more interactive and there can be animations, videos, etc. which make much easier to understand the topic in question.” (student of 3rd year of Public Works Engineering).

Besides, this evaluation included comments about weak points of the web site. Also the students’ regular assignments included comments about weak points of some particular web pages. For example, some students complained about the partially confusing arrangement of the first home page, or about having difficulties to understand the text in some given web pages.
Of course, all these comments have helped us to correct initial deficiencies and to improve the course according to the students’ wishes and needs.

Acknowledgements

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