Two examples of education in Acoustics for undergraduate and young postgraduate students

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ACOUSTICS 2012

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This paper deals with two projects dedicated to young students in acoustics. First project is dedicated to undergraduate students and deals with the presentation of general acoustic concepts by means of musical approaches. In this project untitled "scientific concerts", we present the three characteristics of sound (intensity, pitch, timber) using multimedia animations, scientific presentation and musical examples played in real time by professional musicians. The presentation will show examples of animations and musical illustrations. Second project is dedicated to young postgraduate students who are entering the university (semester 1). The aim of this course is to discover the phenomenon of acoustic propagation outdoors and to use the scientific method (question, hypothesis, experiment, prediction, evaluation). This project is a mix between the Problem Based Learning method and the classical teaching (course, exercises). The presentation will show the structure of the course and some examples of results obtained by the students.

1 Introduction

Teaching of acoustics is proposed in France in several towns at different levels. The French society of acoustics SFA gives a list [1] of the different universities and engineer schools which allow students to follow this type of courses.

The teaching of acoustics at Université du Maine, in Le Mans, is now realised for the two levels Bachelor and Master enabling students to work as technician with a Professional Bachelor degree, as an engineer with a Master (MSc or Master Degree) or to stduy as a PhD student. Today, these courses are given to about 220 students for the Bachelor level and to 60 students for the Master Degree Level.

In this context, we develop specific actions for young students. On the one hand, we wish to communicate about these courses to high school students who are acoustics, sound or music fanatics. On the other hand, we wish that students arriving at the university can adapt gradually to undergraduate levels.

For this, we have recently developed two concepts for both types of public. First concept was born from the collaboration between professional musicians and researchers of the LAUM (Laboratoire d'Acoustique de l'Université du Maine) and is a mix between art and science. This concept is called "scientific concerts" and aims at presenting simply the fundamentals of acoustics for high school students.

Second project was born with the design of a new diploma, made for converting a two years teaching (DEUST Vibration Acoustique Signal) very well known and appreciated by industry into a Bachelor degree untitled "Engineer Sciences" ("Sciences pour l'Ingénieur" in French). The idea was to propose an original learning approach for semester 1 in order that many students can discover progressively the university working.

This paper presents these two projects. First section deals with the "scientific concerts". The principle is presented and some examples are given. Second section deals with the courses developed for semester 1 of the Bachelor degree. We present the general method and compare this approach with the "Problem Bases Learning" approach.

2 Scientific concerts

2.1 Context and objective of the project

Today, many projects mixing arts and science are proposed in different areas. Particularily, acoustics is a very good candidate for mixing science and arts, since music is very near from many physical problems such as room acoustics and musical acoustics. Some examples of project using art for presenting science exist in France, such as the "astro concert rock" [2] presenting astronomny. Another project mixing acoustics and music is also presented in France for preventing young people from ear damage. This project, untitled "Peace and Lobe" [3] presents the history of amplified music and the danger of high levels. The scientific concerts differ from this approach by presenting the physical aspects of acoustics which includes intensity, pitch and timbre.

The "scientific concerts" were created by acousticians and musicians working together at Université du Maine (Le Mans, France). The aim of this project is to present acoustics fundamentals during a concert for young students or non scientist people. For this, the mix between scientific presentation, real time demonstration and musical interlude enables the public to alternate between focus and entertainment. The music is played by a quintet composed of four saxophones and a drum. Moreover, many sound accessories are used in order to present demonstrations the three main sound characteristics.

2.2 Organization of the project

Today, the project enables to present the three major characteristics of the sound perception, sound intensity and loudness, pitch of sound and timbre.

From the scientist point of view, this musical conference can not be treated as a classical conference for which the talk can be improvised on the basis of the scientific knowledge. In this particular concept, the whole talk has to be completely written and known in order to present only the important ideas and to respect the timing.

The scientific presentation is based on a series of web page developed by the "Pôle de Ressources Numériques" at Université du Maine. These pages contain flash animations, videos and sounds to illustrate the three different concepts.

The production has been worked with an art director in order to make the oral presentation fluent and easy to understand.

2.3 Scenario contents

We present in this section the contents of scientific presentation done in the "scientific concerts" for the three different parts.

2.3.1 Sound loudness

Scenario of the first part (sound loudness) is presented in figure 1 and show how oral presentation, sound demonstration and musical excerpt alternate to make the concept clear for listeners. This scenario is built in three major parts. First part aims at discovering the phenomenon with perception, second part presents physical aspects of sound loudness, than last part is dedicated to decibels and danger of high levels.

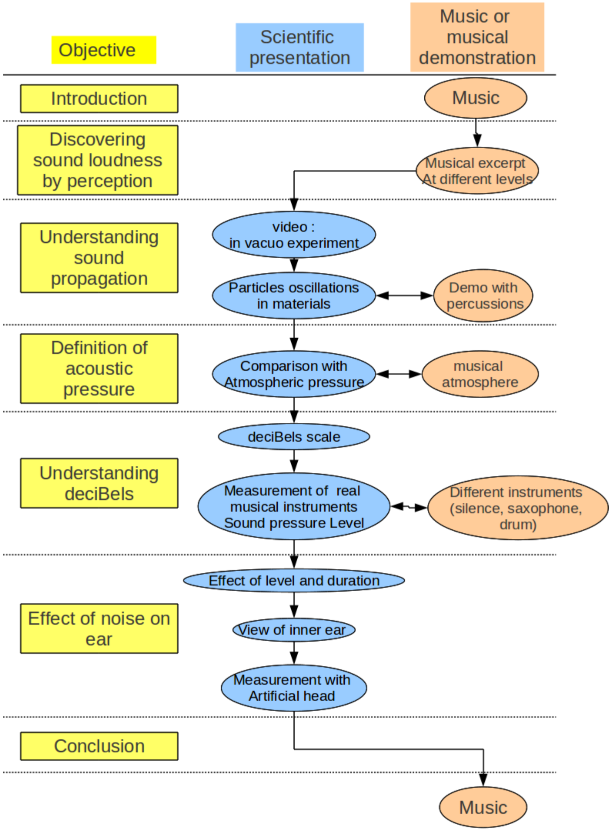

Figure 1: Sound loundness scenario.

The most important aspect of this part is to understand that acoustic pressure is a very low variation of atmospheric presssure and that these very low pressure variations lead to high acoustic levels which can damage strongly the ear. For this, we use a analogy between atmospheric and acoustic pressure as shown in figure 2.

Figure 2: Analogy between atmospheric pressure and acoustic pressure. (a) View of the atmospheric effects. (b) schematic view of of the acoustic effect.

Real time measurements of acoustic levels while musicians playing are performed in the middle of room and at the drummer ears. The effect of the listening duration is also presented in order to prevent young people to listen music at high level during a long time. A original tool, called "acoustical head" developed by ESEO is used in order that young people measure the level of their own music player (mp3).

Figure 3: Acoustic head used for measuring acoustic level of music players.

2.3.2 Pitch

The aim of this section is to show the relation between pitch perception and frequency. Pitch is illustrated by listening to different musical instruments and simpler sounds, such as a tuning fork or a glass excited by friction. Drum brushes which produce a random noise which pitch can not be identified are also played. Specific phenomena such as the missing fundamental are not presented. The signals produced by the pure tone sources are observed on a real time oscilloscope presented to the public. Real time signals enable to introduce the period and the fundamental frequency of a simple signal (sinusoid). The comparisons of two different sounds (tuning fork at 440 Hz and singing glass at 600 Hz) enable the public to link between the perception of pitch and the fundamental frequency represented by the number of oscillations per second shown by the real time oscilloscope. An example of Flash animation explaining the sinsuoidal signal is given in figure 4.

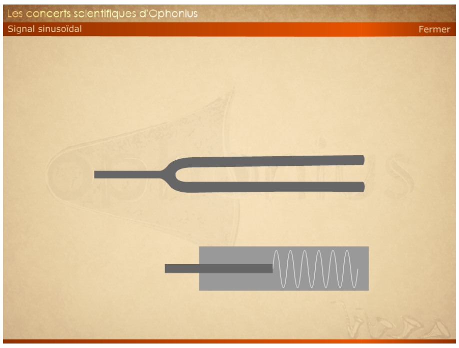

Figure 4: Presentation of the sinusoïdal signal in order to explain the role of the fundamental frequency in the pitch perception.

2.3.3 Timbre

The timbre is illustrated by musical examples generated by two different instruments (flute, and soprano saxophone) playing the same tune at the same loudness. Then differences in the sounds emitted by different instruments (tuning fork, flute, saxophone) are analysed in real time using the RTSPEC software [4]. The analysis of the real time spectra of periodic sound (tuning fork, flute, saxophone) gives the listeners the understanding of the fundamental frequency and harmonics.

Differences in the spectra enables to show the differences in timbre. Finally, the signal produced by drum brushes and applause are analysed in real time, which permits to show the concept of non tonal sources like random or pseudo-random noise.

2.4 Diffusion of the ”scientific concerts“

The ”scientific concerts“ have been designed and have been presented for the first time at the end of year 2009. Today, they are going to be presented in the frame of a project concerning diffusion of knowledge to young people in Pays de la Loire in France. This project aims to attract young people to scientific carriers and to show the role of science in the society. The scientific concerts will be given in high schools to present acoustics and to enable young people to meet researchers in acoustics.

3 One example of acoustic teaching for postgraduate students

3.1 Context and objective of the course

This project is conducted in the frame of an acoustic course given to young students at Université du Maine, in Le Mans. This course is proposed during semester 1, to students who did not learn acoustics in high school. The general aim of this course is to adapt the teaching for going gradually from high shool teaching to university teaching. Second semester is realised in a more classical way (course, exercices, practice).

The educational aim of this project is the following. Students should be able to

- conduct a scientific method (question, hypothesis, experiment,prediction, evaluation),
- model and measure acoustical phenomena related to the geometrical attenuation law of sound intensity,
- present their work clearly.

We choosed to propose a teaching based on the concept of project in order that all the different courses provide knowledge in relation with a scientific question asked to students at the begining of the course. PBL (Problem Based Learning or Project Based Learning) gave us interesting information for designing our teaching. However, we did not apply all the principles of the PBL method and we choosed to build a course made of a mix between traditional teaching and PBL method.

3.2 Project Based Learning

In Problem-based learning (PBL), students learn by solving problems and reflecting on their experiences. PBL is well suited to helping students become active learners because it situates learning in real-world problems and makes students responsible for their learning [5]. This ”active pedagogy“ enables the student to be interested in the course, to become autonomous, to acquire knowledge, to develop the work inside a team, and to develop their motivation. Some examples of PBL exist in acoustics and are dedicated for Master students [6] or to non acousticians [7].

Non exhaustive basic elements of PBL are given below [8] and are used in the following of the paper to show the distance between our teaching and a PBL teaching:

- Students work in little groups with 12 participants maximum.
- The objective of the project comes from true life or professional life.
- The work is done alternatively inside the group and alone at home.
- The objective of the different steps of the project are clearly defined. The different steps of the project are clearly organised along the time.
- Regular evaluations are performed in order that students can measure their levels.
- The expected skills of students are clearly written (the student should be able ...)
- The progressing method is deduced from professional situation.
- Experimental approaches are realised at first to illustrate the phenomena.

3.3 Geometrical Acoustic Attenuation Learning

We present in this section the organization of the course dedicated to the discovery of acoustic wave propagation in free field (geometric attenuation). This course is organized in five weeks as shown in figure 5.

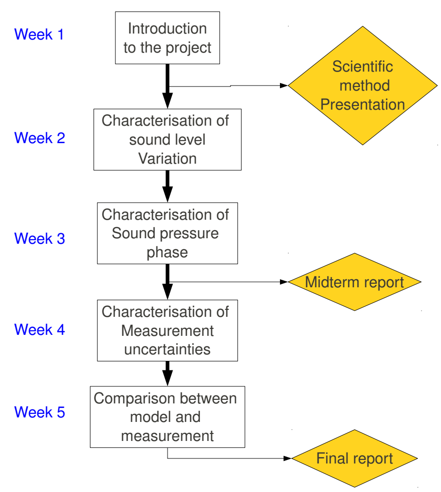

Figure 5: Structure of the teaching during the five weeks.

3.3.1 Presentation of the scientific method

One of the aim of this course is that student understand and discover the scientific method along the five weeks. This method is structured as presented in figure 6. This structure is one of the different models that can be used. It shows the usual approach we use in acoustics. All the courses are organised following this structure.

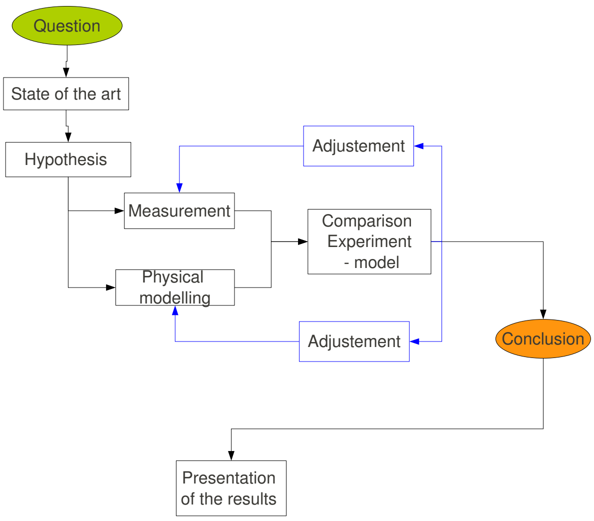

Figure 6: Scientific method principle.

3.3.2 Organisation of the courses

The organisation of the courses is shown in figure 7. All these courses are given along the five weeks following the progression shown in figure 5.

propagation project.pdf

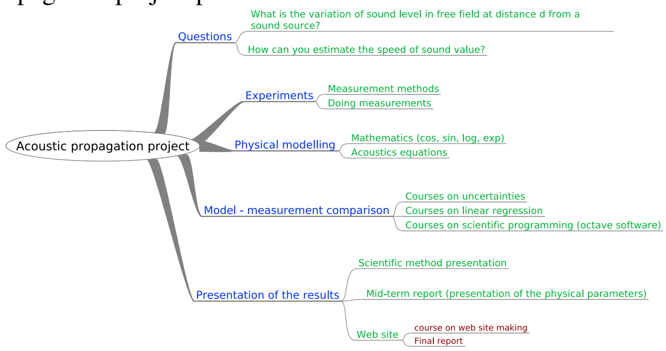

Figure 7: Different courses given inside the project.

3.3.3 Evaluation of knowledge

Students have to produce three intermediate reports presenting, the scientific method, the structure of their project (with preliminary results) and have to build a website which presents the whole project including the scientific method. Each week, the students must write a report which presents the experimental results respecting the code of scientific writing. The teacher returns this report in order to make that the student learns how to write a scientific report. Finally, teaching evaluation have to be done by students each week so that they can auto-assess their knowledge level.

3.3.4 Comparison with PBL

This project teaching uses courses which are all connected to a particular question asked at the beginning of the project. However, we can not call this approach PBL since differences exist between PBL and this particular approach as shown below :

- Students do not work in little groups with 12 participants maximum. We have to organize measurements with 16 or 18 students.
- The objective of the project comes from true life. Indeed, the question concerning sound level asked at the beginning of the project can be observed regularly. Moreover the question about the speed of sound was treated by scientists in the middle of the eighteenth century.
- The student have to do some work inside a group when making experiments and has to write reports alone at home.
- The objective of the different steps of the project are clearly defined. The different steps of the project are clearly organised along the time.
- Regular evaluations in the different courses are performed in order that students can measure their levels. Students have to do one or two evaluation in a week.
- The expected skills of students are clearly written
  - they should be able to conduct a scientific method
  - they should be able to measure a sound level amplitude and a phase difference with a specific measurement chain
  - they should be able to estimate the value of the sound speed using the scientific method
  - they should be able to estimate the validity of the geometric attenuation model.
- The progressing method is based on the scientific method, deduced from research activity.
- Experimental approaches are used at first to illustrate the phenomena. However, theoretical courses are given in parallel during the week.

4 Conclusion

This paper presents two different approaches used for presenting acoustics to young undergraduate and postgraduate students. First approach is a combination between science and art and enables to explain the three major characteristics of sound (loudness, pitch, timbre) during a concert, called ”scientific concert“ using physical presentations, sound demonstrations, and musical interludes. In the future, we hope to develop new modules for presenting the physics musical instruments and room acoustics in the frame of the ”scientific concerts“.

Second approach is a teaching based on a project dealing with sound propagation in free field. The Project Teaching (PT) has been designed using some elements of the PBL (Project Based Learning). Students have to answer questions about sound propagation by following a scientific method. This method enables to organize the different courses such that all the knowledge given to the students can be applied in the frame of the project.

Acknowledgments

The authors acknowledge Ophonius' musicians for helping in the design of "scientific concerts" and acousticians colleagues from LAUM for the design and implementation of the teaching project method at Université du Maine.

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