A teaching approach about acoustics integrating different ICT and combining knowledge from different fields

Roser Pintó, Digna Couso, Julian Oro
CRECIM, Universitat Autňnoma de Barcelona, Spain, crecim@uab.es

Abstract

A teaching sequence about acoustics has been prepared for a school-university partnership with secondary school students without prior instruction on the subject. It is implemented in a computerized laboratory at the university and different ICT tools (applet, simulation software and MBL) are integrated. Research studies of science education, pedagogy and psychology provided foundations for the sequence. The paper describes many of the different and relevant components that a sequence needs to integrate for taking benefit of the theoretical knowledge from the above fields. Analysing outcomes from a teaching sequence without taking care of the teaching approach used can disguise the real results or lead to misinterpretations.

Rationale

The elaboration of evidenced-based teaching sequences that has to be applicable in real situations turns out to be an integrative process that needs to take into account research results coming from different and separate fields. This means that knowledge from pedagogy, from psychology, from science education and, of course, from science itself, have to be combined. Moreover, if it is decided to integrate some informatics tools along the sequence, it is also necessary to incorporate knowledge from the ICT field: suitability of the tool, properties, etc. In the sequence presentation it is opportune to suggest some teaching approach for an efficient way of using the sequence in a specific context and for a particular school level (Andersson, 2003).

For us, teaching Physics in school is conceived as one of the school activities and so, as an element that should contribute to the general education of the student developing their cognitive capacities as well as the social ones, encouraging both their knowledge and their skills, promoting their positive attitude for science issues as well as for learning in general. We cannot disengage a Physics teaching sequence of the environment where it will be taught and so, the approach that the teacher will offer. The achievement of the objectives is not only influenced by the selection and sequencing of the contents but also on the teaching approach, the class atmosphere, the way to propose the students' activities, etc. Differently said, the learning outcomes are very much dependent on the teachers' conceptions about understanding and learning and, on the circumstances taken into account when planning and when implementing each piece of the sequence.

Under such perspectives, we present relevant steps of an innovative sequence about acoustics integrating activities proposed for students using three different informatics tools. Its selection and the suitability of each of them according to its peculiarities are also described. The sequence relies on research results about the teaching and learning of waves (from Maurines 2003, Witmann et al. 2003, Tarantino et al, 2005), and about general principles on learning and understanding Sciences (Donovan and Bradford 2005, Gunstone 1999 Schraw et al 2006), on sequencing science contents (Buty et al. 2004, Leach & Scott 2002, Meheut and Psillos 2004) and on reading images (Kress 2006) etc.

A teaching sequence integrating applet, freeware application and MBL technology

Our intention here is to present an evidence-based teaching sequence that is being changed according students response trough a process of developmental approach (Lijnse, 1995). The main goals of the sequence are to make pupils aware of sound pollution, increase pupils understanding of what is sound, how it is produced and how it can be attenuated and also to make teachers cognisant of ways to integrate different ICT in science classroom. Pieces of research around students understanding each of the concepts involved, about using the ICT and, about the sequence' utility for teachers' professional development are no matter of this paper.

An special scenario: REVIR

The scenario where the sequence is implemented is not usual. The REVIR is an initiative of the research centre CRECIM in which secondary school students of Catalonia have access to a computerized laboratory at the University (Faculty of Education). CRECIM prepares teaching sequences addressed to some scientific content integrating different ICTs. Students 12-16 years spend a complete morning working in small groups with specific material prepared for the session. The teachers of these students attend also the session in order to observe students' response working with computer tools and possible ways to implement them in their own lessons.

Relevant features of the sequence on acoustics for students 12-14 without prior instruction

1. Contextualizing and intrinsic motivation. Establishing a central core

From the literature we know that in order to allow intrinsic motivation to develop, three basic needs should be addressed: (1) the support of autonomy, (2) the support of competence and (3) the support of social relationships. (Krapp 2002 and Mikelskis-Seifert, 2005). This view was considered when planning the sequence.
As a way to engage students in the subject, the sequence begins posing a meaningful problem to the students:

We are a rock band practising in the attic of a building. The police have come while we were practising due to some complaints from the neighbours. We must reduce the sound intensity but we have no other room for our essays. How shall we manage?

Our purpose is to place students in a real context with some significance for them and to give directionality to the tasks that will be done during all the session.

To become engaged in solving a question, to feel challenged of finding a solution of a problem or satisfying a curiosity are reasons for an intrinsic motivation. We wish students experience a **need to know** (Lijnse & Klaassen, 2004) and such approach seems to be successful.

2. Communicating the session goals

For helping students to face this complex problem within the time limitations they have, some material has been prepared which guide the students across the different steps necessary to solve the problem.

However, before starting we try to assure that students understand the steps of the general sequence, become aware of what is expected from them and be clear about our final goals. So, students' **metacognition** is promoted in order they can anticipate their way to work.

What we need for solving the problem?
In order to know how to reduce sound intensity it is necessary to recognise it. That drives us
1. Understanding what is sound, from the physics point of view
2. Working with special instruments for visualizing sound.
3. Analysing sounds produced by students' voice.
4. Analysing sounds produced by musical instruments or an amplifier
5. Measuring sound intensity
and, at the end:
5. Find ways for reducing the sound intensity produced bv the rock team

Fig 1

3. Exploring students' preconceptions

Sound and noise belong to the students' everyday experience and so, it is expected some previous rudimentary mental representation about them. Students are asked some questions for their conceptions to emerge, which later, through engaging in a socratic dialogue, can be driven to the interest/need to know what sound really is.

4. Building the wave concept by means of an applet

An essential idea for understanding sound seems to be the concept of longitudinal travelling wave. A feasible way to introduce it to students is to use an applet, which overcomes the general difficulty of static representations of dynamic phenomena. As Monaghan & Clement point out *"simulations are particularly useful to scaffold students in their* ***building of mental representations*** *of not "easily" visible models or phenomena (DNA, radioactivity, etc). The created mental images should play an important role in understanding and learning. There is growing evidence that forming a visualizable model as a representation that is more general than single examples, but not as abstract as mathematical, may be central for understanding in science students"*. (Monaghan & Clement 1999).

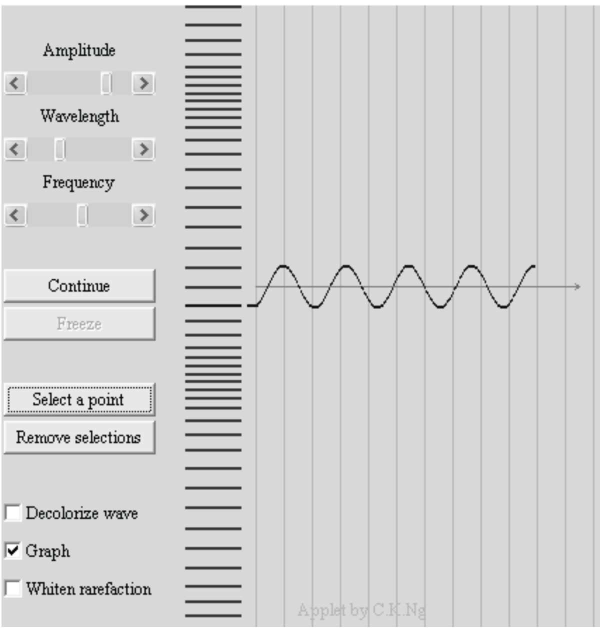

Fig 2

Which simulation or applet to chose? As Tarantino et al. (2005) remark when referring to wave propagation, students find very difficult performing the shift from the two levels of representation: one involving the analysis of the pulse as a whole and the other one describing the behaviours of the atoms/molecules of the medium. We selected an applet that seemed to be able to avoid such difficulty, showing the relation between both representations. The following image gives an idea of the applet we have used. Graph is interpreted as the representation of the change of pressure evolution of air particles.

http://www.ngsir.netfirms.com/englishhtm/Lwave.htm [19]

5. Analysing waves using Audacity

Having understood the link between the sinusoidal representation of sound waves and the actual variations of pressure of air molecules (sound), students are at this point ready to analyse sound waves. With this purpose, we use the freeware application Audacity, which objective is to reinforce the construction of the wave model and, as well, to make students aware of wave's diversity.

Students analyse the waves of their sounds in front of a microphone by means of Audacity, which draw graphs Δ pressure-time. Students feel very engaged in using an ICT allowing them to see results of their own real actions (with the voice) reflected in the computer screen. The application makes possible that students realise that an specific sound, as the one of a vowel, has a very similar shape on the screen, whatever the emitter/student.

[19] The meaning attributed by students to the representation in the applet was analysed to detect its efficacy but, it is not here the place where to describe its results.

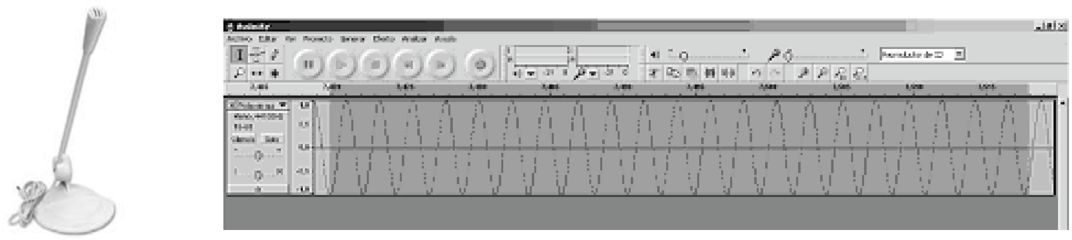

Fig. 3

The work with waves having similarities and differences makes easy to establish the need of new concepts such as **period** or **frequency**. These two scientific terms evoke something coming from the waves of their own sounds and usually they actually become meaningful along the activity. The scaffolding process of this task for such knowledge construction is reinforced by students working with their peers in small groups along the whole session.

6. Extending concepts to different contexts

The generalization of the concepts of wave, period or frequency can be achieved by applying them to different musical instruments. Sounds from real instruments or from computer files corresponding to some frequency (i.e. 440 Hz) are also represented and analyzed with Audacity.

7. Linking each new step to the central core

The students' enthusiasm analyzing their voice cannot hide the main objective of the session: to solve the "rock team problem". Students are warned about the steps covered and the ones that are lacking. Along the path teacher retrieves and continuously establishes links among the pieces or fragments. We assume that: *"Information stored in memory, if organized around core concepts, can be much more effectively retrieved and applied than isolated pieces of information. The reason that experts in a field remember more than novices is that the former see information as organized sets of ideas and novices see it as separate pieces"* (Donovan & Bransford, 2005).

8. Realising the need of new instruments and recognizing the limits of Audacity

Until now, Audacity has supplied graphs representing the pressure-times of a single point where the wave is travelling but no any graph that would indicate the pressure that different points of the path receive in a particular moment (graph Δ pressure-position). Measuring the changes of sound pressure in different points, that is the level of sound, close or far from the sound source, should be done through new equipment.

9. Measuring levels of sound with MBL technology

Now students learn to measure levels of sound. They can establish certain relationship between the sound they perceive and the sound level that a sonometer measures (in decibels). Sounds, as computer files, opened through Windows Media Player, are reproduced by loudspeakers connected to the computer and registered by the sound sensor.

10. Integrating concepts

Scale intensity in dB and Pa is presented and some exercises proposed in order to integrate the previously built concept of change of pressure in particles of air (Pascals) and the new but more familiar one: sound level (dB). As Taber (2006) says: *"Learning topics as isolated chunks of knowledge is less useful, more difficult and a lot less inspiring than a learning experience that reflects the conceptual integration that characterizes science".*

11. An inquiry activity: Retrieving all the previous concepts needed to solve the preliminary problem through an open-ended labwork

At this moment, students are able to interpret the meaning of sound waves and to measure sound levels at different places. So, they are "equipped" to solve in a scientific based manner the "rock team problem".

To solve the problem of attenuating the sound produced for their loudspeaker, students can use, at their own will, some boxes covered with different insulating materials. The instrument for measuring will be the sonometer of MBL equipment. This inquiry activity requires to think about the best experimental design to get clear conclusions.

12. Revising the sequence. Including a model of sound absorption

Having obtained evidence of the students' self-construction of mental representations about the reasons for the sounds absorption, we have included in the teaching sequence some rough ideas of reflection, refraction and diffraction of sound waves. The sequence was revised. Agreeing with the developmental research approach (Lijnse, 1995) the evaluation of the sequence drives to subsequent redesigns that are driven from theory-based expectations and from students' products and responses.

In brief

To summarize, we have presented a research based teaching sequence integrating different informatics tools, each of them appropriate for a specific purpose. The sequence has the perspective of a teaching approach that considers the social construction of knowledge, the relevance of understanding, categorizing and relating pieces of knowledge, the needs of an intrinsic motivation, the significance of making students aware of their progress, the teachers' importance of knowing the starting point of students. Our standpoint is the consideration that the elaboration of teaching sequences is an ongoing process of refinement that tries to join knowledge from very different fields, it intends to fit into students' needs and responses and develops through the analysis/research of its results.

References

Andersson, B., Frank Bach, F., Hagman, M., Olander, C. & Wallin, A. (2003) Discussing a rationale for the design of teaching sequences. In ESERA 2003 Proceedings: http://www1.phys.uu.nl/esera2003/programme/session2.htm

Buty C., Tiberghien A., Le Maréchal J-F. (2004). Learning hypotheses and an associated tool to design and to analyse teaching-learning sequences. In Méheut & Psillos (eds), International Journal of Science Education, 26:5, 579-604.
Donovan, M.S. and Bransford, J.D. (as part of the National Academy of Sciences Committee on How people learn). (2005) How Students Learn: History, Mathematics, and Science in the Classroom. National Academies Press, Washington
Gunstone, R. (1999). The importance of specific science content in the enhancement of metacognition. In P. J. Fensham, R. F. Gunstone, & R. T. White (Eds.), The content of science: A constructivist approach to its teaching and learning (pp. 131–146). London, England: The Falmer Press.
Krapp, A. (2002) Structural and dynamic aspects of interest deveplopment: theoretical considerations from an ontogenetic perspective. Learning and Instruction, 12, 383-409.
Kress, G. & van Leeuwen, T. (2006) Reading Images. The Grammar of Visual Design. Routledge.
Leach, J. & Scott, P. (2002). Designing and Evaluating Science Teaching Sequences: An Approach Drawing upon the Concept of Learning Demand and a Social Constructivist Perspective on Learning. Studies in Science Education, 38, 115-142
Lijnse, P. (1995). "Developmental Research" As a Way to an Empirically Based "Didactical Structure" of Science. Science Education, 79(2), 189-199.
Lijnse, P., & Klaassen, K. (2004). Didactical structures as an outcome of research on teaching-learning sequences? International Journal of Science education, 26(5), 537-554.
Maurines, L. (1993) Spontaneous reasoning on the propagation of sound. In: J. Novak (Ed.) Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics. Cornell University, Ithaca, NY
Meheut, M. & Psillos, D. 2004 Teaching – learning sequences: aims and tools for science education research. International Journal of Science Education (special issue), 26 (5). 515 –652.
Mikelskis-Seifert, S. Muller, C.T. Physics in Context: Implementation of new instructional concepts - findings on thedevelopment of students' interest and motivation. In Pinto, R and Couso, D. (eds.), Proceedings of the fifth international conference of ESERA (Barcelona, Spain)
Monaghan, J. M. & Clement, J. (1999). Use of a computer simulation to develop mental simulations for understanding relative motion concepts. International Journal of Science Education 21, 9, pp. 921– 944
Schraw, G., Crippen, K.J., & Hartley, K. (2006). Promoting Self-Regulation in Science Education: Metacognition as Part of a Broader Perspective on Learning, Research in Science Education 36: 111–139
Taber (2006) Conceptual integration: a demarcation criterion for science education? Physics Education, July 2006, pp286-287
Tarantino, G., Fazio,C., Guastella, I. (2005). Designing and Validating a Teaching/Learning Sequence about Elastic Wave Propagation: The Role of Pedagogical Tools. In Pinto, R and Couso, D. (eds.), Proceedings of the fifth international conference of ESERA (Barcelona, Spain)
Wittmann M.C., Steinberg R.N. & Redish E. F.(2003) Understanding and affecting student reasoning about sound waves, International Journal of Science Education, 25, 991-1013.