Institute of Phonetic Sciences,
University of Amsterdam,
Proceedings 24 (2001), 147-154.

A DIGITAL LEARNING EXAMPLE IN PHONETICS[1]

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Abstract

In this paper I will give a short overview of what Digital Learning (DL) is and why it might be very useful. I will focus at the digital content that is needed for DL. Based on my experience from another university I worked with, I developed two digital applications in my former research area: acoustical phonetics. The results show the added value of DL in the case of the treatment of the relation between shape of the vocal tract and the resulting vowel sound, with just the use of rather simple tools, for example MS Excel. I will make a suggestion for the set up of a typical acoustical phonetic DL unit: its components and some examples of content. Finally, I will give a short survey of some my own experiences in building DL units and the use of the applications in teaching

1 Introduction

The last three years I did much work as a consultant and senior lecturer at the University of Higher Professional Education of Amsterdam (HvA) at the Economics Department on developing digital content for my students of Finance and Accounting and trend watching in digital learning. As I have nearly every year some reason to visit my former colleagues at the phonetics institute, there are many occasions to discuss applications to phonetics of what I've learned in other disciplines. So happened last year: being invited for a lecture about my experiences in digital learning, I immediately caught the idea to please my former colleagues with an example of DL taken from one of my former research topics: the relation between vocal tract shape and produced vowel. I was highly satisfied when I watched the power of the application of rather simple tools as for example Excel in those models of acoustical phonetics which were in those 80's so hard to imagine for my students. And for me so hard to explain to them with just crayon and (the classical) blackboard.

[1] Based on a lecture held for the scientific staff at the Institute of Phonetic Sciences, Amsterdam, February 2001.

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[3] If you would like to know more about the subject of DL just contact me by e-mail at: Stella.Polaris@quicknet.nl

In this paper I will in short explain what digital learning might comprise, what you could do in DL, and what is even more important: what you shouldn't do. My contribution will end with the rather simple, but instructive, examples I developed to study the relation between vocal tract shape and vowel sound.

I hope you will take some advantage of the lessons I learned in DL. For a more thorough guide to DL and related stuff I may refer you to for example: Prentice Hall's on line Distance Learner's Guide (www.prenhall.com/dlguide) or Mirande *et al.* (1997).

2 Digital learning, or how do we call it?

What's in a name? A name is just a handhold for us to indicate what we are talking about without having to mention each time its underlying definitions. Unfortunately, some sciences suffer from discussions (or maybe: from people who discuss) about the one-and-only definition of a specific concept. The same applies to the field of learning with computers. It's about the same as quarrelling about for example the definition of the flu: which are the symptoms of it. Everyone knows that not always all the symptoms that are characteristic for the flu really do show up. It's the same story with learning with computers: so many people so many definitions, because people like to underline they are looking at the subject from a *different* point-of-view. Sure, most of these names indicate different types of use of the computer in learning, but that is not what I want to deal with in this paper. For this reason I will use the rather neutral term of digital learning (DL), with which I want to express that I focus on the *digital content* that is being used for learning.

The main characteristics of DL in its most wide sense normally comprise *some or all* of the following aspects (remember the flu example):

- Digitization of the course material (of course)
- Place independency (availability independent of where the student is)
- Pace independency (the student may study at his own pace)
- Web-based (using web technology such as browsers, etcetera)
- Asynchronous (lecturer and student are not necessarily on line at the same moment)
- Interactivity (i.e. there is some sort of interaction between the student and the material)
- Collaboration oriented (for team work)

Normally, one chooses from such a list the specifications considered to be important for the DL. That is the reason why the list of terms in the area of DL is still growing (e-learning, virtual classroom, web-based training, etcetera).

3 Components of DL

The infrastructure for DL consists of three parts, as visualized in Figure 1:

- Communication (for example FTP, webmail, chat, discussion groups)
- Content management system (CMS; for example Blackboard, Lotus Learning Space or WebCT)
- Content (for example an applet to demonstrate how a model works or a course).

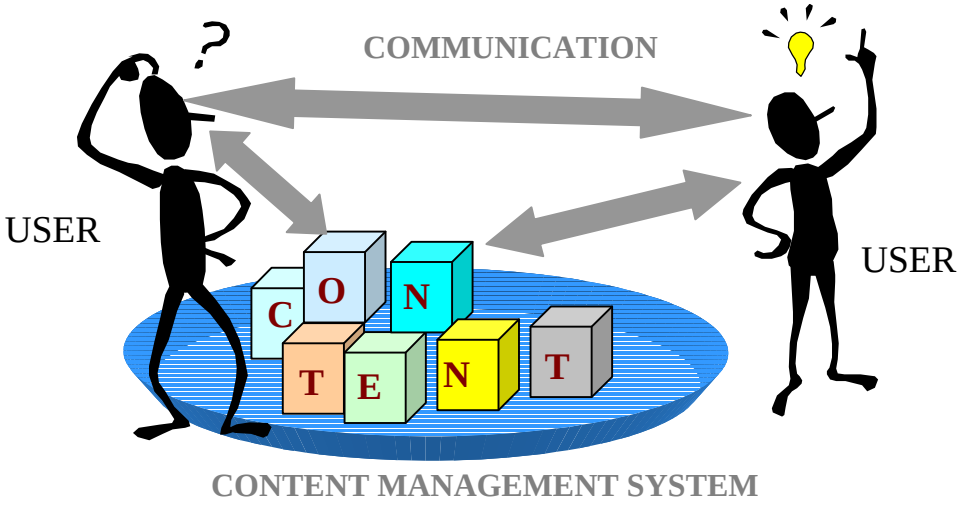


Fig. 1: The components of Digital Learning: Content, organized in a Content Management System, communicated electronically to and between users. My focus is at the *content* we offer our students.

Content is the most basic part of the system; by content I mean: the stuff we are talking about with students when we are teaching classes, but in digital form, for example a model of the distribution of sounds in vowel space made clear in a spread sheet.

If we would like to manage or distribute our digital content to our students we do need some sort of medium, just as we need for example Windows 2000 or Linux to do some manipulations with our files. Normally, by CMS is being meant for example Blackboard (which is the main stream of platforms in the Netherlands; website: www.blackboard.com) or WebCT (www.webct.com). CMS's are mainly used for their features with respect to content organization, communication abilities or student management. I must emphasize that nearly all type of content distribution is also possible from a simple website without any use of Blackboard nor other CMS, as long as you are not interested in student management etcetera.

By communication I mean every sort of inter-human communication by means of computer-to-computer communication: from File Transfer Protocol (FTP, file transfer from one computer to another) to discussion groups.

I am just interested in content and that is what this paper is about.

4 Why should we be interested in DL?

All participants in the educational process may take advantage of DL:

- The student who may take an individual routing through the course(s)
- The lecturer who may reuse parts of older work, and who may make quick and less expensive updates
- The organization that scores in public relations towards future students and customers.

Sure, it is hard to count how much you did win by introducing DL, especially if you take into account other aspects than the financial point-of-view. It is easy to consider the low costs of electronic distribution as very attractive, but on the other hand, the costs of development digital content are very high and don't pay back that

soon. What matters, is what *you* consider a valuable outcome for your organization, for example: less costs of distribution and a higher grade of student satisfaction.

5 How to develop good content?

You need the same skills for developing content as you needed for the writing of your course book in former days, PLUS some other capabilities. The major extra needed skills are:

- Technical: how do you realize an application of for example an acoustic model of speech
- Logical: the application MUST work smoothly and correctly
- Sense of design: it must be attractive to your students.

Above all, if you are thinking to work together with other people, you must stick to some standard. There are many standards, but a good reference can be found at: www.cenorm.be/isss/Workshop/lt/ from the European Committee for Standardization CEN.

6 Two examples in acoustical phonetics

I have talked enough about why and how we should be interested in DL. Let's now turn to the two examples I have developed in order to show how great the difference may be between those old days and nowadays, using DL.

The example I have taken from the basic theory of acoustical phonetics in which we try to provide for a simple, understandable, model of the relation between the sound produced (in this case: vowels) and the shape of the vocal tract. I have done work in that field, especially Bonder (1983) is relevant, here. In the paper cited, I show how for the lossless case the relation between vocal tract shape, modelled as a 4-tube, and the formants F1 and F2 on the other hand, can be described by an analytically solvable set of equations. Given the diameters r1, r2, r3, r4 of the 4-tube, the F1 and F2 of the vowel can be calculated, and vice versa: the ratios of the successive diameters can be obtained from the F1 and F2. In the lossless case, the formants are uniquely determined by the shape of the 4-tube, but the inverse problem doesn't have unique solutions. In the lossless case, a set of equivalent 4-tubes produces the same F1 and F2; the lossy case eliminates this problem of non-uniqueness.

Here is not the place to elaborate more on the formulae underlying the model; we just refer to Bonder (1983). I have used the formulae in a spreadsheet of Excel 2000 in order to produce an application with which you may explore the relation between shape and sound.

In fact I have developed two examples about the same problem: how does the vowel position change when we change the diameters of the vocal tract model.

Figure 2 is a screenshot of the application in which is shown how the vowel moves through the F1-F2 space (at the right) as one of the diameters of the tube is set to a larger or smaller value (at the left). This application is interactive as you may click on one of the diameters of the 4-tube and you will see its consequences in vowel space.

Figure 3 is a screenshot of the second application I made, in which you may, interactively, set a starting value for the tube and a final value (at the left); as a result you will see (at the right) the trajectory of the formant values

As said, these applications may look more of the same. However, what we may learn from these examples is that you should think well before developing applications for your lessons. This is not a new statement, of course, but the difference with former days is that the *digital applications* are very expensive to develop.

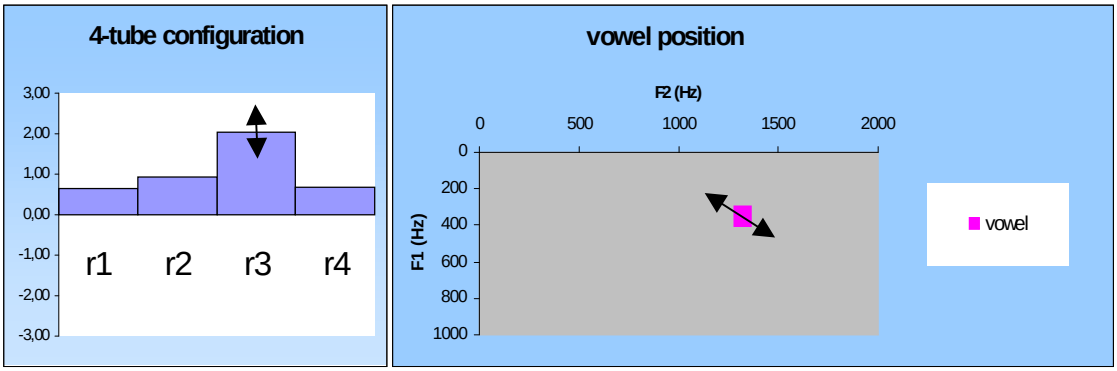


Fig. 2: Interactive model of the relation between change of shape and vowel shift.

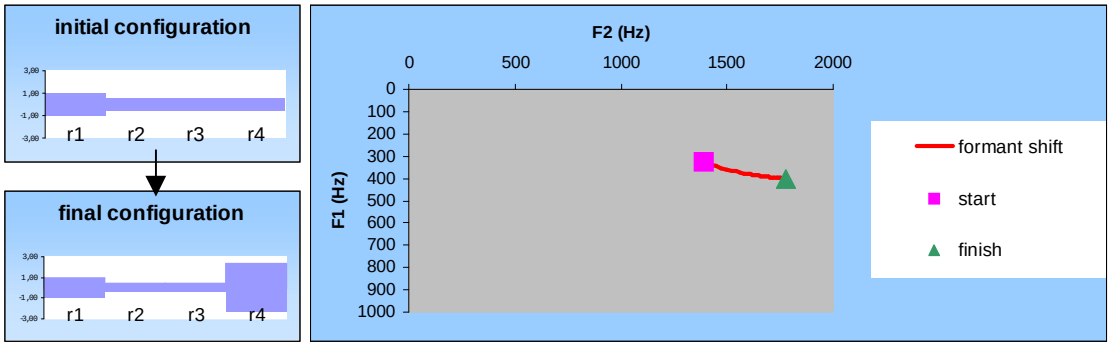


Fig. 3: Interactive model of the relation between a set vocal tract transformations and the resulting vowel shift

7 What is the difference with the old days?

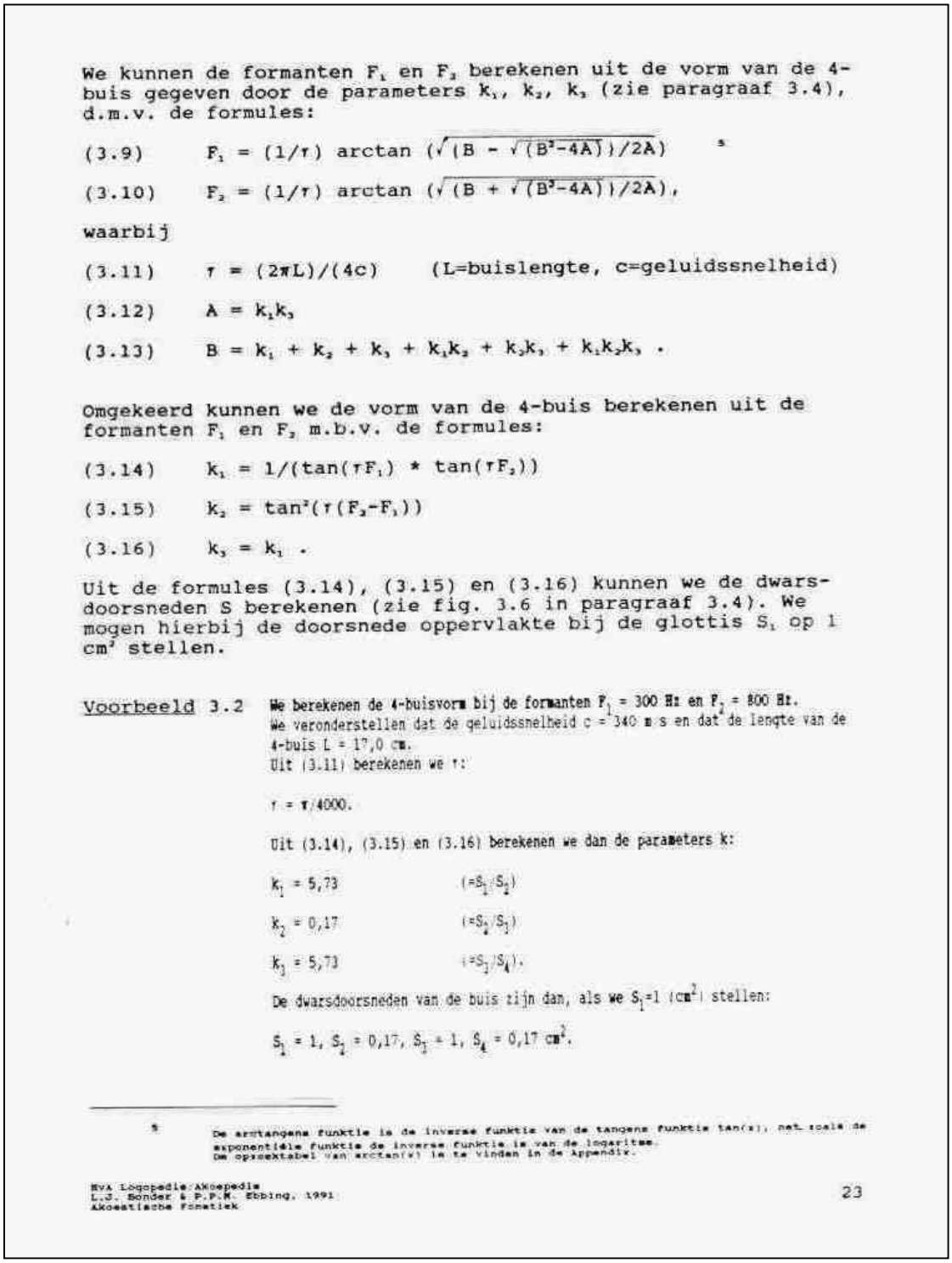
There is a sharp difference between how I used to explain the subject of the relation between shape and vowel sound produced and the new possibilities of the digital era. Below is a screenshot of a page of the course book in Acoustical Phonetics I used for my students in Speech and Hearing Therapy of the Hogeschool van Amsterdam. The explanation and calculation of ONE example of how a shape resulted in a special vowel sound did not give them any feeling in general of how the relation works out for different shapes of the vocal tract.
The digital applications at the other hand, demonstrate clearly how the relation between shape and sound works out. In other words: they provide you with a “look and feel” sensation.

8 What can we do in phonetics?

I will restrict my suggestions to the area I am familiar with: acoustical phonetics.

But first some general advice when starting with building DL units:

- Identify the "learning atoms" of the knowledge base in the field you teach
- You should only try to use DL in areas where digitisation yields added value (avoid using it in subject areas like training of social skills).
- Use the travel guide concept, i.e. use the same structure for all applications: in that way the material will be more attractive for your students.
- Avoid abundance of frills: the more frills the less speed of your application; besides: more frills don't make your work better.



We kunnen de formanten F_1 en F_2 berekenen uit de vorm van de 4-buis gegeven door de parameters k_1, k_2, k_3 (zie paragraaf 3.4), d.m.v. de formules:

(3.9) $F_1 = (1/\tau) \arctan (\sqrt{(B - \sqrt{(B^2-4A)})/2A})$ [5]

(3.10) $F_2 = (1/\tau) \arctan (\sqrt{(B + \sqrt{(B^2-4A)})/2A})$,

waarbij

(3.11) $\tau = (2\pi L)/(4c)$ (L=buislengte, c=geluidssnelheid)

(3.12) $A = k_1 k_3$

(3.13) $B = k_1 + k_2 + k_3 + k_1 k_2 + k_2 k_3 + k_1 k_2 k_3$.

Omgekeerd kunnen we de vorm van de 4-buis berekenen uit de formanten F_1 en F_2 m.b.v. de formules:

(3.14) $k_1 = 1/(\tan(\tau F_1) * \tan(\tau F_2))$

(3.15) $k_2 = \tan^2(\tau(F_2-F_1))$

(3.16) $k_3 = k_1$.

Uit de formules (3.14), (3.15) en (3.16) kunnen we de dwarsdoorsneden S berekenen (zie fig. 3.6 in paragraaf 3.4). We mogen hierbij de doorsnede oppervlakte bij de glottis S_1 op 1 cm^2 stellen.

Voorbeeld 3.2 We berekenen de 4-buisvorm bij de formanten F_1 = 300 Hz en F_2 = 800 Hz. We veronderstellen dat de geluidssnelheid c = 340 m/s en dat de lengte van de 4-buis L = 17,0 cm. Uit (3.11) berekenen we τ:

$\tau = \pi/4000$.

Uit (3.14), (3.15) en (3.16) berekenen we dan de parameters k:

$k_1 = 5,73$ $(=S_1/S_2)$

$k_2 = 0,17$ $(=S_2/S_3)$

$k_3 = 5,73$ $(=S_3/S_4)$.

De dwarsdoorsneden van de buis zijn dan, als we S_1=1 (cm^2) stellen:

$S_1 = 1$, $S_2 = 0,17$, $S_3 = 1$, $S_4 = 0,17$ cm^2.

[5] De arctangens funktie is de inverse funktie van de tangens funktie tan(x), net zoals de exponentiële funktie de inverse funktie is van de logaritme. Een opzoektabel van arctan(x) is te vinden in de Appendix.

Hva Logopedie/Akoepedie
L.J. Bonder & P.P.K. Ebbing, 1991
Akoestische fonetiek

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Fig. 4: A page of my old course book in acoustical phonetics (from 1991) with which I used to explain the relation between shape and vowel sound.

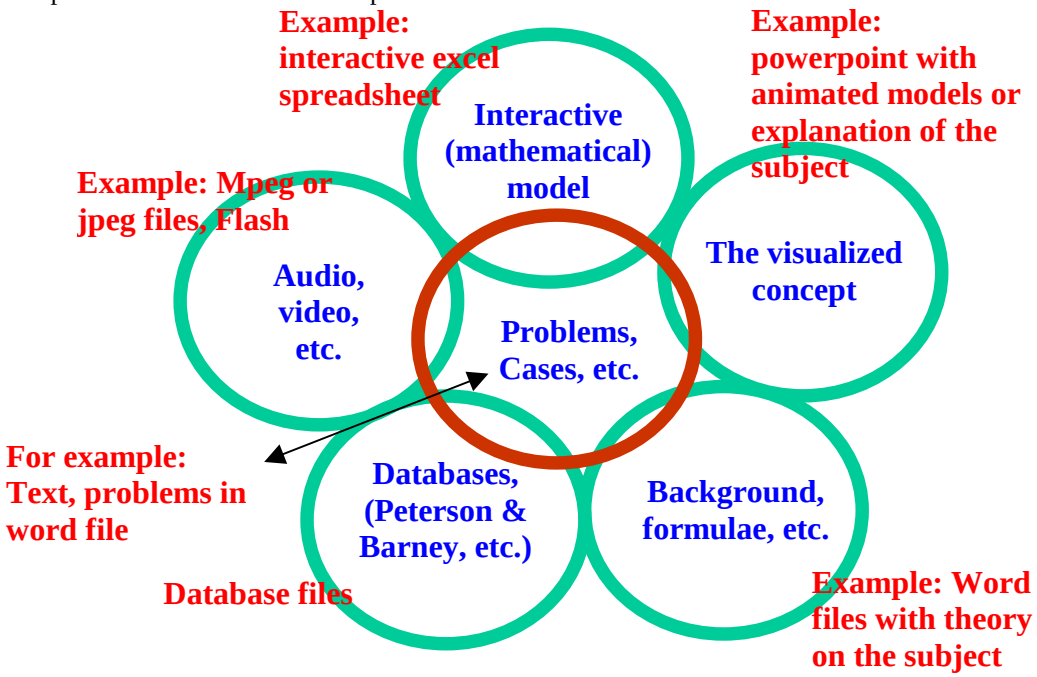

Fig. 5: A suggested structure for DL units in acoustical phonetics.

With these recommendations in mind, we come to a global map of how a DL unit in acoustical phonetics can be composed of modular subunits: the concept is displayed in Figure 5.

The better the modular design of your DL units and subunits, the more and the faster you will see the Return on Investment (ROI) of your efforts: you may easily reuse your modules in other cases and circumstances.

9 My own experience with DL content development

In those 3 years I was involve in the design and building of content for my students of Business Administration the most striking experience to me were the following aspects.

- Your application MUST work correctly; not working software is much more annoying than a book with some errors.
- Design is very important, but not every lecturer is a good designer, not even after taken courses.
- Due to these and other reasons DL is very expensive to develop. Some authors mention a cost of € 2000 – 7000 per instruction hour! Of course, this amount depends on the frills incorporated in your application.
- After some time when you are more skilled in building DL, you will have the revenues of your efforts, especially when you have many students and when you have reached the point of having built a vast library of “learning units” or when you and your colleagues cooperate in developing DL.
- DL really adds in many cases much to the classical way of teaching, e.g. the look and feel sense.

10 Conclusions

My final conclusions with respect to the use of DL is that it is important to:

- Identify the goals of your use of DL
- Identify your learning units to be put into DL style
- Be prepared to put much effort in developing DL
- Start with really simple examples like the ones I have presented in this paper
- Not to aim at covering at once all the subjects in your field with DL
- Collaborate with your colleagues inside or outside your department.

After some time you will be very satisfied with the results and the added value of what you have built, just as I did with those two examples in Acoustical Phonetics!

References

Bonder, L.J. (1983): "Equivalency of lossless n-tubes", *Acustica* **53:** 193-200.

Connick, G.P. (ed.) (1999): *The Distance Learner's Guide*, Prentice Hall Inc.

Mirande, M., Riemersma, J. & Veen, W. (1997): *De digitale leeromgeving*, Groningen:Wolters-Noordhoff .

Bookmarks

Standards according to the European Committee for Standardization: www.cenorm.be/isss/Workshop/lt/

The Distance Learner's Guide (on line): www.prenhall.com/dlguide