

A New Modern Tool for Education in Measurement and Metrology

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ABSTRACT: *This paper presents a new modern tool for education in metrology and measurement as well as some experiences and remarks concerning its development. Firstly, the need for the development of such a tool is explained, reflecting increased requirements put on personnel dealing with measurement in many areas of everyday life. Next, the main general advantages of the multimedia teaching tool are presented, followed by a brief introduction to the international project COMET, funded under the support of the Leonardo da Vinci framework.*

In the main part of the paper the authors give an overview of individual elements of the multimedia tool being developed, in particular in the preparatory phase. It also discusses some particular experiences of the authors during the development of such a complex educational material. The text is supplemented with graphical samples.

1 INTRODUCTION

There is no doubt that metrology and measurement have a key position in many areas of everyday life: science, research, production, testing and certification find their base in measurements. While metrology is more a research science for highly specialised experts, it has, together with the appropriate measurement equipment, a great impact in practical life. In modern industries, measurements represent up to 10-15% of the production costs. In Europe of today the costs for measurement and instrumentation is equivalent to 6% of the combined gross national product.

The qualification and skills of persons working in this area must keep pace with the increasing precision of measurements, more sophisticated measuring methods and means, continuing research as well as the considerable amount of newly adopted EU normative documents. Knowledge in metrology and measurement is necessary also for managers especially of small and medium size enterprises (SMEs) which don't employ their own metrologists. These managers should consider metrology and measurement in their technological decisions and innovation policy.

This development resulted in an increased demand for training in the area of metrology and measurement. A needs analysis showed that the potential of the traditional approaches to vocational training (face-to-face training courses consisting of lectures, exercises and laboratory training) has reached its limit performance and can not fully satisfy the actual and future requirements. Although the teaching material is still mostly in printed form, the use of *Information and Communication Technologies* (ICT) in the training increases now more and more. In the sections to follow we mention our experiences with the development of modern multimedia tools, aimed at the education in metrology and measurement.

2 MODERN EDUCATIONAL TOOLS

The summits in Lisboa (March 2000) and Stockholm (March 2001) declared the EU policy concerning the use of ICT services (Internet especially) by educational institutions, enterprises and individuals. The summits have stressed the importance of ICT for the creation of a so called *society of knowledge*, for higher quality of education and subsequently for the economical growth; for removing barriers of employment among individual states, etc. A practical result is a wide acceptance of different projects, submitted via EU grant schemes (e.g. Leonardo da Vinci, FP6), contributing to reach this aim.

In general, one can mention the following innovative features of utilising ICT in education:

- highly *illustrative* - instead of the so called *static information* (provided by printed material), the multimedia package stresses the expert content by its dynamical graphics (video sequences, graphical animation), use of hypertext structure and incorporating other interactive supports (like indexes, registers, calculations, dictionary),
- *knowledge concentration* - one can find comprehensive information (even not going into big depth) about selected topics at one place,
- high *flexibility* and *adaptability* - individual target groups have different training needs, thus a flexible modular structure of the ICT educational products enables the selection of the appropriate information for the given user,
- facilitated *access* to the training - Internet offers the best possibilities for individual vocational training.

All above-mentioned points, concerning the use of ICT in the educational process, stress increased *efficiency* of the training that has a real economical impact.

3 WHAT IS A COMET PROJECT?

Obviously the creation of a multimedia development package is a long-lasting and expansive matter. Therefore, a consortium of 10 institutions (from 7 European countries) has submitted a proposal for an international project entitled *Computer Aided Training in Measurement and Metrology* (COMET) within the Leonardo da Vinci framework. The acceptance of the project was confirmed in summer 2001 and the official starting date was November 1, 2001. Project lasting is planned for 36 months, finishing in November 2004. For marketing reasons we decided to name the developed tool as Metromedia and therefore, the Metromedia logo appears in all parts of the product.

The specific aim of the project is to develop and disseminate a *multimedia training package for vocational training in the area of metrology and measurement*. The purpose of this multimedia package is to improve the quality and efficiency of the vocational training in the above mentioned area, to facilitate the access to this training as well as to contribute to a wider use of information and communication technologies in vocational training.

The complete product consists of:

- *multimedia courseware* including lectures, exercises, tests, and supporting modules (calculation tools, dictionary), all in hypertext form, supported by graphics (including full-colour static figures, two- and three-dimensional computer animations, video sequences). This multimedia courseware will be available on a WEB-site as well as on CD-ROM,
- *supporting teaching material* in printed form (including textbook, working sheets for lectures and exercises, tables, tests, dictionary, etc.).

Totally 10 institutions from 7 European countries take part in the project. Two of them belong to the Vienna University of Technology (VUT), project promoter.

Ct.	Institution	Contact person
A	VUT, University Extension Centre	Franz Reichl
A	VUT, Inst. of Production Technology	Peter-Herbert Osanna
A	Austrian Standards Institute	Joanna Gajdek
D	Steinbeis Transfer Centre	Dietrich Hofmann
EL	Western Greece and Epirus U.E.T.P.	Marios Cassimatis
F	Institut Méditerranéen de la Qualité	Antonio Mazzei
NL	University of Twente	Paul Regtien
SK	Slovak University of Technology	Martin Halaj
SK	Mega&Loman, Ltd.	Ján Miklášik
UK	Whitestone Business Communications	Jackie Grove

The area of metrology and measurement is very wide, therefore only particular topics have been selected. The whole content is organised and developed in so-called *modules*, arranged in work packages for the sake of clarity. Totally 31 modules should be developed, organised in 10 work packages.

The primary target group of the project includes staff working in metrological laboratories of industrial enterprises, calibration and testing laboratories. In addition, it is expected that the developed multimedia training package will be widely used also for the training of managers especially of SMEs, testing and calibration laboratories as well as for students in the initial vocational training. The development of the multimedia training package in English, German, French and Slovak versions will enable its direct use in local languages of many European countries. The main users should be continuing education centres offering continuing education, open and distance learning, WEB-based courses, higher education institutions offering different types of education as well as companies and laboratories for the internal training of their staff.

Content is divided into 31 modules arranged in 10 WPs.

Work package	Module
1 General introduction	1 history of metrology and meas.
	2 quantities and units
	3 measuring principles
	4 measuring instruments
2 Meas. instr. and devices	5 physical principles of meas.
	6 design and manuf. of meas. ins.
	7 image and signal processing
3 Measurement I	8 temperature
	9 pressure
	10 flow and flow rate
4 Measurement II	11 material level
	12 length, position, dimension
5 Measurement III	13 roughness
	14 geometrical properties
6 Measurement IV	15 angle
	16 frequency of rotation
	17 humidity
	18 force
7 Measurement V	19 mass
	20 torque
	21 power
	22 voltage
	23 current
8 Measurement VI	24 resistance
	25 experiment design
	26 models of measurement
9 Utilisation of meas. data	27 uncertainty in measurement
	28 measurement process control
	29 international organisations
	30 metrological systems
	31 accreditation and certification
10 Legislative aspects	

4 A LONG WAY TO THE FINAL PRODUCT

In this section we review the main elements of the multimedia teaching tool presented, together with several remarks concerning their preparation.

Hypertext processing of the educational texts enhances its educational impact, providing users with structured information. Links are often directed to individual topics within a single module, e.g. from sensor listings to details on individual sensor types. Links that point outside the module make access directly from the explanatory text to other elements of the whole multimedia tool - animations, video sequences, calculation programs, exercises.

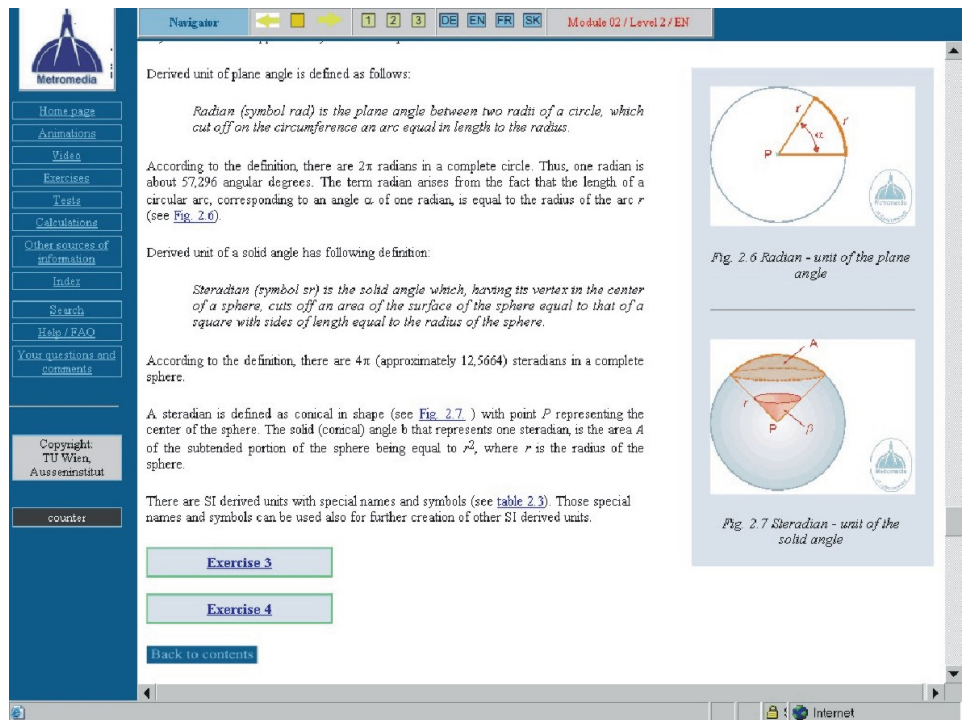
Since experts write their educational texts in MS Word (all together about 700 pages), several problems occur when processing the material into hypertext form. The plain text can be converted quite easily, using defined text styles, but problems occur when a large number of equations and special characters is inserted in the text. Another complication is caused by the multilingual approach of the whole package - one must provide links in four language mutations. This is a rather time consuming task, being error prone. Due to technical reasons it was decided to make all links within the module as well as those pointing outside the module directly in the MS Word document, followed by some post-processing of the whole material to the hypertext mode.

Another point on which had to be decided in the beginning of the project was the philosophy on multiple windows opening. Most people dislike pop-ups. The consortium decided to have the main educational text in one main window (mostly full screen) and all other material to be opened in one common new window. In practice, the user can click on animation links which then opens in a new window. After a next click on another link, to open a new item (e.g. full sized figure, calculation program, exercise, etc.), the original contents of the window (for instance the running animation) is replaced by a new contents.

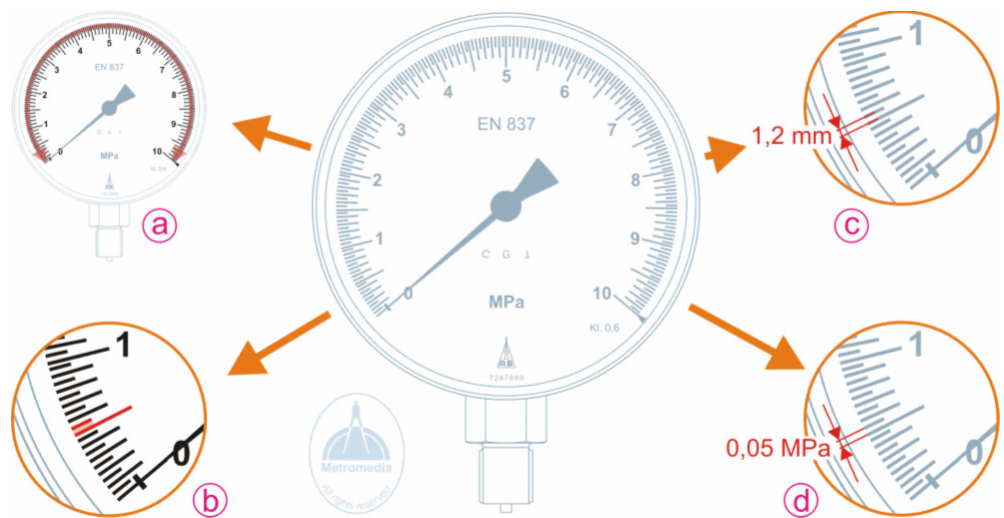
Figures in the final version of the software are mostly full colored. Only a few figures adopted from other sources (definitely with quotation of the source) were used. A massive number of figures was originally drawn exclusively for this educational material. Many of them are unique, describing several features presented in the text, at one place.

When creating figures, the utmost importance was given to their readability. To reach this, two actions were taken. In the first place, drawings are exported at 100% in 400 dpi resolution, 8-bit color. The resolution is quite high, but when using *.png format, the file size did not increase dramatically. It was decided to let prevail readability of the resulting figure over reduced file size.

Secondly, figures are inserted into the text at 50% of the original size, but after clicking on the figure the user obtains the full sized figure in a new window. Since the whole multimedia teaching tool is delivered in four languages, it was recommended very much to avoid



Example of the educational text, providing text information, figures, animations, exercises and self-tests



Example of the comprehensive figure, explaining several features of the analogue scale

legends directly written in the figure. A better way was to provide figures with abbreviations and numbers with the explanation being put in the captions below the figure. The figures remain the same for all four languages, and only the captions are multilingual. This all may seem very trivial, but realizing that about one thousand figures should be drawn, the problem is not that trivial at all.

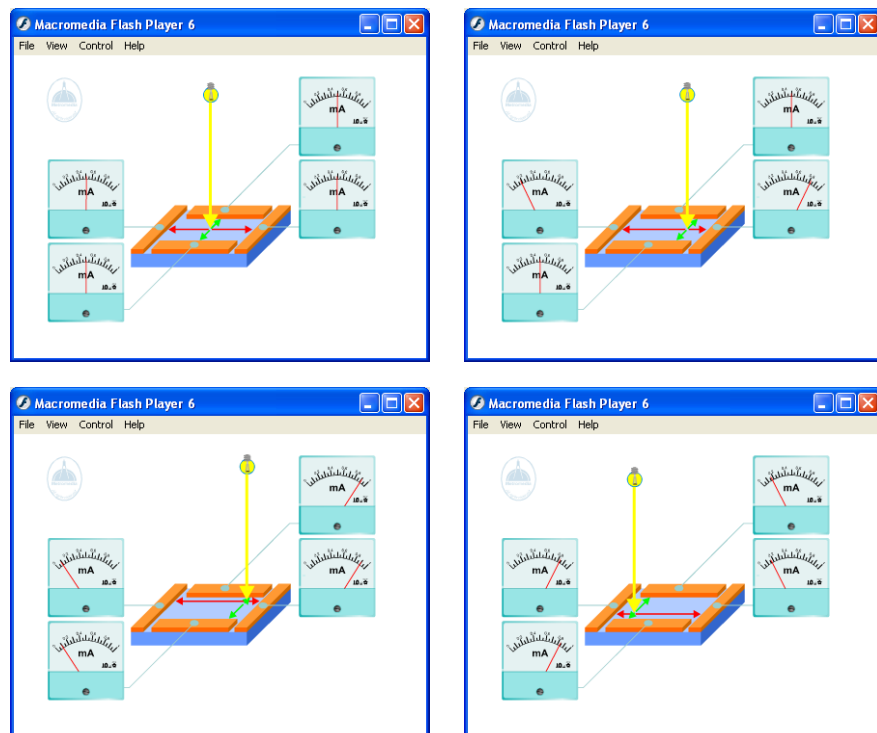
Animations represent a virtuous feature of the whole multimedia package. Both 2D and 3D animations are developed, with a total number exceeding 200. Their main advantage is to introduce *movement* in the description of the respective topic. Many of them are based on the static figure used for text supporting, so the animation starts in a similar way as the original figure. This avoids people to get confused by different visualizations of the same problem.

The animations are created using Macromedia Flash technology. The choice for this technology is based on two criteria:

- it is powerful enough to enable the creation of the anticipated animations. By choosing the static figure as starting point for the animation, this figure could simply be imported into Flash avoiding to redraw it. This approach appeared to have saved much time, even when taking into account some technical difficulties as usually occur when importing static files (the compatibility of various graphic formats is not always trouble-free despite the claims of many providers).
- it is wide-spread in the Internet community, in such an extent that it is almost a standard for animations on the Internet (together with animated gif files, obviously). Although other animation software packages allow saving of the final animation into Flash format, the resulting file is considerably larger compared to animations that are directly created in Macromedia Flash.

When creating animations, some important aspects have to be considered carefully. Firstly, it should be made clear whether or not a particular phenomenon or idea is suitable for animation. When it is found suitable for animation indeed, the scenario of the animation has to be created. This phase is not as evident as it seems to be. The animation scenario should be prepared by the author of the particular text where the animation should be placed. Several authors – although experts in their respective field – had problems to think in *moving* figures: where should start the animation, what part of the figure should change, which

Example of an animation - several stages of the PSD detection. Position of the incoming light beam is detected along two axes. This animation gives the user visual perception of individual current signals, measured by four ammeters. The figure just shows four of the stages, visualising the changes of the ammeters' indicator.



feature of the animated scene should be stressed, how to visualize invisible phenomena, etc. This makes that a close cooperation between the expert and the animation author is required. Conducting two or three consecutive corrections before the final animation was no exception, apart from limitations set by the Macromedia Flash software, often requiring corrections of previously adopted scenarios.

Animations are really a powerful tool that enhances educational possibilities to previously unreachable quality. Their preparation is a very comprehensive and time consuming task, however. On the other hand, they are widely accepted and with great enthusiasm by the students.

Calculation programs should help the user in understanding the topic presented and assist him to solve some of the exercises provided. The technology that is used for creating calculation programs is based on the html format and java applets. The main motivations for using this technology was the simplicity (avoids the use of some runtime program) as well as the open source nature (no licensed program language was required). On the other hand, this technology shows limitations for certain types of calculation programs.

Calculation programs deal with different types of tasks: conversion among individual measurement units, calculation of simple formulas (e.g. angular velocity, barometric pressure, etc.), conversion from read-out units to units of the measurand, for instance resistivity-to-temperature conversion for resistive thermometers. What goes for animations that goes for calculation programs too: a close cooperation between the text expert and the programmer is required.

Tests are meant for self-testing; they allow the user to check his/her understanding of the topics presented. Each test contains an average of 10 questions, consisting of three main types: fill in missing word(s), select a proper answer out of three alternatives, and write down some statement (definition, list of certain phenomena, etc.). At least three tests are available for the shorter modules; longer modules have up to 15 different tests. Their evaluation is semi-automatic, which means that the proper answers appear after clicking the relevant button, but a comparison of the given answer with the correct one must be done by the user.

The *index* contains important entries from all modules. Each entry comprises a definition of the entry as well as a number of sub-chapter in the text, where more details can be found. This is an efficient way to provide linked information without the necessity to link all modules to each other.

The item *further reading* belongs also to the group of supporting material. Its main aim is to provide links to other information sources that deal with individual topics in more detail. When browsing the Internet, one can find an enormous number of interesting pages that provide full details on very specific topics. Due to this vast number of web sites only a few of them are selected and listed in the “further reading” section. It is obvious that the prepared multimedia teaching tool can not go into such details, thus users can get more information visiting those web sites. We have selected mainly free information sources that do not require paid registration.

Video sequences represent another approach for visualization of the respective topic. The problem with video sequences is obviously the file size being in competition with video quality. Therefore they are used quite rarely in the teaching tool. A further aspect is the language of the accompanying spoken text. Should there be four different languages and four speakers? Or just one language (English) and subtitles in the other three languages? Or should spoken language be avoided and only provide subtitles in four languages? This issue has not been solved satisfactorily yet.

5 CONCLUSION

The state of development of the above described multimedia training tool for education in measurement and metrology can be observed at the free project web site www.metromedia-online.com. The site should be fully functioning at the end of the project, i.e. November 2004. Besides the introduction of the project to a wider public, we want to present also several experiences and remarks arising during the development of this ambitious but important project.

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