



## **Learning Environment for Physics Laboratory Activities**

### **Project Internal Report**

## **LEPLA - TECHNICAL FRAMEWORK REQUIREMENTS**

## LEPLA - Technical Framework Requirements

Internal report of the Socrates- Minerva Project 99843-CP-1-2002-1-PL-M entitled:  
'Learning Environment for Physics Laboratory Activities - LEPLA'

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## I. Objective of the report.

Report is aimed on concluding the recognition of the needs to be satisfied and requirements imposed by the envisaged users of the LEPLA environment and to provide the solid and realistic site specification that includes:

- Handheld technology to be used
- Functions and tools offered by web based environment, the interactive functionality
- Structure indications.
- Technology of the web site
- Standards and formats to be used.
- Electronic security measures (i.e. password protection, back-up system)
- Acquisition of software facilitating defined needs.

The report is recognised as a foundation for the design and development of the LEPLA platform.

## II. Recognition process.

The undertaken recognition activities concerned:

### Educational needs

1. Expected nature and features of the learning resource and material.
2. Possible ways of use in learning/teaching practice.
3. Fields and level of physics experiments to be covered by the LEPLA material (depth and breadth of resources)
4. Existing concepts of the web based learning resources.

### Technical needs

1. Hand held technology in hands of user groups.
2. Connectivity and effectiveness of the use of the Internet resource by envisaged users groups.
3. Choice of web technology available and required.
4. Recommendations for design of the structure of the vortal, functions and elements.

Recognition and studies have been undertaken through:

1. Working contacts with the representatives of the user groups in Partner countries (school teachers, university lecturers – approx. number of 100 educators contacted).
2. Practical observation of the students experimental activities (project partners' teaching experience).
3. Studying educational resources (papers, conference presentations, samples of Internet based resources on the interactive multimedia learning environments- ILME's ) such as: GIREP - Group International de Recherche sur l'Enseignement de la Physique, IOP-Institute of Physics, Becta - British Educational Communications and Technology Agency, HyperPhysics, OpenUniversity, IETUserLab, WebStyleGuide.
4. Analysing information on the technology, software tools, effectiveness and availability.

## III. Expected nature and features of the learning resource and material.

The following have been recognised:

- a) The LEPLA site should provide a simple, user-friendly and effective way of finding the relevant information and well balanced and integrated (well defined, complete but not redundant) material which can be immediately put into experimental practice.
- b) The experimental modules should consist of descriptive part with basic theory, details of the experimental setup and procedure, sample data, data analysis methods, complete set of programs controlling the experiments and other necessary files easy to be downloaded – forming 'all in one' package.
- c) The learning modules should be compact, clear and informative, enriched with movie clips, still photographs, graphics, animations, sound.

- d) Learning materials should be diversified into easy identified groups: by hand held technology (type of the calculator), difficulty level (basic, upper), nature of the module: ready to make single experiment, extension, project, guide. As far as possible the modules should be offered in two hardware versions (for TI83 and TI89/92 calculators)
- e) Different functional areas of the web site should be clearly identified and separated with an easy and simple hierarchical navigation through the contents.
- f) There should be supplementary materials extending the main-path material (related experiments, real life examples, problematic observations) motivating and stimulating students for self studies.
- g) The separated teachers section should provide additional material for assessment and information about pedagogical aspects and technical difficulties.
- h) Environment should provide intercommunicating tools between users, creation of user groups, forums and mailing lists.
- i) The implementation of the automatic evaluation tools (remotely filled forms, open comments) must be supported.
- j) The implementation of tools for collecting information and making statistics on users and site traffic is required.
- k) Future development and upgrading of the material done remotely by the author should be possible.
- l) It is necessary to develop complete language localizations of all structural elements and learning materials.

#### IV. Possible ways of use in learning/teaching practice.

It is expected that LEPLA portal will be used a combination of a direct medium which pages will be read online and as a delivery medium providing access to the content that is downloaded or printed. The specially prepared e-books (pdf files) will facilitate this type of use.

The online use calls for concise content and compact form with the volume and nature of the visual elements adjusted to the bandwidth limitations on average user access while the expected off line use requires relevant paging and adjustment of the page sizes to facilitate printouts on standard paper sizes.

There are several possible scenarios of lab activities based on this system.

- a) As the guidance during the laboratory session.  
Students having permanent access to the learning module follow the instructions, prepare and perform experiment, collect data and perform analysis.
- b) Preparatory/supportive for students.  
Student acquaints himself with the experiment file before the regular experimental session in the university laboratory room. Better preparation for the practice saves time in the lab. Reference data can be used for further analysis of his own results. This saves teacher's time spent on describing details of procedure and reduces performance and analysis errors.
- c) Do-it-at home activity.  
Student gets the experimental set from the university and performs the experiment at home. Detailed step by step instruction enables self performance. Multimedia elements are particularly useful in this scenario. Easy available reference data can be used for self assessing the results. This approach is extremely promising in case of vocational courses and external evening courses as well as in case of poorly equipped physics rooms in some high schools.
- d) Substitution of the real experiment.  
Student who is not equipped with the experimental setup does not perform the experiment himself but gets the clue about the activity details from the multimedia material. Provided premade data files are used by him for data analysis and preparation of the lab report. This approach is the least valuable but still provides minimum contact with the experimental technique.
- e) Preparatory/supportive for teacher.  
Teacher can prepare (develop experimental setup following the attached detailed description, collect – download all necessary calculator software) the experiment (or expand, modify or use as a foundation for its own) provide students the guidance, learning material - text, methods of data analysis, an self assessment – sample data.

## **V. Fields and level of physics to be covered (depth and breadth of LEPLA resources).**

The experimental activities will be addressed to two levels of physics teaching: upper secondary school level and introductory courses at the university undergraduate level.

Within the limit imposed by the availability (and costs) of sensors and elements of the experimental setups, LEPLA learning material should cover:

- mechanics (steady, accelerated, harmonic motion),
- thermodynamics (gas transitions, calorimetry),
- electricity (DC circuits)
- magnetism (electromagnetic induction)
- optics (physical, wave)
- radioactivity.

In addition the modules on experimental data analysis and elements of statistics are foreseen.

The thesaurus providing biographical notes, contextual notes from the history of science should be developed as enhancement of the educational quality of the materials offered.

Experimental modules should follow one of the three types:

Single experiments centred on a basic experiment to be performed with RTL (Real Time Laboratory) apparatus, containing a detailed description of theoretical basis, apparatus set up and data acquisition procedures, basic data analysis

The Extensions - aimed at extending the investigation performed with single experiments with a less detailed description of procedures, whereas the focus is on interesting and somehow intriguing aspects of the phenomena investigated.

Project modules combining experiments of both types aimed at offering one or more possible paths through a wide topic of investigation emphasizing activities that help the student to construct understanding and his knowledge buildup.

The learning materials should not be trivial but offer carefully selected, coherent and high quality information. However they will not be aimed on replacement the traditional written resources.

Use of the multimedia elements such as graphics, plots, still pictures and/or movies should provide information in compact, attractive and easy digestible way. The balance between the necessary information and interactive functionality must be monitored.

## **VI. Hand held technology to be used.**

The "handheld technology" means portable, compact data-loggers with compatible sensors, controlled by and used together with programmable graphing calculators or computers. These versatile devices give complete, modern, flexible and efficient data acquisition systems enabling basic experiments to be performed quickly and efficiently. Access to the implemented mathematical tools makes it possible to perform immediate experimental data analysis.

The undertaken recognition of the hand held hardware already in hands of the target groups the LEPLA material lead to the conclusion that we should consider the use of the following technology:

- a) Graphic calculators: Texas Instruments TI83 and TI83 Plus, and TI89, TI92 and TI Voyage 200.
- b) The data acquisition systems: TI Calculator Base Laboratory (CBL and CBL2) and Vernier LoggerPro.
- c) Sensors and probes to be used: 1. developed by Vernier and/or other equivalent manufactured by: ZENIT, MAD, 2. Developed or modified by project partners.
- d) Calculator software (freeware): 1. standard, universal software such as: Vernier Physics, DataMate, Ranger, 2. Software for Logger Pro interface (LabPro), 3. universal data logging software developed (or modified) by project partners, 4. single purpose -individualised programmes developed by project partners for particular experiments.
- e) Computer software for PC-calculator communication and data analysis: 1.free software such as: TIConnect, TI GraphLink, 2. Specialised software: Vernier Graphical Analysis, LabPro, TI Interactive. 3. standard software such MSEXcel.

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**VII. Connectivity and effectiveness of the use of the Internet resource by envisaged users.**

From the connectivity point of view two main groups of the LEPLA users and visitors of the web site have been identified:

- a) Individual home users accessing Internet through modem connections via the local Internet Service Providers (with effective speed 56Kbps) or ISDN, DSL, cable medium speed connections (up to 2Mbps).
- b) Institutional users (universities) - accessing through Local Area Networks (up to 100Mbps Ethernet backbone).

It is established that volume, contents, and file types should be optimised on the low loading speed and low effectiveness and capacity of the network bandwidth enabling effective access to the portal for users (students and teachers) with phone modems (at home).

Keeping the balance between appearance of a web site and the loading time should be of special care. The most demanding, slow-loading web site elements (graphics, movies) should be either optional or offered in two versions - compressed and full capacity. The overuse and redundancy of elements should be avoided.

**VIII. Choice of web technology.**

- a). Operating systems and web browsers

Survey of the envisaged LEPLA target groups suggest that the use of three main operating systems: Microsoft Windows (95, 98, ME, XP, 2000), Macintosh MacOS or UNIX/Linux should be supported in the portal.

The minimum requirement concerning support of the web browsers are: Netscape Navigator (v.4.79 or 6.0 and above, Internet Explorer (v. 5 and above). It is recommended to adjust the site to support other, less popular browsers such as Opera, CyberDog and Mozilla.

The technology used in the portal must be multiplatform: the students using the different Microsoft Windows systems, Macintosh or UNIX computers should access the portal's content in the same way.

- b). Web server placement and safety measures.

The in-house Web server developed and continuously maintained at the dedicated computer server at Partner institution (1PL) is recognised as the most effective and robust solution.

The main LEPLA server is established on the dedicated Intel P4 computer server connected to the fiber-optic backbone network of Technical University of Łódź (Poland). This backbone network is the part of LodMAN (Metropolitan Area Network in Łódź) and the academic computer network in Poland (NASK). These Polish networks have active high speed uplinks to the European academic and commercial telecommunication networks. The efficiency of the available network connection reduces the need of developing mirror sites providing better access for local users.

Regarding the nature of the web site (no commercial, open educational resource) there is no need for a special security or confidentiality measures except of standard (software) tools against web intruders and viruses. In order to ensure that a catastrophic hardware failure would not result in losing the LEPLA material the standard regularly back up onto a secure and reliable storage medium (CDROM) is established.

The established reserve mirror secures continuous access to the LEPLA materials.

The "mirror" placed in Padova (Italy) is the auxiliary server with the full contents and functionality of the portal. When changes in the content and the database of the portal occur the mirror will be updated on a regular basis to warrant the security of LEPLA main server. The main cause of the preparing mirror site is the break/failure of the connection with the main server. The user will be automatically redirected to the working mirror. The database on the main server will be subsequently updated with the information from the mirror due to the content changes (new users, statistical data etc.) occurred during that fault time.

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c). Web server technology.

Recognition of the web technology concerned effectiveness, flexibility on using on multiple operating systems platforms and availability including costs of acquaintance, auxiliary software, resources and documentation.

As a result of the survey the Apache web server and PHP-Nuke Web Portal System engine and MySQL database were chosen as versatile, easy to be adopted, available at no costs, technical platform for development of the LEPLA portal.

Justification

1. Versatility.

Apache has been the most popular web server on the Internet. The August 2002 Netcraft Web Server Survey found that 63% of the web sites on the Internet are using Apache, thus making it more widely used than all other web servers combined. The Apache HTTP Server Project is an effort to develop and maintain an open-source HTTP server for modern operating systems including UNIX and Windows NT. The goal of this project is to provide a secure, efficient and extensible server that provides HTTP services in sync with the current HTTP standards. There are three interesting for us technologies embedded into the Apache: PHP and Perl interpreters and the secure connections with SSL technology. Some part of the website will be prepared with the aid of JavaScript technology.

2. Flexibility.

PHP (recursive acronym for "Hypertext Pre-processor") is a widely-used general-purpose scripting language that is especially suited for Web development and can be embedded into HTML. Using PHP is different from a script written in other languages like Perl or C - instead of writing a very complicated program with lots of commands to output HTML, one writes a HTML simple script with some embedded code to do something (eg. output some text). The PHP code is enclosed in special start and end tags that allow you to jump into and out of "PHP mode".

One of the strongest and most significant features in PHP is its support for a wide range of databases. Writing a database-enabled web page is incredibly simple. The following databases are currently supported: Adabas D, Ingres, Oracle (OCI7 and OCI8), dBase, InterBase, Ovrimos, Empress FrontBase, PostgreSQL, FilePro (read-only), mSQL, Solid, Hyperwave, Direct, MS-SQL, Sybase, IBM DB2, MySQL, Velocis, Informix.

There are three main fields where PHP scripts are used.

- Server-side scripting. This is the most traditional and main target field for PHP. You need three things to make this work. The webserver, PHP parser (server module) and a page with PHP script. You can access the PHP program output with a web browser, viewing the PHP page through the server.
- Command line scripting. You can make a PHP script to run it without any server or browser. You only need the PHP parser to use it this way. This type of usage is ideal for scripts regularly executed using cron (on \*nix or Linux) or Task Scheduler (on Windows).
- Writing client-side GUI applications. PHP is probably not the very best language to write windowing applications, but if one knows PHP very well, and would like to use some advanced PHP features in client-side applications one can also use PHP-GTK to write such programs. You also have the ability to write cross-platform applications this way.

PHP-Nuke is an easy to use, very flexible Web Portal System, with modular construction, with storytelling software, News system, etc. and three zones for peoples. The goal of PHP-Nuke is to have an automated web site to distribute news and articles with users system. Each user can submit comments to discuss the articles, just similar to for instance the Slashdot portal and many others.

3. Availability - free software.

PHP-Nuke is portal engine written in PHP **free** software (GNU licence) and requires Apache Web server with PHP and a database running on the server (one selected from MySQL, mSQL, PostgreSQL, ODBC, Adabas D, Sybase or Interbase). Support for 25 languages, Yahoo like search engine, Comments option in Polls, lot of themes, File Manager, Headlines, download manager, frequently asked questions (FAQ) manager, advanced structure with the blocks system, surveys and reviews system, newsletter, categorized articles, multilanguage content management and a lot more.



Main features include: web based administration, top page, simple access statistics page with counter, user customisable box, friendly administration GUI with graphic topic manager, option to edit or delete stories, option to delete comments, moderation system, Referrers page to know who link us, sections manager, customisable HTML blocks, user and authors edit, search engine, backend/headlines generation (RSS/RDF format), and more friendly functions. In addition the mechanism of the JavaScripts can be used for preparing separate "flying" windows for experimental module's sub pages, slideshows etc.

d). Software required.

The choice of the vortal technology and envisaged nature of the contents calls for acquisition and use of a computer software facilitating development of the content of the vortal elements and the learning modules. There is no need for uniform software across project partners as long as they will follow the HTML standard, uniform templates and file types. Therefore the given below list of the recommended software is indicative and open:

- a) Software for preparation of the learning modules with php scripts technology and in the html format:
  - Macromedia Dreamweaver
  - Microsoft FrontPage with CodeCharge Studio for PC or Macintosh
  - Quanta Plus for Unix machines
- b) Preparation of the movie clips:
  - QuickTime - for preparing MOV format movies.
  - Pinnacle Studio - for preparing MPG format movies.
- c) Preparation of the e-book pdf files:
  - Adobe Acrobat
- d) Preparation of the still pictures:
  - MS Photo Editor
  - Adobe Photoshop Elements

## **IX. Recommendations for the design of the vortal structure, functions and elements.**

### **A. General indications:**

1. The LEPLA vortal structure should be hierarchical with track guidance within the separated users' zones.
2. The personalized user's page should provide access to the individualized information on mail accounts etc.
3. The main function and services characterising the nature of LEPLA should be clearly seen and visually differentiated from auxiliary items.
4. The paths to different LEPLA resources should be emphasized facilitating quick access and retrieval of the wanted information. Sub pages that should not exceed 3 'screens' and approx 10-15 sec of loading time (standard modem connection).
5. The simple navigation based on visual logic should be applied consistently throughout the whole site.
6. The organization of elements on the page: text, graphics, multimedia should keep balance between visual sensation and information. The information should be prioritized and aimed on attracting and engaging visitor in use of the offered material.
7. Each experimental module is characterized by flags (keywords), which inform users about: field of physics (thermodynamics, electricity etc.), level of difficulty, and type of calculator used.

### **B. Detailed indications:**

1. General structure of the vortal will be based on the four zones:
  - Visitors zone: which contain some basic information's on the Project (students activities, handheld technology etc.), about the cooperating institutions (Partners), and the Experiments proposed inside the vortal.

- Registered users (students and teachers) zone: contains the Experimental modules, separate module with downloadable files, Feedback (Four ways to contact LEPLA team: general Error Report Form, Vortal Evaluation Form, Experimental Module Evaluation Form and Simple Info Form).
- Teachers zone: additional information prepared for teachers only
- Administrators zone: special modules (eg. Users maintenance module, Article's editor etc.) and pages with information on the seminars, prepared non-published materials etc.

Access to the non-visitor's zones is based on the registration (nickname and password) and standard login/logout mechanism.

The hierarchical link structure with a central "jumping off" home page providing access to the lower level elements.

## 2. Elements of the vortal (standards, file types).

- a) Each experimental module will be divided into several standard sub pages containing text, pictures and/or movies, links to other pages, links to downloadable files etc.
- b) Each sub page (for instance DATA ACQUISITION page in each module) should be provided in the separate html document.
- c) Links and bookmarks at sub pages should be explicitly given (such as: <http://www.uni.edu.nl/physics/yellow.html> for external page or within module structure such as: DATA ANALYSIS sub page ->fig 23) as precise indications for the server administrator about placement in a real server's files' structure.
- d) Figures, equations, movies etc should be uniquely named/numbered. Name of the file should include the name of the sub page of appearance and element unique number. For instance second picture on the Theory sub page should be named as theory-fig02.jpg.
- e) All pictures must be prepared in formats suitable for Internet browsers (PNG, GIF and JPEG formats are chosen).
- f) Picture size is limited (in screen pixels) to maximum width 300 pxls and height dependent on page needs.
- g) Photographs are preferred in JPEG format.
- h) Schematic diagrams, plots etc. should be in GIF or JPEG format with the attached editable source in the Colour - Graphics Metafile format (CGM). If it is possible in schematic diagrams symbol should be used instead of full names of elements.
- i) Calculator's screenshots must be saved with frames, in the original screen size offered by the TI Connect software with standard 72 dpi CRT resolution, provided in the PNG or GIF format.
- j) Equations must be prepared as pictures in GIF format: the basic size of symbols is 10 points. While using MS EquationEditor or MathType the default 12 pts basic standard should be used specifying size of subscripts, symbols etc. The following standard is proposed: 10/7/5/14/12 points, all variables styled italic, while vectors styled as bold. The name of the equation file should include the name of the sub page of appearance and equation unique number.
- k) Movie clips and animations should be in the MPEG-2 (MPG) or QuickTime (MOV) formats. Size standard: not less than 240x180 and not more than 320x240, 12-18 frames per second with preferably file size less than 300 kB for modem connections and 1MB for high speed connections (alternative).
- l) Each movie clip should be associated by the single frame picture representing contents, provided in a JPG or GIF format, with size equal to the clip's frame size (used as button).
- m) Sound effects (recorded) can be provided only in cases when it is crucial for understanding.

## C. Elements of the structure of the learning module.

Each learning module will be divided into several standard sub pages accessed independently from within each sub page:

- Introduction – with experiment title, historical notes, experiment objective and links to all module sub pages. Information of the estimated time consumption of preparation and performance of experiment will be provided.
- Theoretical model – concise theoretical introduction to the phenomena concerned.

- Experimental set-up – description of the experimental set-up and experimental procedure (including movie clips, pictures, photos, diagrams, etc.).
- Sample data – collection of the sample data obtained during experiment (sets prepared for the analysis with the calculator's programs and with MSExcel)
- Data analysis – the procedures of the data analysis (divided by two sub pages – for the calculator and for the MSExcel).
- Teacher's guide (accessible within the teachers zone only)
- Additional questions and tests.
- Text version (in Adobe Acrobat PDF format) printable
- References
- Evaluation forms.

For all modules there are prepared common pages, so called 'Help Boxes', with information how to work with calculators, programs, data analysis procedures, CBL, sensors etc.

## X. Final indications

1. A buildup of a small-scale prototype for testing site navigation and development of the GUI should precede the main design of the site. The 'inside' readers providing indications for structural changes should test this prototype.
2. Before publicizing the URL address the 'true scale' prototype should be subject to the testing by the limited number of external readers providing critique on the overall design and effectiveness of the portal and information on the bugs, errors etc.
3. The language localization of the common structural elements should be carefully tested and overviewed by native referees.
4. The detailed site documentation (on file structure, links and bookmarks, common elements, files etc.) should be collected from the initial stage of the design, facilitating further development and reducing redundancy of stored elements.

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