

## DEVELOPMENT OF VIRTUAL LABORATORY FOR EVALUATION AND CONTROL OF WORKPLACE HAZARDS

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**Abstract.** This paper describes a design of a virtual laboratory for engineering students undertaking courses related to monitoring, evaluation and control of occupational environment. The lab is divided into modules that provide concise overviews and descriptions of the basic concepts in topics like noise, vibrations, microclimate conditions, chemical factors and lightning. Each module contains interactive technical exercises which foster the understanding of the basic principles and practices for collection, detection, identification, calculation and interpretation of qualitative and quantitative data related to risk factors that may adversely affect health and safety of people in working environment. The results of the first version of the Virtual Laboratory and details of its development are provided.

**Keywords:** virtual laboratory, working environment, occupational hazards.

### Introduction

Involving students in solving practical problems is an important component of their studies to help them gain practical experience and skills that can be used in their future career [1]. The laboratory experience represents one of the few hands-on experiences in engineering education. This experience serves to reinforce theoretical concepts discussed in engineering courses and provides an experiential learning process. In order to have effective laboratory experience, extensive personnel time must be used to assure well-organized experience with detailed procedures, and updated equipment. Often, even after extensive investment of time and resources by the university, the actual student experiences in these laboratory courses may not be positive [2]. The students express that some of deficiencies of laboratory experience are related to: fear from damage of expensive equipment and lack of familiarity with the measurement methods. Interactive software could potentially address some of the deficiencies enumerated above and improve the students' learning experience and performance.

The combination of information technology and an appropriate learning approach has shown a huge potential to be integrated in the education field [3]. A virtual laboratory can be defined as an environment in which experiments are conducted or controlled partly or wholly through computer operation, simulation, and/or animation either locally or remotely via the Internet. With regard to the computer animation type of virtual laboratory, the experiment is often a graphical model of the actual experiment.

This type of virtual laboratory does not include physical hardware, but it allows the user to observe the process and the end product by way of animation. It often allows users to direct the process and the end product with some controllable variables of the experiment in the software [4].

Development of virtual laboratories is not a novel idea. There is a tremendous amount of virtual laboratory software on various subjects available in the literature and on the Internet sites. In the area of occupational health and safety, there exists commercially available software named IHVL (Industrial Hygiene Virtual Laboratory). IHVL was created in CD-ROM format and it contains a Lab module and Notebook module that interact with one another. Labs are multimedia and feature an index listing of available modules, instructions, and an experiment window where the user can perform techniques, view photos and videos, and enter calculations and data from observations. Notebook is filled with questions that demonstrate understanding of the key concepts and lab material. The questions are designed for maximum retention of the material. In some cases, questions require the user to make calculations and to extrapolate conclusions. Navigation is performed through the simple and intuitive navigation bar at the bottom of each page. Instructions are easy to follow and unintrusive to the learning experience [5]. Development and efficacy testing of IHVL has been fully described in [6; 7].

The purpose of this paper is to present development of a virtual laboratory for engineering students undertaking courses related to monitoring, evaluation and control of occupational

environment at the Faculty of Environmental and Manufacturing Technology and the Faculty of Ecology and Environmental Sciences, Technical University in Zvolen.

### Materials and methods

The process of creating a virtual laboratory is based on the approach proposed by Huang [8] and it consists of five phases:

- phase 1 – Understand – understand who will use the module (target group) and address how the module will help the users learn (educational challenge, needs assessment);
- phase 2 – Design – design the module for your user (learning design), from a user's point of view (usercentric);
- phase 3 – Build – build interactivity and multimedia components using best practices (media development and coding);
- phase 4 – Test – see how well your users respond to the module (user testing, usability heuristics);
- phase 5 – Improve – evaluate how well students learned and how well the module performed (evaluation of learning outcomes).

The development approach takes advantage of the existing software technology (e-learning authoring software Articulate Storyline®), multimedia technology (digital video, still photography, sound), and a logical and structured approach to the presentation of materials. Storyline is a powerful standalone tool with unparalleled interactivity features that will help build dynamic, engaging content — including simulations, screen recordings, drag-and-drop interactions, click-and-reveal activities, quizzes and assessments, and much more. Building courses in Storyline is a combination of adding the content to the slide and then creating interactive elements. Storyline provides a wide range of publishing formats (by default to Flash but also including publishing for iPad and HTML5), as well as the option to preview the content prior to publishing.

From the pedagogical point of view, the design of a virtual laboratory must consider both conventional and modern learning theories [1]. The virtual laboratory should support not only constructive and experience-based learning, but also collaborative learning, practical hands-on experience, and creativity without fear that something could get broken. According to the conventional learning theory, cognitive framework was used that is based on four types of knowledge: declarative (“knowing that”), procedural (“knowing how”), schematic (“knowing why”), and strategic (“knowing when, where, and how our knowledge applies”). Furthermore, the virtual laboratory with simulation of the measurement devices developed by the authors is based on the instructional methods proposed by Gagné [9] and provides opportunities for exploration. These methods include:

- gaining attention,
- informing students of the objective,
- stimulating recall of prior knowledge,
- presenting the stimulus,
- providing learning guidance,
- eliciting performance,
- providing feedback,
- assessing performance,
- enhancing retention and
- transfer of learning.

### Results

The lab is divided into modules that provide concise overviews and descriptions of the basic concepts in topics like noise, vibrations, microclimate conditions, dustiness, chemical factors and lightning. Each module consists of six submodules: Introduction, Theoretical Background, Measurement, Evaluation, Control and Check Test (Fig. 1).

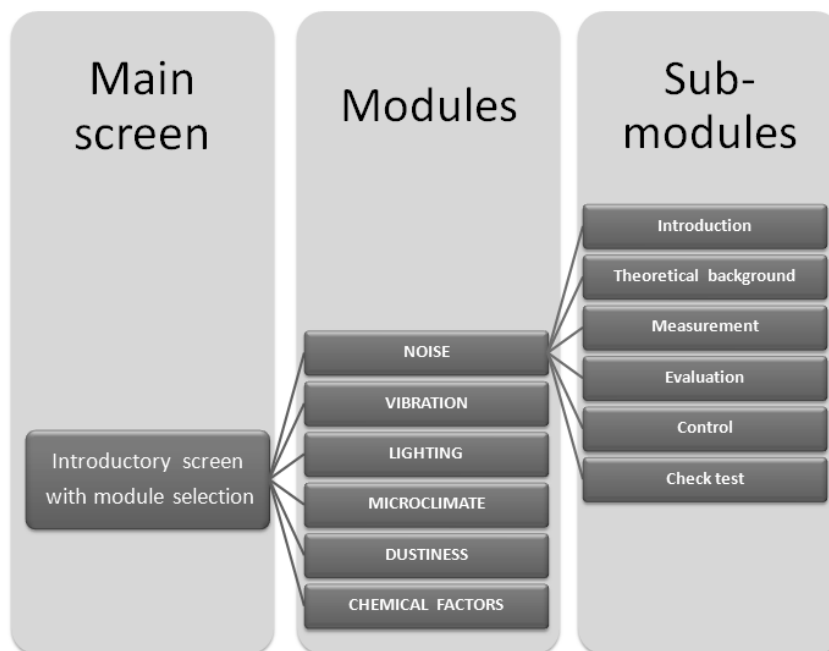


Fig. 1 Modular framework of virtual laboratory

In addition, each module contains interactive technical exercises which foster the understanding of the basic principles and practices for collection, detection, identification, calculation and interpretation of qualitative and quantitative data related to risk factors that may adversely affect health and safety of people in working environment (Fig.2). The content of each module includes still and video photography demonstrations of field use, interactive animation of measurement and calibration techniques and text pages for instructions. At present time a virtual laboratory is available only in the Slovak language but the English version will be prepared upon completion of testing.

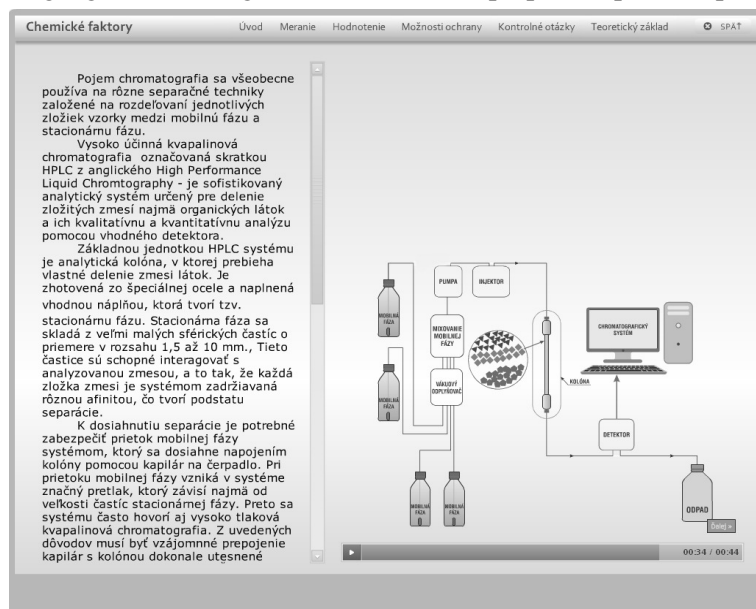


Fig. 2. Example of interactive exercise in Chemical factor module: HPLC system building

## Conclusion

As we progress through the digital age, educators must take care to ensure that pedagogy drives the development of technology tools and not vice versa. As universities experience declining budgets and increased demand for all resources, technology may provide some efficiencies and economies. However, these technology tools should be student-centered and pedagogically based [2]. The virtual

laboratory is an emerging trend for engineering education. Students can conduct experiments via a computer in a time-efficient and cost-effective way [8; 10]. In this paper, we described development of a virtual laboratory for evaluation and control of occupational hazards. The future work includes user-based evaluations of the usability of the developed lab and learning effectiveness measurement.

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