Interactive Demonstration of PeTEX Platform for e-Learning and Telemetric Experimentation

A holistic approach for tele-operated experiments in production engineering

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Abstract—Particularly in environments where experiments are the core elements of learning, it is considerably important how experiments are accessible and operable. Especially in the field of production engineering education, real-time remote “hands on” laboratories did not exist in the past. During the EU funded project “Platform for e-learning and Telemetric Experimentation (PeTEX)”, the team has designed and developed a prototype of a networked and distributed learning environment for individual and cooperative lifelong learning aiming at experiment-based education in production engineering. The distributed prototype consists of three physical real laboratories in the areas of material characterization in forming technology, cutting using a milling machine and joining using friction stir welding. The experiments are holistically integrated into the modularized learning material. The proposed demonstration will focus on the example of material characterization in forming technology and will include the presentation of online learning material and the tele-operated experiment.

Index Terms—Engineering education, e-learning, interactive systems, international relations, laboratories, learning systems, online learning, remote laboratories, experiments.

I. INTRODUCTION

The principle goal of this project was the development of a comprehensive prototype of tele-operated experiments in the field of production engineering and integrating them into a didactical conceptualized learning environment [8, 2, 3]. Within the environment, individual and group oriented learning frameworks have been constructed, which are able to sustain a multi-country learning community.

The physical real laboratories are developed by the project partners, which are located in three European countries:

- Germany (TU Dortmund University, Institute of Forming Technology and Lightweight Construction – IUL),
- Italy (University of Palermo, Department of Mechanical Technology, Production and Management Engineering – DTMPIG) and
- Sweden (Stockholm Technology University – KTH, Department of Production Engineering).

The Center for Research on Higher Education and Faculty Development (HDZ, TU Dortmund University) contributed to the development and deployment of the educational model and moderated the collaborative designing processes during the lifetime of the project [7].

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II. CONCEPTUALIZATION

The whole platform system is based on a customized installation of the Learning Management System Moodle
including interactive self-learning modules, a learning community area where the social software components for course communication, user-generated content, and resource sharing have been integrated. Within that context, the learner is provided with access to the telemetric experimental set-ups. An overview of the pieces and how they play together is shown in the overview of Fig. 1. All learning-objects are integrated in, or obtainable via Moodle. Fig. 1 shows the entire Moodle screen in the middle with the opened course for the uniaxial tensile test, consisting of several lessons. The foreground shows:

1. an interactive learning module, designed with the e-learning authoring tool LernBar [4],
2. the Moodle-window for conducting the experiments,
3. and the window with Moodle-tools for peer-reviewing (Workshop).

It is also intended to install the OpenMeetings plug-in [9] to allow convenient video-conferencing, both within the entire learning-community as well as in the domain-specific courses.

A. Competence Development as Learning Walkthrough

In this project, learning is conceptualized as a competence development activity. Competences can be achieved by distinguishing and pedagogically structuring the learning environment into knowledge-oriented, skill-oriented, and performance-oriented learning outcomes [1] providing the basis for learning activities.

The development of competences is designed as a “walk” through modularized learning objects (see Fig. 2), such as instructions (information, knowledge, methods, tools, etc.), learning activities (exploring the tele-operated experiments, data analysis, interpretation, summaries, structuring, questions, answers, etc.), and performance activities (collaboration, collection, producing glossaries, portfolio work, discussions, etc.).

Fig. 2 shows the socio-technical structure of the various modularized activities in the learning environment: a learner “walks” through these modularized learning activities, exploring research questions, conducting tele-operated experimentations, finding answers, making interpretations (discovery learning), and finally, discussing results with peers and writing a lab-report as final assessment.

- The red bar represents the learning community area, where the social software-components for course communication, user-generated content, and resource sharing have been integrated, e.g. a video-conferencing tool with screen-sharing functions, and the Moodle-tools for peer-reviewing.
We call this approach “experimental e-learning”. Using walk through a learning path aimed at:

The proposed demonstration will illustrate one of the appropriate modules will be shown. The learner will through the developed learning material organized in interaction using a modern web browser [Fig. 3]. 

This framework facilitates the configuration of walkthroughs as specific training sequences for different levels, from beginner to advanced levels. The latter, more complex self-directed exploratory- and problem-based learning walkthroughs will have comprehensive means of navigating through the entire environment, with the opportunity of interacting with all learning objects, and finding solutions for complex problems.

For the current prototype stage, PeTEX has defined three consecutive learning levels:

- During the testing phase, the beginner-level students will receive a specified guideline for “walking” through the learning environment, and for carrying out a predefined experiment.
- Intermediate-level learners will have to solve a subject-specific real-world scenario, applying the learning objects, and experiments in a self-directed way.
- Advanced learners will have to design own research questions. They will have to write a proposal and check it with their supervisor. After his agreement they will get full opportunity carrying out their own experiments.

We call this approach “experimental e-learning”. Using the approach of socio-technical systems and networks, technical, educational and social aspects are integrated into the design process.

III. THE INTERACTIVE DEMONSTRATION

The proposed demonstration will illustrate one of the tele-operated real-time experiments – the uniaxial tensile test. In the field of manufacturing engineering, namely the area of forming technology, this is one of the most important and fundamental tests for material characterization. This experiment has been comprehensively adapted – according to engineering design, automation and the overall handling of the entire process – as well as holistically integrated for tele-operated interaction using a modern web browser [Fig. 3].

During the demonstration, systematic “walks” through the developed learning material organized in appropriate modules will be shown. The learner will walk through a learning path aimed at:

1. Introducing to forming technologies in connection with material characterization
2. Becoming acquainted with relevant process information to be used and the fundamental parameters affecting the process behavior

3. Dealing with different kinds of test questions used for assessment and to highlight important aspects

After the learner completed some of the theoretical aspects, the demonstration will continue to show the real-time, tele-operated uniaxial tensile test carried out by the learner itself. This learning step focus on setting up and configure the experiment, running it as well as interact with it and finally analyze and discuss the data and results.

While setting up the laboratory experiment, the learner is provided with an interface consisting of:

- A real-time camera stream
- Input fields for parameter set-up
- A graph building up corresponding to the runtime
- Fields where the running measurement data are shown

Firstly, the learner prepares the test machine by placing the specimen at its appropriate position using a 6-axes robot. Therefore, the robot carefully maneuvers to pick up the specimen and transports it to the clamping position. Steps are shown in Fig. 4. The set-up process finishes with the automatic, force and distance controlled clamping of the specimen.

Secondly, using the provided interface the learner can now configure the experiment by adjusting the test parameters. When the test has been started the live stream delivers a continuous and adjustable look at the experiment.

Finally, after the experiment has finished, either by user interaction or pre-configured limits, the learner is provided with the raw data and results as well as the video stream and the data which where used to build up the graph during the experiment to use it for his/her own analyses and for discussion within the community as well as the final lab report.

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