

Platform for eLearning and Telemetric Experimentation (PeTEX). A Framework for Community-based Learning in the Workplace.

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ABSTRACT

The EU-funded project *PeTEX-Platform for e-Learning and Telemetric Experimentation* aims to design and establish a prototype of an e-learning platform for the development, implementation, and delivery of educational and training programs in the field of manufacturing engineering. The development of tele-operated experimentation and its provision to distance learners opens new dimensions of knowledge acquisition, particularly where experiments are the core elements of learning. The principle goal of this project is to establish individual and group oriented learning for different target groups like students and professional workers within a platform-system able to sustain a multi-country learning community. Hence, an educational model is designed which integrates the tele-operated experimentation platform with teaching content and learning activities in order to support a successful learning walkthrough for different target groups.

Categories and Subject Descriptors

K.3.1 [Computers and Education]: Computer Uses in Education – collaborative learning, computer-managed instruction (CMI) computer-assisted instruction (CAI), distance learning.

General Terms

Design, Experimentation

Keywords

Engineering education, socio-technical online learning, interactive learning systems, learning platforms, workplace learning, remote laboratories, tele-operated experiments.

1. INTRODUCTION

The unique aspect of *PeTEX - Platform for E-Learning and Telemetric Experimentation* is that teaching and learning arrangements involve interactive live experiments through a real-time video-based access into three physical-real laboratories.

Remote laboratories in engineering education are nothing new. According to [1], a wide range of distance learning environments have been developed and deployed over the last decade, particularly in electronics, microelectronics, control engineering and robotics. However, remote “hands on”- laboratories in *production* engineering education, surprisingly, did not yet exist.

The prototype-portfolio of the PeTEX environment provides experimental learning for material testing and machining capabilities in the important production engineering fields

forming, cutting, and joining [2]. The physical-real laboratories are located in the three European countries of 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, Department of Production Engineering - KTH). The Center for Research on Higher Education and Faculty Development (TU Dortmund University, HDZ) contributes to the development and deployment of the educational model and moderates all collaborative designing processes during project lifetime.

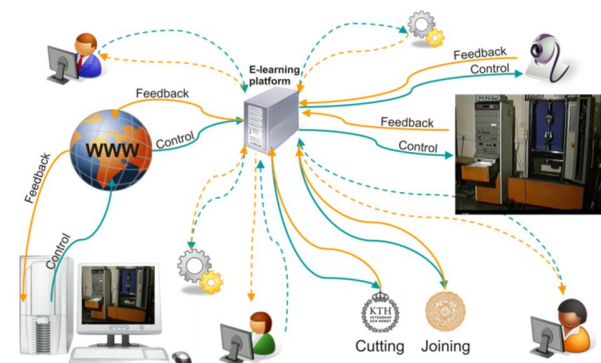


Figure 1. Principle of the PeTEX distribution of tele-operated experiments

A framework to integrate the technical, educational and social dimensions in the design is provided by the approach of socio-technical systems and networks [3]. Instances of learning and teaching in socio-technical environments provided by the participatory design discourse suggest that new approaches should be situated in a specific context and embedded within social interactions and didactical methods [4], [5].

2. Objectives of tele-operated experiments in manufacturing engineering

The objective of tele-operated experiments in manufacturing engineering during the PeTEX prototype stage is to enable learners to effectively carry out material characterization tests with the uniaxial tensile test (1), to weld metal sheets using the innovative technique of friction stir welding (FSW) (2) and to set up the appropriate parameters for an effective cutting process as

well as to gain knowledge in advanced material and machining process monitoring and optimization (3).



Figure 2. Tele-operated Tensile Test: real-time values (top bar); video stream with buttons to control and interact with the experiment (upper left); set-up panel for test configuration (right); real-time diagram including access to the test archive (left)

Within the subject of forming, one of the most important tests for material characterization – the uniaxial tensile test – has been adapted for tele-operated usage (see Fig. 2). Furthermore, the aspect of joining will be included in the telemetric experiment for friction stir welding (FSW), a solid-state welding process. Such an approach allows students to remotely control and use a CNC milling machine in order to perform a number of FSW experiments and to test the joints by remotely using a testing machine.

2.1 Fields of work to apply tele-operated experiments in manufacturing engineering

These experimentation capabilities are deployed in a great variety of academic as well as professional manufacturing engineering’s fields of work, e.g.

- ground-based and advanced research,
- product development,
- manufacturing optimization,
- quality control to achieve safe, accurate and efficient materials, and
- component and structural testing.

For example in the field of friction stir welding, it should be observed that a greater diffusion of the FSW process and its specific characteristics would have positive effects first of all on the local transportation industries. In this respect, a typical example is given by the Sicilian sme working in the manufacturing of nautical products. Here, joining is a crucial technology to obtain effective hybrid joints (between composite laminates and metallic blanks) but also between lightweight material parts. It should be observed that, today, we are definitively facing a growth of the market of nautical products: on the basis of data from UCINA (Unione Nazionale Cantieri Nautici

e Industrie Nautiche ed Affini) it can be stated that, as far as Italy is regarded for instance, the value registered for the Italian production of pleasure crafts for the year 2005 amounted to approx. 2.5 billion Euro, with a 9% increase over the previous year. Today, such industries, with specific reference to the sicilian environment, are characterized by the application of consolidated know-how and are rarely associated with innovative knowledge, especially as far as manufacturing technologies are concerned.

2.2 Target Groups and Potential Impacts on Workplace Learning

According to the *UK National Institute of Adult Continuing Education* “Workplace Learning is that learning which derives its purpose from the context of employment. It should address the needs and interests of a variety of stakeholders including employees, potential employees, employers and government. It is a process of learning which will

- enable individuals, employers, and organisations to respond to the changing nature of economic activity;
- contribute to improved efficiency and productivity in employment;
- meet the personal and career development needs of individuals” [6],
- respond to new domain specific developments and progresses.

Hence, the two main target groups of the proposed PeTEX-community are students at the partner universities – as potential employees -and industry employees of the associated partners. On the basis of their technical background, the potential industrial knowledge seekers can be further classified into two groups (Figure 3). The members of the first group are already technically qualified and willing to enhance their knowledge and skills with regard to current improvements and changes in manufacturing technologies. The members of the second group come from technical areas other than manufacturing engineering and are interested in gaining a fundamental knowledge of production science.

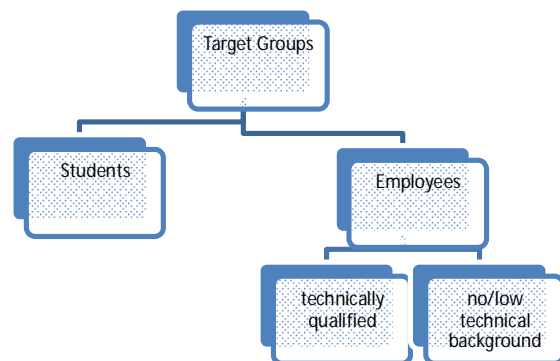


Figure 3. Proposed target groups

Considering the potential impact on and the benefits to the target user groups, the project aims at improving conditions for lifelong learning, acquiring specialized knowledge in manufacturing technology from different European institutions, increasing convergence, opening the educational program to different groups from industry and academia, facilitating intercultural exchange, increasing virtual mobility and new flexible forms of access to knowledge, and enhancing the communication and cooperation competencies.

The main advantage of PeTEX for small and medium-sized companies is the opportunity to enhance their technological skills. Moreover, telemetric experimentation will allow companies to try innovative joining processes without facing huge expenses (machines, fixtures, technical upgrades...) and with the possibility to 24/7 access to innovative learning contents, get feedback from experts and/or a wide community of users. At the same time, students will be able to experience the actual effect of the most relevant process parameters on the mechanical effectiveness of the obtained joints.

The possibility to run tele-operated experiments will enable workplace learners as well as students not provided with the necessary technological and scientific prerequisites to get a full comprehension of the domain specific material processes, considering both the theoretical point of view and the process potential for actual industrial applications. This will increase the possibility to share valuable resources, like machines or a certain infrastructure with other locations, which do not dispose of these specialties.

3. Pedagogical Concept

Current discussions in higher education centre on the turn “from teaching to learning” [7]. Concepts promoting the shift from teacher-centered teaching to student-centered learning concepts are nothing new. However, discussions about didactic and educational learning approaches have gained impetus as new community platforms emerged. The new approach claims to support teaching and learning differently. It holds that a new balance between teaching and learning is essential for supporting creativity and best learning effects. Learning-centered approaches promote a re-orchestration of teaching and learning arrangements where learning is regarded from the learners’ viewpoint.

In this contribution, learning is defined with the constructivist approach, positing that learning processes are socially constructed: “Learning is an active process of constructing rather than acquiring knowledge and instruction is a process of supporting that construction rather than communicating knowledge” [8]. “Individuals make sense of their own world and everything with which they come in contact by constructing their own representations or models of their experiences” [9]. Learning is not defined as simply the transmission of data from one individual to another, but as a social process whereby knowledge is co-constructed in a situation within a community of practice [10], [11]—as “situated action” [12] within socio-technical networks [13], e.g. at companies’ workplaces and workers’ or students’ ‘home offices’.

3.1 Exploratory, discovery, experiential, and experimental learning

In the presented set-up involving remote laboratories, exploratory learning is based on Internet-supported tele-operated, live experimentation in real-time in the field of mechanical engineering for different manufacturing technologies [14].

According to [15], “exploratory learning is an active process in which a learner (...) finds out and constructs his own meaning”. Learners “... interact with the world by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments” [16]. This means learners explore something (e.g., hypotheses, ideas, and results) without a given narrow solution path. This type of learning model is demonstrated

e.g., in case-based or project-based scenarios. An extended concept of this learning model is linking students’ learning with research [16]. This model of ‘inquiry learning’ is based on exploratory learning approaches also known as discovery learning [15].

Similar to discovery learning, Kolb’s “experiential learning theory” [17] covers four steps: *concrete experiences* (being involved in a situation, doing something), *active experimenting* (testing a theory by making a plan and following it), *reflective observing* (looking at an experience and thinking about it), and *abstract concept-making* (forming theories about why an experience happened the way it did). In the PeTEX project, *experimental learning* is defined as combined forms of *discovery learning* and *experiential learning*.

3.2 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 [18] so that they can provide 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.).

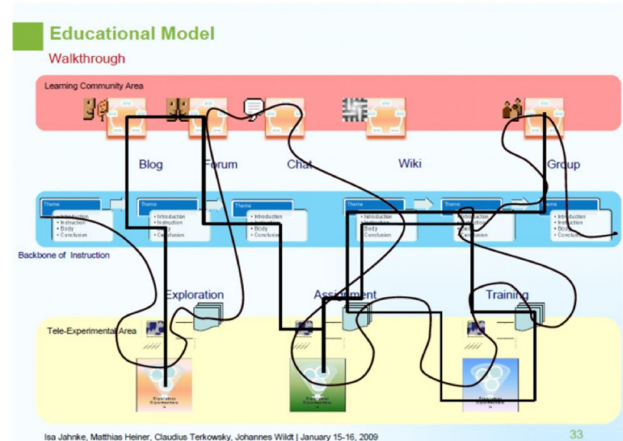


Figure 4. Educational Model – Walkthrough (the two different lines symbolize paths of two different learners)

Fig. 4 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 report (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 (*Workshop*), forums, blogs, wikis, chat-channels, etc.

- The blue bar represents the *Backbone of Instruction*, integrating the interactive learning modules. These comprise the necessary theoretical foundations of the three experimental test beds.
- The yellow bar represents the three remotely accessed experimental test beds, and the related interactive software interfaces.

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: 1) 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. 2) Intermediate-level learners will have wider opportunity for defining test bed settings, and, 3) advanced learners will have to solve a subject-specific real-world scenario, applying the learning objects, and experiments in a self-directed way.

4. Online environment Moodle

The PeTEX project-team decided to deploy *Moodle* (“Modular Object-Oriented Dynamic Learning Environment”, available at: <http://moodle.org/>) as the technical and graphical user interface as the basis for the PeTEX-system. Moodle is an online platform integrating learning objects in a highly modularized way. Hence, it facilitates e-learning design for individual as well as community activities in the form of path-oriented and self-directed walkthroughs. The characteristics of Moodle are compatible with the social constructivist approach, which holds that a new balance between teacher-led instructions and learner-led construction must be achieved.

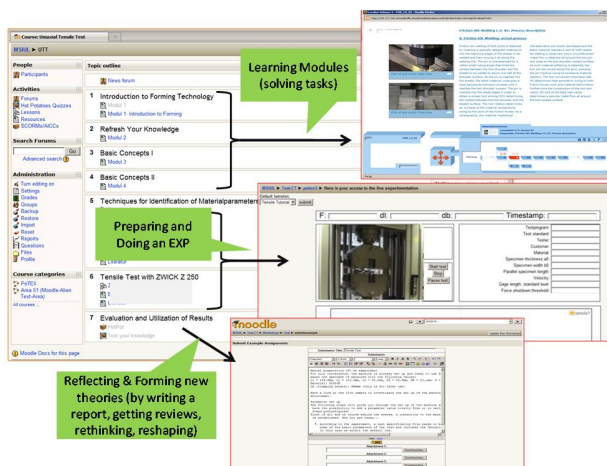


Figure 5. Experimental online learning (Screenshot PeTEX). In the background, the Moodle graphical user interface is to be seen. All PeTEX learning objects are integrated in or accessible via the Moodle-LMS.

All learning-objects are integrated in, or obtainable via Moodle. Fig. 5 shows the entire Moodle screen with the opened friction stir welding-course, consisting of seven lessons. The foreground shows: a) the interactive LernBar learning module, b) the Moodle-window for conducting the experiments, c) and the window with Moodle-tools for peer-reviewing (*Workshop*). It is also intended to install the *openmeeting* plug-in to allow for convenient video-conferencing, both within the entire learning-community as well as in the domain-specific courses.

5. Conclusion

The effect of this project is merging different types of learning: it provides individual and group oriented knowledge acquisition in the field of manufacturing engineering as well as social and intercultural learning in a multi-country learning community. These processes may bring about a kind of collective identity by means of building up group awareness between different target groups within a socio-technical software system. A free access to limited e-learning modules and remote experiments will remain an important incentive for new users. In this way, the complete dissemination of the technical contents will be guaranteed to form a basis for sustainability and continuous development according to the vision of the project.

In general, the obtained and tuned prototype, also on the basis of its modularity concepts, will be further extendable in the future, considering new nodes of the network, i.e. new laboratories connected to the platform, in which further experiments will be carried out, or increasing the level of automation of the considered and presented remote controlled experiments.

6. ACKNOWLEDGMENTS

The PeTEX team sincerely thanks: Prof. Dr.-Ing. A. Erman Tekkaya, Dr.-Ing. habil. S. Chatti, TU Dortmund University (IUL), and Dr.-Ing. U. Dirksen, Poynting GmbH, Dortmund, Germany as well as Prof. Dr. J. Wildt, M. Heiner, M. Schaefer, TU Dortmund University (HDZ), and Prof. F. Micari, Prof. E. Lo Valvo, Prof. L. Fratini, PhD R. Licari, PhD G. Buffa, Department of Mechanical Technology, Production and Management Engineering (DTMPIG), University of Palermo, Italy, Prof. M. Nicolescu, P. Johansson, Kungliga Tekniska Högskolan (KTH), Department for Production Engineering, Stockholm, Sweden for their great cooperation during the project. Furthermore, we thank M. Spiess, M. Sappok, S. Grunert, M. Hoffrichter, TU Dortmund University (IUL), and N. Karcan from TU Dortmund University (HDZ) for elaborate web-authoring with LernBar and Moodle, Dr. P. Ilyes, Goethe-University Frankfurt/Germany (Science and Technology Studies, Institute for Cultural Anthropology and European Ethnology) for strong support, and S. Voss, D. Weiß, A. Mereu, C. Bremer, R. Müller, A. Tillmann and Prof. Dr. D. Krömker from stadium-digitale - Central eLearning-Facility of Goethe-University Frankfurt/Germany for providing and supporting us with LernBar.

This project has been funded with support from the European Commission.

Project-code: 142270-LLP-1-2008-1-DE-LEONARDO-LMP;
This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



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