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“**EVALUATING LAB@FUTURE, A COLLABORATIVE E-LEARNING LABORATORY EXPERIMENTS PLATFORM**”

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Abstract

This paper presents Lab@Future, an advanced e-learning platform that uses novel Information and Communication Technologies to support and expand laboratory teaching practices. For this purpose, Lab@Future uses real and computer generated objects that are interfaced using mechatronic systems, augmented reality, mobile technologies and 3D multi user environments. The main aim is to develop and demonstrate technological support for practical experiments in the following focused disciplines namely: Fluid Dynamics - Science subject in Germany, Geometry - Mathematics subject in Austria, History and Environmental Awareness – Arts and Humanities subjects in Greece and Slovenia. In order to pedagogically enhance the design and functional aspects of this e-learning technology, we are investigating the dialogical operationalisation of learning theories [1] so as to leverage our understanding of teaching and learning practices in the targeted context of deployment. To be able to evaluate the lab@future system in its entire complexity an evaluation methodology including several phases has been developed, performing formative as well as summative evaluations.

1. Introduction

The Lab@Future project (the project full name being - ‘School LABoratory anticipating FUTURE needs of European Youth’) is a research and development project, funded by the European Union (EU) as part of the Information Society Technologies (IST) program.

The project investigates the means by which pedagogical insight and state-of-the-art technologies can be harnessed in the development of e-learning technological tools so as to facilitate and enhance innovative approaches to teaching and learning in European high schools. In order to achieve this remit, pedagogical research in the [Lab@Future](#) project is underpinned by learning theories that highlight the significance of social and cultural aspects of teaching and learning practices in context whilst recognizing the dynamic nature of tool use behaviour. Given this consideration, [Lab@Future](#) e-learning technological tools strive to support established ways of teaching and learning in focused contexts whilst nurturing emerging and innovative practices in teaching and learning methods. [Lab@Future](#) strives to achieve this by facilitating flexibility and exploration in tool use mechanisms when teaching and learning, therefore enabling the user to introduce new teaching methodologies and learning activities under a common communication and collaboration technological environment [2].

The main goal of the Lab@Future project is therefore, to research and develop a prototype

** Authors are listed in Alphanumeric order*

system for supporting secondary school laboratory education. The overall rationale is that, both the pedagogical and technological effectiveness of the developed system will be evaluated at real educational sites i.e. school laboratories, educational venues e.g. museum and historical sites. In summary, key pedagogical and technological features integrated in the Lab@Future project include the following:

pedagogical features such as

- Real problem solving, collaborative learning, exploratory learning, interdisciplinary learning

technological features such as

- E-learning and m-learning
- Open learning environments
- Communication and collaboration platforms for learning
- Mixed and augmented reality for learning
- Shared virtual learning environments

2. Theoretical framework and Pedagogical Context

The three major pedagogical theories that [Lab@Future](#) supports are *activity theory*, *the theory of expansive learning*, and *social constructivism*. The Lab@Future platform is focused on supporting novel pedagogical concepts and learning practices based on constructivism, combined with action oriented learning such as real-problem solving, collaborative learning, exploratory learning and interdisciplinary learning. When working with the outlined pedagogical theories, we recognise the fact that there are diversities and variations in emphasis when applied to learning research. Therefore, in order to achieve a workable compromise with regards to the various facets of these three theories, research in the [Lab@Future](#) project in capitalising on exploiting the dialogical aspects of these theories so as to facilitate positive debate in the perception of teaching and learning from the viewpoint of these three theories.

Activity theory and *the theory of expansive learning* determining that ‘subjects’ or participants (e.g. students and teachers) in a learning activity consciously and unconsciously are engaged in dynamic learning goal or object formation. This entails that the outcome from a learning experience or activity cannot always be predicted because it will be influenced by several factors operating within the contextual environment or community in which teaching and learning takes place. This pedagogical stance therefore, emphasizes the fact that knowledge emerges as a result of disturbances or conflicts in learning activity, which results in the construction of novel practical activity systems and artefacts for use in real life contexts. Therefore, participants in a learning activity are essentially involved in constructing new:

- Learning activities
- Methods for teaching and learning
- Tools for exploring and interacting with learning objects (e.g. application sharing tools, content management tools etc.).

3. Evaluation methodology

The project puts a strong emphasis on the evaluation of prototypes. It takes into account the rich empirical results of former projects on European laboratory learning and their recommendations [4, 7], while also undertaking empirical evaluations for every different lab@future experiment prototype developed. The lab@future experimental prototypes (tested

at several schools per country from eight different European countries) are built based on specified learning scenarios for laboratory experiments on Fluid Dynamics, Mathematics, environmental sciences and Arts & Humanities. The evaluation methodology based on pedagogical and socio-technical theories aims at assessing the usability and usefulness of the lab@future system from a holistic perspective [3].

Since the pedagogical criteria play a central role for the development of the lab@future system (i.e. defining experimental settings, technical requirements and the evaluation methodology), we developed a multi-step procedure involving the consortium in the derivation process in order to elaborate a shared understanding of these criteria and their relevance for the lab@future development. They are derived from the pedagogical framework with the intent of providing a basis for forecasting effects of lab@future technology in more long-term curricular use. In addition to that, a more general evaluation regarding changes in learning cultures and organizational influences and opportunities for new teaching and learning is carried out, with the aim of trying to anticipate effects of the system on the work system and its overall activities.

Our methodological framework is based on CIELT (Concept & Instruments for evaluating learning technologies [4, 5], supporting heterogeneous teams in defining design goals and evaluating the fulfilment of these goals on the levels of technical requirements, pedagogical and didactic objectives, and changes in the organization of the system into which the new technology and new pedagogical approaches are introduced.

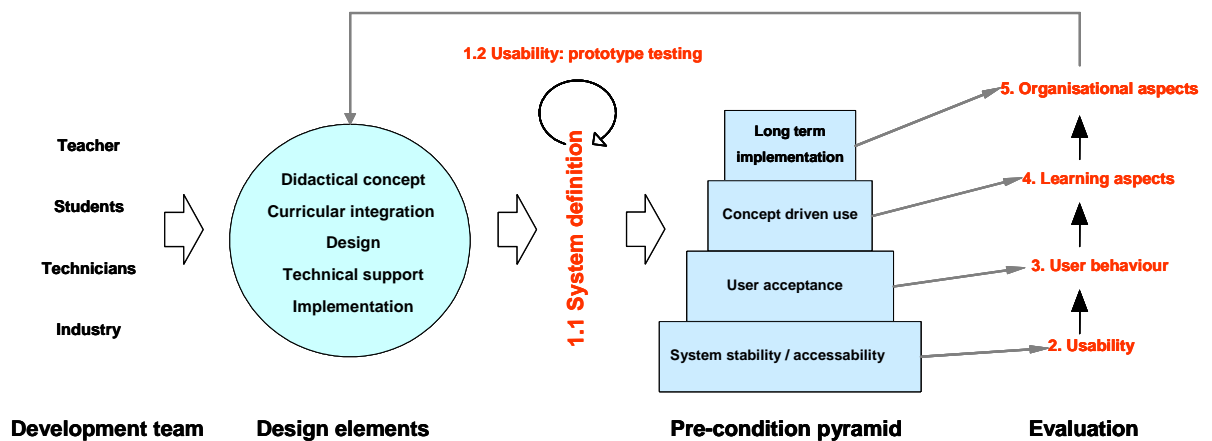


Figure 3: Overview of CIELT

Figure 3 shows an overview of CIELT. On the left hand side of the figure the different persons of the development team involved in a project are listed, displaying the heterogeneity of such teams. Core design elements are described, which have to be integrated in order to define an e-learning system (figure 3-point 1.1). The prototype testing focusing on usability (figure 3-point 1.2) is considered to be the first step in the evaluation process, setting the stage for any real world application and evaluation of the system. For the following steps in an evaluation process, the precondition pyramid needs to be considered. This pyramid proposes different levels of requirements that need to be fulfilled for evaluating specific aspects of an e-learning system. All steps are to be carried out in real world settings involving users of varied backgrounds in order to support user-centered evaluation and system design.

To be able to evaluate the lab@future system in its entire complexity an evaluation methodology including several phases has been developed, performing formative as well as summative evaluations [6]. The formative part consists of two phases (phase 1 and 2) and provides intermediary results with the aim to modify the ongoing development of the

lab@future system. The summative evaluation (phase 3) aims to assess the overall quality of the lab@future system. After the final system has been implemented and will be available over a longer period of time assessments against anticipated needs are performed. Different roles are assigned to the schools involved in the evaluation. Moderator Schools participate in a detailed and comprehensive evaluation, which takes place either at the schools or in the laboratories of lab@future project partners. At Remote Sites evaluations also involve the application of mobile technologies in museums or outdoor. Learner Schools are engaged applying the web-end solution of the lab@future system to provide a picture of the different application options at schools as well as providing insights into the varying demands to schools.

Table 1 presents all phases of the lab@future evaluation with respect to the development state of the lab@future system.

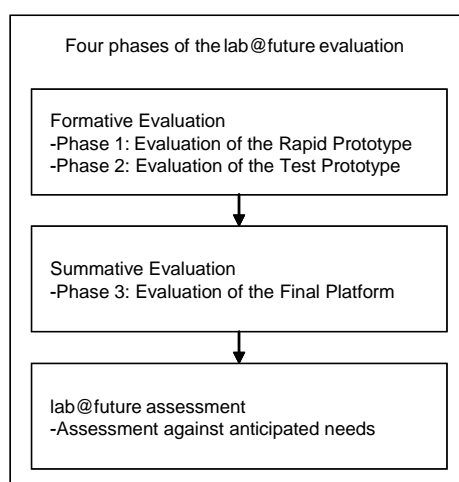


Table 1: Phases of the lab@future evaluation design

The phases of the lab@future evaluation design are described as follows:

Formative evaluation of the rapid prototype: To ensure a level of high quality of the design and implementation processes, the evaluation design takes into account three complementary perspectives. The first perspective of the rapid prototype evaluation focuses on technological requirements such as technological accessibility of the system and system performance in terms of communication and collaboration capacity. A real life situation is simulated, using several computers with different system set-ups. The reliability and responsiveness of the system is evaluated across these set-ups. In addition to the performance test, users with expert knowledge in different areas are asked to evaluate the user interface(s) of the lab@future system. Finally, end user evaluation provides fundamental information about how actual users interact with the lab@future system and what their concrete problems are. The main goal is to find out which aspects of the system are good or bad, and how the design can be improved. Targeted test tasks (based on the pedagogical requirements) carried out with the lab@future rapid prototype (small-scale experiments) are investigated. One moderator school with six pupils and two teachers participates in the evaluation.

Formative evaluation of the test prototype: For the second phase of the formative evaluation the lab@future test prototype has integrated the Fluid Dynamics, the Geometry, the History and the Environmental Awareness experiments. In addition to collaboration and communication functionalities the lab@future test prototype evaluation analyzes learning and teaching process. To be able to evaluate these processes the evaluation is performed over a longer period of time. For this reason the participating end users use the lab@future system for six teaching units' up to 50 minutes within 3 weeks. During these sessions a Learner school observes these sessions via an on-line connection. They are able to follow the session

via PC to monitor the used system features. Furthermore a survey in the participating schools is conducted, regarding changes in learning cultures, organizational influences and opportunities for new teaching and learning methods. The survey constitutes a base line for the actual technology use in schools.

Summative evaluation of the final platform: During this evaluation Moderator Schools are involved in an in-depth evaluation aiming at an integration of the lab@future system into their curricula. They use the lab@future system for several weeks, including the experiments in their regular class. Therefore a comprehensive evaluation of pedagogical criteria, organizational aspects, as well as the usability of the technical requirements is provided. To allow the comparison between collaborative learning supported by the lab@future system and the traditional more individualistic learning, project members attend and observe “normal” courses for several days. This information is then compared with observations made during the experimental sessions using the lab@future system.

Assessment against anticipated needs: The last stage of the evaluation process focuses on the actual use of the lab@future system in the real world (outside the research labs). To be able to draw a comprehensive picture several dimensions of use have been identified.

In Figure 4 a graphical depiction of a proposed set of dimensions that are used to analyze the context of use is presented.

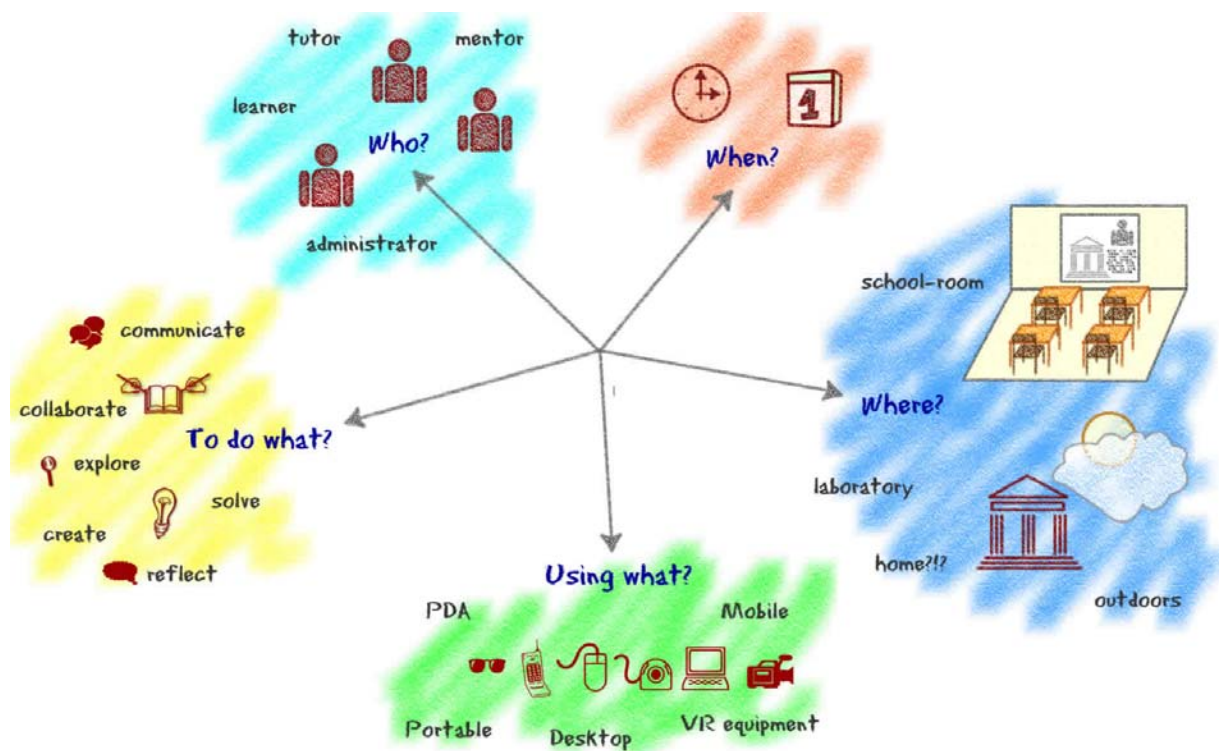


Figure 4: Dimensions of use

The main data basis for this assessment is provided by log files identifying frequency of use, duration, non use etc. (see dimension “when the lab@future system is used”, “to do what”). To be able to interpret the monitored usage patterns this information is then correlated with user profiles (i.e. who is using the system) based on questionnaire data as well as organizational analysis data, collected in the previous evaluations.

8. Conclusions

The Lab@Future project is focused on researching and developing innovative ICT for teaching and learning by pioneering the implementation of a “mixed and augmented reality” into an e-learning platform incorporating: 3D, Virtual reality, mobile and wireless technologies. In the meanwhile, [Lab@Future](#) research and design procedures are underpinned by pedagogical concepts drawn from the constructivist theory of learning, in combination and dialogue with activity theory, especially the theory of expansive learning. This approach to developing an e-learning environment introduces innovative features to e-learning that are based on a constructivist and expansive framework so as to provide an enhance and enrich common teaching environment in schools throughout Europe. Towards this end, [Lab@Future](#) is adopting a novel approach to evaluating the usability and usefulness of technological tools presented in the e-learning environment, which involves use of real educational site engaged in collaborative ‘e-laboratories’ learning sessions or what we refer to as ‘Lab@Future Experiments’. We applied this methodology to several European schools. This process has started at December 2002 and will complete at the end of the project, May 2005. Currently, the first set of results implies impressions for the system stability, usability and initial user behaviour. The method utilized questionnaires and interviews to evaluate the rapid prototype environment. Each experiment involved two (2) teachers and six (6) students. On system stability the platform components were reported as sufficiently integrated. On usability the user interface level was reported as sufficiently integrated. User behaviour with respect to the audio-conferencing was deemed of extreme importance and use while video-conferencing, stimulation and component help was deemed important to visualize results. User behaviour on virtual task accomplishment was regarded stimulating and satisfying, nevertheless it was more time consuming than expected.

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