EUROLEARN-EUROPEAN WELDER: BLENDED LEARNING FOR WELDING ENGINEER EDUCATION

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Abstract

This paper provides an overview of *Eurolearn-European Welder*, a EUREKA funded project that aims to develop and validate an innovative pedagogical framework for organizing, and delivering vocational skills development by using a blended learning training approach. Utilizing an application from the welding industry, and harmonized training guidelines from industry standards bodies, the project developed training for welding engineers that combines an online learning environment and lab practice. The paper describes the LAMS based, train-the-trainer program, and reports on the feedback received from its evaluation in various EU member States. The authors argue that the same training principles could be transferred to a wide variety of industry sectors.

Introduction

Implementation of the Lisbon Strategy requires a change of attitude regarding the deployment of training principles, and for supporting virtual presence for company based training at many levels in an organization. The EUREKA funded project *E!3118 Eurolearn-European Welder* (2004–08) contributes directly towards the Lisbon goals as it deals with all the aspects of in-company training via innovative approaches to technology enhanced teaching.

The project aims at the development of a blended learning training program that meets the requirements of harmonized European guidelines for the education of welders, by covering theoretical content as well as practical welding tasks. Adopting a blended learning approach to training, and utilizing a combination of advanced Information and Communications Technologies (ICT) and hands-on laboratory-based practice, the project examines the effectiveness of such an approach and its applicability in various industry settings.

The project consortium is comprised of higher education institutions and Small to Medium Enterprises (SME) companies from EU member states. Project partners took different roles in the development of the project, and as per the Eureka practices they were funded by their respective National Agencies. The partners represented by the authors of this paper were responsible for implementing the prototype blended training in an online environment based on the Open Source software Learning Activity Management System (LAMS, 2003).

This paper presents the methodology used for the development of the prototype, presents a high level view of the system design, and concludes with a discussion of the project findings and of knowledge transfer prospects.

Training Prototype Overview

The project combines the use of multiple teaching/learning technologies. It includes laboratory practice and computer based training, i.e. a training prototype focusing on a specific concept, or a series of inter-dependent tasks, dealing with the overall skill set that a Welding Trainee must have. This paper presents this practical training prototype which is built using the Open Source Learning Management System LAMS.

The prototype includes text, graphics, video and other multimedia content, organized and presented in strict Work Sequences, or for direct access to individual subjects following the model of Activity Based Training. Further, it allows for offline study, laboratory practice, as well as asynchronous and real time communication with the trainers. The practical training and practice in welding, including test welding, are based on relevant instruction and exercise schedules as per the Guidelines developed by the International Authorization Board and the European Welding Federation (EWF) regarding the required training of Welding Personnel (IAB/EWF 2005). The content addresses the needs of Fillet welders, Plate welders and Pipe welders, and as in a real-world industrial setting, a Work Order (WO) or Welding Procedure Specification (WPS) is used as a training instrument to allow access to the theoretical content. The Work Order is also used as the basis for theoretical simulations to allow students to evaluate the consequences of their actions.

Pedagogical Foundation

Given the objective of closely adopting real-world processes in the context of EWF certification guidelines, it was decided to use Activity Based Training as the foundation for the prototype for the training sequences for fillet welder according to IAB/EWF 2005 guidelines and with the stainless steel TIG141 welding process.

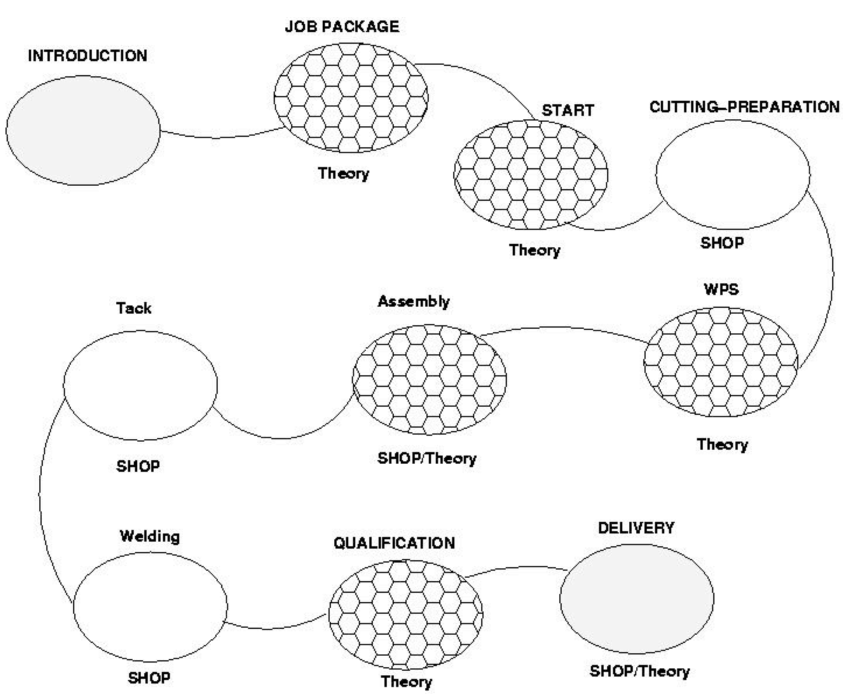
In Activity Based Training (ABT) the training follows real-world production activities according to the production path of a predefined structure or product as shown in Figure 1. This is in contrast with traditional methodology where students move procedurally through training from theoretical content to practice.

Following the decision to utilize ABT as the pedagogical approach, the training was organized accordingly in different modules that deal with theory or practical exercise work. In this model, students are expected to collaborate in a workshop or laboratory session, which is an important aspect of the methodology itself. When working in an industrial environment the worker has to work together with other personnel in order to meet the requirements in quality, time, and budget.

As learning has a social aspect, the adopted blended learning approach placed an emphasis on collaborative activities (Vygotsky, 1978) and computer-based communication supporting collaborative and participatory models the training design (Barab & Duffy, 2000).

The course consists of several job elements. Figure 1 below shows how one job package is built up of different elements, some of which are pure theory elements, and others are a mixture of theory and hands-on training. The training will be carried out in a workshop, or in a laboratory. Video streaming and/or video-conferencing may be used in theory packages.

Figure 1: A sample job element



Job Packages

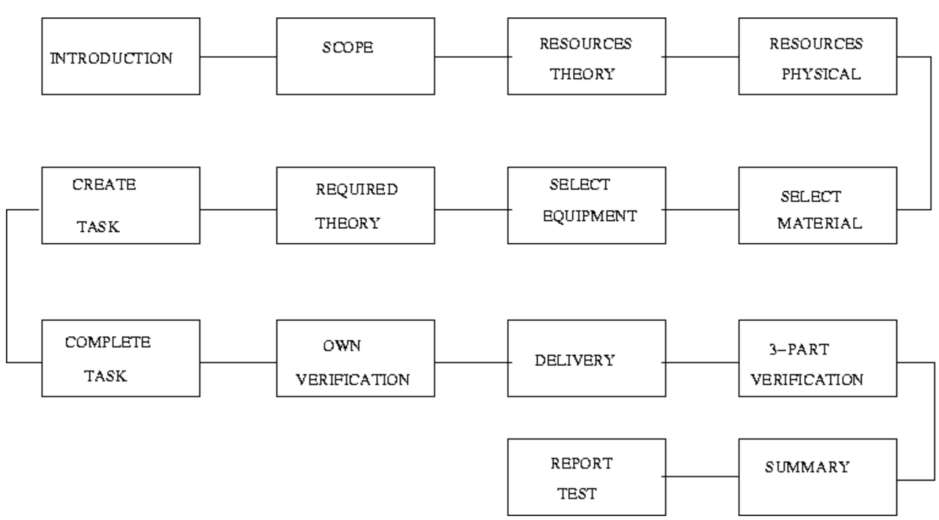
Further, the concept of a job package is defined as a collection of job packages, which are modeled in the prototype as *learning elements*. A job package is a complete set of specific activities that must be mastered in the welding industry in order to handle the whole production process. The activities are modeled according to the ISO 3834 Quality Assurance standard, and they include at least the following:

- drawing of the structure to be fabricated
- work description with which methods shall be used in the production
- work description with process description of the work process for reaching the target and the knowledge required
- quality assurance requirements for the ingoing elements
- quality assurance description of the outgoing elements
- work package description for the work to be done
- reference to available resources for the work
- reference to environmental resources or requirements or restrictions
- requirements for prerequisite knowledge, or knowledge to be obtained
- cooperation strategy with other in a defined group or to related groups.

Learning Elements

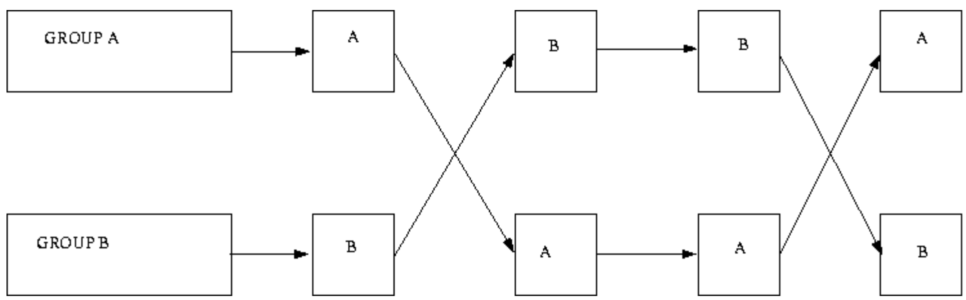
A learning element consists of both theoretical content as well as practical work. The practical task, when completed must be verified by the student as well as by a third party. This ensures both that the student feels responsible for the part itself, and also that he becomes aware of the Quality Assurance (QA), which is very important within the welding activities. The figure below shows a simplified design where no loops are included in the process flow.

Figure 2: A sample learning element



A central philosophy within fabrication is that the person who produces a product shall not be the one carrying out the quality control of the same product. To establish the same methodology in education an alternative production flow must be introduced whereby the product alternates between students or student groups. For example, when a part is produced by student A at a certain stage then student B will carry out the quality control of the part. Student B will then use the part from A in his own production and then transfer it back to A for the following quality control, as shown graphically below.

Figure 3: Alternating quality control



This process ensures that the students will become familiar with and will use the standard definitions and actions in the industry. It will consequently be mandatory to switch the objects for this purpose in order to avoid the case where a person verifies himself. If defects or nonconformance are found, then the necessary corrective actions must be carried out by the student.

Training Delivery

The training and practice in welding, including test welding, are based on relevant instruction and exercise schedules as per the Guidelines developed by EWF. The training prototyping is simulating the construction of a wood-burning oven, and both theory and practice address the needs of Fillet, Plate and Pipe welders. As in an industrial setting, a Work Order (WO) or Welding Procedure Specification (WPS) and associated Control Mechanisms are used as a training instrument to allow access to the theoretical content.

The blended learning training includes in-class lectures in combination with laboratory practice and online sessions. In terms of piloting and evaluation, welder trainers will first work closely with project partners in becoming familiar with the training approach for planning the pilot sessions. During the pilot testing, welder trainees will be shown the prototype and will be guided in its use. During the pilot testing, whereby welder trainees can follow the training at a self-paced basis, will allow the evaluation of the effectiveness of the prototype.

System Implementation

The prototype implementation followed an iterative development model using Rapid Application Development (RAD). At different stages of the development, it was exposed to expert trainers and subject matter experts for evaluation and guidance. However, prior to any development, a detailed user needs analysis was carried out.

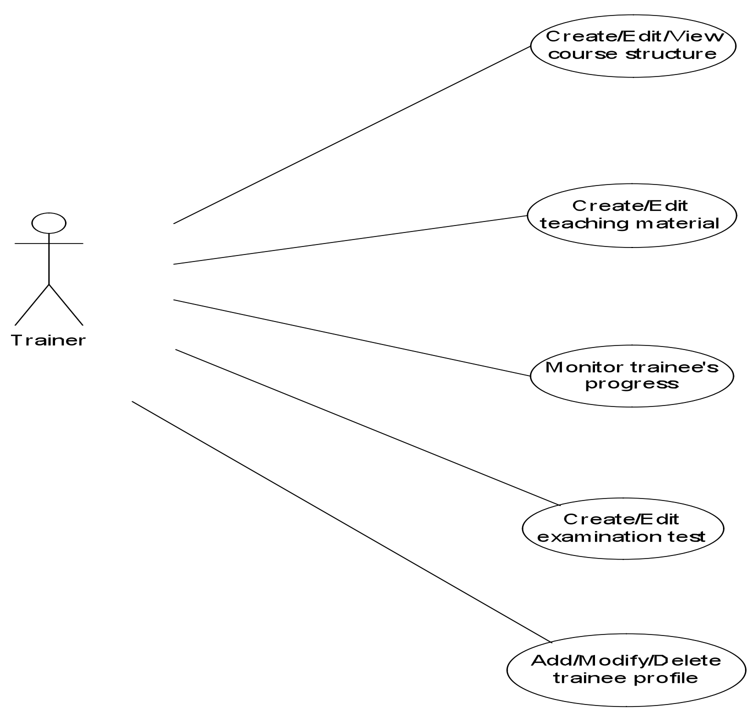
User Needs Analysis

During System Analysis a number of key target user groups were identified and for each target group a set of requirements was specified. For the purposes of the project these target groups were:

- Welder Trainees
- Welder Trainers
- Welding Engineer Managers

The requirements for each of these groups were modeled as Unified Modeling Language (UML) use-cases. For example, the UML use-case "actor" Welder Trainer was defined, and the associated requirements were identified. An example of this use-case is shown graphically in UML below.

Figure 4: Use-case for actor Welder Trainer



At a more technical level, additional roles such as that of course author and system administrator were also modeled. However the emphasis was placed on modeling the key groups stated above and to facilitate the development, certain assumptions were made. For example, it was assumed that the Welder Trainees would have minimum or no previous experience in the topics covered. The Welder Trainers would oversee the Blended Learning training, and would provide feedback to the project team. Finally, given the scope of the project, the role of the Engineer Manager at the factory floor was modeled but it was not implemented within the prototype.

Content Selection and Organization

A number of factors were taken into account when deciding the amount, level, and type of training content, and of course its online presentation. For example, the assumed Trainee Background had an impact on formulating the theory content and the associated practical exercises. Typical Trainer concerns (e.g., effectiveness of the training, its cost, duration, required resources) were also taken into consideration. However, above all, the selected content had to remain within the frameworks of international and European standards (e.g., EN-ISO-9606, EN287-1) for welding training and certification.

On the technical side, content organization and associated system development adopted international interoperability specifications, such as compatibility with the Sharable Content Object Reference Model (SCORM) Standard (ADL, 2004). Generally, the content includes text, graphics, video and other multimedia content, organized and presented in strict Work Sequences, or for direct access to individual subjects. Additionally, asynchronous and real time communication with the trainers is an available option.

System Design Views

The prototype system was designed for use mainly by the target groups specified in the user needs analysis. For instance, upon entering the environment, a Welder Trainee is presented with a practical problem description and then will have to follow the repeating process of *study-practice-take online test,* using Work Orders and Job Packages. Figure 5 shows a sample trainee screen that gives access to resources and shows the progress towards the completion, using standard Welding procedures.

Figure 5: Trainee view of guides and resources

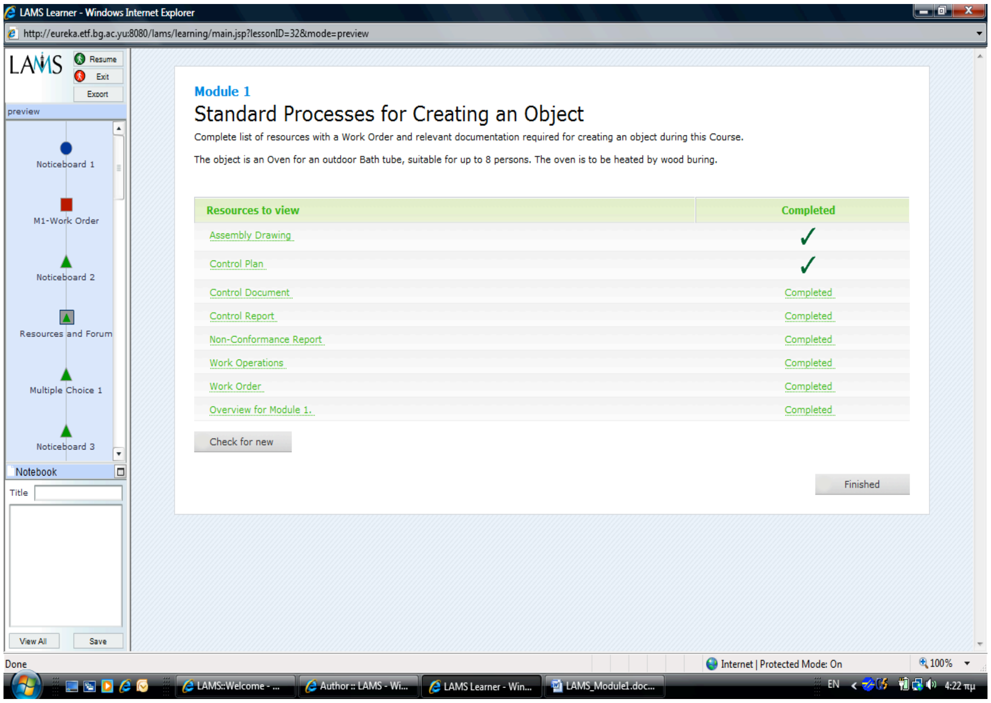


Figure 6 shows one screen that guides the trainee in Studying the Assembly Drawings for the practice problem in question.

Figure 6: Studying assembly drawings

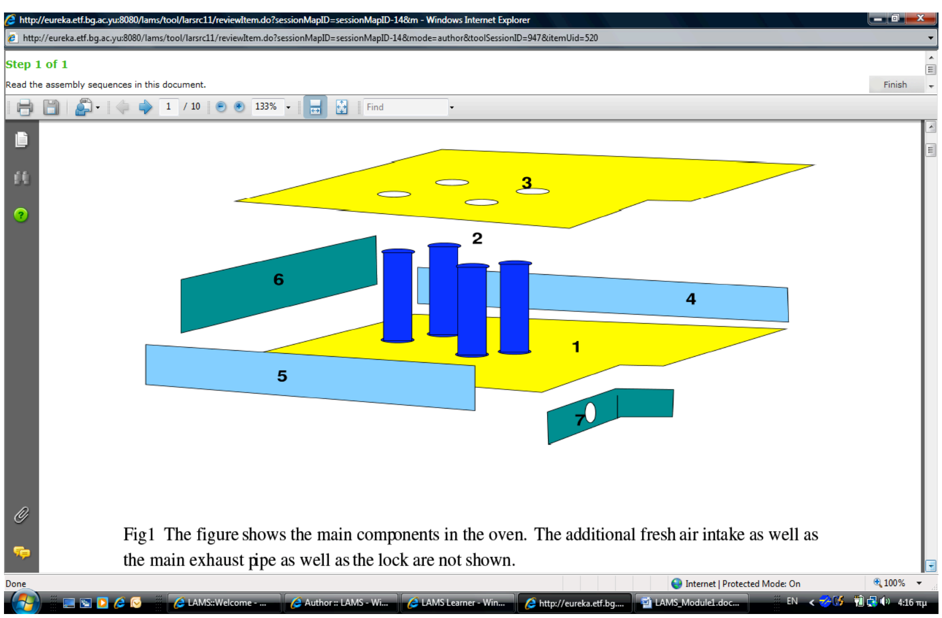
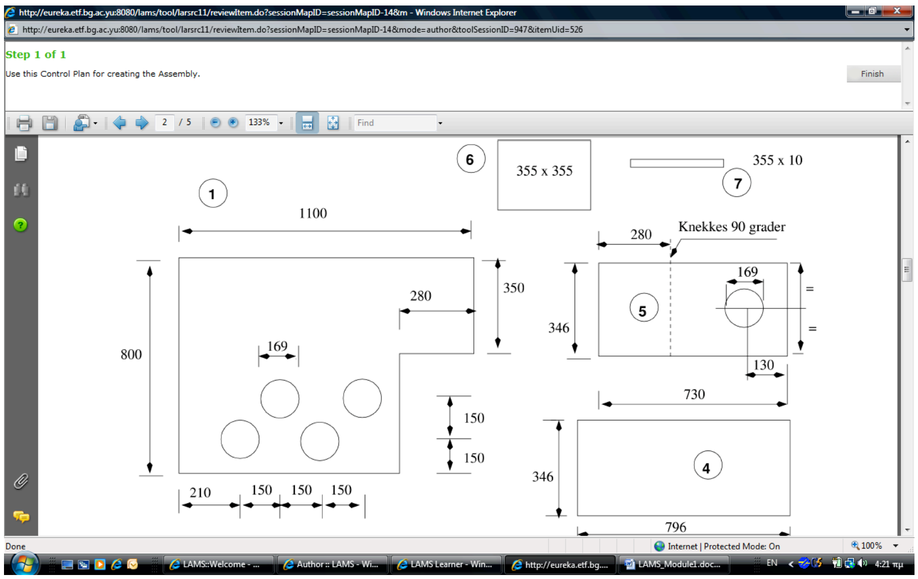


Figure 7 shows a schematic that is associated with the Control Plan assembly sequences for the practice problem in question.

Figure 7: A drawing plan schematic



Prototype Evaluation

Evaluation was an ongoing process that started at the early stages of the project and continued until the final versions of the implementation, and whenever possible, appropriate changes and revisions were made to the prototype based on the feedback received.

Partners and subject matter experts were asked to give their feedback on all aspects of the environment and the overall training approach. Evaluation factors included the user friendliness, navigation, type, amount and level of training content offered, as well as the overall effectiveness of the blended learning approach. These evaluations were conducted both informally via open discussions, and more formally via the use of interviews and questionnaires.

Feedback was generally very positive about the overall approach and the future possibilities. Indicatively, all participants in the evaluation studies agreed that the same training principles could be transferred to a wide variety of industry sectors.

Main concerns from trainers included the possible lack of technology in industrial settings, or the lack of basic computer skills by the target trainee group (i.e. welder trainees). However, at the same time trainers were supportive and confident that the proposed blended learning approach will enable trainees master the required skills faster and more effectively. Suggestions included more testing and evaluation and determining the right balance of the multimedia content to the practical sessions.

Comparison with Traditional Welding Training

The table below summarizes the main differences between traditional training approaches and ABT.

Traditional Training	ABT
Goes through sequential modules, each concentrating on a single topic	Goes through a production process and moves along this process until the product is finished
Not well suited for blended learning that includes laboratory practice	More appropriated for blended learning that includes laboratory practice
One topic is taught in full at a time	A number of topics are taught simultaneously in order to explain a special step in the production process. However the topics will usually not be completed fully in a single step. Further, the content of the topics are taught when needed in order to relate the topic directly to the practical production process
Topics are not taught when needed	The topics are taught when needed
Not well suited for just in time teaching	Allows for just in time teaching
Test pieces is being used, which do not motivate the student	A product is being made, that means a practical approach, motivating the student
Cooperation approach and Quality Assurance not stimulated	Cooperation approach and Quality Assurance is stimulated
Topic oriented	Task and process oriented

Conclusions

This paper reported on the implementation of *Eurolearn-European Welder*, a EUREKA funded project that developed and validated a blended learning prototype for delivering vocational skills development. The prototype targets welding engineer trainers and welding trainees. The underlying pedagogical framework was based on harmonized training guidelines from industry standards bodies.

Utilizing a combination of interactive resources and hands-on laboratory-based practice, the project examined the effectiveness of such an approach and its applicability in various industry settings. Evaluation feedback received from actual welding engineer trainers and subject matter experts was generally positive and encouraging, as it supported the potential of the training approach adopted.

Such a training approach can indeed provide adult welders with a second chance at education, and can reach those disadvantaged by limited time, distance, or due to a physical disability. Blended learning benefits trainees as it exposes them to multiple ways of engaging with theory and practice. It can have direct economic benefits to welding organizations through the reduction of training and travel costs, and the increases in productivity.

More generally, it enables training organizations to offer high-quality training to large numbers of users simultaneously. Finally, given these factors, the same training principles could be transferred to a wide variety of industry sectors including manufacturing, construction, electronics, and automotive industries.

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