



A Methodology-Driven Software Infrastructure for Work-Based Learning

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1. The Challenges of Work-Based Learning

In today's busy work environments, learning activities are more and more performed at people's workplaces. This is particularly true for knowledge workers in software organisations who will no longer attend traditional training courses but acquire knowledge through various forms of self-organised learning. In this context, work-based learning is very closely related to web-based learning and training.

However, work-based methods of learning and training as well as web-based collaboration and communication are not yet as widely spread as they should be.

Many companies are still reluctant to introduce these methods due to financial reasons and because they have their doubts about the efficiency of these forms of training. They are looking for smooth technical solutions and easily applicable forms of learning and co-operation.

2. The CORONET Project

The CORONET (Corporate Software Engineering Knowledge Networks for Improved Training of the Work Force) system provides a combination of technical and methodological solutions especially designed for work-based learning and training. It consists of two major components:

1. The learning methodology: CORONET-Train



2. The platform supporting this learning methodology: WBT-Master.

The CORONET project consortium combined expertise in software and knowledge engineering, knowledge management and development of web-based courseware with know-how in learning environments, hypermedia didactics and work-based learning methods. There were partners who specialised in the development of the methodology (Fraunhofer IESE, Fraunhofer IGD, University of New South Wales) and others who took care of the development of the technology (Centro de Computação Gráfica, Atlante, Institute for Information Processing and Computer-Supported New Media (IICM) at the University of Technology Graz), complemented by the application partners DaimlerChrysler and HIGHWARE sarl. In addition, a Pedagogic Advisory Board was formed of independent experts from academia (University of Tübingen, University of Heidelberg) in order to consult the consortium in questions related to didactics and work-based learning.

3. State-of-the-Art in Collaborative Learning

The baseline of our research into collaborative learning environments was a survey on the state-of-the-art in work-based collaborative learning methodology and technology. We identified the following general principles and recommendations (for related literature refer to [17, 18]):

- Learning tasks shall be based on real-life tasks or authentic situations.
- Learning tasks require and motivate the co-operation or collaboration (co-construction and exchange of knowledge) of learners in a group.
- Learning contents must be applied in different situations and from different perspectives so that knowledge workers learn to use the acquired knowledge and skills flexibly.
- Instructional support has to be provided; this is required because success of self-organised and social learning processes in networked learning communities depends very much on the provision of a sufficient information base for the learning process and the adaptive support of the group processes.
- To be successful, infrastructures in support of collaborative learning must be able to adapt to different competence levels of knowledge workers.



- Learning environments need to facilitate the access to relevant knowledge repositories in the organisation.
- Learning environments need to facilitate the access and communication to relevant subject matter experts and peer learners, which are engaged in a similar learning topic or process.
- Collaborative learning processes need to realise central features of a “learning community”, i.e.:
 - Promote the development of both individual and socially shared knowledge;
 - Support the knowledge workers to learn from their experiences and mistakes;
 - Support and instruct the learning group on how to reflect their individual and collective experiences, identify their learning needs, and continually evaluate their knowledge and experience development (promotion of meta-cognitive processes);
 - Initiate the sharing and negotiation of knowledge by development of a positive learning culture;
 - Take care that the group members are structurally interrelated and remain open-minded to external knowledge resources;
 - Take care that the group members respect each other, even when they have opposite opinions and discuss them controversially;
 - Strive to support the development of a group-oriented identity.
- The learning environment must provide specific methods to support collaborative net interactions, i.e. it needs to introduce roles or guidelines for moderating collaboration on specific tasks or defining specific interaction rules for the virtual cooperation; it should provide graphic representation tools to create a collectively visible problem space; it should provide a network moderator to help the group regulate their communication processes, to co-ordinate the group activities and to initialise and maintain their negotiation processes.

4. Problems & Solutions

In the domain of Software Engineering (SE) there is a special need for systematic work-based collaborative learning because:

- SE is mainly a team-oriented work process. For this reason, learning on the job should be embedded into social processes allowing interaction among



- individuals.
- Technical and knowledge development in the domain of SE is characterised by fast growth and high dynamic change. This requires not only continuous learning, but also the ability to co-operatively manage the multiple problem-solving and learning demands in this domain.
 - Multiple and complex tasks in SE processes require the ability to specialise and view the processes from different perspectives. Software engineers should get acquainted with the occurrence of multiple perspectives and learn how to co-operatively handle them while doing their job.
 - Efficiency of learning has to be improved in general. In the context of the tremendous resource bottleneck in the SE domain, this task becomes even more important.

Systematic management of knowledge is a key factor in this context. Therefore, the concept of corporate knowledge networks is used as a framework for:

- Creating and exploiting knowledge assets,
- Sharing knowledge for use and re-use, and
- Learning from others and with others.

In response to the needs in the SE domain, and taking the state-of-the-art of work-based collaborative learning as a starting point, the CORONET system (i.e. CORONET-Train methodology and WBT Master platform) has been designed to offer the following features [14]:

- Support for long-term competence development: the CORONET system has to facilitate the systematic development of competencies, in a long-term, career-path-oriented approach focusing on SE subject matters. The learning is adapted to different competence profiles of the potential users and specific learning needs [13, 19].
- Collaboration through networking: The system has to focus on web-based collaboration between learners on different competence levels, and on the usage of a corporate knowledge network, which is transformed into a learning network [7]. The links between the users are part of the didactical design, initiated and supported by the structure and by the functionality of the learning environment.
- Integration of Learning by Training and Work-Based Learning [16]: The interlocking of work and learning can happen in different ways, for example:
 - Learning contents of web-based training



originate from real work situations; authentic problem constellations can be generated.

- Learners participate in real project work processes, they can take over real tasks or parts of tasks within a running project in order to learn while a tutor or mentor guides them [4, 12].
- Brainstorming sessions are triggered by a real work problem. The results of the session are directly applied in the work situation.

In work-based training, learning needs are met as they occur in the workplace (learning on demand). The approach is supported by modern concepts of instructional design, such as the engagement theory [11].

- Support for reciprocal learning: Learning by teaching, coaching or mentoring – and thus improving both technical know-how and social skills.
- Integration of collaborative e-learning with knowledge management: This is done by applying advanced knowledge structuring methods, by facilitating on-demand creation of learning materials, and by providing flexible annotation mechanisms and recording mechanisms for discussion threads.

WBT-Master is the platform that has been developed to support the CORONET-Train methodology and to realise its basic principles. Generally speaking, WBT-Master tools are designed to work with the so-called Corporate Memory. The Corporate Memory is made up of the stored enterprise knowledge that is found within the company. It includes huge collections of documents residing on the WBT-Master server, portals (i.e. references to information resources available from the Internet), on-the-fly material (i.e. annotations to documents, contributions to discussions, question-answer dialogues, etc.) and the personal knowledge of organisational members.

WBT-Master enables synchronous and asynchronous communication among distributed teams and team members. This includes discussion forums, brainstorming sessions, chats, annotation facilities etc. The variety of communicational tools is intended to support collaboration between different users working together.

Although focussed on the software development domain, the CORONET experience offers some more general insights into how comprehensive learning environments that integrate aspects of traditional e-learning with innovative knowledge management can



be used to develop subject matter skills and competencies in a much broader range of business disciplines.

5. The CORONET-Train Learning Methodology

CORONET-Train offers three classes of methods:

- Learning methods: They define processes and activities that are adequately tailored to specific learning situations and learning needs of software engineers. The description of processes and activities is made from the perspective of those who wish to acquire new knowledge and skills related to a specific subject matter.
- Knowledge transfer methods: They define processes and activities that subject matter experts can apply in order to disseminate their know-how and help software engineers satisfy their learning needs.
- Knowledge engineering methods: They define processes and activities that are needed to develop, structure, and maintain learning resources, to set-up and maintain the software infrastructure (i.e., the learning platform), to administer the users of the infrastructure, and to introduce and manage the learning environment.

These methods are used in a number of learning scenarios (cf. Figure 1). The following scenarios were developed in order to show how CORONET-Train can be applied to support frequently occurring learning situations in software organisations:

- Web-Based Training:
 - Design of training sessions by experienced knowledge workers
 - Development of courseware
 - Individual subscription to training sessions
- Web-Based Tutoring: This scenario is similar to the Web-Based Training scenario. The principal difference is that the tutor or trainer does not trigger the development of courseware, but instead collects a number of heterogeneous documents which can be used for the training session.
- Web-Based Mentoring: A mentoring session is a one-to-many synchronous communicational session with interested learners [8]. The mentor is supposed to support the learners in their knowledge acquisition process.
- Web-Based Knowledge Mining: The WBT-Master



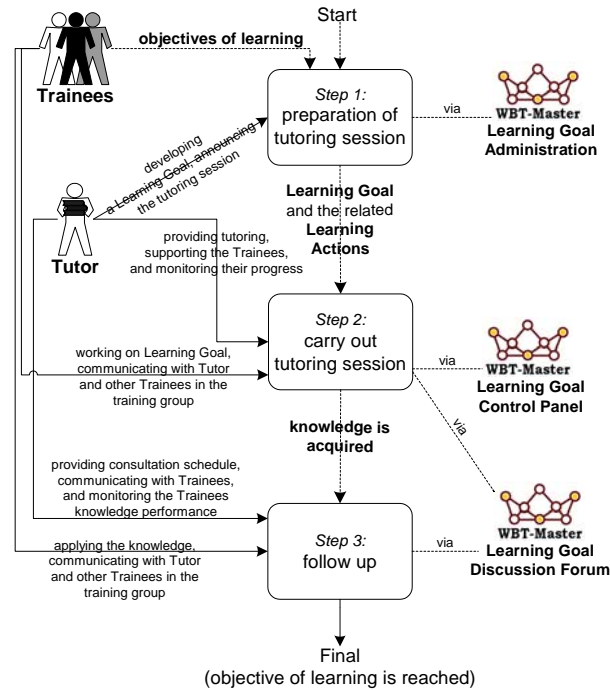
server offers information about documents or subject matter experts. So-called Knowledge Cards can be used to find relevant learning resources, work through relevant materials and communicate with experts and with others working on similar materials.

- Web-Based Knowledge Delivery: The WBT Master server can be configured in such a way that relevant learning resources are automatically delivered to an individual desktop. Communication with subject matter experts and peers working on similar learning resources is possible via the desktop.
- Web-Based Collaborative Problem Solving: In this asynchronous learning scenario, knowledge workers select a moderator whose task is to initiate and organise a brainstorming session in which a solution to a problem is collaboratively elaborated.
- Web-Based Gathering and Integration of Personal Knowledge: In this scenario, knowledge can be transformed into a training resource. Typical examples of this application are collaborative document writing or co-operative courseware authoring [5, 9]. Topics can be discussed via a structured discussion forum, while co-operation is performed through shared folders.
- Web-Based Virtual Classroom: The Virtual Classroom can be seen as a working place for the trainers/tutors in which they prepare training sessions for a group of trainees. They can create a new classroom library by selecting the necessary learning resources and they can also describe the learning paths to be followed by the trainees in setting up a classroom curriculum.

Experience showed that an extensive methodology report does not necessarily provide sufficient guidance for those who want to introduce the system to learners. For this reason, each of the learning scenarios was clearly described in a separate guidebook, together with a step-by-step guidance of how to make the most of the functionalities in order to achieve the respective learning goals.



Figure 1: Example of a learning scenario: Web-based tutoring [3]



6. The CORONET platform WBT-Master

The CORONET infrastructure WBT-Master provides the users with the adequate functionality needed to perform selected learning scenarios including an innovative collaborative e-learning and knowledge management functionality.

The main reason for constructing WBT-Master and not using an existing WBT system can be stated as follows. The state-of-the-art survey in WBT systems conducted at the beginning of the project and our experience in working and building WBT systems showed that many WBT systems do not take into account the latest advancements in teaching or learning paradigms – they simply reflect Web technology. However, such a technical approach to building WBT systems has a number of drawbacks, since WBT systems are primarily about teaching and learning, rather than about technology. Thus, WBT systems should actually combine conventional and innovative tools compatible with the current Web technology to support well-known, well-tested techniques, and also to enable implementation of new and innovative teaching and learning paradigms and scenarios in a Web-based environment.



In constructing WBT-Master we followed two important principles – modularity and reuse of material. Ensuring modularity of the system was important not only to support different scenarios defined by the CORONET-Train methodology, but also to ensure that the system is extensible with new teaching and learning paradigms or scenarios.

In supporting reuse of learning material we took the following approach. Conventional Web-Based Training (WBT) systems utilise HTML documents as learning resources. Ordinary Internet hyperlinks (references) are used to create such navigable data structures as courses, chapters, books, etc. Typically, various WBT tools such as annotations, email, discussion forums, and personal bookmarks are used to add additional value to the basic documents published on the WWW. WBT-Master considerably extends this state-of-the-practice technology [10]:

- In addition to existing data structures based on hypermedia links, it introduces such new innovative composite learning resources as reusable Learning Units, Learning Goals, Knowledge Cards, Mentoring Sessions, Knowledge Domains and more.
- In addition to especially prepared training materials, anything that is part of the stored enterprise knowledge, such as technical documents, presentations, or the personal experiences of employees can be used as learning resources via the internet or intranet. The system essentially supports the involvement of human subject matter experts as learning resources.
- Since all information services operate with unified data structures, results of any collaboration (discussion sessions, brainstorming sessions, annotations, question-answer dialogues, etc.) can be seen as new training material and can be reused by others.

The software infrastructure WBT-Master may be seen as a combination of learning resources, data structures which combine learning resources to accomplish a particular training task, and tools for working with such learning resources and data structures. These tools always reflect a particular learning scenario from the CORONET Train methodology and allow users to access and create new learning resources, or to add information to existing learning resources. Of course, such learning resources might be exchanged between the WBT-Master tools, i.e. they can be reused in other



WBT-Master tools.

7. Evaluation & Experience

When comparing the CORONET system to more than a dozen existing commercial e-learning systems, it turned out that practically all elements of the CORONET system – if looked at in isolation – are present in existing systems. However, none of them covered all elements of the CORONET system at the same time. Even more important than the broad range of functionality offered by the CORONET system is its high degree of modularity and its methodological discipline. Modularity and a precise description of the underlying methodology allow prospective users to customise the system in a way that it provides support to web-based collaborative learning in the most effective and efficient way. Effectiveness is achieved by offering exactly those learning scenarios that are requested most. Efficiency is achieved by capitalising on the reusability of learning materials across learning scenarios.

In order to evaluate the CORONET system, suitable contents were produced and the CORONET application partners (DaimlerChrysler and Highware) conducted a series of industrial case studies. The results of these studies demonstrated – to a different extent – the feasibility, effectiveness and efficiency of the proposed approach [15].

Another point was brought up during evaluation: The introduction of complex new methodologies such as the CORONET system into a software organization needs to be carefully prepared. First of all, special attention should be paid to the acceptance of the software infrastructure and the new learning methodology by offering effective guidance to the users, i.e. the software engineers, and those who are in charge of managing the whole learning environment, i.e. the Learning Managers.

Apart from usability and acceptance problems, there should be awareness on all levels that these new ways of learning at the workplace will affect existing business and development processes, and will require changes in established habits and beliefs of software engineers and managers. The introduction of collaborative learning and knowledge exchange in an organisation is actually a matter of corporate culture and should therefore be actively supported on management level.



8. Conclusion and Outlook

A major strength of the CORONET system is its ability to cover the whole bandwidth of learning settings, from long-term competence development through dedicated web-based training, tutoring and mentoring to short-term problem-solving through quick information access and fast learning. It offers collaborative approaches for all relevant learning settings. In particular, the CORONET system promotes and supports the development of sustained interpersonal relationships. In this way, it helps to establish learning networks in which people of equal and different competence levels practice both individual and group learning, experience-based learning, learning with multiple activities and resources, and knowledge sharing.

Currently, the main risk to successful industrial dissemination of the CORONET system can be associated with usability problems. Thus, one of the main future tasks will be the step-by-step enhancement of the WBT-Master public domain prototype into a commercial product. Regarding the methodology, future work will focus on further integration of collaborative learning with experience management [2].

As a final conclusion, it can be said that the CORONET system has proven to be a good basis for future commercialisation activities. This includes, for example the enhancement of Fraunhofer IESE's courseware development [5, 6] and process learning methodologies [1], Highware's improved training services, and IICM's step-by-step enhancement of WBT-Master towards a commercial product.

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