Virtual Learning on Building Sites – Didactical and Technological Experiences and Implications

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Abstract — The project „Virtual Learning on building sites – (Vila-b)“ deals with the testing and development of an innovative further training approach. The sector of ecological old building renovation is witnessing a high need for training both in terms of human resources and as a result of the technological development. Compared to the classical attendance learning, the Vila-b approach combines three learning environments in terms of “Blended Learning“. This approach concentrates above all on learning in the actual work process supported by digital media.

Key terms - Learning in the work process; virtual learning; development-logical didactics.

I. INTRODUCTION

A. Objective of the project

The current technological change in the world of work is also clearly visible in the sector of ecological building. At the same time two problems can be identified which counteract the need for further training: On the one hand the clientele of the relevant skilled workers is not necessarily keen on further training. On the other hand the time and cost pressure within the sector does not offer any room for time-consuming further training measures far away from the workplace. This is why the project “Virtual Learning on the building site – (Vila-b)” is testing a concept which facilitates learning adapted to the occupational reality and supported by the advantages of digital media. The project mainly aims at the development of a further training course named “skilled worker for ecological and environmentally-friendly old building renovation” to be established in a competence centre. The article will first describe the context of the idea of the project as well as its didactical and technological basic principles. It will be shown how the further training concept will be developed and implemented. Finally the currently available results will be presented as well as an outlook to the tasks which remain to be tackled.

B. The original context of the project

The change of paradigms in the world of work during the 1990ies entailed a new orientation in terms of the then strongly traditional and Tayloristic shaping of the conditions of production and work [1]. This was replaced by an enrichment of the occupational tasks particularly known as the concepts of “job enlargement” and “job enrichment” [2]. This new orientation and enrichment of work was supported by further accompanying measures resulting in the implementation of self-organized team or group work, the reduction of corporate hierarchy levels and in the continuous further development of the necessary specialist and individual competences of the staff. At the same time the companies were prepared to establish a new learning culture calling for a life-long and self-organized learning of the employees in order to successfully face the swiftly changing and ever more complex world of work.

In order to implement this “new” kind of learning, “learning in the work process” will be used both as a method and a learning environment above all for the target group of skilled workers” highlighted in this article. By linking of learning and working within the work processes, knowledge is generated where it originates. At the same time, active and acting oriented learning takes place on an individual level. This contains phases of holistic acting (planning, realization and evaluation) and thus facilitates the required holistic competence development process [3].

However, the organisational framework conditions have to be adequately adapted. Initial and further training concepts are needed which help to develop and to support the required competences. Above all in today’s digitalized world, digital media are deeply integrated into the work processes due to an increased application of personal computers and the Internet. Thus it is crucial to extend the initial and further training measures in the companies by the use of E-Learning concepts.

Apart from all pedagogical ambitions, the current discussion of environmental and economic policies in the building sector forms the background of the project. The increasing use of sustainable and ecologically reasonable (renewable) raw materials comes along with (long-term) economic incentives of old building renovation in the face of continuously rising prices for energy. Above all the numerous small and medium-sized enterprises (SME) now have the opportunity to structurally position themselves on the competitive market of the building industry.

Overall the three aspects (change of the world of work, new learning culture on an organisational and individual level as well as the market opportunities in the sector of ecological renovation) led to the implementation of the project “Virtual Learning on the building site (Vila-b)”.

1 The project “Vila-b” is supported by funds of the Bundesministerium für Bildung und Forschung – BMBF (German Federal Ministry for Education and Research) and the European Union – ESF.

2 The target groups for the further training measures are skilled workers in the occupational groups of joiners, carpenters, drywallers and roofers.
II. DIDACTICAL BASICS OF THE PROJECT

A. The term E-Learning

In an increasingly digitalized world of work, work processes are no longer shaped in a conventional way but rather supported by digital media. The use of these media (PC, Internet, mobile data appliances etc.) has nowadays become more or less implicit. Due to the increasingly improved technological opportunities, adequately designed learning processes, above all computer-based training and web-based training, are widely applied in corporate initial and further training [4].

E-Learning is often mentioned in this context. Nevertheless E-Learning is generally described as “learning with the aid of electronic media” [4] or as “application of new media in learning situations” [5]. Thus the term is used “as a collective noun for every kind of electronically imparted teaching and learning” [6]. In every day’s language E-learning is meanwhile standing for a term opposed to the synonymous terms of learning with digital or electronical media.

The problem of a concrete definition of the term E-Learning can be justified with its numerous fields of application and target groups. Nevertheless there is mutual consent that the use of media in learning processes reveals a rough tripartition. It starts with a distributive and rather teacher-centred dissemination of specialized knowledge (e.g. in terms of Internet research), the application as a medium of interaction between teachers and students (e.g. forum on a topic) up to a collaborative use by the students themselves (e.g. self-organised creation of a homepage).

Thus E-Learning does not automatically entail self-organised learning. In the beginning, media pedagogy had often argued with the key word “E-Learning”. Currently certain scepticism can be witnessed in the field of educational sciences because not all expectations could be fulfilled. Due to a change of paradigms in adult further training, digital media are nowadays mainly used as supportive means for learning processes. This is mainly due to an integration of constructivism and a focus on self-organised learning processes of the individuals [7].

B. Combined learning environments – Blended Learning and virtual learning

From the point of view of educational sciences, the application of digital media in the learning process has always been legitimized by the advantages of the technical realisation: more flexibility in terms of time and place and independence from the learning environment supports active and individual learning of the individual. This (ideally) results in the desired competence development on the levels of methodical and individual competences. The company also benefits with regard to cost saving as a result of a broad and swift availability of know-how.

All in all the added value of the support of learning processes is not only the result of a mere introduction and use of digital media. Moreover a didactical concept adapted to all possible advantages is required [5]. This is where the concept of “Blended Learning” has been established. This concept combines different learning environments and methods. Blended Learning “combines phases of virtual learning, in-class lectures and aims at linking the potential of E-Learning and traditional forms of teaching methods [4]. It is a “didactically coordinated combination of media, medial further training offers and methods” [4].

Similar to the problematic of a general understanding of E-Learning, Blended Learning is equally not sufficient to describe the basic pedagogical design element of the further training concept of Vila-b. The project Vila-b excels by an additional innovative element in the form of “mobile learning” by making use of a small, portable and efficient mobile terminal (Ultra Mobile Personal Computer – UMPC) as a learning instrument. With reference to segments of information technology (computer-aided communication, computer-aided cooperation or software technology) the term “Virtual Learning” [8] will be introduced based on the present concept (cf. Figure 1: Concept of “Virtual Learning”).

![Figure 1: Concept of „Virtual Learning“](image-url)

Virtual Learning thus describes a way of learning which a) makes use of digital and/or electronical media in the learning process in terms of E-Learning,

b) combines different learning environments into the learning process according to the concept of “Blended Learning,

c) includes a „mobile“ component, in this case a mobile terminal and/or UMPC.

As for the project Vila-b, the differentiation of the learning environments according to this concept will be used. During in-house lectures the participants will be familiarized with the use of the mobile terminals and will be taught the specialized basic knowledge on ecological and environmentally-friendly old building renovation. “Learning on the building site” with mobile terminals allows for situation oriented and problem solving learning by tapping into the experience knowledge stored in a data base or by facilitating a direct communication with seniors and colleagues in the real work process. “Learning in the PC workplace” aims at making use of the learning experiences on the building site in order to deepen and reflect specific contents adapted to the specific needs of the users.

The target oriented and joint application of the three learning environments within a further training measures makes use of the respective advantages: Apart from specialized and methodological basics, in-class learning offers a direct interaction among the students and/or between students and teachers. Thus informal contacts between the users of the Vila-b further training course will be established. Above all for learning processes shaped by the use of digital media it has been shown that in-class learning phases are of great importance for the later exchange of information and for the communication via
the media [9]. The use of technology for learning on the building site offers new cooperative forms of learning and at the same time allows for cooperative processes that are oriented to problem solving [9]. Learning in the PC workplace calls for an active reflection of the just experienced learning processes and offers the opportunity to act in the sense of self-organized learning. Nevertheless a minimum of learning contents and learning times have to be achieved in order to meet the requirements for a successful completion of the further training measure.

The term „Virtual Learning“ places the concept next to information technology, underlines the use of the mobile terminals and thus delimits the concept from an unspecific form of E-Learning. At the same time the link to Blended Learning calls for media pedagogically oriented didactical concepts. Both aspects are crucial for the design and the implementation of the further training course of Vila-b. At the same time the term “Virtual Learning” within the framework of the project must be further theoretically underpinned.

C. Learning theoretical aspects and competence levels of development logical didactics

The didactical basics for the design of learning contents represent a development logical didactical approach which concentrates on competence development by working on concrete work tasks and on problem solving in challenging real work situations.

In terms of learning theory, development logical didactics constitutes a further development which – in contrast to behaviourism – makes use of some elements of the constructivist approach [10]. The orientation to concrete work tasks thus clearly differs from the stimulus-reaction scheme of learning on the one hand but also from learning processes based on the mainly experience-based construction of knowledge. The orientation on real (work) tasks makes greater demands on the ability of self-learning in the context of work situations and contains active learning and self-reflection processes in the context of real work situations. In addition the perspective of holistic learning processes is in the focus of development logical didactics: Knowledge and acting form a unit and allow the gaining of both implicit and explicit learning experiences. This means that competence development is not only perceived as a behavioural change oriented to consequences or as a mere context-specific generation of knowledge and skills. With regard to an innovative use of the mobile terminals, the application of new media cannot only be regarded as a programmed instruction or as an acting oriented simulation. Moreover it promotes real problem solving during the work processes.

Based on these reflections the question must be raised how the learning contents may be didactically arranged in a development logical order which reveals a learning development. Considerations of a respective competence model lead to a multi-dimensional implementation which differs in terms of depth and/or levels of learning contents, with regard to the spectre of the learning contents and in terms of the phases of a holistic action. Therefore the context orientation of the learning contents as a result of the different work tasks is relevant.

The competence acquisition model created by Dreyfus and Dreyfus illustrates the five-level development path from a “novice” to an “expert” [11]. A slightly modified version of this approach has been discussed for some time in the German speaking countries [12]. The contents of learning processes can be formulated as competence requirements on different levels. Nevertheless the holistic approach is being pursued and the learning contents are always focused on concrete work processes.

Comprehensive studies carried through in the health sector [13] and in the automotive sector (car mechatronic) [14] confirm the model in its basic form, above all in terms of its horizontal arrangement of competence levels. In addition these studies show the relevance of the incorporation of competences into the domain specific work interrelationships: Occupational competences are typified by a close link to the respective occupational sector and to vocational education and training [12].

All in all this results in a model of competence development for Vila-b which

a) arranges the competence levels based on Dreyfus & Dreyfus,

b) takes into consideration the holistic work process and
c) can be found within the context of the respective work task.

The three dimensions can be well mapped in a “Content Cube”.

The figure underlines the clearness and additionally offers a rough structuring aid for the technical processing and the allocation of the learning contents. Nevertheless a strong structuring is also implicit for the students – and does not correspond to the original idea of Vila-b: Learning should start wherever it is necessary for the current problem and adheres to an individual ranking dependent on the respective skilled worker and the work process in question.
III. TECHNOLOGICAL BASICS OF THE PROJECT

A. The database system

The technological fundamental structure is based on a central data base system for the management of contents. It contains standardized specialist and technological information (cf. Figure 3, Training content/ Product information) as well as learning contents emerging within the framework of work processes and based on the experience knowledge acquired by the skilled workers (cf. Figure 3, Learning contents/ Know-how).

The project applies the Open Source Content Management System Typo3 as a programme. The learning contents are thus developed by adhering to Internet standards in order to facilitate both a mobile system for learning on the building site and a browser-based learning in a PC workplace.

The interface between the learning application and the skilled workers must be realized in a way that mobile learning on the building site and learning within the work process make practical sense and are applicable. The technological implementation of this interface will be realized based on the Radio Frequency Identification (RFID) technology.

In practice a learning process may e.g. be triggered by a problem resulting from a work situation of a skilled worker at the building site. The worker scans the barcode assigned to the problematic component with the aid of a mobile terminal. The user surface then indicates all proposals or information available for the respective component. Due to the shaping of the surface, the explorative and development logical structure of the learning contents and the intuitive operation, deeper and more detailed solutions can be found for the problems. The learning experience acquired during the execution of the work processes can later be retrieved, deepened and reflected in the PC workplace.

The mobile learning system to be developed offers additional social components to the user. The option for the generation and incorporation of User Generated Content (UGC) allows for the addition of comments on the indicated contents element. In addition the skilled worker can highlight the information in order to facilitate a quick access to experience knowledge according to the current situation.

B. Contextual Inquiry

In order to safeguard the optimal mobile terminal, the project partner TZI\(^1\) will carry out an analysis of the usability of the selected testing equipment. In the form of a Contextual Inquiry the technical performance of the mobile terminals will be assessed with regard to aspects such as practicability, handling, robustness of the device, scanning and photographic functions, memory and documentation options based on predefined criteria and on practical observations. The final choice of a device is currently not yet finalized. Comprehensive reports will follow in the course of the project.

IV. USE OF VOCATIONAL EDUCATIONAL SCIENTIFIC METHODS IN THE PROJECT

After the description of the didactical approach and the technical implementation we will now show how the concrete learning contents will be accessed. This will be achieved by applying vocational educational scientific research methods with the aim to "identify the characteristic work tasks and the incorporated requirements for qualification and to look at the didactical benefit of these tasks for competence development" [15]. A detailed description of this methodology can be found in Becker and Spöttl [15]. The present article will just concentrate on a short presentation of the meanwhile established vocational educational research methods.

A. Sector analyses

A sector analysis will be carried through as a preparation for the occupational domain in terms of contents [3, 18]. Analyses of documents, specialist literature, vocationally oriented statistics and market analyses etc. will serve as a specialist orientation on a macro level and will also describe the current development as well as the initial and further training in the sector. Depending on the project tasks and the popularity of the sector, a sector description may be envisaged as a reduced variant.

B. Case studies

Case studies are planned for the second level in order to analyse the organisational structures of occupational work processes. On company level, corporate processes, orders, task inventories or codes will be investigated. This will be done in the form of company visits, i.e. visits to building sites. A set of observation and interview instruments has been developed for the identification of organisational structures during visits to building sites.

C. Work process analyses

On a third level, the actual work processes will be analysed. This will also be done on the occasion of visits to building sites. Therefore level 2 (case studies) and level 3 (work process analyses) may be seen as a unit within the project Vila-b. These visits will be carried through by at least two researchers. One person should have specialist expertise and knowledge in the field of ecological renovation of old buildings. The analysis of work processes will also apply an observation and interview

\(^{1}\) The project partner TZI (Technologie Zentrum Informatik der Universität Bremen) is responsible for the technical implementation and programming within the project.
instrument which has been developed in cooperation with specialist experts and which was optimized after a testing phase. The work process analyses aim at identifying the core work processes of the skilled workers. At the same time it has to be determined, which competences, methods, and tools are required for the coping with these core work processes.

D. Expert-skilled worker-Workshops

After having identified the core work processes and the required competences of the skilled workers with the aid of work process analyses, the next step will be an assessment and/or a logical ranking. In the form of a moderated so-called “expert-skilled worker-workshop” experts (skilled workers, master craftsmen, training managers) will be supported to arrange the competences into a “correct” ranking. This ranking is set up in a development logical way and reflects the steps to be taken to advance from a “novice” to an “expert”. The preliminary results of the work process analyses will thus be validated and/or modified or amended during this process.

V. RESULTS AND CURRENT CHALLENGES OF THE PROJECT

A. Previous results of the case studies and the work process analyses

The case studies and work process analyses available so far have identified the following core work processes as relevant for a skilled worker for ecological and environmentally-friendly renovation of old buildings:

<table>
<thead>
<tr>
<th>TABLE I.</th>
<th>CORE WORK PROCESSES FOR ECOLOGICAL BUILDING</th>
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<tbody>
<tr>
<td>1</td>
<td>Fitting of windows in an old building</td>
</tr>
<tr>
<td>2</td>
<td>Planning and realisation of insulation of external walls (surface building)</td>
</tr>
<tr>
<td>3</td>
<td>Planning and realisation of external walls (connected to a building)</td>
</tr>
<tr>
<td>4</td>
<td>Insulation of a roof (steep roof and flat roof)</td>
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<tr>
<td>5</td>
<td>Planning and realisation of a conversion of an attic floor with ecological insulation</td>
</tr>
<tr>
<td>6</td>
<td>Insulation measures and renovation of a basement</td>
</tr>
<tr>
<td>7</td>
<td>Planning and realisation of extensions and upgrading of buildings</td>
</tr>
</tbody>
</table>

Apart from work process analyses, a company workshop was carried through with building contractors and with producers of building materials. The aim was to investigate further applications for the project Vila-b from the point of view of the companies. Group discussions showed that there is additional potential above all in the acquisition of information (in terms of standards and building stipulations to be adhered to) and in the documentation of performed work processes. Therefore these issues will be integrated into the further course of the project.

B. Open questions and outlook

The article provided a short insight into the project Vila-b and has shown the didactical basics, the technical design of the concept as well as first preliminary results. Nevertheless the following four questions and/or tasks remain to be clarified:

a) Draft of the learning contents: The identification of the core work processes including the necessary competences forms the background for the draft of learning contents. Therefore the specialist and methodological contents will be prepared through images, videos as well as product information material necessary for the coping with the tasks (both in the real work process and during exercising and post-processing with the aid of acting oriented learning tasks).

b) Theoretical underpinning of development logical didactics: The development logical arrangement as a learning theoretical description is a further development of constructivism which so far has not been adequately theoretically underpinned. The competence structuring model is said to be well applicable in practice. It must, however, still be validated in a more sustainable way in terms of empirical underpinning. Thus the project must work out the theoretical basics and justify them if possible. This is valid for conducive criteria, aspects of the design of the competence model as well as the chances and risks of virtual learning.

c) Evaluation of competence development: The issue of the conduciveness of the project measures is closely linked to the preceding issue. Two test groups will be summatively evaluated in order to optimize the further development prior to a “regular” application. It will be a challenge to open up informal learning times and implicit learning for an assessment and eventually for a formal certification.

d) Implementation of a competence centre: One of the objectives of the project in the long term is the financially self-supporting integration of the further training concept into a supra-regionally operating competence centre. This will be a sustainable contribution for the qualification of skilled staff in the building sector. This result of the sector analysis is not only important for the SME of the sector but also with respect to the economic potential of the ecological renovation of old buildings in Germany. A successful implementation of the described structure will be crucial for a transfer of the concept to further occupational sectors.

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