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Supporting Learning by Doing in a Work-process-oriented Curriculum

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Abstract: Work-process-orientation is a new concept in vocational education and training (VET). Structure and content of a work-process-oriented curriculum (WPOC) are derived from a "typical professional task" in an occupation. This new curricular framework for VET is called "learning arena". This paper analyzes the characteristics of a learning arena and identifies technical requirements to support an online or blended WPOC. Based on these requirements we suggest an approach to systematically support learning by doing within a WPOC. The approach can be characterized as: guide the learning process according to the corresponding WPOC model, enable doing by integrating work-related application tools, support learning by embedding associated learning materials in application situations, and conduct outcome-based assessment by collecting and evaluating work results. The implementation of a dedicated e-learning environment adopting this approach is presented.

Keywords: Work-process-oriented Curriculum (WPOC), Vocational Education and Training (VET), Learning Arena, Learning by Doing

1. Introduction

Since 1996 a new framework for Vocational Education and Training (VET), called "learning arenas" (in German "Lernfelder"), has been introduced in Germany. In the concept of learning arenas, learning situations in schools are related to the actual work activity in a particular occupation and the work-process-oriented knowledge as the pivotal factor in the design of vocational curricula (Rauner, 2007). In a work-process-oriented curriculum (WPOC), the content matter is no longer based on the structure of the reference disciplines, but is oriented towards the actual work requirements (KMK 1999). The classic distinctions of "theory equals school-based learning" and "practical experience equals work-based learning in companies" or "knowledge equals school-based learning" and "know-how equals work-based learning in companies" are to be removed through the orientation of school-based content to the practical requirements of the vocational and professional work (Fischer and Bauer, 2007).

The learning arena approach has been developed in German context with a long tradition in organizing VET in a "dual" mode between schools and in-company training. However, WPOC shifts the focus from "dual" to a stronger work orientation, which makes it easier to transfer and apply to other educational systems that cannot count on long experience with a dual system. WPOC has gained special attention in many countries as an innovative approach to adapt VET to emerging skill profiles. For example, the Chinese government promoted a curriculum reform in VET through adopting and adapting the ideas of learning arenas (Zhao & Xu, 2008).

Recently some efforts have been made to support learning and work tasks in an educational context that is compatible with a learning arena approach by using digital media (e.g. Howe and Staden, 2015). However, the support is limited in delivering instructional materials to students. The work described in this paper aims at developing a technical approach to support online or blended WPOC systematically and, on this basis, at implementing a dedicated e-learning environment.

2. Characterizing Learning Arenas and Identifying Technical Requirements

In this section we analyze the characteristics of learning arenas and identify technical requirements to develop an e-learning environment.

2.1 Structural Learning Processes

From the perspectives of curricular structure, a learning arena consists of several concrete learning tasks called "learning situations". The learning situations themselves are set up according to pedagogical principles. Through these learning situations it is possible to simulate typical activities from the particular occupational context from the actual work-processes and to connect such processes with traditional educational content. However, they are not exactly identical with tasks at the company since they have to take the educational mission and goals of the vocational schools into account (KMK 1999). While performing an activity, action-oriented learning takes place. This includes phases of holistic acting (e.g., information-gathering, plan, decision-making, implementation, monitoring, and evaluation) and thus facilitates the required holistic competence development process (Tramm and Krille, 2013). In practice, a learning process is usually triggered by a problem resulting from a work situation. Professional tasks or problems in VET are solved like in the real world of work in sequential and logical steps (activities). The activities make up a complete, multi-dimensional work process that copes with a corporate work order, corporate problem-solving or unknown tasks (Spöttl, 2005).

Technically speaking, in order to guide and scaffold learning in the whole process of a work-process-oriented curriculum systematically, it is required that the whole curriculum can be described in a manner that the e-learning environment can support learners to perform activities one by one following the structural process model.

2.2 Action-oriented Learning

When learning is linked to work-processes, it has to be designed in a way that the competence of coping with today's challenges at the workplace grows (Spöttl, 2008). Therefore, the core objectives of the newly structured occupational profiles and of the curricula is that learning through experience should develop from informal, unplanned learning into a self-directed and constructive mode of learning (Spöttl and Windelband, 2013). Didactic reference points are situations that for the exercise of the profession are important for learning. These can be summarized by the following points (Niedersächsisches Kultusministerium, 2001):

- Actions to be executed as automatically as possible by the learners are information-gathering, planning, performing, checking, and finally evaluation.
- Actions should be a holistic capture of the professional reality, including technical, safety-technical, economic, legal, ecological, social aspects.
- Actions need to be part of the learners' integrated experience and need to be reflected in relation to their social impact is reflected.

It is required that the e-learning environment can facilitate learners to conduct actions in real or simulated work situations.

2.3 Acquisition of Knowledge and Skills within Application Context

Learning arenas are thematic units that are oriented towards vocational tasks and procedures. The thematic units can also be included within learning arenas from an academic point of view. Conveying orientational knowledge, system-oriented action and networked thinking are promoted particularly within an action-oriented classroom. It is therefore indispensable that the respective work and business processes are provided with the relevant academic background information (KMK, 1999).

2.4 Outcome-based Assessment

Assessment in vocational learning usually requires the learners to demonstrate that they can carry out the tasks required by their area of study, and that they understand why they are working in this way (Niedersächsisches Kultusministerium, 2001). It is a typical outcomes-based assessment (OBA) that focuses on the results or learning outcomes to be achieved rather than on the content of the learning.

One of the strongest arguments in favor of outcomes based assessment is that it is inclusive, offering clear standards and valid processes through carefully specified outcomes which identify knowledge and practical skills and open the door to conventional vocational assessment practices as in the workplace (Niedersächsisches Kultusministerium, 2001).

3. Technical Approach to Deliver WPOC in a Blended or Online Scenarios

Based on the requirements identified in the last section, we developed an approach to support learning by doing within an online or blended WPOC. The approach is inspirited by the ideas of IMS Learning Design (LD) (Koper and Tattersall, 2005), an international e-learning technical standard. Learning design has emerged as a distinct field of research, which is concerned with the development of methods, tools, and resources for helping learning designers in their design process. By adopting an approach of a pedagogy-specific learning design language (Miao, et. al. 2014), we develop a scripting language for representing a WPOC. If a WPOC has been described as a formal process model by using such a scripting language, the computer can configure learning environments and scaffold the learning process. This section will present how our approach meets the requirements identified in the last section.

3.1 Guide and Scaffold Learning Processes Using a Formal Process Model

As mentioned above, we develop a scripting language for modeling a WPOC. The conceptual model of this scripting language is illustrated in Fig. 1. Using this scripting language, a learning arena can be specified by setting values of the attributes of the learning arena (e.g., title, description of the typical professional task, learning objectives, prerequisite, organization of the occupation, objects of the occupation, time schedule, methods, requirements of the occupation, and assessment standard) and by defining a sequence of learning situations, from simple situations to complex situations aligning with cognitive development. A learning situation represents a learning task that was pedagogically transformed from a concrete work task. A learning situation is specified by setting values of attributes of the learning situation (e.g., title, learning situation description, time schedule, learning objectives, learning content, difficulties and important points, and assessment standard) and by defining a set of learning phases, a set of learning activities, or a set of their combinations. From the perspectives of curricular structure, a learning phase is consisted of a set of coordinated learning activities. Whether a learning situation should be represented as phases or as activities depends on the characteristics and granularity of the corresponding learning task. As the elementary unit of a curriculum, a learning activity has to be specified by describing attributes such as title, roles, tool, completion condition, and a concrete task towards an assessable artifact such as writing a report, make a learning plan, generate a solution, make a performance in real- or simulated work environment. In order to fulfill the task, work guidance and information resources about associated theoretical knowledge and practical skills are defined in the activity. After a learning arena is represented as a formal process model using the scripting language, the e-learning environment can guide and scaffold the learning process according to the model by using an enactment service, or called engine.

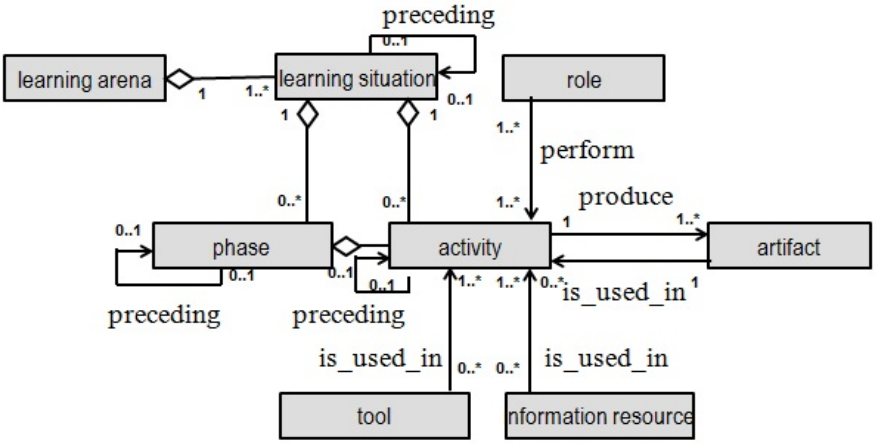

Figure 1. The Conceptual Model of a Learning Arena.

3.2 Enable Doing by Integrating Application Tools for Work

While executing the process model, the engine enables learners to perform tasks in the authentic or simulated environments. In today's digitalized world, digital media are deeply integrated into the work processes due to an increased application of information and communication technologies (ICTs). The tools such as Word, PowerPoint, and Excel are usually used in work-processes, so they are integrated within the e-learning environment for supporting the most activities. Meanwhile, certain domain-generic tools such as Concept-map and Mind-map are integrated in the e-learning environment for conducting action-oriented learning. In addition, the e-learning environment provides mechanisms to integrate some third-part domain-specific application tools based on an international standard -- Business Process Management Notation (BPMN) for performing jobs in various fields. For other domain-specific application tools that have no standard interface, our approach suggests to integrate with virtual machines in which those application tools can be deployed and used. Furthermore, in order to support learning through a form-based workflow, the e-learning environment can transfer a form or certain data items within a form from one activity to another.

3.3 Support Learning by Embedding Associated Learning Materials in Application Situations

While performing work-oriented activities, interdisciplinary aspects (e.g. technology, economy, ecology, and law) may be needed. Rather than structuring learning content according to scientific rationality in normal discipline-based curricula, our e-learning environment enables teachers to organize and provide information fragments to represent multi-disciplinary knowledge and various practical skills needed for performing the current activity. Our approach suggests that each activity will be clarified by describing the activity goal and expected artifact such as an analysis or a solution. The instructions and guidance about how to carry out the activity are described in general. If the learner can complete the activity and submit the artifact successfully, the learner is competent to carry out the activity. When the learner lacks of knowledge or skills for solving the problem, she or he can find associated information chucks about theoretical knowledge and practical experience arranged by the teachers in the activity or search by themselves.

3.4 Conduct Outcome-based Assessment by Collecting and Evaluating Work Results

As mentioned above, in each activity certain a work-related application tool should be integrated. The Word, PPT, and Excel tools are used frequently to collect work results such as a plan, an analysis, a solution, a survey, or a work report. Sometimes, professional application tools such as AutoCAD can be used for understanding the job or designing a part. The e-learning environment can collect the work results in the form of files and data as evidences. Various forms of assessment such as self-assessment, peer-assessment, and teacher assessment can be supported by the e-learning environment for judging the competence levels. It is important to note that in blended learning the learner may do performance in physical environments. Assessment can be conducted based on direct observation or the digital documents such as video clips or pictures that records the performance.

4. Implementation of a Web-based E-Learning Environment

By adopting the approach described above, we implemented a web-based e-learning environment for supporting learning by doing in a WPOC. As illustrated in Fig. 2, the core system of the e-learning environment consists of mainly four modules: learning material management, virtual machine management and application tool-set, curriculum authoring tool, and curriculum player. Teachers can upload digitalized learning materials categorized by attributes such as subject-structured topics and media-types to the repository. Some work-related tools are integrated into the system. When a teacher designs a WPOC, she or he can define the curriculum structure as a diagram by using the curriculum authoring tool. When defining an activity the teacher can specify how to fulfill the task as guidance, which application tool will be used, and which artifact is expected to produce. Accesses to information

chunks should be clearly linked to learning materials in the repository. Because of the limitation of the space of this paper, this paper focuses on presenting the curriculum player.

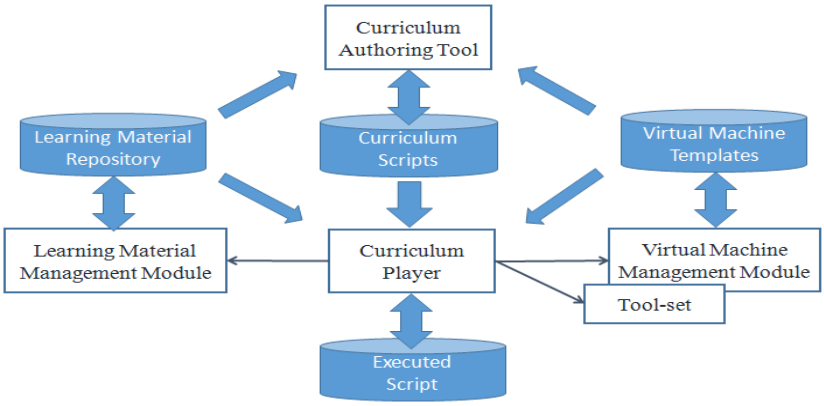

Figure 2. The Implementation Architecture.

The function of the curriculum player is to deliver an online or blended WPOC. The curriculum player consists of a curriculum engine at server side and a user agent at client side. After a WPOC is specified using the curriculum designer, a set of rules describing the learning process is coded by using a customized Business Process Management Notation (BPMN) (called a curricular scripting language). Interpreting the curricular script, the curriculum engine will guide and scaffold the participants involved in the learning process to remain compliant to the given rules. The user agent will render the user interface according to the information received from the curriculum engine.

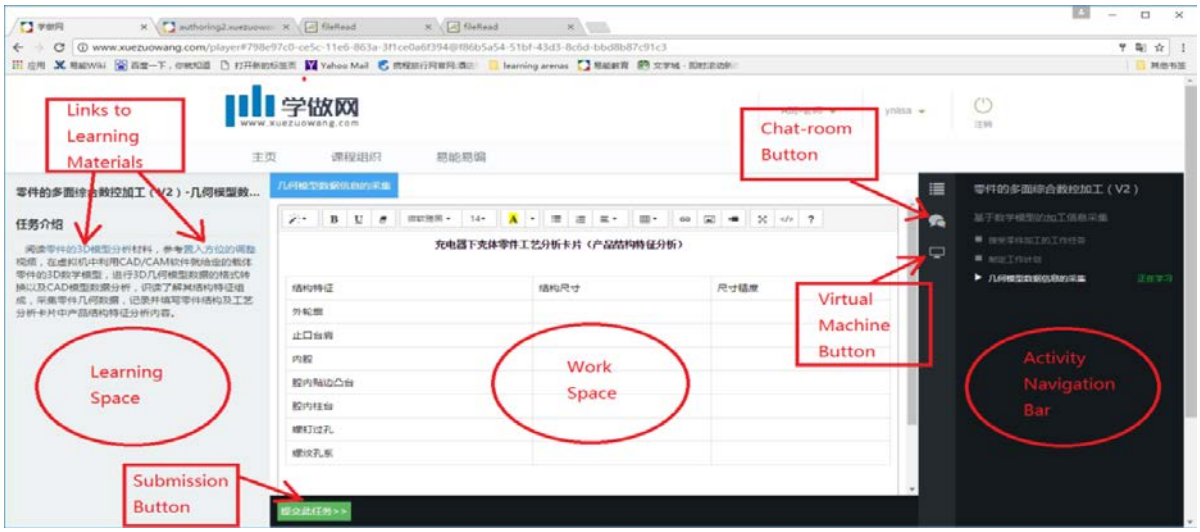

Figure 3. a Screenshot of the Curriculum Player

In Fig. 3, the user interface (UI) of the curriculum player is shown within a web browser. The tool has three columns: learning space, work space, and activity navigation bar. The activity navigation bar lists executed phases and learning activities of the learning situation. Currently, the user is taking a course “Advanced Numerical Control Machining” and working in the third learning activity that is highlight in the activity navigation bar. The learning space instructs the learners how to fulfill the current task (“Collect information from a geometric model”). In the work space a text-editor with an initiated table for performing the task is available according to the script. It is expected to fill the table with data collected from a geometric model. In order to support user to work anytime, anywhere, in any machine with a browser and internet connection, a virtual machine with the deployment of an AutoCAD with a template is arranged. If the user clicks the virtual machine button (the icon of a machine) on the left side of activity navigation bar, a virtual machine window will open and present to the user as a pop-up window. The user can work on the virtual machine without the need to prepare work environment, because the work environment has been deployed based on an image of a virtual machine as a template. So, the user can concentrate on analyzing and gathering the data by using the AutoCAD. If the user

doesn't know how to collect information from the geometric model, she or he can click the links (marked blue) to access information chunks about "how to analyze 3D model of a part" and "how to adjust the orientation of the part". Then, the associated learning materials will be presented to the user. While performing the activity, the user can discuss with others who are in the same course class or in the same project team by switching between chat-rooms. After the learner submits the fills the table by clicking the button at the bottom, the following activity will be triggered according to the formal process model of the curriculum. It may be an "analyze process arts of the part" or a "peer assessment activity" according to the definition of the script.

5. Conclusions

In this paper, the authors analyzed the characteristics of the learning arena, identified technical requirements, and develop an approach to support learning by doing within a WPOC. The approach can be characterized as: guide the learning process according to the process model representing a work-process-oriented curriculum, enable doing by integrating work-related application tools, support learning by embedding associated learning materials in application context, and conduct outcome-based assessment by collecting and evaluating work results. Furthermore, the implementation of an e-learning environment by adopting this approach was presented. The e-learning environment supports action-oriented learning that is different from a subject and science-orientated system of didactics.

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