Integrated Implementation of Virtual Teaching to Support Employee Qualification in Learning Enterprises

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Abstract: The increasing globalisation and the change of culture and structure of enterprises cause a continuous product innovation in shorter and shorter cycles and a varied organisation. "Knowledge" and "Competence" become important competitive factors as well as decisive resources for enterprises. This will require new qualifications of the employees and lifelong learning will be an important key factor. In research and development as well as in factory planning, the internationalisation process requires that new competences will be developed. The "Institute for Manufacturing Engineering and Production Management" (FBK) at the University of Kaiserslautern, has developed a holistic teaching concept to fulfil this demands. The total concept, ViteFBK (Virtual Teaching at the FBK), consists of different components and learning phases, which include different multimedia based teaching and learning methods. The multimedia technology offers exciting new opportunities for building up competence in international collaboration on problem solving projects.

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1. INTRODUCTION

Through the present change of the production society to the information society, essential features of the organisation and the situation of work forms have changed. The organisational structures have changed from strictly hierarchically forms to small flat, cross-linked teams and the external control of the employees is more and more replaced by entrepreneurial thinking and integrated, global co-operation. The prevention of division of labour (Taylorism) to an integrated system concept, puts the employees to new challenges.

This change of paradigm in structure and culture of enterprises along with the increasing globalisation, causes a continuous product innovation in shorter and shorter cycles and a varied organisation. The organisation has been developed as a project organisation with more flexible work forms, as well as a continuous process innovation with a permanent increase of productivity. Therefore, "knowledge" becomes an important competitive factor and another resource of production in addition to capital, work and ground. In the future, education and knowledge will be competitive and decisive resources for the enterprises.

Such a change requires new qualifications of the employees and lifelong learning will be an important key factor. In research and development as well as in factory planning, the internationalisation process requires that new competence will be developed. To be able to deal with Information and Communication Technologies (ICT) as well as the operation in world wide distributed teams, becomes more and more important.

New qualification concepts are required. Such a concept describes below, how it's able to provide the new skills to employees of learning enterprises.

2. QUALIFICATION AS A KEY ELEMENT TO IMPLEMENT KNOWLEDGE MANAGEMENT IN LEARNING ENTERPRISES

The change to the learning organisation and the introduction of new management concepts, like knowledge management, create new requirements with regard to the employee's qualification. Such a modification in enterprise structure and enterprise culture, requires new aspects in the personnel evolution.

The knowledge management is mainly focused on the documentation and transfer of knowledge in the enterprises. This means that the employee must receive methods and tools, which allow him this transfer of knowledge and

also the extraction of knowledge from the organisation for his tasks. The procurement of methods as well as the conversion into practice, is still not considered enough at the teaching institutes (schools, universities, academies). Especially the transfer from theory into practical application is not considered, because of modern information and communication methods, which first have to be implemented in a multimedia surrounding. New learning concepts must therefore be developed and everyone, who wants to teach with multimedia, must define his teaching completely new.

In addition to the technical redefinition of the lessons in the multimedia environment, teaching contents beyond conventional methods must be considered and integrated. An integrated concept must therefore be developed, including all aspects from didactic via methods up to multimedia tools, and will represent the complexity of real conditions in the learning enterprises.

On the one hand, the evolution of an integrated teaching concept requires particular demands on the employees. On the other hand, the integration of pedagogic and didactic elements is necessary. The term "integration" describes the integration of required features in the concept, and these features will be outlined briefly below.

- *Complex thinking as well as learning in cross-linked structures (→ Systems Thinking)*

The fundamental discipline, on which all others are built on, is the networked thinking in sense of systems thinking. With systems thinking, the interaction and relationship of cause and effect and the adaptation of changing processes, are crucial.

- *Lifelong learning (→ Personnel Mastery)*

The employees have to understand themselves as living subjects, which have to learn continuously to develop their personal vision. This creates an intellectual basis for their daily work and builds up a cumulative personnel mastery.

- *More conscious dealing with mental models (→ Mental Models)*

The organisation has to make their mental models visible and has to reflect critically about them. Senge describes the mental models as "deeply ingrained assumptions, generalisations, or even pictures or images that influences how we understand the world and how we take action. Very often we are not consciously aware of our mental models or the effects they have on our behaviour." (Senge, 1990)

- *Learning in teams (→ Building Shared Vision, Team Learning)*

The organisation is not based on individual learning, but on team learning and sharing of visions, and only if the vision is adapted by all employees the fundamental basis is set. Schools and universities are mostly focused on individual learning.

- *Self-scheduled learning and learning on-demand (just-in-time learning)*

To realise a lifelong learning, it is necessary to drill every single employee about the responsibility of knowledge adaptation, and also delegate the responsibility for the learning time to the individual. The learning becomes a just-in-time learning.

- *Integration of work and learning*

The integration of work and learning is based on the assumption that learning is triggered by the needs, which occur in daily working processes. The learning gets a new dimension and must be designed so that it fits into the actual problem solving process. The employee should have the chance to adapt to the problems, which occur at work and this results in a problem oriented learning approach.

- *Double-loop- and deutero-learning*

With double-loop learning, the values, standards and strategies are reviewed in the learning process as well as in all actions. With deutero-learning, the learning of the learning gives new aspects to the employees about what kind of learning (single or double-loop learning) might best fit in the specific occasion.

- *Professional methods, social, personnel and media competence as well as emotional intelligence*

To master the complexity in industrial environment, the basic competence patterns have to be developed. In the last years, the media competence has become more influent, due to the change from the industrial society to the information and knowledge society. Also the emotional intelligence seems to revolutionise the interaction in teams and may provide some increase in efficiency.

A future holistic teaching concept has to consider all these changes in the learning environment, and they must be included in a completely new learning process. A teaching concept is presented below, in which most of the above mentioned features are integrated.

3. VIRTUAL TEACHING AT THE FBK

The institute "Manufacturing Engineering and Production Management" (FBK) at the University of Kaiserslautern, has developed a concept for a holistic teaching concept to fulfil the demands mentioned above. The total concept, ViteFBK (**Vi**rtual **Te**aching at the **FBK**), consists of different components and learning phases, which include different multimedia based teaching and learning methods. ViteFBK is an open concept, which combines new demands and new technological possibilities. The following description is not only about realised parts, but also about planned components, and deals with the structure of ViteFBK and the used media.

3.1 Structure of Virtual Teaching at the FBK

The structure of ViteFBK is characterised by two phases.

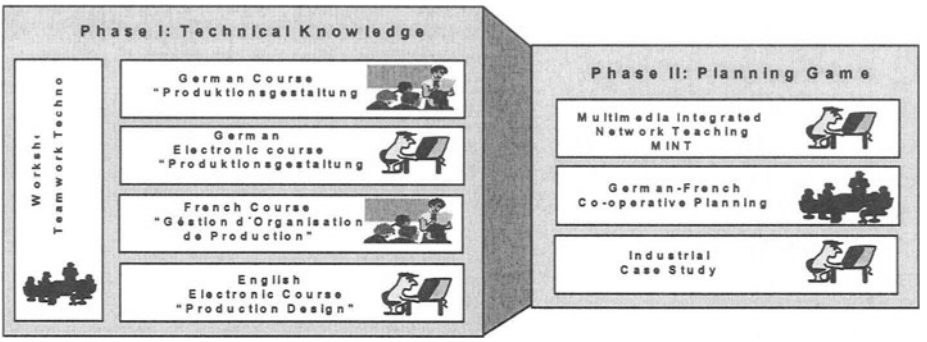

Fig. 1: Structure of ViteFBK

Although you cannot define an exactly separation of these phases by time, due to they overlap in reality, we will use the notion to be able to explain the concept sufficiently.

The main part of ViteFBK is the German course "Production Design" combined with a planning game. The focus of the first phase is the obtaining of technical knowledge and the second phase - the planning game - is based on this technical knowledge. This is not only important for the transformation of the technical knowledge to ***experienced knowledge,*** but also for the obtaining of important ***key qualifications***. Figure 1 below shows the different phases and their components.

3.1.1 Phase I - Obtain specific knowledge

The basic skills, methods and technical knowledge for the planning game will be obtained during this phase and the FBK offers a workshop named ***"Teamwork Technologies"***, due to the great importance of teamwork. This workshop is included in the current teaching curriculum and its goal is the obtaining of conventional ***teamwork technologies***. Students should visit this workshop, so that the basic methods of teamwork are well known and trained. Furthermore, FBK has planned to offer a revised version of the workshop for company employees.

The course ***"Production Design - Interaction of work structuring and logistics design"*** is dedicated to the obtaining of the theoretical basics. The content of the course are the basics of work and motivation psychology, work structuring, work and production control, transport and warehouse systems, as well as logistic systems and supply chain management. Beside the theoretical knowledge, it is focused on the integration of field experience. Therefore, various examples of industrial projects are integrated, which have been realised by FBK or some companies, and to increase the practical relevance, the course is held by an "agent professor" from Robert Bosch GmbH.

Beside the traditional course at the FBK, there is also an ***electronic course*** in German on CD-ROM available (you will find more details to this point at the description of used media). Furthermore, a short version of the course is held by the co-operation partner ENIM (École Nationale d'Ingénieur de Metz), France, and is called ***"Géstion d'Organisation de Production"***. An electronic CD-ROM-course in English named ***"Production Design"*** is also under construction.

3.1.2 Phase II - Planning game

The planning game is the climax of the course "Production Design". The participants have to perform a real data based factory planning for an assembly area and plan the logistics connection to the suppliers. The participants are divided into groups and given different planning data. The teams have to solve their individual planning task and they therefore need a high degree of self organisation as well as efficient teamwork. After an 84 hours planning period, the teams have to present their solution of the problem.

To create a realistic situation, the teams have a wide decision scope. By this, creativity is encouraged and the teams have to handle the problem and find solutions independently. Another significant part of the planning game is the specific distribution of wrong information and the secrecy of important

information (until the teams ask for this information). The game management has to play different roles during the planning game and the teams can e.g. get a turnover prediction by a fictitious marketing manager or ask for information about existing business agreements from a member of the union. The final presentation of the teams is also integrated in a role game. During this presentation, the team members have to explain their solutions to fictitious members of the company's managing board, some department managers and a representative of the union.

There are different ***variants of the planning game***. The three main variants are the ***"German-French Co-operative Planning"***, the ***"Multimedia Integrated Network Teaching (MINT)"*** and the ***"Industrial Case Study"***.

The planning teams within the ***"German-French Co-operative Planning"*** are mixed with students from the University of Kaiserslautern, Germany, and the ENIM (École Nationale d`Ingénieur de Metz), France. For this purpose, there exists a student exchange program, which lasts four days. In both Kaiserslautern and Metz, the language for the final team presentation is German but during the planning period, the respective country languages and English are accepted communication possibilities to increase the language learning. In this variant of the planning game, the teams have to work in group rooms, which are fitted with moderation material. The intensive co-operation in these small rooms leads to an intercultural exchange besides the fulfilment of the planning task.

The ***"Multimedia Integrated Network Teaching (MINT)"*** is based on a multinational level. In this case, the participating universities of the planning game are connected via Internet. There are eight people in each planning team, two from each participating university. The planning task can only be solved by using modern information and communication technology and the intercultural exchange must also be done with electronic media. Another problem is the lack of time, due to the global distribution of the participating universities. Beside the technical and interdisciplinary goals, the knowledge exchange in international teams and dealing with modern information and communication technology, are the main goals of MINT.

The ***"Industrial Case Study"***, which is still under construction, is a special version of the planning game for the further training of company employees. It is essentially based on the MINT-variant, but a shortening of the content was necessary. Furthermore, it is focused on dealing with modern information and communication technology as well as the necessary adaptation of teamwork technologies. The methods for solving technical problems and the common use of teamwork techniques are assumed to be known by the industrial employees.

3.2 Used Media

The realisation of the complete concept, ViteFBK, requires use of various media. To give an overview of this topic, we will describe both the actual used media and the planned use of media in the future. Figure 2 shows the predominant use of media in ViteFBK.

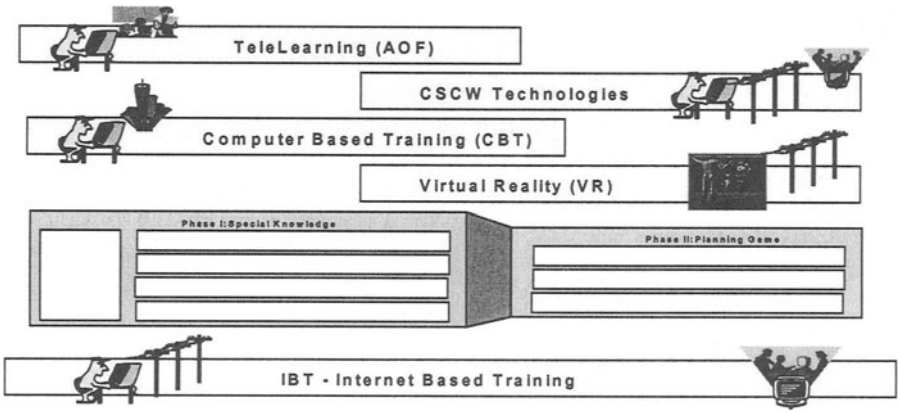

Fig. 2: Predominant use of media within ViteFBK

3.2.1 TeleLearning with Electronic Course (AOF)

TeleLearning is not only a substitution, but could also be an addition to the course. The course participants can use TeleLearning for the repetition or the preparation of tests. For this, there is a multimedia based slide- and audio-document available on CD-ROM (including the complete German course "Production Design"). In the near future, there will also be an English short version (with about 60% of the complete course). These CD-ROMs allow the students to use the learning material at home.

The used recording and presentation program is the ***"Authoring on the fly - AOF"*** tool, developed by the institute "Algorithms and Data Structures" at the University of Freiburg, Germany. It enables a synchronous recording of the computer projections and all projection editing, including all graphical markings and progress indications, during the lecture. The advantages of this program, compared with common presentation programs, are on the one hand the small expenditure of preparation to get into it and on the other hand, the possible usage of AOF documents on different computer systems (Sun, SGI, Linux, Windows NT).

3.2.2 Guided self-learning with Computer Based Training (CBT)

In the context of ViteFBK, a CBT-program (Computer Based Training) with the title ***"Methods of factory planning and tools for factory automation"*** will be developed. This program will combine the theoretical basics of the course with some field experience. The ***multimedia design*** enables the interactive access to ***field information*** (e.g. via animations or video sequences), ***self-learning effects*** will be intensified by learning controls in a game context and the ***learning motivation*** will be increased by infotainment aspects.

To guarantee the practical relevance, some companies participate in the CBT design and this way we ensure to get practical information from the participating companies. It is also a possibility to evaluate the practical relevance, due to the companies, who will use the CBT for their own employee's education.

3.2.3 Communication and co-operation technologies

The used media play an important role in the planning game variants "MINT" and "Industrial Case Study". These variants use ***CSCW-technologies*** (CSCW = Computer Supported Co-operative Work), which help the team members solve the planning task.

Communication can be done e.g. via ***Phone, Fax, Email, Chat***, group specific established ***News-Groups*** as well as ***Audio-*** and ***Video-Conferencing-Systems***. At the transition to communication and co-operation tools, ***Whiteboarding*** and an ***Application Sharing*** is also used. With the help of the new BSCW-tool (Basic Support for Co-operative Work), developed by the GMD in Darmstadt, Germany, there exists ***Shared Workspaces,*** which can be used as common electronic group rooms by the teams for data management and information warehousing.

3.2.4 Virtual-Reality-Tools (VR)

In the future, a ***virtual planning room*** will be developed, which represents the planning room itself. In the planning game, the participants have to handle with rather abstract or symbolic views of the planning object, and it makes therefore sense to use interactive multimedia technologies to create a better understanding. The visualisation of the planning environment is realised in a Virtual Reality (VR) environment. The technological quasi-standard VRML (Virtual Reality Modelling Language) enables three dimensional scenarios via Internet for the teams. The goal of the VR-interface is to integrate the user as an active part of a three dimensional

virtual environment to increase his efficiency and effectiveness in the problem solving process.

The team members have the possibility to manipulate the planning objects in the planning room and to realise and discuss the changes immediately. For the realisation of this scenario, there will be symbolised characters or people in the virtual room, who can move independently and discuss with each other, e.g. by chat or Internet-based audio tools. This way the ***communication ability*** under abstract conditions and the new Information and Communication Technologies (ICT) are trained.

3.2.5 Internet Based Training (IBT)

The introduction of an ***Internet Based Training (IBT)*** serves different goals. On the one hand, the IBT is used for the ***administration*** of the course. Furthermore, you can use it for the distribution of information and course-material or inform about current links to relevant Internet pages. Also the administration of dates, the enrolment of students or further administrative purposes are potential uses.

In the planning game variants "MINT" and "Industrial Case-Study", the IBT is mainly used for the ***provision of distributed information*** of the planning task.

The students have the possibility to use ***discussion rooms*** in the IBT, which are realised as newsgroups. In the future, these rooms should be realised via VR and they should give the possibility to discuss current questions with the teachers by using a video-conferencing system. This way the different aspects of information and communication could be considered. There will also be a new communication system with the creation of **virtual learning rooms**, which enables and trains a self organised team-learning.

Another goal for the future is the integration of **knowledge databases** in the IBT, where the students can perform a thematic search for specific information not only during the course, but also during the planning game.

4. EXPERIENCES AND DERIVED MEASURES

Within the ViteFBK, there have always been interviews with the participants, responsible teachers and administrators to collect immediate suggestions for the improvement of the course. Some specific results of the interviews as well as some observation results are discussed below.

4.1 Experiences with the total concept of ViteFBK

The **complete concept** of ViteFBK received in general high recommendations from both students and administrators. In general, the students like the planning game with the practical application of the technical knowledge and the training of key qualifications in a role game context.

Within the planning game variant ***"German-French Co-operative Planning"***, the intercultural exchange was evaluated as especially interesting. The recognition of the ***cultural differences*** was a central point during the problem solving process, and demanded unexpected high efforts with regard to the self organisation of the planning teams. The problems occurred mostly because of language problems and different levels of technical knowledge. To solve these problems, the FBK and the ENIM agreed to extend the French course "Organisation de Production" and to prepare the French students to the necessary German and English technical vocabulary.

The experiences with the planning game variant ***"MINT"*** were also very positive in general. In this case, there was a high recommendation for the international orientation and especially for the ***use of information and communication technology in international teamwork***. The noticed problems were on the one hand communication problems, which were caused by continuously appearing technical problems. To improve this process in the future, an extensive technical preparation will be necessary for a better adaptation of the participant's hard- and software knowledge. On the other hand, problems with the difference in knowledge and also organisational difficulties, occurred. To solve these problems, the English version of the course "Production Design" will be developed and a better organisational agreement between the participating universities is recommended.

4.2 Experiences with used media

The ***IBT*** was used in the "MINT" variant of the planning game. The students were pleased with the existing functions but made some completion and improvement suggestions. Because of the consciously chosen HTML realisation, there have not been any technical problems.

The use of ***CSCW technologies*** was evaluated as especially interesting by the "MINT"-participants. The use of Email, News-groups, Chat and Whiteboards caused mostly no problems. There have however been some comprehension problems by using the shared workspace, but they could often be solved by an explanation. Only the audio- and video-conferencing

systems were affected by serious technical problems. As mentioned above, a better adaptation of the participant's hard- and software knowledge will be necessary to solve these technical problems.

During the summer term 1998, a group of six volunteers prepared the planning game only with ***TeleLearning (AOF)***. The results of this group (AOF-group) were equivalent with those groups, who visited the course during the term. The interviews with the AOF-group members showed a very positive evaluation of TeleLearning. They emphasised the free determination of learning-time and place, and they reported on a reduced total preparation time. All members of the AOF-group answered, that they would prefer the TeleLearning against participating in the course. But at the same time the participants of the course agreed that they would like to go the course and use the TeleLearning only for test preparation or to reflect specific issues. Both learning behaviours are supported by the different learning possibilities and it is therefore possible for the students to create their own optimal learning environment by using different learning elements.

5. EVALUATION OF THE COMPLETE CONCEPT

The evaluation of the described concept can be done in several ways. Beside an evaluation from the students point of view, a **scientific-pedagogic evaluation** is also of interest.

The scientific-pedagogic evaluation is based on an evaluation guide, which was developed for virtual teaching concepts. The focus lays on the following features:

- Features with general reference to teaching methods
- Features with regard to the competencies to be provided
- Features with regard to the learning form
- Features with regard to the dealing with complexity
- Features with regard to the learning process

The evaluation of the ViteFBK includes the above mentioned features, which have to be used for a future holistic teaching concept (figure 3). The evaluation of the individual modules and the concept overall, illustrates that only integrated learning concepts make sense in multimedia learning environments for knowledge procurement and complexity mastering. Individual modules can indeed stand by themselves, but must be combined reasonably in accordance with the requirements of the entire learning goal. The guide for evaluation also gives some ideas for the necessity of integration. It makes clear that every teaching method can only cover a particular field.

Teaching and learning will vary much in the next years by the integration of multimedia. It seems, that there are enormous potentials for improvement in teaching result by usage of multimedia. The expenditure for the evolution of integrated teaching concepts must not be underestimated. In addition, it must also be natural that the implemented concepts need a continuous development. Otherwise the relation to real problems will be lost and the transfer of theoretical knowledge into practical problems disappears.

Multimedia Integrated Network Teaching (MINT)				
Attributes with general relevance to the learning method				
A1: Learning Space	Stationary	Optional	Mobil	
A2: Learning Time Flexibility	Small	Medium	High	
A3: Multimedia Usage	Small	Medium	High	Very High
A4: Learning Preparation	Necessary	Partly Necessary	Not Necessary	
A5:Intercultural	None	Partly	Very high	
Attributes with regard to the competence evolution				
B1: Learning Field	Content-Business	Methodical problem solving	Social-Communicative	Affective Reflexive
B2: Competence Learning	Business Competence	Method Competence	Social Competence	Personnel Competence
B3: Media Competence	None	Medium	High	Very High
B4:Problem Solving Competence	No		Yes	
B5: Handling Competence	No		Yes	
Attributes describing the learning form				
C1: Learning Form	Foreign Controlled	Self Controlled	Discovering	
C2: Social Learning Form	Individual		Co-operative	
C3: Group Learning Situation	None	Central	Distributed	
Attributes with regard to complexity mastering				
D1: Information Complexity	Small	Medium	High	
D2: Behaviour Complexity	Small	Medium	High	
D3:Communication	Small	Medium	High	
D4: Technology Complexity	Small	Medium	High	
Attributes with regard to the learning process				
E1: Learning Category	Single-loop-learning	Double-loop-learning	Deutero-learning	
E2: Closed Learning process	Partly		Completely	

Fig. 3: Evaluation model used for ViteFBK (example of the MINT module)

6. CONCLUSION

The practical experience and the scientific evaluation of the concept ViteFBK, show the relevance of future holistic teaching concepts. It is clear that these concepts have to be developed in interdisciplinary teams, due to the wide aspects of implemented teaching methods and the use of high tech multimedia tools. The integration of industrial aspects seems to be a key issue and the acceptance of the students shows that the efforts are honoured. To prepare the students for the expectations of the next millennium, which are impressed by knowledge, complexity management and learning enterprises, there is only one way for the future education. We have to redesign the curriculum at the universities in the sense of holistic teaching concepts to meet the demands of the future.

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8. BIOGRAPHY

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