E-LEARNING BASED COMPETENCE DEVELOPMENT IN LOGISTICS SOFTWARE APPLICATION FOR SIMULATION AND VISUALIZATION

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ABSTRACT

Logistics is one of the areas where simulation and visualization software is typically applied in practical problem-solving processes. Precondition is sufficient knowledge and understanding on simulation methodology, but also on the syntax, functionality and applicability of professional software packages used. Within this context the paper addresses a learning-while-working scenario presenting the idea and implementation of respective simulation-focused learning resources in a web-based portal. It elaborates simulation competence requirements in logistics, discusses design constraints concerning e-learning material to meet those requirements and gives examples on simulation knowledge representation and interactive knowledge application for logistics simulation and visualization.

INTRODUCTION

In logistics process design and systems engineering the use of discrete event simulation and 3D visualization techniques has become a fundamental methodological approach. There is a wide range of generic or specialized, continuously developing simulation and visualization software tools aiming to support logistics planning. The challenge to the user (i.e. the logistics planning person) consists in both understanding the tool's methodical background and application constraints and keeping track of current functionality according to latest software updates. Especially the latter requires dynamically adjusted training material far beyond a simple README file enlisting changes over the previous version. Instead, e-learning modules are a more promising alternative as they can be provided equally well via the software developer's website or within a dedicated e-learning environment – if designed in a proper way.

From reviewing literature it becomes pretty obvious that simulation competence development closely matches the concept of e-learning. The major reason for this is a quite "natural" one: both fields simulation and e-learning work with the same medium – the computer. This makes their combination particularly convenient; neither change of context nor any additional tool is required. This also contributes to successful learning as subjects tend to be conveyed best in what might be considered their native environment (Rushkoff 2013).

In the early stages of simulation-focused technology-based learning (Neumann et al. 2005) intelligent tutoring systems aimed to present certain aspects of a typical classroom-based simulation course in a computerized way (Taylor and Siemer 1996). With the emergence and wide-scale accessibility of the internet web-based interactive learning environments for teaching simulation facilitated collaborative learning in a heterogeneous environment (Atolagbe, Hlupic and Taylor 2001). Nowadays, simulation education is represented in proprietary, commercial or open virtual learning environments. Topics covered range from theoretical foundations and optimization methods to simulation exercises and cases. Fonseca et al. (2009) compare a variety of those online and blended learning applications and conclude on the use of simulation software, professional-oriented approaches and friendly online environments as being necessary to successfully complete simulation courses. The success in terms of achieving professional simulation competence amongst others depends on the availability of authentic rather than abstract simulation problems and usability of professional rather than academic simulation packages within the e-learning environment. This way simulation learners work already with situations and tools they might get in touch with at their workplaces.

Due to the tools' and their use cases' increasing complexity an e-learning module supporting competence development in logistics software application for simulation and visualization needs to be designed in a way enabling

- easy-updating or extending with regard to the specific software tools explained and applied,
- flexible choice of the way of learning, the mode of knowledge presentation and the method of knowledge application or assessment, and
- personalization in terms of topics and competence level to be achieved.

Especially the latter requires in-depth understanding of what are competence requirements of the individual

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person and even more which competences at what level are required at the labor market. To get an insight into those user needs and market requirements a European project is being run aiming to provide access to attractive training material and to a diagnosis tool for identifying individual competence gaps.

Against this background the paper elaborates requirements for simulation competence in logistics, presents the structural framework for developing professional competence and discusses e-learning design issues for applying simulation and visualization tools within a simulation-focused learning scenario. At the end, concluding remarks summarize findings and identify next steps in the project.

REQUIREMENTS FOR SIMULATION COMPETENCE IN LOGISTICS PRACTICE

The lot4eng.com (Logistics Open Training for Engineering Competence) project has been inspired by the shortage of logistics engineers, which has already been and is yet to be faced by many countries across Europe. Therefore, the objective of the project is to enhance engineering and managerial skills of employees at risk of developing a competence gap in the field of logistics (i.e. employees of logistics, manufacturing or distribution enterprises, and coaches, trainers or vocational trainers in logistics). This is to be achieved by providing access to high quality e-learning materials.

In order to ensure that training materials developed within this framework match current requirements at the labor market, a questionnaire-based survey was run with logistics managers at different management levels and from different types of (logistics) companies. Outcomes of the survey form the basis for developing web-based, interactive training materials that address those needs and enable logistics practitioners (but also newcomers to the field) to develop and improve professional competencies according to their individual requirements.

Table 1: Bloom's Taxonomy

Evaluation	You can pass judgment on something (e.g. assess, conclude, decide, verify)
Synthesis	You can create something new as a result of analysis (e.g. compose, create, design, generate, plan)
Analysis	You can break something down (e.g. compare, detect, order, simplify)
Application	You can take something from one context and use it in another (e.g. choose, collect, complete, develop, use)
Comprehension	You understand what you know (e.g. associate, classify, differentiate, explain, identify, summarize)
Knowledge	You know something (e.g. define, describe, list, match, name, relate)

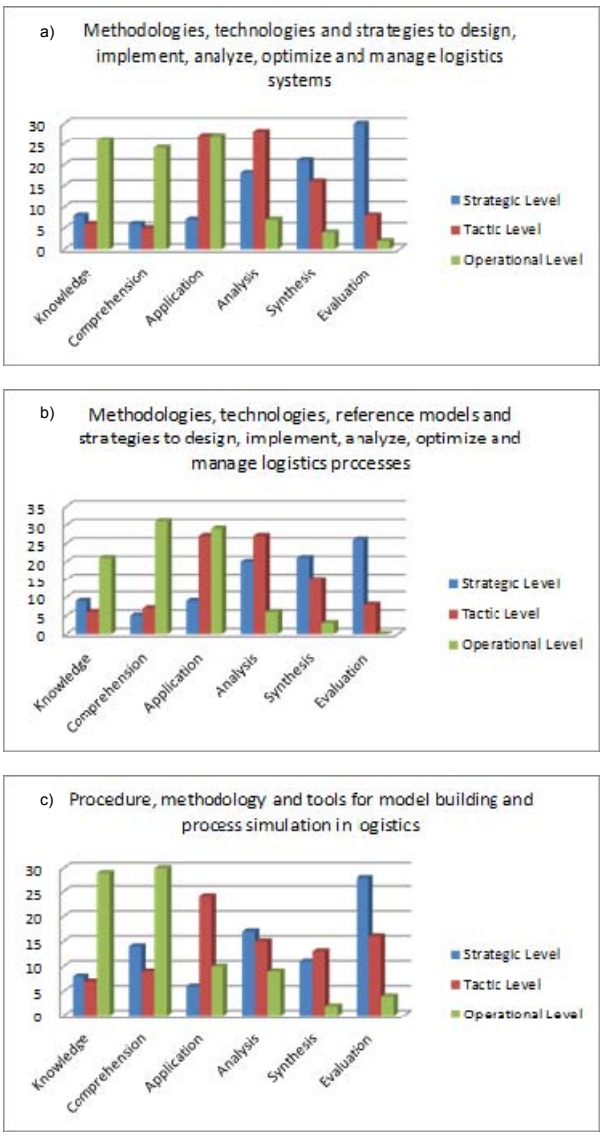

Figure 1: Competence Requirements in Logistics Practice

In the survey participants were asked to indicate the level of thinking (according to Bloom's Taxonomy for educational objectives (Bloom 1956), see Table 1) they would expect to find with a logistician at a certain management level (i.e. strategic, tactical or operational) for a number of managerial and engineering competence areas. Amongst others, questions addressed methodologies, technologies and strategies to design, implement, analyze, optimize and manage logistics processes, systems and networks on one hand and procedure, methodology and tools for model building and process simulation in logistics on the other. Comparing the frequency distribution of responses to those questions (see Figure 1) it becomes visible that the required level of both planning and simulation competences generally increases with the management level the target person is expected to work at:

- *Supervisors in an operational role or first line managers* (i.e. operational level) are expected to

demonstrate a profound understanding on logistics systems and process design, implementation, analysis, optimization and management and eventually apply this understanding within a certain context. With regard to model building and simulation this type of managers should at least understand the procedure, methodologies and tools.

- *Managers or consultants planning, coordinating and controlling different parts of the logistics network* (i.e. tactical level) are expected to apply methods, technologies and strategies for logistics system and process design, analysis and optimization and even further to look for interrelationships and patterns, understand generic structures or make interferences. For this type of managers almost the same average level of competence is required with regard to model building and simulation.
- *Senior managers, senior consultants or directors with considerable experience in logistics management or senior executives who have assumed logistics responsibilities from another business discipline* (i.e. strategic level) are also expected to break down information on logistics system and process design, analysis and optimization into their component parts, but also to demonstrate some ability to create new patterns or structures or propose alternative solutions. For this type of managers almost the same average level of competence is required with regard to model building and simulation.

From this it can be concluded that e-learning material aiming to support model building and simulation competence development in general (i.e. independent of a particular tool) needs to be designed in a way providing introductory knowledge and fundamental understanding, but also allowing to proceed towards a higher competence level if intended. This can only be achieved by modularly structuring the material, providing competence-based and learning-goal oriented access to different parts of the material, and enabling interactive knowledge application through quizzes at different levels of difficulty and analyzing or running case studies at different levels of complexity.

STRUCTURAL FRAMEWORK TO DEVELOP PROFESSIONAL COMPETENCE

Based upon the previously discussed analysis of user needs in terms of competence development and taking into consideration the necessity for applying certain software tools enabling simulation model building and experimentation as well as visualization of the outcomes of a logistics system design process in a three-dimensional virtual reality the e-learning module will be subdivided into independent but interlinked units. Apart from sections explaining basics of simulation methodology and logistics simulation and introducing into logistics simulation projects, the material comprises units introducing to basic functionality of and providing advanced insights into a particular simulation package (DOSIMIS-3) and a tool for creating 3D representation of logistics systems (taraVRbuilder). All units can either be combined within an educational module to be embedded in a learning management system, like e.g. the moodle platform (see Figure 2), or used by providers of those tools as add-on material to their web-sites.

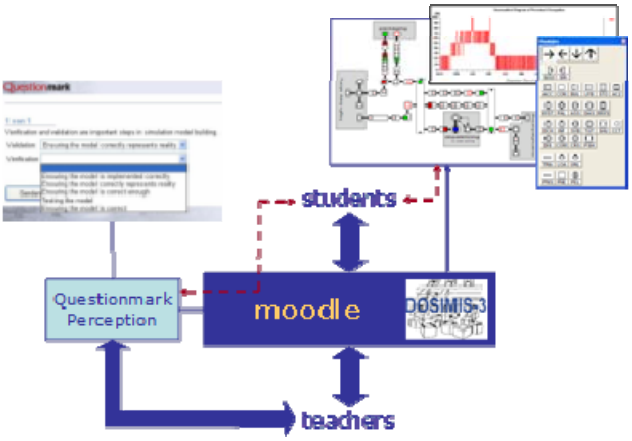

Figure 2: Educational infrastructure

However, within the context of the lot4eng.com project there is a quite different focus: In the first instance e-learning material is not meant to be used in university classes nor as a kind of online tutorials with software providers. Instead the material aims to support logistics managers and engineers in updating and extending their professional competence – amongst others in the field of modeling and simulation. Due to their daily workload time resources for attending classroom training are often limited; therefore learning while working, i.e. workplace learning, is a more promising approach. Although here another challenge is still to face: to help a professional on-the-spot and when dealing with a specific problem in actively creating and successfully passing individual learning processes through guidance-on-demand in a virtual environment.

For this, preconditions are easy real-time access to necessary information resources directly in the workplace (e.g. via an internet portal), almost immediate personalized support in real-life problem-solving (e.g. through a question-based access to specific multimedia instructions), and clear understanding of personal competence deficits and training needs (e.g. based upon individual competence gap analysis). The lot4eng.com platform (see Figure 3) has been designed exactly to fulfill those preconditions. For each of the three target groups addressed, logistics managers, logistics engineers and logistics teachers, there is a specific competence test. Here, user's competences as demonstrated in the test are matched against the target competence level as required from the competence survey. Depending on the results a list of e-learning

units (lessons) is proposed with the help of which missing competences might be developed. All e-learning material contains multimedia elements, is interaction-based, encourages knowledge application and is available in English as well as in the local languages of those countries addressed by the project (Poland, Italy and Germany).

Figure 3: The lot4eng.com portal

In addition to those characteristics, implementation of alternative pedagogical strategies facilitating the acquisition of simulation modeling knowledge is helpful in order to allow learning processes that match with personal preferences. Concerning the latter Atolagbe, Hlupic and Taylor (2001), for example, identified the following concepts as particularly suitable ones for simulation competence development:

- *Learning with scenarios* (i.e. using a real-world scenario as the vehicle for instruction);
- *Learning by doing* (i.e. coaching in step-by-step operations required to perform a particular task);
- *Practicing with contents feedback* (i.e. providing remediation of a problem whenever an error or misconception has been detected); and
- *Free exploration* (i.e. enabling navigation around a case scenario without intervention by the learning environment).

This way informal self-learning is supported rather than formalized educational processes. For the purpose of the lot4eng.com project this exactly meets intentions: support workplace learning with logistics practitioners who want to or need to apply simulation and visualization for logistics problem solving in their daily work. This is achieved best by offering instruction-like and problem-based modules (Neumann 2008) strengthening practical knowledge transfer, whereas description-oriented modules focusing on transferring theoretical knowledge are less suitable here.

E-LEARNING DESIGN FOR APPLYING SIMULATION AND VISUALIZATION TOOLS

Within the lot4eng.com platform simulation and visualization competence development is embedded in an e-learning module on "Application of Logistics Software" (see Figure 4). This module comprises units introducing into software in logistics (overview and general classification), briefly explaining simulation methodology and illustrating how simulations projects are run particularly in the logistics area. This is completed by units on how to use a specific software tool in which a simulation package's syntax is demonstrated, but much more important its problem-oriented application is explained and illustrated.

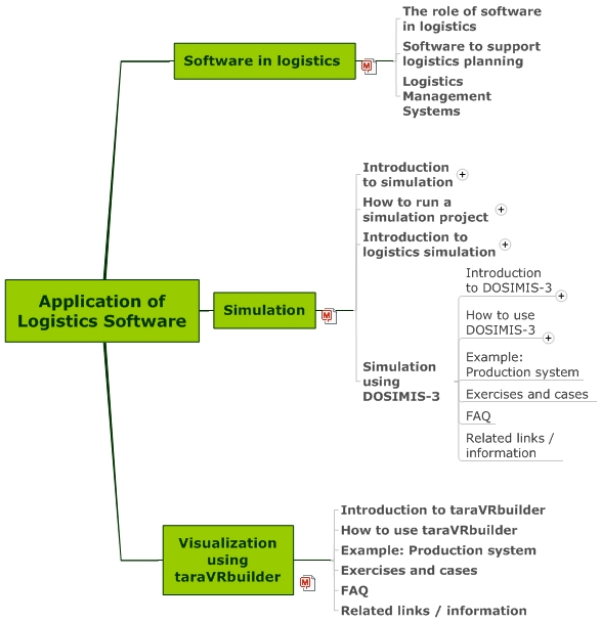

Figure 4: E-learning module structure

For the moment, those tool-specific units cover a simulation package, DOSIMIS-3, on one hand and a 3D dynamic visualization package, taraVRbuilder, on the other. *DOSIMIS-3* (http://www.sdz.de) is a simulation package specialized to answer questions related to functionality and performance measures of logistics systems and processes. It provides an extensive library of components from the material-flow and logistics world, enabling model-building by a few clicks on the basis of a well-structured conceptual model. With this, model building and simulation is brought closer to the experts in the application area – in our case material flows and logistics enabling them to implement and use a simulation model themselves. *taraVRbuilder* (http://www.tarakos.de) is a software tool for 3D configuration and visualization of conveying, material flow and storage/warehouse equipment using virtual reality technology. Models are built from a wide-range library of scalable, animated 3D components eventually even representing specific manufacturer's product catalogue. Possible applications exist in the fields of sales support, planning, engineering and documentation.

It can also be used as a software tool within the context of the "digital factory".

Both software tools were chosen as they are commercial packages well known in logistics practice, but offering demo versions free of charge. They originate from Germany, but they are available at least in English language and used in other countries as well. In terms of the DOSIMIS-3 simulation package the tool has already been translated into several other languages with the two other project languages Polish and Italian amongst them. With this it is possible (and necessary) to prepare and provide instruction media (and not just descriptive texts) in two or even four different languages in order to be as close as possible with the potential users.

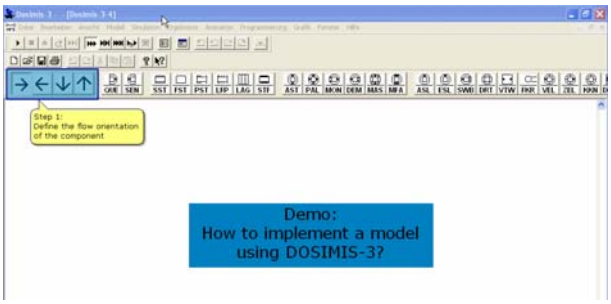

Figure 5: Exemplary demo for DOSIMIS-3

Generally, both units are sub-structured and designed along the same lines. An introduction to the respective software is followed by a kind of interactive tutorial on how this package is being used (see Figure 5). The tutorial first explains in an exploratory way structure and elements of the graphical user interface and presents standard functionality (What is to be found where?). The next section focuses on basic functionality of the software package in order to illustrate how to build a model, how to navigate through a (more complex) model, how to set parameters with model components or how to let the model come to life in simulation, animation or visualization. Additional sections of the tutorial go into detail with specific modeling challenges, presentation of results, and the package's import or export functionality. Working through this material should enable the user to understand what the software package might be used for and how. To deepen knowledge and understanding hopefully acquired from following the tutorial a specific example is given (see Figure 6) which demonstrates the entire application process from introducing the problem and question (including a draft of the system and its parameters) and presenting the complete model to showing and commenting on how the model is being build step-by-step.

After this, exercises and cases request for practical experimenting. Challenges presented to the user include functionality exercises ("Show where you can find…" or "Click on the right button for…"), discovery exercises ("What kind of system/process is represented here?"), model building exercises ("Build a model of the following system/process!"), small case studies and a quiz. A section containing (multimedia) answers to an open set of frequently asked questions and a list of related links or further information sources provide hands-on guidance and direct support to self-directed applications and business projects.

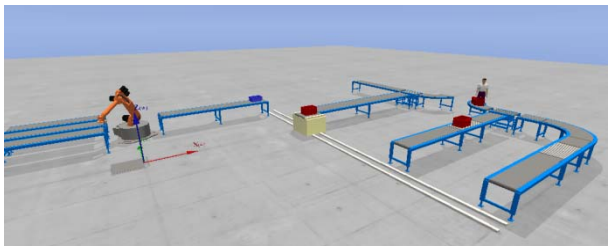

Figure 6: Example from taraVRbuilder

This common structure is applicable to any other kind of software tools too and therefore forms the basis for an open collection of learning units which also can easily be updated with eventually evolving software functionality. In order to enable easy and direct access by the user the units are designed from the user's point of view rather than following the software's structure and functionality. This is achieved by applying a question-based approach. Here, it is assumed that a user does not want or need to get demonstrated full software functionality in a compact sequence, but s/he comes with a particular problem or question concerning software operation. And this problem needs to get solved or this question needs to get answered within the user's specific context. Therefore, each of the demonstrations is related to a "How to …" question. These small-scale learning resources can then be accessed in alternative ways. This includes working through a guided case, following a learning path, scrolling through a listing and navigating through a logical grouping represented by a mindmap.

In contrast to typical e-learning modules learning progress does not need to be assessed inside the module itself, but is to be demonstrated by reusing the competence gap analysis tool of the lot4eng.com portal. Currently, this requires to answer questions only and not to demonstrate any competences or skills in applying simulation software or model building and simulation to solve a problem in logistics planning or operation. Turning this knowledge-focused approach into a competence-oriented one still enabling automatic evaluation and feedback remains an open task.

CONCLUSIONS

The paper presented an approach and environment for e-learning based competence development in logistics software application for simulation and visualization. Due to founding any learning resource development on the results of a survey for competence requirements with logistics managers and engineers, materials

structuring, design and usability can be expected to be close to potential users' needs. However and apart from finalizing implementation, next steps need to focus on giving proof of practicability and functioning in terms of both, technical and learning aspects. For this, final beneficiaries will be involved.

Today, it already can be concluded that e-learning is a promising way to support simulation competence development in a practical environment, i.e. directly at the workplace. Instead of formal training settings keeping human resources away from their daily business, informal and self-learning while working can nicely be integrated in professional problem-solving activities. Precondition is a proper design and structure of the material related to the use of commercial software packages and its availability within an internet platform enabling personal competence gap analysis as well.

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