SIMULATION-BASED TRAINING MODULES FOR INDEPENDENT TRAINING OF EMPLOYEES IN THE AUTOMOTIVE INDUSTRY

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ABSTRACT

The goal this work is to describe the conception and implementation of a simulation-based training environment, which is supposed to be used to train employees in the field of automotive logistics by the principle of cause and effect. Today's jobs are shifting away from executive positions to rather service-orientated jobs and thus change quickly. This leads employees to adjust their skills and knowledge to the demands of the job market. The focus of training concept is put on the characteristics of andragogy, self-directed learning, as well as "on the job training", all based on the constructivism' learning approach. Aside from the theoretical principles of learning, practical examples of (simulation-based) training concepts are analyzed. Content-wise the training module is based on the standard processes of the internal logistics in the automotive industry. The implementation is done with the discrete-event simulation software "Plant Simulation".

Keywords: simulation-based training, internal logistics in the automotive industry, employee training

1. LITERATURE REVIEW

A high extend of simulation based training programs exist in the field of medicine. More than 86% of medicine students are using simulation as a part of education within their studies (Passiment 2011). Concerning logistics, most of the training programs are developed for students or in the context of employees' professional development (usually commercial programs). Examples for the former can be found in (Siddiqui Khan and Akhtar 2008, Mustafee and Katsaliaki 2010). Nowadays employee training is also been executed by mobile learning, in the form of tasks that can be conducted of the cell phone of the employee (Witt et al. 2011).

General learning theory divides learning concepts into behaviorism and constructivism, while the letter means that learning contents should not be reduced to very basics tasks but be left in their original complexity (Ziltener 2005). Based on that concept, learning is generated within the learning process (defining one's own theory and then trying to prove it) and not in form of an objective result. For every individual there are different styles of effective learning (Staemmler 2005) and different reasons for why to learn. Since the training environment of this work is specified on training employees, it is supposed to vary from the teaching process of children or in school. Differences in how to teach children and grown-ups are essential (Knowles Holton and Sawnson 2005). There are evidences for adults mainly having subjective intentions to learn, in contrast to children who usually learn because they are advised to. For that reason, keeping up adults motivation is of highest importance and can only be guaranteed by taking into account their own experiences, as well as their situation of life (see figure 1).

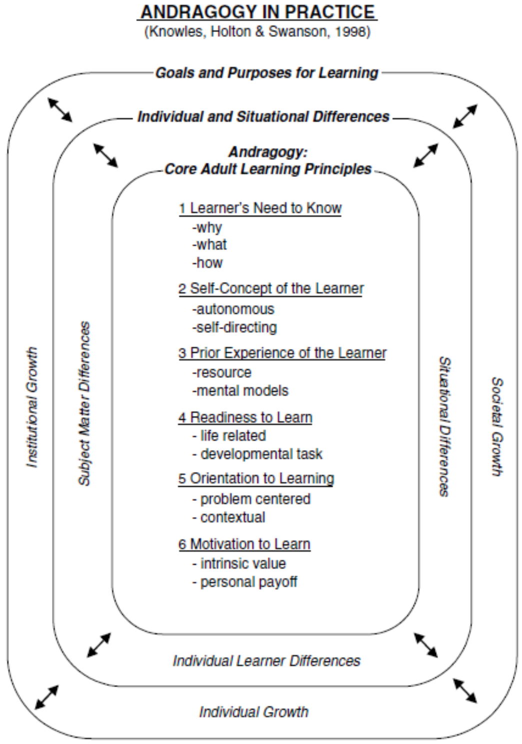

Figure 1: Andragogy in Practice (Knowles et al. 2005)

In contrast to other fields of simulation, like virtual and augmented reality, the developed learning environment is designed for employees in planning or management departments. When teaching with VR and AR, usually operative tasks, for instance picking and packing, are being taught where the main principle of teaching is the visual presentation. Material flow simulation is rarely used to implement 3D-visualized models, as its focus lies on transforming input data to quantitative results. Still the graphic demonstration of a simulation run is not ignored since the acceptance of teaching individual is heavily depending on them to understand what content they are taught and the relation to their daily business.

2. STANDARD PROCESSES OF THE INTERNAL LOGISTICS IN THE AUTOMOTIVE INDUSTRY

The process of the internal logistics starts with the receiving department at the receipt of goods and ends in sending the products to each of their customers at the outgoing goods department. In between these stages the products (purchased material) run through checking areas, warehouse operations (i.e. picking and packing), warehouses and assembly logistics, before it is mounted to complete vehicles. All included processes are associated to procurement, production logistics as well as distribution departments. (Klug 2010, Laffert 2000)
As the first differentiation from other departments related to logistics, procurement department can clearly be distinguished from fields like purchasing department. Main tasks of purchasing department are to select suppliers and to analyze their performance, while procurement has to work with the selected suppliers. Its primary function lies on supplying the plant with goods and organizing and executing the receipt of goods. Operative contents within the receipt of goods are accepting and unloading of deliveries and transporting them to further steps like checking areas or buffering places.

Any logistics inside the assembly hall can be clustered as assembly logistics. Its focus is aimed on adequately supplying the assembly line with goods of the right quality at the right time. In addition to that any tasks regarding supermarkets, where “Carsets” or sequences are arranged, belong to assembly logistics. “Carsets” contain a certain amount of parts that will all be mounted into one car, while a sequence is a sorted amount of one part family for the next n cars. Both are used to decrease the area needed close to the assembly line just as improving the mounting process for the worker.

Preparing the completed cars for their department and sending them out to the customer are the major functions of distribution logistics. In that sense, preparing means physically arranging the cars for the upcoming transports, like putting plastic foils above them to reduce weather influences or to fasten them into prefabricated pallets. Since deliveries can include more than one mode of transport it might also be necessary to install transshipment devices.

Further details regarding the standard processes of the automotive logistics will be described in the implementation of the model.

3. CONCEPTION

In general the conception is based on the assumptions of the learning theory and some practical examples regarding efficient training of employees. Requirements for successful learning environments which are being taking into consideration and defined measurements on how to encounter them are as follow:

Table 1: Requirements of adult learning and how to encounter them

Requirement	Measurement
Take into account the learners knowledge and experience.	Implementing processes comparable to the standard processes of the users’ job.
Relate the learning contents to the learners’ situation in life.	Developing learning scenarios that treat characteristic problems of his daily job or the neighboring departments.
Do not just give the learner information to read or view but let him act himself.	This Requirement is already accounted by using simulation as the learning method
Do not judge about the learners’ performance. Let him reflect himself about his progression within the learning process.	The simulation run does not finish by showing a subjective score based on the developers opinion. Instead objective key figures are presented and can be reflected by the learner based on his on view.
Use interaction between the learner and the simulation model as a replacement for the non-existing teacher to keep up the motivation.	Dialogue boxes are used the create communication and interaction between the user and simulation model.

The standard processes which are also the foundation of the simulation model were already presented in chapter 2. Characteristic problems of the related logistics departments are the basis for the implemented learning scenarios. These function not just to present learning content but also to provide a basic understanding of how the underlying simulation model works and what processes and interdependencies exist.

The knowledge which can be gained by the training program is based on the concept of cause and effect, where causes are exclusively parameters that can be changed by the user and influence the system’s behavior (effects). As mentioned before, the targeted learning process of the learning environment is heavily characterized by constructivism and thus is not targeting on just bringing up print or video material for the user to watch and then try to replicate. The learning process of the presented environment depends on successive changing of parameters (act) and watching as well as reflecting the results afterwards. Results are illustrated by visualizing the simulation run and simultaneously showing the most important key figures within diagrams. At the end of every simulation run these key figures are reviewed in dialogue boxes to give the user an overview of the performance of the last run. Reflecting the results into perceptions is what makes the learning process and thus the main task of the user.

Additionally an introduction dialogue will be presented when opening the simulation model. That dialogue is supposed to give the user essential information about the training program. In general, the interaction of the user and the model is of high importance, because this leads, guides and limits the learning process. Any kind of interaction is implemented in dialogue window elements which open up every time the user needs to get some information.

To increase the user acceptance of the learning program it is supposed to be user friendly. When working with adult learners these need to know what they are learning and why they need to learn. While it is very hard to work on that "why"-part, not knowing the individuals to teach and developing a "teacher-less", self-directed learning environment, the main goal of the concept is to treat with the "what"-question. Therefore the concept is heavily content-driven and focuses primarily on the implemented processes, the learning content and how both is presented in the simulation model.

4. IMPLEMENTATION OF THE MODEL

As described in the abstract, "Plant Simulation" was used as the tool to implement the simulation model. It is among the standard software for simulating material-flow processes in the automotive industry (Mayer and Pöge 2010). Plant simulation allows the implementation of discrete event simulation models and therefore is able to reconstruct most of the logistic processes of the automotive industry in accurate fashion while maintaining a high grade of abstraction to keep up a low computational cost.

The first thing to view for the user is the introduction, which is supposed to provide basic information about the content of the learning program and how to work with the model. It is displayed in a dialogue box (figure 1) and appears every time the model file is opened. If needed it can also be opened by clicking the button in the upper left corner of the user interface (see figure 3). In addition to that, the introduction dialogue allows the user to navigate between the different areas of the plant so that first impressions of the related logistics and production steps can be obtained. These areas are described more precise within the instructions dialogue.

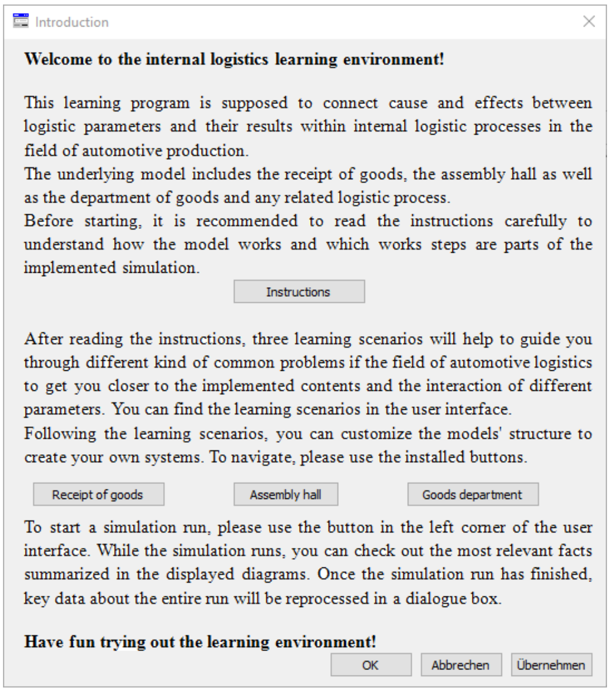

Figure 2: Introduction dialogue in Plant Simulation

In general, the entire coordination and navigation of the user is taking place in the user interface. A user friendly environment was highly prioritized in this work, as it may decrease possible rejection of users regarding simulation models. Most of the interaction is realized by buttons and dialogue boxes.
Next to the navigation, results of the ongoing simulation run are displayed in preinstalled diagrams, which are showing live data of key figures.

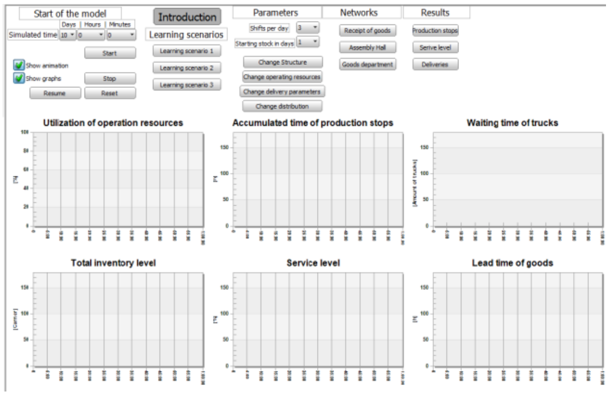

Figure 3: User interface in Plant Simulation

The user interface allows the user to:

- Open the introduction and instruction
- Start, stop and resume the simulation
- Change the parameters and the structure
- Start the learning scenarios

- Navigate between the areas of the plant
- Watch the key figures in both diagrams and tables

To get in touch with how the model works, three learning scenarios are developed. In these scenarios common problems of the related logistic departments are treated. Therefore problematic states are implemented which need to be solves by the user. The difficulty increases from one to another and while it is rather obvious what needs to be changed in the first scenario, the user needs to develop a deeper understanding of the underlying system to fix the problems of the later scenarios. After the simulation run of a learning scenario has finished, the results will be presented in a dialogue box (figure 5). This dialogue box also contains a button that leads the user to the box to change the related parameters (figure 6).

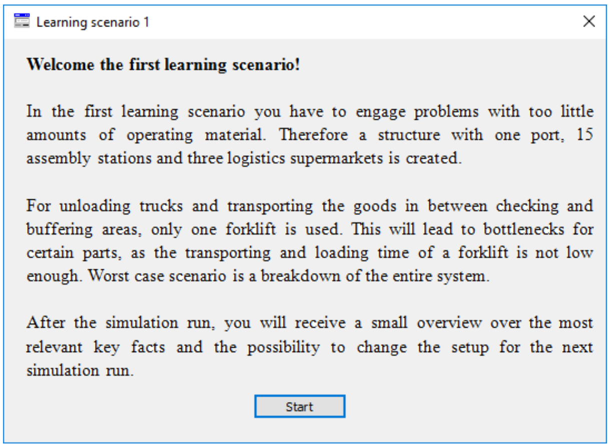

Figure 4: Dialogue window of the first learning scenario in Plant Simulation

Figure 4 shows the text of the first learning scenario. The text itself just provides some basic information as the more detailed information about the modeled production system should already be gathered by studying the instructions. With clicking the “start”-button in this dialogue, the model will change the structure to the setup of the first learning scenario and afterwards run the simulation for a simulation time of 10 days, which is enough to cause the system to collapse. Once the simulation has finished, results will be summarized inside another dialogue box and it is left to the user to reflect the performance of the last run.

The next step is to change the related parameters in a fashion that solves the occurring problems (see figure 6). Finding out the changes that need to be made is part of the learning process and relies on the principle of constructivism. The user can change the parameters and run the simulation as often as he wants and figure out how the changes affect the systems’ performance.

As long as a user is working on the learning scenarios, he is limited to change the parameters concerned. Structural adaptations are not allowed at that point in time as those go in hand with high investment costs and thus are not the first answer to logistical problems.

Outside of the learning scenarios it is possible to change the entire structure and mostly every procedural parameter, however processes themselves cannot be changed as the implementation of a self-learning model was not part of this work.

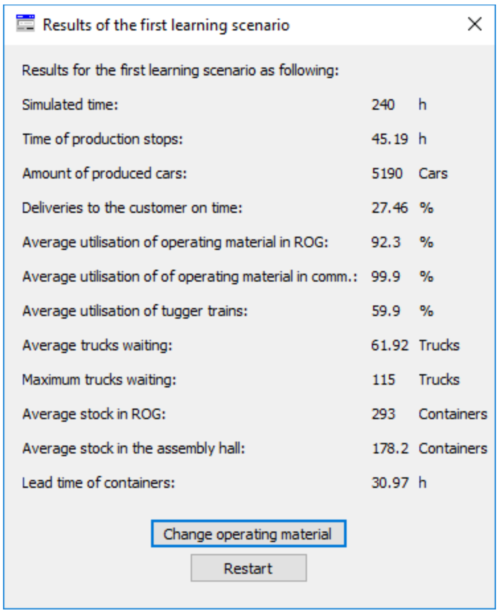

Figure 5: Exemplary results of a simulation run in Plant Simulation

Clicking the “Change operating material”-button will lead to the following window. As seen in figure 6, some of the parameters are colored in grey meaning they cannot be changed in that scenario. Regarding the other variables, the user is free to change the numbers and restart the simulation with the new setup. Parameters concerning the assembly or the general structure of the model can be found in different dialogues, but as these are irrelevant to fixing the problematic situation of the first learning scenario they are locked at that time.

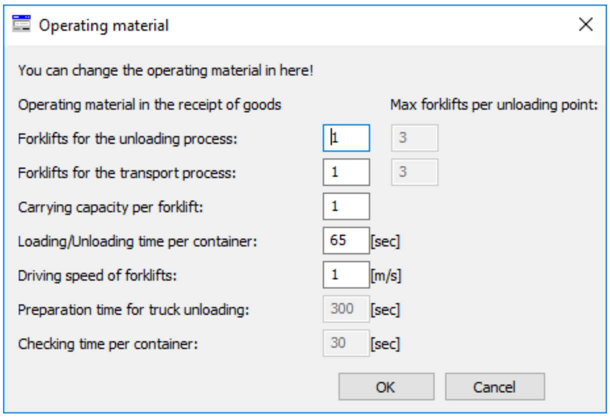

Figure 6: Parameter changing dialogue for operating material in extracts in Plant Simulation

The presented diagrams are showing the live status of the current simulation run. Key figures of production stops, service level, lead time, utilization, waiting time and stock level were chosen to provide enough information to deduce the performance of the current run. These key figures are the most important parameters of logistic systems, still the user is free to find other defining numbers of his performance by clicking at the implemented material flow elements. As a consequence, more experienced users can evaluate their performance in a more precise fashion and in this way progress faster in their learning. At the end of each run, key figures are compressed into average and maximum values, as those are otherwise very hard to identify out of the presented diagrams.

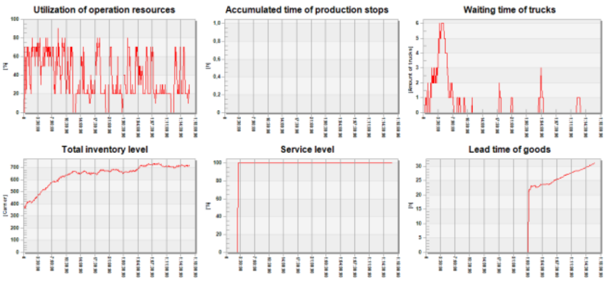

Figure 7: Exemplary diagrams of key figures in Plant Simulation

The simulation model was implemented by separating the plant layout into the receipt of goods, the assembly hall and the goods department, each being represented by one network in plant simulation. Parameters are not just including quantities and capacities of resources, but also the structure of the plant. Therefore the "automatic model construction" is used, which allows users or trainers to configure the layout to their own needs before running the simulation.

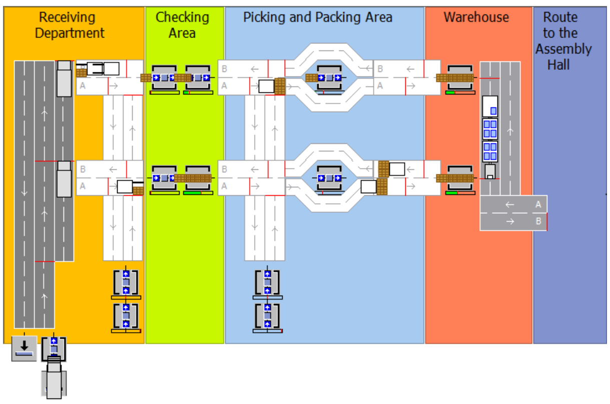

Figure 8: The receipt of goods in Plant Simulation

Figure 8 presents an example of the implemented network of the receipt of goods during a simulation run. Colors divide different parts of the network and different kinds of transportation units have different icons as well. On the left side of the picture the trucks (grey icons) are being emptied by forklifts (white icons). Next to that process, the unloaded goods (large load carriers, brown icons) are checked in regard to their quality and usability inside the checking area. In the picking and packing area the delivered good are prepared for either being stocked or delivered right into the assembly hall. On the right side of the picture one tugger train is taking out small load carriers (blue icons) of the warehouse to deliver them into the assembly hall.

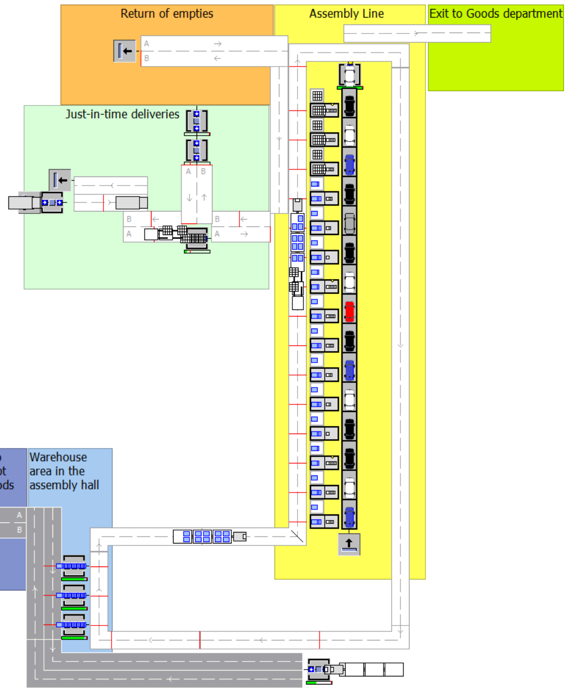

Figure 9: The assembly hall in Plant Simulation

The assembly hall during production is shown in figure 9. Similar to the receipt of goods, different colors represent various working areas. The production line is centered in the middle of the picture. Purchased parts are delivered to small buffer places close to the assembly line, where they are mounted into painted car bodies. At the end of the assembly line, cars are finished, filled with mediums and from there driven to the goods department. Deliveries to the assembly buffers are taken out of the warehouses (light blue area) by tugger trains or supplied directly to the assembly hall (Just-in-time area) and then brought the assembly line by use of forklifts.

After exiting the assembly hall cars will enter the goods department. Before carrying them out to the customers either by ship, train or truck they need to be prepared for the upcoming transport. Depending on the mode of transport, packaging material is used to guarantee the prevention of any damage during the transport. The three modes of transport in action are shown in figure 10.

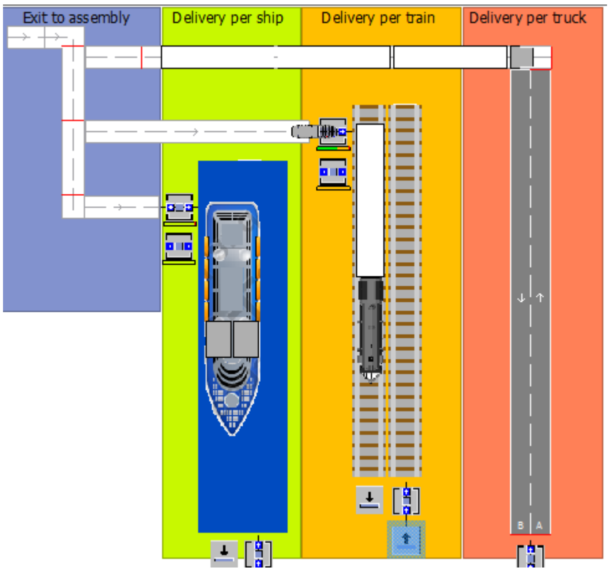

Figure 10: The goods department in Plant Simulation

As displayed, the visualization is an important factor, since it increases the learning effectiveness by maintaining the learner's attention and the imprinting process of the simulated contents (Ewleszyn 2011). The graphic elements and diagrams can be disabled in the users interface to increase the speed of the simulation run if needed.

5. RESULTS

The models functionality was tested by using 20 sets of different random number streams for every of the three learning scenarios. It appears that the results between every run differ but all go into the same direction. For example, production stops will income in every run but their timing depends on the moment of certain deliveries and the production program of the assembly. With fixing the "broken" parameters these production stops disappear which reveals the concept of cause and effect inside the implemented processes.

This enables users to gain knowledge about the underlying logistic processes, understanding of the elements' interdependencies and experience about characteristic problems of their working environment.

The verification of the model was done by using the methods of sensitivity analysis, monitoring certain situations within simulation runs and the internal validity which was already proven with the interdependencies between parameters and results.

Another goal of this work was to meet the theoretical requirements for effective self-directed learning. These goals were met by using simulation as the training method and dialogue boxes to "interact" with the user.

For further prospects, the learning environment should be tested by employees within the automotive logistics. That was not part of this work, but is essential regarding the acceptance of a simulation based learning program. In addition to that a web or browser-based approach needs to be evolved, like running the simulation model inside the browser to further decrease possible reservations towards the simulation software.

REFERENCES

Arnold, D., 2006. Intralogistik – Potentiale, Perspektiven, Prognosen. Springer Verlag Berlin Heidelberg, p.84

Ewleszyn, M., 2011. Auswirkungen von Medien auf Schulleistungen am Beispiel von Bildschirmmedien. In: R. Arnold. Pädagogische Materialien: Hochschulschriften. 12th ed., p.19

Klug, F., 2010. Logistikmanagement in der Automobilindustrie – Grundlagen der Logistik im Automobilbau. Springer Verlag Berlin Heidelberg, 183-204

Knowles, M., Holton III, E., Swanson, R., 2005. The Adult Learner. Elsevier Butterworth-Heinemann, San Diego, 7th ed., 4, 61-69

Laffert, J., 2000. Informations- und Materialflüsse in internationalen Logistiksystemen der Volkswagen AG. Kassel University Press GmbH, Kassel, 41-48

Mayer, G., Pöge, C., 2010. Auf dem Weg zum Standard – Von der Idee zur Umsetzung des VDA Automotive Bausteinkastens. In: G. Zülch, P. Stock. Integrationsaspekte der Simulation: Technik, Organisation und Personal. KIT Scientific Publishing, Karlsruhe, p.29

Mustafee, N., Katsaliaki, K., 2010. The Blood Supply Game. Proceedings of the Winter Simulation Conference, 327-338

Passiment, M., Sacks, H., Huang, G., 2011. Medical Simulation in Medical Education – Results of an AAMC Survey. Association of American Model Colleges, p.1

Siddiqui, A., Khan, M., Akhtar, S., 2008. Supply Chain Simulator: A scenario-based educational tool to enhance student learning. Department of Systems Engineering, King Fahd University of Petroleum and Minerals, Dhahran, 252-261

Staemmler, M., 2005. Lernstile und interaktive Lernprogramme. Deutscher Universitäts-Verlag, GWV Fachverlage GmbH, Wiesbaden, 1st ed., p.51

Witt, C., Ganguin, S., Kuszpa, M., Mengel, S., 2011. Mobile Learning in the process of work: Participation, knowledge and experience for professional development. In: N. Pachler, C. Pimmer, J. Seipold. Work-Based Mobile Learning – Concepts and Cases. Peter Lang AG, International Academic Publishers, Bern, 152-154

Ziltener, A., 2005. Gestaltung mediengestützter Lernumgebungen. Hochschule für Wirtschafts- Rechts- und Sozialwissenschaften St. Gallen, 18-24