

## **MOTIVATION OF STUDENTS FOR FURTHER EDUCATION IN SIMULATION BY AN APPLIED EXAMPLE IN A RELATED OTHER COURSE IN ENGINEERING EDUCATION – A CASE STUDY**

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### **ABSTRACT**

The present paper explains, how a simulation-based study course raised significant interest in discrete-event simulation, finally undergoing a simulation focused course. The simulation based course during the course “Production structures and design” used a model for own studies, acting as a test-bed for optimal setup-time optimization. An easy access to simulation technology was provided by an Excel-based front end, where any figures related to the model were available for student’s analysis. Nevertheless the students started to act on their own with the Enterprise Dynamics based simulation model, discovering the benefits of simulation. High-quality elaborations of the students were finally achieved, going far beyond of just answering the related questions. In addition, due to the part-time study program, interest in the company’s approach on production planning raised. Subsequently the demand for further dedicated courses in computer simulation raised and were finally addressed.

### **1 INTRODUCTION**

The University of Applied Sciences Technikum Vienna is committed to continuously improving the quality of its courses. This task has been particularly addressed by the German speaking DicFo Forum (Forum Didactics in Universities) platform (Lehner 2008). All lecturers are encouraged to investigate the pool of different teaching methods that this web-based platform contains, as well as to interactively add new methods to that particular source/base of knowledge.

In particular, the course “Production structures and design”, consisting of three hours per week attendance and one hour per week of distance learning, was newly set up. The course is included in the part-time masters study program “International Business Engineer”, at the university. A part of the students continued studying after finishing the previous bachelors program and a smaller part entered the course from different other subject areas. This raised the problem of different knowledge bases, heterogeneous professional backgrounds and various industrial domains.

At the beginning of the course, the different backgrounds and histories were addressed in order to achieve an encouraging and sustainable quality of learning (Thomschitz 2002).

### **2 THE BASIC COURSE CONCEPT**

#### **2.1 Application of Simulation for Education in General**

Simulation in education as a simulation based course as well as a simulation-focused course (Page and Kreuzer 2006) is a well-known and widely documented topic. With regard to pilot or military training, simulation is an indispensable method for achieving high level skills necessary to the future profession. This is especially relevant due to the fact that in the English-speaking area, the borderline between simulation and gaming is continuously diminishing (Macedonia 2002, Arango et al. 2008).

Essential training in discrete event simulation is also supplemented by various additional materials. Referring to (Schriber 1991), the book included additional copy templates for transparencies, and later issues (Law and Kelton 2000, Page and Kreuzer 2005, Kelton 2006, Rossetti 2008) have already provided digital presentation support for teaching the topic as well as self-study on the corresponding websites.

A survey in applied simulation packages for embedding simulation models in an e-learning course available via <http://elearningtech.pbwiki.com/ToolSatisfaction> showed that none of the dedicated simulation packages, neither in continuous nor in discrete-event simulation, was mentioned at all or had more than three responses. Instead, visualization packages, dedicated animation software or problem-specific programs are used to provide knowledge interactively. On the other hand, a lot of resources deal with simulation in e-learning available via <http://www.e-learningcentre.co.uk/eclipse/Resources/simulation.htm>. Furthermore, according to the authors own experience, these packages limit or even block the chance for students to get acquainted with simulation technology. Because of this, the tools create the threat of losing any connection between the models and the real targeted application. Additional analysis was done on this in (Ip, Jacobs and Watkins 2008).

## 2.2 The Concept

The first steps in simulation-based learning were already done in the 1960s, providing the BeerGame developed by the MIT (Duijts 2001), and addressing supply chain management. There, one needs to distinguish between simulation models and interactive gaming approaches (Klug and Mayer 2000, Sihn 2008).

For this course, the topic of optimal setup-time production planning was targeted which provided the students with a dedicated simulation-based problem specific task (see also Steinrücke 2007). The task itself was divided into two parts, a preparation and a specific, more complex simulation part. The preparation part was initially intended to limit the problems of using the simulation package itself and to provide appropriate knowledge for solving the second task.

The simulation-based environment was a test-bed where students were able to achieve results easily and quickly.

## 3 THE MODEL ENVIRONMENT

### 3.1 The IT-Environment

The whole environment was developed using Enterprise Dynamics 7.2 and its standard library, with minor modifications as well as Microsoft Excel using DDE as a common interface between both programs. Enterprise Dynamics 7.2 also provides a student's license free of charge, limiting the number of model items to a maximum of 30. Due to the fact that the model didn't exceed this limit, students used the environment mostly at home.

Apart from achieving the appropriate solution, it was observed that the 3D animation that comes with Enterprise Dynamics clearly raised the interest in the package. This observation was comparable to the results in (Kindley 2002). Therefore, the motivation for using the package on ones own significantly increased.

### 3.2 The Simulation Model

The simulation model consisted of the model itself, and the external parameterization, based on multiple Excel spreadsheets.

The selected unit of time was hours. The simulation model itself was built using standard components from the Enterprise Dynamics library, configured for that particular purpose. Figure 1 shows the 2D model:

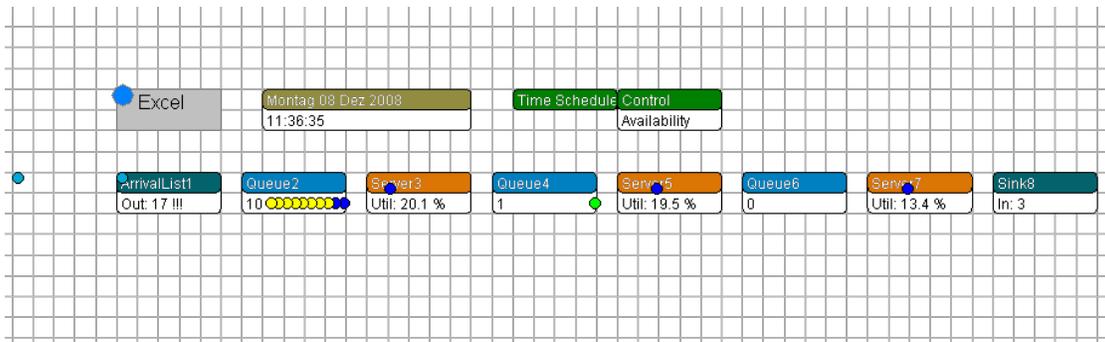


Figure 1: 2D model

The different types of products were displayed as different circles, in which every color represented a particular type of product.

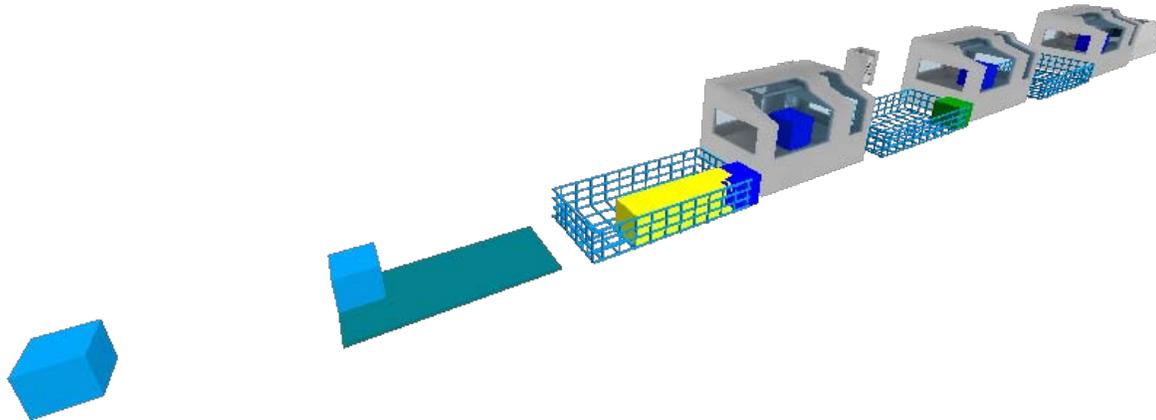


Figure 2: 3D model

This design was chosen to provide a quick and complete understanding of the particular situation and the problem. There was no demand for huge and complex specifications or any other sophisticated approach to explain the system. Restrictions to the system (40 hours per week production time, no overtime and definite sequence) were clearly communicated and gave the students a clear picture.

### 3.3 The Excel Data File

In addition , an Excel file was prepared, showing all relevant data to the students. These relevant data were:

- Processing time of product types on every server

	A	B	C	D	E
1	Produkt-nummer	Produkt-bezeichnung	Bearbeitungszeit Server 1 (h)	Bearbeitungszeit Server 2 (h)	Bearbeitungszeit Server 3 (h)
2	0	kein Vorprodukt	0	0	0
3	1	Produkt A	3	4	2
4	2	Produkt B	5	2	4
5	3	Produkt C	4	7	6
6	4	Produkt D	6	7	6
7	5	Produkt E	8	5	4

Figure 3: Production times

- Setup times:

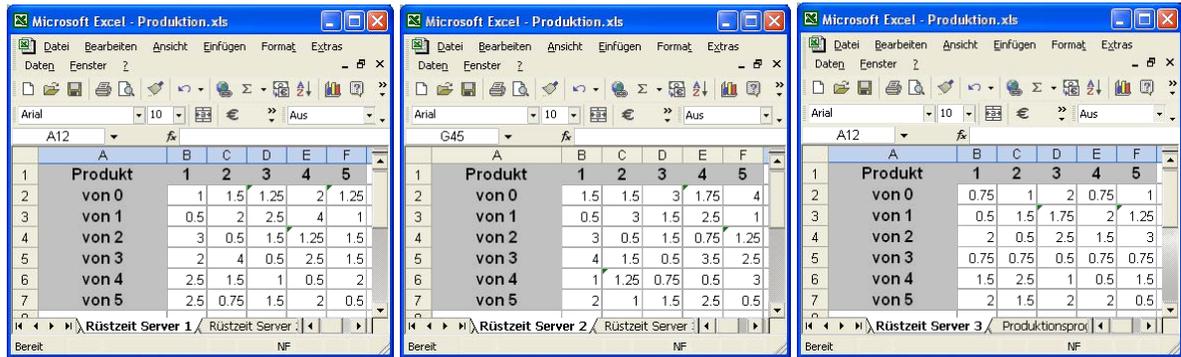


Figure 4: Setup times

These setup times were different for every server and dependent on the product sequence.

- The production program, containing individual students specific programs:

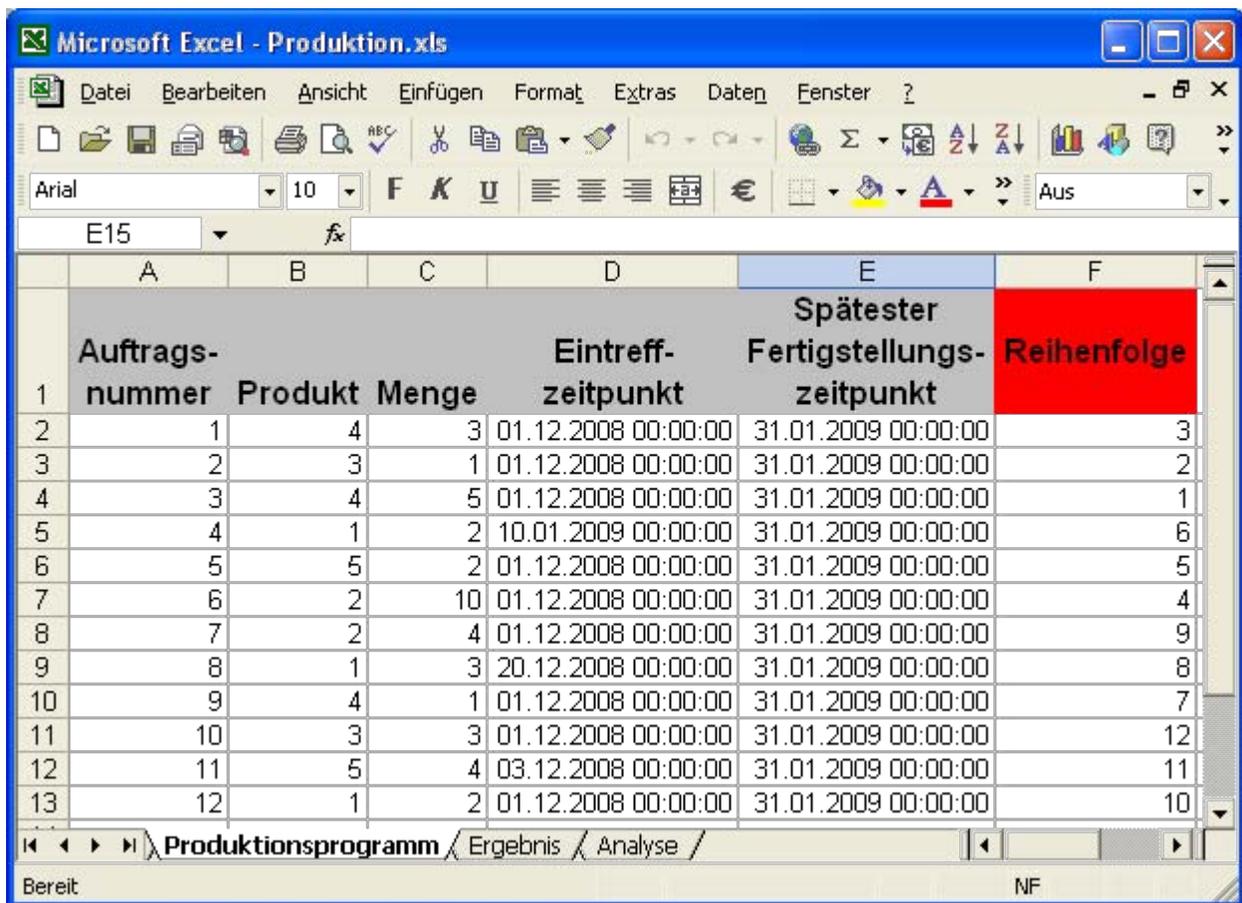


Figure 5: Production Program

In the red column “Reihenfolge” (eng.: sequence), different production sequences were to be entered and calculated through the simulation environment, providing results in the result windows (“Ergebnis”).

Due to the fact that the system asked the user which column to fill in with the parameterized sequence and the results, a complete protocol of all simulation experiments was done. This approach was easier to achieve compared to the Enterprise Dynamics internal experiment Analyzer and was designed to improve the production program step-by step, encouraging the students to develop a plan for tests, analyze the results and to continue further.

Students were given individual product sequences, but setup times and processing times remained common for all of them. It was thus possible to perform teamwork as well as individual work in solving this task. Due to the fact that none to the students had experience with simulation up to this point, a certain restricted feeling emerged. Predicting problems with the programs as with any new software, students were given three months for solving the two tasks and for compiling a maximum 6 page report.

### **3.4 The Tasks**

For every student, an individual production program was provided in two files. Every production program contained 12 orders and a total amount of 40 products.

For the first task, two months were given for producing all 40 products in total. This covered a lot more time than needed; therefore the only focus was set on minimizing the setup times. This problem was analytically solvable, which nearly all students discovered.

The first task was designed in preparation of the second task, where three lots of four orders per lot had to be finished within two weeks. In particular for the first four orders, the first two weeks were set as production duration, weeks 2 and 3 (overlapping with the first four) for the next four orders and finally weeks three and four for the production of the last four orders.. This provided a total time of four weeks, which was definitely not sufficient for keeping the timelines.

As a further restriction to the second task, students were asked to minimize the delay times in case orders were finished after the last planned finishing time. This was set as higher priority to minimize the total setup time.

### **3.5 Problems to be Faced**

The entire environment was installed and tested within the IT-infrastructure of the university's campus. The possibility of using the environment at home caused some additional minor disturbances, all them solvable.

## **4 RESULTS OF THE ELABORATIONS**

Citing General George S. Patton "Don't tell people how to do things. Tell them what to do and let them surprise you with their results." the results exceeded by far the initial expectations of the teacher; namely, that students focused only on the task, without taking any other information into account. Instead, students started to investigate the differences between optimal order sequence according to total through time vs. optimal order sequence according to total setup time. Even if not requested, some investigated literature and scripts from earlier courses, stating, why those optimization approaches could not be applied to this particular example. Students were also surprised to learn that such a simple looking example included such a high amount of complexity.

Task 1 was solved analytically, and achieved by nearly all of them (> 95%).

In task 2, students achieved a reduction of production delays by up to 27.83%.

Even if the maximum number of pages was limited to six, students exceeded the required number of pages; Due to the high value personal learning content of the exercises, they were further encouraged to communicate. Having been impressed by the possibilities of testing various order sequences with simulation, they requested additional information and feedback.

Summing up, the students demanded more lectures and information about simulation and its capabilities in the next two semesters. Lectures were adapted to address these demands, focusing on Enterprise Dynamics as well as on Arena, a simulation package some of them had become acquainted with in their bachelor program.

### **4.1 Further Feedback And Statements Of The Students**

Some citations of the reports (translated to English):

Martin Horvath, BSc (class president):

"Despite my skepticism at the beginning concerning the simulation program, after several tests and logical approaches, the package was easy to use and understand. The given tasks were challenging, but never overtaxed the participants. By performing the tasks of the distance-learning part, I was able to learn the program and developed my first own logical approach-

es to problems in production planning. For the future, it is clear that a mix of different kinds of approaches for solving a problem is better, than focusing on only one parameter.”

Thomas Alexander Löwy, BSc:

“Finally it shall be mentioned that the simulation package “Enterprise Dynamics” is a well designed and helpful tool for simulating production processes. Due to the fact that it contains a vast amount of functionality, which the author of this report can only roughly estimate, it is expected to be capable of solving highly complex problems. Therefore, it is desirable to have further courses to learn additional functionalities and possibilities of Enterprise Dynamics”

Further selected student statements:

- “I re installed the whole package twice because I couldn’t believe that optimal total throughput time and optimal set-up time are not the same!”
- “On Monday, I will definitely have a look into the production department of my company, because now I want to know how everything works there.”
- “Can we have more information about simulation, please?”

It was regarded as a very interesting example and resulted in the wish for further simulation-based lectures. Therefore also other lectures such as marketing and the like started to set up simulation based management games, communicating the basics of marketing on a new level of quality.

The whole lecture was evaluated and received top grades (see Figure 6). Impressive 3D animated simulation models are now an anchor for Open House days to promote the whole study program.

Lehrveranstaltungsfeedback						
Name der LV	Produktionsstrukturen und -design					
LV Leiter	DI Klug					
Studiengang	MIWI 1					
<b>1 Durchführung</b>		trifft zu	trifft fast zu	trifft fast nicht	trifft nicht	Total
Information über Ziele, Inhalte und Methoden	26	2	0	0	28	
Struktur der LV	23	5	0	0	28	
		richtig	zu groß	gering		
Stoffmenge	25	2	0		27	
<b>1 Durchführung forts.</b>		trifft zu	trifft fast zu	trifft fast nicht	trifft nicht	
Unterstützung der Arbeitsmaterialien	19	9	0	0	28	
Möglichkeit zu Übung, Diskussion, Projekt	25	3	0	0	28	
Praxisbezug	25	3	0	0	28	
<b>2 Lehrbeauftragter</b>						
angenehmes Lernklima	27	1	0	0	28	
Interessante, anregende LV	23	5	0	0	28	
<b>3 Teilnehmer</b>						
Aktive Beteiligung, Fragen	21	7	0	0	28	
<b>2 Gesamteindruck</b>						
Bin mit LV zufrieden	21	7	0	0	28	
	75%	25%	0%	0%		
<b>Total</b>	210	42	0		252	
	83%	17%	0%	0%		

Figure 6: Course Evaluation

## 5 OUTLOOK AND NEXT STEPS

To teach simulation to students in the next semester, the next course will be divided into two parts. On one hand, a distance-learning course, based on the open source e-learning platform Moodle, available via <http://moodle.org/>, will be set up according to individual demands in order to become acquainted with Enterprise Dynamics or Arena, as well as an on-site training, emphasizing data analysis, stochastic and basic process modeling with UML.

The Moodle part will be set up with all necessary components such as discussion forums, glossary, tests, wiki, timetables and chat rooms, to achieving optimal support that is necessary for any e-learning course.

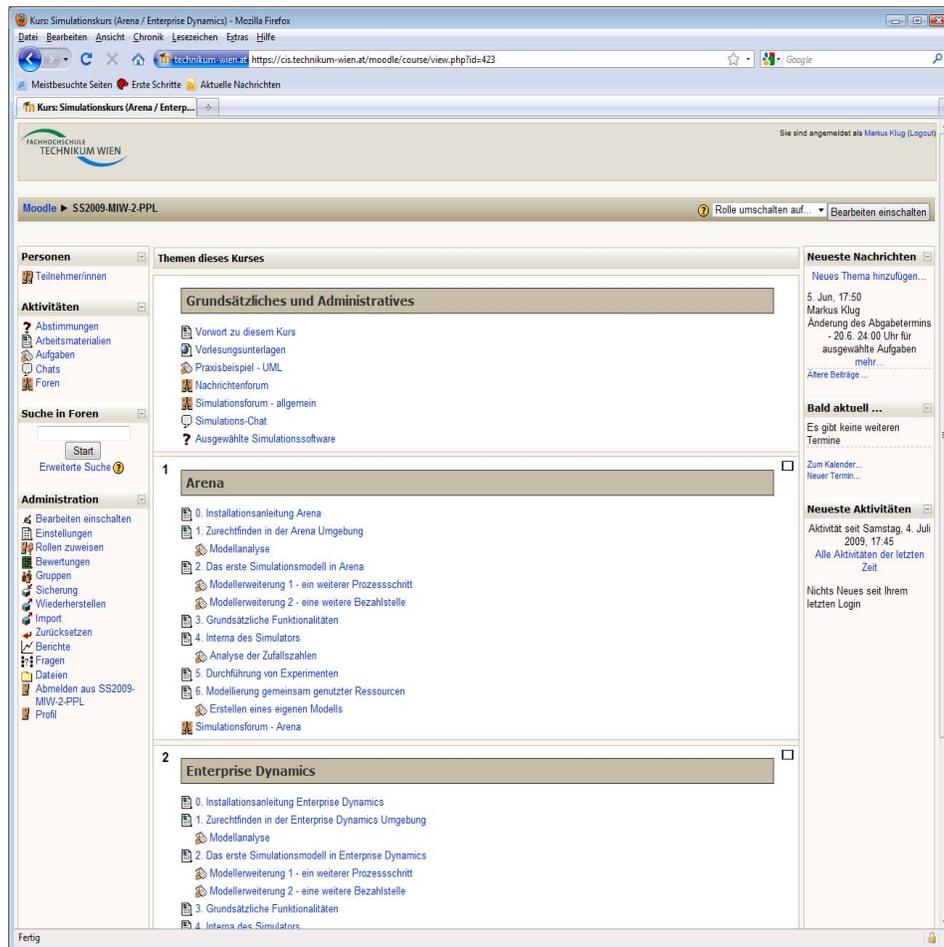


Figure 7: The draft Moodle course (in German)

A next step includes planning to start programming, as none of the students have programming experience. The goal and challenge will be to get them thinking in programming structures.

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