Modeling and Computer Simulation

Modeling and Computer Simulation

19/04 - 21/04 (FON) 26/04 - 28/04 (UNIVAQ) 03/05 - 06/05 (UNIZA)

Planned ECTS: 2

Number of learners: 25

Mode of delivery: Online

Status: COMPLETED

Course public access: Public

Contributors:
Igor Balaban, Nikola Zornić, Peter Márton, Vittorio Cortellessa

Course learning outcome	Level	Weight
Students are able to identify problems in system that can be solved using modeling and computer simulation.	Applying	1
Students are able to formulate simulation experiments.	Creating	1
Students are able to compare simulation experiments and conduct sensitivity analysis.	Understanding	1
Students are able to evaluate results of the simulation in order to improve the system.	Analysing	1
Students are able to identify model input parameters from the observation of the system.	Applying	1
		Total weight: 5

Topic / Unit name	Workload	Learning type	Mode of delivery	Groups	Collaboration	Feedback	Mandatory activity	Assessment		
								Points	Type	Providers

Introduction to Modeling and Computer Simulation

Introduction to Modeling and Computer Simulation

Introduction to Modeling and Computer Simulation Definitions: system, model, simulation. Why do we need MCS, advantages and disadvantages. Types of models and simulation.	60 min	Acquisition	Online	Synchronous	Teacher present	No	No	No	No	No			
Total unit workload	1h												
System dynamics													
Introduction to system thinking, modeling system structure, causal loops													
Introduction	45 min	Acquisition	Online	Synchronous	Teacher present	No	No	No	No	No			
System dynamics model building	135 min	Discussion	Online	Synchronous	Teacher present	No	Yes	No	No	No			
System Dynamics preparation for theoretical assessment	180 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No			
System dynamics theoretical assessment	45 min	Assessment	Online	Synchronous	Teacher present	No	No	Teacher	No	15	Summative	Teacher	
Total unit workload	6.75h												
System dynamics tools: causal loop diagrams and stock and flow diagrams													
CLD examples	45 min	Practice	Online	Synchronous	Teacher present	No	Yes	No	No	No			

CLD practice	135 min	Production	Online	Synchronous	Teacher present	Yes	Yes	Teacher	No	No		
Stock and flow diagrams introduction	45 min	Practice	Online	Synchronous	Teacher present	No	Yes	No	No	No		
Stock and flow diagrams practice	135 min	Production	Online	Synchronous	Teacher present	Yes	Yes	Teacher	No	No		
System dynamics tools preparation for practical assessment	240 min	Practice	Online	Asynchronous	Teacher not present	No	No	No	No	No		
System dynamics tools practical assessment	60 min	Assessment	Online	Synchronous	Teacher present	No	No	Teacher	No	20	Summative	Teacher
Total unit workload	11h											

Queueing-based software/hardware modeling

Queueing Theory - Example modeling and solution in the software/hardware domain

Introduction to queueing theory Basic concepts: service center, queue, scheduling policies, routing. Performance analysis: Input parameters (workload, service rate), Output indices (response time, throughput, utilization).	60 min	Acquisition	Online	Synchronous	Teacher present	No	No	No	No	No		

Preparation for software/hardware context modeling Investigation of approaches for modeling software/hardware systems in their standard lifecycle.	120 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Queueing Networks in the context of Software/Hardware Providing semantics to QN in the context of SW/HW systems: service centres as platform devices, jobs as resource requests originated by users while executing the software.	60 min	Discussion	Online	Synchronous	Teacher present	No	No	No	No	No
Operational laws and bottleneck identification Utilization law, Little's law, Forced flow law. Bottleneck identification and possible removal actions.	90 min	Acquisition	Online	Synchronous	Teacher present	No	No	No	No	No

Laboratory on QN solver A Queueing Network solver will be used in collaboration with students to solve a driving example. A special emphasis will be given to the interpretation of results (e.g., sensitivity and "what-if" analyses).	180 min	Practice	Online	Synchronous	Teacher present	No	No	No	No	No
Queueing Network practice One or more case studies will be provided to students, with the goal of building and solving QN models.	90 min	Assessment	Online	Synchronous	Teacher present	No	No	No	No	No
Total unit workload	10h									

Process oriented simulation

Introduction to process oriented simulation

Basic system analysis - system components Introduction - definition of system - components - customers and resources and their attributes - example	30 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No
Basic activities - customer arrival, customer departure, waiting for free resource, delay (service) Introduction - definition of system - components - customers and resources and their attributes - example	45 min	Discussion	Hybrid	Synchronous	Teacher present	No	No	No	No	No
Introduction to simulation software AnyLogic AnyLogic environment - Example of simple simulation model	30 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Simple service system model - museum - selling of tickets The teacher describes the museum and the first subsystem - selling tickets. It is a simple process - the customer arrives, he/she wants to buy the ticket, he/she is waiting in a queue if necessary, the customer leaves the subsystem. The teacher discusses with students basic activities in this system and they prepare mutually the simulation model concept.	45 min	Discussion	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Simple service system model - museum - selling of tickets - AnyLogic The teacher describes the basic blocks of the AnyLogic simulation software - create, queue, delay, sink. The students use the simulation software to create a simulation model.	30 min	Practice	Hybrid	Synchronous	Teacher present	No	Yes	Teacher	No	No
Looking for own system and examples of systems Students are looking for their own systems to develop own model during the course. They are reading and watching different sources - web, TV, journals...	45 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No

Simple service system - own system and model Students select their own system to simulate. Students work in groups. Students use their knowledge and develop their skills.	45 min	Production	Hybrid	Asynchronous	Teacher not present	Yes	Yes	No	No	No
Simple service system - quizz The students answer questions in the quiz. The teacher receives feedback about the real understanding of the subject matter.	30 min	Assessment	Online	Asynchronous	Teacher not present	No	No	No	No	No
Total unit workload	5h									
Modelling of advanced processes										

Advanced process oriented modelling 1 The teacher introduces students to the advanced process oriented modelling - ways and possibilities to create a simulation model that reflects different facts in the modelled systems.	30 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No
Advanced service system model - museum - selling of tickets The teacher describes the museum and the first subsystem - selling of tickets. The teacher gives additional information about this subsystem - priority in waiting for disabled customers, arrival of customers in groups, two employees in the cashdesk	45 min	Discussion	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Advanced service system model - museum - selling of tickets - AnyLogic The teacher describes ways to simulate new facts about the subsystem in the AnyLogic simulation software - new customer, customer class, queue priority, service, resource pool. The students use the simulation software to create a simulation model.	30 min	Practice	Hybrid	Synchronous	Teacher present	No	Yes	Teacher	No	No
Advanced process oriented modelling 2 The teacher introduces students to the advanced process oriented modelling - ways and possibilities to create a simulation model that reflects different facts in the modelled systems.	30 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Advanced service system model - museum - exhibitions The teacher describes the museum and the following subsystems - exhibitions. The teacher gives additional information about these subsystems - turnstiles, selecting from more possibilities for customer service, creating of customer groups for a guided exhibition, new resources - guides	45 min	Discussion	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Advanced service system model - museum - exhibitions - AnyLogic The teacher describes ways to simulate new facts about the subsystem in the AnyLogic simulation software - selecting from options in the service, different ways to model customer service, creating customer groups (batches). The students use the simulation software to create a simulation model.	30 min	Practice	Hybrid	Synchronous	Teacher present	No	Yes	Teacher	No	No
Advanced service system 1 - own system and model Students select their own system to simulate. Students work in groups. Students use their knowledge and develop their skills.	45 min	Production	Hybrid	Asynchronous	Teacher not present	Yes	Yes	No	No	No

Advanced process oriented modelling 3 The teacher introduces students to the advanced process oriented modelling - ways and possibilities to create a simulation model that reflects different facts in the modelled systems.	30 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No
Advanced service system model - museum - breaks and interruptions in services The teacher describes the museum and the following subsystems - exhibitions. The teacher gives additional information about these subsystems - planned and unplanned breaks and interruptions in services (lunch break, failure, ...)	45 min	Discussion	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Advanced service system model - museum - breaks and interruptions in services - AnyLogic The teacher describes ways to simulate new facts about the subsystem in the AnyLogic simulation software - planned and unplanned breaks and interruptions in services (lunch break, failure, ...). The students use the simulation software to create a simulation model.	30 min	Practice	Hybrid	Synchronous	Teacher present	No	Yes	Teacher	No	No
Advanced service system 2 - own system and model Students select their own system to simulate. Students work in groups. Students use their knowledge and develop their skills.	45 min	Production	Hybrid	Asynchronous	Teacher not present	Yes	Yes	No	No	No

Advanced service system - quizz The students answer questions in the quiz. The teacher receives feedback about the real understanding of the subject matter.	15 min	Assessment	Online	Asynchronous	Teacher not present	No	No	No	No	No
Total unit workload	7h									
Animation in the simulation model										
Animation - introduction The students are watching videos about animation and its importance in the simulation model.	30 min	Acquisition	Online	Asynchronous	Teacher not present	No	No	No	No	No
Animation - museum The teacher describes how animation could be used for the museum simulation model. Students discuss the possible ways and requirements.	45 min	Discussion	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Animation - museum - AnyLogic The teacher describes ways to create animation in the AnyLogic simulation software. The students try to develop the possible application of different animation features.	30 min	Practice	Hybrid	Synchronous	Teacher present	No	Yes	Teacher	No	No
Animation in different simulation tools Students are discovering different simulation tools and what animation environments they offer.	45 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Animation - own system and model Students create own animation. Students work in groups. Students use their knowledge and develop their skills.	45 min	Production	Hybrid	Asynchronous	Teacher not present	Yes	Yes	No	No	No
Total unit workload	3.25h									

Statistical evaluation of output data, Experiments										
How to evaluate simulation outputs - what type of results are required by customers? Students are looking for a definition of simulation outputs. They are reading different final reports of simulation studies from open access libraries.	30 min	Investigation	Online	Asynchronous	Teacher not present	No	No	No	No	No
Recording of simulation outputs - introduction The teacher introduces theory related to simulation output recording.	30 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Simulation results - museum - AnyLogic The teacher describes ways to record simulation outputs in the AnyLogic simulation software. The students try to use possible applications of different statistical tools.	30 min	Practice	Hybrid	Synchronous	Teacher present	No	Yes	Teacher	No	No
Simulation results - own system and model Students create their own statistics in their simulation models. Students work in groups. Students use their knowledge and develop their skills.	45 min	Production	Hybrid	Asynchronous	Teacher not present	Yes	Yes	No	No	No
Experiments - introduction The teacher introduces theory related to experiments and their evaluation.	30 min	Acquisition	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Experiments - museum - AnyLogic The teacher describes ways to define experiments in the AnyLogic simulation software. The students try to develop applications of different statistical tools.	30 min	Practice	Hybrid	Synchronous	Teacher present	No	Yes	Teacher	No	No
Experiments - own system and model Students define and execute their own experiments with their simulation models. Students work in groups. Students use their knowledge and develop their skills.	45 min	Production	Hybrid	Asynchronous	Teacher not present	Yes	Yes	No	No	No
Interpretation of simulation outputs The teacher introduces experience and knowledge related to simulation output interpretation from real simulation studies.	30 min	Discussion	Hybrid	Synchronous	Teacher present	No	No	No	No	No

Simulation results - quizz The students answer questions in the quiz. The teacher receives feedback about the real understanding of the subject matter.	15 min	Assessment	Online	Asynchronous	Teacher not present	No	No	No	No	No
Total unit workload	4.75h									
Total course workload	**48.75h**									