INTRODUCTION TO SYSTEM DYNAMICS PRINCIPLES (8 ECTS)

1. Course Description

The course aims at providing students with a complete knowledge of the principles and steps for modeling dynamic problems, with a particular focus on complicated dynamics, which can lead to misperceptions and mismanagement. The preferred paradigm is the system dynamics modeling process.

2. Learning Outcomes

Knowledge and understanding

Students develop proficiency in the application of theories, methods, techniques, and computer-based tools to deal with complex dynamic problems.

They develop an intuitive understanding of the behavior arising from the underlying structure of feedback loops, stocks and flows, delays and nonlinearities which shape the system under investigation.

In their learning process, students represent the cause-and-effect structure of the system, they derive the dynamics of the system by simulation, and they develop skills in designing effective policies in accordance with the structure-behavior relationships investigated.

The understanding of the behavior of the system over time is achieved by computer-based tools for modeling, simulation and analysis.

Applying knowledge and understanding

Students receive training into the practice of the system dynamics modeling, from problem formulation to policy design, within a variety of disciplines and across disciplines.

Examples from practical situations are used in every lecture with a particular emphasis on public management topics.

Making judgments

At the end of the course, students are able to describe and explain in detail the dynamics of a problem, to formulate hypotheses about its behavior, to build a model that reproduces the structure-behavior relationships investigated, and to make a judgment about the reliability and usefulness of the model.

Communication

Students are encouraged to actively participate in class. They present and discuss the results of their case studies in class and to interested academics.

To a large extent tools for modeling and analysis are also used for communication. The graphical stock and flow structure and the causal loop diagrams are indeed seen as tools for effective communication at an intermediate level between imprecise narratives and formal simulation models.

Learning skills

Facing challenging management tasks, students understand the need for simplification.

Modeling does not take place in isolation and, therefore, students also develop skills encouraging collaboration and team working.

Finally, students deepen their understanding of the structural causes of dynamic behavior and hone their skills with system dynamics software tools.

3. Course Content

The course is structured primarily around the following topics:

a) The modeling process

- The purpose of modeling
- The client and the modeler
- Steps of the modeling process
- Problem articulation: The importance of the purpose
- Formulating a dynamic hypothesis
- Formulating a simulation model
- Testing, policy design and evaluation

b) Tools for systems thinking and simulation modeling:

- The concept of feedback
- Modeling feedback with causal loop diagrams (CLDs)
- Simple structures (positive loop, negative loop, coupled loops, loop polarity and shifts in loop dominance)
- Stocks and flows
- The right level of aggregation
- Model formulation (rate equations, auxiliary equations, table functions, levels, delays)
- Interactions of the fundamental modes of dynamic behavior (S-shaped growth, S-shaped growth with overshoot, overshoot and collapse, stasis or equilibrium, randomness, chaos)
- Understanding of the model behavior
- Policy analysis

c) Examples of effective use of system dynamics modeling in the real world: Case studies

- Epidemics, innovation diffusion, and the growth of new products (the SIR model and the Bass diffusion model)
- Urban planning and social welfare
- Tourism management
- Solid waste and public health management

4. Course Design

The course is comprised of lectures, seminars, group discussions, students' presentations, modeling sessions and individual assignments/papers. An overall attendance rate of 80% in scheduled sessions is required, and attendance is mandatory in the group discussions, students' presentations, and seminars, and active participation is required in those sessions.

5. Student's Evaluation

Assessment is carried out by means of evaluation of individual and group assignments. For a passing grade the student must (a) have pass marks on all the assignments; (b) have participated in the mandatory sessions; (c) have an adequate overall attendance rate. In addition, the grade is based on a project report and its presentation.

An ECTS grade is provided to the student at the end of the course according to the A—F scale. Students not successfully fulfilling all the course requirements within the regular time frame have the option of a re-sit the following semester.