Program Review Report (Programsensorrapport) 2018:

Master's Degree in System Dynamics (Systemdynamik)
Department of Geography

External examiner: Hans Björnsson, Chalmers, Gothenburg, Sweden

Date: January 30, 2019

Contents

1. Role of the examiner and the examination process

As an external examiner of the System Dynamics Program at the University of Bergen I understand that my main duties are:

- to report on the structure, content, academic standards and teaching of program, including the availability of adequate resources;
- to evaluate all forms of assessment which contribute to students' degree results;
- to evaluate, and help ensure fairness and consistency in, the assessment process;
- to comment on quality and quality improvement measures;
- to provide my recommendations to the faculty as well as the academic leadership;

My examination as reported in this document was carried out in the context of my expertise and knowledge of the academic standards of other comparable programs, and of key internal and external reference points.

My examination has been carried out

- through studying documents describing the program aims; the intended learning outcomes, curriculum, and teaching and assessment strategies of the program and modules; and the link between particular modules and the program as a whole, budget and workload documents, and
- by visiting the university to interview faculty and students; this visit took place January 18, 2019

2. About System Dynamics education, research and applications

System Dynamics is a computer-aided approach to policy analysis and design. It applies to dynamic problems arising in complex social, managerial, economic, or ecological systems - literally any dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality. Organizations such as OECD, UN, and WHO now call for systems thinking to tackle increasingly complicated and comprehensive problems.

System dynamics is a "paradigm" and methodology for understanding and changing the behavior of systems. It is used by governments and corporations to formulate and analyze policies. The fast economic and technological development, together with the global nature of most issues, has made System Dynamics and "System Thinking" more important than ever.

System dynamics courses are taught at a number of universities throughout the world. However, only a small number of institutions offer graduate degree programs with substantial training in system dynamics. In most cases, the system dynamics curriculum is part of a larger curriculum in a school of, for example, Business or Public Policy, and the primary means of educational delivery beyond a few introductory courses is research mentorship with individual system dynamics faculty. In a few cases, the system dynamics curriculum is part of a larger "system sciences" program that covers a wide variety of different modeling approaches. The System Dynamics program in Bergen is one of the few programs in the world that offer substantial coursework and a graduate degree in System Dynamics. It is internationally unique in its comprehensive coverage of the field. The program at the University of Bergen is commonly considered to share the top position with M.I.T. in the U.S.A.

3. System Dynamics education in Bergen

The System Dynamics program is under the realm of the Department of Geography. Two master's programs and a PhD program are offered:

- The master's program in System Dynamics is a two-year program that results in a Master of Philosophy in System Dynamics,
- The Joint European Master's program in System Dynamics is a two-year program that is a cooperation with three European universities; University of Radboud in the Netherlands, University of Palermo in Italy, and the University of Lisbon in Portugal. The program has been sponsored by EU that has offered stipends to students from the whole world. A new Erasmus Mundus application will be submitted February 15, 2019.

International diversity has been a hallmark of the Bergen program; each year, students come from many countries and 98% of the degrees have been awarded to students from outside of Norway. Student projects commonly are based on problems in developing countries, emerging economies, as well as in developed countries. Consequently, online courses and other activities are increasingly developed and used as part of the teaching. Whatever the delivery mode, the goal is the same: to educate future planners and managers so they will be able to:

i. use computer-based modeling, simulation and visualization in the identification and analysis of complex, dynamic problems that span social sectors and scientific disciplines;
ii. identify solutions to such problems in the form of strategy development, policy design, and decision making; and
iii. help stakeholders understand relationships between the structure and dynamics of social systems. This computer-based modeling approach utilizes a systems thinking perspective and, in turn, enhances that perspective. The synergistic value emerges from the iterative process of thinking systemically about the world around us, formulating equations to specify our thoughts, observing simulation results, analyzing a model's structure in light of its behavior, and then refining that computer model *and our mental model* to reflect new insights and their policy implications.
iv. Transfer knowledge that explains dynamic complexity by way of web-based interactive learning environments.

4. Program structure

The master's program consists of course work, project work, and a final master thesis. There is no undergraduate program and students are recruited from a multitude of disciplines which makes the graduate programs truly interdisciplinary. During each of the first three semesters the students have to take three courses, each course worth 10 study units. In addition, special topic courses are offered each semester. In general courses include projects that require one or a series of independent modeling project. The finals semester is for thesis work worth 30 study units. The program structure and philosophy are described in an article published by the faculty "Systems Education at Bergen"[1]

[1] *Systems* **2014**, *2*(2), 159-167

a. Courses

First semester (autumn):

SD302 Fundamentals of Dynamic Systems
SD303 Model-Based Analysis and Policy Design
SD304 System Dynamics Modeling Process

Second semester (spring):

SD308 Policy Design and Implementation
SD321 Model-Based Socioeconomic Planning
SD325 Client-Based Modeling
SD322 Special Topics in System Dynamics, Policy
SD323 Special Topics in System Dynamics, Applications
SD324 Special Topics in System Dynamics, Methodology
(One of The last three courses may substitute for a spring course)

Third semester (autumn):

SD309 Model-Based Interactive Learning Environments
SD310 Writing Course and Project Description
SD330 Natural Resource Management

Fourth semester;

SD351 Master Thesis in System Dynamics

b. Delivery methods

The delivery format and assessment of students is summarized in the following table:

SD302	Fundamentals of Dynamic Social Systems	Lectures, Discussions and Projects	Written exam
SD303	Model Based Analysis and Policy Design	Lectures, Case studies, Discussions and Projects	Written exam
SD304	System Dynamics Modeling Process	Lectures, Computer Labs, and Major Project	Assessment of Term Project incl Oral Presentation
SD308	Policy Design and Implementation	Distance Learning Course; Lectures, assignments	Written exam
SD321	Model Based Socioeconomic Planning	Lectures, seminars and Computer Labs	Project Grading
SD325	Client-Based Modeling	Lectures, Seminars, computer Labs	Project Grading

SD309	Model Based Interactive Learning Environments	Lectures and Workshops	Project Grading
SD310	Writing Course and Project Description	Lectures, Seminars, and Assignment	Assignment (Proposal Writing) Grading
SD330	Natural Resource Management	MOOC: Online task, videos, games	Online Exam
SD302	Fundamentals of Dynamic Social Systems	Lectures, Discussions and Projects	Written exam

c. Quality development – course assessments

The courses have been developed and updated over the time. They are designed so that they follow a logical order. It is a very ambitious and demanding program. The course material is extensive and the faculty engagement in the students goes beyond what is common. The master theses that I have studied are very ambitious, and cover real and relevant problems in economics, management, natural resource management, etc.

5. Students and results

The program has been successful in attracting highly qualified students from around the world. Students come, and continue to do so, from many countries around the globe. The interest is steadily growing which will continue to increase the competitiveness of available student slots. Notably however, is the low number of domestic students. There is no natural creation of awareness of the systems thinking/system dynamics field of study. An undergraduate program would help with this. There is a great value in coupling undergraduate education with a robust graduate program. Students who learn about system dynamics as undergraduates are more likely to pursue advanced studies in the subject. The faculty of the program also has the ability to assess the capabilities of such students in depth before accepting them into graduate programs. In the absence of such an undergraduate program, several of the existing social and natural science undergraduate program could include courses in systems thinking and modeling.

The students enter the master programs with various background, but all at least with an undergraduate degree, BSc or similar, in relevant fields. Students with a background in social sciences, including business administration and psychology, as well as natural sciences, including engineering, are eligible for admission.

a. Study Result 2018

Below is a summary of enrolment and results from the courses taught during 2018

Subject	# of Students		Average Grade	Distribution of grades					# of Fail (F)
	Registered	Completed		A	B	C	D	E	
Policy design and implementation	72	29	B	8	11	8	2		
Model-based socio-economic planning	46	30	B	11	8	11			
Client-based modeling	11	10	A	3	7				
Natural resource management	20	16	B	2	8	5	1		

Spring 2018(second semester)

Subject	# of Students		Average Grade	Distribution of grades					# of Fail (F)
	Registered	Completed		A	B	C	D	E	
Fundamentals of dynamic social systems	47	45	C	6	7	18	10	4	
Model-based analysis and policy design	30	26	B	12	10	1	3		
System dynamics modeling process	37	35	B	12	16	5	2		

Fall 2018 (first semester)

Subject	# of Students		Average Grade	Distribution of grades					# of Fail (F)
	Registered	Completed		A	B	C	D	E	
Model-based interactive learning environments	10	9	A	9					
Writing Course	***9***	8	Pass						
Natural resource management	30	25	B	4	15	4	1		
Special topics course	7	7	Pass						

Fall 2018 (third semester)

b. Interviews with students

During my visit to the university I had the opportunity to talk to both first and second-year students of the program, including two visiting students from Ukraine participating in the special Ukraine program organized by the System Dynamics Group.

The students expressed that they were very content with the program. Many of them had received information about the program from the Internet, some others from friends of teachers. The fact that they represented many different scientific domains was very much appreciated. Some of the first-year students expressed that they would like to collaborate more in their major projects and that a little more emphasis could be given to “business problems”. Second-years students meant that these requests are met during the second year. There was a common understanding of the intention and logics of the courses as well of the expected learning outcome that was emphasized in course descriptions and by the faculty themselves. Some suggested changes in the distance learning course, especially how it was scheduled during the semester. All students expressed that they had to work very hard and hardly had a chance to take advantage of weekend for leisure activities. The second-year students were of the opinion that the hard work during the first year was necessary to give them enough knowledge and skills so that they could apply System Dynamics to real world problems of their master theses. Many students looked forward to being able to be engage in larger international projects in which their thesis work could be a part. This possibility was something they had learned from earlier students.

All students were very content with the faculty and expressed admiration for the way they were always accessible when needed and how they were willing to listen to their issues, problems and suggestions.

The students found all examination fair and sometimes a useful learning experience in itself. As for expected future job opportunities, all students were positive.

c. Recruitment of students

Recruitment of new students to the program has to a large extent been depending on web pages, faculty advisors at other universities and mouth-to-mouth reputation. The student body is overwhelmingly international. More domestic students should be recruited that could benefit from the international environment. A way to increase domestic applicants to the program would to introduce System Dynamics in several undergraduate programs at the university.

d. Learning outcome

Objectives of the program as well as expected learning outcomes are well described for all courses

e. Examination Principles

Examinations in the program are through four hour written exams or through assessment of project work, including oral presentation of such work. Exams are rigid and demanding. In the MOOC course there is an online examination.

6. PhD Program

Besides the master level study programs there is a PhD program that, in part, collaborates with the University of Palermo in Italy. The program is very international, and the number of active PhD candidates are 16, all but two foreigners. This means that besides an above average teaching load each faculty also advises at least 5 PhD candidates.

PhD projects fall mostly with the interface between natural and social sciences domain dealing with issues such as energy transition, climate change, land use, ocean- and land-based resources or food. But business issues, development of methods, techniques and tools, and interactive learning environment development and assessments are also topics in some projects.

During 2018 three candidates received their PhD degree.

7. Resources available to the program and the research environment

a. Faculty

The System Dynamics faculty is a research group at the Department of Geography, but is reported as an independent unit in the accounting of teaching work load. The group has three tenured faculty positions. The workload is high, and the group produces much above average course credits (study points) according to budget documents. (178% at master's level and 127% at PhD level on a three-year average basis, and 188% and 446%, respectively, in 2018 alone).

The faculty is carrying a heavy work load and there is an imminent need for a faculty recruitment plan. Two of the three faculty members are at the stage when it is necessary to start to plan for their replacement when they retire

The current work load is probably not sustainable and to remain a leader in the field the University needs to provide the program with additional resources. Faculty in the field do not abound and the competition for most qualified personnel is intense. The work load that currently leaves too limited time for research may render the program less attractive to by young potential faculty that needs to build their CVs by undertaking research and not only spend their time teaching. As a first step, the system dynamics program should be provided base financing. A new faculty position should also be offered and search for its filling should begin. It may take more than a year to find the right candidate for such a position.

b. Faculty research and network

The faculty is engaged in several research projects, all in collaboration with international universities and organizations. This is important because many students may find thesis opportunities associated with such collaborative activities. The group is a partner in two EU Horizon 2020 projects:

- SUREFARM -sustainable farming in Europe (Prof B Kopainsky)
- CO-CREATE -obesity among young Europeans (Prof B Kopainsky & Prof P Davidsen)

Other projects include:

- An EEA project about BIO-economics with Riga Technical University (Prof P Davidsen)
- Project with UNEP (EU financed) "Africa's Co-existence Landscapes: Securing their Future for People, Elephants and other Wildlife" (prof P Davidsen/Prof B Kopainsky)
- ERASMUS+ project in Ukrain (Prof em. D Wheat) and MOOC (Prof E Moxnes/Prof P Davidsen)
- Member of External Advisory Board for 6 research projects in Latvia (prof P Davidsen)

The group's network is very international, and the faculty members are frequently involved in expert assignments at institutions around the world; as expert consultants and research collaborators, as board members of the International System Dynamics Society, and as discussants in PhD examinations. The annual Conference organized by The SD Society will be held in Bergen in 2020. The group is also frequently hosting leading international researchers.

The MOOC developed by the System Dynamics group (Prof E Moxnes) makes use of system dynamics to analyze natural resources management. This MOOC is now used as an integral part of teaching programs at Worcester Polytechnic Institute in Massachusetts in the U.S.A, and at Nijmegen School of Management/Radboud University in the Netherlands, The System Dynamics program at the University of Bergen, and is taken by individuals in UNEP and other students around the world.

The system Dynamics group is working with iseeSystems, U.S.A., the main developer of System Dynamics software ("Stella"), to develop Interactive Learning Environments.

8. New initiatives

Many of the above projects will continue to exist in coming years. There are also some new initiatives:

a. A project proposal "Coastal Ocean Assessment for Sustainability and Transformation" has been sent to Belmont Forum. The project is a collaborative undertaking with the University of Maryland in the U.S.A. and institutes in the Philippines, Japan, and India. (Prof. P Davidsen)
b. A proposal about a Strategic Partnership to be financed by the Erasmus+ program has been submitted together with European partners. The motivation behind the

proposal is the lacking capacity of teaching system dynamics in Europe. The idea is to develop a series of MOOCs that will be offered around the world. (Prof. E Moxnes)

9. Summary and recommendations

The systemic nature of social and economic problems is increasingly evident to observant citizens around the world. Developing international capacity to address such problems is important. The System Dynamics program is a world class program with a reputation that serves University of Bergen well. The university has an opportunity to use the SD faculty to further its ambition of being a leading institution for interdisciplinary education and research. The demand for graduates with competence in systems thinking/system dynamics is growing, as has been expressed by many not least in strategy documents of EU.

The most urgent issue has to do with the faculty that is aging. If recruitment of new faculty is not initiated in the very near future, the whole program is at risk. To sustain the program for the future and to be able to educate more students, the program will need more faculty. To allow students to take classes in system dynamics at the undergraduate level, if such courses are offered, it is important that the various departments at the University of Bergen allow their students to take a minimum of classes outside their own department

In summary

- Unique program with international reputation
- Carefully designed courses with well described objectives and learning outcomes
- Demanding interdisciplinary program
- Enthusiastic students from different countries and disciplines
- Faculty leaders in the field and engaged in the students
- Global network of researchers and research institutions
- Produces people with systems thinking skills much in demand in industry as well as governments
- Many research opportunities

But…

- High workload that may not be sustainable
- Risk of faculty shortage in a couple of years unless new recruitment is started soon
- Would benefit from more domestic students