

Program Review Report (Programsensorrappport) 2019:

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

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The Review Process

As an external program reviewer ("programsensor") 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.

This review report discussing the academic year 2019 is based on my reading various documents, such as course plans, course reading list, exams, student recruitment and retention, and theses, as well as web pages. I have also visited the System Dynamics Group and met with students and faculty.

Several discussions were held with professors Pål Davidsen and Erling Moxnes. I have during the year also had contacts with professor Birgit Kopainsky. Two meetings were held with students, each about 90 minutes. The first meeting involved students in second year of the program and the second meeting involved students from the first study year.

My focus has been on the objectives and learning outcomes, on the structure and content of the course program, and on student numbers and character. But I have also had the opportunity to take part of budget and resources available for the program. Possible and planned new program activities and improvements have also been discussed.

About System Dynamics education, research and applications

Fast economic and technological development, sustainability and climate change problems together with the global nature of most issues, has made a systems approach or holistic view more important than ever. System Dynamics and “System Thinking” are prime tools in such approaches. System dynamics is a “paradigm” and methodology for understanding and changing the behavior of systems.

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. It is used by government as well as private organizations to study consequences of policies and strategies of complex problems. Organizations such as OECD, UN, and WHO now call for systems thinking to tackle increasingly complicated and comprehensive problems.

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 have the top position followed by M.I.T. in the U.S.A. where the area was established about 60 years ago.

The Program

Structure

The System Dynamics program is under the realm of the Department of Geography. A master’s program 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. During the first 3 semesters the students enroll in coursework; three courses each semester worth 10 study credits each. The courses progress in a natural way with one of the third semester courses prepares the students for the master thesis work during the fourth semester.
- A second program, The Joint European Master’s program in System Dynamics ended 2018 but may be started again if it will receive EU funding. It was a two-year program run in 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 was sponsored by EU that has offered stipends to students from the whole world. A new Erasmus Mundus application was submitted in 2019.

- The PhD program has currently 16 students enrolled, a very large number considering that there are only 3 regular faculty in the SD Group.

The character of the Program

There is no undergraduate program and students are recruited from a multitude of disciplines which makes the graduate programs truly interdisciplinary. 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.

Courses

In general courses include projects that require one or a series of independent modeling project. The final 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

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. The following courses were taught during 2019:

¹ *Systems* **2014**, 2(2), 159-167

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

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

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

<u>SD309</u>	<u>Model Based Interactive Learning Environments</u>	Lectures and Workshops	Project Grading
<u>SD310</u>	<u>Writing Course and Project Description</u>	Lectures, Seminars, and Assignment	Assignment (Proposal Writing) Grading
<u>SD330</u>	<u>Natural Resource Management</u>	MOOC: Online task, videos, games	Online Exam

My review of course curriculums, course projects and exams indicate a thorough and fair examination that guarantees that the students have become with and understood the fundamentals in each course. My discussions with the students, both first year and second year students, confirm this observation.

Students and results

The program has been successful in attracting 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 at Bergen. 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 currently discussed proposal to create a **new undergraduate degree** in collaboration with areas of strength at the university. The suggested topic for such a degree “Sustainability and Systems Approach” is both timely and recognized as very important. I believe that such a program, except for being a feeder program to master programs in the participating areas, including System Dynamics, would be very favorably judged by public and private organization.

The students enter the master program 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.

During 2019 the following course results were registered:

Subject	# of Students		Average Grade	Distribution of grades					# of Fail (F)
	Registered	Completed		A	B	C	D	E	
Policy design and implementation	25	22	A-/B+	12	10				
Model-based socio-economic planning **	41	25	B	7	12	6			
Client-based modeling	15	14	B+	9	3	2			
Natural resource management	17	10	C+	2	2	3	3		

Spring 2019(second semester)

** Several students registered but did not show up since they did not receive financing or because they were denied visa

Subject	# of Students		Average Grade	Distribution of grades					# of Fail (F)
	Registered	Completed		A	B	C	D	E	
Fundamentals of dynamic social systems	53	48	C+	12	10	11	8	7	1
Model-based analysis and policy design ²	38	33	B+	11	7	5	5	5	3
System dynamics modeling process	48	44	B	17	14	9	4		

Fall 2019 (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	15	14	A-	9	3	2			
Writing Course	13	13	Pass						
Natural resource management	34	28	B-	1	15	4	5	3	
Special topics course	15	13	A-	9	2	1	1		

Fall 2018 (third semester)

Discussions with students

During my visit to the university I had the opportunity to talk to both first and second-year students of the program. The students expressed that they were very content with the program. Many of them had received information and recommendations about the program from teachers at their university. A few others had received information from friends, past students, and from the Internet. The fact that they represent 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 they wanted interaction with organizations outside the university in which system dynamics was used.

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. Since the students have different domain interests it is essential that the intensive courses have enough flexibility to allow for different contextual circumstances. The students expressed satisfaction with this aspect.

Some suggested changes in the distance learning course, especially how it was scheduled during the semester. The course format means that there is a considerable time lag between a student question and the reply which causes the students to hesitate asking questions.

A couple of students thought that the program should place more emphasis on training communication skills, especially in terms of visual communication.

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 the faculty is engaged and 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. They also expressed appreciation of the “peer program” introduced last year and in which second year students serve as teaching assistants and that can be approached any time when assistance is needed.

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

Learning outcomes

Objectives of the program as well as expected learning outcomes for all courses are well described in program descriptions and course outlines. They are also emphasized at the start of each course. They are also extensively described on the web pages of the program.

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.

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.

The 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).

Two of the three faculty members are at the stage when it is necessary to start to plan for their replacement when they retire. Replacement for the two soon-to-retire faculty members have been guaranteed by the university.

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.

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.

Several new research initiatives are in progress or are being discussed. It is outside the scope of this report to further discuss or evaluate these projects. It is, however, appropriate to ascertain that they all will benefit the master program as well as the PhD program.

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
- Continued improvements of distance learning courses needed

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.

Two urgent issues has to do with the new faculty recruitment and the attracting native students. Recruitment of new faculty should be initiated soon, not to risk the survival of the program as flagship. 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. Such changes are essential in order to attract native students to study the field of system Dynamics.