

Program Review Report (Programsensorrappport) 2021:

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

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Brief summary of findings

- Growing need for systems solution and people skilled in analyzing complex dynamic problems
- The SD program at University of Bergen is unique program with international reputation. Produces people with systems thinking skills much in demand in industry as well as governments
- Matured structure with carefully designed courses with well described objectives and learning outcomes
- Demanding interdisciplinary program
- Enthusiastic students from different countries and disciplines
- Drop-out rate normal and happens at early stage
- Faculty leaders in the field and engaged in the students
- Faculty load very high, meaning less time for research
- Global network of researchers and research institutions
- Many research opportunities
- Very impressive MOOC developments in international collaborations
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But...

- High faculty workload, meaning less time for research, may not be sustainable
- Necessary to bridge the gap between retiring and new faculty
- Would benefit from more domestic students. Can possibly be recruited from undergraduates program of the university by introducing SD courses as electives

Contents

1. Roll of the examiner and the examination process
2. About System Dynamics education, research and applications
3. System Dynamics education in Bergen
4. Program structure
 - a. Courses
 - b. Delivery Methods
 - c. Quality and course assessment
5. Students and results
 - a. Study results 2021
 - b. Interviews with students
 - c. Recruitment of students
 - d. Learning outcomes
 - e. Examination
 - f. Student involvement in course development/evaluations
6. PhD Program
7. Resources available to the program and the research environment
 - a. Faculty
 - b. Faculty research and network
8. Summary and recommendations

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 review and comment on:

- The study program's profile and structure
- Admission, program completion, dropout rate
- Literature and practical implementation
- Methods of teaching and assessment, in relation to the learning goals
- Assessment processes, grading scale, grade distribution
- Assessment of and suggestions for evaluation and quality development of the program
- Management and administration of the study program, available resources, academic and social activities

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

- by reading the self-evaluation report provided by the faculty
- 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, students, a doctoral candidate, and a post-doc; this visit took place February 23-24, 2022
- by participating via Zoom in a session in which first year students presented and discussed course assignment

Several discussions were held with professors Pål Davidsen, Erling Moxnes and Birgit Kopainsky. Two meetings were held with students, each about 60 minutes. The first meeting involved students in second year of the program and the second meeting involved students from the first study year. The meeting with the doctoral candidate and the post-doc lasted for two hours.

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.

2. About System Dynamics education, research and applications

Fast economic and technological development, energy, sustainability and climate change problems together with the global nature of most issues challenging mankind today, 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.

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.

My review concerns the first of these two programs.

International diversity has been a hallmark of the Bergen program; each year, students come from many countries and the majority 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 master program 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 final semester is for thesis work worth 30 study units. The program structure

and philosophy are described in the self-evaluation of the program (Fall 2020) and in an article “Systems Education at Bergen”¹.

In the discussions with students and faculty the content and structure of the courses were discussed. It was suggested that a change may be made so that the third semester course SD330 and a second semester course, e.g. SD325, change place in the structure.

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(elective)*
 - SD323 Special Topics in System Dynamics, Applications (elective)*
 - SD324 Special Topics in System Dynamics, Methodolog (elective)*
- (One of The last three courses may substitute for one of the compulsory spring courses)

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:

<u>SD302</u>	<u>Fundamentals of Dynamic Social Systems</u>	Lectures, Discussions and Projects	Written exam
<u>SD303</u>	<u>Model Based Analysis and Policy Design</u>	Lectures, Case studies, Discussions and Projects	Written exam

¹ *Systems* **2014**, 2(2), 159-167

<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, animations, games	Online 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. A possible improvement may be to let the third semester course SD330 change place with a second semester course, e.g. SD325.

It is a very ambitious and demanding program. The course material, text books and articles is extensive and the faculty engagement in the students goes beyond what is common.

The MOOC course is offered globally and it currently involves more than 700 students. The students I talked to are very happy with the interactive learning environment. And it is indeed a very impressive development. According to Professor Moxnes it will be possible to get the whole master degree on/line.

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 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. The number of domestic students are increasing, but the fraction is still rather small. Students who learn about system dynamics as undergraduates are more likely to pursue advanced studies in the subject. Several of the existing social and natural science undergraduate program can include courses in systems thinking and modeling. Students in the bachelor programs in economics, political science, sociology, administration and organization, and information science at the University of Bergen have the opportunity to take a full year of elective courses. The faculty is making efforts to attract students to introductory system dynamics courses.

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 2021

Subject	# of Students		Average Grade	Distribution of grades					# of Fail (F)
	Registered	Completed		A	B	C	D	E	
Fundamentals of dynamic social systems	44	37	B	11	11	8	6	1	
Model-based analysis and policy design	34	25	A/B	14	6	2	2	1	
System dynamics modeling process	46	39	B	15	12	7	5	0	

Fall 2021(first semester)

Subject	# of Students		Average Grade	Distribution of grades					# of Fail (F)
	Registered	Completed		A	B	C	D	E	
Policy design and implementation	30	30	A	20	10	0	0		
Model-based socio-economic planning	54	31	B		27	2	2		
Client-based modeling	20	20	A/B	6	10	0	4		

Spring semester (Students starting 2021)

Subject	# of Students		Average Grade	Distribution of grades					# of Fail (F)
	Registered	Completed		A	B	C	D	E	
Model-based interactive learning environments	26	25	A	22	1	0	2	0	
Natural resource management	62	52	C	1	13	20	10	8	5
Writing course and project description	22	18	Pass						3

Spring 2021 2nd year students

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

The students were very satisfied with having chosen to study system dynamics at Bergen. The introductory semester is very intensive and makes the students work very hard. 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. 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 (SD308), and would like to see more live interaction with teachers.

All students expressed that they had to work very hard, especially during the first semester, 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 engaged 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. There was also a general agreement that they received enough help by teaching assistants.

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 be to introduce System Dynamics in several undergraduate programs at the university.

Students starting fall 2020

Accepted offer	44
“No show”	9
Students end of 2021	21

Students starting fall of 2021

Accepted offer	37
“No show”	18
Students end of 2021	16

Origins of students accepted fall of 2021 remaining in the program at the end of 2021:

Iran	3
Nepal	2
Norway	2
Sweden	1
Ghana	1
China	1
Kenya	1
Morocco	1
Netherlands	1
Belgium	1
Pakistan	1
Nigeria	1

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.

f. Student involvement in course development/evaluations

A special Program Board has been established to be responsible for quality assurance including course evaluations. The board is made up of faculty, students from both year 1 and year 2, and of an external member (a former student). The board has

recommended several measures to improve the program and the students' social life that has been adopted.

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 2021 one candidate 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. The workload measured as production of student-years per faculty member is close to double that of the average SV-faculty.

The faculty is carrying a heavy work load and there is an imminent need to speed up the faculty recruitment plan. Two of the three faculty members will retire this coming summer. One new faculty position has been filed and a search is ongoing for the second replacement position. It will probably take some time to get the two new professors established on-site. This may become a problem if the retiring professors cannot bridge the time until the faculty members are established on-site. A possibility will be to try to recruit short term visiting faculty.

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 years to find the right candidate for such a position.

b. Faculty research and network

In spite of a heavy teaching load 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)

A project “Coastal Ocean Assessment for Sustainability and Transformation” is financed by the 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)

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)
- Erasmus+ MOOC project (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 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. Currently more than 700 students around the world are engaged in the MOOC.

Currently the System Dynamics group is involved with five partner universities to develop 8 MOOCs teaching policy-oriented System Dynamics. The project is funded by EU’s Erasmus+ program. University of Bergen has the leading role in the project (Prof E. Moxnes).

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. 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 student body is very international and very motivated. The study program is intensive and the faculty is very engaged with the students. Students are given opportunities to impact the execution and content of courses. There is healthy social connection between the students.

The program structure and content has matured over time and there is no urgent need for changes. This is also a conclusion from the many recognized system dynamics experts whose endorsements are included in the self-assessment from the faculty. During this review process one possible change in the flow of courses was identified.

The most urgent issue has to do with the replacement of faculty that is retiring. The group will need to rely on visiting faculty to bridge the time gap between retirement departures and the arrival of new faculty. To sustain the program for the future and to be able to educate more students, the program will need more faculty.

It is desirable that the program engage more domestic students. Although there has been a slight increase in applications of such students to the program, they still only make up a small fraction of students accepted. 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