2018

Center for Computing in Science Education

ANNUAL REPORT

CCSE

Center for Computing
in Science Education

Abstract

The Center for Computing in Science Education (CCSE) aims to become an international hub for the research-based integration of computing into science education. Computing – using computers to solve problems – has changed research and industry. And the use of digital technologies is expected to impact all of society. However, computing is not yet fully integrated in the contents of educations – neither in the sciences nor in other disciplines. CCSE wants to change that. Computing and programming should be an essential skill in all science educations, and the contents and form of the educations should be changed accordingly. This requires new learning materials and new teaching methods and approaches. These materials and methods should be based on research on how students learn computational modeling and how computational modeling affects learning of the specific discipline. Therefore, CCSE needs to develop a related research activity in computational science education research.

In 2018 the center has consolidated its position nationally and internationally. New personnel was hired and activities were extended to new areas. The research group in computational science education research is now growing. One new grant for student research projects was awarded from the Thon foundation, a grant for international partnership between UiO, Michigan State University and Oregon State University was awarded and a major application on active learning was submitted to DIKU. We now have a basis for a research group with an excellent opportunity to build a strong activity in the coming years. A particular ambition will be to extend the activity towards computing in mathematics and bioscience education.

The center has contributed to develop a culture for teaching and learning. CCSE personnel is contributing to workshops, seminars, courses and retreats at the Department of physics, at the Faculty, at the University of Oslo, nationally and internationally. We are actively teaching student-active teaching methods and are building a portfolio of courses in computational methods for teachers and faculty.

The integration of programming has been extended to all bachelor programs in science with an introductory course in scientific programming – adapted to the specific disciplinary context – in the first semester. This provides a foundation that subsequent courses can build on. We have now also initiated collaborations with the humanities and the social sciences at UiO. In addition, our partner, the University of Southeastern Norway, has made significant advances in integration programming in all engineering programs.

A major development in 2018 was the national decision to integrate programming in the mathematics education in schools. We have been part of developing the new curricular guidelines, and we are now taking an initiative to teach teachers and the teachers of teachers to program and to integrate programming into their teaching. This is a significant challenge because of the enormous scale of the endeavor. We have established a nationally recognized brand, ProFag, with courses for teachers both in high school (11-13) and in middle school (8-10). We have also received significant funding (10 Mkr) to build such an activity. This development has led to a realignment of the school related activities, and our school interaction program will be completely reorganized in 2019.

Digitization will be an important theme in education in 2019 and the coming years. CCSE has the experience and competence to drive digitization in education – and as a Center for Excellence in Education we have a mandate to do it. We are happy to take on this challenge and help transform education to fully integrate computing in 2019.

Contents

Mission and goals

VISION
CCSE will become an international hub for research-based integration of computational methods in education.

GOALS
- Develop research-based learning materials with deep integration of computing
- Develop research-based methods and approaches for integrating computing in curriculums
- Transform student learning and teaching culture
- Engage students through student-driven projects and practices
- Disseminate and adapt practices across disciplines nationally and internationally

REALIZING THE VISION: FROM THE PRESENT STATE TO THE TEN-YEAR GOAL

Present state (2016)

Existing interdepartmental culture for CSE with some excellent teaching practices and strong student engagement. Math and programming integrated in first semester. Full CSE integration in 2 of 6 basic physic courses and partial integration in other courses. Two textbooks have been published internationally. The research basis for methods and approaches is sparse.

Five-year goal (2021)

The center has initiated a research-based approach to curriculum change and teaching and learning methods in partnership with students. Full integration of CSE in 4 of 6 basic physics courses, with two new textbooks, 2 of 4 math courses, and 1 astronomy course. A pilot extension of CSE into biology; a pilot adaptation by an external partner; a pilot school interaction program; and pilot studies of learning outcomes and teaching methods in 3 courses.

Ten-year goal (2026)

The center is an internationally leading hub for research-based approaches to CSE, with a strong educational research activity; an international repository for methods and materials; and strong student partnership. Full integration of CSE into 6 of 6 basic and 2 advanced physics courses, 4 of 4 math courses, and 2 astronomy courses. Extensions of CSE to 3 other disciplines at UiO. Adaptation of CSE at 2 external partners. A well-running school interaction program.

Perspectives on digital competence

Digital competence has become an important skill in society, industry and education. However, what actually constitutes digital competence in often unclear. At the Center for Computing in Science Education we have a clear vision for how to reform education to ensure students are prepared to face tomorrows challenges: We need to integrate the use of computers to solve problems – computing and programming – into all aspects of education across disciplines and across the entire educational ladder. Students need to learn how to work effectively with machines – computers – that are becoming gradually more intelligent. We all need to become literate in the use of computing – to obtain computational literacy. We need to learn to think, argue, analyze and be creative using computing and programming. This does not mean that everyone should become computer scientists. Instead students should learn to use computers in their disciplinary context.

The key observation, that is often overlooked, is that computing extends the mathematical toolbox in a fundamental way. Since the mathematical toolbox has been a major constraint on the selection of topics, examples and exercises in a science like physics, this opens a completely new approach to disciplinary education. In addition, it also opens up education in other disciplines to modeling and simulation.

The focus on digital competence will increase in 2019, with good reason. The advent of new technologies, represented by breakthroughs in machine learning and AI, and the rapid growth of new industries that require competence in computing and data science, will change all of society, including education. The Ministry of education introduced its strategy for digitization in higher education in 2017. This strategy points to the importance of digital competence at all levels in higher education – for researchers, students, teachers, and administration. Similarly, EU's strategy for the digital single market points to the need for all professionals to master digital skills in their respective fields. CCSE is in a unique position to lead the digital transformation in education because we already have worked twenty years with a vision of how to integrate computing and digital competence into education. We have experience with how digitization can and will change the content of education, the practice of teaching, and the methods of research.

Higher education institutions should provide their students with a research-based education. If all educations integrate computing, this means that a university needs to have research activities and research-based competence in three related fields: (1) In the specific disciplinary field: For example, a bioscience education must build on high quality bioscience research; (2) In the computational field: An education with a computational element must build on a strong research activity in this area; and (3) In education research. Only the largest institutions are able to build top research activities in all these areas and provide high quality, research-based education that integrates the computational and digital perspectives.

We are convinced that the approach and strategy of CCSE will become more important as more and more stakeholders, institutions and students realize the importance of an up-to-date education with a modernized curriculum. The growing digital divide – between parts of the population that have digital access and master the digital technologies and the rest will only widen. The only realistic solution is to address this challenge through education. We need to include digital skills – deep, non-trivial skills – throughout the education. However, this requires a new generation of teachers and researchers who can build computational curriculums and educate tomorrows teachers.

Highlights from 2018

DIGITAL COMPETENCE

The concept of digital competence and its importance for government and industry has grown to become one of the main themes both in society in general and for education in particular during 2018. CCSE provides a clear solution – integrate the use of computers to solve problems, computing, into the curriculum across educations. In 2018 CCSE personnel have contributed with our insights into many events organized by universities, stakeholders, NGUs, student-organizations and industry – nationally and internationally. We expect many of these interactions to lead to longer term collaborations and partnerships on how to build educations for a digital future.

PROGRAMMING IN SCHOOL AND TEACHER PROFESSIONAL DEVELOPMENT

During 2018 the national political discussion about programming in schools has moved from discussing whether programming should be part of the school curriculum, to discussing how to do it. Norway has decided to follow the approaches of Sweden and other countries and introduce programming in mathematics and then integrate the use of programming and computing into other subjects. The current plan is for programming to be introduced in mathematics starting from fall 2020. This poses a significant challenge since few teachers are sufficiently proficient in programming or know how to use this in order to improve learning in the subjects they are teaching. We have therefore taken a local and national initiative to educate teachers as well as to renew teacher educations. This is done in collaboration with the Oslo school administration, selected schools, partner institutions, and government. CCSE in collaboration with KURT (the competence center for teaching in science and technolgy at UiO) has developed ProFag for both high school and secondary school, we have organized national conferences and workshops, and we have hired Andreas Haraldsrud in an adjunct position. In addition, we have had an experienced and visionary high school teacher from the US, John Burk, as a visiting scholar at CCSE for the whole academic year from 2018-2019. We are now in a position to take a national lead in this area, although this requires national funding and resources.

CENTER CONSOLIDATION

The main focus in 2018 has been the consolidation of the center and establishing dissemination models. We have hired a new administrative leader and established administrative routines and funding schemes. We have established a contract with the University of South-Eastern Norway, providing a basis for a long-term collaboration. The position of the center as a source of competence is consolidated and spreading within the university, nationally and with governmental bodies. We expect further new routines to be established as we move into new localities and become co-localized in March 2019.

EDUCATION RESEARCH ACTIVITY

A goal of the center is to develop a research activity to address the effects of the integration of computing in science education. In 2018 we have initiated several projects involving bachelor-, master-, and PhD-students. Two master students have initiated studies of student motivation and learning when introducing computing in bioscience. One master student has addressed student motivation and learning when integrating computing in introductory mathematics courses. We have initiated a design-based research project on computational essays and how they affect student learning. We have also initiated a project to address the use of learning assistants adapting the Colorado Learning Assistant model to a Norwegian and European context. We are starting to broaden our education research focus from physics towards mathematics and bioscience. Elise Lockwood, a leading expert on computing in math education from Oregon State University, have visited several times and is initiating a research project at UiO. We have also established an international partnership (INTPART) on computing in science education between UiO, Michigan State University (MSU) and Oregon State University that will form a basis for building the education research activity. We have established a summer student research program at UiO, with three students participating in 2018, which will expand in the coming years. Our research activity on learning analytics with PhD-student John Aiken is now also established and the first research articles have been submitted.

PROFESSOR MORTEN HJORTH-JENSEN RECEIVED THE 2018 THON AWARD FOR EXCELLENT TEACHING

The prize is 500.000 kr and was given to Professor Hjorth-Jensen during the Thon prize ceremony in the University Aula on March 8nd. The prize was awarded Hjorth-Jensen for his genuine affinity to students and his ambition to help each student develop herself. He is one of the best liked educators at UiO, while at the same time imposing high standards. He has received the UiO education award three times – for different courses each time. He was an early adaptor of student-driven teaching. He has over many years worked to improve the educational programmes at UiO and was the programme leader for the physics programme as it introduced programming in the curriculum. He has developed the courses in computational physics and machine learning, which are highly regarded and very popular. He has also developed a group in computational physics with a renowned learning environment, and has educated the most master students at the department over the past ten years. Recently, he has also developed a new, cross-disciplinary master program in Computational Science, which unites sciences, economics, and finance. We are very proud to have him as a central part of CCSE. Congratulations, Morten!

CULTURE DEVELOPMENT

CCSE has played key roles in the educational development activities at the Department of Physics and the Faculty in 2018. Together with KURT we have organized seminars for learning assistants and faculty in the beginning of each semester, we have organized a summer institute with focus on student active learning in biosciences, and we have initiated a learning assistant (LA) program with weekly pedagogical training for learning assistants in selected courses. The annual Christmas seminar in 2018 was a great success with over 80 faculty present and presentations from top international researchers as well as internal presentations on instructional development.

INTERNATIONALIZATION

The center has adapted a more international perspective in 2018. Our collaborations with institutions in Europe are gradually maturing. We have been invited to develop a cross-institution program in computational physics. CCSE has also been central in UiOs collaborations with China in 2018. We met with the Chinese delegation visiting Norway in March, and we were invited to participate in the Norwegian delegation to China in April. Our collaboration with the National University of Defense Technology has led to the disseminiation of CSE methods across 35 universities in China. A delegation from NUDT visited UiO for two weeks in November 2018 to exchange

experiences and to learn how to integrate computing into introductory physics courses. We have hosted several international visitors, including a one-year sabbatical stay of John Burk. The international collaborations have matured into a strategic partnership through a successful INTPART grant – providing 1.5 mill kr per year for integrating computing in science education across three institutions, UiO, MSU and OSU.

DISSEMINATION

During 2018 we have established a model for dissemination, and a goal is to ensure that the model is research based. Two key elements of the model are the use of students to develop new learning material for courses and establishing research collaborations, since the use of computational methods in research is found to be the most important factor for adapting computing in educational programs. Dissemination to the biosciences bachelor program has been a particular success. Here we see broad adaptation that includes support from leadership, integration with research activities, and key personnel taking initiative to integrate programming and develop courses and study programs. In 2018 Lex Nederbragt was also invited into the leadership group of the center – allowing CCSE to learn from the experiences now built up in biosciences. The way computing has been integrated in biosciences can serve as a model for disseminiation in other fields, and Nederbragt will play an important role in spreading CSE further. We have also initiated activities in the direction of political science and the humanities, which we hope will turn into new courses in these fields over the next few years. Computing and programming is also a key element in the new honours-programme developed at UiO, which will build a basis for further disseminiation. We have initiated collaborations with several other institutions. In 2018 we organized a workshop on programming and computing with Matric, and our partner USN has made major progress in their introduction of CSE into engineering programs – establishing a national model that can be spread to other institutions.

STUDENT RESEARCH PROJECTS

CCSE has received two grants from the Thon foundation to develop student research projects. In 2018, 15 bachelor-students were involved in research projects of more than one month duration. This is possible because our students have acquired relevant programming and computing skills early in their studies, and therefore have can contribute meaningfully already after one year. The projects also provide students with a chance to experience the world of research and to demonstrate other aspects of their skills and abilities early on. Three students have been involved in the Thon project on student education research projects. This program has an international focus, and 2018 was a pilot year. One Norwegian student and two US students participated in the program, and one research paper was published. One of the US students is continuing as a PhD-student in physics education research.

Lessons Learned

The activity of the center is progressing nicely and according to plans. However, there are some challenges we are experiencing – expected or not – that will inform our activities over the coming years.

External events and developments have inspired changes in our priorities, goals and milestones. In particular, the focus on digital skills have become a national priority – in particular in school education. We perceive this as an opportunity, but in order to seize the moment, we need to reprioritize our activities. This means that we will reorganize our action plan and milestones in 2019 to better reflect both internal and external developments.

RESEARCH

The ambition to develop an internationally visible research activity is a bold proposition, which requires strategic planning and hiring, partnerships and resources similar to that of other research initiatives. To develop a strong activity in physics education research and computational science education research at UiO require a long-term perspective. We have started this process in physics, but we also need to start this process in mathematics and biosciences. This requires leadership commitment and resources. We are currently applying for external funding to build this activity. However, in the end such an activity must be motivated from the disciplines themselves.

INSTRUCTIONAL DEVELOPMENT

We have a very active core group who contributes actively to course and material development. A challenge is to extend this group and ensure that teachers who are recruited to the most important courses can be motivated to contribute to development. More development should also be done by seniors and not only by PhD- and summer students. The development group should also be widened to include more faculty in chemistry, bioscience, mathematics and computer science.

Another challenge is the varying competence and use of computational methods among faculty. Recent research by Caballero has shown that the faculty's own use of computational methods is a significant factor in adaptation of computation methods in teaching. While we have started developing courses and summer institutes for teaching faculty, we suspect that full integration will only come from faculty who also have a deep research interest in computational fields – at least in a transitional period until computing becomes a widespread method that all faculty is expected to master. This insight provides us with important input for recruitment strategies.

We have also found that didactic perspectives also are important when introducing computational methods in various disciplines. This is an important aspect of the summer institutes that Caballero has been organizing through the Picup project at MSU. We will therefore argue that didactic perspectives on the use of digital and computational methods should be included in the basic pedagogical training provides for all faculty.

In the learning assistant project, we have found that methods for student active learning that have been developed in the US may not be directly transferrable to a European context where participation in teaching activities is largely voluntary. We are therefore exploring ways to incentivize participation.

CULTURE FOR LEARNING AND TEACHING

The culture in the core group is strong, but we need to continue to work to include a wider range of faculty in seminars, courses and workshop. We must also ensure that the whole department and the whole Faculty feel that CCSE is a common good that contributes to improve teaching for all.

DOCUMENTATION

We need to improve documentation of improvements in teaching and student learning – and to establish both baseline and continual measurement practices. This must involve improved usage of measurement tools and custom-made surveys as well as interviews and standardized tests. We have started introducing standardized test to measure learning outcomes in physics courses. This will provide us with a more quantitative basis for learning analytics studies. However, we also need to be able to analyze learning from a wider variety of assessments and to develop more specialized assessments to address how students develop their computational literacy throughout their studies. This is addressed in the S-ASSESS project which is starting in 2019.

Plans and Priorities for 2019

The main activities of the center will follow the action plan. However, several new developments that are timely and important will have impact on the priorities for 2018. In 2019, we will therefore update and rewrite the action plan to reflect these changes.

DIGITIZATION

The growing important of digitization will affect the activities of the center. We will focus on redefining the interpretation of "digital competence" to ensure it includes aspects such as programming, computing and data science, and to extend an understanding of computational literacy as an improved term to describe a deeper integration and application of skills. A significant national and international challenge is to educate teachers and to re-educate the workforce. This requires a combination of disciplinary, computational and educational competence that we have in CCSE, but which is not present in many other institutions. We will therefore establish both a Norwegian and a European network to educate the teachers of tomorrows teachers, to build competence in computational science education research, and to educate PhD-students to meet this need for competence across Europe. We will also focus on professional development for teachers with particular focus on computational proficiencies.

DISSEMINATION THROUGH PARTNERSHIPS

The partnership with University of Southeastern Norway has made excellent progress in integrating programming in engineering education, the department of biosciences has made excellent progress in the bioscience, and NUDT have disseminated their activity throughout China. This provides an excellent basis for dissemination through partners. These partners are now in a position where they can begin their own dissemination activities. In 2019 we will continue to support these partners and develop new partnerships along similar lines.

SCHOOL COLLABORATIONS

All schools in Norway need to prepare for the change in curriculum from 2020. This requires a significant effort to ensure teachers have the necessary background in both programming and didactic knowledge on how to integrate programming in various disciplines. We have already started a project with middle schools in Oslo. In 2019 we will continue and expand this project, expand it to high schools and expand beyond Oslo. Our ambition is to build and lead a national initiative in this field. We are the only group in Norway with the experience, competence and skills to drive such a development, but we need resources to scale our model to a national level.

COMPUTING IN MATHEMATICS EDUCATION

We will extend our collaboration with Elise Lockwood at Oregon State University and build a mathematics education research activity with focus on the effects of computing. Elise Lockwood will have an extended sabbatical stay with CCSE in 2019, and this poses an excellent opportunity to establish such an activity. The goal is that this will have a positive impact on instructional development and curricular design in mathematics.

NEW LOCALITIES – ESTABLISHING A HUB FOR COMPUTATIONAL TEACHING

CCSE will move into their new localities in March 2019. This is an opportunity to build CCSE as a hub for educational development at the Faculty and as a meeting place for teachers and students. In 2019 we will prioritize to build new traditions in our new localities.

CULTURE DEVELOPMENT – INCREASING THE IMPACT

We will also focus on including more teaching faculty and students in the activities at CCSE to broaden its impact. In particular, we will develop and expand the learning assistants project to include more courses in physics and mathematics, and to extend the project also to other disciplines.

Activities and plans

WP1: Research-based development of learning material

Leader: Hjorth-Jensen

GOAL

Develop flexible learning material that deeply integrates the use of computing based on research-based pedagogy. Hereunder, (1) Develop a repository of teaching material and evaluation methods; (2) Develop textbooks and interactive and modularized material with integration of computational methods and programming examples; (3) Study usage and effects using big data approaches, interviews, and observation; (4) Provide writer support including writing groups and use of students to improve texts; Develop CSE publishing tools; Build partnership with Springer on CSE book series.

ACTIVITIES

Textbooks

A major objective of the center is to develop high quality learning material. The material should demonstrate how the integration of computing can change the exposition, examples, exercises and activities of the subject matter. This material must be developed by highly qualified teachers who also master computational methods and approaches. Typically, textbooks are written and continuously improved over years. Our ambition is that this incremental development and improvement should be based on research into how the learning material is used by teachers and students and how that use affects student learning. Thus, the development of material should be paired with the education research activity of the center.

Textbook: Waves and oscillation

Associate professor Arnt Inge Vistnes has developed the textbook Waves and oscillations that fully integrates the use of computing in this classical field of mechanics. This opens for a more research-near text with modern methods and examples that are interesting and useful for the student. For example, the student learns to solve the wave equation in one and two dimensions also in non-trivial situations, and modern methods of analysis, such as the use of wavelets are both explained, implemented and applied to relevant problems. The textbook was published by Springer in 2018. accepted for publication by Springer and was translated from Norwegian to English in 2017. CCSE financed the translation of the textbook to English.

Other textbook projects

In 2018, PhD-students Svenn-Arne Dragly, Simen Tennøe, Milad H. Mobharan, and Andreas Solbrå together with Lex Nederbragt received an offer to publish their textbook for BIOS1100 with Springer. The textbook is to our knowledge the first of its kind in introducing computational methods and programming in a bioscience context to first-year bioscience students.

In 2018, Malthe-Sørenssen and Dysthe signed a contact with Springer to publish their book "Thermal and statistical physics using Python". The book is currently in production and is expected to be finished in 2019 and published in 2019 or 2020.

In 2018, Morten Hjorth-Jensen and Danny Caballero published a paper on how to integrate computing in physics educations (CITE). This paper forms a basis for our activity and points to how computational methods can be introduced in both learning materials and practices.

Writer support

The center aims to support the development of learning material by developing a community for writers, by developing and supporting the essential infrastructure and tools for writing, publishing and use, and by distributing and publishing the results. The main tool for textbook development is docOnce, which is developed and supported by CCSE. We provide support for teachers who want to use docOnce.

Infrastructure and distribution

CCSE has initiated and supported the introduction of Jupyter notebooks. A Jupyter notebook is a document that combines text with markup, mathematics, images, and runnable code – including complete programs. The notebook can be edited by students so that the can include their own comments and notes as well as their own programs. Exercises and projects are often distributed in notebook form, so that students can finish the notebook and hand it in. Jupyter notebooks will form one of the main platforms for dissemination in 2019. CCSE has support-

ed a university-wide hosting service for Jupyter notebooks through JupyterHub at UiO. JupyterHub provides a web-based interface for students to work on notebooks and run programs using only a web browser. Thus, students do not need to install any specialized software on their computers. This simplifies the "bring-your-device" approach, because students can use any device in the classroom. This platform also greatly simplifies the distribution of material.

FYS1120 and learning progressions

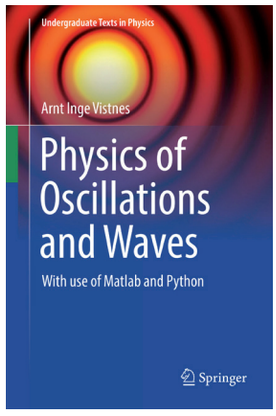
We have started to work systematically with learning progressions. In the course FYS1120 Electromagnetism we have developed a set of tutorials. The course has developed a clear learning progression for each week. The learning progression is based on a detailed set of learning outcomes for the particular week. Main concepts and conceptual questions are addressed in plenary sessions with all students. Then students meet in group sessions where they work on tutorials. The tutorials are designed to bring students from the main concepts introduced in the lectures and build the skills needed to address homework problems. Homework assignments bring the students all the way to the level expected in the final assessment. This requires a careful design of the learning progression, where care is taken to ensure students are able to transfer their skills and knowledge between the various activities. Computational methods are introduced as part of the learning progressions. In 2019 the method will be extended to include modeling and computing sessions.

Student participation

Students play an important role in the development of learning material. CCSE financed 20 summer student scholarship in 2018. These scholarships are tools that we use to stimulate to the development of learning material and to engage students deeply in the development of new learning material. Teachers and departments can apply for resources that they use to hire a student to develop new learning material that integrates computing in a course. Priority is given to courses that need transformation. For example, in 2018 3 of 20 student projects were awarded to a new course in statistics which is offered to bioscience and chemistry students. And 2 of 20 students developed materials for a new course on data science and machine learning. Students present their results in a workshop after the summer, and teachers and students present their results at the annual CCSE conference to disseminate the results and inspire other teachers.

TEXTBOOK ON WAVES AND OSCILLATIONS

The textbook *Physics of Oscillations and Waves* is the result of many years of development by Arnt Inge Vistnes. Vistnes was one of the first implementors of Computing in Science Education at UiO, starting with his work on integrating computing into courses in electromagnetism and mechanics, and then followed by a thorough work on the integration of computing into the learning material for Fys2130 – Waves and oscillations. The book contains numerical methods, computer programs, examples and exercises that provide a student with all the tools necessary to address a problem in this field of physics using a computational, theoretical and experimental perspective. Vistnes is a visionary educator and with this book he demonstrates how computing can be effectively integrated into the basic physics curriculum, and how this can improve the exposition and explanations of the underlying physical phenomena.



Research basis for curriculum development

The research basis for new learning material will be investigated by the research education activity of the center. The first project to address student learning and feedback directly is the S-ASSESS project, where a structured assessment method is developed to address student learning directly. In addition, PhD-students and student researchers will address student learning of computational methods in various science context.

PLANS AND PRIORITIES FOR 2019

- Initiation of writing workshops for teachers who develop new curriculum
- Extended use of JupyterHub and Jupyter notebooks
- Funding for writing retreats for teachers
- Development of new material for courses in computational methods, introductory courses where there is currently sparse high quality material, material for second-semester courses in bioscience and material for second- and third-semester courses in mathematics.
- Engaging students in testing and checking learning material to reduce errors and improve readability

ACTION PLAN

Action	Description	2017		2018		2019		2020		2021		Milestones and Deliverables
		i	ii	i	ii	i	ii	i	ii	i	ii	
A1.1	**Repository for material and evalution methods**											
	Establish repository			D								Working repository
	Enable stakeholder feedback					D		D			D	Yearly usage reports in A0.4
A1.2	**Develop and test textbooks and interactive and modularized material**											
	Publish textbook 1: FYS2160: Thermal Physics (D = editions)					D					D	Published book
	Test and evaluate textbook 1 (teacher, students, PhD1, Postdoc)					M					M	Reports for A1.1; Adjusted material
	Publish textbook 2: FYS1120: Electromagnetism (D=editions)							D				Published book
	Test and evaluate textbook 2 (teachers, students, PhD1, Postdoc)										M	Reports for A1.1; Adjusted material
	Develop textbooks 3-6: Continuous development		o	o	o	o	o	o	o	o	o	Preliminary books
	Develop material for two math courses,. Publish in repository					M					M	Material in repository
	Develop material for AST2000: Astrophysics. Publish in repository										M	Material in repository
A1.3	**Support research on effects of material using data, interviews & observations**									M		
	PhD1 Project		o	o	o	o	o	o	o	o		Research project of PhD1
	Postdoc Project			o	o	o	o	o	o	o	o	Research project of Postdoc
	Publish research articles on results					M		M			M	Publish 1 article/yr
A1.4	**Writer support**											
	Establish writer groups and organize yearly meetings		M		M		M		M		M	Yearly meetings
	Support writing escapes for textbook and material authors		M		M		M		M		M	Support 2-4/yr; Report through A0.4
	Systematic use of student evaluation to improve texts		M		M		M		M		M	Support 1-2/yr; Improved texts
	Develop and support 'doconce' - a writing tool for cross-platform publ.		D		D		D		D		D	Yearly releases
	Develop and support Jupyter and JypyterHub at UiO		D									Established JupyterHub@UiO
	Establish partnership with Springer to publish book series				M							Initiated partnership

Table legend:
M: Milestone, D: Deliverable, o: Ongoing
Colors indicate progress. : according to plan, : adjustment, : delayed

Comments

A1.1: The repository development has been delayed to integrate with the PICUP project.
A1.2: Textbook development is progressing in FYS2160 – Thermal Physics, but has been delayed in FYS1120 – Electromagnetism.
A1.3: PhD-student 1 will address learning in FYS1001 – Introductory physics and BIOS1100 – Introduction to Computational Modeling for Bioscience. The postdoc is focusing on learning progressions, computational essays in Fys1120, and learning assistants.
A1.4: Most of the actions are proceeding according to plan. However, the repository has been delayed to coordinate with the PICUP project.
A1.5: Activities that support writers have been postponed. Jupyter and docOnce activities are as planned.

Activities and plans

WP2: Research-based development of methods and approaches

Leader: Malthe-Sørenssen

GOAL

Develop research-based methods and approaches for the integration of computing in a disciplinary context. Hereunder, (1) Student-active learning: Develop, apply and evaluate traditional and new learning methods in CSE courses; (2) Develop and test research- and industry-near CSE cases in collaboration with stakeholders; (3) Develop and study methods for assessing student work and collecting data for CSE courses; (4) Develop and test methods that use innovative digital and physical learning environments; (5) Develop, test and evaluate study programs and courses.

ACTIVITIES

Student-active learning and learning assistants

CCSE and KURT (The competence center for teaching in science and technology) has been actively involved in promoting the use of student-active teaching methods in general. However, to ensure that our activities in this area follow the same principles as we area teaching – activity – we have developed a project that aims to include both teachers and learning assistants actively in student-active learning. This will occur through the Learning Assistants project (see box).

Extended projects in introductory mechanics

In some courses we have also developed project-based activities for the most motivated students also early in the bachelor-education. In the course "FYS-MEK1110 Introduction to mechanics" (350 students), we have replaced three homework assignments with one larger assignment where students build a larger computational project – a molecular dynamics code. This project will also provide students with an introduction to research and a motivation to participate in relevant research projects during the summer.

Interactive engagement and student identity

With the hiring of post-doc Tor Ole Odden in CCSE and a PhD student, Anders Lauvland, in the Department's Physics Education Research (PER) section, the capacity for physics education research has been considerably strengthened. One aspect of this research activity is to understand how interactive engagement approaches influence physics students' identity, motivation and learning, in order to use such approaches constructively in improving higher education in physics. How students respond to, and work with, computational methods is a central question. This research activity also includes three master students and the co-supervisors of these: Tone Fredsvik Gregers (IBV); Ragnhild Kobro Runde (IFI), Maria Vetleseter Bøe (FI), Lex Nederbragt (IBV) and Ellen Karoline Henriksen (see box). Two half-day seminars have been held in 2018 to establish common theoretical and methodological ground for these investigations. Research on the implementation of the Learning Assistants program is also a part of this activity.

Computational Essays

In the fall of 2018, members of the CCSE ran a pilot study to develop a new type of teaching tool known as a "computational essay" in UiO's intermediate electricity and magnetism course (FYS1120). Computational essays are reports that use text, pictures, and computer code in order to explain a topic or present an argument. Participating students in the targeted course volunteered to do open-ended projects (either individually or in groups) in which they created a computational simulation to answer a question they found interesting. They then wrote narrative descriptions of their investigations in a computational notebook which incorporated their code. 17 students took part in the pilot, writing essays on topics including relativistic particle accelerators, lightning safety, plasma confinement, and novel mechanisms for public transit. Students presented these essays to their peers in informal meetings at the end of the semester, and also took part in semi-structured interviews that focused on their views of computation as it related to learning science as well as their process of writing the computational essays. Analysis of these interviews is ongoing, however preliminary results show that the students greatly appreciated the creative opportunities afforded by the open-ended structure of the programming project, reporting that it led to an increase in both learning and motivation. Based on the success of the pilot we plan

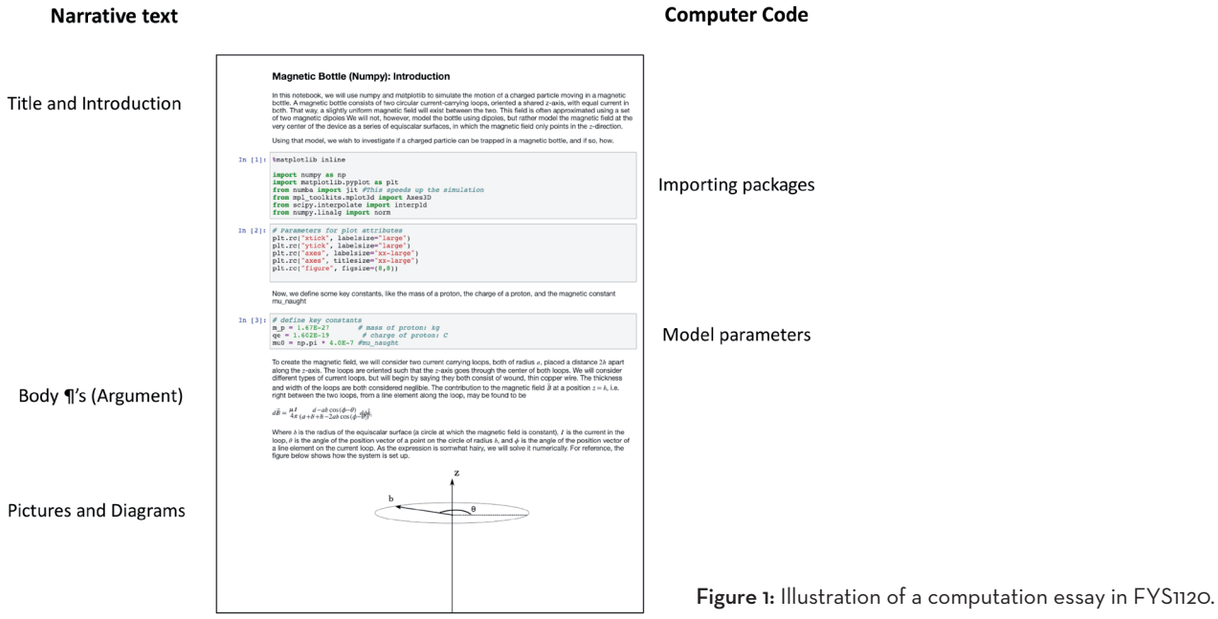


Figure 1: Illustration of a computation essay in FYS1120.

to expand the computational essays to the rest of the electricity and magnetism course next year.

Think-aloud interviews and sensemaking in introductory physics

In 2018, PhD-student Odd Petter Sand from CCSE built on pilot studies from the previous fall to conduct think-aloud interviews with first-year bioscience students at the University of Oslo. These students follow a newly developed integrated programming course in their very first semester (BIOS1100), where the other main components are biology and mathematics. In their second semester, these students attend a physics course, and the interviews had them work computationally with a simple model of radioactive decay. The task was designed to have the students make sense of the model in regard to the physical situation it represented.

These interviews led to a talk, a poster and a conference paper that were presented at the AAPT Summer Meeting 2018 and Physics Education Research Conference (PERC) 2018. These conferences were both held in Washington, D.C. in the summer of 2018, and serve as a meeting place for the Physics Education Research (PER) community. The paper was later published in the conference proceedings and presents one of the interview cases where computation was not only important for the student making sense of the model she was working with, but also provided an answer to the question of how to interpret the results correctly.

Pathways project and learning analytics

The goal of the pathways project is to develop predictive models that explore student choice at large time scales with real world data gathered for all students. In 2018, John Aiken published a paper in Physical Review: Physics Education Research (PRPER) which investigated the use of quantitative methods in physics education research (PER) through a focus group, interviews, and a literature review. It demonstrated that while community expectations of quantitative research has evolved, the literature using quantitative research has not. Aiken also submitted another paper to PRPER where he used a machine learning model to investigate how computing is implemented in physics curricula at the university level across the United States showing that faculty use of com-

puting in research was the most likely explanatory feature for implementing computing in education. In another paper submitted to PRPER Aiken addressed a machine learning model investigating student pathways in a physics bachelor's degree program. In addition to providing explanatory features for why students may stay or switch from a physics major it also introduced new methods to PER for analysing predictive output of models.

Student exchange program

In 2018 CCSE employed three researchers at the undergraduate and masters level. Matt Ring, an undergraduate student from Michigan State University, participated in the summer Thon program investigating how curriculum changes in chemistry courses differentially effects students from varying backgrounds. This work was presented at the Mid-Michigan Symposium for Undergraduate Research Experiences (Mid-SURE). Alyssa Waterston, an undergraduate student from MSU, participated in the summer Thon program investigating how Advanced Placement credits differentially effects student's time to graduation. This work was presented at Mid-SURE and it's currently in preparation. Finally, Robert Solli, a Master student from UiO had one paper accepted in the Physics Education Research Conference Proceedings. This paper describes a machine learning model that attempts to connect student grades to their click behavior within video lectures.

PLANS AND PRIORITIES FOR 2019

- Extend the Learning Assistant project to more courses
- Extend research activity to mathematics and bioscience education research
- Develop research seminar series in new localities
- Extend computational essay project to one large-enrollment (200+ student) class
- Extend use of standardized assessments in introductory classes
- Extend student research projects and include supervisors from MSU

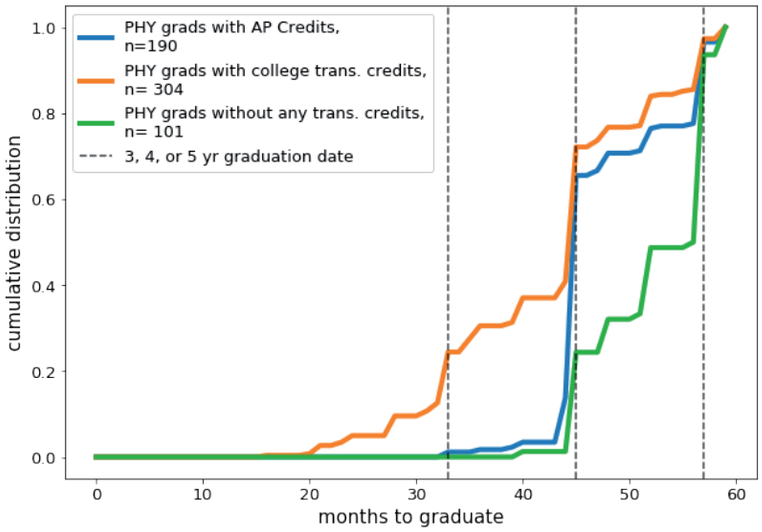


Figure 2: Having just one Advanced Placement credit has a profound effect on students graduating on time. The dashed lines indicating 3-year, 4-year, and 5-year graduation times respectively. While this plot only represents physics majors, it is true for other STEM majors as well. (Plot created by Alyssa Waterson during Thon summer internship).

ACTION PLAN

Action	Description	2017		2018		2019		2020		2021		Milestones and Deliverables
		i	ii	i	ii	i	ii	i	ii	i	ii	
A2.1	**Student-active teaching using CSE**											
	Evaluate traditional learning methods for CSE courses (PhD1, students)				M		M		M		M	Reports for courses
	Develop student-active methods: project-based, tutorials, collaborative		o	o	D	o	o	D	o	o	D	Methods for 3 courses in repository
	Investigte and Evaluate effect of methods				M			M			M	Reseach articles; Repository entries
	Publish research articles on results								M		M	Published 1 article/yr
A2.2	**Research-near and work-life relevant education by integration of computing**											
	Develop and test cases in collaboration with stakeholders					M				M		Cases in repository; Research articles
	Develop and test data-based exposition and examples						M				M	Examples in repository; Research art.
	Develop and test research-near projects with stakeholders				M				M			Projects in repository; Research art.
	Publish research articles on results				M		M		M		M	Published 1 article/yr
A2.3	**Methods for assessing student work and collecting data**											
	Develop and test assessment methods: Digital exams					M				M		Exams from 2 courses in repository
	Develop and test assessment methods: Project-based courses						M				M	Projects from 2 courses in repository
	Pilot study of effect of new approaches in FYS-MEK1110: Mechanics (PhD2)				o	o	o	o	M			Research article from study
	Pilot study of effect of new approaches in INF1100: Programming (Postdoc)						o	o	o	o	M	Research article from study
	Pilot study of effect of new approaches in FYS3150: Comp. Phys (PhD2)							o	o	o	o	Research article from study
	Use 'devilry.org/canvas' to collect, categorize and study student work								M			Data from 2 courses analyzed
	S-ASSESS Project				o	o	o	o	o	o	o	Research project of Postdoc
	Publish research articles on results								M		M	Published 1 article/yr
A2.4	**Methods using innovative digital and physical approaches**											
	Develop and test innovative digital collaboration using github						M					Use in 1 course, results in repository
	Support and test innovative use of 400 m² learning center								M			Use in 1 course, results in repository
A2.5	**Develop, test, and evaluate study programs and courses**											
	Evaluate effect of study program change 2016 to 2017 (PhD2)						M				M	Research (M1: physics; M2: biology)
	Establish semester committees for course coordination				M		M		M		M	Established; Reports for A0.4
	Establish impact evaluation committees with regular meetings				M		M		M		M	Established; Reports for A0.4
A2.6	**Appoint senior researcher to build and coordinate educational research**				M							Appointed

Table legend:
M: Milestone, D: Deliverable, o: Ongoing
Colors indicate progress. : according to plan, : adjustment, : delayed

Comments

A2.1: Student active methods are developed for FYS-MEK1110, BIOS1100 and FYS2130. The PhD-student and master students will focus primarily on BIOS1100 – Introduction to computational modeling for bioscience.
A2.2: Data-based methods are developed in the course FYS2160 – Thermal physics, FYS1120 – Electromagnetism, and FYS-STK3155 – Data science and machine learning.
A2.3: This project has been financed with three new positions and will start in 2019.
A2.4: The new learning center is used in BIOS1100 and git and github is used in FYS3150 – Computational Physics, and FYS-STK3155 – Data science and machine learning.
A2.5: This activity will be evaluated and possibly initiated in 2019.
A2.6: The research group will be developed gradually by adjunct positions and education of PhD-students and postdocs. Currently adjunct professors are hired instead of a full-time researcher.

LEARNING ASSISTANTS PROJECT

The University of Oslo has long aimed to make its teaching and learning activities more student-active. As part of this effort the CCSE has begun an initiative to improve small-group teaching in the physics and math departments through the use of the Learning Assistant (LA) model. The LA model is a method for integrating active learning into courses which was developed at the University of Colorado, Boulder, in the early 2000's. The cornerstone of the model is the Learning Assistants, pedagogically-trained students who facilitate group discussions during lecture and/or small-group teaching sessions. To implement the model, during the fall semester of 2018 we established a weekly pedagogical training seminar for group teachers in two courses from the physics and math departments. Simultaneously, the professors for these two courses worked to develop conceptually-focused discussion exercises to be used by the group teachers during their teaching.

In addition to establishing the learning assistant program, the CCSE has also begun collaborating with the Physics education research section at the Department of Physics to research the effects of the program on the students in the courses and the LAs themselves. During the fall of 2018, LAs from the two different courses participated in focus group interviews and answered a short survey focusing on their role as an LA, the weekly pedagogy seminar, and interest in a teaching career. Preliminary results indicate that the LAs' views on the teacher role had evolved during the LA experience, from a notion of the teacher as a "provider of correct answers" towards a teacher acting as a facilitator of discussion and a support in the students' active learning process.

The LA project at UiO continues into the spring semester of 2019 with LAs from three physics courses. This will also allow us to further develop the research on the LA program and to collect a larger and richer data material concerning the outcomes of the LA program for both students and for the LAs.

Activities and plans

WP3: Development of a culture for teaching and learning

Leader: Henriksen

GOAL

Develop a culture for teaching and learning across the science departments. Hereunder, (1) Develop school-university transition program and investigate effects on recruitment, retention, and results; (2) Improve student culture through student spaces, mentor programs and startup seminars; (3) Develop teacher culture through annual teacher retreat, teaching in teams, workshops and seminars with focus on teaching, and learning and curriculum development; (4) Develop quality systems and student evaluation methods to enhance constructive alignment and ensure quality development through systematic feedback and improvement; (5) Promote teaching skills renewal through pedagogical courses, educational sabbaticals, and career goals for teaching proficiency and excellence.

ACTIVITIES

InterAct

InterAct is a project for educational change at the Faculty for Mathematics and Natural sciences. The project aims at introducing new, cross-disciplinary study programs based on the challenges we expect students to meet during a lifelong career. The program focuses on four areas: active learning, teacher culture, learning environment and backward design. The project is based on the concept of constructive alignment. The idea is to start with a clear vision for what students should have learned when they finish a study program. For example, the new physics program started from a discussion of what it meant to be a scientist, then what it meant to be a physicist, which subsequently lead to the overall learning outcomes for the study program. The general learning outcomes included both disciplinary outcomes, cross-disciplinary outcomes, and generic skills. Finally, learning outcomes in specific courses are designed to be aligned with the general learning outcomes. In 2018 the focus of the InterAct program has been on master education and on developing plans for building generic skills also for master students. Particular focus has been placed on activities to learn scientific communication and writing.

Developing teacher culture

The development of a strong teaching and teacher culture is important to improve the quality of the education and eventually also for student learning. In 2018 we have focused on extending meeting places for teaching faculty and teaching assistants. Together with the Faculty and the Departments, we organize day-long seminars every semester where we focus on teaching and learning, called "Real Utdanning" (aimed mainly at faculty) and "Real undervisning" (aimed mainly at teaching assistants). KURT (Competence-center for teaching in science and technology) and CCSE has contributed to teacher seminars at various departments at the Faculty as well as a cross-faculty meeting. In addition, the Department of Physics has organized two one-day teaching seminars (May and October).

Renewing experimental physics education

There has recently been a strong, international focus on renewing the form of the laboratory based experimental physics courses. We have invited two of the main researchers in this field, Ben Pollard and Heather Lewandowski, to give talks and interact with faculty at the department. Their research and educational development activities indicates that student motivation and learning increases if the structure of laboratory exercises is redesigned. Even though the main focus of CCSE is in computational methods, we wanted to broaden the discussion also of research-based education in laboratory courses. We hope this will have impact also on the laboratory courses over time.

Seminars

CCSE is working systematically to build a culture for teaching and learning by establishing meeting-places to exchange experiences on teaching practice and be inspired and informed on education research. In 2018 we arranged several seminars with invited national and international speakers that were open for all teaching faculty and students. In addition, we organize a yearly Christmas seminar focusing on Computing in Science Education.

Competence-center for teaching in science (KURT)

In order to support the Faculty's activities to promote professional development in teaching, the Faculty has established a Competence centre in STEM teaching (KURT). KURT is directed by CCSE member by Cathrine W. Tellefsen and includes participants from all the departments at the Faculty for mathematics and natural sciences. The center aims to be the hub for professional teacher development at the Faculty. The activities organized by KURT range from speaking at seminars on the use of student active methods to publishing hands-on tips on teaching on the web-site. KURT also arranges a "journal club" where participants read, present and discuss international research concerning student-active learning, professional development of teaching assistants, and other topics of relevance for developing the teaching and learning culture – and skills - among UiO science teaching staff.

PLANS AND PRIORITIES FOR 2019

- Develop and provide courses in Python programming for newbies.
- Organize summer institute on computational methods for physics teachers in collaboration with MSU facilitators, educate our own facilitators.
- Evaluate the course "Physics education research and practice" (10 ECTS) – a course that provides an introduction to Physics education research methods and practices.
- Continue to provide and improve teaching workshops for teaching faculty and teaching assistants.

MASTER STUDENTS INVESTIGATION

Master students investigate the implementation of computational elements in undergraduate biology higher education and in school physics

Three master's degree projects were initiated in 2018 related to CCSE. Two half-day seminars (in March and November) have been held in 2018 with these three master's students and other CCSE staff in order to explore theoretical and analytical perspectives and relevant previous research to help the MSc students move on in their research projects.

Two students from the University of Oslo's science teacher education program do their Master's degree projects at the Department of Biosciences in collaboration with CCSE staff and co-supervisors from the Department of Physics. Both projects are related to the course BIOS 1100, "Introduction to computational models for bioscience", which is part of the first semester in the bachelor program in biosciences at the University of Oslo. 169 students were signed up for this course in the fall semester 2018.

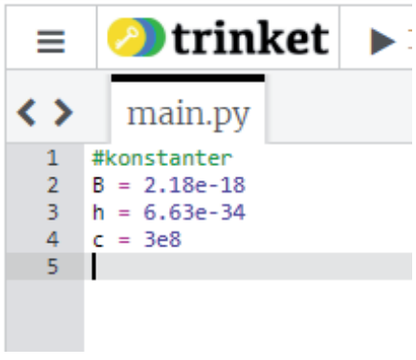


Figure 3: Screen shot from the Python program calculating the wavelengths of photons resulting from transitions between energy levels in the hydrogen atom. Here, relevant constants are defined in the program.

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In her project, ***Marthe Mjøen Berg*** collected questionnaire data from BIOS 1100 students at the beginning and at the end of the semester, aiming to investigate students' attitudes and expectations for using computer modelling in bioscience. Data are being analysed in spring 2019. Preliminary results indicate that BIOS 1100 students had a lower interest for this particular course than for the bioscience bachelor program as a whole. Male students expressed a higher expectation of success and higher gratification with the course than did their female peers. Respondents expressed that they expected the computational aspects of the course to be more challenging than the biology content.

Lars Erik Revheim Håland has looked at how BIOS 1100 students actually approach programming tasks they encounter in the course. Which strategies do they choose for tackling the assigned programming tasks, and which aspects of the tasks do they find particularly challenging? Data for this study comprise sound recordings of student discussions while working together on programming tasks, and focus group interviews where students were invited to reflect on their work with the tasks. Håland also uses items from the questionnaires mentioned above. Preliminary results indicate that students' problem-solving strategies were not optimal; instead of analytically approaching the problems with their knowledge of biology and of programming, students searched for worked examples of similar programming tasks and adopted a trial and error strategy. Students experienced the programming aspects of the tasks as more challenging than the aspects requiring biological insight. On the positive side, students acknowledged that programming was more interesting and useful to them when tied closely to biological issues: one student expressed that *"I didn't know that programming and biology went together so well. I have seen and learned that it is and will be a good tool"*.

Tormod Carlsen Likværn develops and tries out simple programming tasks to be used in the optional physics subject (Physics 1) in year 12 in Norwegian upper secondary school. The tasks are designed to help students work towards learning goals defined in the national curriculum and to illustrate for them the central role of modelling with computer programs in physics research. The programming tasks have been designed in dialogue with CCSE staff, and during 2018, a programming task related to Bohr's model of the hydrogen atom has been tried out in two physics classes at a school in the Oslo area. Focus group interviews have been performed with students from the two classes, and analyses are ongoing to find out how the physics students approach the programming task, what they find interesting and challenging in the task, and which aspects they find motivating (or the contrary) and why. This project is a collaboration between the CCSE, the Department of Informatics and the Department of Physics. The ongoing reform of Norwegian school curricula, where programming is expected to become part of the curriculum for upper secondary physics, makes this master's project particularly timely.

ACTION PLAN

Action	Description	2017		2018		2019		2020		2021		Milestones and Deliverables
		i	ii	i	ii	i	ii	i	ii	i	ii	
A3.1	**School-university transition program**											
	Establish school-university transition base study				M							Report (PhD2)
	Develop and test adapted transition practices							M				Practices in repository; Research art.
	Study effects on motivation, retention and results										M	Research articles
	Publish research articles on results						M		M		M	Publish 1 articles/yr
A3.2	**Student-spaces, mentor programs and startup seminars**											
	Study student self-organization in student spaces							M				Research report
	Develop student-teacher off-curriculuar activities in student spaces			M								Initialize; Regular acticities
	Support and extend student-student mentor program	o	o	o	o	o	o	o	o	o	o	Report from mentoring programs
	Support startup seminars focusing on learning-to-learn, study strategies	o	o	o	o	o	o	o	o	o	o	Reports from seminars
A3.3	**Teacher culture development**											
	Establish annual teacher retreat to focus on sharing and development		M		M		M		M		M	Yearly retreats; Reports
	Organize regular educational workshops and seminars	o	o	o	o	o	o	o	o	o	o	Reported workshops and seminars
	Develop teaching teams for main introductory courses						M				M	Teams in 2 courses; Report
	Study effects on learning environment and student evaluations						o	o	o	o	o	Research (PhD2, Postdoc)
A3.4	**Quality systems and student evaluation methods**											
	Develop and test efficient web-based student evaluation system				M		D		D		D	M: Implement system; D: Reports
	Present and discuss student evaluations at teacher retreats				M		M		M		M	
	Develop effective group-based evaluation systems for courses								M		D	M: Implement; D: Reports
A3.5	**Promote teaching skill renewal**											
	Develop pedagogical courses and workshops for CSE skills				M		M		M		M	M: Reported courses
	Support educational sabbaticals for course development				D							Implemented at Faculty
	Establish career goals for teaching proficiency and excellence										M	Develop; Implement pilot
	Establish teaching academy of excellent teachers at Faculty									M		Established pilot

Table legend:
M: Milestone, D: Deliverable, o: Ongoing
Colors indicate progress. : according to plan, : adjustment, : delayed

Comments

A3.1: The school-university transition program has been postponed because a major development and research project on the integration of computing in schools have been established instead (See WP5).

A3.2: Startup seminars are well functioning and will continue to be developed in 2019. Student-student mentor programs have been postponed because focus has been placed on learning assistants instead. The need for such programs will be reevaluated in 2019.

A3.3: Teaching days are running at several departments, including the Department of Physics. Teaching teams will gradually be introduced in 2019 and 2020 as new teachers are taking over courses. Teams will be strengthened through the Learning Assistants project.

A3.4: A group-based evaluation system is in use at the Department of Physics. New student evalution systems have been postponed, awaiting the Excellent Teaching Practitioner system at UiO.

A3.5: A summer institute was organized in 2018 with facilitators from University of Minnesota. A summer institute on the integration of computational methods into physics courses will be organized in 2019. Data-based methods are developed in the course FYS3155 – Data science and machine learning. The establishment of teaching proficiency standards will have to wait for the University of Oslo's central decision on its excellent teaching practitioner status system.

Activities and plans

WP4: Student-driven activities

Leader: Tellefsen

GOAL

Develop a set of student-driven activities to engage students deeply in educational development. Hereunder, (1) Establish student partnership board; (2) Support educational research projects where students collaborate with pedagogical researchers; (3) Support student development of material, exercises and case studies; (4) Support that student teaching assistants develop, share and document expertise through mentoring, courses, and workshops; (5) Support student-developed instruction initiatives such as short courses, seminar series and science competitions; (6) Support student innovation projects; (7) Support research activities for bachelor students; (8) Support student internships in research and industry.

ACTIVITIES

Student development of curriculum

Bachelor- and master-level students contribute to curriculum development and the development of teaching practices through (1) direct development of learning material, (2) participation in teaching activities as teaching assistants, and (3) through student research activities. Bachelor- and master-students are hired to develop new learning material. Every year, CCSE publishes calls for summer student development projects for teaching faculty. The departments coordinate the applications. The applications are evaluated by the CCSE working group and prioritized depending on how well they align with the objectives of CCSE and the quality of the project. In 2018 we received applications for 1.2 million kroner and rewarded 1.1 million kroner for projects, providing the departments with 22 summer student projects. The teaching faculty are then responsible for finding students for the projects. The students are hired directly at CCSE and we have meetings with all students at the beginning and end of their working period. In 2018 22 students worked on curriculum development in subject areas such as nuclear physics, introductory chemistry, introductory astronomy, introductory geoscience, introductory statistics and in several bioscience courses. In biosciences, support was provided to develop exercises for BIOS1100 – Introduction to computational modelling in bioscience, as well as to third-semester courses. The students who were involved in developing material, were also hired as teaching assistants in the course. In addition, summer students were hired to develop exercises in subsequent courses in bioscience, such as the first course in physiology. Students are teachers presented their results and experiences from the application of the results at the annual CCSE Christmas seminar.

Student research projects

Introducing students to research already in the bachelor program is a goal of CCSE. We provide students with relevant skills – computational methods – that make them attractive as research assistants already from the first year. We have therefore developed student research projects that hired 12 bachelor students in 2018 (See box). In addition, we have initiated several research and development projects where students are involved. We have also bachelor- and master-students to contribute to data processing using machine learning and data science methods to study large-scale educational data such as learning data from the usage of video lectures in large-enrolment classes. This resulted in one published article in 2018 by Robert Solli, John Aiken and Danny Caballero. The paper describes a machine learning model that attempts to connect student grades with their click behavior with video lectures.

PLANS AND PRIORITIES FOR 2019

- Establish one fully student-directed project in 2019
- Continue summer student projects with focus on Jupyter notebook applications
- Develop basis for qualification system for teaching assistants
- Extend student research projects to 20 students/yr
- Apply for additional funding for further summer student projects.

ACTION PLAN

Action	Description	2017		2018		2019		2020		2021		Milestones and Deliverables
		i	ii	i	ii	i	ii	i	ii	i	ii	
A4.1	**Establish student partnership board**											
	Establish board, organize regular meetings and reports to leadership				M		M		M		M	Established; Meetings
A4.2	**Support educational research project using students**											
	Support use of students for in-class observation and reporting			o	o	o	o	o	o	o	o	Reports on use
	Support student-driven data collection and evaluation projects											Reports on use
A4.3	**Support student development of material**											
	Support 3-6 summer students/yr to develop exercises and cases	o	o	o	o	o	o	o	o	o	o	Reports on use; Results in repository
	Support 2-4 student blog/web projects/yr	o	o	o	o	o	o	o	o	o	o	Reports on use; Results in repository
A4.4	**Develop and document students' pedagogical expertise**											
	Organize biannual teaching assistant workshop		D	D	D	D	D	D	D	D	D	Workshops organized
	Support student-organized teaching retreats					M			M			Reported retreats
	Support student-driven pedagogical mentors									M		
	Implement qualification system for teaching assistants										M	Pilot implementation
A4.5	**Support student-organized courses, seminars and competitions**											
	Support student-developed instruction through scholarships	o	o	o	o	o	o	o	o	o	o	Report on use
	Establish and support student science competitions	o	o	o	o	o	o	o	o	o	o	Report on use
A4.6	**Support student innovation projects**											
	Support 2-4 student innovation projects/yr	o	o	o	o	o	o	o	o	o	o	Report on use
	Organize yearly student innovation meeting				M		M		M		M	Yearly meetings arranged
A4.7	**Support research activities for bachelor students**											
	Organize research projects for 2nd, 4th, 6th semester students,	o	o	o	o	o	o	o	o	o	o	Yearly reports
	Support 1-3 student teams working on summer research projects	o	o	o	o	o	o	o	o	o	o	Yearly reports
A4.8	**Support 2-5 student summer internships in research or industry**	o	o	o	o	o	o	o	o	o	o	Yearly reports

Table legend:
M: Milestone, D: Deliverable, o: Ongoing
Colors indicate progress. : according to plan, : adjustment, : delayed

Comments

A4.1: The student partnership board has not yet been established. Priority has been given to build the school activity in 2018.
A4.2: Education research projects started in 2018 according to plan. First paper from student researcher published in 2018.
A4.3: Student development of material is proceeding according to plan.
A4.4: Teaching assistant workshops are organized. Student-driven activities in educational development will be postponed until good models have been found.
A4.5: Student-organized courses have not been prioritized in 2018. Focus has been on education research and international student exchange.
A4.6 Student innovation has not been prioritized in 2018. These projects will be reevaluated along with the action plan in 2019.
A4.7: Research activities have been significantly extended through external funding.
A4.8: Summer internships have been financed through external financing from Thon foundation.

GRAND CHALLENGES FOR STUDENTS – THON SUMMER PROJECT 2018

Bachelor-students in physics have learned basic computational methods already in the first semester. This provides them with skills that are directly useful for research projects. However, the students have little experience with research and how it is conducted. We have therefore established a program where students participate in research projects with top international researchers. We have selected three fields of research – computational physics, geoscience and neuroscience.

During the first year of the project in 2017, students explored three different project directions. The students were taught by PhD-students and senior researchers – providing them with detailed instructions on how to set up and analyze large-scale simulations on the national computational infrastructure and local supercomputers.

In the second year, we selected three students from the first year to be team leaders for the new students. Each senior student got a small team of 1-2 students to supervise. The senior students introduced the new students to the research questions, the research literature and the methods used to set up, run, and analyze simulations. This provided both senior students and junior students with a useful learning experience both in research and team work.

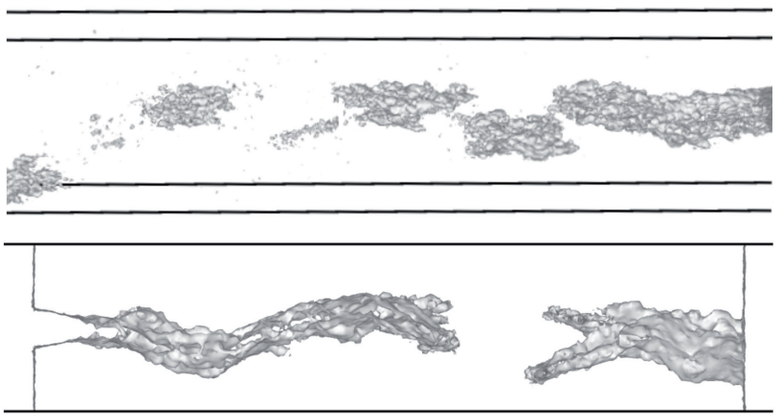

Figure 4: Illustration of simulations of supershear fracture – a fracture propagating faster than the (Rayleigh) speed of sound in the material. Simulations by Didrick Kruse.

Activities and plans

WP5: Dissemination, dialogue and communication

Leader: Mørken

GOAL

Develop and apply a research-based approach to dissemination locally, nationally and internationally. Hereunder, (1) Disseminate learning material; (2) Disseminate internally at UiO; (3) Extend to other programs at UiO; (4) Extend horizontally to other institutions nationally and internationally; (5) Extend vertically to the school system.

ACTIVITIES

CCSE has a major role to play in how to define and develop computational skills

The importance of digital skills is increasing and stakeholders from government to industry are focusing more on digital competence and digital skills from school through university education. CCSE has a unique approach since we are focusing on digital skills in a disciplinary context. CCSE therefore stands to take a leading role in defining what constitutes digital competence and how to integrate digital competence in disciplinary educations. In 2018 CCSE has been closely involved in strategic and developmental processes at the departments, the Faculty, at the university, nationally and internationally. (See the product list for an overview of activities).

Extension beyond science

We have initiated work to develop learning material for introductory courses in political science. Two summer students, one with background in political science and one with a background in computational physics has developed examples and exercises that integrate computing in a course in political science. A central part of the new honours program at UiO will be digital skills. Humanities students will learn to program, and both science and humanities students will analyze real data using computational data science methods. We are continuously working to develop more examples to illustrate how computing can be integrated in learning materials in many disciplines.

External dissemination

CCSE personnel has been invited to a number of seminars at external institutions, both nationally and internationally. Many institutions in Norway, Europe and the US are in the process of developing new curriculums or establishing activities in computational science, and CCSE are in a position to contribute and help this development. In 2018 we plan to initiate a European partnership to develop the competence needed to educate the next generation of teachers and researchers with computational competence.

International disseminiation

CCSE har a long-term collaboration with the National University of Defense Technology in China. They have previously introduced basic programming courses using curricula developed at CCSE. In 2018 at NUDT delegation with physics teachers visited CCSE in order to learn how to integrate computing into basic physics courses. NUDT has disseminated their programming course to 35 other Chinese Universities, and we expect a collaboration on physics education to have a similar impact.

Visiting scholar – John Burk

In the academic year from 2018 to 2019 John Burk has stayed at CCSE for a whole year at a visiting scholar. John Burk is an outstanding teacher at St. Andrew's School in Delawere. He has extensive experience with introducing computing as part of mathematics and physics, he is an outstanding popular science writer, and he has published several articles on the integration of computing in the school curriculum. He has contributed to build up our school activity program, and contributed to develop our understanding of didactic perspectives. We are honoured that John Burk selected us for his sabbatical stay, and hope that this would form the basis for a long-term collaboration.

School partnership

The school activity has grown significantly in 2018, becoming a major activity at CCSE. (See box).

PLANS AND PRIORITIES FOR 2019

- Confirm CCSE as the national resource on computing in education and digital competence from schools to higher education and research
- Consolidate extension to bioscience also in second and third years

- Become recognized as the national leader for computing in school education
- Provide incentives for students to be involved in dissemination activities

ACTION PLAN

Action	Description	2017		2018		2019		2020		2021		Milestones and Deliverables
		i	ii	i	ii	i	ii	i	ii	i	ii	
A5.1	**Internal dissemination at UiO**											
	CSE workshop for UiO leadership at various levels	o	o	o	o	o	o	o	o	o	o	Workshops arranged
	CSE workshops on computational methods and practices for faculty				M		M		M		M	Workshops arranged
	CSE workshops on computational methods for teaching assistants			M		M		M		M		Workshops arranged
A5.2	**Extension to new programs at UiO**											
	Extension to bioscience program											
	Develop plans and study programs with department leadership		M									Plans developed
	Develop new introductory CSE course for biology students		o	o	M							Course implemented
	Develop new textbook for introductory courses		o	o	D					D		Preliminary textbook; Published text
	Integrate CSE into other biology courses						M		D		D	Initiate; Implemented in 2 courses
	Test pilot courses on biology student groups, evaluate and improve		M						M			Reports
	Evaluate and adjust CSE approaches in new courses								M			Reports
	Evaluate and review approach and study program design									M		Reports
	Extension to other programs (chemistry, geoscience)							o	o	o	M	Materials and texts in repository
A5.3	**Extension to other institutions**											
	Extension to University College of Southeast Norway											
	Develop introductory course and material for programming		o	o	o	D						Course developed
	Adapt material from UiO to local courses				o	o	o	D				Adapted material and texts
	Research and evaluate adaption, iterative improvement					o	o	o	M	o	o	Research (PhD1, Postdoc)
	Develop material for other University Colleges								o	o	M	Material (if applicable)
	Extension to other Universities											
	Support adaptation and extension through workshops and support			o	o	o	o	o	o	o	o	Reports on workshops arranged
	International extensions											
	Study application of material at Michigan State University		o	o	o	o	o	D	o	o	o	Research articles
A5.4	**School partnership**											
	Develop school visit program		o	o	o	o	o	M				Material developed
	Pilot school visit program with partner school						D		D		D	School program initiated
	Evaluate and improve visit program								o	o	M	Report from evaluation
	Extend program to other schools									o	M	Other schools included in program
	Research effect on recruitment, retention and exam results									o	D	Research (Postdoc)
	Research effect on school teachers									o	D	Research (Postdoc)

Table legend:
M: Milestone, D: Deliverable, o: Ongoing
Colors indicate progress. : according to plan, : adjustment, : delayed

Comments

A5.1: CCSE has developed workshops for leaders, teachers and students. This work is well on track. See product list for details.

A5.2: Extension to bioscience is progressing according to plan (see box). Extension to chemistry and geoscience is gradually extended through student projects.

A5.3: A collaboration agreement between UiO and University College of Southeastern Norway (USN) is signed, and the progress at USN has been exceptional in 2018 (see box). CCSE has initiated collaborations with most other universities in Norway in 2018, and have also actively communicated our results to possible international partners.

A5.4: The school exchange program has been postponed in order to coordinate with new developments in the school curriculum.

INTRODUCTION TO COMPUTATIONAL MODELLING IN BIOLOGY –INTEGRATING COMPUTATIONAL MODELLING INTO THE BIOSCIENCE BACHELOR PROGRAM

Lex Nederbragt with contributions from Mark Ravinet, Anja Røyne, Ida Scheel, Hans Petter Hersleth and Marianne Fyhn.

BIOS1100 - "introduction to computational modelling in bioscience"

2017 saw the introduction of new bachelor programs in all science disciplines at UiO, and with it, now also the bioscience program introduces computational modeling early in the program. Students are already exposed in the first semester with the compulsory course BIOS1100 - "introduction to computational modelling in bioscience". CCSE has played a central role in developing this course, and it was given for the second time in 2018. The course is based on a new textbook written by four PhD-students in neuroscience who all have backgrounds in computational physics. The textbook is the first of its kind to introduce programming in Python and computational modelling fully anchored in a biological context. The course is taught by Lex Nederbragt using novel, active learning methods in the new active learning classroom at the Department of bioscience.

An important part of the design of BIOS1100 is to introduce students to programming and modelling through *biological problems*. In this way, the students see the relevance of the material taught, which is important for student motivation and learning. Problems ranging from population growth and dynamics, inheritance, DNA analysis and disease epidemics are used to gradually introduce more complex programming and modelling methods.

New this year was the extensive use of Participatory Live Coding as the main technique to teach programming. With this technique, a teacher (or teaching assistant) does live programming, with the students copying and executing the exact code or commands that are being written. The instructor reads what is being typed out loud,

Figure 5: Illustration of classroom used for BIOS1100. (Photo: Lex Nederbragt)

explaining the different elements and principles. Teacher and students all execute the commands or program, leading to an immediate evaluation of the results. Crucially, the session contains many, often short, exercises, where students are asked to solve a small related problem on their own. This approach appears to work better than lecturing about programming or relying on students to read a textbook. What is taught is immediately applied. The experience from 2018 told us that the technique leads to high student satisfaction, but can be time consuming, leaving little time for independent student-driven work on exercises. For the future, a better balance between live coding and independent problem solving by the students will be sought.

BIOS1100 also aims to teach students the required mathematics in order to be able to develop and implement appropriate computational models. This year, we were able to enroll an external, skilled teacher from the Institute of Mathematics, Arne Sletsjøe, for this part. He taught three chapters from the book 'BioCalculus'. In the group sessions we aimed to integrate the mathematics with the programming when implementing sim-

ple models. Students reported that they did not always see the connection between the mathematics and the rest of the course, which will be addressed in further iterations.

Besides BIOS1100, students also took BIOS1110 a course on cellular and molecular biology, in the same semester. In BIOS1100, some of the exercises were based on material the students had just learned in BIOS1110. Students appreciated the connection between the two courses, but they reported wanting a more balanced coupling, i.e. to have programming exercises in BIOS1110 as well. The third course the students took was a basic Chemistry course, where computing was not a major aspect of the teaching.

The students of the 2018 edition of BIOS1100 are also the subject of two Masters' degree projects that address students' attitudes and expectations towards using computional modelling in bioscience, and the approaches used by the students during programming tasks.

Beyond the first semester

Our long-term goal is for students to experience computing and modelling across many courses throughout the bachelor program to ensure that students develop and use these skills in a disciplinary context. For students in the Biosciences bachelors program, the first three semesters consist of obligatory courses. Students that took BIOS1100 in the fall of 2017 have been through two more semester of the biosciences program. Most of these courses have introduced elements of computational analysis that build on the skills from the first semester.

Second semester

In the second semester, courses use the Python in some of the practical work.

BIOS1120 – Physiology: In this course, students explore physiological phenomena using simple programming in Jupyter notebooks. The code was heavily «scaffolded» and the students were asked to either change parameters in the code or use sliders to change parameters in equations to be used. The feedback from students was good. They reported that they liked exploring concepts and functions in this way. The reported that they got a better understanding of some principles. In 2019, we expect all students to have completed BIOS1100 and our goal is to build on this knowledge, offer practical training and extend their expertise by introducing data analyses, plotting of data, uncertainty estimation and simple regression analyses.

FYS1001 – Introduction to Physics: In FYS1001 computations have been integrated into some of the weekly seminar exercises. Students responded positively and report they get a lot out of them as long as they were heavily «scaffolded» - meaning the students don't need to do a lot of coding themselves. Asking students to change equations, update plots and use it to visualise and test models works well. For the next iteration, exercises will be more simplified and scaffolded.

BIOS1130 – Biochemistry: In this course, computer labs are used with Graphical User interface-based programs (PyMOL) to visualise protein structures and gain insight into their structure and function. Although the program is Python based, students do only a minimal amount of programming. In addition, they learn to use both Excel and Origin to plot their data and to do curve fitting. There is a clear potential to replace these tools with programming in Python.

Third semester

In the third semester, two of the three courses use the language R for their analytical work. R is cur-

Continues on the following page

rently used by many biologist and many relevant tools are currently available only in R. However, the use of R is currently declining compared with Python and R is not a language well suited to learn good programming practices or general aspects of computational literacy.

BIOS1140 – Evolution and Genetics: Students were introduced to R, learned how to handle and visualise datasets and gained insight in to the basics of programming in R. Importantly, students were shown how they can use R to demonstrate complex concepts in the field of evolutionary genetics. In general, this went well although there were some teething troubles at the beginning. The level of complexity had to be adjusted later in the course to adapt to the level of the students. Some students reported they felt they could have had more freedom to explore the code that they put together. For future editions, a suggestion would be to give students additional tasks outside the classroom that build upon what they learn during the data lab sessions.

STK1000 – Introduction to Applied Statistics: R is an integrated part of the teaching of STK1000 through the whole semester. It is demonstrated in the lectures and practiced by the students in the weekly assignments. The students also practice through two mandatory assignment sets, where descriptive statistics and statistical analysis by using R is central. STK1000 is a 'user course' provided by the Institute for Mathematics, where the largest student groups come from the bachelor program in bioscience and the bachelor program in geology and geography. During the summer 2018, three CSE summer students (one from Biosciences, one from Geology and one from Mathematics) worked on finding suitable data sets and creating accompanying mandatory assignments, two assignment sets with data from biosciences and two assignment sets with data mainly from geology.

The road ahead

The descriptions of how the different courses implement computations show that we have started on a promising path towards integrating computation in all subjects in the first three semesters. However, the second and third semester courses use a lot of scaffolding (giving students pre-made code that they could modify, rather than write a program from scratch. Also, the modelling aspect of Computing in Science is not really expanded on, and mathematics education is as of yet not sufficiently integrated. We clearly have a potential for a deeper integration of computing and computational modelling in these courses.

Once students start the fourth semester, they choose from a range of courses, gradually specialising into a particular domain in the Biosciences. The next major step in the integration of CSE into the bioscience program will be to achieve integration of computational modelling in these courses, where appropriate, and to create new courses leading to a specialisation in computational biological modelling.

The Department of bioscience is the first to introduce such as a clear computational perspective in the study program in Norway and probably also internationally. We are excited to work with the CCSE to provide tomorrow's biologists with an education that includes teaching them computational skills that we believe are essential for their careers - no matter their chosen career path.

PROFAG – PROGRAMMERING I FAGENE (PROGRAMMING IN THE SUBJECTS)

During 2018 CCSE has extended its work on integrating computing in science education to include the Norwegian school system.

Background

In the school year of 2017/2018 three schools in Norway tried out a new school subject called Programming and Modelling X (Utdanningsdirektoratet, 2017). This is an optional subject for year 12 or 13 especially suited for students doing science and mathematics. For the school year of 2018/2019 it was decided by the Norwegian MoE to expand the number of schools offering this subject to 50. CCSE realized that the teachers who were going to teach this subject would need training in scientific programming. We therefore developed ProFag – programming to enhance the understanding of the subject (Norwegian: subject = fag). The decision to develop ProFag was also motivated by the major curriculum renewal for the Norwegian school system that will be implemented from the fall of 2020. In this reform, programming will be a mandatory part of both mathematics, natural science and other subjects throughout the school system.

Since most of the Norwegian teachers in mathematics and natural science are not familiar with computer programming, and much less how to teach this to a diverse group of students at different ages, CCSE joined efforts with the Department of informatics and developed in-service teacher training courses for both lower secondary school teachers (year 8-10) and upper secondary school teachers (year 11-13). The approximate number of teachers in need of this competence in 2020 is 40 000.

ProFag content

Knowing a discipline is not the same as knowing how to teach the discipline(Cochran-Smith & Zeichner, 2006). There is little knowledge and research on how to teach computing in science education. Teaching is a profession, and in-service teacher training in scientific programming needs to address how children of different ages can develop computational literacy and how programming can contribute to deep learning in mathematics and science. Programming is more than writing code. It is a way of thinking and a way of addressing problems. Computational literacy (CL) involves at least three different aspects (diSessa, 2018);

1. *Material CL:* being able to program (make/write code)

Figure 6: ProFag in-service teacher course. (Photo: Simen Kjellin/UiO)

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2. *Cognitive CL:* using computation to solve problems and to understand the world
3. *Social CL:* communicating about computation and how it is used

The ProFag-courses aim to address all three of these. In addition, the ProFag-courses focus on how programming can (i) strengthen the content understanding in mathematics and natural science and contribute to deep learning, and (ii) how programming can change the content by enabling the students to work with more realistic problems and use of real data.

Dissemination

CCSE has given a two-day course for upper secondary school science teachers in 2018. The first day was in June. During the summer, the teachers had access to help on a digital, social platform, and they returned for the second day in September. The course material is available online with free access for everyone: https://uio-profag.github.io/vgs. The course had 42 participants from 25 different schools from Stavanger in the south to Sandnessjøen in the north of Norway. For lower secondary school, ProFag has a project with the Education Department of Oslo City Council (UDE) called ProFag:U, allowing 42 teachers to attend one full day and four half-days of in-service teacher training. The first full day took place in November 2018 and the four half days in the Spring of 2019.

One major challenge with the curriculum renewal is finding a model for competence dissemination. In ProFag:U we develop modules for the teachers to work on as part of the local training of their colleagues. They work in four steps; 1) Preparatory work 2) Cooperation 3) Try out and 4) Rework, see figure 2. All the material is available on Canvas: https://uio.instructure.com/courses/14016

Further development – where do we go from here?

The ProFag courses give valuable input on how to meet the challenges of the teacher. For each course we iterate on the resources available online.

At the University of Oslo, we have an integrated five year master program to become science teachers for year 8-13. These students attend the disciplinary courses given at the faculty for math and science and hence learn scientific programming.

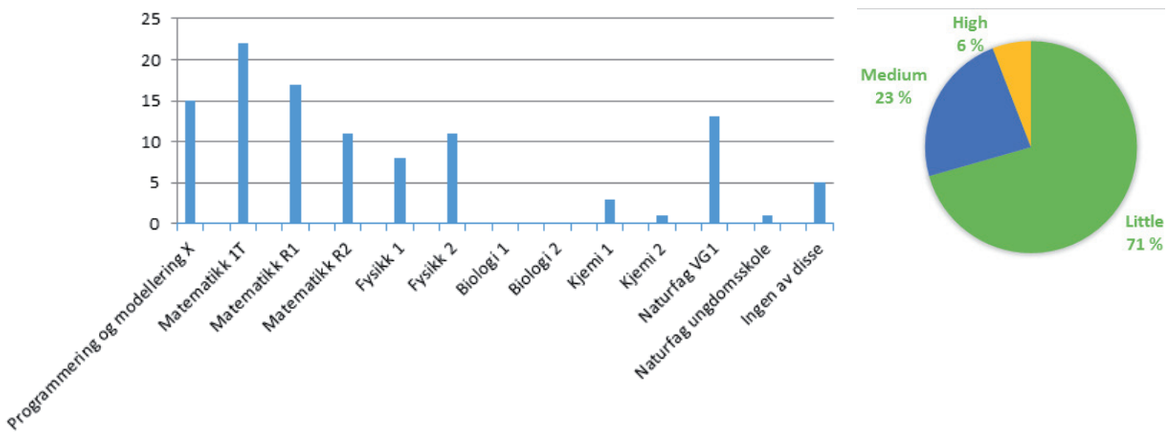


Figure 7: (Left) The background of teachers participating in ProFag. (Right) Teachers attending ProFag:U responding to the question "To what extent are you comfortable with programming?" before the first day of the course.

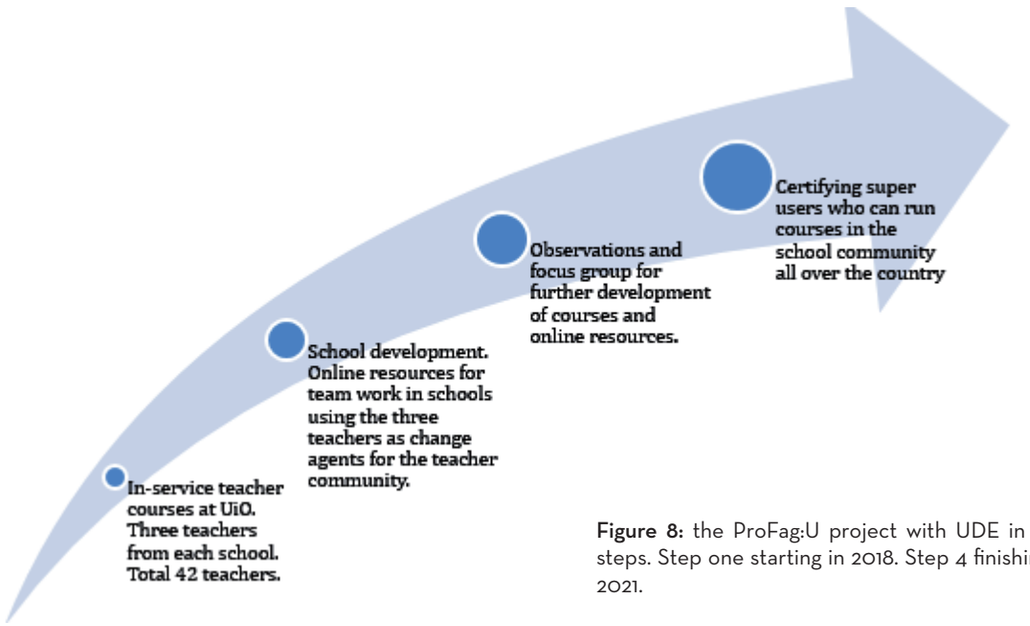
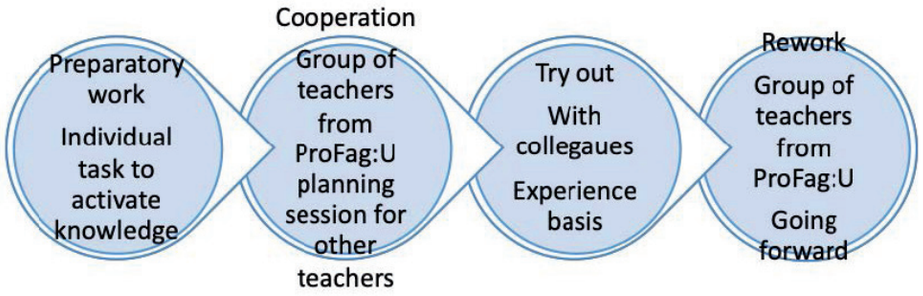


Figure 8: the ProFag:U project with UDE in four steps. Step one starting in 2018. Step 4 finishing in 2021.



However, the rest of the teacher educators in Norway have little or no focus on computing in science education. Thus, there is also a need to teach the teacher educators. And to focus on *teaching* computing and not only to use it for yourself for the UiO pre-service teachers.

References

- Cochran-Smith, M., & Zeichner, K. M. (2006). Studying Teacher Education. The Report of the AERA Panel on Research and Teacher Education: Routledge.
- diSessa, A. A. (2018). Computational Literacy and "The Big Picture" Concerning Computers in Mathematics Education. *Mathematical Thinking and Learning*, 20(1), 3-31. doi:10.1080/10986065.2018.1403544
- Utdanningsdirektoratet. (2017). Forsøkslæreplan i programmering og modellering X Retrieved from https://www.udir.no/kl06/PRM1-01

University of South-Eastern Norway

Report from the CSE activity at USN

Ole Marius Lysaker and Randi T. Holta, USN

In spring 2018 the project «An engineering education for the future" was initiated at USN. The project addresses a reorganization and coordination of the engineering education at the newly fusionized institution USN. As part of the engineering program, as students will have a 5 ECTS course in scientific programming in Python in the first semester. Furthermore, scientific programming will be used as a tool throughout the study program in courses in mathematics, physics and related subjects.

ACTIVITES

The Faculty for Technology, Natural Sciences and Maritime Sciences (TNM) consists of 6 institutes, Campus Porsgrunn, Campus Kongsberg and Campus Bakkenteigen. In total, TNM offers 13 bachelor engineering programs. Adding an additional course of 5 ECTS in the first semester therefore implied a complete redesign of all the engineering degrees at TNM. All courses, programs and study directions had to be adapted to the new regime. Seven working groups were established, where one group was responsible for the sciences and computational education.

The mandate for this working group was: (i) to suggest a common structure for the introduction of a computational perspective on the education in the science, (ii) to develop a common framework for the basic education of programming, and (iii) develop a common structure the the first mathematics course across all campuses and program aiming at a common exam in 2021.

The following people were appointed to the working group: Professor Marius Lysaker (Porsgrunn); Associate professor Andre Vagner Gaathaug (Porsgrunn); University lecturer Morten Borg (Porsgrunn); Professor Lars Morten Johansen (Kongsberg); Professor Måns Dainel Larsson (Kongsberg); Unversity lecturer Joakim Bjørk (Kongsberg); Professor Ulrik Hanke (Bakkenteigen); Associate professor Nhon van Vo (Bakkenteigen); and student councelor Merete E. Hovet (Bekkenteigen).

The following activities have been carried out in 2018:

- May 2: "Kick-off in Porsgrunn" Programming in education, workshop (30 people); Talks by Knut Mørken (CCSE) on CCSE; Svein Linge (Campus Porsgrunn) on "Experiences from introducing programming in teaching"; Willem Meijer on "The students' experience with programming-based teaching".
- June 12: Seminar in Holmenstrand "Redesign of the engineering education at TNM" (40 people).
- October 15: Working group seminar (30 people)
- December 15: Seminar at CCSE (4 people from TNM attended)

The working group has organized several meeting in the fall of 2018. Focus for these meetings have been how to insert the new programming course and how to introduce computing in subsequent courses. This requires defining the contents, learning outcomes, pedagogical boundary conditions, teaching methods and learning materials for the new course in scientific programming.

All engineering programs at Campus Porsgrunn, Kongsberg and Bakkenteigen today has Python and computational methods integrated in the education, but to various degrees. Therefore the working group and other key personnel have worked to develop and coordinate learning materials for computational courses across the various locations.

Members of the working group have also several times visited middles schools to teach Python programming. The feedback from students and teachers have been very positive. Two of the middle schools have been inspired to start their own elective course in Python programming.

STATUS

USN and TNM has decided to take a nationally leading role by introducing scientific programming as an integrated part of the professional education. Today, scientific programming is included in physics and mathematical courses at the engineering educations. Furthermore, there are plans for how programming will be integrated into the individual courses in various study programs.

Fall year 1	Spring year 1	Fall year 2	Spring year 2	Fall year 3	Spring year 3
Programming (5)	Mathematics 1 (10)	Physics (10), Statistics (5)	Mathematics 2 (10), Chemistry (5)	Mathematics 3 (5)	

This is demonstrated in the course matrix. All students have a common course in scientific programming from 2020. This ensures a common basis in programming for all engineering students. The matrix shows courses where it is natural to integrate computing. USN has also decided that Mathematics 1 will be a common course across all campuses. This entails a common curriculum, common learning outcomes, and a common exam. Numerical methods and scientific programming plays a central role in this course, which starts in 2021.

FUTURE PLANS

The main focus for the working group will be to (i) develop learning materials for the new course in scientific programming, (ii) teach the teaching faculty at TNM Python and scientific programming, (iii) continue coordination of courses across campuses, and (iv) increase the visibility of USN as a partner in a CoE.

R&D-based education at CCSE

STUDENT-ACTIVE LEARNING AND R&D BASED EDUCATION AT CCSE

Physics education research have rigorously documented the effect of student-active teaching methods, yet these methods are sparsely used[1]. This has motived researchers to develop a research-based approach to dissemination that takes into account the many complexities of educational change[2]. Our dissemination strategy builds on these research-based recommendations. We therefore strive to provide easily modifiable materials; disseminate research ideas in addition to curriculum since users often modify methods; adapt approaches to realistic situational constraints; and involve faculty as partners and provide support.

Based on these insights, CCSE and KURT (the Competence center for teaching in science) have initiated a set of measures to disseminate the use of student-active teaching. Research findings are presented at faculty workshops; we partner directly with teachers in important courses to develop student-active methods and include teacher students in mentoring and instructing teaching assistants (TA) both during the TA workshops, and in individual and group sessions. We are developing a week-long Summer Institute, in collaboration with University of Minnesota, where teachers engage in both understanding research and applying it to their specific situations over an extended time period. Similar initiatives are developed to teach computational methods and how they can be used in student-active teaching scenarios. This development depends on the close collaboration between experienced instructors, didactic researchers, education researchers.

These experiences are now extended into the Learning Assistants project, where we also provide Learning Assistants with an extended course in relevant pedagogy extending over a whole semester and closely integrated with their teaching activity. This forms a basis for an even stronger focus on raising the level of pedagogical competency in the teaching faculty.

ADDED VALUE OF R&D BASED EDUCATION AT CCSE

A particular strength of the integration of computational methods is that it also changes the dynamics of the learning situation: The students learn tools that allow them to address research-based problems early on, apply work flows that are the same as found in research, and engage in discussions with peers and instructors on issues that are open and exploratory instead of closed and binary (right/wrong) as often found in science curriculums. This is an essential component of our vision and philosophy – the integration of computing opens new opportunities for student activities that previously could not be pursued.

The learning material and approaches that are developed by students and teachers are designed to encourage and simplify student activities and peer discussion. However, this depends on a strong research-basis in computational methods related to the particular discipline. The examples and problems must be developed by researchers that master both the computational and disciplinary aspects of the field. In addition, the research education group provides direction as to what approaches are fruitful, and studies the effects of methods and materials directly. Interactions between teaching faculty – with the relevant research background – and education researchers will be facilitated by the center through workshops and summer institutes. In these situations, we can also provide

1 Henderson, C. & Dancy, M. H. "Impact of physics education research on the teaching of introductory quantitative physics in the United States". *Phys. Rev. Spec. Top. - Phys. Educ. Res.* **5**, 020107 (2009).

2 Henderson, C., Dancy, M. & Niewiadomska-Bugaj, M. "Use of research-based instructional strategies in introductory physics: Where do faculty leave the innovation-decision process?" *Phys. Rev. Spec. Top. - Phys. Educ. Res.* **8**, 020104 (2012); Dancy, M. & Henderson, C. "Pedagogical practices and instructional change of physics faculty". *Am. J. Phys.* **78**, 1056–1063 (2010).

example and scaffolds for examples and exercises that can be adapted to the specific situations.

Several student-active methods have recently been introduced in both FYS1001 and BIOS1100. Students solve quizzes in small groups in the learning laboratory, and work with combinations of computers and physical props to learn programming concepts. Initial results from interviews with students in the course, showed that a non-significant group of students lacked basic skills that were needed to succeed in the course. A well-known method from Software Carpentry – live coding where an instructor writes code and all students write the same code on their individual computers – was therefore introduced. The effects of these practices will be addressed as part of the education research groups activities.

MEASURING EFFECTS OF R&D BASED EDUCATION

In our plans for an evaluation and impact framework, we addressed the challenge of developing meaningful indicators for student learning in courses with integrated computing. We are applying input and output indicators for student production, grades and evaluations and for teacher and teaching assistant participation in workshops and seminars. However, real insights into student learning depends on effective assessment tools that address both the learning process as well as learning outcomes. There are many standardized assessments from physics education research. We will apply these tests systematically, but these assessments do not measure effects related to computational modelling. This is the reason we have initiated the S-Assess project, which will be a focus of the education research group at CCSE. We have also started to apply standardized assessments in the introductory courses in mechanics and electromagnetics in physics, and will report on these tests as the results are collected.

STRUCTURAL MEASURES TAKEN TO DEVELOP R&D BASED EDUCATION AND STUDENT ENGAGEMENT

CCSE have initiated several measures to develop R&D based education. The summer student projects, where teaching faculty are provided with summer students that can help them translate their disciplinary experience in defining good problems into computational problems provide a good starting point and a good stimulus for teaching faculty. However, we need to ensure the use of these students are more systematically coupled to summer institutes and teacher workshops. Student-driven projects, including student researcher and students performing education research, will help with student engagement and will provide teaching faculty with insight into student thinking. A broader use of think-aloud interviews and analysis of student learning activities in classrooms will also provide teachers with more insight into the learning process and help teachers improve and direct their research. This provides a direct coupling between the education research activity and instructional development.

CONTRIBUTIONS TO INSTITUTIONAL DEVELOPMENT

Activities of CCSE are closely connected with many key, strategic development at the University of Oslo that impact the development of the culture for teaching and learning. CCSE organizes pedagogical education for teachers and teaching assistants through Real Undervisning and Real Utdanning. Two day-long seminars are organized before spring and fall semesters for teachers and teaching assistants. This has developed into an arena for educational development at the Faculty.

CCSE is central in the educational development program InterAct, which is directed by WP leader Knut Mørken. The InterAct project has redesigned all bachelor programs (2017) and all master program (2018). InterAct

currently focuses on professional skill development for master students.

CCSE is also central in the new master program in Computational Science, which started in 2018. The program is the most cross-disciplinary program at the Faculty, with study direction for all Departments, and it is the most popular study direction in Physics. Several new courses and new model for cross-disciplinary education have been developed in this program, which is directed by WP-leader Morten Hjorth-Jensen. He has also developed a new course in Applied data-analysis and machine learning (FYS-STK3155), which has rapidly become one of the most popular advanced courses at the Faculty with 130 enrolled students in 2018.

CCSE has also played a central role in the Faculty's process to form a new strategy, both by providing direct input into the strategy process, by participating in strategy seminars, and because Malthe-Sørenssen is a member of the Faculty board. The new strategy contains a clear vision for digitization and its importance for both education and research at the Faculty.

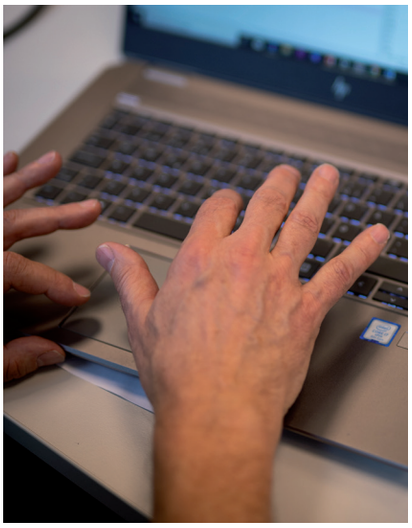
CCSE has been invited to write a part of the new master plan for ICT services at the University. The plan contains a section describing the need to integrate computing in all educational programs and what physical and intellectual infrastructure is needed for this to succeed.

Malthe-Sørenssen has taken the initiative for the new honours program at UiO. This is the first honours program in Norway, following the Dutch model from University of Utrecht. The program is a collaboration between the Faculties for Mathematics and natural sciences and Humanities. A key element in the program is digital competence. In the second year students will learn cross-disciplinary methods, which means that humanities and later social science students will learn programming and data science. This provides a path to develop and test out our dissemination model also when extending to disciplines further from the sciences.

CCSE has initiated the development of the Learning Assistant program, which initially impacts courses in physics and mathematics. However, the ambition is that the program can be extended across the whole university, providing a model for pedagogical training of Learning Assistants in many disciplines. We are also exploring how the LA model must be adapted to address issues in courses with computational content.

CCSE has also been involved in the development of the model for the excellent teaching practitioner program at UiO. Malthe-Sørenssen has two times been an external member for the ETP evaluation process at the University in Bergen – through our good collaboration with bioCeed – and has provided important input to the process at the University of Oslo. However, the model at UiO has some severe shortcomings that may undermine the whole process, and we will in 2019 work to reduce these shortcomings.

CCSE has also been invited to participate in the University of Oslo's process to apply for European University in partnership with 6 other universities across Europe.



Teaching ProFag in CCSE's new locations.

Organization and management

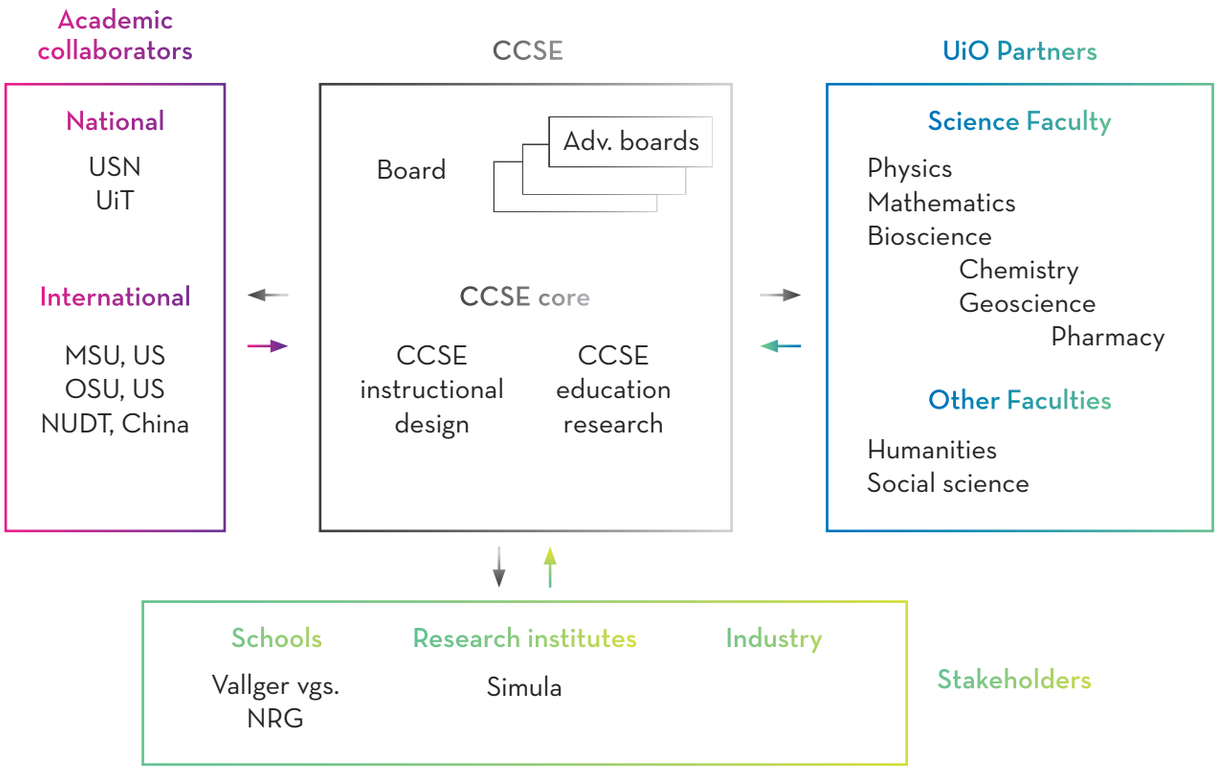
CCSE is directed by Professor Anders Malthe-Sørenssen and supported by an administrative leader, Tone Skramstad. The director is supported by a working group, with an advisory and coordinating function, consisting of the five work-package leaders, the administrative head, director of studies at the Faculty, and a student representative.

The center has a board with representatives from the four main departments, Departments of Physics, Mathematics, Computer Science and Bioscience, a student representative, and two external representatives. The board will have two meetings a year.

The various departments provide contributions to the center in the form of in-kind contributions. For example, the Department of Physics provides a 20% in-kind resource for each of the teachers in the six main courses in physics. This in-kind contribution represents the time teachers use for educational development, but has only to a small degree been realized in 2018. In addition, the Department of Physics provides an in-kind contribution in the form of compulsory work for PhD-students that is used for educational development. Two students have contributed to BIOS1100, one student contributes to BIOS1120 – Physiology, and one student contributes by the integration of computational exercises in FYS1001 – Introduction to physics.

The center has an education research group directed by Associate Professor Marcos D. Caballero and director Malthe-Sørenssen. The group has regular group meetings, and organize invited seminars and researcher visits to CCSE.

Additional advisory boards will be established to support the education research activity, evaluation, and input from stakeholders and students.



NEW EMPLOYEES 2018

Tone Skramstad *(administrative head)* joined CCSE as our new office manager. She comes from a position as manager for the Observatory and has extensive experience from administrative positions at the University of Oslo. She is also an author of a book about the history of the Observatory. In CCSE she is in charge of outreach and communications as well as being the head administrative officer.

Tor Ole Odden *(post-doc)* finished his PhD in Science Education Research at the University of Wisconsin – Madison. The topic of his PhD-research was on sensemaking. He has extensive experience with direct observation in teaching situation, and brings with him a deep understanding of science education research which is complementary to the physics education research competence already in CCSE. He is also responsible for building up the Learning Assistants project at the Department of Physics at UiO.

Andreas Haraldsrud *(senior lecturer, 20%)* is a teacher at Valler high school where he has developed the course "Modellering og programmering X". He has written a textbook for this course and taken the initiate to get the course approved nationally. In the textbook he introduces numerical methods to high school students with examples and exercises using Python as the main language. He provides a very important experience as a teacher which is essential when we address how to integrate computing in the school curriculum.

John Burk *(Visiting scholar)* is the director for academic innovation at St. Andrew's School in Middletown, Deleware. He is a physics teacher with extensive experience from introducing computational methods in physics and mathematics, and he is a computer science teacher. He has published several articles on how to integrate computing in the school curriculum. He also writes a popular science blog, Quantum Progress, with approximately 8000 views/month. He is with CCSE for a one year sabbatical visit. (Photo: Julie Kalveland/UiO)

Lex Nederbragt *(WP leader)* is a Senior Lecturer at the Department of Biosciences, and head of education and training for the Center for Bioinformatics. He leads the implementation of CSE in the bachelor degree at the Department of Biosciences and is responsible for BIOS1100, the introductory course in programming for biology students. He has extensive experience as a Software Carpentry instructor. He leads the Advisory Council for eInfrastructure at UiO. He provides the perspectives from bioscience education to CCSE.

We are all very happy and proud to have all of these fantastic people join us at CCSE!

Personnel

CENTER PERSONNEL

Name	Function	Position	Unit
Anders Malthe-Sørenssen	Center leader	Professor	Physics, UiO
Tone Skramstad	Head of administration	Office manager	CCSE
Knut Mørken	WP leader, 20%	Professor	Math, UiO
Morten Hjorth-Jensen	WP leader, 20% Course development, 20%	Professor	Physics, UiO
Ellen Karoline Henriksen	WP leader, 20%	Professor	Physics, UiO
Cathrine W. Tellefsen	WP leader, 20% Teacher education	Leader teacher education program	KURT, UiO
Hanne Sølna	Administrative mentor	Director of studies	Faculty Adm, UiO

STUDENT REPRESENTATIVES

Name	Function	Position	Unit
Didrick Kruse	Student representative		UiO
Jonas Fløde	Student representative		UiO

External projects

Granting body	Project title	Project period	Funding	PI/partners
Intpart/NRC	US-Norwegian collaboration on fluid-consuming processes	2017-2019	4500 kkr	PI: Anders Malthe-Sørenssen
Thon stiftelsen	Cross-disciplinary grand-challenges for students	2017-2019	1500 krr	PI: Anders Malthe-Sørenssen, Marianne Fyhn, Bjørn Jamtveit
Thon stiftelsen	Student-driven research for improved science education	2018-2021	1500 kkr	PI: Danny Caballero
FinnUT/NRC	Structured assessment method for improved student learning	2018-2023	6000 kkr	PI: Anders Malthe-Sørenssen
Norgesuniversitetet	eAssess	2018-2020	1800 kkr	PI: Omid Mirmotahari, Dept. of Computer Science, UiO; CCSE is a partner
Intpart/NRC	International partnership for Computing in Science Education	2019-2022	4500 kkr	PI: Morten Hjorth-Jensen

Accounting 2018

BUDGET AND EXPENDITURES – DIKU FUNDING 2018

Item	Account No	Budget 2018	Expenditure 2018
Staff costs	5* and (9*)	3 406	5 568
Travel costs	7*	300	682
Dissemination	6* and 7*	710	744
Other costs	6*	710	153
Other costs	7*	600	144
Total		**5 726**	**7 291**

BALANCE 2018 – DIKU FUNDING

Balance transferred from 2017	6 304
Disbursement from Diku 2018	4 847
Available amount	11 151
Expenditure	7 291
Balance	**3 861**

Budget and expenditure

Total Budget and Expenditure 2018

FUNDS

	Budget 2018	Expenditure 2018
Diku	4847	7 291
Inkind	9 070	10 127
Other sources		
Total	**13 917**	**17 417**

EXPENDITURE

Item	Account No	Budget 2018	Expenditure 2018
Staff costs	5* and (9*)	11 597	15 694
Travel costs	7*	300	682
Dissemination	6* and 7*	710	744
Other costs	6*	710	153
Other costs	7*	600	144
Total		**5 726**	**17 417**

Diku Funding for current 5-year period

Item	Account No	Expenditure 2017	Expenditure 2018	Budget 2019	Budget 2020	Budget 2021	Sum
Staff costs	5* and (9*)	1 788	5 568	3 508	3 613	3 613	17 697
Travel costs	7*	163	682	300	300	300	1 745
Dissemination	6* and 7*	453	744	1 010	1 010	1 010	4 227
Other costs	6*	87	153	1 010	1 010	1 010	3 270
Other costs	7*	200	144	-	-	-	344
Sum - Total		**2 691**	**7 291**	**5 828**	**5 933**	**5 541**	**27 283**

Total allocation	
Remaining funds	- 27 283

Overall Funding and expenses for current 5-year period

INCOME

	2017	2018	2019	2020	2021	Total
Diku	9 694	4 847	4 847	4 847	-	24 235
Inkind	6 470	9 190	9 542	9 904	9 775	44 880
Other sources	75	-	-	-	-	75
Total income	**16 239**	**14 037**	**14 389**	**14 751**	**9 775**	**69 190**

EXPENDITURE

Item	Account No	Expenditure 2017	Expenditure 2018	Budget 2019	Budget 2020	Budget 2021	Sum
Staff costs	5* and (9*)	2 610	15 694	11 945	12 303	12 171	54 723
Travel costs	7*	168	682	300	300	300	1 750
Dissemination	6* and 7*	453	744	710	710	710	3 327
Other costs	6*	87	153	710	710	710	2 370
Other costs	7*	200	144	600	600	600	2 144
Sum - Total		**3 518**	**17 417**	**14 265**	**14 623**	**14 491**	**64 315**

List of products

Dissemination – external events

THE ROLE OF CCSE

Topic	where, for whom	who	when
How to integrate computing in science education	Invited seminar, University of Tromsø	Malthe-Sørenssen	08.01.2018
Beregninger inn i biotudanningen fra 1. semester	Invited seminar, University of Tromsø	Nederbragt	08.01.2018
How to integrate computing in science education	Invited seminar, Uppsala University	Malthe-Sørenssen	10.01.2018
How should computing influence the core undergraduate curriculum in science and mathematics?	Presentation to Chinese delegation to Norway, Organized by SIU, at University of Oslo	Malthe-Sørenssen and Mørken	13.03.2018
Renewing the contents of science education by integrating computing: Opening for creativity, collaborations and applications	Invited seminar, Norwegian delegation visit to China	Malthe-Sørenssen	18.04.2018
Renewing the contents of science education by integrating computing: Opening for creativity, collaborations and applications	Invited talk, Visit of Sun-Yat-Sen University to University of Oslo	Malthe-Sørenssen	02.05.2018
Fornyelse av utdanning ved integrasjon av beregninger	Invited faculty seminar, University of Stavanger	Malthe-Sørenssen	03.05.2018
Renewing the contents of science education by integrating computing: Opening for creativity, collaboration and applications	Invited talk, Swedish E-Science Research Center, Stockholm, Sweden	Malthe-Sørenssen	14.05.2018

Continues on the following page

Topic *(continued)*	where, for whom	who	when
Renewing the contents of science education by integrating computing: Opening for creativity, collaboration and applications	Invited talk, IT-konferansen 2018, Strømstad, Sweden	Malthe-Sørenssen	06.06.2018
Renewing the contents of science education by integrating computing: Opening for creativity, collaboration and applications	Invited talk, Department of Physics, Uppsala University, Sweden	Malthe-Sørenssen	10.06.2018
Renewing the contents of science education by integrating computing: From Bachelor to PhD	Invited talk, Faculty of Mathematics and Natural Sciences, Uppsala University, Sweden	Malthe-Sørenssen	10.06.2018
Center for Computing in Science Education – experiences from a Center for Excellence in Education	Foredrag for DEA komite på besøk i Norge, UiO	Malthe-Sørenssen, Mørken, Tellefsen	09.10.2018
Renewing the contents of science education by integrating computing	Institute seminar, Institute for Physics, NTNU	Malthe-Sørenssen	19.10.2018

CONTRIBUTIONS TO SEMINARS, WORKSHOPS AND CONFERENCES

Topic	where, for whom	who	when
Matematikk og programmering	Seminar for søkere til NRG, Norsk Realfags Gymnas	Malthe-Sørenssen	23.01.2018
Bruk av datamaskiner i naturvitenskap – en ny vitenskapelig praksis og dannelse?	Forum for vitenskapsteori, Universitetet i Oslo	Malthe-Sørenssen	24.01.2018
Fremtidsrettet utdanning – Hvordan gi studentene digital kompetanse for forskning og arbeidsliv?	Vårseminar, MN fakultetet, UiB	Malthe-Sørenssen	05.04.2018
Understanding the brain using computers	Foredrag ved Oslo International School, Bærum	Malthe-Sørenssen	10.04.2018
Educational development: Computing in science education in a wider perspective	Invited seminar, Norwegian delegation visit to China	Mørken and Sølna	18.04.2018
Programmering og modellering i biovitenskapsutdanning	Invited faculty seminar, University of Stavanger	Lex Nederbragt	03.05.2018
Hva skal vi med numeriske beregninger i fysikk	Invitert foredrag ved Norsk Fysikklærer konferanse	Malthe-Sørenssen	06.08.2018
Programmering I skolen – muligheter og utfordringer	Foredrag ved ProFag frokost-møte, UiO	Malthe-Sørenssen	12.10.2018
Hvorfor lære programmering i skolen	Foredrag, Seminar om programmering i skolen, Arrangert at UiO, Simula og Oslomet	Malthe-Sørenssen	12.11.2018

Continues on the following page

Topic *(continued)*	where, for whom	who	when
Introduction to ProFag	Invited talk, visit of Chinese Minstry of Education to UiO	Tellefsen	08.06.2018
Potential of programming in mathematics. Teachers developed a practical school lesson.	Lecture for a group of Swedish high school teachers at Kleindagarna at Mittag-Leffler Institute I Stockholm	Mørken	07.06.2018-09.06.2018
Programmering og Modellering X – et nytt fag	Physics teachers national conference	Haraldsrud	06.08.2018
Programming in all disciplines!	Lecture at the network day for high school teachers in the Møre and Romsdal region	Mørken	15.08.2018
Introduction to ProFag	Utdanningskomiteens besøk ved UiO	Tellefsen	10.09.2018
Lifelong learning and digital competence	Oslo Rector Summit 2018	Tellefsen	03.10.2018
ProFag: Realfaglig programmering i skolen	NTG science teacher seminar	Tellefsen	17.10.2018
Programmering i naturfag	Naturfagkonferansen	Tellefsen, Mørken	18.10.2018
Why programming in mathematics?	Inspirational day for high school teachers at the University of Oslo	Mørken	01.11.2018
Why programming in mathematics?	Lecture at network day for mathematics teachers in the Vestfold region	Mørken	21.11.2018
The new core elements in mathematics	Lecture at network day for mathematics teachers in the Eastern Akershus region	Mørken	30.11.2018
Programming in school: possibilities and challenges	Lecture at network day for mathematics teachers in the Western Akershus region	Mørken	30.11.2018

WORKSHOPS AND CONFERENCES ORGANIZED BY CCSE

Topic	where, for whom	who	when
Programming in Python (PiP)	Python-course for science education faculty at MN	Tellefsen, Rose, Gregers	30.10.2017-14.05.2018
ProFag vgs 1 (high schools)	Course for 40 high school teachers	Tellefsen, Mørken	12.06.2018-20.12.2018
Programming is more than coding	FIKS conference workshop (200 attending)	Tellefsen, Mørken	21.09.2018
Programming in school – possibilities and challenges	FIKS breakfast meeting (100 attending)	Malthe-Sørenssen, Tellefsen, Mørken	12.10.2018
Workshop on scientific programming (with Matric)	Matric, UiA (40 attending)	Tellefsen, Mørken	05.11.2018-06.11.2018

Continues on the following page

Topic *(continued)*	where, for whom	who	when
Programming in schools	Half-day seminar organized with Simula and OsloMet (200 attending)	Malthe-Sørenssen, Tellefsen	12.11.2018
ProFag-U (middle school)	Course for 40 middle school teachers	Tellefsen, Mørken	19.11.2018-
Programming in physics education	Workshop with NUDT delegation (20 attending)	Malthe-Sørenssen, Mørken, Tellefsen	05.12.2018

CONTRIBUTIONS TO POLICY AND THE PUBLIC DEBATE

Topic	Where, for whom	Who	when
Dyp digital kompetanse – integrasjon av programmering i utdanning	Presentasjon for KD	Malthe-Sørenssen	09.03.2018
Digitale ferdigheter for fremtidens arbeidsliv: Hvordan fornye fagenes innhold og sikre at alle elever og studenter opparbeider relevant «computational literacy»	Invitert foredrag, Lanseringskonferansen 2018	Malthe-Sørenssen	07.05.2018
Digitale ferdigheter for fremtidens arbeidsliv: Hvordan fornye fagenes innhold og sikre at alle elever og studenter opparbeider relevant "computational literacy"	Presentasjon for Marianne Synnes, Stortingsrepresentant for Høyre, Stortinget	Malthe-Sørensen	12.06.2018
Digitale ferdigheter for fremtidens arbeidsliv: Hvordan vi arbeider for å fornye fagenes innhold og sikre at alle elever og studenter opparbeider "computational literacy"	Foredrag for utdanningskomiteen ved Stortinget under deres besøk ved UiO	Malthe-Sørensen, Mørken, Tellefsen	10.09.2018
Algoritmisk tenkning/Computational literacy: Digitale ferdigheter for fremtidens skole	Invitert foredrag for Lied-utvalget	Malthe-Sørenssen	25.09.2018

Dissemination – internal events

CCSE SEMINAR SERIES

Title	Who	When
Students' understanding of metrics in college mathematics education	Zack Reed, Oregon State University	18.04.2018
Role of computing in combinatorics in mathematics education	Elise Lockwood, Oregon State University	18.04.2018
University students' negotiation of physics identity in informal physics programs	Claudia Fracchiolla, National University of Ireland Galaxy, Ireland	20.02.2018

Continues on the following page

Title *(continued)*	Who	When
How to run an effective learning assistants program	Elanor Close, Texas State University	23.05.2018
Development and initial assessment of GlowScript Blocks, a new tool for introducing programming in introductory physics	Hunter Close, Texas State University	22.05.2018
Tablet Computers as Notebooks and Apparatus in an Introductory Lab Course	Ben Pollard, University of Colorado - Boulder	04.06.2018
Real labs for young physicists	Ian Bearden, Niels Bohr Institute, Denmark	04.06.2018
Disciplinary discernment of three-dimensionality in virtual learning environments (VLEs)– important for teaching and learning physics and astronomy?	Urban Eriksson, National resource center for physics education, Lund University, Sweden	04.06.2018
Programming: A tool for meaning-making and a transductive link between semiotic systems	Kim Svensson, National resource center for physics education, Lund University, Sweden	04.06.2018
AST2000 Satellite mission	Robert Hagala, Department of Astrophysics, UiO	04.06.2018
Model while you measure: Making better physics lab courses	Ben Pollard, University of Colorado – Boulder, USA	06.06.2018
Bringing computation into physics courses through research and reflective practice	Danny Caballero, Michigan State University and CCSE	12.12.2018
Engaging Students in Authentic Scientific Practices in Physics Lab Courses	Heather Lewandowsky, University of Colorado-Boulder	14.12.2018

CCSE EDUCATIONAL DEVELOPMENT ACTIVITIES (POLICY AND TEACHING)

Topic	Where, for whom	Who	When
Computational and data science at UiO	Internal seminar on computational and data science, UiO	Malthe-Sørenssen	06.03.2018
REAL education, seminar	Teachers at Faculty of Mathematics and Natural Sciences, UiO	Tellefsen	12.01.2018
Seminar on development of education	Department of Physics, UiOs	Tellefsen, Malthe-Sørenssen	12.04.2018
Computational science education research	Internal seminar at CCSE	Malthe-Sørenssen	12.03.2018
Education research at CCSE	Department seminar on education, Department of Physics, UiO	Malthe-Sørenssen	12.04.2018
Structured assessment method for improved student learning	S-Assess meeting, Department of Informatics, UiO	Malthe-Sørenssen	24.04.2018
Utdanning og forskning – behov for digitale ferdigheter	Foredrag på fellesseminar med Utdanningskomiteen og forum for forskningsdekaner, UiO	Malthe-Sørenssen	15.05.2018

Continues on the following page

Topic *(continued)*	Where, for whom	Who	When
Oppsummering og perspektiver på CCSEs aktivitet	Dialogmøte mellom CCSE og MN fakultetet, UiO	Malthe-Sørenssen	29.05.2018
Utdanning og forsknings – innspill til IT-masterplan	Invitert foredrag, komite for IT-masterplan, UiO	Malthe-Sørenssen	29.05.2018
Education research at CCSE	Talk at MN faculty strategy meeting, Husøy	Malthe-Sørenssen	05.06.2018
Learning assistants and learning progression in Fys1120	Talk at Department seminar, Department of Physics, UiO	Malthe-Sørenssen	11.10.2018
Coordination and specialization: Two examples and a perspective	Talk for executive committee, European Universities project, UiO	Malthe-Sørenssen	20.12.2018
BIOS1100: Innføring i beregningsmodeller for biovitenskap – erfaringer og evaluering	Real utdanning – fagdag for utdanning ved MN fakultetet	Nederbragt	11.01.2018
Decompiling Knowledge to Distill Learning Goals	Real Undervisning, Faculty seminar on teaching	Odden	12.01.2018
Active learning in large-lecture physics at UW Madison	Department of Physics teaching seminar	Odden	11.10.2018
Nei, forelesning er ikke død... The role of lecture in student-centered teaching	Real Undervisning, Faculty seminar on teaching	Odden	15.08.2018

WORKSHOPS AND CONFERENCES AT CCSE

Topic	Where	Attendance	When
CCSE-NUDT seminar on computational methods in physics education	CCSE, UiO	20	05.12.2018
CCSE Internal Seminar	Lysebu, Oslo	15	05.03.2018
Computing in Science Education Annual Christmas Seminar	CCSE, University of Oslo	90	12.12.2018

Visitors

Who	Topic	When
Zack Reed, Oregon State University	Presentation of Mathematics education research	18.04.2018
Elise Lockwood, Oregon State University	Presentation of mathematics education research	18.04.2018
Elise Lockwood, Oregon State University	Research interviews with mathematics students	01.08.2018-20.08.2018
Claudia Fracchiolla, National University of Ireland Galaxy, Ireland	Scientific presentation	20.02.2018
Elanor Close, Texas State University	CCSE seminar series	23.05.2018

Continues on the following page

Who *(continued)*	Topic	When
Hunter Close, Texas State University	CCSE seminar series	22.05.2018
Ben Pollard, University of Colorado - Boulder	Talks and presentation of experimental education	04.06.2018-06.06.2018
Ian Bearden, Niels Bohr Institute, Denmark	CCSE focus seminar on education research	04.06.2018
Urban Eriksson, National resource center for physics education, Lund University, Sweden	CCSE focus seminar on education research	04.06.2018
Kim Svensson, National resource center for physics education, Lund University, Sweden	CCSE focus seminar on education research	04.06.2018
DEA Danish delegation	Information about CCSE and Centers for Excellence in Education	03.09.2018
NUDT delegation	Visits to courses, common seminar, discussions about teaching practices	23.11.2018-06.12.2018
Heather Lewandowsky, University of Colorado-Boulder	CCSE winter seminar	14.12.2018

Publications

Scientifc publications

- Odden, T.O.B., & Russ, R.S. (2019). Defining Sensemaking: Bringing Clarity to a Fragmented Theoretical Construct. *Science Education*, 103(1), 187-205
- Odden, T.O.B., & Russ, R.S. (2018). The sensemaking epistemic game: A model of student sensemaking processes in introductory physics. *Physical Review Physics Education Research*
- Odden, T.O.B., & Russ, R.S. (2018). Recurring questions that sustain the sensemaking frame. 2018 *Physics Education Research Conference Proceedings*
- Sand, O.P., Odden, T.O.B., Lindstrøm, C, & Caballero, M.D. (2018). How computation can facilitate sensemaking about physics: A case study. 2018 *Physics Education Research Conference Proceedings*
- Aiken, John M., Chastity Aiken, and Fabrice Cotton. A Python library for teaching computation to seismology students. *Seismological Research Letters* 89.3 (2018): 1165-1171.
- Aiken, John, and Marcos D. Caballero. Student pathways through the physics major. *Bulletin of the American Physical Society* 63 (2018).
- R. Solli, J. M. Aiken, R. Henderson, and M. D. Caballero, Examining the relationship between student performance and video interactions, 2018 PERC Proceedings [Washington, DC, August 1-2, 2018], edited by A. Traxler, Y. Cao, and S. Wolf.
- M. D. Caballero, and M. Hjorth-Jensen, Integrating a computational perspective in physics courses, *arXiv* 1802.08871 (2018)
- A. Leary, P. W. Irving,and M. D. Caballero, The difficulties associated with integrating computation into undergraduate physics, arXiv 1807.03581 (2018)
- N. T. Young, G. Allen, J. M. Aiken, R. Henderson, M. D. Caballero, Using random forests to determine important features for integrating computation into physics courses, *arXiv* 1810.07859 (2018)
- J. M. Aiken, R. Henderson, M. D. Caballero, Modeling student pathways in a physics bachelor's degree program, *arXiv* 1810.11272 (2018)
- M. D. Caballero, and L. Merner, Prevalence and nature of computational instruction in undergraduate physics programs across the United States, *Physical Review Physics Education Research* 14, 020129 (2018)

Scientific talks and posters

- **International Learning Assistant Conference**, Nov 2018, *Poster Presentation*: "The Learning Assistant Model in a Scandinavian Context" T.O.B. Odden and A. Lauvland.
- **2018 Physics Education Research Conference**, July 2018, *Presentation*: "Vexing Questions that Sustain Sensemaking" T.O.B. Odden and R.S. Russ.
- **American Association of Physics Teachers Summer Meeting**, July 2018, *Presentation*:

"Grokking: The Endpoint of Sensemaking" T.O.B. Odden.
- **Physics Education Research Conference 2018**, *Poster*: "Towards a model of student pathways in STEM", J. M. Aiken.
- **American Association of Physics Teachers Summer Meeting**, July 2018, *Presentation*: "Can Machine Learning Predict When STEM Students Switch Majors?" J. M. Aiken.
- **American Association of Physics Teachers Summer Meeting**, July 2018, "How to get students to engage in computational sensemaking". O. P. Sand.
- **Workshop on New Horizons in Teaching Science**: June 18-19, 2018, University of Messina, Messina, Italy, "Integrating a Computational Perspective in Science Education", Morten Hjorth-Jensen, see: http://mpe2018.unime.it/2018/06/08/international-workshop-on-teaching-in-science/

Op-eds and articles in the media
- Programmering i fysikkundervisningen, Cathrine W. Tellefsen and Andreas D. Haraldsrud, Fra Fysikkens Verden, 2018.

Books
- Arnt Inge Vistnes, *Waves and Oscillations*, Textbook in Fys2130 – Waves and oscillations, Springer, 550 pages, 2018.
- Simon Tennøe, Andreas Solbrå, Milad Mobarhan, Svenn-Arne Dragly, Lex Nederbragt, *Introduction to analysis and modeling in biology with Python*, Textbook in BIOS1100 – Introduction to computational modeling in bioscience, 400 pages, 2018.

Social media
- Facebook: www.facebook.com/CentreForCSE/
- Web: www.mn.uio.no/ccse/
- Blog: www.mn.uio.no/ccse/om/aktuelt/blogg/

Student activities

STUDENT DEVELOPMENT OF LEARNING MATERIAL

Course and topic	Student	Teacher	When
Exercise-development in electromagnetism	Anders Bråte	Anders Malthe-Sørenssen	01.11.2018-31.12.2018
JupyterHub and docOnce support	Kristian Gregorius Hustad		01.01.2018-31.12.2018
Introduction to statistics	Jens Kristoffer Haug Mathias Fron Sander Wågønes Losnedahl	Ida Scheel	20.06.2018-20.07.2018
BIOS1120 – Physiology	Halvard Sutterud	Marianne Fyhn	20.06.2018-20.07.2018
Fys-mek1110 – Mechanics	Tommy Myrvik Anders Johansson	Andreas Gorgen	20.06.2018-20.08.2018
Introductory courses in political science	Ellen Emilie Henriksen Trond Wiggo Johansen	Bjørn Høyland Morten Hjorth-Jensen	20.06.2018-20.08.2018
Computational thinkning for the humanities	Yngve Severin Bloch-Hoell	Dag Trygve Truslew Haug	01.11.2018-31.12.2018
Fys-stk3155 Data analysis and machine learning	Andreas Godø Lefdalsnes Kristine Baluka Hein	Morten Hjorth-Jensen	20.06.2018-19.08.2018

Continues on the following page

Course and topic *(continued)*	Student	Teacher	When
Geo1105 – The earths inner and outer processes	Kristine Halvorsen	Anders Mattias Lundmark	20.06.2018-19.08.2018
MAT4100 – Introduction to numerical analysis	Kin Andre Arntsen	Knut Mørken	20.06.2018-19.08.2018
KJM1100-General chemistry	Eirill Strand Hauge	Carl Henrik Gørbitz	20.06.2018-19.08.2018
BIOS3000 – Design and analysis of biological studies	Hallvard Austin Wæhler Mathias Fon	Torbjørn Håkan Ergon	20.06.2018-19.08.2018
BIOS1100 – Introduction to computational models for bioscience	Oda Selvåg Hovet Dejana Mitrovic Clare Mcenally	Lex Nederbragt	20.06.2018-19.08.2018

STUDENT RESEARCHERS

Theme	Students	Supervisors	When
Friction: Nano-asperities in water-wetter SiO2	Anders Johansson Erik Alexander Sandvik	Malthe-Sørenssen, Sveinsson, Jamtveit	20.06.2018-19.08.2018
Earthquakes: Supershear rupture	Didrick Kruse Magnus Ingstad Fredrik Leiros Nilsen	Malthe-Sørenssen, Sveinsson, Jamtveit	20.06.2018-19.08.2018
Earthquakes: Impact models	Eline Prytz Andersen Eivind Støland	Malthe-Sørenssen, Sveinsson, Jamtveit	20.06.2018-19.08.2018
Neuroscience: Effective methods for analysis of electrode and position data for grid cell studies	Halvard Sutterud Ada Hagaseth Bjørg Vårli Håland	Lepperud, Fyhn	20.06.2018-19.08.2018
Machine-learning methods for analysis of student use of video lectures	Robert Solli	Aiken, Caballero	01.01.2018-31.12.2018
Machine-learning method for student pathway analysis	Matthew Ring Alyssa Waterson	Aiken, Caballero	20.05.2018-20.07.2018

Grafisk design: Maria Hammerstrøm

UiO : Universitetet i Oslo

Senter for fremragende utdanning

Center for Computing in Science Education
A Center for Excellence in Education from 2016–2021

Center leader
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