2019

Center for Computing in Science Education

ANNUAL REPORT

CCSE

Center for Computing
in Science Education

Summary

The Center for Computing in Science Education (CCSE) aims to become an international hub for the research-based integration of computing in 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.

Education research: In the first three years the center has developed its concept and consolidated its position nationally and internationally. We have established a research group in computational science education research, with two adjunct professors: Danny Caballero from Michigan State University and Elise Lockwood from Oregon State University, three phd-students, one post-doc and several master students. We have received four research grants to support our activity providing an additional 13 mill. NOK for research and internationalization. The group has already produced excellent results on our understanding of computational literacy and the use of computational essays and in learning analytics. We have also received two incoming international researchers on sabbaticals – a strong indicator for excellence. This gives us an excellent opportunity to build a strong activity in the coming years, with a particular ambition to extend the activity towards computing in mathematics and bioscience education.

Culture of teaching and learning: 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. We have taken the initiative to develop a pilot Learning Assistants program, and this initiative will now be spread across the whole Faculty and the whole university in collaboration with the Center for Teaching and Learning at UiO. We have also organized two Summer Institutes focusing on active learning in bioscience (2018) and integration of computing in physics education (2019) with a total of 60 participants from the whole of Norway.

New bachelor programs: The Faculty of Mathematics and Natural Sciences renewed all its study programs in 2017 through the InterAct project. CCSE personnel have been central in the InterAct process whereby all study programs were redesigned according to principles of backward design and constructive alignment. After the reform, all study programs integrate computing. We are particularly proud that the new study program in bioscience includes a programming course in the first semester. The University of Oslo is, as far as we know, the first university to provide such a course and such an integration of computing in bioscience. This is an exciting pilot that will be studied in our research activity and continuously improved through our instructional development practices.

Introductory programming courses: 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, providing a model for extension to engineering programs across Norway.

Computational literacy in schools: A major national development has been the decision to integrate programming in the mathematics education in schools. CCSE has been a driver in this process by contributing to developing the new curricular guidelines, new textbooks, and training teachers and the teachers of teachers 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), and we have established collaborations with other universities to disseminate the practice. We have also received significant funding (10 Mkr) to build such an activity. This development has led to a complete redesign of our priorities and of the school related activities in the center.

Computational literacy in the Honours-program: CCSE has been instrumental in developing and running the new Honours program at the University of Oslo. The honours-program is an interdisciplinary bachelor program with students from both science and the humanities. The program is directed towards ambitious and talented students, and was the most competitive program in Norway when it was launched in 2019. The thematic focus for the program is artificial intelligence, and in the second year the program focuses on computational skills. A new course in computational methods for the humanities is piloted in this program and is developed in a collaboration between CCSE and the Faculty of the Humanities. A new course on interdisciplinary data science projects spanning science, humanities and social sciences for the Honours-students is developed by CCSE and will be taught from 2021.

Computational skills for PhD-students: The Faculty of Mathematics and Natural Science was recently granted a MSCA COFUND program for 32 PhD-students. The program will train a new generation of computationally proficient research leaders to digitally transform the European education, research, government and industry sectors. The program is directed by CCSE and will recruit a cohort of PhD-students, provide them with 6 months of intensive training in computational and data science skills, and distribute them across 8 internationally leading research groups at UiO. The program allows CCSE to extend its program to the PhD-level and develop a set of courses to train PhD-students in computational methods.

Dissemination: CCSE has developed a research-based approach to dissemination, with carefully selected approaches for each stage in the dissemination process. We have successfully spread our practice across the sciences at UiO, across educational levels from school to PhD training, and are currently disseminating beyond the sciences. We have developed essential tools to develop and distribute learning materials, courses, and summer institutes to train faculty, and have successfully spread our practice across institutions nationally. We have an international partnership (INTPART) for computing in science education with three US institutions, and our practices have been spread to 35 Chinese universities.

Digitization will be an important theme in education in the coming years. Indeed, the new national strategy for Artificial Intelligence (AI) called for AI to be integrated in higher education. 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 and AI in education in the next decade.

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 modelling and simulation.

The focus on digital competence will increase in the years to come, 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 and a new strategy for AI in 2020. These strategies point to the importance of digital competence at all levels in higher education – for researchers, students, teachers, and administration – and CCSE is used as a case example in the strategies. 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 2017–2019

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. This is clear from the digitization strategy for higher education from the Ministry of Education (2018), EUs digital single market strategy (2018), the integration of algorithmic thinking and programming in the school curricular reform of 2020, and the national strategy for Artificial Intelligence (2020). CCSE provides a clear solution – integrate the use of computers to solve problems, computing, into the curriculum across educations. 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.

CENTER ESTABLISHMENT AND CONSOLIDATION

The main focus in 2017 was the establishment of the center. Administrative routines have been introduced, working groups and boards have been selected, funding schemes have been established and reports and contacts have been formed with partners nationally and internationally. The student-based activities, including student involvement in curriculum development and student research projects, have more than doubled after establishing the center. The position of the center as a source of competence was established within the university and with governmental bodies. The main focus in 2018 and 2019 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 spreading within the university, nationally and with governmental bodies. Moving into new facilities in 2019 we have established the center as *the* central meeting place for education in the Faculty, and established a tradition of CCSE talks and meetings for teaching faculty.

PROGRAMMING IN SCHOOL AND TEACHER PROFESSIONAL DEVELOPMENT

During 2018 the national political discussion about programming in schools 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 starting from 1-13 in 2020. This curricular reform 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 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 Center for Teaching and Learning in Science at UiO) has developed ProFag (Programming in context) for both high school and secondary school, and we have organized national conferences and workshops.

We have built up a team to support this activity led by Cathrine Tellefsen. We have hired Andreas Haraldsrud, the high-school teacher who developed the new high school subject Modeling and programming and wrote the first textbook in this subject. 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 have built a solid team and routines around ProFag are now in a position to take a national lead in this area, although this requires national funding and resources. We are also preparing to start an education research activity to understand how programming affects student learning in schools and how to provide professional development for teachers to support the curricular change.

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. 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. This project is gaining significant international attention, has already led to high-profile publications, and has expanded to include international collaborators. 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, spent her sabbatical at CCSE in 2019 and initiated a research project with students at UiO.

We have also established an international partnership (INTPART, 4.5 mill NOK) on computing in science education between UiO, Michigan State University (MSU), Oregon State University (OSU), and University of Colorado – Boulder (UCB) which will form a basis for building the education research activity and disseminating best practice. We have established a summer student research program at UiO, with three students participating in 2018, and over 20 students and faculty from Norway, US and China in 2019. Our research activity on learning analytics with PhD-student John Aiken is now also established and a sequence of research articles have been published.

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 two summer institute with focus on student active learning in biosciences and integration of computing in physics, and we have initiated a learning assistant (LA) program with weekly pedagogical training for learning assistants in selected courses. We also observe a noticeable increase of interest from faculty and departments who want to improve their teaching. The national change in the requirements to become an associate or full professor, with significant more weight placed on instructional development, has also had a major impact on the institution, with more focus on teaching and learning from both faculty and departmental leaders. The close connection between KURT and CCSE – we are collocated and have a large overlap in personnel – also ensures that CCSE is at the center of educational development at the Faculty. The annual Christmas seminars have been great success with typically 80-100 faculty present and presentations from top international researchers as well as internal presentations on instructional development.

INTERNATIONALIZATION

The center has gradually adapted a more international perspective. 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 UiO's collaborations with China. We met with the Chinese delegation visiting Norway in March 2018, and we were invited to participate in the Norwegian delegation to China in April 2018. Our collaboration with the National University of Defense Technology has led to the dissemination 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 and a half-year sabbatical stay of Elise Lockwood 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 four institutions, UiO, MSU, OSU and UCB.

PROGRAMMING FOR BIOSCIENCE STUDENTS

2017 saw the introduction of new bachelor programs in all science disciplines at UiO. Now all programs include a computational aspect – including bioscience. CCSE has played a central role in the development of the new introductory course in computational modelling in bioscience – BIOS1100 – a first semester course that is compulsory for all bioscience students. 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 to provide an introduction to programming in a biological context and is accepted for publication by Springer. The course was taught by Lex Nederbragt using novel, student-active methods in the new learning laboratory at the Department of bioscience. The course and the learning laboratory were a focus of the Minister of Education's visit to UiO in October 2017. Two MSc-students and one PhD-student study the implementation of computational approaches in BIOS 1100.

DISSEMINATION

We have established a research-based model for dissemination, which we are actively employing in our dissemination work. 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 bioscience bachelor program has been a particular success at UiO. 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. Lex Nederbragt from the Department of Biosciences has been included in the leadership group of the center – allowing us to learn from the experiences from biosciences. The way computing has been integrated in biosciences can serve as a model for dissemination in other fields, and Nederbragt will play an important role in spreading CSE further.

We have also initiated activities in the direction of chemistry, geoscience, pharmaceutical science, political science and the humanities, which we hope will turn into new courses in these fields over the next few years. Computing and programming are also key elements in the new Honours-program developed at UiO, which will build a basis for further disseminiation. We have initiated collaborations with several other institutions. For example, 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 and 2019, 30 bachelor-students were involved in 4-6 weeks science research projects. This is possible because our students have acquired relevant programming and computing skills early in their studies, and therefore have can contribute meaningfully in research projects already after one year. The projects provide students with a chance to experience the world of research and to demonstrate other aspects of their skills and abilities early on. Over 15 students have been involved in the Thon project on student education research projects. This program has an international focus. In 2018 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. In 2019, the project organized an international workshop on quantitative and machine learning methods in physics education research and supported 10 students from Norway, US and China..

SENIOR LECTURER CATHRINE WAHLSTRØM TELLEFSEN RECEIVED THE 2019 THON AWARD FOR EXCELLENT TEACHING

The prize is 500.000 kr and is given to Tellefsen during the Thon prize ceremony in the University Aula on March 5. The prize was awarded Tellefsen for being an excellent teacher who also is genuinely engaged in helping others develop as teachers. She works systematically to "change the system" in order to improve the quality of education and teaching, in particular at the Faculty of Mathematics and Natural Sciences, but also at the university in general, nationally and internationally. She is the leader of the CCenter for Teaching and Learning in Science and a work package leader at CCSE. She is leading the ProFag initiative to provide professional development training for teachers and helping them integrate programming into their teaching to improve student learning in the disciplinary subject. She has also recently rewritten her textbook in Physics to include programming examples and problems. We are very proud to have her as a central part of CCSE. Congratulations, Cathrine!

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 programs at UiO and was the program leader for the physics program 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!

PROFESSOR KNUT MØRKEN RECEIVED THE 2017 THON AWARD FOR EXCELLENT TEACHING

The prize is 500.000 kr and was given to Professor Mørken during the Thon prize ceremony in the University Aula on March 2nd. The prize was awarded Mørken for his visionary work as an educator. Mørken is the founder of the InterAct program at the University of Oslo. The program aims to redesign the education based on constructive alignment between what students need to learn to meet tomorrows demands, the learning outcomes of study programs and courses, and the learning activities. He has advocated reverse design of study programs – starting from the wanted outcomes and the main objectives, and then designing the detailed contents. He has been a key driver for the implementation of Computing in Science Education at the University of Oslo, where he has provided an essential mathematical perspective to the curricular reform. He has also developed new courses and textbooks that integrate computing in math education, and he has worked to develop a strong learning environment so that students can develop personally as well as professionally throughout their education. Knut Mørken is the leader of the bachelor program in mathematics and is a popular communicator of educational design practices nationally and internationally. We are very proud to have him as a central part of CCSE. Congratulations, Knut!

ILLUSTRATIVE FILMS AND PODCASTS ABOUT CCSE AND INTEGRATION OF COMPUTING

Two films that illustrate how computing is integrated into the bachelor educations at UiO have been published. The target audience is prospective students and the general public.

Films:
Computational science at the University of Oslo: https://youtu.be/0vLutIsrglo *(english)*

Computational methods in study programs at UiO: https://youtu.be/T6Wa59E7S-Y *(norwegian)*

Podcasts:
Research projects for bachelor-students: https://soundcloud.com/nokutpodden/den-om-forskende-bachelorgradsstudenter *(norwegian)*

Bachelor-students who teach: https://soundcloud.com/nokutpodden/den-om-studenter-som-underviser *(norwegian)*

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 2020 and 2021 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 or motivate 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

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 the coming years. In 2020, we will therefore update and re-write 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, data science and machine learning, 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-skill 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. This will first be realized through the TraCS – Training in Computational Science – MSCA COFUND project led by CCSE. 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 2020 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 2020 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 spent an extended sabbatical stay at CCSE in 2019. During this stay she initiatied research activities that we want to expand through a joint PhD-position in 2020. The goal is that this will have a positive impact on instructional development and curricular design in mathematics.

NEW LOCALITIES – CONSOLIDATING A HUB FOR COMPUTATIONAL TEACHING

CCSE moved into new localities in March 2019. This has given us an opportunity to build CCSE as a hub for educational development at the Faculty and as a meeting place for teachers and students. In 2020 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. We will also expand our summer institute initiatives and develop low-threshold meeting places for teaching faculty who are interested in improving their instructional design and integrating computational approaches in their courses.

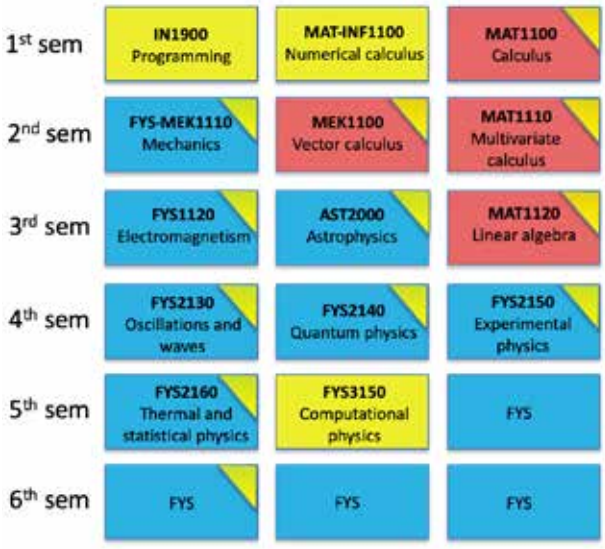
Integration of computing across science programs at UiO

The basic premise of CCSE is that the use of computing has changed the practice across disciplines. This change must be reflected in the contents of the educations in order to prepare students for a career in research, industry, government or education. At UiO we are in the process of transforming all bachelor programs in science in order to integrate the use of computational method. We illustrate this transformation process for the bachelor program in physics.

INTEGRATION OF COMPUTING IN THE PHYSICS BACHELOR PROGRAM

The bachelor program in physics and astronomy is illustrated in Fig. 1. In the first semester, students are introduced to the methods needed to study physics. Before 2007 these methods included calculus (MAT1100), numerical calculus (MAT-INF1100) and programming (INF1000). Initially, physics students had the same course in programming as computer science students. However, we found that physics students were not able to effectively transfer the skills and knowledge from a general programming course – where they often learn to write a ticket ordering system, but not to solve mathematical problems – to the context of mathematics and physics. Physics and mathematics are focused on mathematical problem solving using a computer, and students were not trained in this in a traditional computer science course.

Fig. 1: Structure of the bachelor program in physics.



AN INTRODUCTORY COURSE IN SCIENTIFIC COMPUTING OPENS NEW OPPORTUNITIES

In 2007, the computer science course was replaced by IN1900 Introduction to scientific programming using Python. This changed the game. Now all physics and mathematics students had a common platform in scientific computing that could be built on in subsequent courses. In addition, this allowed a close coordination between the three courses in the first semester. For example, in calculus students were introduced to the concept of the derivative in week 1. Then, they were introduced to the numerical aspects and uncertainties of how the derivative was calculated numerically in week 2. And finally, the students implement numerical derivation in a program in week 3. Students report that this coordination is successful and helps see the connections between disciplines – it helps students with the transfer. We have found the introduction of an introductory course in context-specific programming to be an important element to succeed with integrating computing.

STAGES OF INTEGRATION

Subsequent courses can then be redesigned to build on the coordinated introduction in the first semester. This redesign typically occurs through a series of stages. First, examples and exercises with computational practices are introduced, often developed with the help of student transformation teams. Then learning outcomes are refined to include a computational perspective, and assessments and practices are aligned with the outcomes. Finally, the whole exposition and contents of the course is redesigned by deep integration of computational methods – rethinking what parts of physics of mathematics to include, how it is presented and practiced, what activities the students are focusing on, and how progress is assessed and feedback provided to students. This deep redesign has occurred in two physics courses, where new textbooks have been written and published, is being finalized in

MAT1100: Calculus

Week 1:
The derivative is defined

$$\frac{df}{dx} = \lim_{\Delta x \to 0} \left(\frac{f(x+\Delta x) - f(x)}{\Delta x} \right)$$

MAT-INF1100: Numerical calculus

Week 2:
The numerical derivative is introduced

$$\frac{df}{dx} = \left(\frac{f(x+\Delta x) - f(x)}{\Delta x} \right) + O(\Delta x)$$

IN1900: Scientific computing

Week 3:
The numerical derivative is implemented in Python

```
def dfdx(f,x):
  h=1e-10
  dfdx=(f(x+h)-f(x))/h
  return dfdx
```

Fig. 2: Coordination of themes between three first-semester courses.

two other physics courses, and is developed in the further physics courses. We have found that such a deep integration requires faculty with significant teaching experience and a research activity where computational methods are developed and used in order to be able to see how computing is changing the discipline and its practice. Similar changes have also occurred in the courses in mathematics, providing students with a unified approach to computational methods across courses from three departments.

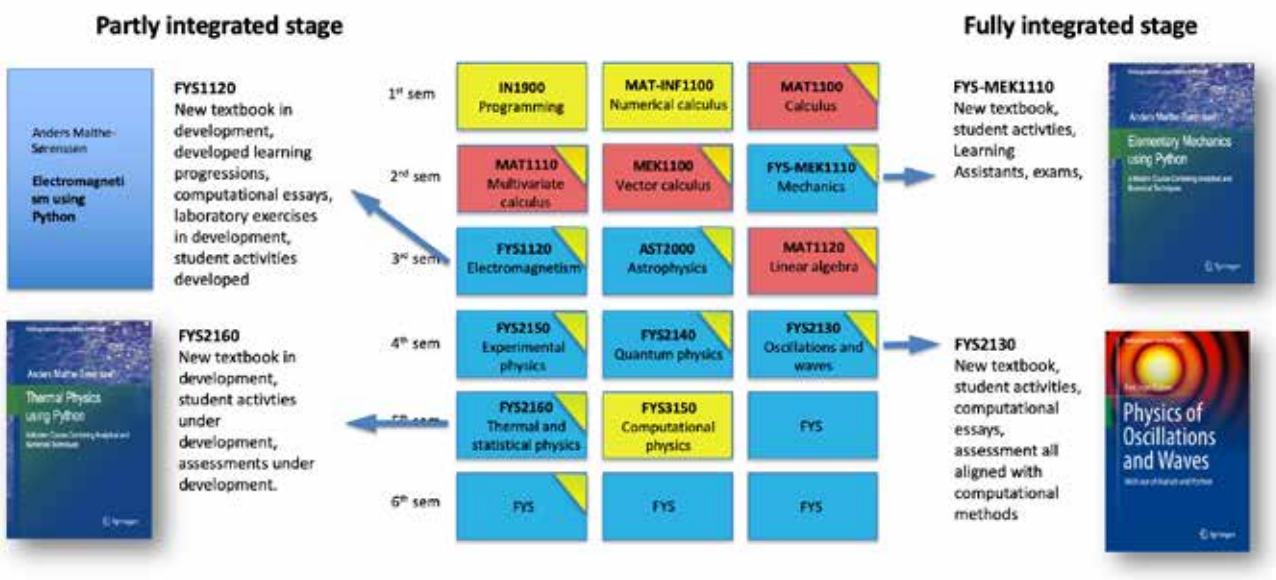
PROGRAM-WIDE LEARNING OUTCOMES IN COMPUTATIONAL METHODS

To support and coordinate the introduction of computational methods, skills and knowledge across courses, a program-wide set of learning outcomes in computational methods and digital skills have been developed. These learning outcomes include direct skills such as numerical methods, programming skills, and visualization, but also more advanced skills and knowledge such as good programming practices, documentation, collaboration, verification and testing, symbolic computing and statistical modeling. These learning outcomes have been developed and tested in collaboration and coordination with Michigan State University.

EXAMPLE – IMPACT OF COMPUTATIONAL METHODS

How does computing affect and change how we teach a subject? A classic example in mechanics in physics is what is called ballistic motion – the motion of a projectile. Typically, we want students to learn to apply Newton's second law to motion in two or three dimensions, and the first example is in the form of the motion of a projectile without air resistance. Students are asked to find what angle the projectile must be launched at in order for it to land as far away as possible. This requires 2-3 pages of mathematical calculations and leads to a closed-form answer – a mathematical expression. This tends to provide students with a binary mindset – either their answer is wrong, and they need to go through their whole mathematical derivation once more to find the error, or it is correct and they move on to the next exercise. In particular, we also find that

Fig. 3: Illustration of the stages of integration in the fundamental physics courses.



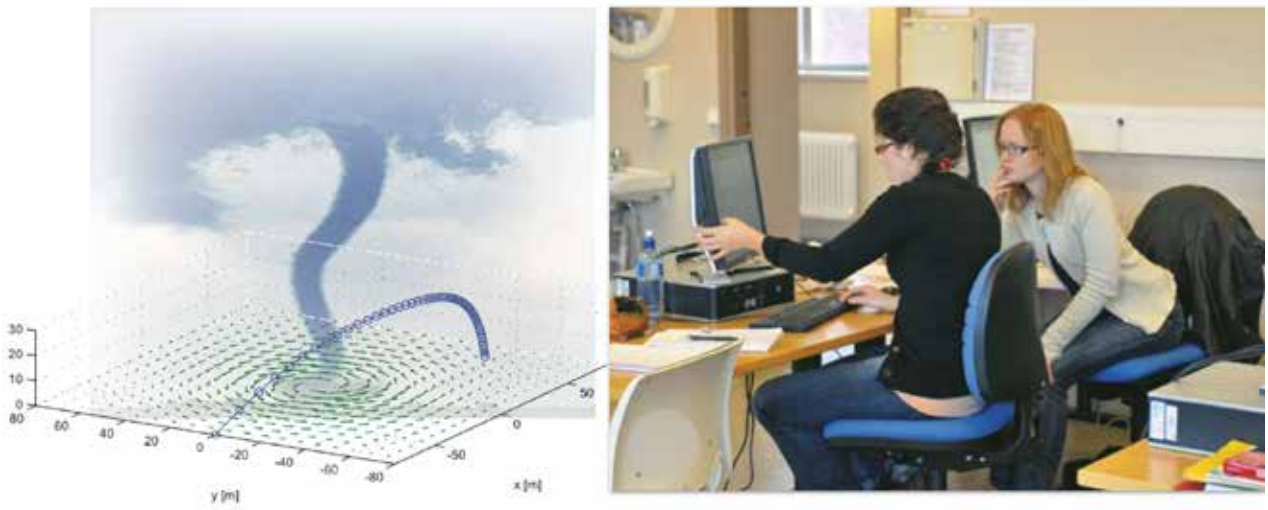


Fig. 4: Illustration of the calculated path of a probe in a tornado and student-student interactions in computational problem-solving.

students spend most of their time with activities related to derivation of mathematical expressions and not with applying and reasoning using physics principles – which is unfortunate from a physics didactic perspective.

This example can be changed with the introduction of computing. We can instead introduce the students to the concept of a tornado chaser – a researcher trying to drive into a tornado to release probes to study a tornado – a concept eminently demonstrated in the 1994 movied Twister. We can ask students to model how a probe can be launched through a tornado in order to find the velocity field. This requires the introduction of air resistance, still focuses on learning how to apply Newton's second law of motion, but opens for new perspectives and student activities. And the problem can only be solved with computing – it cannot be solved with traditional mathematics alone. However, the students must test their numerical model to a case they can solve with traditional mathematics, which still requires them to solve the classical physics problem.

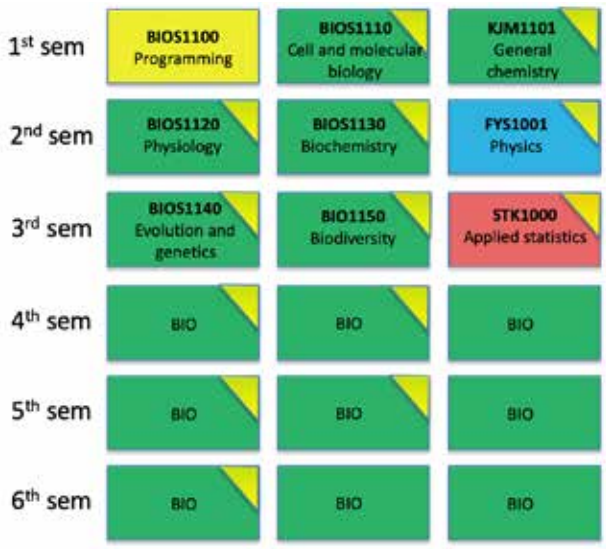
The results of this calculation is open. All students typically all get different results. The trajectory of the probe as illustrated in Fig. 4 are all different. Students then need to discuss with their peers in order to figure out if this difference is physically reasonable or due to errors in their application of the principles of physics, numerical methods, or visualizations. This changes the dynamics of the student interactions and students spend more time on activities that are authentic and closer to the scientific method.

In addition, the computational approach opens for exploration: Students may be curious as to what would happen to a feather in a tornado – inspired by the introduction in the movie Forrest Gump – or they may wonder what may happen to a cow in a tornado – inspired by the movie Twister. Indeed, students are seldom able to resist to try out the limitations of the computer program when they first have written it up.

IMPLEMENTATION IN OTHER PROGRAMS

Similar developments are gradually occurring across all the science bachelor-programs. We have found that an introductory course in programming adapted to the scientific context is essential and have therefore included this in bachelor programs across the sciences. In addition, we have found that a broad integration – into courses in mathematics and statistics in addition to the disciplinary courses opens for easier coordination and transfer for the students – allowing them to build robust representations of knowledge across fields.

Fig. 5: Illustration of structure of the bachelor program in bioscience, where the yellow tag indicates the integration of computational aspects.



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 2020 and published in 2021.

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 (see box), 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 and from 2019 notebooks can also be included in digital exams at UiO. CCSE has supported 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

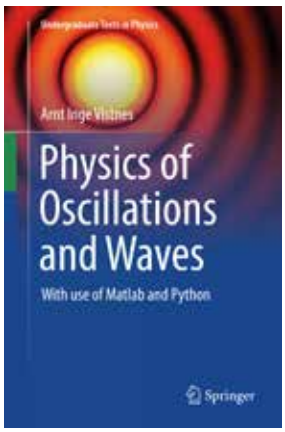
We have started to work systematically with learning progressions. In the course Fys1120 Electromagnetism we have developed a set of tutorials. The course has developed a clear learning progression for each week. The learning progression is based on a detailed set of learning outcomes for the particular 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 2020 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 scholarships in 2019. 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 (see box). 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 2019 3 of 20 student projects were awarded to a new course in statistics which is offered to bioscience and chemistry students, 2 of 20 students developed materials for a new course on data science and machine learning, and 5 students were awarded to a new course in programming for humanists 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.

Repository

The original plan for CCSE was to develop a national and international repository for learning material that integrates computational methods across sciences. However, through our collaboration with Michigan State University, we have become involved in their NSF-financed Partnership for Integration of Computation into Undergraduate Physics (PICUP) project (http://gopicup.org). One goal of this project is to provide an international repository for learning material that integrates computing in physics. We have therefore postponed the introduction of the CCSE repository to evaluate how best to interface with the PICUP project as well as with other disciplines and Norwegian and European communities.

PLANS AND PRIORITIES FOR 2020

- 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

TEXTBOOK ON PROGRAMMING FOR SCHOOL TEACHERS

"Programmering i skolen" is written for mathematics and science teachers in middle school and high school (8-13) in Norway. It is an introduction to programming for use in mathematics and science, and therefore uses examples and theory from these subjects throughout the book. The book includes a wide range of topics, from basic programming and data science to object-oriented programming and numerical methods. Python is used as the major programming language, but block based coding with Scratch and MakeCode for micro:bit is also addressed.

The book takes the teachers perspective throughout, and continuously focuses on what pupils typically find hard when learning new topics, and how to deal with that. Part of the book is dedicated to classroom methods, presenting a variety of activities that can be directly applied. "Programmering i skolen" is to be published by Universitetsforlaget in the spring of 2020.

ACTION PLAN

Action	Description	2017	2018	2019	2020	2021	Milestones and Deliverables
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	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	Research project of PhD1
	Postdoc Project	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
(New)	**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 will in the first 5-year period be integrated with the PICUP project.
A1.2: Textbook development is progressing in Fys2160 – Thermal Physics, but has been delayed in Fys1120 – Electromagnetism. Texts in mathematics are continuously updated. New texts in computational physics and machine learning under development.
A1.3: PhD-student 1 addresses learning in Fys1001 – Introductory physics and BIOS1100 – Introduction to Computational Modeling for Bioscience. The post-doc 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 activities that support writers have been postponed to wait for more writers to join. KURT has hired Jupyter and docOnce activities are as planned.

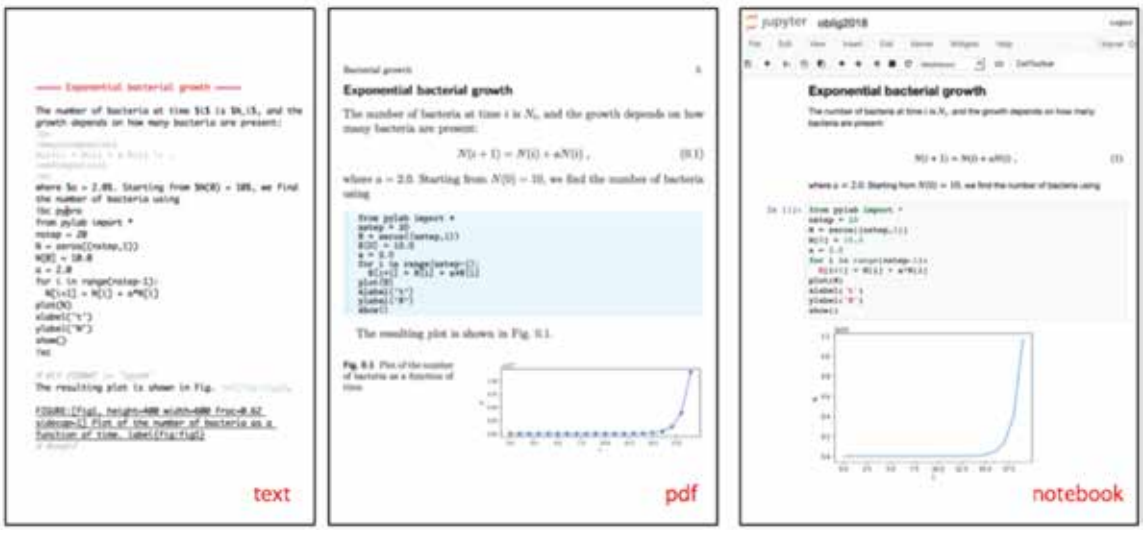
DOCONCE DEVELOPMENT

We aim to develop new learning material that combines text, illustrations, mathematics and programs. The material should be flexible and modular and easily be transformed to any distribution. To meet these requirements, Hans Petter Langtangen developed the formatting and transformation tool 'docOnce'. The underlying idea is that you write your text once, and then transform it into whatever form you need. The tool is particularly suited to develop text for learning material that includes mathematics and programming. The tool is widely used in our textbook projects and for producing learning material. Five textbooks have already used the tool and four new textbooks under development at CCSE is using it as part of the development.

DocOnce has full support for both LaTeX and Jupyter notebooks – and it is fully programmable, which is well appreciated in a center that aims to integrate the use of programming. The tool also simplifies the workflow using collaborative tools such as git. For example, if you write a text, you can compile that text into a LaTeX file which a published will use for typesetting, you can compile it into plain html or more advanced html-type formatting such as Sphinx. In addition, you can compile the text into a Jupyter notebook - which is an editable document that also contains runnable code and dynamic visualizations. Jupyter notebooks are used for distribution of course material, exercise and student hand-ins in the new course BIOS1100 and in several physics and chemistry courses.

The continued development of docOnce is therefore important for CCSE. We have therefore hired a software developer, Alessandro Marin on the S-ASSESS prosjekt who also will be responsible for docOnce support and development. He will also provide docOnce courses as part of our support to faculty and students that develop learning materials and textbooks.

Fig. 1: Illustration of the docOnce text file (left), the corresponding compiled pdf (center) and the corresponding Jupyter notebook (right).



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 Center for Teaching and Learning in Science) 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 several projects that aims to include both teachers and learning assistants actively in student-active learning. One of these approaches is the Learning Assistant project (see box). However, we have also developed several initiatives at the various departments to support and promote active learning methods.

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 and 2019 to establish common theoretical and methodological ground for these investigations, and regular research-group meetings have been started in 2019. 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). A full implementation for 150 students were implemented in 2019. 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 published and show that the students greatly appreciated the creative oppor-

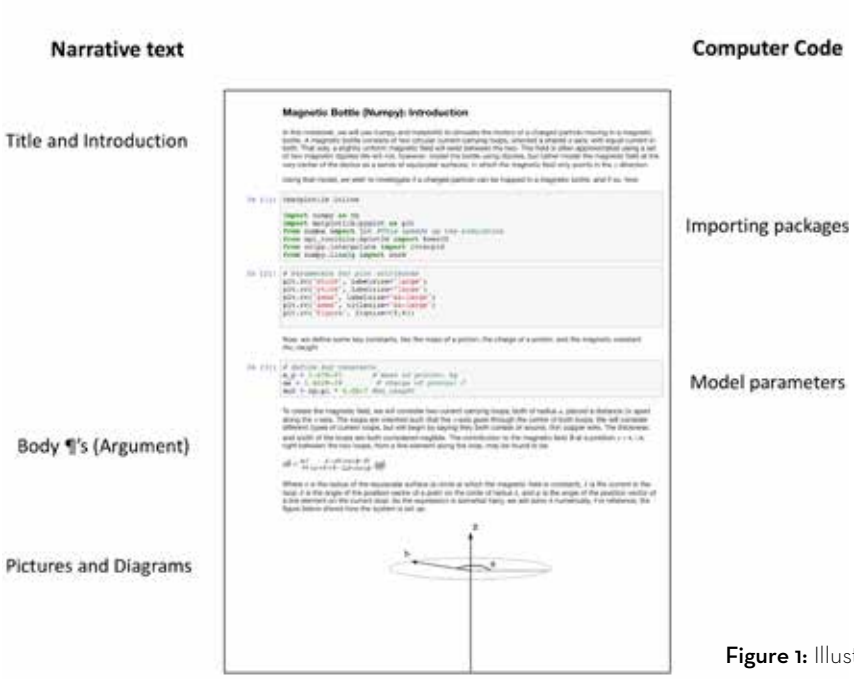


Figure 1: Illustration of a computation essay in FYS1120.

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

During 2019 members of the CCSE continued the development and use of computational essays in the intermediate electricity and magnetism course. After the successful pilot implementation in 2018, computational essays were extended into a mandatory part of the course for all students. The overall results were strongly positive—nearly all students successfully wrote and presented computational essays on a wide variety of subjects. Commonly-chosen topics included the effects of relativistic effects on particle accelerators, medical applications for accelerated particles, lighting safety, and novel applications of railguns. In interviews students reported initial trepidation, having had little previous experience with either open-ended projects or writing in their physics courses, but all interviewed students reported the experience as interesting and motivating, and most recommended that it be continued in subsequent semesters.

In addition, in 2019 two research articles were accepted (and one published) based on analysis of data collected from the pilot implementation of computational essays. One article, accepted to The Physics teacher and forthcoming in 2020, provided a concise description of the idea behind computational essays and an argument for their usefulness in physics teaching. The second article, published in Physical Review Physics Education Research, used the pilot results to propose a theoretical framework for computational literacy in physics. The second article received a prestigious Editor's recommendation in the journal.

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.

LDA machine learning model

During 2019, Tor Ole Odden, Alessandro Marin, and Danny Caballero began a project to use machine learning methods in order to analyze large amounts of educational research literature. Using methods from the sub-field of Natural Language Processing, they were able to analyze a dataset of over 1300 papers generated by in the physics education research community from 2001-2018 and extract out a set of key themes that have seen varying levels of research interest within the community over time. Additionally, they were able to track the prevalence of these themes over that time and show that the field of physics education has seen several waves of interest, beginning with an initial focus on student cognition in the early 2000s which gave way to a focus on problem-solving in the late 2000s. Their results have also shown an increasing trend since 2010 towards sociocultural views of teaching and learning, with a specific focus on student identities, communities of practice, and institutional change. The results of the project have been compiled into a paper submitted to Physical Review Physics Education Research in early 2020. Based on the success of this project, they have plans to apply similar methods to a much larger dataset comprised of over a century's worth of educational research literature published in the journal Science Education, as well as other subfields such as mathematics, chemistry, and biology education.

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

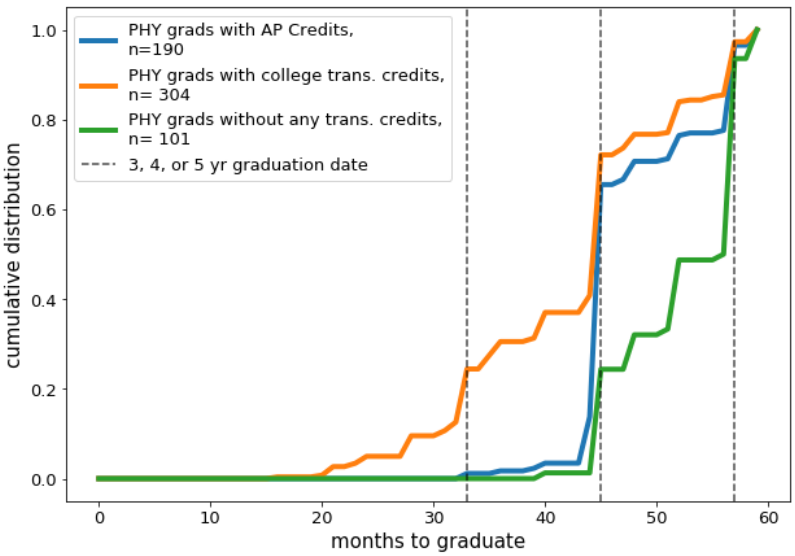


Figure 2: Having just one Advanced Placement credit has a profound effect on students graduating on time. The dashed lines indicating 3-year, 4-year, and 5-year graduation times respectively. While this plot only represents physics majors, it is true for other STEM majors as well. (Plot created by Alyssa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

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 published another paper in 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 computing 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. The program was extended to 15 students and faculty from Norway, China and the US in 2019. Several papers are under submission from these student projects.

Standardized assessments

In order to gain more insight into student learning when we introduce changes in instructional design, we have started to introduce standardized tests at the beginning and at the end of large-enrollment courses. In 2018, we introduced a pilot of the CSEM test in introductory electromagnetism (Fys1120), and in 2019 we rolled the test out for the whole class (170 students). The students were incentivized to participate in both the initial and final tests. The tests provided insights into the starting competence of the students compared to typical US institutions, and in what areas the students had the largest gains. Standardized tests will be introduced in three additional physics courses in 2020 – in mechanics (Fys-mek1110), in quantum physics (Fys2140), in Oscillations and waves (Fys2130), and in experimental physics (Fys2150).

Research seminar series

In 2019 CCSE moved into new facilities with new meeting rooms. We have established regular seminar series on instructional design and education research. The full list of talks can be found in the list of products. The seminar series have been well attended with participants from physics, chemistry, mathematics, computer science, biosciences, and education. The seminar series is providing an avenue to focus on research-based instructional design at the Faculty.

PLANS AND PRIORITIES FOR 2020

- Extend the Learning Assistant project to more courses and publish results from UiO
- Extend research activity to mathematics and bioscience education research
- Extend the research seminar series and consolidate research group meetings
- Extend computational essay project to one additional large-enrollment (100+ student) class (Fys2130 – Oscillations and waves)
- Extend use of standardized assessments in introductory classes (Fys-mek1110, Fys2140 Quantum physics, Fys2130 Osciallations and waves, and Fys2150 Experimental physics)

ACTION PLAN

Action	Description	2017	2018	2019	2020	2021	Milestones and Deliverables
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	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
(New)	**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, and Fys1001 – Physics for applications.

A2.2: Data-based methods are developed in the course Fys2160 – Thermal physics, Fys 1120 – Electromagnetism, and Fys-stk3155 – Data science and machine learning.

A2.3: This project has been financed with three new positions from the Norwegian Research Council (S-ASSESS) and started 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 2020.

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. A full-time associate professor position will be announced in 2020.

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.

Pilot study in 2018

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.

Initial research in 2018

In addition to establishing the learning assistant program, we also started to research the effects of the program on the students in the courses and the LAs themselves. 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.

Expansion in 2019

In the spring semester we recruited and trained 20 learning assistants from three physics courses (mechanics, waves and oscillations, and quantum mechanics), using a training program that had been refined based on feedback from the pilot. In the fall semester, we trained an additional 10 learning assistants from two physics courses (electricity and magnetism, thermodynamics) and one math course. Putting all of these physics-courses together, we have managed to extend the learning assistant program to cover nearly all of the physics courses taken by physics majors within their first two years of study.

Pre-service teachers observe and supervise LAs

In addition to training learning assistants, we have also continued with educational development in the targeted courses by hiring pre-service teachers (lektorstudenter) to both develop new educational materials and supervise the learning assistants. In the spring semester of 2019, we hired 3 pre-service teachers (two for mechanics and one for quantum mechanics) who worked closely with the course instructors to devel-

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op discussion-based, conceptual exercises that could be used by the learning assistants in their teaching. These pre-service teachers also directly observed the LAs' teaching to evaluate the effectiveness of the exercises and give feedback to the LAs. In the fall semester of 2019, we re-hired two of the pre-service teachers to continue this work in the electricity and magnetism course.

Design-based research project

Throughout 2019 we continued to collect data on how the learning assistant training affects the LAs' adoption of active learning techniques and views of teaching and learning. At the end of each semester, Anders Lauvland, Ellen K. Henriksen and Maria V. Bøe conducted focus-group interviews with the learning assistants to collect feedback on their experiences and probe their changing views on teaching and learning. The team has additionally collected pre- and post-surveys, and collected quantitative data on the learning assistants' teaching through the use of a standardized observation protocol. These data are currently under analysis, with the goal of a published research article by the end of 2020.

CONFERENCE ON THE INTEGRATION OF COMPUTATIONAL THINKING IN SCIENCE

Adjunct Professor Danny Caballero organized a conference titled "Advancing Interdisciplinary Integration of Computational Thinking in Science" May 2-5 2019. The conference was sponsored by the American Association for Physics Teachers (AAPT). Postdoc Tor Ole Odder from CCSE provided examples of best practice from UiO at the conference. The conferences gathered the most influential researchers working on computational thinking and produced a conference report with recommendations on policy and implementation. The conference focued on five key issues: (i) Integration of computation must emphasize values native to the discipline in which computing is being integrated and demonstrate a clear alignment with existing standards, (ii) Educational leaders need to recognize that relevant computing content differs across the sciences, ruling out a "one size fits all" notion of integrating computing in science, (iii) Diversity, Equity and Inclusion must be built into all efforts to integrate computation with science education, (iv) K-12 teachers need sustained professional development and support to learn and teach science while leveraging computing, (v) Research is needed to understand and assess computational integration. There are relatively few theories of how computation impacts science learning. There are also very few useful assessments for charting progress. The themes are in line with the priorities of CCSE.

IMPEL - INTERACTIVE ENGAGEMENT AND MOTIVATION IN PHYSICS LEARNING

The IMPEL project is directed by the Physics Education Research group at the Department of Physics. However, the project is closely linked to CCSE's activities. IMPEL does research on students' motivation and learning in physics higher education. The project investigates how motivation, physics identity and experienced learning outcome are shaped by different teaching and learning situations students meet, including computational approaches and various "active learning" environments as well as more traditional learning situations. During 2019 and 2020, IMPEL collects questionnaire responses from bachelor students in physics at five Norwegian universities. Additionally, we collect focus group data at the University of Oslo to complement the quantitative results. IMPEL aims to contribute to developing a future-oriented and inclusive physics education through identifying how different teaching and learning approaches, particularly computational and "active learning" approaches, can best be utilized to support student learning and motivation.

IMPEL
–
Interactive engagement and motivation in physics learning

Links: https://www.mn.uio.no/fysikk/forskning/prosjekter/impel/

STUDENT-ACTIVE LEARNING BY PROGRAMMING IN ASTRONOMY

Professor Frode Hansen, Institute of Theoretical Astrophysics, University of Oslo

In the third semester, students in the Physics and Astronomy bachelor program take AST2000 Introduction to Astrophysics. This course provides the students with a novel approach to learning – by planning and performing a virtual space mission. The students develop a large numerical project where they write a scientific style report (or a set of blogs), which forms the basis for the assessment.

Visual space mission: The project is structured as a space mission where the students need to use the different parts of the curriculum to succeed in getting a space probe to arrive at and land on a chosen destination planet. Central to the project is a virtual

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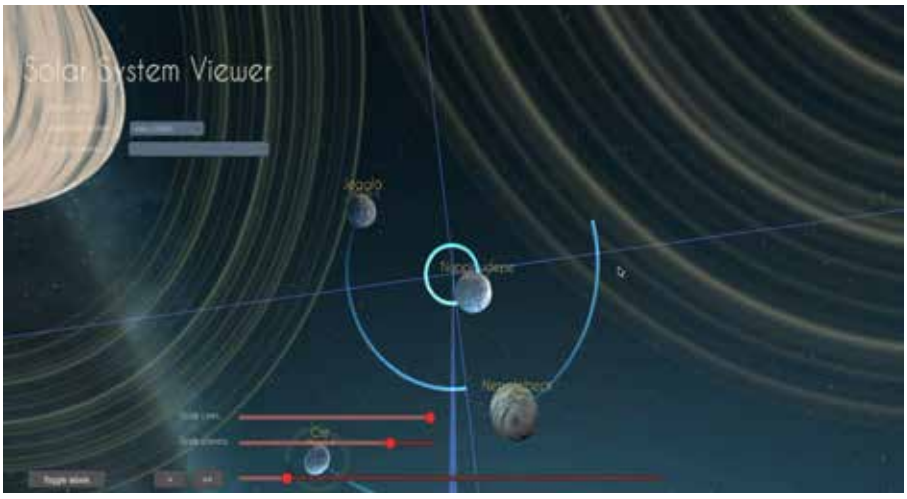


Fig. 1: An example of a randomly generated solar system

solar system created by Nicolaas Groeneboom using the 3D game engine Unity. Every student is given a home planet in a uniquely randomly generated solar system (see Fig. 1) and choose the destination of their space probe.

Virtual rocket: Students start by constructing a virtual rocket engine. Using the thermodynamics of gases, the students write a python program to simulate and study gas particles in a virtual box. Then, by making a hole in the box, they study a simplified model for a rocket engine. The students need to fine-tune their engine to ensure the rocket with payload escapes their home planet.

Virtual analysis: Students combine parts of the curriculum to select and analyze their destination planet. They model the climate to find which planets may support liquid water and possibly life, and analyze light spectra to determine the composition of the planetary atmospheres. The write programs to orient their spacecraft based on image recognition of images taken by the spacecraft camera (see Fig. 2).

Finding the path in space: In order to navigate the spacecraft between the planets in the virtual solar system and successfully land on their planet of choice, the students must apply Newton's law and solve the resulting equations of motion numerically. The whole mission is visualized providing the students with an exciting result of their hard work in the form of a visualized space mission (Fig. 3).

Student experiences: Students report that the course is work-intensive and challenging, but fun and rewarding. Student point out that the project is highly motivating and that they feel much more comfortable with programming afterwards.

Reflections on the integration of computing: This course provides an excellent example of how the use of computing can change the way a course is taught, allowing students to explore, explain and understand the underlying concepts while solving a problem that is inaccessible without computing.

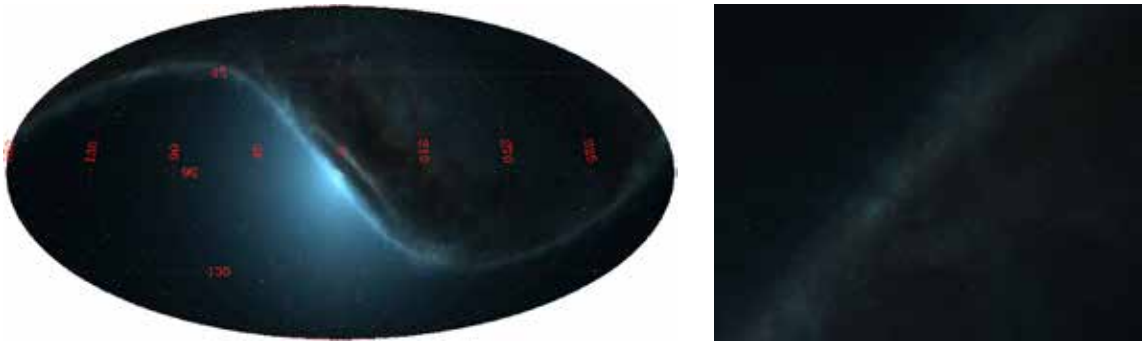


Fig. 2: Students find the orientation of the spacecraft camera by writing a program which can recognize the flat image on the right in the spherical picture of the celestial sphere on the left.

Fig. 3: Examples of visualizations from students' spacecrafts during landing.

THE S-ASSESS PROJECT

CCSE was in 2017 awarded a 6 million kroner grant from the Innovation in the public sector funding scheme of FinnUt, the education research program of the Norwegian Research Council (NRC). The grant went to the project "Structured assessment system for improved student learning".

Providing students with timely feedback – assessment – is important for student learning. Assessments may be formative – aimed at providing feedback to help students improve – or summative – focused, instead, on evaluating student learning. Assessment methods must be based on research to ensure that they contribute to learning in a constructive manner.

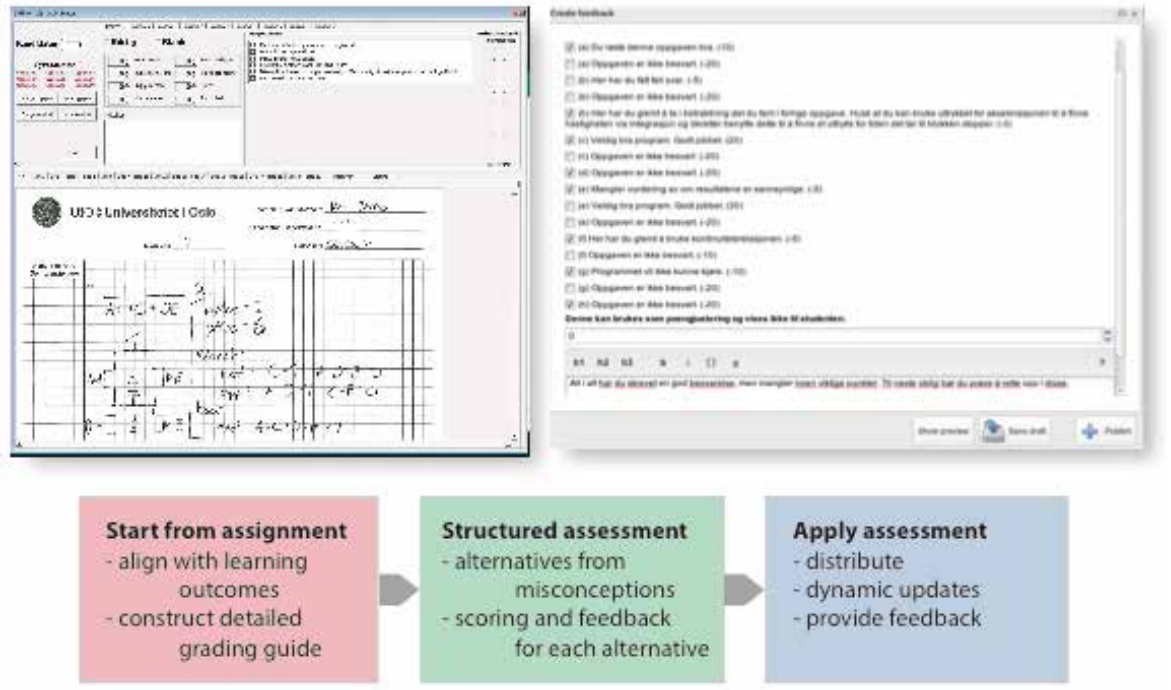
The goal of this project is to develop, validate and implement an assessment system to be used for teacher-, peer- and self-assessment for general courses as well as for courses that integrate computing. The system will structure the way assessments are performed to ensure research-based feedback to students and more valid and reliable grading of exams. We will accumulate structured data on student learning that will be used to improve and automate feedback.

To ensure a research-based assessment system, we need research to develop and validate effective assessments and to develop assessment structures, such as rubrics or checklists, that are adapted both to traditional scientific concepts and understanding as well as concepts and understanding linked to a computational approach to science.

The project is developed in collaboration with the Department of Informatics and is closely linked to the 1.8 million kr eAssess-project granted by Norgesuniversitet, in which CCSE is a partner.

The grant will finance a PhD-student and a postdoc that will work on the research needed to realize the innovation. In addition, CCSE, the faculty and the Department of physics will jointly fund a software developer to develop the web infrastructure for the project.

Fig. 2: Illustration of checkbox-based assessment structures from UiO courses.



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. In 2019, the focus has been on implementing transferable skills training with a particular emphasis 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 2019 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 (Center for Teaching and Learning in Science) 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) each year..

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. Starting from 2020 the introductory laboratory courses in physics will also include the E-CLASS assessment developed at University of Colorado – Boulder.

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 2019 we arranged regular 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.

Teaching assistant workshop

We consider the professional development of teaching assistant to be important and have developed biannual teaching assistant workshops that are compulsory. The workshops are designed to provide teaching assistant with basic pedagogical tools and skills needed to effectively teach smaller groups. The workshop is compulsory for teaching assistants. The workshop was in 2017 extended to include teaching faculty with great success – opening for sessions where teaching faculty and teaching assistants coordinate their activities at the beginning of the semester. In 2019, we had 250 participants in August, and 190 in January. We also arranged a seminar for English speaking teachers with 25 participants in January.

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 Center for Teaching and Learning in Science (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 2020

- Develop and provide courses in Python programming for newbies
- Prepare summer institute on computational methods for bioscience teachers
- 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.

ACTION PLAN

Action	Description	2017		2018		2019		2020		2021		Milestones and Deliverables
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 2020. 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 2020.

A3.3: Teaching days are running at several departments, including the Department of Physics. Teaching teams will gradually be introduced in 2020 and 2021 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 evaluation systems have been postponed, awaiting the implementation of 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 was organized in 2019. A summer institute on the integration of computational methods into bioscience courses will be organized in 2021. 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.

ELISE LOCKWOOD'S EXPERIENCE AT CCSE

Elise Lockwood is an associate professor of Mathematics Education Research at Oregon State University. She spent her sabbatical from August to December 2019 at CCSE. Here are some of her reflections from that visit:

"My research project was focused on better understanding students' experiences with the integration of computing into mathematics coursework at the University of Oslo. UiO has uniquely designed their program to integrate computing into students' mathematical and scientific experiences – they have created three courses that all mathematics students take in their first semester that together provide students with immersive programming experiences with applications in mathematics and science. Part of this focus on computing at UiO has resulted in the creation of a Center of Computing in Science Education (CCSE), which is where I was housed during my stay in Oslo. The CCSE aims to support and better understand computation in mathematics and science education. Because of the center and faculty members' interests in computing, and because of the kinds of experiences students at UiO get in terms of computing, I had a chance to learn more about the students' experiences and to improve my own understanding of computational thinking and activity as it relates to mathematics education. I addressed the following research questions:

- What are students' experiences in mathematics courses in which computing is integrated into the mathematical content? What are their opinions of computing in this setting?
- How can we improve the teaching and learning of mathematics by incorporating computing into mathematics classes, and how can we improve the teaching and learning of computing in mathematics classes?

To address these research questions, I gathered survey data and conducted two rounds of focus group interviews about UiO students' experiences with computing in mathematics classes. I have begun some preliminary analysis, although the second round was just gathered in late November, so I expect to do most of my analysis and writing in the coming months. These data will help me answer my research questions and better understand how students are viewing and experiencing computing here at UiO. I am optimistic that these data will result in a publication. It was also just really nice to get to talk with these students and get to know them a bit. They were great!"

"Overall, I knew that UiO was ahead of the game globally in terms of computing in mathematics education, but I hadn't known the extent to which other universities in Norway were also interested in these phenomena. Now, as a result of these meetings, I feel like if I were to come back to Norway, I would have connections beyond just UiO."

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.

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

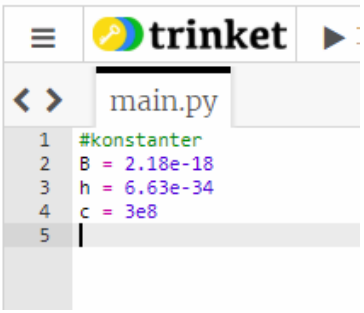


Fig. 3: Screen shot from the Python program calculating the wavelengths of photons resulting from transitions between energy levels in the hydrogen atom. Here, relevant constants are defined in the program.

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.

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 2019 we received applications for 1.4 million kroner and rewarded 1.2 million kroner for projects, providing the departments with 21 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 2019 21 students worked on curriculum development in subject areas such as nuclear physics, introductory chemistry, introductory astronomy, introductory geoscience, introductory statistics, pharmaceutical science 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 (13) bachelor students in 2018 (2019) (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 2020

- Establish one fully student-directed project in 2020
- 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
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 instead from 2018.
A4.2: Education research projects started in 2018 according to plan. First paper from student researcher published in 2018, and 2 student papers were published in 2019.
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 2017-2019. Focus has been on education research and international student exchange.
A4.6 Student innovation has not been prioritized in 2017-2019. These projects will be reevaluated along with the action plan in 2020.
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 2017–2019

The student research project "Cross-disciplinary grand challenges for students" was funded by the Thon foundation with 1.5 million kr for the period 2017-2020. The project is a collaboration between professors Bjørn Jamtveit at the Njord center at Department of Geosciences, Marianne Fyhn at the CINPLA center at Department of Bioscience, and Anders Malthe-Sørenssen at CCSE and the Njord center, Department of Physics.

The goal of the project is to expose students to high quality research early in their careers. Students in their first, second and third years are invited to participate in bold research projects that are on the borderline between physics and geoscience and physics and neuroscience. Because students at UiO learn programming and computational methods already in the first semester, they have the knowledge and skills needed to contribute meaningfully to research projects already in the first year.

In 2017 12 students were selected to participate in research projects during the summer. The students were grouped into three groups, one group addressed fundamental problems in friction, one group addressed shock and fragmentation processes near earthquakes, and one group developed tools for the analysis of neurophysiological data. The students were given a general introduction to research practices and specific instruction on the use of computational research methods and tools used for the project. All students presented their results in a common workshop at the end of the summer.

Fig. 3: Picture from initial workshop with summer students.

Four students have continued with the research project also during the fall semester – continuing to develop their research project towards a publishable result. One of the students was invited for an extended research stay with our collaborators at the world-leading Collaboratory for Advanced Computing and Simulations at the University of Southern California.

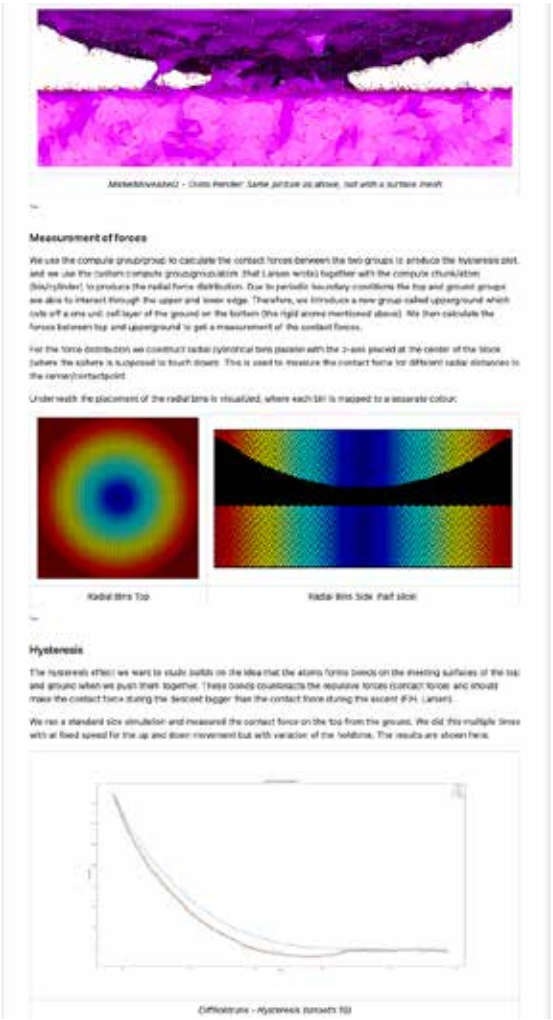


Fig. 4: Illustration of a student workbook in the form of a Jupyter Notebook document. We use similar approaches in both courses and research to ensure the students learn authentic methods.

SUMMER STUDENTS DEVELOP NEW CURRICULUM

At the Center for Computing in Science Education (CCSE) students participate actively in developing new learning material. Sebastian Winther-Larsen is one of 19 students who during the summer of 2017 worked on developing new exercises and examples that integrate the use of programming and computing in various science courses.

Our goal is to renew the contents of the education by integrating programming, but we need help from the students. Students have up-to-date skills and understand how to effectively communicate with other students.

"We often experience that your understanding of a subject reaches a new level when you teach it. This is why we believe students who help make learning material also gain a deeper understanding", says Anders Malthe-Sørenssen.

"We engage students as partners to change the education. By offering students as a resource to teachers, we encourage teachers to make changes in the courses they are teaching. It makes it easier to make those changes. And the students become deeply involved in the changes. Indeed, students may have more updates skills in computing and programming, but teachers have the experience and disciplinary insight to select good problems. In this way, both students and teachers gain from the collaboration," explains Professor Knut Mørken. "We have done this for several years already, but with the center funding we are able to scale the activity up and extend to other disciplines."

Sebastian Winther-Larsen is a master student in Computational Physics, but also has a Master degree in finance. He has developed exercises that teaches students to use Python to solve problems in finance and economics. By including basic programming, it is possible to include realistic data and introduce students to practical and applicable methods.

Fig: Sebastian Winther-Larsen developed exercises in economics at CCSE during the summer of 2017.

Sebastian explains that he also learned from the development work: "The biggest test of your own understanding is if you are able to explain it to others. You have to think carefully when you construct exercises. This is similar to how it is to teach or explain something to other students. But without the direct feedback, of course."

Sebastian greatly enjoyed being a part of the computing in science education project at UiO, because, "I am a strong proponent of programming in education". "When I develop exercises and problems, as in this summer job, I have to write something that the reader can understand. Then I have to think back at how I was able to learn the concepts myself."

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 2017-2019 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. From 2020 we will initiate an EU funded project (COFUND) to develop the competence needed to educate the next generation of teachers and researchers with computational competence (see box on TraCS-COFUND).

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 of 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 scholars – John Burk and Elise Lockwood

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.

In the fall of 2019 (July to December) Elise Lockwood stayed at CCSE as a visting scholar. Elise Lockwood is an outstanding mathematics education researcher from Oregon State University focusing on the impact of computing on student understanding of concepts in mathematics with particular focus on combinatorics. She recently received an NSF CAREER grant on this topic. We are honored that Elise Lockwood selected us for this sabbatical stay and use this stay as a basis for a long-term collaboration.

School partnership

The school activity has grown significantly in 2019, becoming a major activity at CCSE. (See box).

PLANS AND PRIORITIES FOR 2020

- 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
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 (see box). CCSE has initiated collaborations with most other universities in Norway, 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.

INTEGRATING COMPUTING IN THE BIOSCIENCE BACHELOR PROGRAM

The study program in bioscience was redesigned for the new study program in bioscience starting 2017. In this program, skills in computational modelling and programming are included as a learning objective. Students learn to program already in the first semester, and programming and computing are also used in many other courses throughout the program to ensure that students learn to develop and use these skills in their disciplinary context. 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.

Fig. 4: Textbook authors, from left: Andreas Solbrå, Simen Tennøe, Svenn-Arne Dragly, Milad Mobarhan.

Background for the curricular reform in bioscience

The introduction of computing in the bioscience program was the result of a department-wide process motivated by the need for computational skills in bioscience research and to improve the employability of the bioscience students. New experimental techniques across the biosciences are producing vast amounts of data, and new methods for modeling and analysis is needed. The main initiative to develop a new set of courses came from an interdisciplinary research activity on the intersection between physics, computational science and neurosciences – the Center for Integrative Neuroplasticity (CINPLA) led by Professors Marianne Fyhn and Anders Malthe-Sørenssen. However, the department ran a broad and inclusive process in order to gain a consensus for integrating computational methods across the whole curriculum. This process was driven both from the department leadership and from individual researchers. In particular, a strong commitment from leading bioscience researchers such as Fyhn was essential for the success of the reform.

Developing a new curriculum and a new textbook

CSE co-founder Professor Hans Petter Langtangen took the initiative to develop new learning material – a new textbook – in programming for bioscience students in 2014. Langtangen had previously developed the introductory course in scientific programming at UiO and written a best-selling series of textbooks, including "A primer of scientific computing using Python" which is used as the textbook at UiO and in many other institutions nationally and internationally.

Langtangen's vision was to introduce students to programming in a biological context. However, Langtangen fell ill, and the work was continued by four PhD-students in computational neuroscience at CINPLA – all with backgrounds in computational physics: Simen Tennøe, Andreas Solbrå, Milad Mobarhan, og Svenn-Arne Dragly and all supported by CCSE (see Fig. 4). The textbook is developed so that students are introduced to a sequence of biological problems that require computational methods to be addressed. The problems and their sequence have been selected to provide students with a gradual introduction to computational concepts and skills. They start with bacterial growth, continue with plant growth, inheritance and DNA sequencing as illustrated in Fig. 5. The textbook is the first of its kind to introduce programming in Python and computational modelling fully anchored in a biological context. In 2018 the PhD-students and Senior Lecturer Lex Nederbragt

was offered a publishing contract for the book with Springer, and the textbook will be published in 2020.

Piloting the learning material

The learning material and the teaching approach was first tested on a small group of students in spring 2017. Feedback from this pilot round was used to improve texts, exercises and activities. Three summer students financed by CCSE worked on developing additional exercises for the course.

The new bachelor program in bioscience

In 2017 a new bachelor program in bioscience was introduced. In this program, competence in computational methods was introduced as a learning outcome for the program, and a computational perspective was integrated in courses across the whole program. In particular, a new course BIOS1100 – introduction to computational modeling in bioscience was introduced in the first semester based on the textbook material developed. The structure of the bachelor program is illustrated in Fig. 6. There are computational components in all the courses in the first three semesters, illustrated by the yellow tags in the figure.

Teaching approaches in BIOS1100 - "introduction to computational modelling in bioscience"

The course is taught using novel, active learning methods and consisted of large-classroom lectures with live coding and large group sessions with several student-active activities in the new learning laboratory at the Department of bioscience (see Fig. 7). The course aims to teach students basic programming in Python, modeling and the associated mathematical concepts. The course material, examples and ex-

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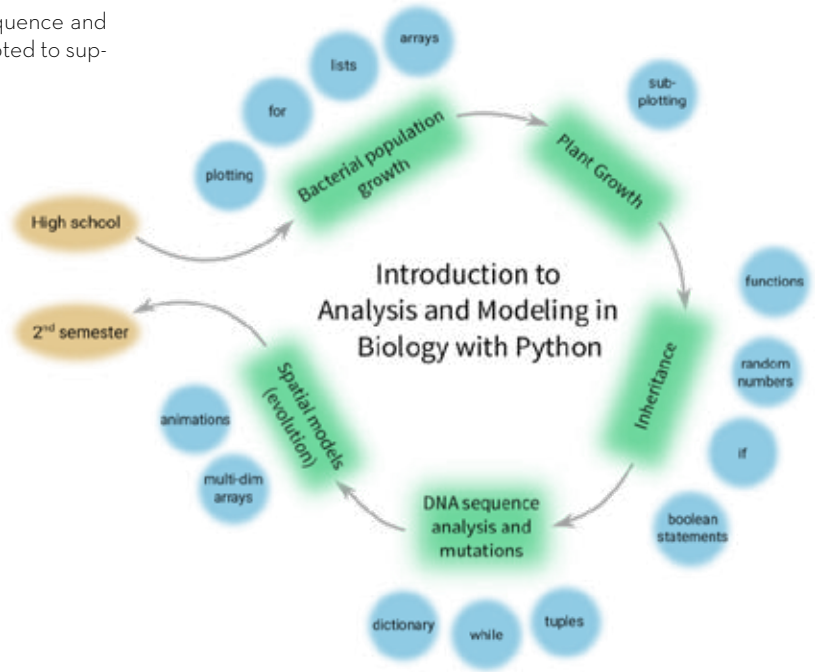


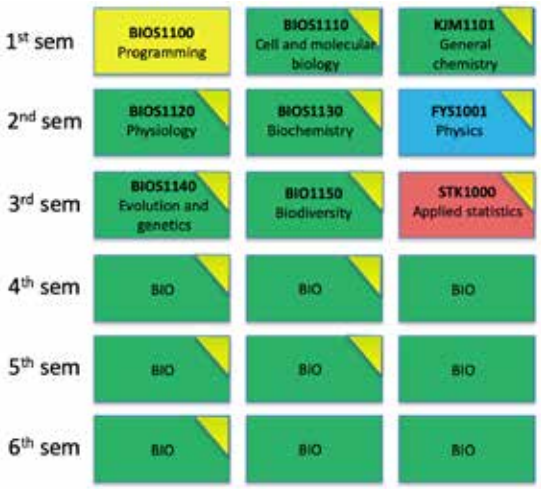
Fig. 5: Outline of the learning sequence and how the biological topics are adapted to support the programming aspects.

ercises are presented in the form of Jupyter notebooks – a computational notebook that combines text, figures, mathematics and runnable code. The notebooks were distributed using the cloud-platform JupyterHub and written using docOnce to produce both pdf texts and Jupyter notebooks. This ensured that students could use their own laptops without any software installation as all programs were run in a web browser. From 2019, notebooks and programming have been integrated into the digital exam environment, thus ensuring a strong alignment between the learning outcomes, student activities and practices and the assessment methods.

The course experiments with a guided instructional pedagogy, "Participatory Live Coding", to introduce programming concepts that may be unfamiliar to biology students. In this practice, a teacher or teaching assistant programs live in front of the students, while the students copy and execute the exact code or commands that are being written. Sessions contain short exercises where students are asked to solve a small related problem on their own. We are in the process of evaluating this pedagogical practice through associated education research projects.

BIOS1100 students were visited by both the Minister of Education and by the Labour party's parliamentary group in 2017 – allowing students to share their experiences directly with the politicians.

Fig. 6: Bioscience bachelor program. Courses in the last 3 semesters are elective.



Integration of computing across courses in the first semester

In the first semester, students take courses in cellular and molecular biology (BIOS1110) and in chemistry (KJM1101) in parallel with BIOS1100. Basic computational elements have been introduced in these courses as well to ensure that students meet computational approaches across context. For example, computational elements are included in the exercises in BIOS1110, while in KJM1101 computing and programming are integrated in the laboratory exercises.

Second semester

In the second semester, Jupyter Notebooks are used in all courses; physiology, biochemistry and physics. Students are provided with pre-developed computational notebooks that they can explore or are asked to modify. Programming and calculations are part of assignments or lab reports.

In physiology, students explore physiological phenomena using simple programming in Jupyter notebooks that are heavily «scaffolded». Students are typically asked to either change parameters in the code or use sliders to change parameters in equations. Students report liking to explore concepts and functions in this way. In physics, computations have been integrated into some of the weekly seminar exercises in the form of «scaffolded» notebooks. In biochemistry computer labs are used with Graphical User interface-based programs (PyMOL) to visualize protein structures and gain insight into their function. In future iteration, analysis and plotting will be done by programming in Python.

Third semester

In the third semester, students switch to the programming language R. This language is a natural choice for the statistics course, and the evolutionary genetics and biodiversity courses also use it, but R is not a language well suited to learn good programming practices or general aspects of computational literacy. Biologists may need knowledge of R since there are many important analysis methods relevant to biological data available in this language. The evolutionary genetics course uses modeling and computation extensively in the datalabs with a combination of the student developing their own programs and scaffolded code.

After the third semester, CSE is part of elective courses such in ecology, advanced biochemistry and biological data analysis. The CSE sections consist mostly of pre-developed code that students will work with, or a mix of pre-developed code and code that students should write themselves.

The road ahead

The integration of computing into the bioscience curriculum is off to a good start. 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. The effort enjoys wide support in the institute's leadership and among staff, and we see the beginnings of a culture change when it comes to the content of the program. However, much work remains to be done before we have achieved a full, comprehensive integration in the entire bachelor program. The next years, we aim to use the current momentum to inspire more teachers to start the necessary development work for CSE integration, particularly in the specialization courses from the 4th semester.

Fig. 6: Minister of Education in discussion with UiO rector Svein Stølen and CCSE director Anders Malthe-Sørenssen (Photo: Ola Sæther, Uniforum)

Fig. 7: Learning laboratory at Department of Bioscience. (Photo: Lex Nederbragt)

During 2018 and 2019 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 Ministry of Education (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 Norway in need of this competence in 2020 is 40 000. Similar challenges will arise in other European countries as programming is integrated into the school curriculums.

Fig. 1: In-service teachers learning to program at CCSE.

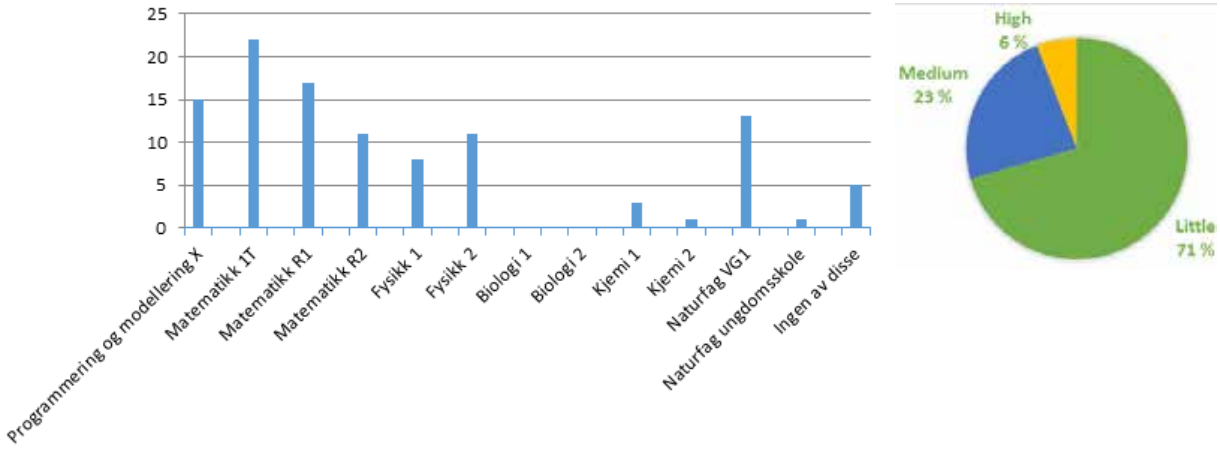


Fig. 2: (Left) The background of teachers participating in ProFag. (Right) Teachers attending ProFag:U responding to the question "To what extent are you comfortable with programming?" before the first day of the course.

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)
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.

IMPLEMENTATION

Pilot courses in 2018

In 2018, CCSE piloted a two-day course for upper secondary school science teachers. 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 was open and available online: 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 had a project financed by 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 openly available at https://uio.instructure.com/courses/14016

Full implementation from 2019

From 2019 the ProFag activities expanded following the models developed in the pilot projects. The activities were financed by a financial scheme called DKOMM – Distributed competence development – which provide financing for schools and schools owners to collaborate with universities on competence development. Collaborations were initiated both by Education Department Oslo and in the neighboring administrative unit, Akershus.

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Fig. 3: ProFag in-service teacher course.

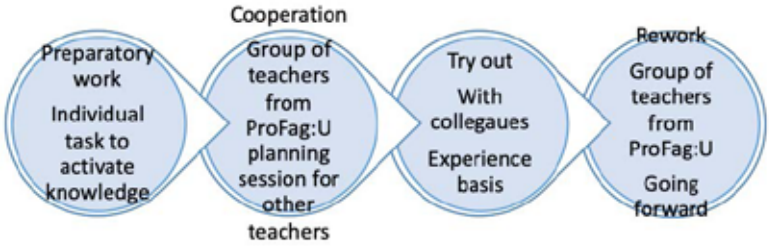


Fig. 4: Illustration of how ProFag includes local competence development at schools.

In 2019, ProFag:U organized 5 six-day course for middle school teachers. ProFag:vgs organized 4 four-day courses for high school teachers. In addition, ProFag organized five one-day courses for high-school teachers, and co-organized one-day courses in collaboration with the University of Tromsø (UiT). All the resources developed for these courses are openly available so that teachers who do not have access to courses can work locally on their own schools.

National project to develop teaching resources

In 2019-2020 ProFag is developing a set of teaching resources on programming and computational thinking on behalf of the National Education Directorate (UDIR). We are developing set of common resources to support 1-10 teachers in the work to integrate programming and computational thinking in the various subjects. We have the main responsibility for modules in mathematics for 1-7 and 8-10 teachers. In addition, we contribute to science modules in collaboration with the Norwegian Center for Science Education.

FURTHER DEVELOPMENT OF THE PROFAG ACTIVITY

Development and research

The ProFag courses give valuable input on how to meet the challenges of the teacher. In addition, the approach we have developed provides a model for how to achieve distributed competence development at schools – an essential component in how to scale up in-service training to all teachers in Norway.

In 2020 we plan to initiate two research project which are essential to ensure the quality of the ProFag educational model, and which also open important and original fields of research. One project is directed at understanding how teachers learn programming and adapt it to their disciplinary context and how to contribute to local competence development at schools. Another project addresses how school students learn programing and how it affects their understanding of the various disciplinary subjects. Both projects will be financed from a combination of resources from UiO, CCSE, and the collaborating schools.

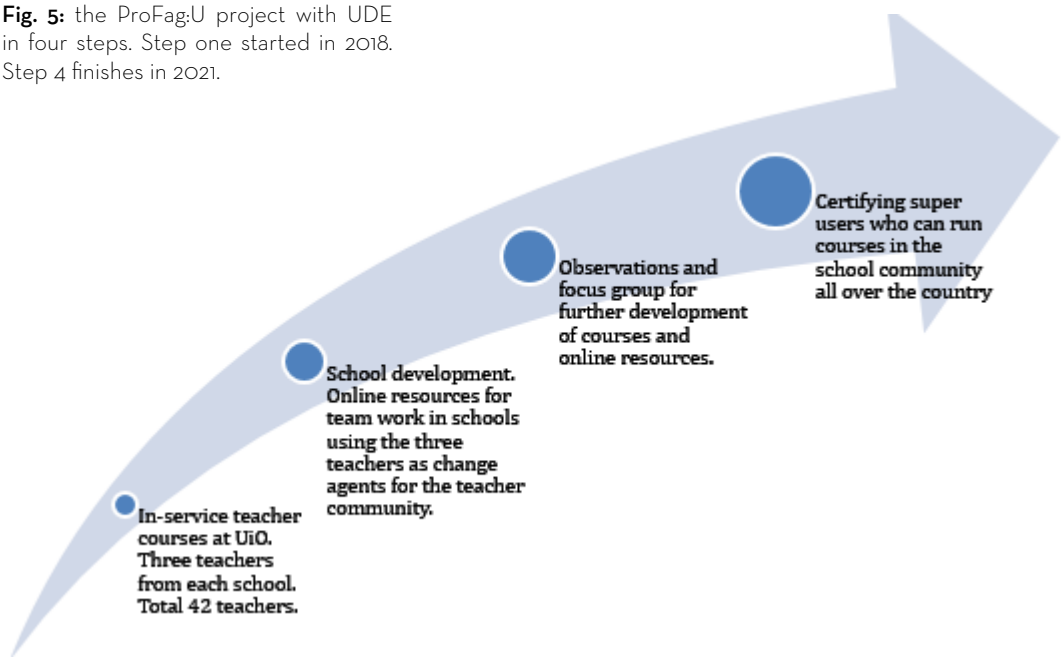
International collaborations

ProFag has initiated a collaboration with Michigan State University and the NSF project "Integrating Computation in Science Across the Mitten", which focuses on how to integrate computational methods into high-school physics courses.

Impacting teacher education

University of Oslo offers 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. However, other teacher edu-

Fig. 5: the ProFag:U project with UDE in four steps. Step one started in 2018. Step 4 finishes in 2021.



cation programs in Norway have little or no focus on computing in science education. Thus, there is also a need to educate the teacher educators. Similar challenges emerge across Europe. Ensuring strong teacher educations with proper basis in the tools of tomorrow – computational and data science and artificial intelligence – will be important to reduce the digital divide across Europe. CCSE and ProFag will start focusing on this challenge in the coming years – e.g. see the TraCS PhD-program described below.

Collaboration with University of Tromsø

CCSE and KURT have initiated a collaboration with the University of Tromsø (UiT) on developing ProFag courses for teachers. Henrik Løvold (KURT) has been hired in an adjunct position at UiT to assist in developing the UiT program and delivering courses for teachers. This is an excellent example of how dissemination can be developed through partnership.

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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 University of Southeastern Norway (USN) across three campuses. An important and new element of the new study programs is that all engineering students will have a 5 ECTS course in scientific programming in Python in the first semester. The course is called "Programming for computing" and will be taught for the first time in 2020. 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.

Working group for 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 in the first mathematics course across all campuses and programs 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).

Working Group Activities 2018

- "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" (May 2018)
- "Redesign of the engineering education at TNM", seminar in Holmenstrand (40 people, June 2018)
- Working group seminar (30 people, October 2018)

The focus of these meetings has been how to insert the new programming course in the study programs 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.

Working Group Activities 2019

The main goal of the working group has been to finalize all course plans for all the science courses at TNM. In total 11 new course plans have been developed and approved for students starting fall 2020.

Programming in schools (1-13)

In 2019 several professional development courses (EVU) for teachers focusing on Python programming was developed at TNM/USN. The courses provide competence in programming and the didactic application of programming in mathematics and science according the new school curriculum of 2020. In total, 90 high school teachers have completed the courses (fall 2019) and 40

high school teachers follow the courses (spring 2020). The courses are:

- "Basic program for mathematics and science teachers in high school" (Campus Porsgrunn and Bakkenteigen), 7.5 ECTS
- "Applied Python-programming for mathematics and science teachers in high school" (Campus Porsgrunn and Bakkenteigen), 7.5 ECTS
- "Basic course in scientific programming" (Campus Kongsberg).

In addition, Finn Haugen has written at textbook, "Python for computations" to be published by Fagbokforlaget fall 2020.

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.

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 play 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.

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)	

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

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).

relevant research background – and education researchers will be facilitated by the center through workshops and summer institutes. In these situations, we can also provide 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 2020 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.

Dissemination model

We have developed a research- and experience-based dissemination model for how to spread best practice across educational levels, context, and institutions. Effective dissemination is based on principles similar to effective teaching – it requires activity and partnership. Simply said, effective dissemination must be based on the same principles as student-active teaching.

Physics education research have rigorously documented the effect of student-active teaching methods, yet these methods are sparsely used[3]. This has motived researchers to develop a research-based approach to dissemination that takes into account the many complexities of educational change[4]. Our dissemination strategy builds on these research-based recommendations. We 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.

TARGET GROUPS AND METHODS

We have developed a set of methods to facilitate dissemination and spreading of good practice. We have developed professional development courses for faculty and teachers; We organize summer institutes where teaching faculty are introduced to both basic pedagogical thinking such as backwards design and constructive alignment in addition to practical and didactical perspectives on how to integrate computing in a specific disciplinary context; We fund and organize student transformation teams: Teams of computationally proficient students that work with context expert students to develop learning material for a course; We develop modularized and documented learning material that can easily be adapted to suit local preferences; and we build a close coupling between developments in education and research because we have found that faculty with a strong science background in computing are most likely to also integrate computing in their teaching.

The methods are adapted to various contexts: Science educations such as bachelor or graduate degrees in mathematics, bioscience, geoscience, materials science, etc.; Humanities and social sciences educations; The 1-13 school system and teacher education; Government and industry. With the growing interest in machine learning and data science methods, we see a growing demand for professional development courses in basic programming to advanced machine learning from government and industry.

DISSEMINATION PLAYBOOK

We have developed a dissemination playbook with a set of typical stages of development and actions at the various stages as illustrated in Fig. 1.

Initialization stage: In the first stage we are contacted by an institution or study program (or we contact an institution) that sees the need to integrate computing in the study program, but need help to get started. In this stage (i) we often meet with faculty individually or group or department meetings to present motivation, experience and results, (ii) we demonstrate learning material and approaches that have been developed, and (iii) we look for alignment between the need for computations in research and in education. In many cases, the research needs are the driver for the integration of computation, because research faculty see the need for computing in order to be competitive in research or as a generic, transferrable skill for the students to become more attractive employees.

Early adaptation: After the initial meetings, presentations and discussions, a partner may decide to start to implement changes in their own study programs. This means that he partner is moving into the early adaptation stage. We support development in this stage by several measures: (i) We finance and help organize student taskforces. We are co-located and closely associated with

3 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).

4 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); Henderson, C. & Dancy, M. H. "Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics". *Phys. Rev. Spec. Top. - Phys. Educ. Res.* 3, 020102 (2007).

the Computational Science master program at UiO. Through this program we meet students who are motivated and have the skills to help develop learning materials – often these students also have experience as learning assistants from UiO courses and from the Learning Assistants program and thus also have basic pedagogical training. (ii) We help identify and motive key personnel and provide them with mentoring if needed. (iii) We can provide examples of learning material either from similar context (e.g. physics examples for a physics program at another institutions), from other context (e.g. bioscience examples for a program in chemistry), or from other levels (e.g. examples from introductory university physics for high school physics curriculum development). (iv) We provide courses, summer institutes and a collegial community for teaching faculty in order to help develop their competence; (v) And we help develop baseline measures and an impact framework to assess progress.

Adaptation: After a few years, partners typically enter a stage of full adaptation. Initiatives span beyond individual course to cross-curriculum projects; faculty initiatives emerge and a closer alignment with the research activities is achieved. In this stage, we help develop learning outcomes and help integrate both leadership and administration in the workflow.

Integration: As the partner start to develop full integration, they start developing their own material and educate their own faculty. At this stage, the partner also may become a partner in dissemination. For example, the experiences gained by integration in the bioscience program helps form new initiatives in the humanities, or the learning material and approaches developed in the USN engineering education provides an excellent example for how other engineering educations can integrate computing in their study program while still fulfilling the national regulations for the engineering degrees.

TOOLS FOR CHANGE

We have also developed a set of tools to help develop and disseminate learning materials and practices (see Fig. 2) – the tools underlying change. We have developed:

- A *web repository* (currently we use gopicup.org) to share and discuss learning material
- A *tool for designing and publishing learning material* that integrates computing: docOnce
- *Methods to effectively distribute programs* by using a serv-

Fig. 1: Illustration of the various stages and associated activities in the dissemination playbook. The bottom scale indicates how far various partner study programs and institutions have progressed.

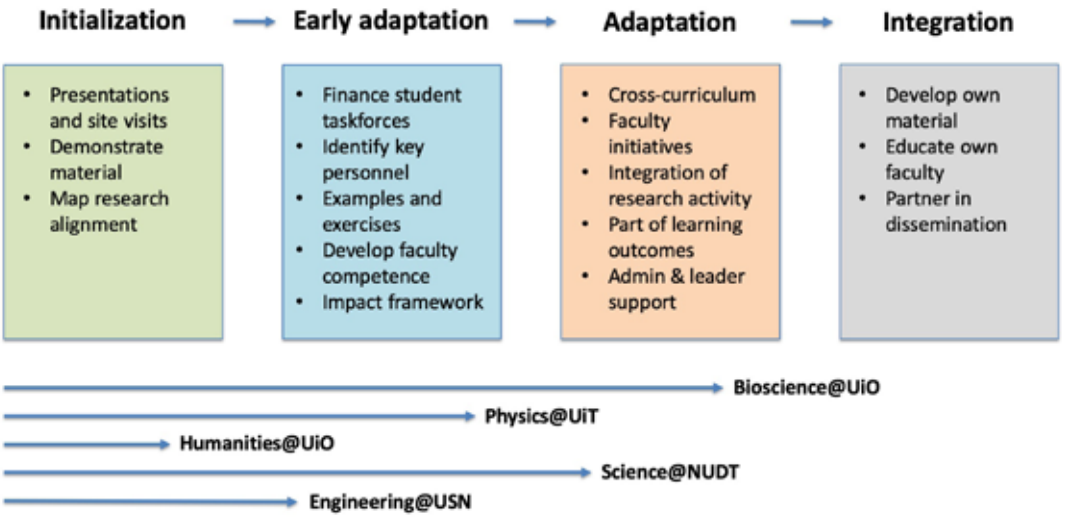
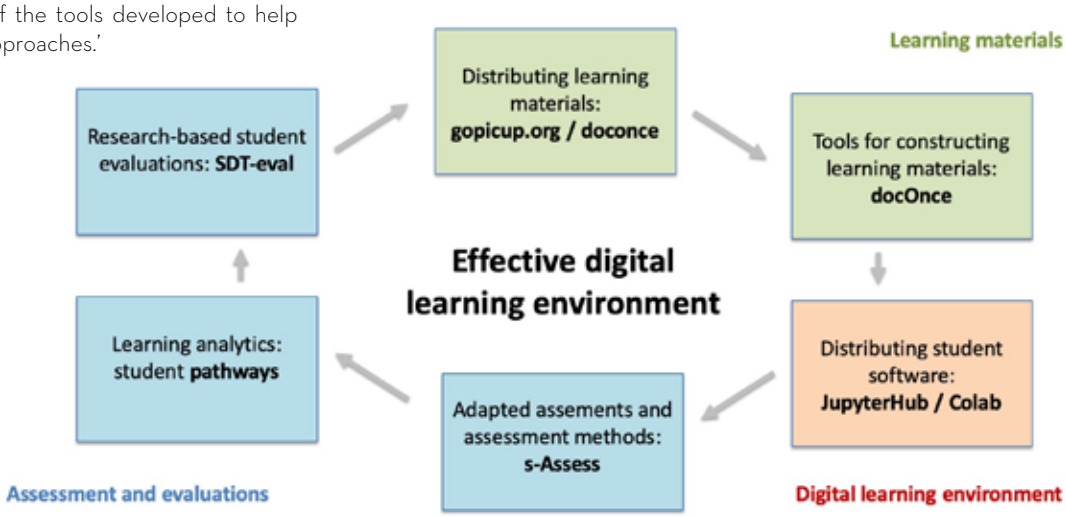


Fig. 2: Illustration of the tools developed to help disseminate CSE approaches.'



er-based solution (JupytherHub or Google collab), which simplifies adaptation since no local software installation is needed

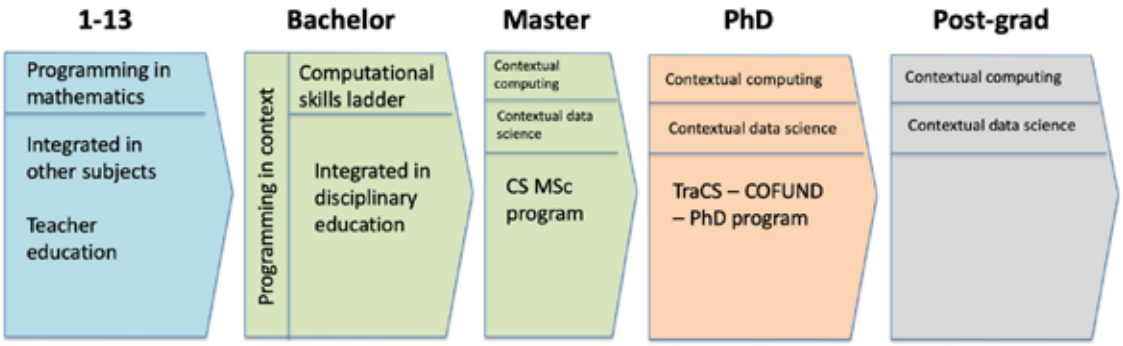
And we are developing:

- *Assessment methods for computational problem solving* in the S-ASSESS project
- Methods to study *student learning pathways* based on learning analytics and high-resolution data collection and analysis
- *Research-based student evaluations* that track instructional development, student learning and student autonomy development.

ACROSS LEVELS AND CONTEXTS

We have developed methods and approaches for integrating computing across educational level and contexts. Fig. 3 illustrates how we have worked with integrating computing from school through post-graduate education. With the introduction of the TraCS PhD-program we also develop a model for the development of computational and data science skills on the graduate level that can also be extended to the post-graduate level or adapted to the needs of industry or government. Indeed, industry partners in the TraCS program have the opportunity to join the PhD-student in the computational skills training program.

Fig. 3: Computational methods have been integrated across all educational levels.



TraCS – Training in Computational Science – MSCA COFUND

CCSE is coordinating a MSCA COFUND project – TraCS – aimed at introducing CSE at the PhD-level starting in 2020.

GOAL

The TraCS doctoral program will train a new generation of natural science researchers with disciplinary, interdisciplinary and transferable skills and a foundation in computational methods - providing them with the knowledge, skills and vision to digitally transform the European education, research, government and industry sectors.

The EU digital single market estimates that **all** professionals will need digital skills[5]. In the context of science and innovation this means that all researchers should build solid skills in computing and data science, *in addition* to a disciplinary basis. This requires training and skill sets that are different from the traditional training of computer science experts, which is difficult to transfer and apply in a disciplinary setting. It requires an integration between research and methods training. An experimental bio-scientist or materials scientists must learn computing and data science with methods and examples that are adapted to their field of research in order for the candidate to be able to apply these methods effectively in their field. This gives them the combination of competences in a discipline and in digital skills needed to impact research and education in their discipline.

TraCS is a 5-year program with 32 PhD positions of 36 months each. The program emphasizes the development of computational skills and application and integration of these skills in a research project, in addition to transferable skills training in a cross-sector secondment in one of 35 international partners. The candidates will go through an initial intensive training in scientific programming, computational science and data science (See Fig. 1). The candidates will then apply and develop these skills in a research project in their science discipline – mathematics, bioscience, geoscience, chemistry, materials science, astronomy or physics – in research groups at UiO. This provides the candidates with skills that significantly improve employability and their impact in their field of research, forming a basis for an exceptional career in research or innovation.

The TraCS program will provide us with a pilot study of a new way to educate PhD-students – in cohorts – and with experience in how to extend CSE to the graduate and post-graduate level.

The overall budget of COMPSC is €8,623,872, of which € 2,603,520 (30%) are provided by the EC and 6,020,352 (70%) are covered by UiO.

5 "Digital Skills & Jobs - Digital Single Market - European Commission", March 2, 2015, https://ec.europa.eu/digital-single-market/en/policies/digital-skills.

Fig. 1: Illustration of the TraCS training program.

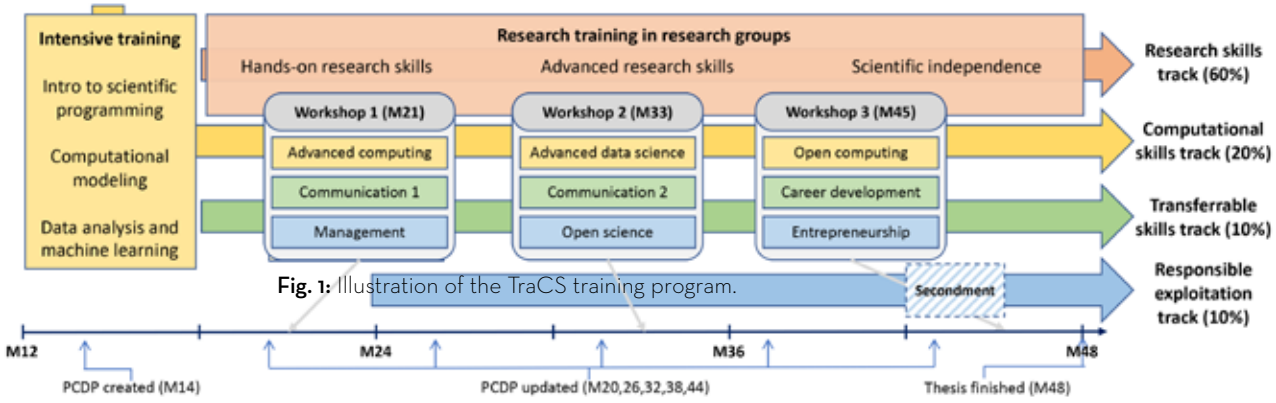


Fig. 1: Illustration of the TraCS training program.

The Honours-program at UiO

CCSE and director Anders Malthe-Sørenssen has been central in the development of the new Honours-program that was introduced at UiO in 2019. The Honours-program offers an individualized, interdisciplinary study program for ambitious and talented students. The program became the most selective program in Norway when it was introduced in 2019 and initiated a nation-wide debate about talent programs in particular and education in general. The program accepts 10 students in the sciences and 10 students in the humanities.

The program is inspired by the honours-program at Utrecht University and consists of an ordinary bachelor degree in science or the humanities, but with more possibilities for individualized program design, with an added set of 30 ECTS in interdisciplinary honours courses. The program has been designed according to principles from honours-pedagogy[6] and in correspondence with Self-Determination Theory the program supports and develops autonomy, competence and connection. Students are encouraged to design their own study program in close collaboration with a scientific mentor. Students take an additional 30 ECTS in addition to an ordinary bachelor – and many students also take additional courses – but under the guidance of a competent mentor. And students belong to the honours cohort that develop their own internal culture.

The program focuses on interdisciplinarity. The first three cohorts will have a common theme – Artificial Intelligence – that will be illuminated from different disciplinary perspectives. The first year of the program has a thematic focus. In the first year honours course we invite a series of top researchers to address AI from their disciplinary standpoint in the form of a lecture. This allows students to observe and reflect on difference between how various disciplines address a scientific problem, how they communicate and argue, and what they choose to focus on. The students engage with the researchers by preparing to ask questions in small interdisciplinary groups, and then reflect on the discussion and the answers in a reflection note. The idea is that the students also will gain a new understanding of their own discipline and their own skills when they work with students from other disciplines or address grand challenge problems that require an interdisciplinary approach.

In the second year, the program focuses on skill development. The humanities students will learn to program Python through a series of cases inspired by research fields in the humanities. The science students will learn research methods from the humanities and the social sciences, such as text analysis, interviews, or case studies. In the second part of the first year, the students will learn to apply data science to a series of cases with real research data from natural science, the humanities and social sciences – learning from each other in interdisciplinary composed themes.

In the third year, the students will work in small interdisciplinary composed teams on projects from leading research groups, industry partners or NGOs.

The honours program provides a small group of highly motivated students that can serve as a pilot group to develop new instructional methods as well as new curriculums such as computational and data science for humanities students. CCSE aim also to study the students and the development of the program in collaboration with international honours pedagogy experts. www.uio.no/honours

6 M. Wolfensberger, Talent development in European higher education, Springer, 2015.

Organization and management

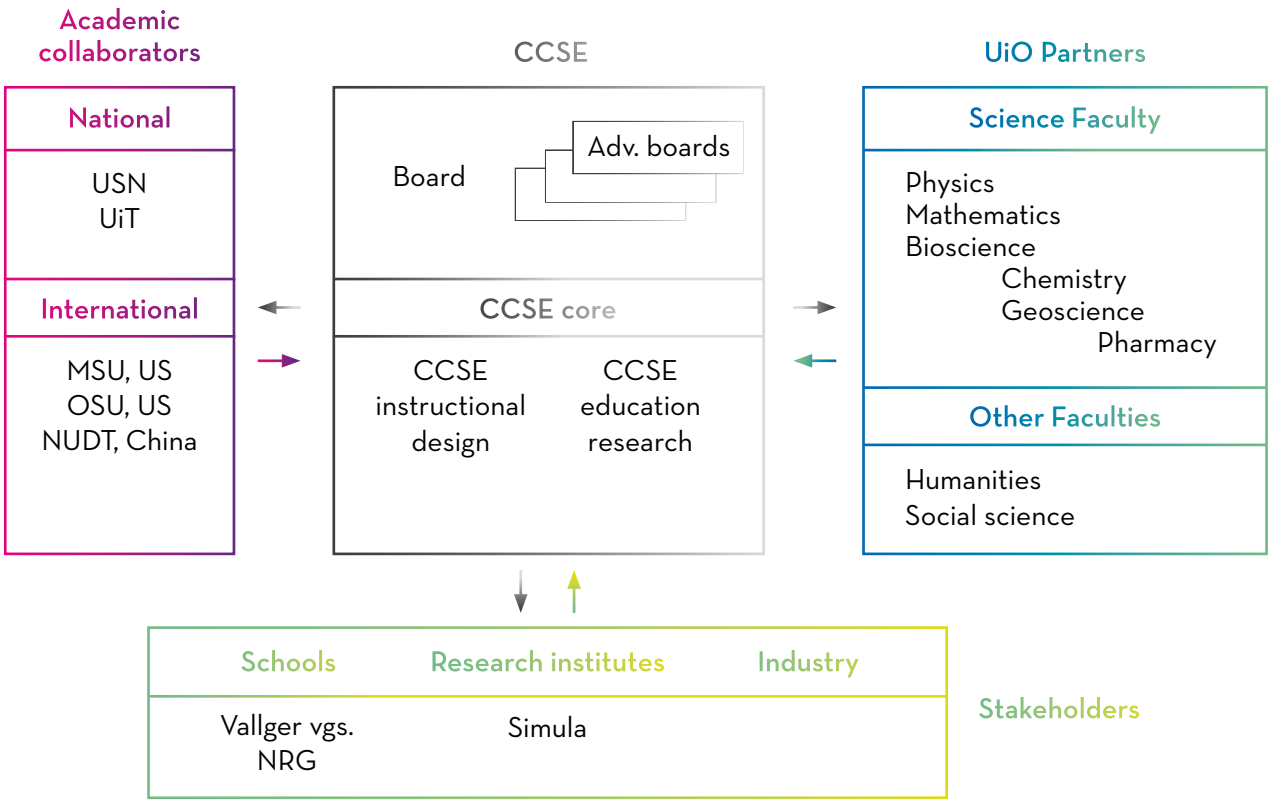
CCSE is directed by Professor Anders Malthe-Sørenssen and supported by an administrative leader, Tone Skramstad. The director is supported by a working group, with an advisory and coordinating function, consisting of the five work-package leaders, the administrative head, director of studies at the Faculty,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



Personnel

Leadership group

Tone Skramstad ***(administrative head)***

Tone 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.

Morten Hjorth-Jensen ***(professor of physics, WP1 leader, 20%)***

Morten is a computational physicist focusing on applied quantum mechanics, quantum computing, and machine learning. He has developed the computational science master program, courses in computational physics (FYS3150) and machine learning (FYS-STK3155). He is a Fellow of the American Physical Society, Member of the Norwegian Academy of Science, winner of the Thon award, and has been awarded UiO's education award 3 times.

Anders Malthe-Sørenssen ***(professor of physics, director CCSE, 35%)***

Anders has extensive cross-disciplinary research, educational and innovation leadership experience. He has developed two master programs, UiO's honours program, courses and textbooks in mechanics, thermal physics, percolation theory, and electromagnetism. He is a member of the Norwegian Academy of Science, winner of the Thon award and winner of UiOs education award 2 times.

Ellen Karoline Henriksen ***(professor of physics, WP3 leader, 20%)***

Ellen is section leader for the Education Research section at the Department of Physics, which is responsible for professional development for teachers. She has experience from education research focusing on motivation and identity of students in schools (1-13) and on the transition from school to university.

Cathrine Wahlstrøm Tellefsen ***(senior lecturer, WP4 leader, 20%)***

Cathrine is the director of KURT – The Center for Teaching and Learning and Science. She has built up the ProFag activity – programming for disciplinary understanding in basic (school) education, the Summer Institutes, and promotes active learning at the Faculty. She is an experienced high-school teacher, author of a science textbook series for high-school, and winner of the Thon award.

Knut Mørken ***(professor of mathematics, WP5 leader, 20%)***

Knut is a founder of CSE and developed and wrote a textbook for the course in numerical calculus (MAT-INF1100). He is the leader of the InterAct project to reform the study programs at the Faculty using a backward-design approach, and the leader of the bachelor program in mathematics. He is the dean of education (2018-2020) and winner of the Thon Award.

Hanne Sølna ***(leader of the study section, MN Faculty, 20%)***

Hanne is the leader of the study section at the Faculty and have been a key driver for the CSE project since 2003. She has broad experience from organizing and developing education transformations and strategy processes. She is also a key driver for the InterAct reform.

Geir-Kjetil Sandve ***(associate professor of informatics, 20%)***

Geir-Kjetil has a background in statistics and leads a bioinformatics group at the Department of Informatics. He has for several years been responsible for the introductory course in programming for computer science students, IN1000. He introduced Python programming in this course and developed methods to use assessments to systematically improve teaching.

Lex Nederbragt *(senior lecturer in bioscience, 20%)*
Lex 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.

Education research

Danny Caballero *(adjunct professor of physics education research, 20%)*
Danny is the Lappan-Phillips Associate Professor of Physics Education, Michigan State University, Leadership Faculty, CREATE for STEM Institute, Michigan State University, and Associate Professor at CCSE. He is PI of several large NSF-funded projects on the integration of computing into high-school and university educations. He is the leading international researcher on the effects of computational modeling on physics education outcomes.

Elise Lockwood *(adjunct professor of mathematics education research, 20%; visiting professor, 2019)*
Elise is an associate professor of mathematics education research at Oregon State University and is starting in a 20% position at CCSE in 2020. She has NSF Career grant focusing on how computations affect student understanding of combinatorics. She spent her six-month sabbatical in 2019 at CCSE where she initiated research projects based on interviews with UiO students.

Tor Ole Odden *(post-doc)*
Tor Ole finished his PhD in Science Education Research at the University of Wisconsin – Madison. The topic of his PhD-research was on sensemaking. He is heading the Learning Assistant project at CCSE, studies computational literacy and the effects of computational essays, and develops a data-driven study of the historical development of education research.

John Mark Aiken *(PhD-student)*
Even though John is a PhD-student, he has long experience and a solid track record in physics education research. He has taught physics classes that integrate computing at several US and European institutions. He has published 15 papers on physics education research in international research journals. His PhD-project focuses the use of machine learning methods to develop a quantitative basis for physics education research studies.

Odd Petter Sand *(PhD-student)*
Odd Petter has a background in computer science and astronomy. His thesis project will address how students learn from making mistakes with a particular focus on mistakes and how to learn from them in computational problem solving across contexts.

Sebastian Winther-Larsen
(PhD-student, S-ASSESS project)
Sebastian has a master degree in both finance and computational physics. He has experience from teaching, both at schools and in higher education, and from scientific computing. His PhD-project focuses on using Evidence-Based Design (EBD) do develop a Conceptual Assessment Framework to assess computations in physics.

Other scientific staff

Andreas Haraldsrud
(senior lecturer)
Andreas has a background as 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. He is also teaching the introductory course in programming for chemistry students, is teaching in the ProFag contextual programming classes for teachers, and has recently written a textbook on programming for school teachers.

Henrik A. Sveinsson
(tenure-track post-doc, 20%)
Henrik has a background in computational physics. He is the project leader for UiO's new honours-program, for which he is also developing and teaching courses in programming for humanists (HON2110) and data-science projects for honours-students (HON2200). He has developed computational content and taught oscillations and waves (FYS2130) and electromagnetism (FYS1120). He is a teacher in the ProFag project and has recently co-authored a textbook in programming for school teachers.

John Burk
(visiting scholar, 2018-2019)
John 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 writes a popular science blog, Quantum Progress, with approximately 8000 views/month. He spent his 2018-2019 sabbatical at CCSE. (Photo: Julie Kalveland/UiO)

Alessandro Marin *(software engineer, S-ASSES project)*
Alessandro has a background as a data scientist, scientific programmer, and has a PhD in bioinformatics. He has long experience with managing scientific software projects with both back-end and front-end experience. He is responsible for developing the software tools necessary for the S-ASSESS project, for developing and maintaining local software such as docOnce, and contributes with data-science expertise in research projects.

Personnel

CENTER PERSONNEL

Name	Function	Position	Unit
Center personnel			
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
Lex Nederbragt	WP leader, 20%	Senior lecturer	Informatics, UiO
Hanne Sølna	Administrative mentor	Director of studies	Faculty Adm, UiO
Education research group			
Danny Caballero	Education researcher (20%)	Adjunct Professor	MSU, CCSE
Tor Ole Odden	Post-doc	Post-doc	CCSE
John Aiken	PhD-student		CCSE
Odd Petter Sand	PhD-student		CCSE
Visitors			
John Burk	Visiting scholar (2018-2019)		CCSE
Elise Lockwood	Visiting scholar (Aug. - Dec. 2019)		CCSE
Instructional development			
Andreas D. Haraldsrud	School development, 20%	Senior lecturer	CCSE, Valler vgs
Øyvind Ryan	Course development, 20%	Ass. Prof.	Math, UiO
Andreas Gorgen	Course development, 20%	Professor	Physics, UiO
Dag Kristian Dysthe	Course development, 20%	Professor	Physics, UiO
Henrik Sveinsson	Course development, 10%	PhD-student	Physics, UiO
Svenn-Arne Dragly	Course development, 25%	PhD-student	Physics, UiO
Andreas Solbrå	Course development, 25%	PhD-student	Physics, UiO
Milad Mobarahn	Course development, 25%	PhD-student	Biology, UiO
Simen Tennøe	Course development, 25%	PhD-student	Com Sci, UiO

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Name *(continued)*	Function	Position	Unit
Marte Julie Sætra	Course development, 25%	PhD-student	Physics, UiO
Solveig Næss	Course development, 25%	PhD-student	Biology, UiO
Elise Thompsen	Course development, 25%	PhD-student	Biology, UiO
Student representatives			
Didrick Kruse	Student representative		UiO
Jonas Fløde	Student representative		UiO

External projects

Granting body	Project title	Project period	Funding	PI/partners
Thonstiftelsen	Cross-diciplinary grand-challenge for students	2017-2019	1500 krr	PI: Anders Malthe-Sørenssen, Marianne Fyhn, Bjørn Jamtveit
Thonstiftelsen	Student-driven research for improved science education	2018-2021	1500 kkr	PI: Danny Caballero
FinnUt/NRC	Structured assessment method for improved science education	2018-2023	6000 kkr	PI: Anders Malthe-Sørenssen
Intpart/NRC	International partnership for Computing in Science Education	2019-2022	4500 kkr	PI: Morten Hjiorth-Jensen
UiO:Life Science	Artificial Biomimetic systems – the Niche of Islet Organoids	2020-2023	3000 kkr	PI: Hanne Scholz, Hybrid Technology Hub (CoE); CCSE is 1 of 3 partners
EU Erasmus+ KA3	Innovating STE(A)M in Higher Education with Transdisciplinary Talent Programs	2020-2022	667 kEUR	Hanze University, University of Oslo (CCSE), 16 other partners including CCSE
EU Erasmus+ KA203 Strategic partnerships for higher education	Exploring how to build a joint European Campus based on innovative education for transferable skills	2020-2022	239 kEUR	PI:Aarshus University, Circle-U university alliance, UiO node: CCSE

Budget and expenditure

Diku Funding for current 5-year period

Item	Expenditure 2017	Expenditure 2018	Expenditure 2019	Budget 2020	Budget 2021	Sum
Personnel and indirect costs	2 556 540	5 567 629	1 925 778	3 445 780	3 333 433	16 829 160
Purchase of services			-	600 000	600 000	1 200 000
Equippment			200 000	200 000	200 000	600 000
Other operating expenses	907 976	1 723 233	1 086 935	961 336	926 360	5 605 840
Sum - Total	**3 464 516**	**7 290 862**	**3 212 713**	**5 207 116**	**5 059 793**	**24 235 000**

Overall Funding and expenses for current 5-year period

INCOME

	2017	2018	2019	2020	2021	Total
Diku	9 694 000	4 847 000	4 847 000		4 847 000	24 235 000
Inkind*	53 634	10 126 587	5 170 439	6 366 553	5 224 514	26 941 725
Other sources	75 000					75 000
Total income	**9 822 634**	**14 973 587**	**10 017 439**	**6 366 553**	**10 071 514**	**51 251 725**

* In addition UiO will give up to 5 mill to "Instructional design projects" within the project period. Approx. 2 mill is already used for this purpose.

EXPENDITURE

Item	Expenditure 2017	Expenditure 2018	Expenditure 2019	Budget 2020	Budget 2021	Sum
Personnel and indirect costs	2 610 173	15 633 502	6 710 142	10 122 009	8 549 630	43 625 456
Purchase of services	-	400 000	400 000	600 000	600 000	2 000 000
Equippment	-	-	-	-	-	-
Other operating expenses	907 977	1 333 946	1 284 346	1 150 000	950 001	5 626 269
Sum - Total	**3 518 150**	**17 367 448**	**8 394 488**	**11 872 009**	**10 099 631**	**51 251 725**

List of products

NATIONAL AND INTERNATIONAL AWARDS

Prize	Name	When
The Olav Thon Foundation, National Prize for Excellence in Teaching	Cathrine Tellefsen	2020
The Olav Thon Foundation, National Prize for Excellence in Teaching	Morten Hjorth-Jensen	2018
The Olav Thon Foundation, National Prize for Excellence in Teaching	Knut Mørken	2017
The Olav Thon Foundation, National Prize for Excellence in Teaching	Hans Petter Langtangen	2016

INTERNAL AWARDS AND TRAVEL GRANTS

Prize	Name	When
The Njord Centre Summer Award	John Aiken	2019
The Njord Centre Diversity Award	John Aiken	2018
Physics Education Research Topical Group Travel Grant	John Aiken	2017

Dissemination – external events

THE ROLE OF CCSE

Topic	where, for whom	who	when
Centre for Computing in Science Education – Erfaring fra oppbygging av en fremragende utdanningssatsing	HiOA	Malthe-Sørenssen	17.01.2017
Bioscience, chemistry, pharmacy or life science?	Presentation for a delegation from Ethiopia	Mørken	25.01.2017
Centre for Computing in Science Education – Erfaring fra oppbygging av en fremragende utdanningssatsing	The Faculty of Law, UiO	Malthe-Sørenssen	13.02.2017
Reflections on mathematics and science education for the future	Presentation for a delegation from South Korea	Mørken	02.03.2017
Centre for Computing in Science Education	Korean University visit to UiO	Malthe-Sørenssen	02.03.2017
Centre for Computing in Science Education	Bulgarian Ministry of Education visit to UiO	Malthe-Sørenssen	07.03.2017
Centre for Computing in Science Education – Erfaring fra oppbygging av en fremragende utdanningssatsing	Faculty of Law, UiO	Malthe-Sørenssen	17.03.2017
Reflections on mathematics and science education for the future,	Presentation for a delegation from ENS – Lyon, France,	Mørken	24.03.2017

Continues on the following page

Topic *(continued)*	where, for whom	who	when
Centre for Computing in Science Education	ENS Lyon visit to UiO	Malthe-Sørenssen	24.03.2017
Centre for Computing in Science Education	Stellenbosch University visit to UiO	Malthe-Sørenssen	11.05.2017
Computing in Science Education	Norwegian Pharmaceutical Research School, Oslo	Malthe-Sørenssen	20.06.2017
Computing in Science Education	Presentation for delegation from Copenhagen University	Mørken	08.12.2017
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
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
Meeting with NTNU about how to integrate computing in diciplines	NTNU	Cathrine Tellefsen	08.05.2019

Continues on the following page

Topic *(continued)*	where, for whom	who	when
Hvorfor kompetanse I realfaglig porgrammering er viktig	Høgskolen Vestlandet	Cathrine Tellefsen	16.01.2019
Dialogseminar	Lied-utvalget	Cathrine Tellefsen	10.04.2019
Møte på UiO	Lied-utvalget	Cathrine Tellefsen	02.05.2019
Preparing a CoE application	iEarth CoE consortium	Malthe-Sørenssen	15.08.2019

CONTRIBUTIONS TO SEMINARS, WORKSHOPS AND CONFERENCES

Topic	where, for whom	who	when
En (video)introduksjon til UiOs studietilbud i realfag og teknologi – utdanninger for framtidens arbeidsmarked,	Presentasjon for rådgivere i skolen	Mørken	09.03.2017
Kan informatikk sammen med matematikk bli morsomt?	Presentasjon på IT-camp for jenter på Institutt for informatikk,	Mørken	15.03.2017
The InterAct philosophy	iEarth workgroup, Department of Geoscience, University of Bergen	Mørken	
Centre for Computing in Science Education	MNT Conference, Soria Moria, Oslo	Malthe-Sørenssen	30.03.2017
Education and exchange	Presentation for SIU workgroup, SIU, Oslo	Mørken	05.04.2017
Computing in Science Education	University of Liverpool, UK	Malthe-Sørenssen	10.05.2017
Building science teacher identity through an integrated program of study	Presentation at Litteraturhuset, Oslo	Tellefsen and D. Jorde	12.05.2017
High performance computing in Nuclear Physics	Lecture at the Advanced Computational Research Experience at Michigan State University	Hjorth-Jensen	01.06.2017
Computing in Science Education	Stockholm University, Sweden	Malthe-Sørenssen	01.06.2017
Science teacher education at UiO	NFSUN conference, Trondheim	Tellefsen and D. Jorde	07.06.2017
InterAct at UiO: Good education is more than good lecures	iEarth workgroup, Department of Geoscience, University of Bergen	Mørken	08.06.2017
How to write good code	Lecture at the Advanced Computational Research Experience at Michigan State University	Hjorth-Jensen	24.06.2017

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Topic (continued)	where, for whom	who	when
Developing a culture for teaching at MN, UiO	Institute for Microsystems, University College of Southern Norway	Mørken	09.08.2017
Science teacher education at UiO	ESERA conference, Dublin	Tellefsen and D. Jorde	21.08.2017
Computing in Science Education	Swedish e-Research Center visit to UiO	Malthe-Sørenssen	07.09.2017
Computing in Physics Education	Invited talk at the 103rd National congress of the Italian Physical Society, Trento	Hjorth-Jensen	11.09.2017-15.09.2017
Computing in the undergraduate mathematics curriculum?	Invited presentation at the annual meeting of the Norwegian Mathematical Council,	Mørken	27.09.2017
En forskningsnær utdanning ved integrasjon av databeregninger og programmering	Fagdag for utdanning, NTNU	Malthe-Sørenssen	02.10.2017
Computing in Science Education	Presentation at the conference in memory of Hans Petter Langtangen,	Mørken	24.10.2017-25.10.2017
Utdanningsutvikling på MN-fakultetet ved UiO	Presentasjon for studieutvalget ved Norges miljø- og biovitenskapelige universitet,	Mørken	25.10.2017
Science teacher education at the MN-faculty, presentation	Helsinki (meeting with teacher educaters)	Tellefsen	27.11.2017
Computing in Science Education; how to integrate computing in Science courses across disciplines	Seminar at the University of Surrey, UK	Hjorth-Jensen	28.11.2017
Computing in Science Education (CSE)	Presentation at Syddanske Universitet, Odense, Denmark,	Mørken	07.12.2017
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

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Topic (continued)	where, for whom	who	when
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
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
Computational literacy and computational essays at The University of Oslo	Research and education from the nano to the human scale – Symposium, The Norwegian Academy of Science and Letters	Tor Ole Odden	08.02.2019
Modeling student pathways in a physics bachelor's degree program	Research and education from the nano to the human scale – Symposium, The Norwegian Academy of Science and Letters	John Aiken	08.02.2019

Continues on the following page

Topic (continued)	where, for whom	who	when
Bringing computation into physics courses	Research and education from the nano to the human scale – Symposium, The Norwegian Academy of Science and Letters	Danny Caballero	08.02.2019
Innleder	Jenter og teknologi – 700 jenter konferanse	Tellefsen	07.02.2019
Studentaktiv læring	Workshop på kurs i universitetspedagogikk	Tellefsen	13.03.2019
Integrated Science Teacher Education at the University of Oslo – from fragmentation to integration	Conference in Freiburg	Doris Jorde, Cathrine Tellefsen	15.03.2019
Lektorutdanning og samarbeid mellom UV og MN	Seminar for utdanningskomiteen, UiO	Kirsti Engelien og Cathrine Tellefsen	19.03.2019
Foredrag om ProFag – realfaglig programmering	Oslo Cancer Cluster	Tellefsen	26.03.2019
Lektorstudenter utvikler læringssentrerte undervisningsopplegg ved instituttenes disiplinfaglige begynneremner	Foredrag på MNT-konferansen i Tromsø	Kristin G. Tsigaridas og Cathrine Tellefsen	29.03.2019
Realfaglig programmering	Realfagskonferansen 2019, Trondheim	Tellefsen, Cathrine Wahlstrøm; Løvold, Henrik Hillestad.	07.05.2019
Programmering i naturfag	*Fagkveld Aschehoug*	Tellefsen, Mørken	29.01.2019
Realfaglig programmering dagskurs	Nettverkssamling Sandnes	Tellefsen, Cathrine Wahlstrøm; Løvold, Henrik Hillestad.	13.02.2019
Beregningsorientering og utdanningsutvikling	Presentasjon for delegasjon fra Norges teknisk naturvitenskapelige universitet	Fyhn, Malthe-Sørenssen, Mørken, Nederbragt, Odden, Sundnes	24.09.2019
Studentaktiv læring – workshop på	kurs i universitetspedagogikk, UiO	Tellefsen	10.10.2019
Programmering for fysikkens skyld	Faglig pedagogisk dag UiO	Haraldsrud, Tellefsen	31.10.2019
Realfaglig programmering dagskurs	4 heldagssamlinger for lærere i vgskole Akershus fylkeskommune	Tellefsen, Cathrine Wahlstrøm; Løvold, Henrik Hillestad.	29.11.2019
Realfaglig programmering – hvilken betydning har det for lektorutdanningen?	Foredrag på Nasjonal lektorudanningskonferanse, Tromsø	Mørken, Tellefsen, Haraldsrud	07.11.2019
Harvesting Canvas data for learning analytics	HuLAR: Technical workshop, Oslo Science Park	Alessandro Marin	27.01.2020
Workshop on Programming and computational Skills in Science programs	University of Århus, Department of Physics	Morten Hjorth-Jensen	23.10.2019

Continues on the following page

Topic *(continued)*	where, for whom	who	when
Integrating a Computational Perspective in Physics (and Science) courses	Ole Rømer seminar, University of Århus	Morten Hjorth-Jensen	23.10.2019
Four days school in Data Analysis and Machine Learning applied to Nuclear Physics	Michigan State University	Morten Hjorth-Jensen, Michelle Kuchera and Matthew Hirn	20.05.2019-23.05.2019
Computing in Science Education, seminar	University of Trento, Department of Physics, Trento, Italy	Morten Hjorth-Jensen	05.03.2019
Computational Essays and Computational Literacy at the University of Oslo	Physics Education Research Conference	Odden, Malthe-Sørenssen	27.07.2019
Workshop Organizer	Workshop on Quantitative Physics Education Research	Aiken	2020
Workshop Facilitator	Machine Learning in PER, American Association of Physics Teachers Summer Meeting	Aiken	2019
Workshop – Teamwork in Software Engineering Courses	NIKT2019 – Norsk Informatikkonferanse	Løvold	25.11.2019
Renewing the contents of science education by integrating computing	Keynote presentation, Norwegian Physical Society Annual Meeting, Oslo	Malthe-Sørenssen	09.08.2019
Quality in education and the link between research and higher education	Keynote presentation at UTFORSK national seminar, DIKU, Gardermoen	Malthe-Sørenssen	25.10.2019

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
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

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Topic *(continued)*	where, for whom	who	when
Programming in physics education	Workshop with NUDT delegation (20 attending)	Malthe-Sørenssen, Mørken, Tellefsen	05.12.2018
ProFag-U (middle school)	Course for 40 middle school teachers	Tellefsen, Mørken, Haraldsrud,	19.11.2018-15.6.2019
Implementing Scientific Programming in the Norwegian Curriculum	CCSE, Teachers and department chairs from math and science disciplines interested in incorporating programming into their curricula	Tellefsen, Burk	27.02.2019
National Summer Institute - integrating computation in undergraduate physics	CCSE, Academic staff teaching undergraduate physics or mechanics	Caballero, Tellefsen, Vistnes, Odden, Young, Kuchera, Orban, Henderson, Waterson	18.06.2019-21.06.2019
ProFag-U (middle school)	Course for middle school teachers	Tellefsen, Haraldsrud, Løvold, Gregers	10.10.2019-20.04.2020
ProFag-U (middle school)	Course for middle school teachers	Tellefsen, Haraldsrud, Løvold, Gregers	07.10.2019-23.04.2020
ProFag-U (middle school)	Course for middle school teachers	Tellefsen, Haraldsrud, Løvold, Gregers	17.10.2019-27.04.2020
ProFag-U (middle school)	Course for middle school teachers	Tellefsen, Haraldsrud, Løvold, Gregers	14.10.2019-30.04.2020
ProFag vgs 1 (high schools)	Course for high school teachers	Tellefsen, Haraldsrud, Løvold, Gregers	16.09.2019-19.03.2020
ProFag vgs 1 (high schools)	Course for high school teachers	Tellefsen, Haraldsrud, Løvold, Gregers	12.09.2019-16.03.2020
ProFag vgs 1 (high schools)	Course for high school teachers	Tellefsen, Haraldsrud, Løvold, Gregers	09.09.2019-26.03.2020
ProFag vgs 1 (high schools)	Course for high school teachers	Tellefsen, Haraldsrud, Løvold, Gregers	19.09.2019-23.03.2020
Programmering i videregående skoler	Programmeringskurs for lærere ved UiT	Henrik Løvold	16.08.2019
Programmering i videregående skoler	Programmeringskurs for lærere ved UiT	Henrik Løvold	18.11.2019
Nettverkssamling ved Tromsdalen vgs	Programmeringskurs for lærere	Henrik Løvold	19.11.2019
Fire parallelle samlinger i samarbeid med Universitetet i Tromsø (spredning av vår modell)	Programmeringskurs for lærere videregående skole	Løvold, Tøgenes, Haraldsrud, Sveinsson	29.11.2019

Continues on the following page

Topic *(continued)*	where, for whom	who	when
Computing in Science Education Hackathon (with Michigan State University)	Workshop	Danny Caballero and Morten Hjorth-Jensen	03.06.2019-07.06.2019
Workshop on honours-education	National workshop with international participation from Hanze University	Malthe-Sørenssen, Marca Wolfensberger	01.04.2019
2-day workshop on AI – programming an intelligent snake game in Python	High-school students from Ullern high schools	Malthe-Sørenssen	09.05.2019

CONTRIBUTIONS TO POLICY AND THE PUBLIC DEBATE

Topic	Where, for whom	Who	when
Center for Computing in Science Education - hvordan integrere programmering i utdanningen	NHOs kompetanseforum	Malthe-Sørenssen	10.01.2017
How to inspire girls to choose science?	Nordic conference on gender equality, Oslo	Rose	08.02.2017
Committee leader, White paper on the integration of computing in undergraduate physics at MSU	Michigan State University	Hjorth-Jensen	20.03.2017
Develop core elements for school subjects, Science	Group for core elements, Udir	Rose	01.06.2017-10.12.2017
Develop core elements for school subjects, Mathematics	Group for core elements, Udir	Mørken	01.06.2017-10.12.2017
Digitalisering av MNT-utdanning	UHR, Oslo	Malthe-Sørenssen	26.10.2017
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

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Topic (continued)	Where, for whom	Who	when
Beregningsorientering og utdanningsutvikling	Presentation for NTNU	*Fyhn, Malthe-Sørenssen, Mørken, Nederbragt, Odden, Sundnes*	24.09.2019
Programmering for å styrke matematikken, er det mulig?	Lærerkonferanse i programmering	Knut Mørken	11.03.2019
Programmering for å styrke matematikken, er det mulig?	Presentasjon for besøk fra Danmarks tekniske høyskole og Borupgaard gymnas	Knut Mørken	09.09.2019
Utdanning og læringsmiljø	Lansering av MNs strategi for MNs ansatte	Mørken, Tellefsen	04.02.2019
Computing in Education	Working group for education in UiO Strategy 2030, 3 meetings	Malthe-Sørenssen	01.01.2019-01.05.2019
Computing in education	Working group for digital strategy for UiO, Strategy 2030, 2 meetings	Malthe-Sørenssen	01.01.2019-01.05.2019

Dissemination – internal events

CCSE SEMINAR SERIES

Title	Who	When
SDT and motivation for biology students	Lucas Jeno, bioCeed, UiB	01.06.2017
The role of practice learning in biology education	Torstein N. Hole, bioCeed, UiB	01.06.2017
Nanohub	Alejandro Strachan, Nanohub, Purdue University, USA	10.10.2017
Learning through gamification in physics	Gerd Kohlmeyer, Meyer-Briggs College, Michigan State University, USA	11.12.2017
Mathematics education research and the role of computing in mathematics education	Elise Lockwood, Oregon State University, USA	14.12.2017
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
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

Continues on the following page

Title *(continued)*	Who	When
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
Teaching through context and problem based learning	Felek Baran, Department of Teacher Education and School Research, UiO	18.03.2019
The State of Equity in College Physics Student Learning in the United States: a Critical Quantitative Intersectionality Investigation	Dr. Jayson M. Nissen, California State University	06.05.2019
Teachers' Intended Learning Outcomes and Students' Attitudes around Computation in High School Physics	Research Associate Daniel P. Weller, Michigan State University	23.09.2019
Student Verification Practices for Combinatorics Problems in a Computational Environment	PhD student Adaline De Chenne, Oregon State University	24.09.2019
Examining how undergraduate engineering educators produce, reproduce, or challenge technocracy in pedagogical reasoning	Dr. Chandra Turpen, University of Maryland	07.10.2019
Institutional Change in STEM: The Role of Peer Observation in the Adoption of Evidence-Based Instructional Practices	Dr. Valerie Peterson, University of Portland	14.10.2019
Innovating physics laboratory with new digital technologies	Associate professor Giovanni Organtini, Sapienza University of Rome	04.11.2019
Paradigmatic Inquiries of Quantitative Methods in Physics Education Research	Dr. Lin Ding, Ohio State University	11.11.2019
Matter & Interactions: A curriculum for the introductory calculus-based course taken by beginning university science and engineering students, takes a contemporary perspective on introductory-level physics.	Dr. Ruth Chabay and Dr. Bruce Sherwood, North Carolina State University	09.12.2019
3D graphics as a side effect of physics computation	Dr. Bruce Sherwood, North Carolina State University	11.12.2019

Continues on the following page

Title *(continued)*	Who	When
Beyond calculus: Computational thinking and visualization in introductory physics	Dr. Ruth Chabay, North Carolina State University	11.12.2019
Integrating Computation into High Schools in Michigan	Dr. Paul Irving, Michigan State University	11.12.2019
P-Cubed a Physics Problem-Based Modeling Curriculum	Dr. Paul Irving, Michigan State University	13.12.2019
Fagfornyelsen 2020 – nytt innhold i matematikkfaget	Renate Jensen, Læreplangruppen i matematikk	11.12.2019
Innføring av beregninger i ingeniørutdanningene på tvers av campuser på USN	Ole Marius Lysaker, University of South-Eastern Norway	11.12.2019

CCSE EDUCATIONAL DEVELOPMENT ACTIVITIES (POLICY AND TEACHING)

Topic	Where, for whom	Who	When
Institute seminar	Department of Geoscience	Mørken, Tellefsen	06.01.2017
REAL education, seminar	Teachers at Faculty of Mathematics and Natural Sciences, UiO	Tellefsen	12.01.2017
Seminar on development of education	Department of Geoscience, UiOs	Tellefsen	26.01.2017
Educational development and InterAct	Seminar for Department Heads, MN Faculty, UiO	Tellefsen, Mørken	09.02.2017
Introduction to the film Hidden Figures	Science Library, Oslo	Tellefsen, Mørken	08.03.2017
Educational development and the InterAct processes	Department workshop at Sundvolden, Department of Bioscience, UiO	Tellefsen, Mørken	20.04.2017
Seminar on the InterAct process	Educational leaders (og programrådsledere)	Tellefsen, Mørken	26.04.2017
To talk your discipline	Seminar, Department of Physics, UiO	Tellefsen, Mørken	04.05.2017
Stimulating renewal of programs and education.	Seminar for Department Heads, Humanistic Faculty, UiO	Mørken	11.05.2017
Full-day education seminar	Ullevål, Department of Physics, UiO	Henriksen, Tellefsen	18.05.2017
Innovation in the PhD-education	Seminar for PhD supervisors, MN Faculty, UiO	Mørken	24.05.2017
Educational development and the InterAct processes	Strategy meeting, Faculty of Mathematics and Natural Sciences, Husøy	Tellefsen, Mørken	01.06.2017
Culture for quality in higher education: Systematic work to improve educational quality	National meeting for Deans of Studies in social sciences, UiO	Mørken	19.06.2017
Computing in Science Education	Norwegian Pharmaceutical Research School, Oslo	Malthe-Sørenssen	20.06.2017

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Topic (continued)	Where, for whom	Who	When
Workshop: Hands-on programming in pharmacy	Norwegian Pharmaceutical Research School and PharmaTox, Oslo	Malthe-Sørenssen	20.06.2017
REAL teaching, seminar	Teaching Assistants at Faculty of Mathematics and Natural Sciences, UiO	Tellefsen	20.09.2017
Centre for Computing in Science Education	Presentation at STUT-meeting for all educational leader at Faculty for Mathematics and Natural Sciences, UiO	Malthe-Sørenssen	26.09.2017
Developing a culture for teaching at MN, UiO	InterAct and ForVei seminar for UiO ambassadors, UiO	Mørken	26.09.2017
Hvordan kan CCSE bidra til kvalitet i utdanningen ved MN og UiO	Real utdanning, Fagdag for utdanning, UiO	Malthe-Sørenssen	10.10.2017
REAL education, seminar	Teachers at Faculty of Mathematics and Natural Sciences, UiO	Tellefsen	10.10.2017
Computing in Science Education	Fagdag for utdanning, Fysisk Institutt, UiO	Malthe-Sørenssen	12.10.2017
Physics teacher competence seminar	Department of Physics, UiO	Tellefsen	12.10.2017
REAL teaching, seminar	Teaching Assistants at Faculty of Mathematics and Natural Sciences, UiO	Tellefsen	10.11.2017
Educational development at MN, UiO	Seminar for heads of departments, Humanistic Faculty, UiO	Mørken	22.11.2017
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
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

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Topic (continued)	Where, for whom	Who	When
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
REAL education, seminar (Norwegian)	Teachers at Faculty of Mathematics and Natural Sciences, UiO	Sand, Tellefsen	10.01.2019
Decompiling Knowledge to Distill Learning Goals	REAL education, seminar for teachers and faculty of Mathematics and Natural Sciences, UiO	Tor Ole Odden	10.01.2019
REAL education seminar (English)	Teachers at Faculty of Mathematics and Natural Sciences, UiO	Tellefsen	11.01.2019
The University of Oslo Learning Assistant Program	Department of Physics, University of Oslo	Odden, Henriksen	14.03.2019
Physics Laboratory Courses: Research and Trends	Department of Physics, University of Oslo	Odden	14.03.2019
REAL education, seminar (Norwegian)	Teachers at Faculty of Mathematics and Natural Sciences, UiO	Tellefsen	15.08.2019
REAL education seminar (English)	Teachers at Faculty of Mathematics and Natural Sciences, UiO	Tellefsen	15.08.2019
Seminar on development of education	Department of Physics, UiO	Sand	17.10.2019
Decompiling Knowledge to Distill Learning Goals	Underverk, Department of Biosciences, University of Oslo	Odden	11.06.2019
Computational Essay Project Update	Seminar on development of education , Department of Physics, UiO	Odden	17.10.2019
Use of standardized tests to measure learning outcomes – examples from Fys1120	Seminar on development of education , Department of Physics, UiO	Malthe-Sørenssen	14.03.2019
Computational Thinking, Computational Literacy, and the CCSE	Seminar at Skolelabben, Physics Department, UiO	Odden	10.04.2018
A Time for Telling (Schwartz & Bransford 1998)	Seminar at Skolelabben, Physics Department, UiO	Odden	13.04.2018

WORKSHOPS AND CONFERENCES AT CCSE

Topic	Where	Attendance	When
Physics teacher competence and the culture for teaching and learning in physics departmets, Guets lecturers from Uppsala University	Department of Physics, UiO	20	10.10.2017
CCSE Internal Seminar	Lysebu, Oslo	15	03.11.2017-04.11.2017
Computing in Science Education Annual Christmas Seminar	CCSE, University of Oslo	90	12.12.2017
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
CCSE internal seminar	Lysebu, Oslo	8	28.02.2019-01.03.2019
Computing in Science Education Annual Christmas Seminar	CCSE, UiO	90	11.12.2019
Center opening	CCSE, UiO	90	11.12.2019

SEMINARS FOR MASTER STUDENTS IN COMPUTATIONAL SCIENCE

Topic	Where	Attendance	When
Deep learning for image analysis applications - overview and challenges	Anne Solberg, Department of Informatics, UiO	40	25.10.2019
CS-seminar and presentation of master thesis	Gaute Einevoll, UiO/NMBU	40	15.11.2019

RELEVANT MASTER THESIS PROJECTS

Topic	Student	Supervisors	Department UiO	Period
Programming with Tychos in Physics 1	Andreas Fagerheim	Henriksen, Odden	Physics	2019-2020
Programming with VPython/Trinket in Physics 1	Jonathan Brakstad Waters	Henriksen, Odden	Physics	2019-2020
Studentar si interesse og meistringsforventning for programmering og modellering i biologi	Marthe Mjøen Berg	Nederbragt, Bøe, Gregers	Biosciences	2018-2019
Programmering i biovitenskapelige problemstillinger	Lars Erik Revheim Håland	Nederbragt, Henriksen, Gregers	Biosciences	2018-2019
Does programming and algorithmic thinking help students in learning linear algebra?	Anne Katrine Bækkelie	Mørken, Lockwood	Mathematics	2018-2019
Can computing help in learning differential equations?	Konrad Thoresen	Mørken, Lockwood	Mathematics	2018-2019
Can computing help in learning linear algebra?	Jalini Srisgantharajah	Mørken, Lockwood	Mathematics	2017-2018

Visitors to CCSE

Who	Topic	When
Lucas Jeno, bioCeed, UiB	Presentation on bioCeed survey	01.06.2017
Torstein Nilsen Hole, bioCeed, UiB	Presentation on bioCeed survey	01.06.2017
Alejandro Strachan, Nanohub, Purdue University, USA	Nanohub collaboration	10.10.2017-11.10.2017
Minister of Education	Visit to CCSE and BIOS1100	20.10.2017
Tor Odden, University of Wisconsin-Madison, USA	Visit to CCSE	03.11.2017-05.11.2017
Parliamentary group, Norwegian Labor Party	Visit to CCSE and BIOS1100	23.11.2017
Elise Lockwood, Oregon State University, USA	Visit to CCSE, collaboration on computing in math education	11.12.2017-15.12.2017
Gerd Kohlmeyer, Meyer-Briggs College, Michigan State University, USA	Visit to CCSE and talks	11.12.2017-13.12.2017
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

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Who *(continued)*	Topic	When
Claudia Fracchiolla, National University of Ireland Galaxy, Ireland	Scientific presentation	20.02.2018
Elanor Close, Texas State University	CCSE seminar series	23.05.2018
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	11.12.2018-16.12.2018
John Burk, St. Andrew's School	Visiting teacher working with how to help the students develop their computational thinking and computational literacy	01.07.2018-15.08.2019
Megan Wawro, Mathematics Department Virginia Tech	Mathematics educational research	20.03.2019-28.03.2019
Jayson M. Nissen, California State University	Presentation of Physics educational research	04.05.2019-08.05.2019
Michelle Perry Kuchera, Michigan State university	Summer Institute - integrating computation in undergraduate physics	16.06.2019-21.06.2019
Chris Orban, Michigan State University	Summer Institute - integrating computation in undergraduate physics	15.06.2019-22.06.2019
Rachel Jeanne Henderson, Michigan State University	Summer Institute - integrating computation in undergraduate physics	13.06.2019-29.06.2019
Alyssa Christine Waterson, Michigan State University	Summer Institute - integrating computation in undergraduate physics	13.06.2019-29.06.2019
Nickolas Young, Michigan State University	Summer Institute - integrating computation in undergraduate physics	21.06.2019-03.07.2019
Adaline Elisabeth De Chenne, Oregon State University	Mathematics educational research PhD student	19.09.2019-25.09.2019
Elise Lockwood, Oregon State University	Visiting researcher	01.08.2019-31.12.2019

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Who *(continued)*	Topic	When
Daniel P. Weller, Michigan State University	Presentation of Physics educational research	15.09.2019-26.09.2019
Adaline De Chenne, Oregon State University	Presentation of Mathematics educational research	19.09.2019-25.09.2019
Chandra Turpen, University of Maryland	Presentation from STEM-research	05.10.2019-09.10.2019
Jennifer Parham-Mocello, Oregon State University	Mathematics educational research	25.10.2019-29.10.2019
Rebekah Elliott, Oregon State University	Mathematics educational research	26.10.2019-30.10.2019
Valerie Peterson, University of Portland	Presentation from STEM-research	14.10.2019
Giovanni Organtini, Sapienza University of Rome	CCSE seminar series	03.11.2019-21.11.2019
Dr. Lin Ding, Ohio State University	Presentation of Physics educational research	10.11.2019-17.11.2019
Benjamin Prescott Hall, Michigan State University	Visiting PhD student	30.10.2019-25.112019
Marlina Forlizzi, Springers	Visiting editior	10.12.2019-12.12.2019
Dr. Bruce Sherwood, North Carolina State University	Presentation of Physics educational research	08.12.2019-13.12.2019
Dr. Ruth Chabay, North Carolina State University	Presentation of Physics educational research	08.12.2019-13.12.2019
Dr. Paul Irving, Michigan State University	Presentation of Physics educational research	11.12.2019-15.12.2019

Publications

Scientifc publications

- Aiken, J. M., C. Aiken, F. Cotton. A Python library for teaching computation to seismology students. *Seismological Research Letters* **89**.3, 1165-1171 (2018).
- Aiken, J. M., M. D. Caballero. Student pathways through the physics major. *Bulletin of the American Physical Society* **63** (2018).
- Aiken, J. M., R. Henderson, M. D. Caballero. Modeling student pathways in a physics bachelor's degree program. *Physical Review Physics Education Research* **15**, 010128, (2019).
- Aiken, J. M., P. Rasouli, B. I. Teigen, An explainable prediction model for round-trip latency in wi-fi networks, submitted to *IEEE conference on network softwarization* 2020.
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- Caballero, M. D., N. Chonacky, L. Engelhardt, R. Hilborn, M. L. del Puerto, K. R. Roos, PICUP: A Community of Teachers Integrating Computation into Undergraduate Physics Courses, *The Physics Teacher*, **57**, 397-399, (2019).
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Scientific talks and posters

- T.O.B. Odden and A. Lauvland. The Learning Assistant Model in a Scandinavian Context. International Learning Assistant Conference, Boulder, Colorado, USA, Nov 2018, *Poster Presentation.*
- T.O.B. Odden and R.S. Russ. Vexing Questions that Sustain Sensemaking, 2018 Physics Education Research Conference, Washington D.C., USA, July 2018, *Presentation.*
- T.O.B. Odden. Grokking: The Endpoint of Sensemaking. American Association of Physics Teach-ers Summer Meeting, Washington D.C., USA, July 2018, *Presentation.*
- J. M. Aiken. Towards a model of student pathways in STEM. Physics Education Research Conference 2018, Washington D.C., USA, July 2018, *Poster.*
- J. M. Aiken. Can Machine Learning Predict When STEM Students Switch Majors? American Association of Physics Teachers Summer Meeting, Washington D.C., USA, July 2018, *Presentation.*
- O. P. Sand. How to get students to engage in computational sensemaking. American Association of Physics Teachers Summer Meeting, Washington D.C., USA, July 2018, *Poster Presentation.*
- Morten Hjorth- Jensen. Integrating a Computational Perspective in Science Education. Workshop on New Horizons in Teaching Science: June 18-19, 2018, University of Messina, Messina, Italy, *Presentation.*
- Mørken, Knut Martin, Computing in Mathematics and Science Education. Invited talk at Mathematics Education — The Next Decade and Beyond; 4TU Applied Mathematics Institute, Netherlands, 2019-04-11 - 2019-04-12.
- Lauvland, Anders; Odden, Tor Ole; Bøe, Maria Vetleseter; Henriksen, Ellen Karoline. Learning assistants' transformed views on teaching and the teacher role after a training program. ESERA Conference 2019; 2019-08-26 - 2019-08-30.
- Odden, Tor Ole. Computational Literacy and Computational Essays at the University of Oslo. Integrating Computational Thinking Conference, Ameircan Association of Physics Teachers, College Park, MD, USA; 2019-05-02 - 2019-05-05.
- Bøe, Maria Vetleseter; Viefers, Susanne F; Bungum, Berit; Henriksen, Ellen Karoline. Norwegian upper secondary students' ideas about the wave nature of matter. ESERA Conference 2019; Bologna, Italy, 2019-08-26 - 2019-08-30
- Henriksen, Ellen Karoline; Bøe, Maria Vetleseter. ReleQuant physics education: Designing learning Resources and investigating student learning in gen-

eral relativity and quantum physics. CERN physics education seminar, CERN, Geneva, Switzerland, 2019-03-21 - 2019-03-21
- Henriksen, Ellen Karoline; Viefers, Susanne F; Bøe, Maria Vetleseter. Project ReleQuant: a research-based learning resource in modern physics for upper secondary school. European Quantum Technology Conference (EQTC19); 2019-02-18 - 2019-02-22
- Henriksen, Ellen Karoline. Developing learning resources and investigating students' learning in general relativity and quantum physics. Heraeus-seminar on General Relativity as a Challenge for Physics Education; Physikzentrum, Bad Honnef, Germany, 2019-02-10 - 2019-02-15
- Odden, Tor Ole; Malthe-Sørenssen, Anders. Computational Essays and Computational Literacy at the University of Oslo. Physics Education Research Conference; Provo, Utah, USA, 2019-07-24 - 2019-07-25.

Internal reports

- Rapport fra pilotprosjekt biologi (report from KURT).
- Rapport fra pilotprosjekt MAT1100 (report from KURT).
- Rapport fra IN1000 (report from KURT).

Op-eds and articles in the media

- Anders Malthe-Sørenssen, Sunniva Rose, Aslak Tveito, *Programmering bør inn i matematikkfaget*, Aftenposten, 30.10.2017
- 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.
- Anders Malthe-Sørenssen, Dag Kristian Dysthe, *Elementary Thermal and Statistical Physics Using Python*, 370 pages, 2019.
- Andreas D. Haraldsrud, Henrik H. Løvold, Henrik A. Sveinsson, *Programming in schools*, Universitetsforlaget, 280 pages, 2020.

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
Modelling and programming, High School course and book	Kristine Baluka Hein	Andreas Haraldsrud	20.06.2017-19.08.2017
JupyterHub and docOnce support	Kristian Gregorius Hustad		01.01.2017-31.12.2017
Introduction to economics	Sebastian Winther-Larsen	Anders Malthe-Sørenssen	20.06.2017-19.08.2017
BIOS1100 – Introduction to computational modeling in bioscience	Can Hicabi Tartanoglu, Dejana Mitrovic, Bernt Helen, Hallvard Heiberg	Lex Nederbragt	20.06.2017-19.08.2017
KJM1101 – Introduction to chemistry	Sverre Løyland, Eirill Stand Hauge	Karoline Fægri	20.06.2017-19.08.2017
MAT-IN1105 – Introduction to scientific programming, Geoscience	Tham Le	Karianne Lilleøren, Geir Stordal	20.06.2017-19.08.2017

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Course and topic *(continued)*	Student	Teacher	When
FYS2130 – Oscillations and Waves	Sebastian Winther-Larsen	Arnt Inge Vistnes	20.06.2017-19.08.2017
MEK1100 – Introduction to mechanics and vector calculus	Valentyna Pysarieva	Karsten Trulsen	20.06.2017-19.08.2017
MEK3570 – Computational solid mechanics	Nithusha Tharmanathan	Kent-Andre Mardal	20.06.2017-19.08.2017
BIOS1110 – Cell and molecular biology	Simen Russnes	Tom Andersen	20.06.2017-19.08.2017
BIOS1120 – Physiology	Stian Ingebrigtsen	Marianne Fyhn	20.06.2017-19.08.2017
BIOS1140 – Evolution and genetics	Alexandra Treimo	Tom Andersen	20.06.2017-19.08.2017
GEO2110 – Mineralogy	Jostein Brændshøi	Bernt Ertzmuller	20.06.2017-19.08.2017
AST2000 – Introduction to astrophysics	Jonas Fløde	Frode Hanssen	20.06.2017-19.08.2017
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
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

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Course and topic *(continued)*	Student	Teacher	When
BIOS1100 – Introduction to computational models for bioscience	Oda Selvåg Hovet Dejana Mitrovic Clare Mcenally	Lex Nederbragt	20.06.2018-19.08.2018
Development of computational essays for fys1120 and other courses	Karl Henrik Fredly	Tor Ole Odden, Dept. of Physics	01.01.2019-31.12.2019
Development of computational essays for fys1120 and other courses	Erling Olbekk	Tor Ole Odden, Dept. of Physics	07.06.2019-31.12.2019
Development of computational essays for fys1120 and other courses	Astrid Helene Lane	Tor Ole Odden, Dept. of Physics	19.08.2019-31.12.2019
Integration of computations in IN5400	Kristian Gregorius Hustad	Anders Malthe-Sørenssen, Dept. of Physics	01.01.2019-31.12.2019
Computational essays and integration of computations	Markus Borud Pettersen	Odden/ Malthe-Sørenssen, Dept. of Physics	24.06.2019-31.12.2019
Computational essays and integration of computations	Kjetil Moe Gulli	Odden/ Malthe-Sørenssen, Dept. of Physics	24.06.2019-31.12.2019
Integration of computing in political science	Solveig Bjørkholt	Bjørn Høyland, Dept. of Political Science	01.02.2019-30.06.2019
Student project in IN-KJM1900 and learning materials in Jupyter Notebooks	Erlend Tiberg North	Jan Roots, , Dept. of Chemistry	24.06.2019-16.08.2019
Developing online resources in ProFag	Isak Kvanneid	Henrik Hillestad Løvold, Dept. of Informatics	01.06.2019-30.06.2019
Developing online resources in ProFag	Fridtjof Gjengset	Henrik Hillestad Løvold, Dept. of Informatics	01.06.2019-30.06.2019
Improvide the integration of mathematics in BIOS1100 – introduction to computing in biosciences.	Åsta Bjørg Dale	Lex Nederbragt, Dept. of Biosciences	17.06.2019-31.12.2019
Code Phonology	Helka Kaunisto, Dejana Mitrovic, Prabin Sharma Humagain	Per Eugen Kristiansen, Dept. of Chemsitry	17.06.2019-31.08.2019
Improve integration of computing in BIOS1130 and BIOS3900	Even Werner	Tone Fredsvik Gregers, Dept. of Chemistry	15.06.2019-01.08.2019
Integration of computing in BIOS3100 Ecology	Mathias Fon, Hallvard Wæhler	Torbjørn Håkan Ergon, Dept. of Biosciences	17.06.2019-31.12.2019
Integration of computing in FARM3120	Luis Miguel Meza Morgado	Hedvig Marie Egeland Nordeng/ Angela Lupattelli, Dept. of Pharm. Science	13.06.2019-16.08.2019

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Course and topic *(continued)*	Student	Teacher	When
Integration of computing in FARM3120	Jon Andre Ottesen, Era Gruda, Kimberly Phan	Hedvig Marie Egeland Nordeng/ Angela Lupattelli, Dept. of Pharm. Science	12.06.2019-30.06.2019
Development of simulations in FARM2120	Erin Beate Bjørkeli	Sverre Arne Sande, Dept. of Pharm. Science	11.06.2019-16.08.2019
Integrating Python in Geosciences	Ellen Birgitte Folgerø	Karianne Staalesen Lilleøren, Dept. of Biosciences	01.01.2019-30.06.2019
Integration of computing in GEO2300	Gard Høivang , Are Frode Kvanum	Valerie Maupin, Dept. of Geoscience	11.06.2019-16.08.2019
Integration of computing in GEO4432	Robin Benjamin Zweigel	Sebastian Westerman, Dept. of Geoscience	01.07.2019-31.08.2019
Integration of computing in AST3220	Alexander Ziegenhorn	Frode Hansen, Dept. of Theoretical Astrophysics	01.06.2019-16.08.2019
Integrating Python for Philosophy students	Yngve Severin Block-Hoel, Davide Andrea Zappulli, Vemund Jernsletten, Hans Robin Solberg	Dag Trygve Truslew Haug, Dept. of Lingvistics; Øystein Linnebo, Dept. of Philosophy, Anders Malthe-Sørenssen, Dept. of Physics	01.11.2019-31.12.2019
Integrating computation in KJM2601	Einar Aurbakken, Robert Brevik, Bastian Skjeldstad	Thomas Bondo Pedersen, Dept. of Chemistry	24.06.2019-31.12.2019
Integrating computation in KJM1130	Sverre Løyland	Einar Uggerud, Dept. of Chemistry	24.06.2019-16.08.2019
Student project in IN-KJM1900 and learning materials in Jupyter Notebooks	Bastian Skjelstad, Ayla Steffenson Coder, Mathilde Ingeborg Nilsen Verne, Erlend Tiberg North	Jaan Roots, Dept. of Chemistry	24.06.2019-16.08.2019

STUDENT RESEARCHERS

Theme	Students	Supervisors	When
Friction: Hierarchical surface structures	Daniel Heinsen, Erlend Lima	Malthe-Sørenssen, Sveinsson	01.01.2017-31.12.2017
Friction: Nano-asperities in water-wetter SiO_2	Anders Johansson, Cecilie Klarpås, Gabriel Cabrera	Malthe-Sørenssen, Hafreager, Sveinsson, Jamtveit	20.06.2017-19.08.2017

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Theme *(continued)*	Students	Supervisors	When
Earthquakes: Supershear rupture and impacts	Didrick Kruse, Erlend Aarskaug, Ivar Haugerud, Eline Andersen	Malthe-Sørenssen, Hafreager, Sveinsson, Jamtveit	20.06.2017-19.08.2017
Neuroscience: Effective methods for analysis of electrode and position data for grid cell studies	Halvard Sutterud, Camilla Lian, Håkon Flydal	Lepperud, Fyhn	20.06.2017-19.08.2017
Machine-learning methods for analysis of student use of video lectures	Robert Solli	Aiken, Caballero	01.11.2017-01.12.2017
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
Cohort effects on physics major attrition	Xu Zhen	Aiken, Caballero	16.06.2019-23.08.2019
A Deep Dive into the FCI Gender-Biased Items using Decision Trees and Random	Zhang Linrui	Aiken, Caballero	16.06.2019-23.08.2019
The Effects of Course Network Topology on Student Pathways	Lucas Charpentier	Aiken, Caballero	16.06.2019-23.08.2019
Exploring the E-CLASS using Item Response Theory	Fu-Anne Wang	Aiken, Caballero	16.06.2019-23.08.2019
Using NLP to investigate student written code	Gabriel Sigurd Cabrera	Aiken, Caballero	16.06.2019-23.08.2019
Using Machine Learning to understand how prior preparation influences GRE scores	Nils Johannes Mikkelsen	Aiken, Caballero	16.06.2019-23.08.2019
Natural Language Processing of Physics Open-Ended Questionnaires	Joseph Wilson	Aiken, Caballero	16.06.2019-23.08.2019
The impact of CLUE curriculum in introductory chemistry courses on student performance and persistence	Matthew Ring	Aiken, Caballero	16.06.2019-23.08.2019
Neuroscience and AI: Unsupervised learning in Boltzmann machines	René Alexander Ask	Marianne Fyhn, Alexander Stasik, Mikkel Lepperød	23.06.2019-20.08.2019

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Theme *(continued)*	Students	Supervisors	When
Neuroscience and AI: Machine learning for neuron activity recognition	Håkon Olav Torvik, Peder Lon Hauge, Johan Andreas Fløisand	Marianne Fyhn, Alexander Stasik, Mikkel Lepperød	23.06.2019-20.08.2019
Molecular dynamics modeling of nanoasperity friction	Mikkel Metzsch Jensen, Simon Elias Schrader, Eivind Støland	Anders Malthe-Sørenssen, Henrik Sveinsson, Bjørn Jamtveit	23.06.2019-20.08.2019
Molecular dynamics modeling of hydrofracture	Magnus Sikora Ingstad, William Eivik Olsen	Anders Malthe-Sørenssen, Henrik Sveinsson, Bjørn Jamtveit	23.06.2019-20.08.2019
Molecular dynamics modeling of faceting phenomena in SiC	Fredrik Leiros Nilsen	Anders Malthe-Sørenssen, Henrik Sveinsson, Bjørn Jamtveit	23.06.2019-20.08.2019
Molecular dynamics modeling of wetted friction	Erik Alexander Sandvik	Anders Malthe-Sørenssen, Henrik Sveinsson, Bjørn Jamtveit	23.06.2019-20.08.2019
Molecular dynamcis modeling of nanoscale creep in SiO_2	Anders Johansson	Anders Malthe-Sørenssen, Henrik Sveinsson, Bjørn Jamtveit, Einat Aharonov	23.06.2019-20.08.2019
Neuroscience and AI: Navigation using recurrent neural networks	Kjetil Moe Gulli, Markus Borud Pettersen	Marianne Fyhn, Alexander Stasik, Mikkel Lepperød, Anders Malthe-Sørenssen	23.06.2019-20.08.2019
Neuroscience and AI: Machine learning for spike sorting	Noah Hegerland Oldfield	Marianne Fyhn, Alexander Stasik, Mikkel Lepperød	23.06.2019-20.08.2019
Molecular dynamics modeling of inverse faceting in nanoporous systems	Edvarda Harnes, Johan Emil Linnestad Larsson	Anders Malthe-Sørenssen, Henrik Sveinsson, Bjørn Jamtveit	23.06.2019-20.08.2019
Neuroscience and AI: Navigation using SLTM	Halvard Sutterud	Marianne Fyhn, Alexander Stasik, Mikkel Lepperød	23.06.2019-20.08.2019
Molecular dynamics of fracture in systems with asperities	Oskar Hafstad	Anders Malthe-Sørenssen, Henrik Sveinsson, Bjørn Jamtveit	23.06.2019-20.08.2019

Graphic design: Maria Hammerstrøm

UiO : University of Oslo

CENTRE FOR EXCELLENCE IN EDUCATION

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

Center leader
Anders Malthe-Sørenssen

Contact address
Center for Computing in Science Education
Department of Physics, University of Oslo, Norway
P.O. Box 1048 Blindern, NO-0316 Oslo