



INFORMATION ABOUT THE HOST INSTITUTION

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ABOUT THE CENTRE

Name of Centre Centre of Excellence in Science and Technology Teaching (CESTEC)
Is the SFU already established at the time of the application (yes/no)? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
Please name any consortium partners for the Centre EnergiRike, Statoil, CMR, Haukeland Hospital, HiB, Borregaard, BTO



ABSTRACT

A *Centre of Excellence in Science and Technology Teaching* (CESTEC) will be established in response to the expectations that research and higher education shall contribute to innovation in society. CESTEC will develop new tools, best-practice examples, and relevant resources to reshape course contents, student activities and study-program structures. The centre will focus on targeted collaborations where students, university staff, and enterprises in the public and private sectors forge a better platform for cooperation and communication. CESTEC will interact with industry to foster emphasis on industrial research challenges in problem-solving assignments and projects; societal challenges will be dissected to find out what the problems are in terms of science and technology. Research projects in science education will be launched to study impact and learning outcomes of the new activities. A new educational framework will be developed so that, when implemented, students and staff alike will contribute to critical thinking and development of innovative ideas.



THE CENTRE PLAN

MOTIVATION AND VISION

The framework for higher education and research has been through a significant political transformation since World War II. The shift is often credited to Vannevar Bush, who argued that science and technology is the key to social and political progress (1). This report paved the way for the establishment of research councils and research institutes in many countries around the world, including Norway, and generation and transfer of research-based knowledge became a visible enterprise in the country. When the Innovation Proposition (2) was passed in Parliament some seven years ago, universities were given additional tasks and are now expected to arm students with the skills and knowledge required to generate ideas and leverage technology. In order to meet this expectation, students graduating from our study programmes need a clear understanding of how science underpins our society and is a crucial tool to solve the challenges of our time. During the past decades there has been a massive convergence between disciplines. New research domains such as bio- and nanotechnology have evolved as inherently cross-disciplinary fields. We believe that our students will become better qualified to meet modern challenges when exposed to innovative applications of science and technology. The study programmes will be transformed to provide the students with knowledge to see the broad perspective and potential impact of being a professional, modern scientist. Collaboration with industry and enterprises, communication with stakeholders, dissemination of scientific findings, fostering a culture of social responsibility and professional integrity will be key components in this transformation. Following Louis Pasteur's motto from 1854 "Chance favours the prepared mind", our goal is to prepare the students' minds to contribute forcefully to generate new knowledge and develop and implement new technologies that will contribute to a sustainable society.

We want to establish CESTEC, illustrated in Figure 1, as an instrument to transform our study programmes in pursuit of this vision. The role of the Centre will be to actively filter the emerging needs in society, in research and among students to develop the educational framework needed for them to apply and communicate science in an innovative and effective fashion in society at large.

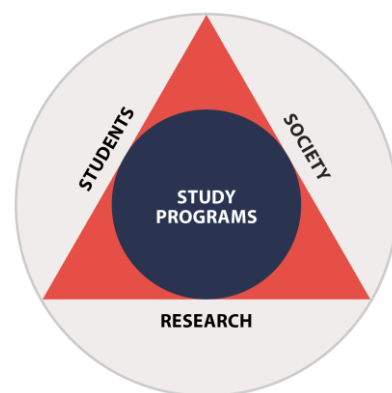


Figure 1: CESTEC, represented by the red triangle, will connect the study programmes and the 'world outside'.



STRATEGY AND INNOVATION

The overall objective of this SFU initiative is to enable the students to apply Basic Science and Technology (BST) to meet needs in industry and society. In order to achieve this, we will 1) develop study programmes that give students in-depth knowledge to meet these needs; 2) create arenas for training the students in communicating with stakeholders engaged in application of science in society; and 3) promote and facilitate a transition toward evidence-based science education (3). These goals will be achieved through realization of the following five integrated missions:

Mission 1: Establish stronger bonds to research institutes, industry and enterprises; WP1 in the action plan

Organize an active consortium with external partners and create space, both physical and virtual, for sharing knowledge, experiences and ideas. Through this consortium site visits and internships will be organized to increase awareness of present challenges in society at large. As a part of the progress, students will be familiarized with enterprises and current challenges in the students' early years. An active recruitment of new partners in industry and enterprises will be undertaken. Adjunct Professors for educational development within innovation, creativity and communication will be employed and an online newsletter for outreach and information will developed.

Mission 2: Enhance the relevance of the teaching contents; WP2 in the action plan

Build a culture among teachers and students to identify and bring in relevant challenges, data and expertise. Establish a resource centre containing tools, literature, contacts, instruments and examples for teacher support. We will develop educational tools to increasing students' knowledge of international guidelines regulating science and technology in society - a competence which is of crucial importance in the global economy. A teacher's forum to promote awareness among the teaching staff about the importance of demonstrating industrial/societal relevance in regular courses will be established. Up-to-date examples from the industry tailored to the students' competence levels will be provided through the Centre consortium.

Mission 3: Renew the design of assignments, exercises, and tasks; WP3 in the action plan

Train students in applying basic knowledge to solve relevant problem and interact with stakeholders. Develop and implement teaching activities that foster students' creative problem solving and communication competences and provide realistic problems anchored in current challenges tailored to the students' competence level. There will be focus on solving practical



problems, made possible by giving students access to laboratories and technical workshops where they can explore their own ideas. The Centre will arrange for consultancy assignments where the students can choose to solve a specific assignment from a company that represents a current challenge for the industry. The assignment may be solved by a single student, a group of students or several groups delivering on the same problem definition. Internships for students to experience authentic problem solving and participation in collaborative and creative reasoning will be organized. Communication to various audiences will be implemented as an integral part of the learning process.

Mission 4: Establish educational research and evaluation; WP4 in the action plan

Establish a research program to monitor and evaluate the effects and learning outcomes of missions 1 - 3 and develop mechanisms for adjusting BST education to industrial and societal needs. We will optimize teaching for learning through a cyclic refinement of the study programmes. In order to facilitate this development, the Centre will engage in research on effects of different types of assignments and exercises on students' learning outcomes (4 - 5). These assignments and exercises will reflect both formative and summative assessment of the students. Whereas formative assessment involves monitoring of student learning, provision of ongoing feedback, and use of low-stakes testing, summative assessment implies high-stakes testing in terms of evaluation of the student at the end of the unit by means of a comparison against a standard of excellence. The effects of different types of formative and summative assessments will be investigated by relating them to course experience, and to students' approaches to the new learning activities in WP1-WP3. By applying alternative modes of student assessment (e.g. formative assessment) it may be possible to enhance the students' experience of learning quality (course experience) which produces deeper processing of the learning material (deep approaches to learning).

Mission 5: Disseminate best practise for action and reaction; WP5 in the action plan

Systematically document and share the outcomes of implemented actions to improve the quality and relevance of the BST. Inform about best practice to stakeholders, nationally and internationally through open-access databases, virtual educational tools and annual conferences on science-and-technology education. Together with the students and the consortium partners we will actively disseminate the results of student internships and project collaborations and findings through printed and electronic media.

IMPLEMENTATION AND ORGANISATION

CESTEC draws its strength from the complementarity of the Department of Chemistry (KI) and the Department of Physics and Technology (IFT) with comprehensive inter-disciplinary expertise in classical physics and chemistry, nanoscience, petroleum and process technology, the consortium of partners in the public and private sector, and the Department of higher educational research at the University of Bergen. We know from surveys

among our partners, our students and our alumni that our above stated missions are wanted and needed. The project activities will be implemented through five work packages (WP), to address the above stated missions (Figure 2). The specific actions under each work package are listed in the action plan from A1-A33. **WP1** (WP leader: Geir Ersland) will establish the centre headquarter and infrastructure and secure management of activities, monitoring of progress and reporting. **WP2** (leader TBA) and **WP3**

(leader TBA) will deliver new tools, best-practice examples, and relevant resources to reshape course contents, student activities and study-program structures. The Centre takes on the task of updating our teachers on the modern development in organised student activities that facilitate motivation, creativity and learning. The aim is to equip our teachers with new tools to improve the attainment of learning goals based on scientific approaches to gauge what students actually are learning in **WP4** (WP leader Åge Røssing Diseth).

The Centre will be organised as shown in Figure 3. The Centre will be managed and operated by a team consisting of a leader and chair (Assoc. Professor Geir Ersland), a co-chair (Professor Leiv K. Sydnes) and an

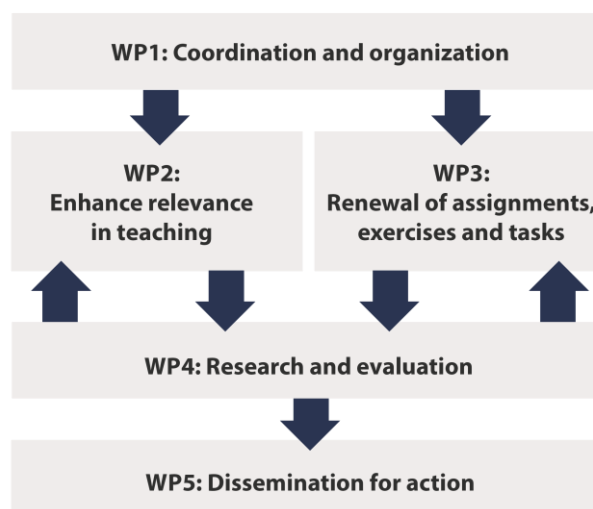


Figure 2: CESTEC workflow and relationship between work packages

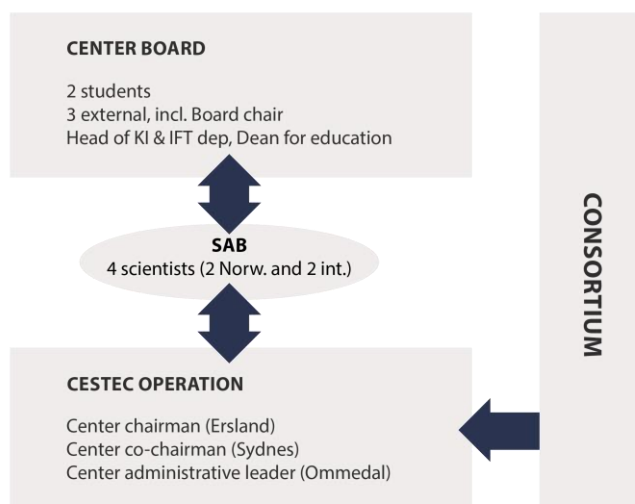


Figure 3: CESTEC organisation



administrative leader (Dr. Hege Ommedal). The Centre leader will have complete financial responsibility, handle NOKUT reports and communications, facilitate and arrange regular meetings with stakeholders, and maintain communication with teachers and students to inform about CESTEC activities, including results from the educational research. The management will be responsible for initiating the work packages. The Centre will have a Board consisting of the department heads from KI and IFT, Pro-Dean for Education, three external member from the consortium and two student representatives, which will monitor the CESTEC activity. A Scientific Advisory Board with two national and two international specialists will also be established to obtain constructive scientific feedback. The CESTEC consortium consists of cooperative partners: STATOIL, Haukeland University Hospital, Christian Michelsen Research and Borregard, and will expand through active recruitment of new partners. Innovation clusters and organisations as EnergiRike, GCE Subsea, NCE Maritime and Clean Tech take part in the consortium. In addition to being involved in specific projects students with good ideas will be encouraged to develop their idea through the Accel Student program. Accel is arranged by BTO in close collaboration with Bergen University College. Special-designed Accel Student courses will be developed for CESTEC students.

EVALUATION, IMPACT AND OUTCOME

The outcome of CESTEC, if awarded, will be a strategic framework of how innovation may be implemented and adopted as part of higher-science-and-technology education. The funding and recognition that follow the SFU award will provide the means for an innovative shift within science- and-technology teaching that otherwise would not come to be. To enable continuous improvement in this regard and stimulate institutional development over time the Centre will carry out evaluations of the new learning activities based on feedback from industry advisors, students, and alumni. This will be complemented by scientific approaches to gauge what students actually are learning in WP4. We will be able to draw on the experience, insight and expertise of the bioCEED Centre of Excellence (CoE) at UiB. bioCEED is deeply engaged in the development of evidence-based teaching in biology as well as student-active teaching and reversed-classroom techniques. The Centre is expected to generate significant funding from our partners in industry to maintain and further develop the targeted collaborations with industry partners and to improve the educational framework post the lifetime of the CoE.



QUALITY IN EXISTING EDUCATION

The research at the Department of Physics and Technology and the Department of Chemistry aims at understanding nature from her building blocks of matter and the origin of the Universe to industrial manipulation of matter to harvest products in a sustainable fashion. The education at UiB is based on this research and its applications and the quality of this education is anchored in an extensive quality assurance system described in the University's Handbook for Quality Assurance of University Education.¹ The ambitions are high, as reflected in the University strategy (2016-2022), which states that i) *UiB shall educate Norway's most attractive candidates* and ii) *by 2022, a total of 85 per cent of the degree candidates will have a relevant job two years after they complete their education.*² The ambitions of CESTEC is also anchored in our Faculty Strategy: *Our education shall give insight and personal development, and provide important competence to research, the working sector and Society*³.

The quality-assurance system (Figure 4), which is embedded in the university structure, is actively used to adjust practise to achieve improvements in the quality of the education. Evaluations from students, teachers and program evaluators are used systematically for this purpose, and the changes implemented are presented in the UiB Education Quality Database.⁴ NOKUT stated in their 2014 evaluation of the University of Bergen that the study-quality work at UiB has high priority and that UiB has an established a system for quality assurance in education that is suitable to achieve the goals for the quality work⁵. This contributes to the ranking of University of Bergen among the 100 top universities in Europe.⁶

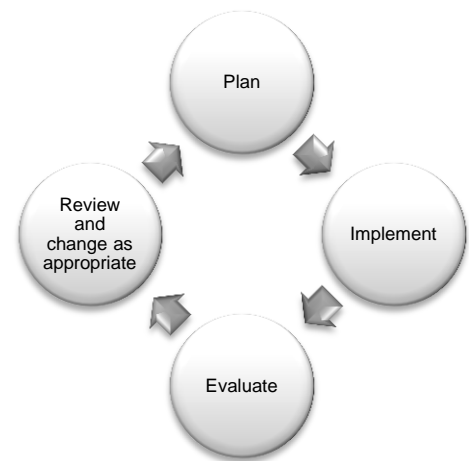


Figure 4 Key elements in the cyclic quality assurance system at UiB.

¹ [UiB "Quality Handbook"](#)

² [UiB Strategy Ocean Life Society](#)

³ [MN strategy 2016-2022](#)

⁴ [UiB Education Quality Database](#)

⁵ [NOKUT evaluation report for UiB 2014](#)

⁶ [THE 2016](#)

INPUT FACTORS

Anchoring and engagement

The SFU initiative is fully supported at all levels at UiB. Through partnership agreements there is also solid support in the enterprises in the private and public sectors. The study programmes are provided with funding and manpower from the KI and IFT departments, and teaching support from other MN departments.⁷

Research strength and quality

KI and IFT have strong research groups in physics, chemistry, nanoscience and petroleum research. The researchers' excellence is documented by partnerships in Norwegian Centres of Excellence⁸, extensive external funding from prestigious institutions⁹, as well as collaboration in international research networks¹⁰ and PhD research schools.¹¹ The researchers publish actively in national and international journals and several staff members act as editors of scientific publications.¹² In 2014, 30 % of the published papers were at level 2.¹³

Education strength and quality

KI hosts the BSc and MSc programmes in chemistry, of which the former was awarded the prestigious EuroBachelor label in 2014¹⁴, and in nanoscience and nanotechnology. The nano-program introductory course *Perspectives in Nanoscience and Nanotechnology* was awarded the prestigious Owl award for high quality in education at UiB.¹⁵ KI is also a partner in the Erasmus Mundus *EMQAL* program¹⁶. Each SFU study programmes is chaired by one experienced educational leader and administrated by one member of the study-administration staff. New members of the teaching staff without documented pedagogical competence are obliged to take courses in university pedagogy. The teachers are highly valued by the students as reflected by students' evaluations and awards received.¹⁷ All education-administrative staff holds at least a master's degree, with significant academic competence within the basic natural sciences or

⁷ Study program construction: [BSc Chemistry](#), [BSc Physics](#), [BSc Petroleum and Process Technology](#), [BSc Nanotechnology](#)

⁸ Centres of Excellence: [Space Science](#), [Petroleum research](#)

⁹ External funding for excellence: [BFS \(2006, 2009\)](#)

¹⁰ [CERN](#), [SNBL/Grenoble](#), Norwegian Centres of Excellence ([Space Science](#), [Integrated Petroleum Research](#))

¹¹ [Nano-network PhD Research School](#), [Petroleum Research School of Norway](#)

¹² [Naturen 03/12](#)

¹³ [DBH: Publication at MN UiB 2014](#)

¹⁴ [Eurobachelor at Department of Chemistry](#)

¹⁵ [The Owl Award](#), [The Owl award to Perspectives in Nanoscience and Nanotechnology, 2010](#)

¹⁶ [EMQAL](#)

¹⁷ The MN Best Lecturer Award ([2009](#), [2011](#), [2014](#))

university pedagogy. Student mobility¹⁸ strengthens the international experience which is highly valued by employers.¹⁹ Both departments regularly welcome international colleagues and students.²⁰

Infrastructure

The departments are well equipped with state-of-the-art instruments, including a helium microscope, a nano lithography lab, a multiphase flow laboratory (IFT) and a 850 MHz NMR spectrometer in the new Norwegian NMR platform²¹ (KI), which are extensively used by BSc, MSc and PhD students under supervision.²² Students' value access to such instruments and this is a motivation factor in the study programmes.²³ The departments are well experienced in providing high-quality teaching in laboratory training supervised by highly competent laboratory engineers. The high-capacity student-training laboratories are designed to ensure solid HSE-quality standards and mandatory student HSE courses are in place. In addition, several of the scientific personnel at the departments are involved in innovation and commercialisation projects and entrepreneurial start-ups with BTO. The Departments are also actively engaged in several industrial and research clusters in the region.

PROCESS FACTORS

In the three first semesters, basic and well established knowledge is taught. From the fourth semester, more advanced and research-oriented topics are covered, leading to MSc studies that focus on individual research and advanced theory. Here, students contribute to new knowledge through their original research performed under supervision. This is in alignment with the E(N)QF²⁴ that emphasizes that students gradually gain more advanced knowledge as the studies progress. The innovative teaching and assessment methods in *Perspectives in Nanoscience and Nanotechnology* (student-active learning in research-based internships, written reports, oral presentations, public poster presentations) and the research-preparing *Projects in Physics* (scientific project work, written reports, oral presentations), the communication course *Scientific communication in English* and the *Bachelor's Project in Chemistry* (scientific work methods, library course, HSE in chemistry,

¹⁸ [DBH: Exchange students \(in/out\) at KI and IFT](#)

¹⁹ [StuderUtlandet.no](#)

²⁰ [DBH: International students at KI and IFT](#)

²¹ [Norwegian NMR Platform](#)

²² [Laboratory research instruments at KI](#)

²³ [MSc Nano evaluation report 2014](#)

²⁴ [European Qualification Framework \(EQF\), Norwegian QF](#)

scientific project work, written reports, oral presentations) are examples of best practice in teaching and assessment methods with high transfer value.

The course *Industrial Organic Chemistry* has significant industrial relevance with specific R & D development tasks related to real industrial processes and a strong focus on HSE elements in industry. The departments are strengthened by several adjunct professors from industry teaching advanced courses with high relevance for science application outside the academia. The research group for Petroleum and Process Technology (PPT) has numerous national and international research collaborations, both with academic and industrial partners²⁵. It was ranked top 4 of 20 in RCN's evaluation of basic and long-term research within technology in Norway²⁶. At BSc level, the PPT students are exposed to industry through excursions to Statoil. Most MSc students work with international institutions during their master work and field courses and task are provided in close cooperation with industry.

The academic qualities of the teachers are a key to a successful SFU centre. A recent survey among students and alumni reveals that these qualities are present at IFT and KI. The purpose and task of CESTEC will be to develop, on the basis of the innovative practises described above and input from students and external partners, a teaching approach that will be implemented in all the study programmes involved on the BSc level. On this basis, we strongly believe that CESTEC will transform the study programmes so that the graduates will be well qualified to apply Basic Science and Technology to meet needs in industry and society.

Students as active key players with engagement and ownership of learning

The students represent a strong pillar in the education environment as teaching assistants and mentors. Senior students are active in recruitment and social activities²⁷ and highly valued by the junior students and the department's staff. The students are agents of educational development by direct involvement in ongoing processes for improving quality in the study programmes and individual courses. The students have a clear voice in educational debates and contribute actively through their representatives in the decision-making program boards. Student feedback is provided

²⁵ NorTex petroleum cluster

²⁶ www.forskningsradet.no

²⁷ Welcome week, MN Information week, International Week, Career day, and as ambassadors to secondary schools



in group discussions that enable rapid adjustments of practice, if necessary. The student organizations are key players in student-social-welfare work in close collaboration with the education leadership in many ways, like working for improvement of the physical learning environment and strengthening the social network among the students.

Outcome Factors

Content, quality and relevance

Surveys among the departments' students show that the key quality elements in the study programmes are good teachers and supervisors. The human resources in the teaching and supportive staff are highly valued. Although most MSc graduates find a relevant job during the first year after graduation, surveys have revealed that our BSc study programmes, and to a certain extent our MSc programmes, lack work relevance in the sense of being incomplete in professional training in innovation, creativity and communication. CESTEC will be established to fill this gap.

Key student data

The MSc students in physics and chemistry are above national average in ECTS production. The BSc students are on national average. The completion rates are not easily comparable between institutions due to differences in program structure and content. However, the number of MSc graduates in physics and chemistry at UiB, UiO, and NTNU from 2012 – 2015 indicate that UiB's programmes perform above average. We are pleased that the total number of applicants to BSc Nano and Chemistry in 2015 was the best in the last four years with 52 and a 42 % increase from 2012, respectively. Key figures for student data will be sent upon request.