Excellent Information Technology Education (ExcITEd)

Information about the host institution

Host institution Norwegian University of Science and Technology (NTNU)		
PO Box address		
Postal code 7491	City Trondheim	Place **[text]**
Telephone 73 59 50 00		
E-mail address postmottak@adm.ntnu.no		

Contact person

Name Guttorm Sindre	
Title Professor / Centre Leader	
Telephone work 73594479	Mobile 94430245
E-mail address guttors@idi.ntnu.no	

About the centre

Name of Centre Excellent IT Education (ExcITEd)
Is the Centre already established at the time of the application (yes/no)? ☐Yes ☒No (Not formally established, but some activities and collaboration between partners is already started)
Please name any consortium partners for the Centre NORD University

Abstract

ExcITEd aims to enhance tertiary IT education in Norway. Within the direct scope of the centre are 17 study programs at the NTNU and 2 at NORD University, and ExcITEd will collaborate closely with the relevant Program Boards. The aim is to increase the students' learning and thus graduate more and better candidates through higher student engagement. Approaches include increased focus on project based education, earlier involvement of students in research and development activities, increased focus on self- and peer-assessment and reflection, both among students and teachers. The centre will also have a strong effort on trying out and partly developing various IT tools for learning, since IT teachers and students have special competence for making advanced contributions in this area. There will be a strong dedication towards dissemination for action, developing open learning resources and experiences to be usable also for IT programs, teachers, and students outside the centre.

Comments

The restriction on the number of CVs (centre director + 2-5 key persons, i.e., max 6) felt quite limiting for us, as the application spans two partners, NTNU and NORD, and there are persons involved in the proposal at all campuses of the newly merged NTNU. There are many more CVs we would have liked to include, for instance Prof. Letizia Jaccheri (now HoD, involved in the H2020 project UMI-Sci-Ed and many outreach activities), Prof. Alf Inge Wang (inventor of the game-based learning platform Kahoot! and other learning games), Prof. Monica Divitini (having experience from several EU and Norwegian Research Council projects on e-learning), Prof. Rune Hjelsvold (Vice-Dean Education, NTNU/Gjøvik and intiation of the CoPCSE community of practice in computer science education), and Robin Munkvold, Head of Studies at NORD University, Steinkjer.

Excellent Information Technology Education (ExcITEd)

Importance

Norway has a growing demand for IT professionals, projected to outgrow the educational production to an estimated shortage of 10.000 by 2030 [21]. Similar trends can be seen elsewhere, like in the EU [20] and US [4]. Despite positive career prospects, many young shun a career in IT, due to lacking awareness or prejudice against the IT profession [17, 29], with girls affected more [12]. The Digital Agenda for Norway[1], Digital Agenda for Europe[2] and the US Bureau of Labor Statistics[3] call for more and better candidates from IT studies, and ExcITEd is a response to this acute need.

Profile and Vision

Our vision is *to put Norway in the forefront of innovative IT education and make IT an increasingly more attractive study choice for young people*, by focusing on three objectives:

1. Enhance the learning in our study programs through increased student engagement and cross-campus collaboration and co-reflection among students and staff.
2. Enhance motivation and career-readiness of the candidates by increased collaboration with potential employers in the design, delivery and quality assurance of the education.
3. Attract diverse talent to IT studies and profession by motivating for and improving the knowledge of IT and its possible career paths among Norway's pre-university youth.

Documentation of educational quality in existing provision

After a recent merger with colleges in Trondheim, Gjøvik, and Ålesund, NTNU alone has 17 different IT study programs in the scope of ExcITEd. NORD University at Steinkjer has two study programs in IT. All in all, ExcITEd will directly have impact on more than 2000 full time students.

Input Factors: (1) *Strong and ambitious leadership committed to educational quality*. The IME faculty renewed its ICT studies through the Dean-initiated project FRIKT (2013-15), making the first years more engaging, motivating project courses being one notable result. The Rector-initiated project NTNU Teaching Excellence (www.ntnu.edu/teaching-excellence) addresses various aspects of learning and assessment. The University of Tromsø and NTNU jointly proposed a system for recognition of pedagogical competence, to make this more significant in hiring and promotion decisions. NTNU demonstrated willingness for change by embracing the Government's request for mergers in higher education. IT, with partly overlapping educations across the campuses, is a discipline with high

[1] https://goo.gl/707myu update: https://www.regjeringen.no/no/aktuelt/norge-trenger-en-ny-digital-agenda/id2402093/
[2] https://ec.europa.eu/digital-single-market/en/europe-2020-strategy http://europa.eu/pol/pdf/flipbook/en/digital_agenda_en.pdf
[3] http://www.bls.gov/ooh/computer-and-information-technology/home.htm

potential for cross-campus synergies and educational improvement from the merger. Hence, leaders on all levels − Rector, Dean and Heads of Department − are strongly committed to the success of ExcITEd. The same applies to NORD, which has gone through a similar merger. In the implementation of its quality assurance system for education, NTNU has shown a strong commitment to support educational evaluation and leadership, and partners in the merger have already implemented the same system. (2) *Long-lasting attention towards recruitment, retention and the gender gap*. The Dept of Computer Science (IDI) started a project in 1997 to recruit and retain more females, later adopted by the whole faculty (www.ntnu.edu/girls). Also, high-school girls are invited to summer camps at NTNU, inspiring many girls to consider an IT career. "*If I hadn't participated in the technology camp, I wouldn't have been studying IT now*" (current female student)[4]. More recently, we initiated a leadership program (www.ntnu.edu/welead/about) for women in IT. The KID network (kid.item.ntnu.no) of enterprises targets undergraduate students of both genders to increase motivation and retention. KID offers industry-related guest lectures, excursions and mentorship resources to highlight the relevance of theory and show the variety of work-roles available. Our students are involved in recruitment work, making promotional material[5] and visiting their former high-schools and education fairs to tell about their studies. Youngsters are introduced to programming through "coding clubs", with heavy presence in Trondheim and Gjøvik (kidsakoder.no/kodeklubb/). Instructors are mostly NTNU students. NTNU Gjøvik is supporting the local high school in setting up an IT competencies program for high school students who would like to specialize in IT (cf. http://goo.gl/jkd4SJ). (3) *Professors with strength in research and innovative teaching.* ExcITEd has several professors with high publication and citation records and good external connections, resulting from involvement in national and international projects[6] and organization of conferences[7]. In addition to core IT publications, many ExcITEd professors have published papers about didactics, e.g., empirical evaluations and experience reports from trying out various teaching approaches. Just taking IDI/NTNU, 100+ such papers have been published in peer-reviewed international outlets from 1992 onwards[8]. (4) *Highly competent students.* As for admission threshold, IDI/NTNU has the best

[4] Documentary of the girls in science and technology at NTNU: https://www.youtube.com/watch?v=oA8IuCsbuEU
[5] An example recruitment video made by our Informatics students: https://www.youtube.com/watch?v=BmQzErWKYnI
[6] We have several ongoing projects funded from various sources like, the Norwegian Research Council, NTNU, IME and the EU H2020 SEAC "Innovative ways to make science education and scientific careers attractive to young people" program; with an ultimate goal to improve teaching quality, (cf. https://excit-ed.com/projects/ and financial resource Appendix 2)
[7] The national conference for ICT in teaching and learning (NKUL) is organized every year from IDI/NTNU: www.nkul.no/ ExcITEd is a major player in the newly established Education & Didactics in IT conference: http://itkonferanse.hials.no/en/ European Conf. on Games Based Learning '15: http://goo.gl/hqpGXS Serious Games Conference '13: http://goo.gl/AEeYVK
[8] List of publications in innovative pedagogies: https://excit-ed.com/publications/e-learning-and-innovative-pedagogies/

Computing students in Norway[9]. Students at the various campuses have contributed to this application through focus groups and questionnaires, and will be making even more important contributions when the project gets going. (5) *Industry support*: Norwegian IT industry is in dire need of people and would like to see us succeed, the mentioned "KID" network one evidence of this.

Process factors: (1) *Research-based education*. Teachers in ExcITEd hold PhDs and are active researchers in their fields. Also, students are stimulated towards research, starting with fun, informal research in undergraduate mini-projects, then gradually progressing towards their master theses. In our courses, we put into practice various forms of active learning, such as inquiry-based learning and follow up with a 'capstone' experience based around a major project. The M.Sc. students in Gjøvik, for instance, are introduced to the research in their field through a series of "Introduction/Specialization to …" (www.ntnu.edu/studies/macs/programme-components) courses in which research papers are thoroughly examined in round-table discussions led by the students. (2) *Strong commitment to Q/A*. In addition to NTNU's default approach of student reference groups per course, IDI gains a lot of additional feedback from our students, via quizzes and polls in lectures or through the LMS, online Q/A forums per course and questionnaires (for single courses, and for each term). IDI's leadership meet once per semester with student representatives (10 students, one per class of the 5-year CS program, and one per class of the 3+2 year Informatics program) to get feedback on how the semester as a whole has worked out. Also, IDI has been running alumni surveys (2007, 2011, 2015) asking former students what types of jobs they had, which topics from the curriculum had been useful to them, and whether something should receive increased attention in our education. (3) *Drive towards new learning and assessment methods*: IIE/NTNU (Dept of Informatics and E-learning) received the NOKUT Education Quality award in 2011 for the "p-lab", a space for student active learning[10]. The Spring 2015 offering of IDI's Software Engineering course (4th semester) was the first trial of flipped classroom in a large cohort (300 students) in a Norwegian university (https://goo.gl/10L1Gs). The 2016 offering has gone further in the direction of creative team projects (http://zab2016.wix.com/zab2016). IIE has been a pioneer in distance and continuing education in IT (e.g., MOOC IT in learning), and both IIE, IDI and NORD have experience with the creation and use of instructional videos. Currently, there are several project-based learning courses during the studies, from mini-projects with a cognitive apprenticeship approach in the first semesters [11, 32], and larger team projects with increasing authenticity later [23, 31]. At NORD, students have projects from the first semester; their GameLab

[9] In 2015, our 5 year program in Computer Science required 55.2 points for admission directly from high school, and our three year Bachelor program in Informatics was in second place, requiring 47.7 points: http://goo.gl/nHtw3x

[10] http://www.nokut.no/no/universitet-og-hoyskoler/utdanningskvalitetsprisen/tidligere-utdelinger/vinnere-2011/

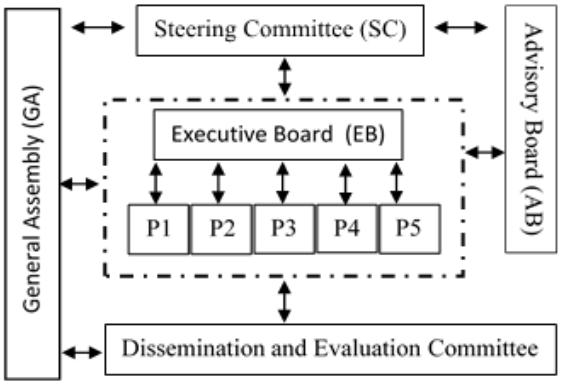
course gives students an experience resembling a regular job in a video game development company (cf. film.nord.no and games.nord.no). Innovation and entrepreneurship is encouraged, many of our students have created world class startups and applications (e.g., https://getkahoot.com/, http://wordfeud.com/, www.mazemap.com/ to mention a few). Both partners have attracted funding from Norgesuniversitetet for a number of innovative education projects[11]. (4) *Student involvement and engagement:* In large classes in the first years of study, older students contribute as assistants in the lab (1/6 or 1/3 of a full time job), and NTNU offers pedagogical modules for these learning assistants[12]. Our large courses use peer-instruction environments and Q/A forums (e.g., piazza.com, Confluence Wiki), many questions answered within a few minutes due to contributions from student assistants or classmates. Students' organizations give courses that supplement the department's offerings (e.g., https://online.ntnu.no/events/), and organize competitions (e.g., https://idiopen.idi.ntnu.no).

Output Factors: *(1) High throughput:* IDI graduated 162 master candidates in 2015, produces more than 1000 study years annually, and the 5 year Datateknologi program is one of the biggest study programs at the NTNU when it comes to credits from its courses and its students[13]. *(2) High student satisfaction:* NOKUT's Studiebarometeret.no gives overall satisfaction scores of 4.5 (of max 5) for NTNU's 5 year integrated Master in Computer Science, and 4.8 for the highest scoring Bachelor program at the Kalvskinnet campus (average for IT programs in Norway: 4.0). *(3) High job relevance:* Studiebarometeret.no similarly gives 4.5 and 4.7 for job relevance of the mentioned studies (country average in IT: 4.2). IDI/NTNU has run alumni surveys (2007, 2011, 2015) asking what topics candidates needed most in their careers, showing good alignment between study programs and job needs. Most of our candidates secure a job at least half a year before graduation. *(4) Innovation:* Our students have received recognition by getting various awards like the "Norwegian Game" Award, "young entrepreneur of the year" award and the "tech achievement of the year" award. Applications like "Fun Run" (developed by six students, reached #2 on the US iTunes Top Apps list) and "Wordfeud" (2013 revenue: 28.6 MNOK) exhibit the world class successes of our student innovations. The lecture quiz tool Kahoot! − now used world-wide − started as a project by IDI's Prof. Wang, further developed by a student in a Master thesis. ExcITEd researchers have recently acquired EU projects in mobile learning, social innovation for learning and STEM education (cf. Appendix 2). Such

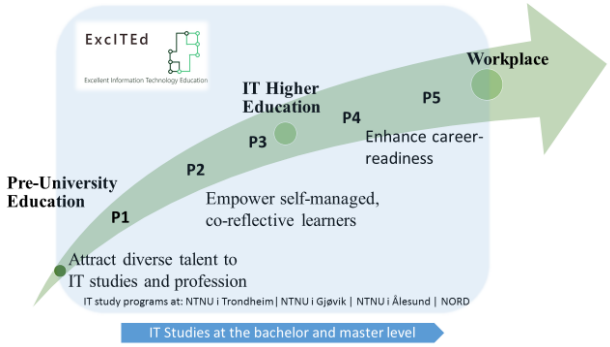
[11] https://norgesuniversitetet.no/prosjekter and select NTNU or NORD in the search box on the right.
[12] Learning Assistant Training (LAOS) program: http://www.ntnu.edu/ipl/laos . Use of Teaching Assistants is standard procedure for many courses at the NTNU, not just IT, but IDI is at the extreme end of the scale. The first semester IT course employed 105 assistants (Autumn 2015), far more than other courses of similar class size.
[13] Source: DBH: https://dbh.nsd.uib.no/dbhvev/student/eksamen_emne_rapport.cfm , and click Universiteter, then Norges teknisk-naturvitenskapelige universitet and scroll down to Datateknologi

international quality research projects provide interesting topics and cases for student summer jobs, master theses as well as research experience for undergraduates. (5) *Student-industry relation:* It is common for NTNU students to work with IT companies on Bachelor or Master theses projects, solving industrial problems. In Gjøvik, all IT students are invited to the free seminar "X Session" (www.hig.no/nyheter/arkiv/2014/x_session), where alumni share their work experiences. In Steinkjer, IT students have a company simulator project course (Game Lab – http://spo.hint.no/about-us/) from the first semester, with a co-supervisor from industry.

Centre Plan



The structure of the centre is indicated in the figure. The *Executive Board (EB)* will consist of the centre director (Prof. Sindre), administrator (100%), and project leaders of our five sub-projects P1-P5. EB will coordinate the centre's activities and regularly assess that progress is according to plan. The *Steering Committee (SC)* will consist of one representative from NOKUT, one for NTNU centrally, one from the IME faculty, student representatives, heads of involved departments, and representatives from the study program boards. The *General Assembly (GA)* consists of student representatives from all courses and study programs affected by ExcITEd innovations, and all the employees involved in the centre. GA will have an annual meeting giving status across sub-projects and generate ideas for further innovation. The *Dissemination and Evaluation Committee (DEC)*, lead by the centre director, will have the overall responsibility for dissemination and quality evaluation. The *Advisory Board (AB)* will consist of representatives from industry (e.g., members of our KID network) as well as international experts: Dr. Arnold Pears (Uppsala U.), Dr. Peter Hubwieser (TU Munich), Dr. Ole Iversen (Aarhus U.), Dr. Mark Guzdial (Georgia Tech), and Dr. Barbara Erickson (Georgia Tech). The educational innovation work of ExcITEd is organized in five projects, although there is a lot of synergy between them. In the proposed projects we follow active learning for engaging students in the process of learning through activities, as opposed to passive learning [9]. Our approach emphasizes critical thinking, skills development and often involves group work. Project-based learning, peer instruction and inquiry-based pedagogy are central to ExcITEd.



P1: "Informed decision". This project will *increase the knowledge of IT and the IT profession for pre-university students in particular*, and help them consider an IT career on a more informed basis. Some choose IT studies for the wrong reasons (e.g., love to play computer games), some disregard IT in spite of having talent, e.g., for lack of role models, prejudice about the studies and profession, or fear that they will not master it – the latter most prevalent in girls [5]. A new elective programming course in middle school to start 2016/2017 is a promising follow-up on the increased interest for programming and will give the young insight in exciting technology. Helping teachers make courses like this successful can reduce prejudice against IT, but it is also important that courses and other activities where kids learn IT provide *role models* of both genders and a view of the breadth of jobs that an IT education can qualify for. ***Current Activities:*** NTNU has a teacher education in Natural Sciences that includes a specialization in mathematics and informatics. NORD University has 4 courses relevant for IT teachers. IIE offers a MOOC in ICT for teachers. NTNU´s resource centre for STEM-education (Skolelaboratoriet: www.ntnu.edu/skolelab), offers continuing education for teachers and support for science education in schools including programming workshops organized by IDI (e.g., Kodeløypa: www.ntnu.no/skolelab/kodeloypa). Internationally, we are involved in the recently started EU project UMI-Sci-Ed[14] to promote IT education in schools. ***Further Activities:*** P1 will establish a network that will promote and support IT education in schools (cf. the UK Computing At School − CAS network [3], Georgia Computes network [15]) as well as support other IT initiatives for the young [8, 10, 13]. The network will bring together different stakeholders, including our industry network, to create synergy and new forms of collaboration that will influence and strengthen our IT education for teachers and the practice of teaching IT in schools. To provide role models P1 will include an ambassadors program, where our IT students, faculty and alumni of both genders will visit schools to tell about their work and lives, as well as produce video narratives with similar content. ***Outcome:*** By the end of our project, IT shall be a more popular study choice among Norway's young – and for girls in particular – than it is today, and high school students shall consider IT career on a more informed basis than today.

P2: "Projects of Becoming" acknowledges that our arriving freshmen have really embarked on two challenging projects: in the short term to become a student, in the longer term (3-5 years) to become an IT professional. P2 *supports first year students in becoming successful managers of these two projects.* Many freshmen are still searching for what to study and what to become, this is of particular importance in IT [14]. Hence, they need to see purpose and role models, not just introductory courses with focus on theory. Many students struggle with the transition from high school to university [28]

[14] UMI-Sci-Ed (2016-2019), Exploiting Ubiquitous Computing, Mobile Computing and the Internet of Things to promote STEM Education, H2020 – SEAC – 10 – 2015.

and “first year experience” is identified as crucial in the success of higher education (cf. first year experience conferences: http://goo.gl/wobwuk). ***Current Activities:*** The centre includes study programs that have different approaches to handle first year experience, adapted to the size and profile of the program as well as the campus facilities. NTNU has a two-week startup program for new students called Teknostart / Realstart and study programs at IDI follows up with projects in some of the courses of the first and second semesters [11, 32]. Study programs at IIE, Gjøvik, Ålesund all share a focus on project work in first year of study, and the centre in total represents rich experience in motivating and engaging students in the first year including support from industry partners on motivating for a career and support from student organizations on social aspects. ***Further Activities:*** The centre will work systematically towards implement in all IT study programs an introductory year that creates engagement for IT, help students develop good working habits and motivates for further studies. Due to the large number of study programs in the scope of our centre, we will learn from each other and initiate different parallel sub projects, based on needs, contexts and suggestions of the students and teachers in each program. This will include adapting course content and creating innovative learning activities for first year students, adapting and developing physical and digital learning environments that encourages social and active learning. We will also focus on identifying and developing support for students that have a high chance of dropping out. ***Outcome:*** P2 will contribute to an optimal first year experience and give insights of how IT studies should be organized to engage students and help them develop good working habits. Empirically-refined approaches and best practices for introduction to IT studies will be openly documented.

P3: “Learning through Construction” aims to *maintain and further develop students’ interest and excitement by creative design of IT artefacts.* The past decade has provided students with many environments and community spaces for learning through construction as well as promoting self-discovery and innovation. ***Current Activities:*** At all involved campuses, there are several project courses where students build IT artefacts in real or realistic settings. NORD has a GameLab already in the first semester, where student teams spend one day a week working in a video game company. NTNU has several team project courses, some with real customers, and also a HackerSpace (hackerspace.ntnu.no) where students can explore self-driven construction projects. In Kalvskinnet campus, the Concurrent lab (https://www.ntnu.no/iie/forskning) employs real-time collaboration systems (e.g., shared screens and projectors) for learning and construction. FabLab in Ålesund (https://www.ntnu.edu/fablab/) offers a playground for learning and innovation. ***Further Activities:*** ExcITEd aims to integrate *“learning through construction”* more systematically and strongly into the

course-work of the students in all semesters of each program. Partner in the centre will collaborate and share experience and guidance through the planned Community of Practice and the centre will support various forms of cross campus collaboration on course and learning activities development. ExcITEd will investigate how different construction spaces and setups support learning, by collecting empirical student data. ***Outcome:*** P3 will increase the use of "learning through construction" and improve our understanding of how this learning method increases students' interest and excitement for IT.

P4: "Sharing and Diversity" aims to *develop highly efficient cross-campus learning spaces.* Following recent university mergers at NTNU and NORD, ExcITEd currently has 19 study programs within its direct scope. Diverse profiles of the study programs enables the partners to cater both to different student preferences and different segments of the job market. Due to similar underlined content knowledge, teachers should collaborate across campuses to reuse learning resources and ensure comparable learning outcome and grading. Equally important is to benefit from the diversity by offering courses across multiple campuses. ***Current Activities:*** Ongoing projects explore synergies and establish communities among staff across campuses, like in data communications courses in Ålesund, Gjøvik and Trondheim, as well as the established Computer Science Education Community of Practice. ***Further Activities:*** The centre will promote and support pilot projects for cross-campus learning. For courses with similar contents and learning objectives across campuses, we will explore and study how learning activities can be run in parallel on multiple campuses while still maintaining the qualities of on-campus learning activities. For specialization courses offered only on one campus we will utilize MOOC-style distance education that further can be offered to a wider community. We will extending the currently developed technologies [8, 27] for capturing students' progress and providing automated feedback for self-reflection and –evaluation. ***Outcome:*** P4 will result in course development and experience and knowledge in cross-campus education. P4 will also develop a number of tools, some specific to one course, others usable across many different courses and programs − not only in IT.

P5: "Career Readiness" aims to *strengthen and expand the education-work connectivity by providing students' with "real-life industry-driven" learning.* As indicated from the ACM/IEEE joint task force on IT curricula [1, 2, 6], the critical element in the success of an IT program is the involvement and active participation of industry. Well established industry participation supports various activities including advice from an industry perspective, student and faculty industry internships, integration of industry projects into the curriculum, guest lectures, and visiting faculty positions from industry. ***Current Activities:*** ExcITEd partners have a long tradition for projects as an essential component in the education, some of them with real customers [16, 23, 30]. Many of our students get valuable experience

through internships and summer jobs in our industry network. ***Future Activities:*** P5 will monitor best practice project-based teaching from other IT educations world-wide, as well as the expected competences from the IT industry (https://goo.gl/XtFfj8). We will intensify our collaboration with the industry so that more students can get relevant summer jobs. Similar to the concept of minimum viable product in lean software development [7], we will collaborate with industry in setting up the *minimum viable competence* for various IT-related summer jobs. ExcITEd will build "students-industry hubs", in order to help qualifying students for summer jobs and getting them in touch with potential employers. ***Outcome:*** P5 will strengthen the education-work connection. Gap analysis between the job market's expectations and current learning outcomes will be used to guide program and course development. Student-industry connection will ensure a smoother transition from education to work for students.

Evaluation: ExcITEd will systematically gather both qualitative and quantitative data on student satisfaction and learning outcomes from the centre's educational interventions, as well as data from alumni, instructors, NOKUT (e.g., Studiebarometeret) and the industry. Learning analytics will be used on top of various channels (e.g., learning management systems, students' progress records). ExcITEd has already established various evaluation activities, through focus groups with students, reference groups with course representatives, interviews with the IT industry and standardized surveys [25, 26]. ExcITEd started this year to use and further develop methods and tools for systematic evaluation, for example we used international standardized surveys to assess students' learning experience, industry's expected skills and information about our alumni's skills development (https://excit-ed.com/quality-assurance/). Drawing from the experience of our international collaborators (e.g., [27, 15]), ExcITEd will further develop its experience on systematic quality assurance and make publicly available an evaluation kit to others. Thus, the evaluation of the center will heavily rely on combined indices, and the impact of the center will be assessed and included in the yearly report.

Dissemination and Internationalization

Dissemination activities will be in focus from day one of ExcITEd and throughout the project, tailored to various stakeholders and practitioners (e.g., policy makers, instructors, learners). In line with our long tradition of publishing about innovative IT education[15] we will intensify our peer-reviewed publications, targeting high prestige international journals and conferences. As a national centre, we will also contribute to national conferences like NIK, NOKOBIT, NOKIOS, and NKUL, the annual conference organized by NTNU which attracts more than 1000 educators. Notably we will keep our

[15] IT education: https://goo.gl/k74o6z e-learning and innovative pedagogies: https://goo.gl/MvQtXW

high involvement in the recently established Norwegian Conference on Didactics in IT education (UDIT) and the national STEM Education conference (http://www.realfag.eventweb.no/).

ExcITEd already collaborates with and learns from the experience of the Swedish Centre for Pedagogical Development in Technology Education from a Student Oriented Perspective (contact: Director Prof. Arnold Pears), the state prize on education and culture award winning group on Didactics of Informatics at TU Munich (contact: Director Prof. Peter Hubwieser), the Contextualized Support for Learning centre at Georgia Tech (contacts: Director Prof. Mark Guzdial and Dr. Barbara Ericson) and the FABLAB@SCHOOL initiative in Denmark (contact: Director Prof. Ole Iversen). ExcITEd has collaborated with them during several international initiatives, like editing special issues in the area of IT education in schools[16] and co-leading international ACM-driven working groups in IT education (reports: [18, 19]). The leaders of these international centers will intensify their collaboration with us and participate on the Advisory Board of ExcITEd (letters of support: https://goo.gl/uNDJ5r). In addition, ExcITEd participates in EU COST action as well as an Erasmus + Knowledge Alliance proposals (cf. Appendix 2) with a focus to build an international network in the area.

Dissemination for awareness and understanding will be conducted at ExcITEd, but our emphasis is on *dissemination for action*, targeting audiences in a position to influence and bring about change within various organizations. Activities will take the form of demonstrations, seminars, tutorials and popular courses in major events (e.g. Norwegian Science Week, NKUL, Researchers Night, UDIT, MakerFair), as well as the establishment of a website, newsletter, and publications in diverse media (including the SFU magazine). In addition, the center will provide seminars to both pre- and in-service teachers at NTNU teachers' departments, in order to ensure the dissemination of ExcITEd to Norwegian schools. NTNU has already initiated a Community of Practice for Computer Science Educators (CoPCSE)[17], which we intend to maintain and promote to a national level. Last but not least, we will disseminate openly available, high quality learning resources that inspire action by learners themselves, be they IT students or other students, in our departments or elsewhere, learning just for themselves or in order to teach others, be they pre-university kids with programming as a hobby or newly retired who seek to understand the world of their grandchildren, be they Norwegian citizens or immigrants or refugees. IT competence is globally needed and can come useful whatever country you end up living in.

[16] Special Issue on Computer Science Education in K-12 Schools: http://dl.acm.org/citation.cfm?id=2767124&picked=prox
[17] https://www.ntnu.no/wiki/display/copcse/Community+of+Practice+in+Computer+Science+Education+Home

Appendix 1

List of References

List of published work related to IT education: https://excit-ed.com/publications/it-education/

List of published work within the broader area of e-learning and innovative pedagogies: https://excit-ed.com/publications/e-learning-and-innovative-pedagogies/

1. ABET. 2015. Accreditation Criteria and Supporting Docs. Retrieved February 22, 2016, from http://www.abet.org/ accreditation/accreditation-criteria/
2. ACM/IEEE-CS. 2015. Joint Task Force on Computing Curricula: Association for Computing Machinery and IEEE Computer Society. Software Engineering 2014: Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering.
3. Brown, N. C., Sentance, S., Crick, T., & Humphreys, S. (2014). Restart: The resurgence of computer science in UK schools. ACM Transactions on Computing Education (TOCE), 14(2), 9.
4. Bureau of Labor Statistics (2014-2015), Employment Projections 2010-2020, available at http://www.bls.gov/emp/
5. Bøe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: young people's achievement-related choices in late-modern societies. Studies in Science Education, 47(1), 37-72.
6. CSTA/ISTE (2011). Computer Science Teachers Association and the International Society for Technology in Education: Computational Thinking Teacher Resources, Second Edition. Available from http://csta.acm.org/Curriculum/sub/CompThinking.html or http://www.iste.org/learn/computational-thinking.aspx
7. Ebert, C., Abrahamsson, P. & Oza, N. (2012). Lean software development. IEEE Software 5:22-25.
8. Ericson, B., Guzdial, M., Morrison, B., Parker, M., Moldavan, M., & Surasani, L. (2015). An eBook for teachers learning CS principles. ACM Inroads, 6(4), 84-86.
9. Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences, 111(23), 8410-8415.
10. Furber, S. (2012). Shut down or restart? The way forward for computing in UK Schools. London: The Royal Society, Retrieved from: https://royalsociety.org/~/media/education/computing-in-schools/2012-01-12-computing-in-schools.pdf
11. Giannakos, M. N., Krogstie, J., & Aalberg, T. (2016). Toward a Learning Ecosystem to Support Flipped Classroom: A Conceptual Framework and Early Results. In State-of-the-Art and Future Directions of Smart Learning (pp. 105-114). Springer Singapore.
12. Grover, S., Pea, R., & Cooper, S. (2014). Remedying misperceptions of computer science among middle school students. In Proceedings of the 45th ACM technical symposium on Computer science education (pp. 343-348). ACM.
13. Guzdial, M. (2016). Bringing computer science to US schools, state by state. Communications of the ACM, 59(5), 24-25.
14. Guzdial, M. (2015). What's the best way to teach computer science to beginners?. Communications of the ACM, 58(2), 12-13.
15. Guzdial, M., Ericson, B., Mcklin, T., & Engelman, S. (2014). Georgia computes! an intervention in a US state, with formal and informal education in a policy context. ACM Transactions on Computing Education (TOCE), 14(2), 13.
16. Jaccheri, L., & Sindre, G. (2007), Software engineering students meet interdisciplinary project work and art. Proc. of the 11th International Conference of Information Visualization (IV'07). IEEE, pp. 925-934.

17. Hewner, M., & Guzdial, M. (2008). Attitudes about computing in postsecondary graduates. In Proc. of the International Computing Education Research Conference (pp. 71-78). ACM.
18. Hubwieser, P., Giannakos, M. N., Berges, M., et al., (2015). A Global Snapshot of Computer Science Education in K-12 Schools. In Proceedings of the 2015 ITiCSE on Working Group (pp. 65-83). ACM.
19. Hubwieser, P., Armoni, M., Brinda, T., Dagiene, V., Diethelm, I., Giannakos, M. N., ... & Schubert, S. (2011). Computer science/informatics in secondary education. In Proceedings of the 16th annual conference reports on Innovation and technology in computer science education-working group reports (pp. 19-38). ACM.
20. ICT Skills Action Plan 2014-2018, "Government, Education and Industry working together to make Ireland a global leader in ICT talent" retrieved 19 Feb. by: http://cork.etb.ie/wp-content/uploads/sites/20/2014/08/14042014-ICT_Skills_Action_Plan-Publication.pdf
21. IKT-kompetanse. (2014). Dimensjonering av avansert IKT-kompetanse: https://www.regjeringen.no/nb/dokumenter/Dimensjonering-av-avansert-IKT-kompetanse/id762445/
22. Kafai, Y. B., Peppler, K. A., & Chapman, R. N. (Eds.). (2009). The Computer Clubhouse: Constructionism and creativity in youth communities. New York, NY: Teachers College Press.
23. Krogstie, B. R., and Divitini, M. (2009), Shared timeline and individual experience: Supporting retrospective reflection in student software engineering teams. Proc. of the Software Engineering Education and Training (CSEET'09). IEEE, pp. 85-92.
24. McKenney, S. & Reeves, T. (2012). Conducting Educational Research Design: What, Why and How. NY: Taylor & Francis.
25. Pappas, I., Giannakos, M., Jaccheri, L (2016). Investigating Factors Influencing Students' Intention to Dropout Computer Science Studies. In Proceedings of the 2016 ACM annual conference on Innovation and technology in computer science education (ITiCSE '16), ACM Press.
26. Pappas, I., Giannakos, M., Jaccheri, L., Sampson, D. (2016). Assessing student behavior in computer science education with an fsQCA approach: The role of gains and barriers. Journal of Science Education and Technology, Springer.
27. Pears, A. (2015). Assuring the Quality of Engineering Education. In: Learning and Teaching in Computing and Engineering (LaTiCE), 2015 International Conference on (pp. 108-111). IEEE.
28. Robbins, S. B., Lauver, K., Le, H., Davis, D., Langley, R., & Carlstrom, A. (2004). Do psychosocial and study skill factors predict college outcomes? A meta-analysis. Psychological bulletin, 130(2), 261.
29. Rustein, D., Snow, E., Biekowski, M. (2014). Computational thinking practices: Analyzing and modeling a critical domain in computer science education. Paper presented at the 2014 annual meeting of the American Educational Research Association (AERA), Philadelphia, PA.
30. Sievi-Korte, O., Systa, K., & Hjelsvold, R. (2015). Global vs. local—Experiences from a distributed software project course using agile methodologies. In Frontiers in Education Conference (FIE), 2015. 32614 2015. IEEE (pp. 1-8). IEEE.
31. Sindre, G., Stålhane, T., Brataas, G., and Conradi, R. (2003), The cross-course software engineering project at the NTNU: four years of experience. In Software Engineering Education and Training (CSEE&T '03). IEEE, pp. 251-258.
32. Svanæs, D. (2015). A maker approach to computer science education: Lessons learned from a first-year university course. In Proceedings of the Workshop of Making as a Pathway to Foster Joyful Engagement and Creativity in Learning (Make2Learn 2015), CEUR-WS (Vol. 1450, pp. 12-20).

ExcITEd: Dissemination Strategy and Activities

Our dissemination strategy follows international best practices and dissemination literature (e.g., the D-Cube framework[1]). Thus, it consists of the following phases: an assessment of the climate of readiness for change, a plan regarding how engagement will be built throughout the projects and a plan for transfer of project outcomes. Although we have already made a dissemination strategy and identified several dissemination activities, during the first months of the centre we will develop detailed roadmaps for our dissemination strategy and activities in each of the projects.

Dissemination activities will be in focus from day one of ExcITEd and throughout the projects, tailored to various stakeholders and practitioners (e.g., policy makers, instructors, learners), both within NTNU/NORD and to other institutions in Norway and internationally. Dissemination activities will not be limited to IT study programs and stakeholders, but also take place to other programs where innovations and initiatives are relevant (e.g. other STEM programs). Our dissemination activities will focus on all the three pillars: *1) Awareness-Building, 2) Development of Understanding, and 3) Encouragement and Ongoing Support of Use/Action.*

Awareness-Building: In line with our long tradition of publishing about innovative IT education (https://excit-ed.com/publications) we will intensify our peer-reviewed publications, targeting high prestige international journals and conferences (complete list: https://excit-ed.com/it-education-resources/). As a national centre, we will also contribute to national IT conferences like NIK, NOKOBIT, NOKIOS, and NKUL, the annual conference organized by NTNU which attracts more than 1000 secondary education teachers from all around Norway. Notably we will keep our high involvement in the recently established Norwegian Conference on Didactics in IT education (UDIT) and the national STEM Education conference. We also plan to establish ExcITEd's website, newsletter, publications in diverse media (including the SFU magazine) and the national journal in HE (UNIPED). Thus, ExcITEd will reach into most of the Norwegian IT instructors in both the secondary and tertiary education.

Development of Understanding: ExcITEd will take an active role by organizing workshops, seminars and tutorials in order to make sure that IT instructors will be able to fully use the project outcomes in their teaching. Activities will take the form of demonstrations, intensive

[1] Hinton, T, Gannaway, D, Berry, B and Moore, K. (2011). The D-cubed guide: Planning for effective dissemination, Australian Learning & Teaching Council (ALTC) www.uq.edu.au/evaluationstedi/Dissemination/Planning_Guide.pdf

courses and hands-on tutorials in major events (e.g., NKUL, Researchers Night, UDIT, MakerFair). Last but not least, the establishment of the ambassadors program will allow us to reach many Norwegian schools and build an understanding around the IT studies and profession.

Encouragement and Ongoing Support of Use/Action: Our emphasis is on *dissemination for use and action*, targeting audiences in a position to influence and bring about change within various organizations. Dissemination will be an ongoing, two-way process aimed at bringing about change in the culture of teaching and learning. In this direction, NTNU has already initiated a Community of Practice for Computer Science Educators (CoPCSE)[2], which is a national arena not only for exchanging opinions but also for spreading and embedding projects' impact. We intend to maintain and promote CoPCSE to a national level, and collaborate with other CoP in relevant fields like mathematics and teachers education. In addition to disseminating openly available, high quality learning resources that inspire action by instructors and learners themselves, ExcITEd plans to initiate a visitors program where IT instructors from other institutions will come and work within ExcITEd as associate partners. This will help visitors pick up innovative learning approaches from ExcITEd and bring them back to their own institutions, and also enable us to learn from our visitors. In addition, we want to initiate small grants supporting innovative ideas from others (visitors or not) and help them with evaluation and constructive criticism. The dissemination activities will allow us to nurture ongoing commitment, ownership and active involvement into centre's mission and goals.

International Dissemination and Involvement: ExcITEd already collaborates with and learns from the experience of the Swedish Centre for Pedagogical Development in Technology Education from a Student Oriented Perspective, the award winning group on Didactics of Informatics at TU Munich, the Contextualized Support for Learning centre at GeorgiaTech and the FABLAB@SCHOOL in Aarhus. ExcITEd has collaborated with them during several international initiatives, like editing special issues, co-leading international working groups and organizing tutorials and courses. ExcITEd will collaborate with these institutions to build an international network of excellence and disseminate in the international arena (letters: https://goo.gl/uNDJ5r). ExcITEd already participates in EU COST actions as well as Erasmus + Knowledge Alliance proposals (cf. Appendix 2). Notably, NTNU has been invited to organize the premier intern. conference in IT education (ACM ITiCSE - http://ucsp.edu.pe/iticse2016/).

[2] https://www.ntnu.no/wiki/display/copcse/Community+of+Practice+in+Computer+Science+Education+Home

ExcITEd: Framework for evaluation and impact

Evaluation of ExcITEd will focus on the desired outcomes and long-term impact of the centre. Throughout the duration of the centre, evaluation will have a formative role, helping us build a shared understanding of where we stand and decide the steps forward. This could mean proceeding with currently successful activities or adjusting the course, for instance to meet new challenges and possibilities arising from organizational or technological changes.

To achieve this, ExcITEd will adopt the Theory of Change (ToC) evaluation framework[1]. The framework encourages logical thinking and critical reflection about outcomes and how to achieve them. By use of the framework, the evolution of ExcITEd will be described both in a diagrammatic way and through the creation of narratives shared by the stakeholders.

Within each of the projects P1-P5, there will be annual evaluation and status reporting related to the output factors for the project, in addition to the mid-evaluation and final evaluation. Evaluation will also be included into all interventions made by the projects into teaching/learning activities. This evaluation should consider the contribution of the activity to the project objectives and should, to the extent possible, be integrated with the institutions' existing processes of quality assurance and course development, as part of evaluating internal impact. Anchoring into existing QA may help ensure commitment by teaching staff and sustainability of the activities initiated through ExcITEd.

ExcITEd will seek to select and combine approaches to data gathering and assessment. This implies using automated gathering across courses and cohorts, utilizing available data and using (and developing) our competence in learning analytics. ExcITEd will also collect self-reported experience of students, staff and other stakeholders, e.g., through standardized surveys, focus groups, reflection notes/workshops (often already integral to courses) and observations. Furthermore, the technology used in learning and collaboration among students and staff may be utilized to collect data for evaluation, which may in some cases include an objective to improve the technology itself. An example of a setting for which it may be appropriate with an exploratory, qualitative and technology-supported approach to the collection of data for evaluation, is team/project work across campuses.

To monitor the progress of the centre towards the desired outcomes and longer term impact, the ToC framework will be used to systematically consider the following aspects: Current situation; Enabling factors / resources; Processes / activities / outputs; Desired outcomes

[1] Hart, D., Diercks-O'Brien, A.G., & Powell, A. (2009) Exploring stakeholder engagement in impact evaluation planning in educational development work, Evaluation, 15, 285-306.

(changes); Longer-term impact / outcomes. The Current situation includes the baseline evidence to which the outcomes and impact need to refer. The outcomes correspond to those described for ExcITEd in the application document. A ToC table will thus be created for the project as a whole and for each of the projects P1-P5. We will create this material in the first 3 months of the centre, which will help us articulate in more detail within each of the projects what we want to achieve and how we can create the desired change.

Within the size limits of the present supplementary document, the table below provides examples of baseline evidence against which we will evaluate our outcomes and impact. Some of the baseline data is already available, whereas the rest will be collected during the first 6 months of the project.

Baseline evidence	P1	P2	P3	P4	P5	SFU
Already have						
Number of students applying to our study programs; Admission threshold (e.g., success rate, grade)	X					
Number, scope and success of initiatives engaging pupils in secondary/high schools in learning about IT, including initiatives particularly targeting females[2]	X					
Course evaluation data about comparable within-campus courses (baseline for evaluating cross-campus activities/courses)[3]				X		
Degree of student-industry connection through various projects/courses (e.g. number of students)					X	
Student and staff involvement with activities related to ExcITEd						X
Internal leadership commitment as demonstrated through involvement in activities related to ExcITEd						X
Knowledge and visibility of ExcITEd externally (industry,schools, public, academia)						X
To be collected						
Knowledge of the IT profession among high school students	X					
First year IT students' experience and misconceptions,		X				
Extent of, success (w.r.t. learning outcomes in the courses) and satisfaction (excitement for IT being a key objective) with existing spaces for learning through construction, spaces categorized.			X			
Gap between job market's expectations and current learning outcomes (currently collecting data)					X	
External use of resources provided by ExcITEd						X

[2] Papavlasopoulou, S., Giannakos, M. N., & Jaccheri, L. (2016). Creative Programming Experiences for Teenagers: Attitudes, Performance and Gender Differences. In the 15th International Conference on Interaction Design and Children (pp. 565-570). ACM Press.

[3] Pappas, I., Giannakos, M., & Jaccheri, L. (2016). Investigating Factors Influencing Students' Intention to Dropout Computer Science Studies. In the 2016 ACM annual conference on Innovation and technology in computer science education (ITiCSE '16), ACM Press.

ExcITEd: Sustainability and Transformation Plan

The vision and subprojects of ExcITEd are *well aligned with existing strategies* at the hosting institutions and the needs of stakeholders. This is an important prerequisite for sustaining the activities and innovations developed in the context of the centre. An equally important prerequisite is an environment that supports educational research and innovation and is willing to change. Educational innovations will be proposed and tested with sustainability in mind. While external funding enables us to innovate and disseminate more, the long-term operation of ExcITEd's new educational practices should not be more costly than current practices, thus sustainable on internal funds.

NTNU and University Nord both have *ambitious leadership committed to educational quality* in general (www.ntnu.edu/teaching-excellence), and are strongly committed to the success and sustainability of ExcITEd. In particular, all levels of the leadership at both institutions − Rector, Dean and Heads of Department – have committed to support ExcITEd, which will facilitate successful transfer of projects achievements into the general practise of education. For NTNU, hosting a centre of excellence in education is a highly prioritized goal in the efforts to attain international excellence in education. Innovation and development in education are pillars of NTNUs Strategy 2011–2020: “Knowledge for a better world”, and a centre will enable the university to use results and developments from long-term innovation to improve teaching and learning in the breadth of the academic field.

At the faculty and department level, there is an equal emphasis on implementing quality in teaching and education, e.g., shown through the process for renewing ICT education at the NTNU IME faculty in 2013. After the ongoing merge process, the new IE-faculty at NTNU will be responsible for the largest portfolio of ICT study programs in Norway, giving a significant area of impact from the start. The professional management of study programs and courses, the many existing examples of innovations, as well as the already established Community of Practise in CS Education, shows that the centre will be hosted in an enthusiastic environment eager to improve its education, and to sustain such an improvement-oriented culture after external funding of the centre ends. A centre will also strengthen national and international collaboration in higher education, as expressed in NTNUs International Action Plan 2014 – 2017. Focus on recruiting and retaining of talented research and education personnel is the key of sustaining the success of the centre.