

Advanced Science Teacher Education (ASTE)

This application represents a joint venture between Department of Science Education (IND), the Faculty of Science at the University of Copenhagen, The Danish School of Education at Aarhus University, University College Metropol and University College UCC - which combines the strongest science¹ and science education research institutions in Denmark with the strongest teacher education environment.

The consortium proposes to strengthen and improve the education of lower secondary science teachers through the design, implementation and evaluation of a new science-teacher programme which also involves a considerable element of in-service training of experienced lower secondary science teachers.

Actual problems in science education at Danish lower Secondary School

Science education in the Danish school suffers from a number of weak points many of which can be traced back to the current science teacher education and others are due to more general conditions. Among the most glaring are:

1. According to the PISA results, the science competencies of Danish pupils are below and near the OECD average and research reveals poor science language skills among Danish students. This correlates to a general lack of strong teaching competency among science teachers indicating a need for improvements in pre-service science teacher training in regards to both content knowledge and didactical competencies.
2. Genuine collaboration between teachers of different science subjects (including mathematics) is both uncommon and random in quality causing missed many opportunities for educational synergy. This is even more important as new descriptions of the science subjects prescribe more and better synergy between the science subjects. An obvious solution would be for science teacher education to involve exemplary forms of collaboration as an integrated part of pre-service training.
3. Evidence from research on science teaching is generally not sufficiently prominent in teachers' planning and organization of their teaching. As a result, science teaching tends to be activity-driven rather than based on learning objectives and assessment of learning outcomes. In order to address this issue, science teacher education should actively create opportunities for future science teachers to reflect on their own teaching practices as well as that of other science teachers in reference to research in science and mathematics education.

¹ In this document, the term "science" is used in the broad sense, including mathematics, so as to encompass the following Danish school subjects: mathematics, physics/chemistry, biology, and geography.

We have also decided to omit all references in the document to enhance readability.

4. The division of science subjects into three separate subjects (biology, physics/chemistry and geography) in the Danish lower secondary school system makes it difficult to realize the potential of the natural science area as a whole, to provide an attractive number of working hours for teachers and to establish productive communities of practice. Science teaching in the Danish school system would benefit as a whole by intergrading these subjects with each other and with mathematics. This requires organisational as well as cultural changes and therefore science teacher education should teach teachers to become effective agents of change. Enabling better integration of the different science subjects could also improve teachers' sense of professional identity which has been shown to be crucial for continued professional development.

It takes dramatic changes and a long term efforts to meet these problems. But having consulted the Ministry of Education we have designed an advanced science teacher education, ASTE, which can be accepted by the Ministry and which to as large a degree as possible solves the posed problems within the given general regulations.

ASTE is based on the following principles:

- The study programme promotes increased science subject matter competencies and has more emphasis on didactical aspects as well as organisational and innovative elements.
- The students learn through working with interdisciplinary problems in an inquiry based environment.
- The students study research literature in order to adopt a research approach towards their own teaching.
- Establishing partnerships between students, internship schools, university colleges, and universities to build bridges between theory and practice.
- Involving universities to provide subject specific knowledge, advanced facilities, and newest educational research.
- Forming networks to enable continued professional exchange between students and internship teachers that can persist after students complete their education.

The ambitious goals of ASTE are to design an integrated programme that includes all the relevant science subjects in teacher education in a way that creates a strong link between teacher education and the professional internship. An important element of the project is to research the potential benefits of integrating these elements in science teacher education in order to provide documentation for possible dissemination into other teacher education programmes.

The research will focus on examining the development of the praxis and knowledge of student teachers in the integrated programme compared with regular student teachers as well as an analysis of the collaboration between the institutions involved in the project (university colleges, universities and schools).

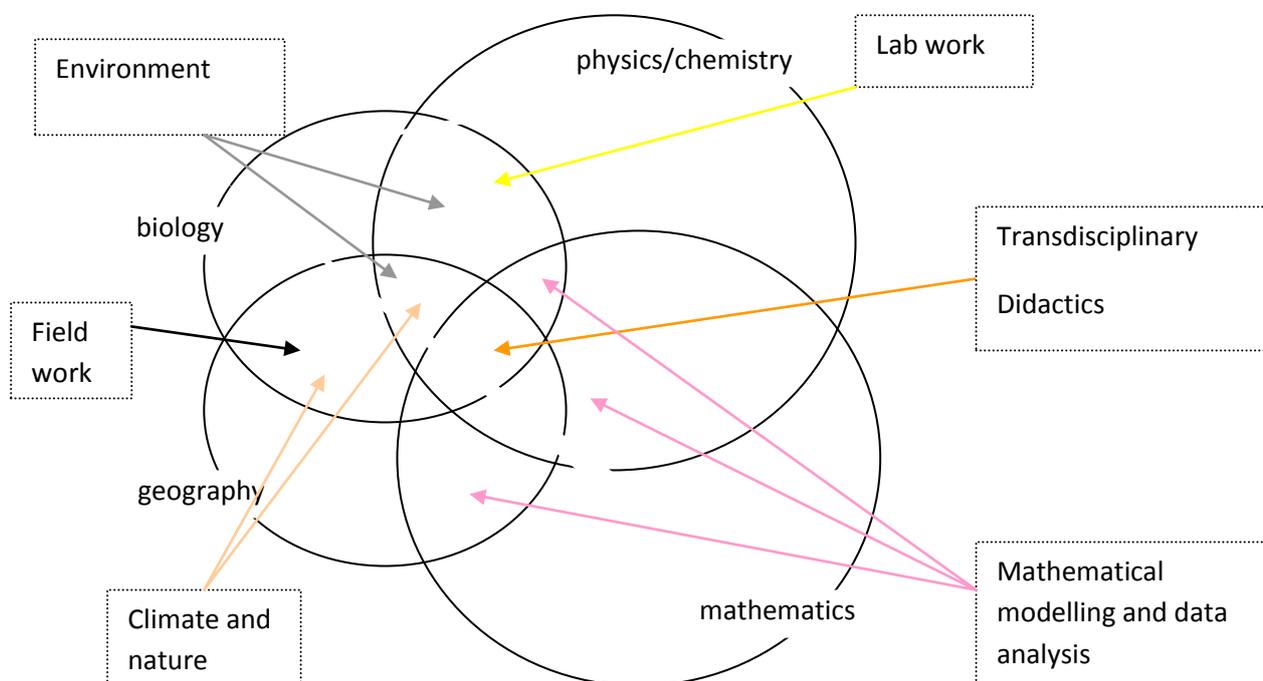
An overview of ASTE

The science teacher programme aims at training teachers with a prominent profile in the science subjects including the didactics pertaining to these subjects. The programme will provide teaching qualifications in all science subjects at lower-secondary level: biology, geography, physics/chemistry as well as mathematics. The potential for learning among all involved in the programme that this cross-curricular combination provides will be one of the focus areas of the project.

The science teacher programme will have an inductive approach – starting with more topics that transcend course subjects moving on to deal with the more distinctive aspects of each science subject. It is the intention to motivate and qualify teacher students to delve into each of the subject as well as to emphasise the importance of cross-curricular teaching, making it a part of the teaching and learning culture in the programme to think cross-curricular. Furthermore the programme will include both mathematics and the pedagogical subjects as part of the cross-curricular courses.

The strong emphasis on synergies across subjects will be one of the key points that will bring students teachers, expert in-service teachers, teacher educators and education researchers together in developing meaningful ways of engaging lower secondary school students in science. Student teachers will thereby be provided with opportunities to participant in and learn about educational development in an exemplary study environment in close relation to actual teaching practices.

An illustration of potential synergy between subjects:



Teachers graduating from the programme can therefore be expected to be attractive to school administrators. Not only can they help alleviate a pressing need for qualified science teachers in lower-secondary school but they will also be able to provide the basis for educational development in science extending to the primary level as well.

Starting in the academic year 2011/12 the new programme will be established with approximately 25 students who have a special interest in the science subjects: biology, geography, physics/chemistry and mathematics as well as an interest in working with organizational development. In August 2012 an additional 25 students will start the education.

Students will be admitted to one of the teacher education departments in Copenhagen: Metropol, Zahle or Blaagaard-KDAS. The student FTE points obtained will subsequently be distributed among participating institutions.

The approximately 25 students will form a permanent study group for the length of the programme. Teaching will take place at various sites throughout the training programme, encompassing seven or eight internship schools², three teacher education departments and two universities. This is an important element of the project as it allows students to become familiar with and develop a relationship with the different types of institutions that is intended to extend beyond the programme.

The subject matter part of the programme will consist of 144 ECTS points. This will encompass the partly integrated main subjects of biology, geography, physics/ chemistry and mathematics at lower-secondary level. In the regular teacher education programme, these add up to 216 ECTS points. The difference of 72 ECTS points is compensated by carefully integrating didactics and subject elements from the involved subject areas and thereby avoiding overlap and repetition. For example, it will be both meaningful and time saving to teach scientific methods, history of science and many didactical elements of science and mathematics as part of the same course rather than relating them to each individual subject.

The overall competence level in each subject will be further strengthened by giving a science focus to other parts of teacher education, namely KLM (Religious Studies, Ethics and Citizenship) and the pedagogical subjects (pedagogy, psychology and general didactics/methodology).

² Five schools with a strong science profiles have already expressed a preliminary interest in becoming internship schools for the programme.

An Illustration of the proposed changes:

The present curriculum in teacher education	The proposed curriculum in teacher education
Psychology, didactics and educational organisation and pedagogic (33 ECTS)	Psychology, didactics and educational organisation and pedagogic with a science focus (33 ECTS)
KLM (Religious Studies, Ethics and Citizenship) (17 ECTS)	KLM (Ethics, Innovation, Project Management and Citizenship) (17 ECTS)
1 st specialisation: Danish, maths or science (72 ECTS) – students choice	Partly integrated main subjects of biology, geography, physics/ chemistry and mathematics (144 ECTS)
2 nd and for some students 3 rd specialisation (72 ECTS or (36 + 36) ECTS) – students are free to choose among all school subjects	
Bachelor project (10 ECTS) – students are free to choose among their specialisations	Bachelor project (10 ECTS) – in science
Internship (36 ECTS) – at different schools during the four years training, mainly in the students specialisations	Internship (36 ECTS) – at the same school during the four years training, in science and mathematics

The 10 ECTS- point bachelor project will have a mandatory science focus. Students will be required to base their bachelor project on a genuine problem from lower secondary science teaching in order to demonstrate a capacity for educational development.

Development of new courses in teacher education

The main purpose of the new science teacher education programme will be to strengthen the student teachers' practical teaching and subject matter skills. Focused teaching-oriented courses in selected science areas will be developed jointly by University and University College lecturers. The aim of this collaboration is to increase the connection between subject content and didactics. A substantial part of the teacher programme will be based on thematic project work that transcends normal subject boundaries with the intention of enhancing synergy between the science subjects. Also, university college lecturers who teach general pedagogy (a total of 33 ECTS points) will be included in the project in order to tone the courses towards science teaching.

The programme will also focus on including the most relevant international research in science and mathematics education in order to increase teacher students' ability to incorporate this in their teaching practices. The students will acquire methods for incorporation and operational use of research findings into their own practical experiences. One example will be the ability for students to observe recordings of their own teaching and relate their reflections to research findings. The common didactical elements of the programme will include key research-based elements such as inquiry-based science education, dialogue and argumentation, motivational theory and lesson studies. This will require the development of programme elements to be prepared through collaboration between the involved institutions.

For the programme we intend to develop the following interdisciplinary courses:

- Teaching physiology, health and statistics – covers main subject areas of biology, geography, mathematics and pedagogical subjects
- Assessment, use and development of teaching materials, including IT and scientific reading and writing
- The history of, view on and epistemology of science and mathematics
- Food and agriculture - teaching nature management, resources, bio-tech and production – covers main subject areas of biology, geography and pedagogical subjects
- Methods in mathematics and science
- Teaching energy and energy supply – covers main subject areas of geography, physics, chemistry and pedagogical subjects
- Aquatic ecology, matter cycles, water resources, sustainability and mathematic modelling – covers main subject areas of biology, chemistry and mathematics
- Using informal learning spaces to teach earth and life's origin and development – covers main subject areas of physics, biology, geography, mathematics and pedagogical subjects
- Ethics, citizenship, innovation, project management and networking – provides the student teacher with tools to become a change agent
- Weather models, climate and climate change – covers main subject areas of geography, physics and mathematics

All together the interdisciplinary courses will cover about 70 ETCS.

The teacher students will also be expected to develop essential innovation and project management skills so they can become effective change agents for science teaching at the level of individual schools. This is a new aspect compared to the existing teacher education programmes and will involve the development of a new 17 ECTS-point course instead of KLM (Religious Studies, Ethics and Citizenship). The new course will encompass project management, innovation and networking and will involve substantial practical involvement in authentic educational problems.

Internship, in-service professional development and collaboration with schools

A core element of the programme is the internship (a total of 36 ECTS points). Internship in the new programme involves teacher education at two levels: (1) science teacher education, and (2) in-service teacher professional development. To create a strong connection and collaboration between the students, the schools, the University Colleges and the Universities, the internship supervisors will also be given courses in teacher professional development as part of the science teacher programme.

In the new programme, each teacher student will be affiliated with a school with a strong science profile in the Greater Copenhagen region. Each school has been selected for its innovative science department, supportive leadership and good teaching facilities in order to provide the students with the best possible

teaching and learning environments. In order for students to become part of the exemplary science teaching practices of these schools, a considerable part of the programme will take place at the participating schools. Copenhagen Municipality has already expressed their intention to participate in the project and a number of schools in the so-called “science- municipalities” in the Greater Copenhagen area have expressed their interest in the project. Internship supervisors at the participating schools will play a crucial role as mentors for the students.

All participating internship supervisors will be offered to be part of a number of on-site courses involving elements of lesson studies and instructional design. Lesson study is a method analysis of lesson practice for professional development of teachers. It is based on reflection by teachers, including collegial teachers or people from external sources such as university faculty members, on fact observed in concrete practices of lessons. Instructional design is the process by which instruction is improved through the analysis of learning needs and systematic development of learning materials.

The development of in-service teacher professional development will take place as a collaborative effort between colleges from University and University College. This will ensure that both teacher education and in-service teacher professional development is based on the most current research and that this knowledge becomes operational for newly qualified teachers. Student teachers will get the opportunity to combine theory and practice under the supervision of in-service teachers and thereby contribute to the solution of authentic instructional problems.

About 15 in-service science teachers will be expected to be enrolled in the professional development programme starting in August 2011 and an additional 5 teachers will be involved in August 2012. The involved teachers would participate in a special intensive in-service course of approximately one week's duration. During the in-service teacher professional development programme, the teachers will participate in joint seminars with student teachers and lecturers from universities and university colleges. These seminars will provide a significant in-service potential resource for participating teachers.

Establishing network of science teachers

As part of the new teacher education programme, a network between teacher students, internship supervisors, university colleges and universities will be established. The network will work on different levels according to the needs of the student teachers. In addition, there will be annual seminars arranged by the universities and university colleges in order to gather all project partners to a yearly status meeting. The networks will be nurtured and supported through the project as best possible for the duration of the project period, but in order to ensure sustainability and relevance it will mainly up to the in-service teachers in collaboration with the teacher students to maintain the network.

Project Organization

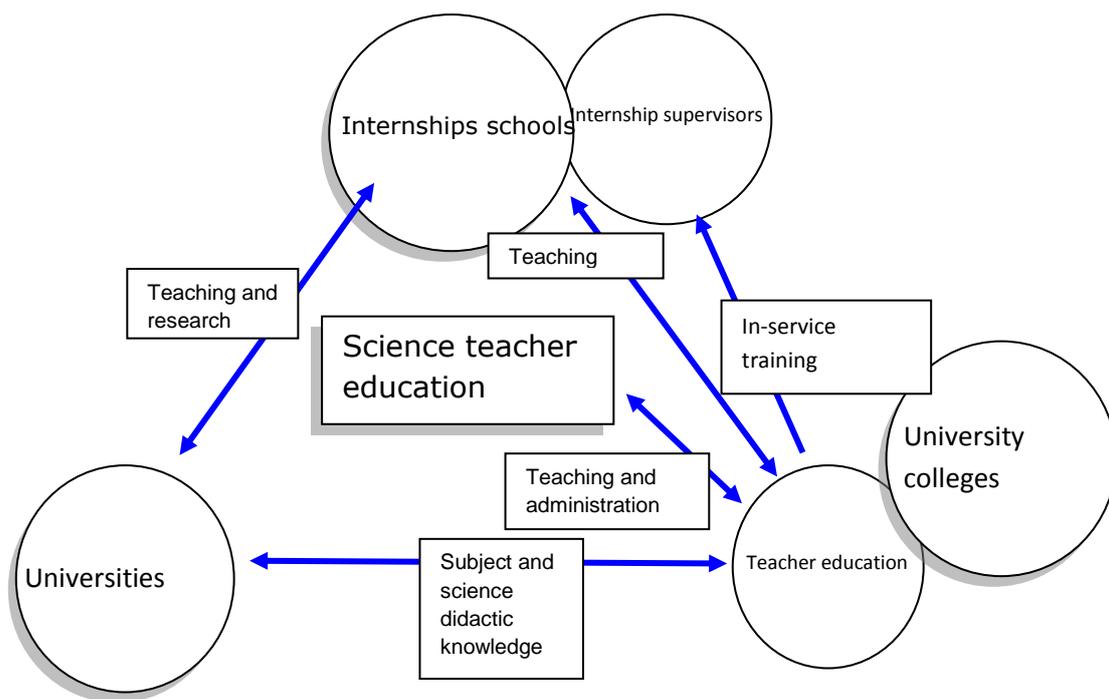
Project management and implementation will be organized within the newly established Center for Science Education, which is a joint venture between four parties: Department of Science Education University of

Copenhagen (IND), The Danish School of Education at Aarhus University, University College Metropol and University College UCC.

The development of the teacher education programme will be done in close collaboration between the university colleges and the relevant departments of participating universities. This will involve taking advantage of the strong research communities and facilities available at the universities and combining them with the experience and expertise of the university colleges to create a unique teacher education.

All four partners will also have a responsibility for the in-service training of project school internship supervisors. The university colleges provide the brunt of the teacher education and in-service training while university science and math educators will offer specific courses and excursions to both in-service teachers and teacher students. In addition, science and mathematics education researchers will be involved in supervising and documenting the project.

An illustration of centre organization



A steering group with representatives from each participating institution and an advisory board with representatives from relevant stakeholders will be established.

We already have agreements to join the advisory board from:

- Subject advisor in Science, Keld Nørgaard, Ministry of Education

- Director, Lene Beck Mikkelsen, National Centre for Science, Technology and Health Education
- Subject advisor in Mathematics, Klaus Fink, Ministry of Education
- Vice-Dean, Henrik Busch, Faculty of Science, University of Copenhagen
- Rector, Stefan Hermann, Metropolitan University College
- Consultant, Jens Prom, Leader of the science education effort, The Municipality of Copenhagen

Research and documentation

The project will be monitored in an ongoing joint effort to provide documentation of progress both within the project itself and among the participating teachers and teacher students. An important part of this documentation will be to investigate the effect of the strong integration of otherwise separated science subjects – including mathematics – in a partnership-based teacher educational programme. The new teacher education programme will serve as a case to investigate some of the following aspects of the project:

- What are the advantages/disadvantages arise from integrating science in teacher development programmes?
- What organisational possibilities and hindrances appear in the collaboration between partnership institutions?
- What effect on teacher motivation and career opportunities does the new teacher education programme provide (particularly the developmental aspect)?
- What effect does the close link between university colleges and internship schools have on student teachers' learning outcomes?
- What opportunities for learning can universities offer the new teacher education programme?

These questions will form the basis for a PhD project that will be defined in detail when the proper candidate has been found. The project will rely on the PhD student and other researchers from the participating universities to provide a continued feedback on various aspects of the project in order to ensure that the project continually is adjusted to the needs and requirements of the participants. As such, the research should be considered to be an integral part of the development project. At the same time, the research will also serve to document the project so that it can be of inspiration for future developments in teacher education.

Perspective

During the project period about 50 students will have started their education as advanced science teachers with special competences in cross curricular teaching and innovation and about 20 internship teachers will have finished their in-service training.

But the impact of ANTE will reach far beyond the project itself. It will set new standards for science teacher education and the valuable lessons that the project has learned will be spread to other teacher education institutions in Denmark. The developed courses and the new ways to collaborate between the involved institutions will provide a solid basis for developing teacher education in Denmark. An important benefit of the project is the improved relationships between universities, university colleges and schools in the Greater Copenhagen area, which will provide a durable basis for future collaboration beyond the project period.