

Activities and research programmes at the Centre for *Science, Mathematics, and Engineering Education Research (SMEER) 2023 – 2025*

The Centre for *Science Mathematics and Engineering Education Research (SMEER)* gathers researchers and lecturers from several subjects and departments at Karlstad University (Kau) to engage in and collaborate on subject-specific education research in the natural sciences (biology, physics, and chemistry), mathematics and technology. Activities are based on international and national networks and on praxis-related research in pre-, primary, and secondary schools, as well as higher education and work organisations. SMEER cooperates with all subject-specific research centres at Kau and with the regional development centre (RUC) to enhance communication between the school sector and academia regarding research and development issues. The SMEER centre is part of the Faculty of Health, Science and Technology. Together with the centres of CSD and CSL, SMEER is also part of the strong and interdisciplinary collaborative environment of ROSE (Research on Subject-specific Education).

SMEER attracts researchers from biology, physics, geography, chemistry, mathematics, and educational work. Research is pursued in both subject-specific and interdisciplinary projects. In addition, there are visiting researchers in the form of guest professors and postdoc researchers, as well as affiliated researchers employed by schools or other universities. SMEER research is done in close cooperation with teachers and school leaders and thus of relevance to school activities and teacher training. SMEER also endeavours to ensure that research is relevant to the needs and challenges of these areas and that research results are disseminated in academia as well as to school practitioners.

Since its establishment in 2010, the research environment of SMEER has evolved strongly with new colleagues, partly through internal external recruitment of doctoral students and senior researchers, partly through supporting junior lecturers' doctoral studies. From the initial staff of some senior lecturers and a few doctoral students in 2010, the centre now has around fifteen PhD researchers and as many doctoral students, along with around ten affiliated researchers in schools and other universities. The centre has gender-balanced research staff.

Activities

The research centre SMEER has three main tasks. The first is to develop and run subject-specific research and doctoral programmes linked to science, technology, and mathematics of the highest quality of relevance to all levels of education. The second task is to provide research substantiation for teacher education in the fields above. The third is to cooperate and disseminate research results to schools and society in the fields in question. Put together, these tasks require general as well specific research expertise.

SMEER's goal is to be a leading education research environment for the science, mathematics, and engineering subjects, nationally and internationally, thus enhancing teacher education and contributing to strengthening teachers' professionalism and students' learning. SMEER researchers pursue research in their respective field, in cooperative interdisciplinary projects, and in association

with the other subject-specific education research groups. SMEER is an active member of ROSE and is represented in their working committee and management team.

SMEER organisation and activities

See below for a description of how SMEER is organised and how are run in terms of budget, seminars, over-night conferences, doctoral programmes, networks, and cooperation.

Organisation: SMEER is organised in accordance with Karlstad University's Rules of Procedure and Delegation of Authority. A new rules of procedure for research centres came into force on 1 Jan. 2021 (Reg.no: C2021/644). The host faculty for SMEER is the Faculty of Health, Science and Technology, but it is mainly financed by the Board for Teacher Education. A director, answering to the faculty and the university management, leads operations and is responsible for budget and external and internal contacts. Operations are annually reported in a document. SMEER's internal communication at Kau takes place via a mail-list, open to anybody announcing their interest, and a homepage. A person responsible for the homepage and seminar series has been appointed. SMEER also has an advisory committee consisting of internal and external members, including a doctoral student representative. The advisory committee is led by a chairperson. For the present period, the advisory committee has appointed a work committee to meet with the director regularly and keep a check on ongoing activities.

Budget: Subject-specific education research and doctoral programmes linked to SMEER are financed through faculty funds and external funding. Annually, the Board of Teacher Education (LUN) allocates a budget to SMEER, which is used to finance the organisation as well as research and doctoral programmes relevant to SMEER activities. The budget is processed by the director and the advisory committee then proposes a budget to the Dean of LUN for decision. Through the budget, SMEER aims to achieve a research environment with good balance between senior researchers, new doctorates, and doctoral students. Supporting the research basis of all school subjects related to SMEER (see above) is an overriding allocation criterion. Criteria for allocating research funding to senior researchers are quality research production and co-funding to increase external research funding.

In house and overnight seminars: SMEER arranges higher seminars characterised by an academic high-quality level and an open, constructive attitude. Seminars are open platform for researchers and doctoral students in our fields to present and develop their projects. Seminars are designed regularly to offer deepened themes in research methodology and theory, as well as national and international guest lecturers. Every year, an overnight seminar is arranged to which all SMEER researchers and doctoral students are invited to develop research content and important aspects of research such as applications and publications.

Doctoral programmes: SMEER affiliated doctoral students study according to general curricula in biology, chemistry, physics, and mathematics that offer education research specialisation. In addition, doctoral students are also registered in educational work. SMEER funds doctoral projects directly through budget allocations or indirectly through co-funding or research projects. SMEER doctoral students are usually enrolled in a graduate school such as KÄKK (Knowledge, subjects and quality in teacher training and the classroom), FontD (National graduate school in science and technology education research) and FUNDIG (Graduate school for the digitalisation of education) are central. SMEER's research environment support and include doctoral students in all its activities.

SMEER affiliated doctoral students are primarily supervised by researchers linked to SMEER and adhere to SMEER guidelines regarding seminar procedures.

Networks and cooperation: SMEER has extensive involvement in networks and cooperation nationally and internationally. At Kau, a great deal of cooperation is carried out within the ROSE organisation. SMEER also works with RUC, the regional ULF node and directly with schools through the Värmland model of competence cooperation. At the national and international levels, cooperation is carried out with several universities through major co-research projects and graduate schools. These networks and projects are presented in the annual reports.

Development areas for 2023 – 2025

Objectives for 2023–2025 include strengthening the development of national and international cooperation and the contacts between schools and academia, as well as ensuring continued high share of externally funded projects and extensive production of research-based books, articles, chapters, text books, and conference presentations. We also continue to support SMEER researchers academic qualifications and career development, as well as recruiting more researchers to the centre.

In the near future, SMEER needs to strengthen the shared identity as SMEER researchers since they are distributed across six departments and two faculties. This is done through seminars, the joint graduate schools, and applications for new joint graduate schools.

In the coming period, SMEER needs to cooperate with the departments to ensure that recruitment to a greater extent will consider skills in subject-specific education research in the appointment process. Staff recruitment is usually justified by the need of lecturing staff rather than the need to strengthen the research environment and the research basis of teacher education.

In the coming period, SMEER also needs to give priority to supporting applications for externally funded graduate schools instead internally funding doctoral students. This would secure the funding of senior researchers' projects.

Finally, SMEER needs to consolidate the link to schools in the surrounding communities and create a basis for recruiting to the master programme in subject-specific education research and by extension to doctoral studies.

Research programmes 2023 – 2025

SMEER has evolved organically out of several research environments and traditions, which is why SMEER has had the inclusive goal of attracting and linking these traditions of various expertise for the benefit of all. It is noteworthy that the SMEER research centre incorporates three different research fields with different paradigms and publication channels (mathematics education, natural sciences education, and engineering education). The three fields also include a more general research tradition linked to generic issues such as modelling approaches, exploratory approaches, and sustainability issues. In addition, subject-specific education research is often linked to certain concepts and teaching approaches. SMEER aims to include differences and areas of expertise and to channel them into some joint research orientations to build a common competence base and

research excellence in some areas. The following non mutually exclusive areas identified as central and common to SMEER activities are to be given priority in the next three-year period:

- Practice-based teaching research
- Subject-specific education theory and conceptual development
- Representations and language use
- Education for sustainable development and the Anthropocene.

Practice-based teaching research

The practice-based perspective is central to SMEER. Research contributing to developing teaching and learning in collaboration between practitioners in schools and higher education is given priority. Practice-based research takes an interest in developing and applying research results in teaching practice, for example, in teaching models or design principles. Design research, research circles and learning studies are examples of research approaches with a practice developing perspective. This type of research often involves elements of further training, which affects and is affected by the implementation of teaching, pupils' learning, and the school organisation, which are thus levels of importance to practice-based research. In recent years, several SMEER projects, externally funded by the EU, the Research Council, and the Swedish Institute for Educational Research, have had this orientation, thus gradually building expertise in this area. The investment in the ULF project (Education, Learning and Research) with a focus on practice-based research in conjunction with academia and school authorities also favours this type of research. SMEER recognises that it is important to build on this successful research area and will prioritise practice-based research in the coming three years.

Subject-specific education theory and conceptual development

Subject-specific education research is an interdisciplinary field drawing on theories of various research fields such as educational sciences, theory of science and sociology. Developing SMEER research requires doing theory generating research and creating shared theoretical frameworks for the whole centre. During the recent years of ROSE cooperation, joint efforts have been made to establish a common framework for subject-specific education based on the concepts of *powerful knowledge* and *transformation*, which was then further developed in the international KOSS network and the graduate school KÄKK, where SMEER has five doctoral students. In addition, much SMEER research rests on specific knowledge domains where powerful knowledge and transformation of knowledge are explored. This applies to areas such as algebra, thermal theory, genetics, chemical bonding, and sustainable development. In the coming three-year period, SMEER will give priority to research aiming towards subject-specific theory and conceptual development and its application in specific educational knowledge domains and contexts.

Representations and language use

Many abstract concepts are treated in natural science, mathematics and technology instruction, or concepts not directly accessible to pupils' senses, but require technical aids representing the knowledge and language use needed to decipher these representations. In short, natural science, mathematics and technology instruction is built on artefacts, representations, and abstract language

use, which become central aspects of subject-specific education research in these areas. Since long, SMEER has pursued research with this approach, linked, for instance, to the potentials of digitalisation to create representations in mathematics and physics, of using artefacts such as thermal cameras to create visual representations, of using models in chemistry and biology instruction, and CAD-models in engineering instruction. This is a long-standing research emphasis in SMEER and central to the transformation of powerful knowledge. SMEER will continue to prioritise activities related to this research interest in the next period.

Education for sustainable development and the Anthropocene

Sustainable development is part of Karlstad University's present vision and a strategic goal for all its operations. Education is a central aspect of sustainable development and over ten years SMEER has produced research in this area that has attracted attention nationally and internationally. Several major projects linked to sustainability and climate issues, based on institutionalised cooperation externally funded by EU, the Swedish Institute for Educational Research, and the Research Council, are presently in progress at the centre. Considerable expertise has been built in this area and cooperation has been established with municipalities to develop instruction. In addition, a joint international master is under way in conjunction with European universities, with an emphasis on Environmental and Sustainability Education. The cooperation with ROSE has a similar focus regarding the Anthropocene, the age and changed reality we now live in due to climate change. Against the backdrop of the urgency of sustainability issues, the successful research built, and the strategic cooperation in ROSE, SMEER aims to prioritise research activities linked to education for sustainable development and the Anthropocene in the next period.