



The Research Centre of Science, Mathematics and Engineering  
Education Research (SMEER)

# SELF-EVALUATION

Periodic Research Review

# Self-evaluation report of SMEER – periodic research review 2022-2023

## Summary

The Centre of Science, Mathematics and Engineering Education Research (SMEER) is the node from which the science, mathematics, technology and engineering education research at Karlstad University is coordinated. The activities are based on international and national networks, practice oriented research related to school, university and working life. SMEER is established with the Faculty of Health, Science and Technology as host, but is mainly funded by the Faculty Board for Teacher Education.

The long-term objective of SMEER is to be a leading research environment in the fields of science, mathematics, technology and engineering education research, at a national and international level, and thereby contribute to research-based teacher education and support teachers' professional development and student learning in these subjects. As a research centre, SMEER is a distributed organisation based on collaboration across faculties and departments of Karlstad University, as well as with schools and teachers in the region.

In line with the distributed organisation of SMEER, a main strategy to accomplish the main objective is to include many different research perspectives and “let a hundred flowers blossom”. The research programme focuses on four areas: practice-based educational research; development of theory and concepts in subject-specific education; representations and language use; and, education for sustainable development and the Anthropocene. Our ambition is that these areas of research encompass excellence and international recognition, as well as contributing to research-based teacher education in science, mathematics, and technology.

## 1 Long-term objectives and strategies

The long-term objective of SMEER is to be a leading research environment in the fields of science, mathematics, technology and engineering education research, at a national and international level, and thereby contribute to research-based teacher education and support teachers' professional development and student learning in these subjects. As a research centre, SMEER is a distributed organisation based on collaboration across faculties and departments of Karlstad University, as well as with schools and teachers in the region.

In order to obtain excellence in research, SMEER aims to continue attracting external funding of research projects. In this way, SMEER has the ambition to keep a strong publication record, with a focus on recognised international journals. A second important aim is to develop collaboration with schools and other partners in society, in order to contribute with school development and professional development of teachers.

In line with the distributed organisation of SMEER, a key strategy to accomplish the main objective is to welcome many different research perspectives and “let a hundred flowers blossom”. The research programme focuses on four areas: practice-based educational research; development of theory and concepts in subject-specific education; representations and language use; and, education for sustainable development and the Anthropocene. Our ambition is that these areas of research encompass excellence and international recognition, as well as contributing to research-based teacher education in science, mathematics, and technology.

In order to achieve the long-term objective and aims, there is a need to strengthen the competence of SMEER. Our strategy for this is to rely on external funding of graduate students, career development

of researchers, and influence the recruitment process of senior researchers. The strategy to strengthen collaboration between SMEER researchers in the distributed organisation and thereby achieve coherence centred around a shared seminar series and website, internal conferences and participation in graduate schools.

## **2 Organisation and management**

Karlstad University (Kau) is a new and rather small university in Sweden with approximately 19,000 students. The university is organised in two faculties, the Faculty of Arts and Social Sciences (Fakulteten för humaniora och samhällsvetenskap, HS) and the Faculty of Health, Science and Technology (Fakulteten för hälsa, natur- och teknikvetenskap, HNT). The Faculty of Health, Science and Technology is the host faculty for SMEER.

The teacher education is the largest branch of education at Kau and it constitutes about 25% of the programme students, including preschool teacher education, elementary teacher education, secondary teacher education, upper secondary teacher education and vocational teacher education. In addition, short teacher education programmes for students with Bachelor's and Master's degrees are also available, including a programme for students with a PhD.

The teacher education is distributed over many departments in both of the two faculties. To organise and take responsibility for the quality of education and research connected to teacher education, there is a Faculty Board for Teacher Education (Lärarytbildningsnämnden, LUN). There is a system of supply and demand, where the Faculty Board for Teacher Education places orders for courses in the teacher education and the departments are responsible for giving the courses.

### **2.1 Organisation of SMEER**

The Faculty Board for Teacher Education has a budget for research connected to teacher education. The main part of this budget is distributed to research centres. Three research centres focus on subject-specific education (subject didactics), connected to subject areas: language and literature (Centre for Language and Literature Education, CSL), social science (The Centre for Social Science Didactics, CSD), and science, mathematics and technology (Science, Mathematics and Engineering Education Research, SMEER). There is also a centre focusing on preschool and sport education (Centre for Child and Childhood Studies in Education and Sport, UBB).

A research centre does not provide educational courses and does not employ teachers and researchers, but coordinates the research across departments, see the attachment *Rules of Procedure for Research Centres*. All the members of SMEER are therefore employed at departments in which they also contribute to teaching. Today, SMEER has members at four departments at the Faculty of Health, Science and Technology (Department of Engineering and Chemical Sciences, Department of Engineering and Physics, Department of Environmental and Life Sciences, and Department of Mathematics and Computer Science), and two departments at the Faculty of Arts and Social Sciences (Department of Geography, Media and Communication, and Department of Educational Studies).

The research centre of SMEER is funded internally within Kau by the Faculty Board for Teacher Education with approximately SEK 5.5 million yearly, whereas minor funding (about SEK 0.3 million) is provided by the Faculty of Health, Science and Technology, see Table 3.1 in *Background*

*data*. In addition, the level of external research funding<sup>1</sup> has been considerable, mounting up to more than SEK 11 million in 2021, see Table 3.2 in *Background data*. Consequently, external funding is very important to sustain the level of research activities at the centre. SMEER includes 16 fulltime employed teachers/researchers (one professor, five associate professors and 10 senior lecturers) and seven lecturers. In addition, one guest professor, one postdoc, and one guest researcher were affiliated to the Centre in 2021; see Table 1.2 in *Background data*. 18 PhD students are connected to SMEER, of which five are employed lecturers being trained to become PhDs or licentiates (enrolled for two years of research studies), see Table 2.1. In addition, there are twelve affiliated researchers including subject researchers assisting, for example, in PhD supervision, researchers from other universities participating in projects and teachers with PhD working in schools, see <https://www.kau.se/en/smeer/research/researchers>.

The way a research centre is organised and steered is regulated by the document *Rules of Procedure for Research Centres* attached to the self-evaluation report. SMEER is governed by a director that is appointed to the centre by the vice-chancellor and the dean of the Faculty of Science, Health and Technology based on the suggestion of the board of SMEER. The current director, who is also the academic director, is Professor Niklas Gericke, and his duties are to organise the daily operations and be the contact person for the dean and the department heads. The director is in charge of the yearly budget and the development of the research programmes.

Connected to SMEER is a board with 14 members consisting of six researchers from SMEER, a PhD representative, and seven external members from Kau, schools and other universities. The chair of the board is Associate Professor Jesper Haglund. The board works with strategic questions to develop networks and assist in evaluations and the budget process and meets once each semester. To assist the director in the internal daily work, a working committee of the board has been created consisting of the six research members and the PhD representative. The working committee includes members from all the departments where SMEER is represented. The working committee meets once each month to support the director and the chair with the continuous work in the centre. The working committee is very important to anchor the development and decision-making process in the SMEER community.

## 2.2 Operations of SMEER

At the heart of the centre are SMEER seminars where we meet physically on a regular basis. The centre has appointed a working committee member, Senior Lecturer Daniel Olsson, as responsible for organising the seminar series and the website of SMEER. All researchers that are given funding from SMEER are expected to give a yearly presentation of their work in a seminar. Also, each PhD student is expected to present his/her research yearly, and we have developed guidelines in which 10%, 60% and 90% seminars with external readers for PhD students are praxis to uphold good research practice and quality (<https://www.kau.se/smeer/forskning/forskarutbildning>)<sup>2</sup>.

The seminar series is also used to provide important competence and infrastructure to the colleagues, and to enculturate new members and PhD students. For example, we regularly invite the person responsible for ethical reviews at Kau to hold seminars, the Grants and Innovation Office is invited to hold seminars on research funding, and the library is invited to hold seminars on publication strategies

---

<sup>1</sup> Note that the large amount of external funding received in year 2019 and 2021 in Table 4.1 in Background data (SEK 33 million and SEK 28 million respectively) relates to grants received for graduate schools those years. These are exclusive calls that are not regularly available.

<sup>2</sup> It is important to recognise that SMEER has no graduate programme of its own. The PhD students are affiliated to the regulations provided by each department, but our guidelines are voluntary recommendations.



and open data storage for researchers. All researchers in SMEER have the possibility to have their research funding applications read and commented by appointed readers at our seminars before submitting them. In this way, the SMEER seminar is the most important instrument that we have to develop a joint research culture and multidisciplinary cooperation within SMEER.

In addition to the seminar series, the website (<https://www.kau.se/en/smeer>) provides much information about our activities to the SMEER members and other stakeholders. All researchers at Kau and elsewhere that are interested can join the SMEER email list through which we send out information about ongoing activities. Also, SMEER invites all SMEER members to an annual two or three day retreat to discuss SMEER activities and develop ideas related to research jointly. These activities strive to build a collegial culture and identity in the group. These activities are intentionally open to all researchers at Kau to generate renewal and build new multidisciplinary collaborations.

There has been a challenge for SMEER in developing a base for research in all areas of teacher education, while simultaneously producing research of high international standard. Another challenge has been to recruit competent personnel externally. Therefore, much of the strategy in SMEER has been to finance graduate studies for lecturers (adjunkter) and to develop competence within the existing staff, or to recruit teachers from the surrounding region as graduate students. To achieve these goals, we have in our budget separated funding for graduate students, senior researchers (project-based support) and a three-year support for colleagues that have newly graduated as PhDs. In that way, we have a strategy to create a flow of new researcher colleagues from a bottom-up perspective. Applications for internal funding submitted by senior researchers have been evaluated for “excellence”, i.e., a good track record of international publications and success in attracting external funding. At the same time, we have also tried to support research in all departments that are involved in teacher education related to science, mathematics and technology. In the budget process, we have also considered gender equality and disciplinary inclusion. For example, we have provided funding for interested teachers from the disciplines that were interested to do research in education.

These above mentioned strategies to recruit competent researchers and develop competence among our fellow researchers, strive towards international excellence and creating a broad base of competence considering gender equity and multidisciplinary. When SMEER was formally initiated in 2010, there were only two senior lecturers employed, five PhD students and three guest professors. All senior lectures and professors were males, and the group did not include subject didactic graduates in all disciplines (biology, chemistry, physics, mathematics and technology). Since then, there has been a great expansion in terms of personnel and the quality and quantity of research, and SMEER has grown and become a much more internationally oriented research environment. Today, we have a larger group of upcoming researchers covering all subjects of SMEER including nine females (four associate professors and six senior lectures) and seven males (one professor, one associate professor and four senior lectures) see Table 1.2 in the attachment *Background data*. In a couple of years, most of the associate professors are expected to be promoted to professors, and a couple of senior lectures to associate professors. SMEER provides support for senior lecturers and associate professors that strive to be promoted by providing opportunities for research funding, supervision of PhDs and support in applying of external funding (see attachment *Appointments Procedure*). The success of this support is evidenced by the fact that a majority of the colleagues in SMEER are progressing in their careers. A challenge is to make the departments that actually employ the researchers jointly take their responsibility to create opportunities for the carer development of their employees specialised towards subject didactics because of the limited resources available in SMEER.

Another tool that we apply to develop our research is the newly established research programme of SMEER. Due to the fact that SMEER has developed organically through the contribution of several guest professors, and researchers that have now left the centre, the competence and interests of the researchers that constitute SMEER reflect the plurality of backgrounds and methodologies. Further,

SMEER is responsible for coordination of the research of three different research areas – science education, mathematics education and technology education – which are overlapping, but still use different publication channels and different conferences, etc., and these differences need to be recognised. In this light, SMEER has adopted a research strategy of “let a hundred flowers blossom” to take advantage of these differences. Hence, we recognise our differences as a means to be able to work in many arenas. In our research programme, we have summarised our research into four prioritised research areas within the domain of science, mathematics and technology education: *Practice-based educational research, Development of theory and concepts in subject-specific education, Representations and language use, Education for sustainable development and the Anthropocene* (See Section 4). These are the areas that span the above mentioned differences, and we will focus our budget for the next years on research connected to these areas.

Yet another tool that we use to improve our research is the yearly report of operations that we deliver to the Faculty Board for Teacher Education as a way to evaluate SMEER (see *Rules of Procedure for Research Centres*). In that report, we describe the *research environment at large, publications, how we used the funding, external funding, networks in research, dissemination of research and impact on the teacher education*. Further, we discuss how the work progresses over time. This report is each year evaluated by the Faculty Board for Teacher Education and compared with the reports provided by the other research centres (see above), and our performance partly influences the distribution of the new budget. Also, the yearly report is evaluated by the Board of SMEER and used as a way to develop the future operations.

Based on the above descriptions, we here summarise the perceived strength and challenges of SMEER related to organisation and management:

Strengths:

- Research in subject-specific education is a prioritised area of research at Karlstad University. The formation and funding of SMEER and other research centres in the area is an expression of this priority.
- A close connection to the discipline is made possible by SMEER being hosted at HNT and most of the members being employed at HNT.

Challenges and development areas:

- Navigating a complex organisational structure, where SMEER is hosted by HNT, but internally funded and monitored by Faculty Board for Teacher Education.
- In comparison with the other educational research centres, SMEER has less support from our host faculty (HNT) in terms of cofunding and interest in educational research.

### **3 Expertise profile**

As described in the text about organisation and management, a research centre at Kau does not employ teachers and staff. That responsibility is designated to the departments, see the attachment *Rules of Procedure for Research Centres*. In practice, the need for teaching, rather than the need for research, is the primary consideration for the decision-making regarding employment of permanent positions in subject-specific education at the departments. However, SMEER and its researchers have the possibility to finance and construct temporary positions for research at the departments, in collaboration with the department heads, such as PhD positions and postdocs. This has been done several times over the years, predominantly with external funding, but also by use of the internal SMEER budget. For the future, more funding is needed to recruit additional postdocs. A system to

make it possible for SMEER researcher to visit universities in other countries is another idea to help further the staff's research expertise.

From a historical perspective when SMEER was initiated as a research centre in 2010, most of the teaching in teacher education in those disciplines was conducted either by senior lecturers with a PhD in mathematics or one of the sciences (biology, chemistry or physics), or by lecturers (teachers with a Bachelor's or Master's degree). There were several attempts to recruit senior lectures and professors with a background in subject-specific education. One professor, and three senior lecturers in science education were recruited, but all of them left after a couple of years for other larger universities. Also, two attempts to internationally recruit a professor in mathematics education have failed<sup>3</sup>. Consequently, SMEER has developed a strategy to support lecturers within teacher education to enrol in PhD studies in science, mathematics and technology education. Secondly, these newly graduated PhDs have to a large degree been supported to continue and develop their careers as senior researchers. Also, SMEER has supported a couple of senior researchers with a background in mathematics and science to take up and start research within mathematics and science education. Externally funded graduate schools have been another way to recruit teachers in school as graduate students.

These internal strategies to develop competence locally within the staff already working in the teacher education programmes has been successful in that of the 16 fulltime employed SMEER members, 14 have been recruited through these strategies. A strength with this way of working has been the close connection between research and education (see further discussion in Section 6). A strategic challenge is that much of the funding in SMEER has been relocated to graduate studies and to support career building of junior researchers without support with research funding from the departments that employ them and have the formal responsibility for these issues. As the centre grows, more funding needs to be directed to fund positions of professors and associate professors, which might be problematic.

To ensure expertise and quality of new recruitments, not only relating to teaching but also research, SMEER researchers within the departments are committed to participate in the advertising and recruitment processes. This development is accentuated as the current SMEER researchers are evolving and becoming senior researchers in their departments.

SMEER researchers have many academic partners, networks, and commitments. First, within Kau, SMEER actively participates in many arenas to influence educational research and its connection to practice. We strive to have representatives in boards such as the faculty boards, and we collaborate with local partners in municipalities and schools in projects such as Education, Learning, and Research (Utbildning, Lärande och Forskning, ULF), and the regional development centre (Regionalt utvecklingscentrum, RUC) (see further description in Sections 5 and 6).

The research group *Research on Subject-Specific Education* (ROSE) is the most recognised and institutionalised internal academic collaboration that SMEER is engaged in within Kau, together with researchers from the two other research centres that focus on subject-specific education (CSD and CSL). In the ROSE collaboration, SMEER contributes to development of a shared theoretical perspective and comparative research on how educational theories can be interpreted and used across our different subjects (see Section 4.2). This initiative has contributed to a change of culture from one of competition for limited internal funding, to one of collaboration, for example, in the form of joint

---

<sup>3</sup> These recruitments were organised by the Faculty of Health, Science and Technology and/or the departments and in some instances (professor of Mathematics Education) supported by extra funding from the vice-chancellor of Kau.

externally funded research projects. During the last years, central funding of ROSE from the vice-chancellor has been reduced and changed to funding from the faculties due to reorganisation. Subject-specific education has been shortlisted to form a part of strategic research at Kau, but the future of the ROSE group is uncertain.

Within the ROSE collaboration, an international network called *Knowledge and Quality across School Subjects and Teacher Education* (KOSS, <https://www.kau.se/rose/samverkan/knowledge-and-quality-across-school-subjects-and-teacher-education-koss>) has been developed, supported by the Swedish Research Council. This network brings together educational research groups, rooted in several academic disciplines at Kau in Sweden, Helsinki University in Finland and the Institute of Education, UCL in England. The network seeks to understand how educators and education systems can ensure that school-based knowledge building reaches its transformative potential. In the network the common theoretical concepts *powerful knowledge*, *transformation* and *epistemic quality* are explored and investigated to understand the qualities that underpin effective learning processes.

Another important outcome of the ROSE collaboration and participation in the ULF project is the graduate school Knowledge, Subjects and Quality in Teacher Education and Classroom (KÄKK, Kunskap, Ämnen och Kvalitet i Lärarutbildningen, <https://www.kau.se/en/rose/kakk>), funded by the Swedish Research Council. This graduate school is a collaboration with University West and Halmstad University and includes 14 graduate students, of which five are affiliated to SMEER.

The most long-term academic collaboration that SMEER has participated in at a national level is the Swedish National Graduate School in Science and Technology Education (FontD, Nationella forskarskolan i naturvetenskapernas och teknikens didaktik, <https://liu.se/en/research/fontd>). More than 10 PhD students from SMEER have participated in that graduate school, and seven of the fulltime-employed teachers/researchers at SMEER have participated in this national programme. FontD has been fundamental for the development of SMEER in that it has provided national and international networks, and that it provides a course programme for SMEER graduate students that is not available locally at Kau.

Another graduate school that SMEER has collaborated with is FUNDIG (Forskerskolan för undervisningens digitalisering), with a focus on the digitalisation of education, in which SMEER has three affiliated PhD students. In recent development, SMEER has collaborated with the other educational research centres of CSD and CSL to develop Master's and graduate course programmes that we see as important for the further development of the centre, see section 6.

In addition to these institutionalised collaborations, SMEER researchers are involved in many national and international networks linked to their different research interests. Just to give a few examples, Niklas Gericke has since 2012 been engaged in the academic committee of ERIDOB (European Researchers in Didactics of Biology) and SMEER researchers hosted a European conference for the organisation with 200 participants in Karlstad in 2016. SMEER researchers are active in the editorial board of the ESERA (European Science Education Research Association) book series (<https://www.esera.org/publications/the-esera-book-series#editorial-board>), and active in many editorial boards of international journals. Further, SMEER researchers are active in national organisations in science and mathematics education. SMEER members have been part of the board of Svensk Förening för Forskning i Naturvetenskapernas Didaktik (FND, <http://www.fndidaktik.se/>), and organised the national Swedish conference in science education in 2014. The biannual national conference for mathematics teachers and mathematics education research was held at Kau in 2016 and 2018, and SMEER researchers were actively involved in organising that event. SMEER researchers are also working with the Swedish National School Agency, the Swedish Institute for Educational Research and The Swedish National Centre for Science and Technology Education (NATDID) in order to develop research and education (see also Section 5).



Based on the above descriptions, we here summarise the strengths and challenges of SMEER related to expertise profile:

Strengths:

- Positive development of research competence of SMEER members.
- Strong and well-developed academic networks within Kau, nationally and internationally.

Challenges and development areas:

- Develop the engagement and cooperation with the faculties for career development of SMEER researchers.
- It is challenging to recruit experienced researchers externally. We want to increase exchange of researchers coming in and out of the research environment.

## 4 Research domains and results

As part of the development of SMEER's research programme during 2022, four overarching areas of research have been formulated. They are not mutually exclusive, but overlapping and help us in describing what is shared across the different subjects that we represent. The areas of research are:

- *Practice-based educational research*: Practice-based educational research contributes to teaching and learning in collaboration between educational researchers and teachers at school as well as in higher education. It takes an interest in development and application of research in the teaching practice, involving approaches such as design research, action research or learning studies.
- *Development of theory and concepts in subject-specific education*: Development of a shared theoretical framework within ROSE has facilitated collaboration and comparative studies across the different subjects of the research centres SMEER, CSD, and CSL. This includes exploring how the notions *powerful knowledge* and *transformation* can be applied in teaching and learning of different subjects.
- *Representations and language use*: Education in mathematics, science and technology involves the introduction of many concepts that are not immediately accessible to our senses. Therefore, teaching in these subjects relies on the use of representations, such as spoken and written language, images, physical artefacts and representations displayed by digital tools. Research in the area includes methods such as discourse analysis and multimodal analysis.
- *Education for sustainable development and the Anthropocene*: This area of research contributes to establishing a sustainable society, in line with the overall strategy of Kau and the Faculty Board for Teacher Education. It involves research on environmental education, and teaching and learning of climate change.

Here follows an overview of the research within the four research areas, including key results, how they contribute to national and international knowledge development, the university's strategy, and the research production and its impact.

### 4.1 Practice-based educational research

Most of the research of SMEER is based on the classroom context, with an interest in the conditions for teaching and learning in our subjects. By conducting research in collaboration between SMEER researchers and teachers at school, practice-based educational research contributes to the vision of the Faculty Board for Teacher Education of "supporting school development, school-based research, and competence development of teachers in school".

SMEER researchers have received external funding for practice-based research from the Swedish Institute for Educational Research (Skolforskningsinstitutet), where researcher-teacher collaboration is a prerequisite for application. For example, Nina Kilbrink has conducted a learning study together with Jan Axelsson, a vocational teacher who has later been recruited as a PhD student, on the teaching and learning of how to weld. Similarly, Niklas Gericke, Daniel Olsson, Teresa Berglund, and Anna Mogren have conducted a longitudinal study on the implementation of sustainable development in collaboration with teachers from five schools in Karlstad municipality.

The Swedish Research Council (Vetenskapsrådet) provides high stakes funding in Sweden, including in the area of educational research, and SMEER has been successful in being awarded funding from this council in recent years. Even though collaboration with teachers is not a precondition for funding from the Research Council, many of the involved SMEER projects have a clear practice-based focus. This includes a project conducted by Nina Kilbrink and Minna Arvidsson on technical, vocational learning in upper-secondary school, and Niklas Gericke, Karin Thörne, and Birgitta Mc Ewen, who have developed and analysed teaching sequences that introduce epigenetics in upper-secondary biology education in collaboration with teachers.

Another project funded by the Swedish Research Council was the *Linking Instruction and Student Achievement project* in which researchers at Kau, among them Jorryt van Bommel from mathematics education, collaborated with researchers from six other universities in three Nordic countries. A main objective has been to investigate how teachers' different teaching strategies can effect student achievement in different school subjects. The study combines large-scale video observations of classroom practices with student achievements tests. The project has generated about 20 publications, and the results are being used in teacher education and have been highly recognised.

School teachers who are recruited to part-time research studies within graduate schools typically conduct their doctoral project in conjunction with their own teaching. For example, within the graduate school Fundig (see Section 2), Lorena Solvang developed a teaching sequence in which upper-secondary physics students studied friction by use of a GeoGebra simulation, and Andreas Borg implemented teaching sequences that involve upper-secondary students' programming in mathematics. In the graduate school KÄKK (see Section 2), Anders Eriksson is developing a new teaching framework in photosynthesis education that includes environmental and societal implications as suggested in recent developments in scientific literacy literature.

Apart from externally-funded projects, SMEER has supported practice-based research with internal funding. For example, Jesper Haglund has conducted research on the introduction of infrared cameras in the study of animals in the teaching of farming, pet care and horse riding in collaboration with teachers at a vocational upper-secondary school.

One impact of SMEER's involvement in research in collaboration between researchers and teachers in schools is that Yvonne Liljekvist and Jesper Haglund are engaged in the national coordination of the government-funded project Education, Learning, and Research (Utbildning, Lärande och Forskning, ULF). The ULF project has been initiated to develop models for collaboration between researchers, schools and teacher education. In that project, collaboration with teachers in upper secondary schools that graduated from SMEER with a PhD in science and mathematics education can be seen, for example, with Anna Bergqvist in Arvika municipality and Elisabeth Mellroth in Karlstad municipality.

## **4.2 Development of theory and concepts in subject-specific education**

The research of SMEER develops theory at the international level in several areas; see, for example, the development of CAVTA in Section 4.3 and the concept of Sustainability Consciousness in Section 4.4. In this section, we focus on the joint efforts within the collaboration in ROSE (see Section 2).

Together with the heads of research in the research centres CSD and CSL (Christina Olin-Scheller and Martin Stolare) and guest professor Brian Hudson from University of Sussex in England, Niklas Gericke developed a theoretical framework for the research group of ROSE. The overall idea is to develop a theoretical framework that could be used comparatively in different areas of subject-specific research. The theoretical framework builds on the concept of *Powerful Knowledge*, which has been developed by Professor Michael Young at the Institute of Education at UCL in the area of curriculum studies as a way to differentiate subject-specific knowledge from general competences. It relates powerful knowledge to the concepts of *transformation* and *epistemic quality*, which have been developed from ideas from the French didactique tradition.

The framework was presented in a position paper in a special issue of the journal of *London Review of Education*, and then further developed in the KOSS network (see Section 2). In the collaboration of the KOSS network, two international anthologies exploring these concepts further have been published by Bloomsbury Publishing. Currently, several researchers in SMEER, such as Yvonne Liljekvist, Jorryt van Bommel and Niklas Gericke, are working with colleagues at IOE in London and Helsinki University to develop the ideas further.

Further, the framework was used as a foundation for the graduate school KÄKK (see Section 2) and is now used and explored further by the graduate students in mathematics and science education connected to SMEER: Per Blomberg, Anders Eriksson, Annika Forsler, Marcus Gustafsson, Jimmy Karlsson and Anna-Clara Rönner. In the graduate school, many SMEER researchers are engaged as coordinators, leaders, course developers and supervisors, such as Yvonne Liljekvist, Jorryt van Bommel, Susanne Walan, Daniel Olsson and Niklas Gericke.

Delphi studies have been conducted to identify powerful knowledge in several projects, for example, in relation to content areas such as infectious diseases, epigenetics and recently photosynthesis. In the transformation process, teachers have been invited to adapt the body of knowledge, or transform it, in line with the goals of teaching using an Education Design Research approach. This has been the case, for example, in the epigenetics project, and now also adopted to create a teaching model for photosynthesis.

This research has had an impact on a comparative perspective on subject-specific education in that we are exploring, in international collaboration, which aspects of subject-specific education are in common, and which differ, over different disciplines and school subjects. It is especially central in developing professional knowledge in teacher education to define what it means to be a teacher in different school subjects.

### **4.3 Representations and language use**

In science, mathematics and technology education research, many abstract concepts are central for knowledge building. The concepts are not accessible directly by the senses, but must be represented in artefacts, visualisations and language use. Therefore, these aspects of education are central to research in these areas, and, historically, research in SMEER has focused on these areas. Prior research projects in SMEER have, for example, dealt with algebraic representations in mathematics, the use of models of chemical bonding and teachers' language use in genetics. The impact of this research is often linked to specific content areas, and of interest to develop teachers' pedagogical content knowledge of how to transform content knowledge into teaching practices. Ongoing projects include the dynamic mathematics software GeoGebra, in which multiple representations of mathematical objects are dynamically linked to promote conceptual understanding in physics education, by Lorena Solvang, and in mathematics education, by Mats Brunström and Maria Fahlgren. Similarly, the use of CAD models in technology education has been investigated by Helen Brink and infrared cameras in physics education by Jesper Haglund. This research has been used in developing teacher education

and in the professional development of in-service teachers in the region. These projects are often developed in collaboration with teachers (see Section 4.1).

Apart from the more practice-oriented impact of this research, theoretical and methodological contributions are also made. In two projects (funded by the Swedish Research Council and the Swedish Institute for Educational Research) in technology education regarding vocational education in welding led by Nina Kilbrink, a new analytical approach has been developed by combining conversation analysis and variation theory into the novel Conversation Analysis and Variation Theory Approach (CAVTA). This research has been published internationally in several journals including methodological journals such as the *International Journal for Lesson and Learning Studies*.

In mathematics education, several projects revolve around the use of digital tools and their impact on knowledge transfer and dissemination of pedagogical content knowledge among teachers. In the project *Facebook and Teachers' Informal Professional Development on Social Network Sites*, run by Yvonne Liljekvist and Jorjyt van Bommel and financed by the Swedish Research Council, teachers' participation and knowledge dissemination on social network sites was investigated. The project explored to what extent these sites become a catalyst for advancing teachers' pedagogical content knowledge, and whether and how social media add value to the complex process of professional development. This research has important impact on our understanding of how to approach teachers in more informal channels.

*Teaching with Learning Management Systems - Making New Learning Spaces in the Digitalized Classroom* is a follow up project to the Facebook project, also funded by the Swedish Research Council, where Yvonne Liljekvist is a participating researcher. The project investigates how the increasingly prevalent use of Learning Management Systems in Swedish upper-secondary schools changes the classroom practices. The question pursued is how content of different subjects (including mathematics) is construed and represented when Learning Management Systems are used. The project draws on a media-ecological perspective and on conversation analysis and will give important insights to the rapid, and often uncritically, implemented digitalisation of the Swedish classrooms, and the impact of commercialised digital tools in classrooms.

#### **4.4 Education for sustainable development and the Anthropocene**

The fourth area of prioritised research connects to sustainability and sustainability education. This area is linked to the vision of Kau as a whole, as well as to the vision of the Faculty Board for Teacher Education that specifically address these issues. In this research area, a research design has been developed in which we closely collaborate with schools and school principals in order to develop teaching practices with an impact on student outcomes in relation to sustainability (see also Section 4.1). In that effort, practice-based and teacher-oriented research has been combined with psychometric and large-scale study methodology.

In a nationwide survey study, funded by the Swedish Research Council, the effects of certification systems in the area of Education for Sustainable Development (ESD) were investigated. The findings were discouraging, as they showed that the great efforts of the Swedish National School Agency and the Swedish Eco School system only generated small effects on students' outcomes. This research has generated large impact on these organisations, and we have now established a collaboration with the NGO *Håll Sverige Rent* that run the Eco School programme. Daniel Olsson is – based on the findings of that study – working in a project funded by Vinnova to develop teaching materials based on research.

In the work to evaluate teaching practices of ESD, Niklas Gericke, Daniel Olsson and Teresa Berglund have generated new theoretical constructs such as *Sustainability Consciousness* and *Action Competence for Sustainability* as outcome variables for ESD. These theoretical constructs have been



developed into psychometric research instruments that have been widely recognised and used in the international research community (see also Section 4.1). The research, has investigated how ESD teaching practices related to the aspects of *Holism* and *Pluralism* can influence these outcome variables. Also here we find novel and high impact results that have been frequently cited in international research. Also outside academia this research has had great impact in school practice in Sweden and other countries via development of joint publications and guidelines in the European ENEC-network including 39 countries. This work has been conducted in international collaboration with Antwerp University in Belgium, and Jelle Boeve de-Pauw and Peter van Petegem. Boeve de-Pauw was employed at Kau part-time for several years, and also functioned as a co-supervisor of PhD students at Kau.

Much of the research in ESD and sustainability education has been conducted in collaboration with schools in the region, especially in Karlstad municipality. In a project aiming to develop ESD teaching practices, which has been supported by Ljungbergsfonden and the Swedish Institute for Educational Research, 10 preschools, four compulsory schools and one upper secondary school participated collaboratively. In the project, several hundred teachers and the school leaders participated in continuous professional development over three years. In that project, a whole-school approach was used, in which SMEER researchers collaborated with researchers from the school leadership training group at Kau (<https://sola.kau.se/sola/>) in implementing ESD.

In another project, funded by the Norwegian Research Council, and led by NTNU in Norway, the aim is to work collaboratively with primary school teachers in Karlstad municipality and several municipalities in Norway to develop critical thinking in sustainability education. Also here an Education Design Approach is used, and the teaching is developed over a three year time span (see Section 4.1). In *Bringing Climate Change Education to School (Briccs)*, Nina Christenson, Jesper Haglund and Niklas Gericke are working with three compulsory schools to develop climate change education in collaboration with the climate psychologists to reduce climate anxiety among students. This work was initiated and requested by Karlstad municipality, and shows that research in SMEER is recognised by the practitioners. The project is conducted in collaboration with Ute Harms and IPN at Kiel University in Germany.

The research output in relation to ESD and sustainability education has been highly cited internationally, and led to many international collaborations in Norway, Denmark, Germany, Belgium and Netherlands. A Marie Curie postdoc, Peter Lampert from Vienna in Austria, is currently working at Kau in a project on *Developing Action Competence for Insect Preservation (DACIP)* in collaboration with local schools. Another postdoc, Wanda Sass from Antwerp University, is employed part-time for one year to develop an ESD framework. Moreover, ESD research at SMEER has had impact internationally via participation in the COST-network European Network for Environmental Citizenship Education (ENEC, <https://enec-cost.eu/>), which has also led to participation in the Horizon 2020 project for open schooling COSMOS (<https://www.cosmosproject.eu/>). Recently, a network called *Education and Bildung in the Anthropocene (EBAN)* has been initiated by researchers within ROSE (see Section 2). SMEER researchers have been active in this network, which includes researchers from all the Nordic countries. The EBAN network is funded by the Swedish Research Council and has so far held one international conference.

To summarise, we would argue that the research in SMEER has been productive in generating a lot of external funding both nationally in Sweden and internationally. The research has generated many publications in international journals with high impact factor and are frequently cited. The research is focused on the teaching practice and there are many collaborations with schools that have generated an important impact on teaching and teacher education. This way of working with schools is time consuming and demands a lot of resources. Therefore, it is a challenge to keep focus on practice-

based research with close collaboration with teachers, while at the same time being at the forefront of international publication and theory building.

The new research programme is a way to define SMEER and build a common identity. At the same time, the strategy of SMEER is to let a hundred flowers blossom. A challenge is to build a common identity while still embracing the different research traditions. In particular, there is a distinction between mathematics education research on one hand, and science and technology on the other. We would summarise our strengths and challenges regarding research domains and results as follows:

Strengths:

- Good track record of external funding and publication.
- International collaboration and high impact of research in the area of ESD.
- SMEER has a broad range of research in different subjects and with different methodological approaches.

Challenges and development areas:

- SMEER has over the years had difficulties formulating a shared research agenda and a clear research profile. The formulation of a research programme in 2022 has been one way to find common ground across our subjects.
- Limited opportunities for low stakes funding with a developmental focus in the educational sciences, in comparison to other research groups at Kau.
- Maintain collaboration with schools between specific projects.

## **5 Collaboration and interaction with the surrounding community**

SMEER's interaction with the surrounding community involves primarily the Swedish school system, although we have collaborations with schools in Norway and Germany through different projects (see Section 4.4). The majority of our research focuses on the teaching and learning of our subjects. In particular, within the area of practice-oriented research, we are dependent on access to classrooms and preschools and, hence, coordination with the school administration and individual teachers in order to conduct research projects. The coordination is made possible through formal collaboration between Kau and the municipalities and schools in the region, such as the regional development centre (Regionalt utvecklingscentrum, RUC).

In Section 4, it was described that one of the prioritised area of research is practice-based educational research (see Section 4.1), showing the importance given by SMEER to collaboration with external stakeholders. In fact, this approach is used in a majority of the research projects conducted within SMEER, see also Sections 4.3 and 4.4. Hence, collaboration and interaction with the surrounding community is evident in almost all the research projects conducted within SMEER, as shown in the described projects in Section 4. Oftentimes, we enter into legal agreements with schools and municipalities in those projects, and part of the budgets are devoted to teachers' involvement in projects. The close collaboration with practising teachers is shown also in graduate schools. As detailed in Section 3, participation in externally-funded graduate schools, such as FontD and FUNDIG, where teachers in school engage in part-time research studies is one of the main ways for us to recruit graduate students by collaborating with schools. This also contributes to integrating our research with the surrounding society. Currently, we have two PhD students that are cofounded by SMEER and the local municipalities (50% each). Moreover, PhDs with employment in schools as teachers, such as Anna Bergkvist and Elisabet Mellroth, are active SMEER researchers. Previously the SMEER researcher Daniel Olsson worked as a school developer at Karlstad municipality. In fact, almost all researchers in SMEER have a previous career in schools as teachers and have extensive

regional and national networks in schools. Still, this strategy is demanding considering the efforts to maintain this collaboration, see discussion in Section 4.

The research of SMEER is not limited to research *on* schools, teachers and pupils. As part of collaborative research efforts, we also strive for establishing research projects where researchers conduct research projects *together with* teachers, through methods like participatory action research, educational design research and learning studies, where researchers and teachers join in formulating research questions, designing teaching sequences, analysing and reporting on results. This way of actively involving teachers in research is frequently occurring, as evidenced by the described research projects in Section 4. This way of conducting research aims to increase cooperation with teachers and schools to increase the quality and relevance of our research. Such collaborative research is further facilitated by the involvement of Yvonne Liljekvist and Jesper Haglund in the national coordination of the ULF project (see Section 3). SMEER's involvement in several research projects funded by the Swedish Institute for Educational Research (Skolforskningsinstitutet), which demands collaboration with the teaching practice, provides additional evidence (See Section 4).

These collaborations have had a great impact on the surrounding community. For example, projects regarding implementation of ESD in schools in Karlstad municipality have included several hundred teachers. These projects, and the BRICCS project relating to climate change education, have been requested by the municipality of Karlstad as a way to improve the quality of teaching, i.e., initiated by the schools not the researchers, implying a high level of trust in our research in the eyes of the surrounding community. Similarly, we have developed a long-standing collaboration with Torsby municipality on technical vocational education. A SMEER researcher, Susanne Walan, is head of Kau's science centre, Kunskapsgatan (<https://www.kau.se/kunskapsgatan>) and the Children's University project to engage 10-12-year-old children in science and technology. SMEER researchers are often participating in media such as specialised press and local press. Many of our practice-based projects have been announced and shown on the web portal *Pedagog Värmland* (<https://pedagogvarmland.se/>) as a way to disseminate the project outcomes to other schools and teachers in the region, but also nationwide in Sweden. All these examples show how the research conducted in SMEER has connections to the surrounding community.

Still, teachers have a heavy workload, and we have a challenge in reaching out and informing schools about our research that we hope could benefit them. In this respect, there is a research-practice gap. Efforts from SMEER in order to close this gap include collaboration with RUC (see Section 3) in organising professional development days for subject teachers and more extended professional development programmes over longer periods, such as Daniel Olsson's coordination of professional development in science and technology.

On a national level, members of SMEER have contributed to curriculum development and the development of professional development material for the Swedish National Agency for Education (Skolverket), evaluation of the professional development programme *The Boost for Mathematics* (Matematiklyftet), and literature reviews targeting school teachers on behalf of the Swedish Institute for Educational Research. Niklas Gericke is part of the editorial board of *ATENA Didaktik*, a journal that targets researchers and teachers in science and technology education, published by NATDID, an organisation with the purpose to support school development based on research in the field. Torodd Lunde is ambassador for NATDID, a contact point for science and technology teachers.

We would summarise our strengths and challenges regarding collaboration and interaction with the surrounding community and results as follows:

Strengths:

- Collaboration and practice-based research in collaboration with schools in the surrounding community is prioritised in the research programme.

- SMEER has developed formal and informal networks in collaboration with municipalities and schools in conducting research projects.

Challenges and development areas:

- It is difficult to sustain collaboration with schools and make it a priority for them to participate in joint research and professional development activities.
- Increase co-funding from collaborators in the surrounding society.

## 6 Interaction between research and education

As a research centre, SMEER does not organise education and is not responsible for education (see Section 2). However, each SMEER researcher are employed in a department that conducts courses in the various teacher education programmes (see Section 1). As subject-specific education is the object of study of SMEER, there is an intrinsic connection between our research and education, in contrast to, for example, most of the research of our host faculty, the Faculty of Health, Science and Technology. This connection concerns education in the school system, as well as at Kau, in particular within the teacher education.

The majority of SMEER researchers are active as teachers in the teacher education programmes at Kau, some of whom are also part of the leadership of teacher programmes and courses. Many SMEER researchers develop courses for teacher education. This gives an immediate opportunity to base the teaching in the courses where SMEER researchers are involved on results from their own research as well as their scholarship in other domains of subject-specific research. The research experience is particularly valuable in the coordination and supervision of independent/degree projects that the teacher students conduct at the end of their teacher education. Almost all those course related to independent projects in teacher education within science, mathematics and technology education are led and conducted by SMEER researchers as part of their positions at the departments of the HNT Faculty.

One of the objectives of SMEER, in line with the vision of the Faculty Board for Teacher Education, is to contribute to grounding the teacher education in educational research in our subjects. Two SMEER members, Jesper Haglund and Nina Kilbrink, are teacher representatives on the Faculty Board for Teacher Education, and thereby have a direct organisational influence on teacher education and educational research at Kau.

As seen in Section 3, offering part-time graduate studies to lecturers in the teacher education programmes at Kau who do not have a PhD degree is part of the strategy to increase the overall competence within SMEER. This strategy also reinforces the connection to research in the teacher education programmes. Involvement in externally funded graduate schools, such as FontD, FUNDIG and KÄKK, has provided funding and structure for this effort.

Even though most of our research deals with teaching and learning in school or preschool, there is also research within SMEER that focuses on teaching and learning in the teacher education programmes. For example, in his PhD project, Mikael Rydin investigates pre-service teachers' beliefs about education on climate change, and Stina Eriksson investigates pre-service teachers' use of analogies in biology teaching. Further, Nina Christenson and Susanne Walan have recently published a study on pre-service teachers' assessment of argumentation on socio-scientific issues (SSI). Also, Maria Fahlgren and Mirela Vinerean have conducted two studies on the quality of digitised tasks designed by prospective upper secondary school teachers as part of a geometry course assignment. For the future, we foresee that research on teacher education will increase in importance.



During 2022, a Master's programme in subject-specific education was launched at Kau. It focuses on school development and targets primarily in-service teachers. Yvonne Liljekvist and Niklas Gericke have been part of developing this programme to strengthen the connection between education and research, as well as between Kau and schools in the region. SMEER researchers will be teaching in the programme, which gives new possibilities to connect the participating teacher students' teaching in schools and their forthcoming Master's projects to SMEER research.

Apart from teaching in the teacher education programmes, SMEER researchers are engaged in other programmes and courses at Kau. For example, Daniel Olsson and Teresa Berglund have developed and given a course in sustainable development for engineering students, to a large degree based on their experience of research in ESD. In this regard, Daniel Olsson is also involved in developing an international Master's programme in ESD in collaboration with Vechta University in Germany, Masaryk University in the Czech Republic and Alpen-Adria University in Austria. Teresa Berglund, Anna Mogren and Karin Thörne teach at the Centre for Teaching and Learning (Universitetspedagogiska enheten, UPE) that supports the teaching competence of all teachers at Kau by providing qualifying courses in higher education. This goes to show the high standard and close connection between research and higher education in SMEER.

However, it has been a challenge for SMEER to argue for the benefit of educational research in the departments of our host faculty, the Faculty of Health, Science and Technology. Research funding directed to the departments have been focused on research in science and technology, but not on educational research about the courses that are given in those subjects, for example, in the engineering programmes. There is a clear area of development to establish collaboration with our colleagues in the departments in the teaching at courses outside the teacher education. One example is the development of practical activities in a mechanics course, taken by engineering and physics teacher students, which has been conducted by Jesper Haglund and Jan Andersson, in collaboration with Marcus Berg, a professor in physics who is responsible for the course. Similarly, Mats Brunström, Maria Fahlgren and Mirela Vinerean-Bernhoff have studied the use of digital tools in support of engineering students' learning of mathematics.

We would summarise our strengths and challenges regarding interaction between research and education as follows:

#### Strengths:

- Research on subject-specific education is intrinsically focused on education, with an immediate relevance for teaching and learning of the subjects in focus in the school system and teacher education.
- SMEER researchers are heavily involved in the teacher education programmes at Kau, contributing to grounding the teaching in research.

#### Challenges and development areas:

- We have a challenge in arguing for the benefit of educational research in the departments of HNT. Collaboration with teachers of courses outside the teacher education programmes is one potential way to increase the relevance of our research within our host faculty.



The Research Centre of Science, Mathematics and Engineering  
Education Research (SMEER)

# BACKGROUND DATA

Periodic Research Review

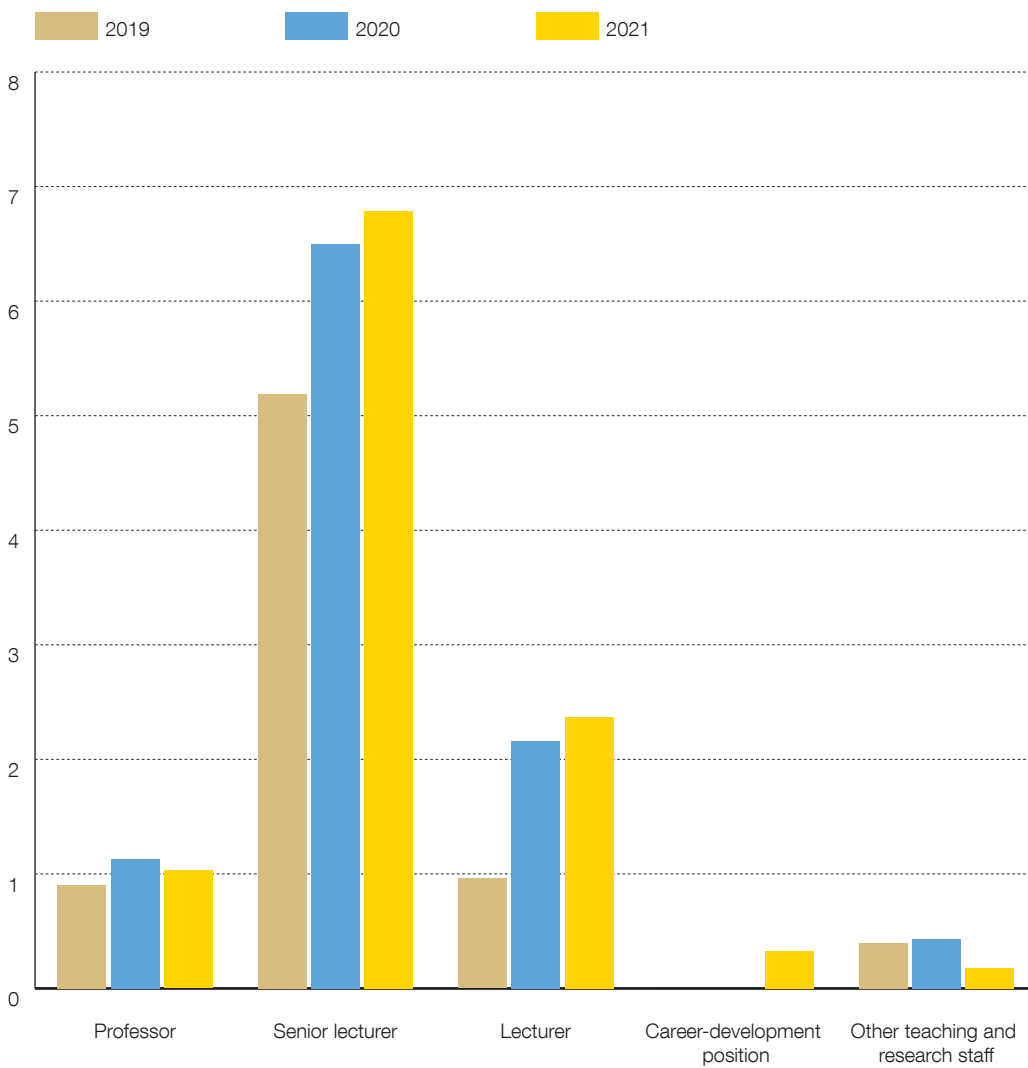
## INTRODUCTION

The purpose of the background data is to provide an overview of the evaluation unit, The Research Centre of Science, Mathematics and Engineering Education Research, SMEER, regarding: staff, financial resources, research funding, internationalisation, bibliometrics, collaborations and utilization of research for the period of 2019-2021. Details regarding data source or possible deviation will be stated in the individual figure text.

## STAFF

**Table 1.1.** Staff categories of the evaluation unit

The graph shows the workforce involved in research activity at the evaluation unit over a three-year period. 'Research activity' includes internal funding, external research funding and commissioned research funding. Staff categories included in the graph are professor, senior lecturer, lecturer, and other teaching and research staff, as well as career-development positions.



Source: KULI

**Table 1.2.** Staff at the evaluation unit (only the past year, 2021)

The table shows staff, based on position, engaged in research at SMEER. The table also includes information about the department where the staff is employed.

POSITION	DEPARTMENT
<b>LECTURER</b>	
Arvidsson Minna	Educational studies
Axelsson Jan	Educational studies
Berglund Teresa	Environmental and Life Sciences
Eriksson Stina	Environmental and Life Sciences
Flognman Jeanni	Engineering and Physics
Taub David	Mathematics and Computer sciences
Uvesten Storm Helena	Mathematics and Computer sciences
<b>SENIOR LECTURER</b>	
Andersson Jan	Engineering and Physics
Brunström Mats	Mathematics and Computer sciences
Christenson Nina	Geography, media and communication
Drechsler Michal	Engineering and Chemical Sciences
Fahlgren Maria	Mathematics and Computer sciences
Lunde Torodd	Engineering and Chemical Sciences
Olsson Daniel	Environmental and Life Sciences
Thörne Karin	Environmental and Life Sciences
Vinerean-Bernhoff Mirela	Mathematics and Computer sciences
Walan Susanne	Environmental and Life Sciences
<b>OTHER TEACHING AND RESEARCH STAFF</b>	
Kostas Kampourakis	Environmental and Life Sciences
<b>CAREER-DEVELOPMENT POSITION</b>	
Lampert Peter	Environmental and Life Sciences
<b>SENIOR LECTURER/READER</b>	
Haglund Jesper	Engineering and Physics
Kilbrink Nina	Educational studies
Liljekvist Yvonne	Mathematics and Computer sciences
Mc Ewen Birgitta	Health Sciences
van Bommel Joryt	Mathematics and Computer sciences
<b>PROFESSOR</b>	
Gericke Niklas	Environmental and Life Sciences
Ruthven Kenneth	Mathematics and Computer sciences



### THIRD-CYCLE STUDIES

**Table 2.1.** Doctoral students

The table contains doctoral students with activity during 2021.

ADMISSION SUBJECT	NAME	YEAR OF ADMISSION	EXTERNALLY EMPLOYED ADMITTED AT KAU (I)	EXTERNALLY FUNDED (COMPLETELY OR PARTIALLY) (X)
Biology	Annika Forsler	2020	(I)	(X)
Biology	Anna-Clara Rönner	2020	(I)	(X)
Biology	Anders Eriksson	2020	-	(X)
Biology	Mikael Rydin	2020	-	(X)
Biology	Harald Raaijmakers	2018	(I)	(X)
Biology	Annika Thyberg	2019	(I)	(X)
Biology	Stina Eriksson	2019	-	(X)*
Chemistry - Chemistry education	Sara Wahlberg	2019	-	
Mathematics	Marcus Gustafsson	2020	-	
Mathematics	Jimmy Karlsson	2020	-	(X)
Mathematics	Per Blomberg	2020	(I)	(X)
Mathematics	David Taub	2020	-	(X)*
Educational work - Technology didactics	Jeanni Flognman	2020	-	(X)*
Educational work - Technology didactics	Minna Arvidsson	2020	-	(X)*
Educational work - Physics didactics	Lorena Solvang	2017	(I)	(X)*
Educational work - Technology didactics	Helen Brink	2017	(I)	(X)*
Educational work - Technology didactics	Jan Axelsson	2019	-	(X)*
Educational work - Mathematics didactics	Andreas Borg	2017	(I)	(X)*

Source: Ladok

\*Co-funded with other departments/facultys at Karlstad University

**Table 2.2.** Graduate licentiate and doctoral students

The table contains the number of students who have completed a Degree of Licentiate or Doctor over the past three years.

SUBJECT	NAME	DEGREE	2019	2020	2021
Biology	Anna Mogren	Degree of Doctor		1	
Biology	Teresa Berglund	Degree of Doctor		1	
Biology	Daniel Olsson	Degree of Doctor	1		
Chemistry Education	Torodd Lunde	Degree of Doctor		1	
Chemistry Education	Sara Wahlberg	Degree of Licentiate	1		
Educational Work	Helen Brink	Degree of Licentiate			1
Educational Work	Andreas Borg	Degree of Licentiate			1
<b>TOTAL SUM</b>			<b>2</b>	<b>3</b>	<b>2</b>

Source: Ladok

## FINANCIAL RESOURCES

**Table 3.1** Profit and loss statement for research per year  
Amounts in SEK 1 000. Using the evaluation unit's account

	2019	2020	2021
<b>INCOME</b>			
Direct government funding <sup>1</sup>	-5 610	5 839	5 760
External funding <sup>2</sup>	-132	0	18
Internal income <sup>3</sup>	-	-114	-908
<b>INCOME TOTAL</b>	<b>-5 742</b>	<b>5 725</b>	<b>4 870</b>
<b>EXPENDITURE</b>			
<b>Staffing costs<sup>4</sup></b>			
Salaries teachers	2 897	-3 197	-2 674
Remunerations	23	-21	-28
Salaries administration and technical staff	55	-41	-70
Other staff costs	75	-16	-52
<b>Other operating expenses</b>			
Other operating expenses <sup>5</sup>	671	-656	-935
<b>Internal costs</b>			
Internal staff cost	26	-28	-8
Other internal costs <sup>6</sup>	1 472	-1 820	-1 429
<b>EXPENDITURE TOTAL</b>	<b>5 219</b>	<b>-5 779</b>	<b>-5 195</b>
<b>TRANSFERS</b>			
Funds for financing grants	-250	-	-
Grants paid	250	-	-
<b>Transfers Total</b>	<b>-</b>	<b>-</b>	<b>-</b>
<b>SUBTOTAL</b>	<b>-524</b>	<b>-54</b>	<b>-326</b>

Source: KULI/Raindance

<sup>1</sup> Funding directly allocated to the research centre SMEER from the Faculties of Karlstad University originating from the Swedish government

<sup>2</sup> Includes revenue from fees, other reimbursements and funding. Funding which can include grants from Councils, other public research funding agencies, municipalities, regions and research foundations.

<sup>3</sup> Internal transactions includes, for example, grants and/or compensations from other parts of the university or from the evaluation unit as well.

<sup>4</sup> Staffing costs mainly refer to costs for personel who receive salary from the evaluation unit.

<sup>5</sup> Other operating expenses can include research conducted at other institutions, materials, costs for hired expertise, other consultants, travel costs, costs for premises of campus, depreciation etc.

<sup>6</sup> Includes mainly indirect costs for the faculty and university levels, printing costs etc. The post also includes internal staff costs, lecture halls, laboratories, offices and other internal expenses.

**Table 3.2.** External research funding

The table shows ongoing research projects and projects granted during 2019-2021. Amounts refers to Karlstad University's share. Project titles are added as a note below the table. *Amounts in SEK.*

FUNDER	TYPE OF FUNDING	2017	2018	2019	2020	2021	2022	2023
Swedish Research Council <sup>1</sup>	Research project	1 368 000	1 734 000	1 878 000				
EU - Erasmus+ <sup>2</sup>	Research project	294 000		294 000	147 000			
Swedish Research Council <sup>3</sup>	Research project		1 517 543	1 517 543	1 517 543	1 249 408		
Swedish Research Council <sup>4</sup>	Research project		1 313 997	1 402 463	1 437 139			
Swedish Institute for Educational Research <sup>5</sup>	Research project		1 550 000	677 300	1 565 943			
Swedish Research Council <sup>6</sup>	Research project		2 997 666	1 498 833	2 997 666			
Swedish Institute for Educational Research <sup>7</sup>	Research project		1 555 000	1 440 141	1 496 213			
Government of Sweden <sup>8</sup>	Research dissemination		96 116	98 294	104 243	113 277	234 138	
Swedish Research Council <sup>9</sup>	Research project				329 510	172 206	175 652	
Swedish Research Council <sup>10</sup>	Research project				1 388 985	1 465 286	1 496 782	
Swedish Research Council <sup>11</sup>	Research project				5 000 000	5 000 000	5 000 000	5 000 000
Swedish Research Council <sup>12</sup>	Research project				691 687	742 678	752 244	750 452
Swedish Research Council <sup>13</sup>	Graduate school for teachers			150 000	600 000	287 000	670 000	193 000
Swedish National School Agency <sup>14</sup>	Evaluation assignment				50 000			
Swedish Research Council <sup>15</sup>	Graduate school for teachers				1 644 000			
The Research Council of Norway <sup>16</sup>	Research project				234 500	234 500	234 500	234 500
Swedish Research Council <sup>17</sup>	Graduate school				671 000	677 000	677 000	718 000
EU - Erasmus+ <sup>18</sup>	Research project				11 891	298 461	227 738	
EU - Marie Skłodowska-Curie Actions <sup>19</sup>	Research project					346 000	924 000	577 000
Swedish Research Council <sup>20</sup>	Graduate school					89 000	4 000 000	5 000 000
Swedish Institute for Educational Research <sup>21</sup>	Research project					580 000	579 608	
<b>TOTAL AMOUNT GRANTED /YEAR</b>				<b>8 956 574</b>	<b>19 887 320</b>	<b>11 254 816</b>		

Source: Raindance project portal

### Projects

<sup>1</sup> Epigenetic literacy and the implementation of epigenetics in school biology

<sup>2</sup> Artifex

<sup>3</sup> Linking Instruction and Student Achievement project (LISA)

<sup>4</sup> Vocational learning in technical vocational programmes

<sup>5</sup> Learning to weld in vocational education

<sup>6</sup> Teachers in the borderland between elementary school, grammar school and comprehensive school

<sup>7</sup> Education for Sustainable Development: A Longitudinal Implementation Study

<sup>8</sup> The Swedish National Centre for Science and Technology Education (NATDID)

<sup>9</sup> Eco-certified Preschools and Children's Learning for Sustainability: Researching Holistic Outcomes of Preschool Education for Sustainability (HOPES)

<sup>10</sup> Teaching with Learning Management Systems - Making new learning spaces in the digitalized classroom

<sup>11</sup> Knowledge, subjects and quality in teacher education and classroom (KÄKK)

<sup>12</sup> Bringing Climate Change Education in School (Briccs)

<sup>13</sup> A Swedish graduate school of teacher training in science and technology education

<sup>14</sup> Evaluation of teaching module of education for sustainable development

<sup>15</sup> A research school focused on sustainable development and classroom teaching of swedish, social studies, and science in compulsory middle school<sup>16</sup>

<sup>16</sup> Critical Thinking in Sustainability Education (CriThiSE)

<sup>17</sup> A Swedish national licentiate graduate school in science and technology education research for in-service teachers

<sup>18</sup> Innovative digital solutions to assess 21st century skills in makerspaces (Assessmake21)

<sup>19</sup> Developing Action Competence for Insects Preservation (DACIP)

<sup>20</sup> The graduate school on gifted education

<sup>21</sup> Developing methods for feedback supporting adults' mathematics learning

## EXTERNAL RESEARCH FUNDING STATISTICS

**Table 4.1.** External research funding statistics. Amount applied for and granted refers to Karlstad University's share. Amounts in SEK 1000.

YEAR	NUMBER OF APPLICATIONS	SUCCESS RATE %	AMOUNT APPLIED (SEK 1000)	AMOUNT GRANTED (SEK 1000)
2019	15	33%	77 000	33 000
2020	17	24%	52 000	5 000
2021	12	33%	106 000	28 000

Source: This information is retrieved from the Podio (2019) and Raintance application portal (2020, 2021)

## BIBLIOMETRIC ANALYSIS AND REFERENCE LIST

### BACKGROUND

The research activity at Karlstad University is expressed, among other things, in scientific publications. This report aims to map the publishing activity and its development over time for SMEER. The report also shows the proportion of internationally co-authored publications where at least one of the authors is affiliated with a university outside Sweden as well as the proportion of publications that are open access, ie freely available online.

### METHOD

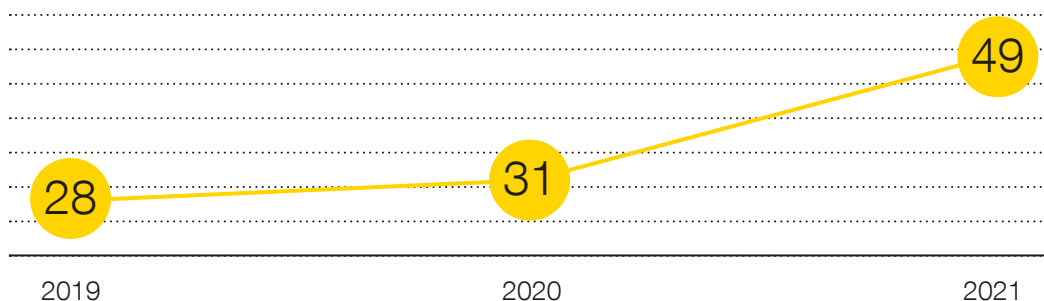
The following tables are based on registered publications in DiVA (Digital Scientific Archive), the local publication repository where researchers, teachers and students register their research publications and essays. DiVA covers all subject areas and publication types.

Publication extraction for the years 2019-2021 has been based on the researchers individual Kau: ID, which links them with their respective publications. The list of researchers that are included in the analyses was provided by the HR department and includes also researchers that are no longer part of the unit but were employed during 2019-2021.

The analysis includes all publications where at least one of the authors is affiliated with Karlstad University. The publication types included in report consist of article in journal, article review, book review, book, chapter in book, conference paper, collection (editor), proceedings (editor), and report. The publication subcategories *presentation, poster, abstracts and "other"* have been omitted from the analysis because these entries are registered to a very varying extent by the researchers. Doctoral dissertations and licentiate theses are reported in detail in other parts of the evaluation and have therefore also been omitted here.

### PUBLISHING OUTPUT

**Table 5.1.** Number of publications between 2019 - 2021



**Table 5.2.** Shows a compilation of the unit's publications sorted by publication type and content

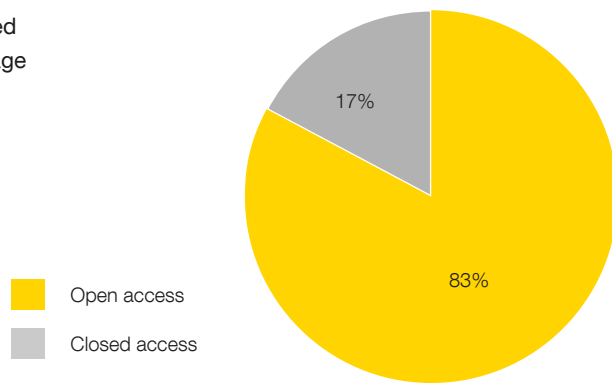
	PEER-REVIEWED	SCIENTIFIC BUT NOT PEER-REVIEWED	OTHER (POPULAR SCIENTIFIC, DEBATE)
Article in journal	62	2	1
Article, review	1	1	
Book		2	
Chapter in book	10	3	
Conference paper	8	4	
Collection (Editor)	1		
Proceedings (Editor)	1		
Report	6	5	1

**OPEN ACCESS**

The Swedish government and many research funders demand that research that is financed with public funds needs to be published open access to make it more accessible for anyone who is interested. So far, this requirement only applies to scientific publications in journals, which is why this report focuses on the proportions of open and closed access for scientific articles.

**Table 5.3.** Share of peer-reviewed articles that are open access vs. Those that are behind paywalls

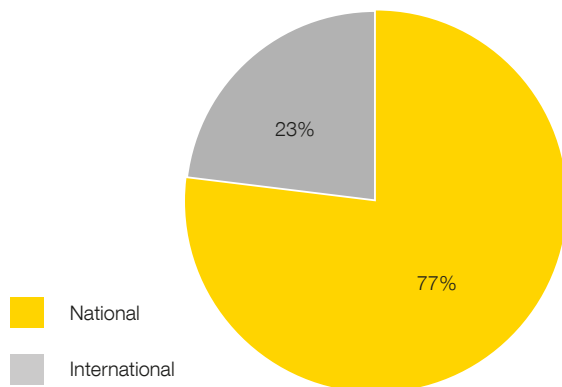
Comparison of the percentage of peer-reviewed articles that are open access and the percentage that are not.



**NATIONAL AND INTERNATIONAL CO-AUTHORSHIP**

**Table 6.1.**

Compares the proportion of the unit's publications with an international profile and publications where all authors were affiliated to Swedish organizations



## **INNOVATIVE IDEAS**

There was one (1) innovative idea connected to SMEER being evaluated within Innovation Office Fyrklöver\* during 2019-2021.

\* Innovation Office Fyrklöver (Karlstad University, Linnaeus University, Mid Sweden University and Örebro University) was established by the government at the end of 2009 and is one of 14 innovation offices in Sweden.

The Background data report is produced by the Periodic research review's administrative Support group; Sofia Andersson, Lovisa Stedt, Charlotte Månsson, Karin Brattfjord, Lotta Utterberg, Magnus Åberg och Patrik Bångerijs.

December 2022





## APPENDIX 1: REFERENCE LIST

---

NOTE! The list aims to facilitate the understanding of which publications are included in the analysis. It is complete but does not follow any reference style to perfection.

---

### ARTICLE IN JOURNAL

---

1. Alamäki A, Kilbrink N. Section VI, Introduction : Learning in Projects and Programming & Case Studies: Models and Concepts. PATT38, Rauma, Finland, Online, 27-30 April 2021. Nordiskt Forum for Forskning och Utvecklingsarbete inom Utbildning i Slojd, Nordic Forum for Development in Craft Design; Techne series: Research in sloyd education and crafts science. A. 2021;28(2)
2. Ariza M R, Boeve-de Pauw J, Olsson D, Van Petegem P, Parra G, Gericke N. Promoting Environmental Citizenship in Education: The Potential of the Sustainability Consciousness Questionnaire to Measure Impact of Interventions. MDPI; Sustainability. 2021;13(20):11420-.
3. Asplund S, Kilbrink N, Asghari H. Visualising the intended practical doing: Future-oriented movements in Swedish vocational school workshop settings. European Research Network Vocational Education and Training; International Journal for Research in Vocational Education and Training. 2021;8(2):160-185.
4. Asplund S, Kilbrink N. Lessons from the welding booth : theories in practice in vocational education. Springer; Empirical Research in Vocational Education and Training. 2020;12(1):1-23.
5. Berglund T, Gericke N, Boeve-de Pauw J, Olsson D, Chang T. A cross-cultural comparative study of sustainability consciousness between students in Taiwan and Sweden. Springer; Environment, Development and Sustainability. 2019;22(7):6287-6313.
6. Berglund T, Gericke N. Diversity in views as a resource for learning? : Student perspectives on the interconnectedness of sustainable development dimensions. Routledge; Environmental Education Research. 2021;:1-28.
7. Borg F, Gericke N. Local and Global Aspects: Teaching Social Sustainability in Swedish Preschools. MDPI; Sustainability. 2021;13(7):3838-3838.
8. Brink H, Kilbrink N, Gericke N. Teaching digital models: secondary technology teachers' experiences. Springer Netherlands; International journal of technology and design education. 2021;
9. Brink H, Kilbrink N, Gericke N. Teaching Modelling Using Digital Design Tools : Experiences of Swedish Secondary School Technology Teachers. PATT38 Rauma, Finland, Online, 27-30 April 2021. Nordiskt Forum for Forskning och Utvecklingsarbete inom Utbildning i Slojd; Techne series: Research in sloyd education and crafts science. A. 2021;28(2):432-438.



10. Enochsson A, Kilbrink N, Andersén A, Ådefors A. Connecting school and workplace with digital technology : Teachers' experiences of gaps that can be bridged. Linköping: Linköping University Electronic Press; Nordic Journal of Vocational Education and Training. 2020;10(1):43-64.
11. Enochsson A, Kilbrink N, Andersén A, Ådefors A. Obstacles to progress : Swedish vocational teachers using digital technology to connect school and workplaces. Routledge; International Journal of Training Research. 2021;
12. Gericke N, Boeve-de Pauw J, Berglund T, Olsson D. The Sustainability Consciousness Questionnaire: The theoretical development and empirical validation of an evaluation instrument for stakeholders working with sustainable development. Hoboken, N. J., USA; Sustainable Development. 2019;27(1):35-49.
13. Gottfridsson H O, Christenson N, Bladh G. Geografiutbildning och geografididaktisk forskning vid Karlstads universitet. Geografilärarnas riksförening; Geografiska Notiser. 2020;78(3):74-79.
14. Gottfridsson H O, Christenson N. Perspektiv på undervisning i geografi - i den svenska grundskolan. Geografilärarnas riksförening; Geografiska Notiser. 2020;78(3):101-111.
15. Gregorcic B, Haglund J. Conceptual Blending as an Interpretive Lens for Student Engagement with Technology : Exploring Celestial Motion on an Interactive Whiteboard. Springer; Research in science education. 2021;51(2):235-275.
16. Haglund J, Henriksson F. Introducing infrared cameras in the study of pigs' physiology and health as cognitive apprenticeship in vocational education. Eurasian Society of Educational Research; . Action Research in Science Education. 2021;4(1):5-11.
17. Haglund J, Schönborn K J. The Pedagogical Potential of Infrared Cameras in Biology Education. University of California Press; The American Biology Teacher. 2019;81(7):520-523.
18. Jeppsson F, Haglund J. Sampublicering med studenter - ett sätt att stärka forskningsanknytningen i lärarutbildningen. Oslo, Norway: Nordic Open Access Scholarly Publishing; Högre Utbildning. 2019;9(1):98-111.
19. Kersting M, Haglund J, Steier R. A Growing Body of Knowledge On Four Different Senses of Embodiment in Science Education. Science & Education. 2021;(30):1183-1210.
20. Kilbrink N, Asplund S, Asghari H. Introducing the object of learning in interaction : Vocational teaching and learning in a plumbing workshop session. Taylor & Francis; Journal of Vocational Education and Training. 2021;:1-26.
21. Kilbrink N, Asplund S, Axelsson J. To Teach and Learn Technical Vocational Content : Ongoing Research in Swedish Upper Secondary Education. PATT38 Rauma, Finland, Online, 27-30 April 2021. Techne series: Research in sloyd education and crafts science. A. 2021;28(2):287-293.



22. Kilbrink N, Asplund S. "This angle that we talked about" : learning how to weld in interaction. Springer; International journal of technology and design education. 2020;30:83-100.
23. Kilbrink N, Asplund S. Att lägga en TIG-svets : En learning study baserad på CAVTA. Stiftelsen SAF i samverkan med Lärarförbundet; Forskning om undervisning och lärande. 2020;8(1):29-54.
24. Kilhamn C, Strömskag H, Hästö P, Liljekvist Y, Häggström J. Editorial. Göteborg: Göteborgs universitet; Nordisk matematikdidaktik, NOMAD: [Nordic Studies in Mathematics Education]. 2019;:1-13.
25. Kowasch M, Cruz J P, Reis P, Gericke N, Kicker K. Climate Youth Activism Initiatives : Motivations and Aims, and the Potential to Integrate Climate Activism into ESD and Transformative Learning. MDPI; Sustainability. 2021;13(21):1-25. :11581.
26. Kuschmierz, P, Beniermann, A, Bergmann, A., Pinxten, R, Aivelo, T, et al. European first-year university students accept evolution but lack substantial knowledge about it: a standardized European cross-country assessment (2021). Evolution: Education and Outreach, 14(17), 1-22.
27. Kvello P, Gericke N. Identifying knowledge important to teach about the nervous system in the context of secondary biology and science education-A Delphi study. Public Library of Science; PLOS ONE. 2021;16(12 December):1-32. :e0260752.
28. Liljekvist Y, Randahl A, van Bommel J, Olin-Scheller C. Facebook for Professional Development : Pedagogical Content Knowledge in the Centre of Teachers' Online Communities. Scandinavian Journal of Educational Research. 2021;65(5):723-735.
29. Lunde T, Drechsler M, Gericke N. Från implicit till explicit : Didaktiska modeller som verktyg för att utmana selektiva traditioner rörande undersökande arbete. NorDiNa: Nordic Studies in Science Education. 2020;16(2):167-182.
30. Mc Ewen B. Construction of a Review About Epigenetics for Biology Teachers and Other Non-experts. Springer Nature; Science & Education. 2021;:1-30.
31. Mellroth E, van Bommel J, Liljekvist Y. Elementary teachers on orchestrating teaching for mathematically highly able pupils. University of Montana; The Montana Mathematics Enthusiast. 2019;16(1-3):127-153. :8.
32. Mogren A, Gericke N. School leaders' experiences of implementing education for sustainable development : Anchoring the transformative perspective. Sustainability. 2019;11(12):3343.
33. Mogren, A, Gericke, N, & Scherp, H-Å. Whole school approaches to education for sustainable development: a model that links to school improvement. Environmental Education Research, 2019 25(4): 508-531.



34. Nilsberth M, Liljekvist Y, Olin-Scheller C, Samuelsson J, Hallquist C. Digital teaching as the new normal? : Swedish upper secondary teachers' experiences of emergency remote teaching during the COVID-19 crisis. Sage Publications; European Educational Research Journal (online). 2021;20(4):442-462.
35. Nordgren K, Kristiansson M, Liljekvist Y, Bergh D. Collegial collaboration when planning and preparing lessons : A large-scale study exploring the conditions and infrastructure for teachers' professional development. Teaching and Teacher Education: An International Journal of Research and Studies. 2021;108:103513.
36. Nyberg E, Castera J, Mc Ewen B, Gericke N, Clement P. Teachers' and Student Teachers' Attitudes Towards Nature and the Environment : A Comparative Study Between Sweden and France. Scandinavian Journal of Educational Research. 2020;64(7):1090-1104.
37. Olsson D, Gericke N, Boeve-de Pauw J, Berglund T, Chang T. Green Schools in Taiwan : Effects on Student Sustainability Consciousness. Elsevier; Global Environmental Change. 2019;54:184-194.
38. Olsson D, Gericke N, Sass W, Boeve-de Pauw J. Self-perceived action competence for sustainability : The theoretical grounding and empirical validation of a novel research instrument. Taylor & Francis; Environmental Education Research. 2020;26(5):742-760.
39. Palmér H, van Bommel J. Teachers' participation in practice based research : a methodological retrospect. Nationellt centrum för matematikutbildning (NCM); Nordisk matematikdidaktikk, NOMAD: [Nordic Studies in Mathematics Education]. 2021;26(3-4):113-130.
40. Palmér H, van Bommel J. Young students posing problem-solving tasks: what does posing a similar task imply to students?. Springer Berlin/Heidelberg; ZDM - the International Journal on Mathematics Education. 2020;52(4):743-752.
41. Pettersson A, Liljekvist Y, van Bommel J. Studying concept elements as away to trace students' conceptual understanding. Göteborg: Nationellt centrum för matematikutbildning (NCM); Nordisk matematikdidaktikk, NOMAD: [Nordic Studies in Mathematics Education]. 2019;24(1):5-26.
42. Raaijmakers H, Mc Ewen B, Walan S, Christenson N. Developing museum-school partnerships: art-based exploration of science issues in a third space. Taylor & Francis; International Journal of Science Education. 2021;43(17):2746-2768.
43. Randler C, Adan A, Antofie M --M, Arrona-Palacios A, Candido M, de Pauw J B, et al. Animal welfare attitudes : Effects of gender and diet in university samples from 22 countries. MDPI AG; Animals. 2021;11(7):1893.
44. Samuelsson C R, Elmgren M, Haglund J. Hot vision : Affordances of infrared cameras in investigating thermal phenomena. Stockholm University Press; Designs for Learning. 2019;11(1):1-15.



45. Samuelsson C R, Elmgren M, Xie C, Haglund J. Going through a phase : Infrared cameras in a teaching sequence on evaporation and condensation. American Association of Physics Teachers; American Journal of Physics. 2019;87(7):557-582.
46. Samuelsson J, Gericke N, Olin-Scheller C, Melin Å. Practice before policy? : Unpacking the black box of progressive teaching in Swedish secondary schools. Routledge; Journal of Curriculum Studies. 2021;53(4):482-499.
47. Sass W, Boeve-de Pauw J, Olsson D, Gericke N, De Maeyer S, Van Petegem P. Redefining action competence : the case of sustainable development. Taylor & Francis; The Journal of Environmental Education. 2020;51(4):292-305.
48. Sass W, Quintelier A, Boeve-de Pauw J, De Maeyer S, Gericke N, Van Petegem P. Actions for sustainable development through young students' eyes. Taylor & Francis; Environmental Education Research. 2021;27(2):234-253.
49. Solvang L, Haglund J. How can GeoGebra support physics education in upper-secondary school : a review. Institute of Physics Publishing (IOPP); Physics Education. 2021;56(5):1-13. :055011.
50. Solvang L, Haglund J. Learning with Friction-Students' Gestures and Enactment in Relation to a GeoGebra Simulation. SPRINGER; Research in science education. 2021;
51. Sund P, Gericke N. Teaching contributions from secondary school subject areas to education for sustainable development : a comparative study of science, social science and language teachers. Routledge; Environmental Education Research. 2020;26(6):772-794.
52. Sund, P, Gericke N, Bladh G. Educational Content in Cross-curricular ESE Teaching and A Model to Discern Teacher's Teaching Traditions. Journal of Education for Sustainable Development. 2020;14(1):78-97.
53. Sund, P, Gericke N. More than two decades of research on selective traditions in environmental and sustainability education : seven functions of the concept. MDPI; Sustainability. 2021;13(12):6524.
54. Tengberg M, van Bommel J, Nilsberth M, Walkert M, Nissen A. The quality of instruction in Swedish lower secondary language arts and mathematics. Taylor & Francis Group; Scandinavian Journal of Educational Research. 2021;
55. van Bommel J, Palmér H. Book Review: Building the foundation: Whole numbers in the primary grades. Maria G. Bartolini Bussi and Xu Hua Sun(Eds.) (2018) The 23rd ICMI study - new ICMI study series. Netherlands; Educational Studies in Mathematics. 2019;100(2):193-199.
56. van Bommel J, Palmér H. Enhancing young children's understanding of a combinatorial task by using a duo of digital and physical artefacts. Taylor & Francis; Early years. 2021;41(2-3):218-231.



57. van Bommel J, Palmér H. Matematik i soffan. Caspar Forlag; Tangenten: tidsskrift for matematikk i grunnskolen. 2020;31(4):6-11.
58. van Bommel J, Palmér H. Young students' views on problem solving versus problem posing. Istanbul Kultur University. Journal of Childhood, Education & Society. 2021;2(1):1-13.
59. van Bommel J, Randahl A, Liljekvist Y, Ruthven K. Tracing teachers' transformation of knowledge in social media. Elsevier; Teaching and Teacher Education: An International Journal of Research and Studies. 2020;87:1-9.
60. Walan. S. The dream performance - a case study of young girls' development of interest in STEM and 21st century skills, when activities in a makerspace were combined with drama. Research in Science & Technological Education. 2021 39:1, 23-43.
61. Walan, S. [Embracing digital technology in science classrooms: Secondary school teachers' enacted teaching and reflections on practice](#). Journal of Science Education and Technology. 2021 29(3), 431-441.
62. Walan, S. (2022). Pre-service teachers' reflections when drama was integrated in a science teacher education program. Journal of Biological Education. 2020; 56:2, 208-221
63. Walan, S., Enochsson, A-B. The potential of using a combination of storytelling and drama, when teaching young children science. European Early Childhood Education Research Journal. 2019; 27(6), 821-836.
64. Walan S, Flognman J, Kilbrink N. Building with focus on stability and construction : Using a story as inspiration when teaching technology and design in preschool. Taylor & Francis; Education 3-13. 2020;48(2):174-190.
65. Walan S, Gericke N. Factors from informal learning contributing to the children's interest in STEM : Experiences from the out-of-school activity called Children's University. Taylor & Francis; Research in Science & Technological Education. 2021;39(2):185-205.

---

#### ARTICLE, REVIEW

---

66. Haglund J. Bokrecension av Fysikkdidaktikk, 2. utgave, av Angell et al.. University of Oslo; Stockholm University; NorDiNa: Nordic Studies in Science Education. 2019;15(3):333-335.
67. Mc Ewen B. The Connection Between the Body and the Environment : a Changing View. Springer Nature; Science & Education. 2020;29:1093-1096.

---

#### BOOKS

---

68. van Bommel J, Palmér H. Matematikundervisning i förskoleklass. Lund: Studentlitteratur AB; 2020.





69. Palmér H, van Bommel J. Problemlösning som utgångspunkt: Matematikundervisning i förskoleklass, 2<sup>nd</sup> ed. Stockholm: Liber AB; 2019.
70. Hadjichambis, A., Reis, P., Paraskeva-Hadjichambi, D., Činčera, J., Boeve-de Pauw, J., Gericke, N., Knippels, M.C. (Eds.). *Conceptualizing Environmental Citizenship for 21st Century Education*. Cham, Switzerland: Springer; 2020.

---

#### CHAPTER IN BOOK

---

71. Andersén A, Ådefors A, Enochsson A, Kilbrink N. Att stärka bron genom reflektion : Lärarutbildares lärande i arbetet med att överbrygga klyftor mellan universitet och VFU. In: Bidrag från universitetspedagogisk konferens: UPE:s rapportserie 2021:1. Karlstad: Karlstads universitet; 2021. p. 13-32. Utveckling av undervisning och examination i högre utbildning : utgiven av Universitetspedagogiska enheten vid Karlstads universitet, 2021:1.
72. Asplund S, Kilbrink N, Axelsson J. Being a Researcher-Teacher in an Action-Oriented School Research Project on Welding : Perspectives, Positions, and Ethical Dilemmas. In: *Doing Fieldwork at Home: The Ethnography of Education in Familiar Contexts*. Lanham, Maryland: Rowman & Littlefield; 2021. p. 119-134.
73. Enochsson A, Kilbrink N, Andersén A, Ådefors A. Att ständigt behöva tänka om : Ett yrkesdidaktiskt dilemma i digitaliseringens spår. In: *Yrkesdidaktiska dilemman*. Stockholm: Natur och kultur; 2021. p. 299-322.
74. Fahlgren M, Brunström M, Dilling F, Kristinsdóttir B, Pinkernell G, Weigand H --G. Technology-rich assessment in mathematics. In: *Mathematics Education in the Digital Age: Learning, Practice and Theory*. Taylor & Francis; 2021. p. 69-83.
75. Gericke N, El-Hani C N, Sbeglia G C, Nehm R H, Evangelista N A. Is belief in genetic determinism similar across countries and traits?. In: *Genetics education: Current challenges and possible solutions*. 1st Cham: Springer; 2021. p. 107-125. Contributions from Biology Education Research.
76. Gericke N, Huang L, Knippels M, Christodoulou A, Van Dam F, Gasparovic S. Environmental Citizenship in Secondary Formal Education : The Importance of Curriculum and Subject Teachers. In: *Conceptualizing Environmental Citizenship for 21st Century Education*. Cham: Springer; 2020. p. 193-212. Environmental Discourses in Science Education, 4.
77. Gericke N, Manni A, Stagell U. The Green School Movement in Sweden : past, present and future. In: *Green Schools Movements Around the World: Stories of Impact on Education for Sustainable Development*. Cham: Springer; 2020. p. 309-332. International Explorations in Outdoor and Environmental Education.
78. Gericke N. How can epigenetics be used to integrate nature and nurture in genetics education?. In: *Genetics education*:



Current challenges and possible solutions. 1st Cham: Springer; 2021. p. 17-34. Contributions from biology education research.

79. Kilbrink N, Enochsson A, Andersén A, Ådefors A. Teachers' use of digital boundary objects to connect school and workplace-based learning in dual vocational education. In: Developing Connectivity between Education and Work: Principles and Practices: Taylor & Francis Group; 2021. p. 119-136.
80. Kilbrink N, Enochsson A, Söderlind L. Digital technology as boundary objects : Teachers' experiences in Swedish vocational education. In: Konnektivitet och lernortintegrierte Kompetenzentwicklung in der beruflichen Bildung / Connectivity and Integrative Competence Development in Vocational and Professional Education and Training: Franz Steiner Verlag; 2020. p. 233-251. Zeitschrift für Berufs- und Wirtschaftspädagogik - Beihefte (ZBW-B), 29.
81. Liljekvist Y, van Bommel J, Olin-Scheller C, Randahl A. Sharing is Caring : Extending the Professional Learning Community Using Social Media. In: Social Media: Influences on Education. Information Age Publishing; 2021. p. x-x. Current Perspectives on Cognition, Learning and Instruction.
82. Lunde T. Undersökande och verklighetsanknuten undervisning i ett allmänbildningsperspektiv. In: Kemi för alla Bidrag från konferensen 1-2 oktober 2018 i Stockholm arrangerad av Kemilärarnas resurscentrum: . Kemi för alla. 1-2 oktober, 2018. Stockholms universitet.. 1 Linköping:: Linköping University Electronic Press; 2019. p. 59-71. Naturvetenskapernas och teknikens didaktik, 5.
83. Parra G, Hansmann R, Hadjichambis A, Goldman D, Paraskeva-Hadjichambi D, Sund P, et al. Education for environmental citizenship and education for sustainability. In: Conceptualizing environmental citizenship for 21st century education: Cham: Springer; 2020. p. 149-160. Environmental Discourses in Science Education, 4.

---

#### CONFERENCE PAPERS

---

84. Andersén A, Kilbrink N, Enochsson A, Ådefors A. Learning pathways between university, school and working life when student teachers use digital multimodal logbooks to cross boundaries. In: Pathways in Vocational Education and Training and Lifelong Learning: Proceedings of the 4th Crossing Boundaries Conference in Vocational Education and Training, Muttentz and Bern online, 8-9 April. Crossing Boundaries, VETNET, University of Applied Sciences and Arts Northwestern Switzerland and Bern University of Teacher Education. 2021. p. 45-50.
85. Andersson J, Haglund J. Lärarstudenter konkretiserar energi genom energiteater. In: Forum för forskningsbaserad NT-undervisning: Bidrag från konferensen FobasNT18 13 - 14 mars 2018 i Norrköping: . Forum för forskningsbaserad NT-undervisning. Linköping: Linköping University Electronic Press; 2019. p. 23-38. Naturvetenskapernas och teknikens didaktik, 3.



86. Berggren M, Isleborn H, Haglund J. Kärnkraftsdebatt ger möjlighet till kritiskt tänkande i högstadiesfysiken. In: Naturvetenskapernas och teknikens didaktik: . Forum för forskningsbaserad NT-undervisning, FobasNT18 13 - 14 mars 2018 i Norrköping. Linköping: Linköping University Electronic Press; 2019. p. 39-48. Naturvetenskapernas och teknikens didaktik, 3.
87. Borg A, Fahlgren M, Ruthven K. Programming as a mathematical instrument : the implementation of an analytic framework. In: Mathematics Education in the Digital Age (MEDA) PROCEEDINGS: . Mathematics Education in the Digital Age (MEDA), Linz, 16-18 September, 2020. 2020. p. 435-442.
88. Brink H, Kilbrink N, Gericke N. Teaching modelling using digital tools in secondary technology education : Teachers' experiences. In: Proceedings PATT37: Developing a knowledge economy through technology and engineering education. PATT37. 3-6 june, 2019. University of Malta, Msida Campus, Malta. 2019. p. 95-102.
89. Fahlgren M, Brunström M. Connected classroom technology to monitor, select and sequence student responses. In: Sustainable mathematics education in a digitalized world: Proceedings of MADIF 12, The twelfth research seminar of the Swedish Society for Research in Mathematics Education Växjö, January 14-15, 2020. The twelfth research seminar of the Swedish Society for Research in Mathematics Education, Växjö, January 14-15, 2020. Svensk förening för MatematikDidaktisk Forskning - SMDF; 2021. p. 11-20.
90. Fahlgren M, Brunström M. Student responses as a basis for whole class discussions in technology-rich environment. In: Proceedings of the Tenth ERME topic Conference (ETC 10): Mathematics Education in the Digital Age (MEDA). The 10th ERME TOPIC CONFERENCE (ETC10): Mathematics Education in the Digital Age (MEDA). Linz, Austria; 2020. p. 183-190.
91. Fahlgren M, Brunström M. Orchestrating whole-class discussions in mathematics using connected classroom technology. In: Proceedings of the 14th International Conference on Technology in Mathematics Teaching - ICTMT 14. Essen, Germany; 2020. p. 173-182
92. Kilbrink N, Asplund S. Using CAVTA (Conversation Analysis and Variation Theory Approach) in a Learning Study on Welding. In: Proceedings PATT37: Developing a knowledge economy through technology and engineering education. PATT37, 3-6 june 2019, University of Malta, Msida, Malta. Msida: University of Malta; 2019. p. 269-276.
93. Liljekvist Y, van Bommel J, Randahl A, Olin-Scheller C. Multi-theoretical approach when researching mathematics teachers' professional development in self-organized online groups. In: Proceedings of the Eleventh Congress of the European Society for Research in Mathematics Education (CERME11) (hal-02418200): . Eleventh Congress of the European Society for Research in Mathematics Education, Utrecht University, Feb 2019, Utrecht, Netherlands.. 2019.



94. Solvang L, Haglund J. Vad händer när dynamiska matematikprogram används i gymnasiefysiken?. In: Forum för forskningsbaserad NT-undervisning: Bidrag från konferensen FobasNT18 13-14 mars 2018 i Norrköping. Forum för forskningsbaserad NT-undervisning, FobasNT18 13 - 14 mars 2018 i Norrköping. Linköping: Linköpings universitet; 2019. p. 133-150. Naturvetenskapernas och teknikens didaktik, 3.
95. Przybilla J, Brandl M, Vinerean M, Liljekvist Y. Interactive Mathematical Maps - A contextualized way of meaningful Learning. In: Bringing Nordic mathematics education into the future. Preceedings of Norma 20, The ninth Nordic Conference on Mathematics Education, Oslo, 2021. p. 209-216. Skrifter från SMDF, 14.

---

#### PROCEEDINGS, EDITOR

---

96. Liljekvist Y, Björklund Boistrup L, Häggström J, Mattsson L, Olande O, Palmér H, editors. Sustainable mathematics education in a digitalized world. : Proceedings of MADIF12. The twelfth research seminar of the Swedish Society for Research in Mathematics Education, Växjö, 2020.. MADIF12, The twelfth research seminar of the Swedish Society for Research in Mathematics Education, Växjö, 2020.. Göteborg: Svensk förening för MatematikDidaktisk Forskning - SMDF; 2021. SMDFs skriftserie, 15.

---

#### REPORTS

---

97. Berg L, Bergsten C, Folestam S, Henriksson F, Karlsson T, Länsberg J, et al. Introduktion av värmekameror i undervisningen vid Lillerudsgymnasiet. Karlstad; 2020.
98. Christenson N, Dahlström M, Grund H. Att identifiera och kommunicera skogens många värden - metodutveckling i norra Klarälvdalen. Karlstad: Karlstads universitet; 2020.
99. Fahlgren M, Brunström M. Geometriska begrepp och metoder i historien : Exempen area och klassiska konstruktioner. Karlstad: Karlstads universitet; 2019. Working Papers in Mathematics Education, 2019:2.
100. Liljekvist Y, Olin-Scheller C, Randahl A-C, van Bommel J. Fortbildning på Facebook: Lärares informella professionsutveckling via sociala medier. Resultatdialog 2019.
101. Nilsberth M, Liljekvist Y, Olin-Scheller C, Samuelsson J, Hallquist C. Svenska gymnasielärares erfarenheter från distansundervisning med anledning av Covid-19 pandemin. Karlstad: Karlstads universitet; 2020. Working Papers in Mathematics Education, 2020:2.
102. Nordgren K, Kristiansson M, Liljekvist Y, Bergh D. Lärares planering och efterarbete av lektioner : Infrastrukturer för kollegialt samarbete och forskningssamverkan. Karlstad: Karlstads universitet; 2019. Studier i de samhällsvetenskapliga ämnernas didaktik, 2019:35. Karlstad University Studies, 2019:11.



103. Przybilla J, Vinerean-Bernhoff M, Brandl M, Liljekvist Y. Rooms of Learning : A conceptual framework for student-centered teaching development in a digital era. Karlstad: Karlstads universitet; 2021. Working Papers in Mathematics Education, 2021:2.
104. van Bommel J, Liljekvist Y. Docentföreläsningar i Matematikens didaktik: Karlstads universitet 12 juni 2019. Karlstad: Karlstads universitet; 2019. Working Papers in Mathematics Education, 2019:1.
105. van Bommel, J. Formulera problemuppgifter 4-6 Skolverket; 2021.
106. van Bommel, J. (Formulera problemuppgifter Fk-3, Skolverket; 2021
107. van Bommel, J. & Palmér, H. Resonemang genom problemlösning, Skolverket, 2021
108. Österholm M, Bergqvist T, Liljekvist Y, van Bommel J. The Boost for Mathematics Evaluation Report. Karlstad: Karlstads universitet; 2021. Working Papers in Mathematics Education, 2021:1.

# Periodic Research Review of The Research Centre of Science, Mathematics and Engineering Education Research (SMEER) at Karlstad University

The review panel has consisted of:

- Professor Jari Lavonen (chair), University of Helsinki, Finland
- Professor Marc de Vries, Delft University of Technology, the Netherlands
- Professor Ellen K. Henriksen, University of Oslo, Norway.

The present review report is based on the information provided to the panel by SMEER staff, notably a self-evaluation report and background material, and on conversations during a digital meeting on February 7<sup>th</sup> and 8<sup>th</sup>, 2023.

## 1. Research and scientific development

The long-term aim (vision) of the Research Centre of Science, Mathematics and Engineering Education Research (SMEER) at Karlstad University (KAU) is to be a leading research environment in science, mathematics, technology, and engineering education, at a national and international level. Environmental education (education for sustainable development) could be added to the list of disciplines, because SMEER has several externally funded research projects and publications in this area. SMEER's research is practice-oriented, but there are also theoretical constructs as outcomes of this research, such as Sustainability Consciousness and Action Competence for Sustainability.

### **Research focus – and “a hundred blossoms”**

The recent research programme of SMEER is an important step towards the long-term aim of SMEER. This programme lists four prioritised practice-oriented research areas: practice-based educational research; the development of theory and concepts in subject-specific education; representations and language use; and education for sustainable development and the Anthropocene. A fifth possible direction to include is mentioned in the Self-evaluation report and was discussed during the digital meeting, namely research on teacher education. On the other hand, it is emphasised several times in the self-evaluation that SMEER includes many research perspectives; “let a hundred flowers blossom”. For example, use of representations and language are topics in several SMEER science, mathematics, and technology education research projects. There are good examples of digital tools and pedagogy integration into this type of research.

Consequently, both focused and broad approaches or areas of research exist at the same time in SMEER at KAU. Broad approaches or areas for research support the broad teacher education task: teacher education should be research-based. A more focused programme, which aims at high-quality research, would be necessary for the long-term aim of SMEER and would support international recognition. There is already evidence of that type of research, which has contributed to educational theories (e.g., a special issue of the Journal of London Review of Education). SMEER researchers are aware of this dual nature of the SMEER research, and research priorities are under continuous discussion. The long-term vision of SMEER seems hard to achieve without a more focused programme and leadership. However, a research environment on international level does not necessarily exclude focus on several subject pedagogy research areas. For example, there could be a



methodological focus, such as educational design research, or a context focus on subject pedagogy research, such as the role of models, the use of representations or language in science education.

### **Collaboration culture**

Based on the self-evaluation report and the digital meeting, SMEER has succeeded in establishing a collaborative culture, which supports research projects and research of senior staff and Ph.D. students. This orientation has saved resources for the supervision of Ph.D. students and contributed to the quality of proposals for external research funding. There are several good examples of collaboration, for instance, in the form of joint externally funded research projects, graduate school collaboration (e.g. KÄKK, FUNDIG and earlier FontD), and international networks (e.g. KOSS). The networks have opened new research lines and supported organisation of master's and Ph.D. education. One interesting network SMEER researchers are participating in is the network for classroom research.

### **External funding**

In the year 2021, SEK 5.5 million was allocated from the budget of the Faculty Board for Teacher Education (Läraryr utbildningsnämnden) to SMEER. In order to achieve long-term aims, the researchers (16 full-time researchers or 1% of KAU's employees) in SMEER have applied for external funding for research projects. In the year 2021, SEK 11 million competitive research funding was received, for example, from the Swedish Institute for Educational Research (Skolforskningsinstitutet) and the Swedish Research Council (Vetenskapsrådet). On average SMEER has achieved SEK 13.4 million external research funding per year in the years 2019 - 2021, which is about 7% of the whole KAU external funding per year. Consequently, SMEER researchers have been very productive in applying for and receiving external funding both nationally and internationally. External funding has been significant for the centre's research activities and research outcomes.

### **Publications**

During the three-year period 2019-2022, altogether 108 publications have been published by SMEER researchers, and altogether 65 of them have been published as refereed articles in journals and 13 in books. The number of publications has increased. Journal articles by SMEER researchers constitute 5% of all journal articles from KAU, which is a very high percentage for a small number of researchers. On average, each SMEER researcher publishes 1.4 refereed journal articles per year, which could be considered relatively high in a university active in teacher education.

In general, about 2/3 of the journal articles have been published in peer-reviewed international journals. About 1/5 of the publications have been published in good-quality international journals, such as Journal of Curriculum Studies, Evolution, Education and Outreach; Scandinavian Journal of Educational Research; European Educational Research Journal; Teaching and Teacher Education; International Journal of Science Education; International journal of technology and design education and Educational Studies in Mathematics.

Consequently, SMEER has a good publication record in international journals. These good results have been achieved in addition to the heavy workload in teacher education. However, the percentage of articles in good-quality international journals could be higher, and a policy supporting this orientation should be established in order to achieve the long-term vision of the SMEER.

## 2. Academic qualifications and ensuring competence maintenance in the short and long term

### **Growing staff, but not at the highest qualification level**

In 2021, SMEER had 16 fulltime employed teachers/researchers (one professor, five associate professors and 10 senior lecturers) and seven lecturers. 18 PhD students were affiliated with the centre, in addition to one guest professor, one postdoc, and one guest researcher. The overview in Table 1.1 in *Background Data* shows that the numbers of senior lecturers and lecturers have increased over the period 2019-2021, whereas the number of full professors has remained constant at one professor. Thus, the centre has succeeded in increasing its staff and expanding its activity, but the proportion of highly qualified academic staff members has decreased. Also, it was mentioned during the digital meeting that the resource situation entails that associate and full professors have a higher teaching load than before and therefore even less time for developing, leading and implementing high quality research.

### **“Home growing” as a staff recruitment policy**

As stated in the Self-evaluation document, recruiting senior academic staff is a challenge for SMEER. The centre has met this challenge by systematically developing the competence of junior academic staff members (so-called “home growing”), and it is expected that several of these staff members may be promoted to full professors during the next couple of years. This is again expected to give SMEER greater visibility and influence locally at KAU and support realization of the long-term vision of SMEER. This policy has a focus on recruiting staff members that may stay in the centre in the long term, thereby developing SMEER activities and securing continuity and predictability. Much of this staff development activity has been funded by external grants, which is a sign of the viability of the approach.

In line with the “home growing” approach, SMEER early career researchers expressed during the digital meeting that they are given good opportunities for developing professionally after their PhD, for instance through a 3-year allocation of research time and through serving as co-supervisors of PhD students shortly after having defended their own dissertation. This is probably fruitful; however, it is possible that this policy has impacted on the research profile of the centre in the sense that staff time and resources have been spent on educating junior staff members, for instance through national PhD research schools such as FontD, rather than on initiating and conducting research projects that require highly qualified and experienced staff.

Despite its high proportion of junior staff members, SMEER has an impressive record of nationally as well as internationally funded research projects (see Table 3.2 in the *Background Data* document), showing that the centre is able to deliver international quality research and enter into collaboration with fellow researchers nationally and internationally. The policy also appears to be sustainable; table 3.2 in *Background Data* show that SMEER has attained a total of ca. 40 million SEK in external research funding over the 3-year period 2019-2021. With 6 senior, research competent staff members over the same period (professors + associate professors), this may be regarded as a good result indicating that the staff is qualified and that administrative support systems are appropriate for succeeding with research proposals.

### **Ensuring research impulses from outside**

It has been challenging to attract and retain guest professors and researchers from other institutions. Because of this, and because SMEER aims to represent a plurality of backgrounds and methodologies, SMEER needs to continue its attention to staff recruitment, competence

development and diversity in research approaches. The negative side of the “home growing” recruitment approach is that impulses from outside the organisation are limited; the policy may lead to academic inbreeding. To counteract this, SMEER has directed much effort at promoting exchange with other institutions; for instance, most SMEER projects have international members and/or advisory board members etc. The early career researchers expressed during the digital meeting that they have good opportunities for collaboration nationally and internationally, and they gave several examples of this.

A complicating factor when recruiting staff from abroad is that staff and students generally need to know Swedish language because teaching is in Swedish at KAU and also because classroom data collection in many cases demands familiarity with Swedish language. However, pragmatic solutions should be sought that might facilitate participation of foreign-language researchers in the activities of SMEER.

### **Organisational structure, recruitment and competence development**

The organisational matrix structure of SMEER (see also chapter 3) is experienced by both senior and junior staff members as functioning reasonably well, although staff members also admitted that the matrix structure can be challenging to navigate sometimes. The early career researchers support each other in this.

However, seen from SMEER’s side, the departments that employ SMEER staff could take somewhat greater responsibility for the staff members’ career development. Also, it is a question whether the dialogue between SMEER and the departments that recruit and employ staff, is good enough in the hiring processes and whether they have the same priorities for recruitment. A staff member expressed during the digital meeting that “STEM departments often hire staff with a view to covering next semester’s teaching, not to supporting SMEER research”. Another staff member expressed that visibility (“grabbing the attention of our departments”) may be a challenge. Despite these challenges, SMEER staff expressed during the digital meeting that the closeness to the disciplinary researchers in the STEM departments is valuable and makes it worthwhile to stick with the matrix structure.

## 3. Organisation, leadership and management

### **An umbrella for research**

SMEER is part of the KAU matrix organisation and an umbrella for research in science, technology, engineering, mathematics, and environmental/sustainable development education. The Faculty of Health, Science, and Technology is the host faculty for SMEER (there are two faculties in KAU).

### **Complex structure**

Teacher education is distributed over many departments in both of the two faculties of KAU. To organise and take responsibility for the quality of education and research connected to teacher education, there is a Faculty Board for Teacher Education (Läraryr utbildningsnämnden, LUN). The Faculty Board for Teacher Education has a budget for research connected to teacher education. The main part of this budget is distributed to research centres. SMEER is one of the four research centres of LUN and focuses on science, mathematics, technology, engineering, and environmental education research. During the digital meeting, it was expressed that the matrix organisation works rather well, and researchers must be self-directed in this type of organisation as one of the interviewees emphasised. Especially, the matrix organisation allows fruitful research collaboration in the subject departments, such as university pedagogy research. On the other hand, some of the

interviewees expressed that not all subject departments fully recognise the work of the SMEER. Consequently, the matrix organisation could make researchers' daily life challenging because they have somehow three or even four "homes".

### **Leadership**

The self-evaluation report describes organisation and leadership of SMEER clearly, and the description follows the recommendation of the document "Rules of Procedure for Research Centres". The director of SMEER, Professor Niklas Gericke, is nominated by the Dean based on the suggestion of the board of SMEER. This democratic procedure looks appropriate. Gericke is also the academic director of SMEER. The director organises SMEER and plans for the use of the yearly budget. From the point of view of the implementation of the research programme, it is important that the budget is allocated to the four focus areas of research.

The chair of the board of SMEER is Associate Professor Jesper Haglund. The board works with strategic questions to develop networks and assist in evaluations and the budget process. The SMEER working committee, of seven members, has been created for supporting daily activities. This committee looks important to anchor the development and decision-making process in the SMEER community. During the digital meeting, the interviewees talked about collaborative, supportive, and encouraging leadership, "when you need help, you got it".

### **Quality assurance processes**

Based on the Self-evaluation document and the digital meeting, it appears that regularly organised SMEER seminars are important for SMEER. They offer possibilities for sharing research project outcomes, for supporting Ph.D. students in their studies, for enculturation, and for increasing the quality of research. These meetings are used also for sharing research and research funding-related issues, such as ethical review practices. It looks important that also the staff members present their projects. Another tool that is used for improving research in SMEER is the yearly report of operations, which is delivered to the Faculty Board for Teacher Education. This is a kind of self-evaluation or progress report and an important part of the quality processes. Third, the SMEER researchers discuss the work progress and the yearly report. The report is evaluated by the Faculty Board for Teacher Education and influences the budget.

During the digital meeting, interviewees emphasised common planning (aiming), making self-evaluation reports, and common reflections as essential for quality work in the SMEER. The quality processes are in line with the KAU, which emphasises transparency and systematic quality assurance processes – "quality culture".

## 4. Collaboration, utilization and impact of research

### **Internal and external research collaboration**

In the Self-evaluation document it is written that SMEER is in itself already a collaborative organisation in that it is distributed over faculties and departments of Karlstad University. Such a position has both pros and cons. The most important pro is that a wide network is available to draw on when it comes to disciplinary knowledge. The most important con is that this position may result in a scattered SMEER population in which individuals may find themselves in a lonely position in their department as their work strongly deviates from what the rest of the department is doing. It seems that the cooperation within scope between the scattered members is taken care of (page 2 of the Self-evaluation document), but how is it with the cooperation between individual SMEER members

and the rest of their departments? A useful strategy that is already used is to do research on KAU teaching. This creates connections between SMEER research and other members in the departments involved in natural science or engineering teaching at university level. New connections can be made by working with colleagues involved in new science or engineering developments that potentially could be of interest for teaching in schools. This is yet an unexplored strategy that may help SMEER researchers to become more recognized by other staff in their department.

KAU-external collaboration seems to be well developed. In the Self-evaluation report particularly the ROSE collaboration is mentioned because of its international links with Finland and England. There is also cooperation at national level with Halmstad University and University West and through national graduate schools such as FontD. Individual SMEER researchers have national and international contacts also

(page 7 of the Self-evaluation document). It is good to see ESERA as one of the organisations in which they play an active role. In later pages of the Self-evaluation report several other examples of national and international cooperation are mentioned (Germany, Norway, Belgium and the Netherlands). On page 13 of the Self-evaluation document also cooperation with local actors is mentioned, which also leads to co-funding. International collaboration seems to be a strength indeed as is noted on the strengths and challenges analysis on page 13 of the self-evaluation report. Young researchers reported in the digital meeting that they are well supported by the management to establish an international network for themselves.

### **Collaboration with schools**

SMEER researchers engage in various practice-oriented research in collaboration with schools and working life. They participate actively also in a national project which aims to make progress in classroom research. This is an important orientation in a university which is active in teacher education. Thanks to the local cooperation, the SMEER research no doubt has an impact on local teachers and their PCK, as is also noted on page 14 of the Self-evaluation report. The cooperation with teachers in research will somehow always have a certain impact on the quality of the teachers. However, this way of working with schools and working-life is time consuming and demands a lot of resources. In the Self-evaluation report there is evidence of how the research outcomes contribute to the development of research-based teacher education and support teachers' and student teachers' professional learning and student learning at school. Sustainability of the cooperation is a challenge, given the limitations schools are faced with. It is difficult to get school teachers actively involved in SMEER research given their many obligations within their schools. Another route to establish collaboration with teachers is via the teacher education programme in which students do small research assignments in schools. When certain directions are provided for those assignments, the many small contributions by students could add up to contribute to SMEER research. This can be combined with the upcoming possibility of involving master's students in SMEER research.

### **Research impact**

Another form of impact is that individual SMEER researchers are involved in national and international developments and projects. The research on sustainable development teaching practices is said to have high impact results that have been frequently cited. It is also stated on page 13 in the Self-evaluation document that the SMEER research has yielded many articles with high impact and citation factors. There were, however, no concrete data on this in the Self-evaluation document nor in the background document. In the meeting with senior researchers, it was stated that these data are made available at university-central level. The panel, however, had the impression that the percentage of articles in high impact journals is not very high and could be larger. Given the high number of total publications per researcher, a strategy could be to raise the quality level and give in a little on the quantity (publish fewer articles but in higher ranking journals).

## 5. Internationalisation, gender equality, research integrity and multidisciplinary collaboration

### **Gender equality and internationalization**

On page 4 of the Self-evaluation document it is stated that gender equity and disciplinary inclusion are taken into account when hiring new personnel. This has resulted in a well-balanced population within SMEER as can be read from the background data document. As has been stated elsewhere in this report, the influence of SMEER on the recruitment of new staff is limited due to the KAU matrix structure of which SMEER is part. In this case that has not had a negative impact on recruitment as the outcome of that recruitment has been a well-balanced population within SMEER. Less balanced is the international nature of the SMEER population. Nearly all researchers are native Swedes. There are challenges in recruiting international staff, again partially due to the limited influence SMEER has on recruitment. It could be an option to start a process towards more internationalization by recruiting more actively in other Nordic countries, as the language issue (teaching in Swedish and doing research in Swedish schools) is less problematic for those countries. Internationalization is important to enrich the experience present within SMEER. Staff recruited from other countries can provide an useful new impetus for research directions.

### **Multidisciplinarity**

Multidisciplinarity is given with the construction of SMEER with its division over faculties and departments and the nature of its research. It is not clear, however, what this means in terms of the nature of the relation between the disciplines. Multidisciplinarity is perhaps a more appropriate term for the SMEER research than interdisciplinarity, as the various disciplines remain and are brought into connection with each other but limited integration of disciplines takes place. There are good examples of multidisciplinary research in the realm of environmental education, in which different STEM education disciplines are involved. Some examples go even beyond the boundaries of STEM education and include elements of philosophy and languages. Most of the research, however, focuses on one school subject or discipline only. There are opportunities for more integrated STEM-oriented research by choosing topics that are common for all STEM school subject teaching such as inquiry-based learning and the learning of concepts. As there is an international interest in connecting or even integrating the STEM disciplines, this would seem a promising topic for the SMEER research also, given the present situation with researchers in different STEM departments.

### **Scientific integrity and research ethics**

In terms of scientific integrity and research ethics, SMEER benefits from a well-elaborated structure for that within KAU. All Ph.D. students have compulsory education in scientific integrity. All research proposals are checked for research ethics issues by independent committees. Ph.D. students are made aware of data management issues and KAU provides good opportunities for responsible data management. In the dialog with young researchers during the digital meeting, it appeared that not all of them are aware of the availability of what is often called 'confidential councillors' or 'confidential advisors'. These have been appointed within each faculty, but some young researchers did not seem to know who to approach in case of moral issues in, for instance, the relation between Ph.D. student and supervisor. It is advisable to include the names of the confidential councillors in the scientific integrity training of young researchers.



## 6. Connection between education and research

### **Education and research internally at KAU**

SMEER states in its Self-evaluation document that interaction between research and teaching may be hard to monitor in their case because SMEER members' teaching duties are tied to the various departments where they are employed, whereas their research efforts are coordinated by SMEER.

On the other hand, SMEER research has a natural connection to education in the sense that education is the *topic* of the research activity. Thus, most SMEER staff members naturally integrate perspectives from their own and colleagues' research in their teaching, which is for most SMEER members tied to the teacher education courses at Karlstad University.

All SMEER staff is involved in teaching, most of it within teacher education, but some of it also in engineering education. One of the early career researchers during the digital meeting said that she had merged educational research into her teaching in a mechanics course. The early career researches gave several examples of how their research on for instance teacher education or engineering education was related to their teaching. Within teacher education, student research assignments sometimes use data that has been collected through SMEER research projects.

The Self-evaluation document states that whereas most research until now has been related to teaching and learning in school and preschool, SMEER intends to strengthen its research within teacher education and higher education in the years to come. The latter might promote the collaboration between SMEER and the different STEM disciplinary faculties where SMEER staff members are employed. Also, research related to teacher education appears to be recommendable since teacher education is central at Karlstad University and since it may be mutually enriching to see research on teaching and learning in schools in connection with teacher education and development of teacher professional competence. However, SMEER might need to consider how much it is wise to expand in new research directions, seen against developing existing competence build-up within the areas where the centre already has a good research activity that warrants further development. It was mentioned during the digital meeting that strengthening SMEER's focus on research on science teacher education may represent challenges internally: participants in the digital meeting expressed doubts about whether it would benefit SMEER to "flag" teacher education research as a priority, since it might not be supported by the STEM departments that see STEM discipline educational research as most important.

### **SMEER research and education in schools**

Another great asset of SMEER for the integration of research and education is its close collaboration and contact with schools in the area. This happens through research and development projects as well as through the part-time graduate studies offered to teachers who may finish a licentiate degree with SMEER. However, relations with schools are challenging and resource-intensive to maintain. The school contact was described during the digital meeting as "messy"; it happens on a person-to-person level as well as on a leadership level, is hard to coordinate and requires considerable staff resources.

Some SMEER research has collaboration with teachers in their work packages, and some of the funding agencies for the educational research at SMEER require school involvement. However, early career researchers expressed during the digital meeting that it can be hard to get the teachers involved as true collaborators in projects, "the teachers want us to give them solutions". This is related to the time and resources allocated to teacher participation.

SMEER only has a handful of master's degree students (this is expected to increase somewhat in the next few years with teachers wanting a master's degree to extend their competence beyond a teaching degree). SMEER is also involved in in-service education for teachers. Both the master's degree programme and other, more short-term in-service courses could offer opportunities for close relations between SMEER research and education in schools. Moreover, there may be an untapped potential in involving teacher students more in research, for instance by letting them work with data collected through SMEER research projects, to involve them in research during their school placement periods, etc.

## 7. Concluding assessment and recommendations for continued development

Overall, the panel was impressed by the quantity and quality of the outcomes of the SMEER research group. Even with a small number of professors and other senior staff, the group has accomplished much in terms of research output and impact. The group has very good past performance in funding acquisition, publishing, collaboration and Ph.D. education. Recommendations in the remainder of this text should be read in the context of this great appreciation for what SMEER has accomplished so far.

### **Research and scientific development**

Even with the small number of senior researchers and professors, there are several indications of SMEER's success in research. First, the number of publications per person in the research community is higher than average in KAU. Second, the amount of external funding per person in the research community is higher than average in KAU. Third, several of the SMEER staff members have had progress in their careers and achieved the title of associate professor. Fourth, SMEER researchers have been invited to various academic activities, such as review and editorial work and to organise conferences. Fifth, SMEER researchers have many academic partners, networks, and commitments within KAU and internationally. In general, SMEER has made extensive progress in research, local and international networking, and achieving external research funding. There is a big difference in the competence of SMEER researchers compared to the starting situation of SMEER in the year 2010. Externally funded graduate schools have been an important instrument in the capacity building of staff members. The internal and external collaboration, in line with SMEER strategy, has been fruitful and is recommended to continue. SMEER may need to discuss its publication strategy, since there is a tension between aiming for higher impact in highly ranked international journals, on the one hand, and serving the needs of a more local science teacher and science education researcher community, on the other hand. Some research topics may be important locally/nationally but may have limited international interest.

### **Academic qualifications and competence maintenance**

Most of the SMEER research staff is «home grown», and it has been a challenge to recruit highly qualified staff from outside KAU. This challenge has been handled wisely through an internal recruitment approach combined with attention to research collaboration and staff exchange with other institutions in Sweden and abroad. The review panel considers the recruitment and staff development policy of SMEER to be appropriate under the circumstances. However, SMEER needs to continue its attention to securing a staff with sufficient breadth and diversity in research backgrounds and approaches. One strategy might be to recruit even more actively from the Nordic area. This would combine greater diversity and international perspectives with the requirements for Nordic language skills.

### **Organisation, leadership and management – and a quality culture**

The matrix organisation works rather well and it allows fruitful research collaboration inside SMEER and in various networks at the departments, faculty, KAU, national and international level. During the digital meeting, several good networks and collaboration models were discussed and analysed. However, the matrix organisation could make researchers' daily life challenging, because they have four "homes".

Based on the self-evaluation report and discussions during the digital meeting, the SMEER researchers are planning together their projects and long-term aims, collaborating on their projects, making annual self-evaluation reports, and reflecting on their work and outcomes. Consequently, a quality culture is well established and important to continue. SMEER employees expressed during the digital meeting that taking part in the present research review was helpful; this is also a part of the ongoing support for the quality culture throughout the organisation. Such a culture is important since it directly impacts what individuals do – which feeds back into the total research output and the standing of the institution at large.

SMEER has a preference for being an organisation with very modest hierarchy, well in line with what is custom in Nordic organisations. Leadership is seen primarily as a supportive and accommodating function. Yet, there are some issues that deserve to be addressed in discussions within SMEER that can be initiated by the management. Perhaps the best way to introduce them is by pointing out that having a long-term perspective of becoming a world leader in STEM education research does not go along well with a number of conditions currently present. In the first place: one cannot be the best in everything. At the moment there is not much focus in the research programme, and many different topics are under investigation. There is a limited budget for staff and Ph.D. students, a high dependence on acquisition of external research money, and the influence on recruitment is limited. Local impact is seen as a priority, and justly so because SMEER is good at it and SMEER cannot exist without support and appreciation by its direct context. Yet, it would be worthwhile to engage in debate about the way the long-term perspective and the research and organisational strategy can be better aligned. It need not be in conflict with the ideal of a 'flat' organisation when leadership initiates and organises discussions on this issue. The committee recommends these debates to be initiated with the reflections in this report as an input.

### **Collaboration and impact of research**

Collaboration of individual researchers with their colleagues in Faculties and Departments can be enhanced by using their expertise in the latest developments in the sciences and mathematics to consider if it is possible to implement a school version of those developments in pre-university education. The collaboration with school could be enhanced by using the small research assignments that student teachers do in schools by connecting those to SMEER's research program. Further possibilities will emerge once the new Master program is fully in place (even though the numbers of Master students may remain fairly modest).

### **Internationalisation, gender equality, research integrity and multidisciplinary collaboration**

Internationalization of staff could begin with recruitment of colleagues from the Nordic countries, as the use of Swedish in teaching and research should be no problem then. With respect to scientific integrity the committee advises to give more visibility to the 'confidential councillors' so that staff and students know who they can approach in situations of tensions or doubts. Multidisciplinary could be enhanced by doing more research into connections between the school subjects or perhaps even integrated STEM education.

### **Connection between education and research**

Continued attention must be given to building up good routines and systems for relations with schools in order to keep up the very important, close relation with the practice field which is essential to the research conducted by SMEER as well as to the teacher education at KAU.

The degree (and kind) of effort within research on science teacher education at SMEER should be thoroughly discussed and seen in relation to the various aims and priorities of SMEER.

### **The long-term aim of SMEER**

The long-term aim of SMEER is ambitious - a world-leading research environment in STEM education research - and difficult to realise under the current conditions. For example, the following conditions need to improve for SMEER to assume a role as an internationally leading research group: English programmes for master-level education and for Ph.D. education, more international staff members, a bigger number of senior researchers, including full professors, a higher proportion of publication in top international journals, and better coherence in the research programme. The research programme should emphasise publishing in high-quality journals.

Another possibility is to lower the long-term aim and aim for a leading position in Scandinavia. This allows better to take local needs related to science teaching at schools and science teacher education into account. However, this modified aim guides SMEER and its researchers to similar and even more ambitious processes.

In both cases, the departments that employ the teacher educators who are future researchers of SMEER should better recognise the important work the SMEER is doing in one main area of KAU: teacher education and continuous research-based development of teacher education. Therefore, a leading researcher in the SMEER should participate in the advertising and recruitment process of subject didactics-related positions at the departments. Moreover, career development possibilities should be offered for subject didactics-related staff members in the departments.

The university has expressed that teacher education is seen as important for KAU. If that is the case, then educational research to support that should be well funded, and given their past performance, SMEER has proven to be worth investing in.

### **Final remarks**

It is clear to the panel that Karlstad University should be very pleased with the performance of SMEER. In one of the panel sessions, the university management stated that teacher education is seen as an important asset for KAU as a whole. If that is the case, it is important to realize that successful teacher education is only possible when sufficient supporting educational research is present, both on teaching in schools and on teaching in the teacher education programme. This needs a certain investment. In its performance so far, SMEER has proven to be well worth investing in. What has been invested so far has yielded more than could be reasonably expected. Investing in SMEER in the future has a potential for a high return-on-investment. The panel recommends further considerations on this in the university management.

The panel wants to thank KAU and SMEER for very open and friendly discussions and hopes that this report can be of help to further strengthen the position of SMEER locally, nationally and internationally.

Helsinki/ Delft/Oslo, February 20<sup>th</sup>, 2023



Jari Lavonen



Marc de Vries



Ellen K. Henriksen