

## PREPARE grants 2025: project descriptions

### **ACCESS: Augmenting the STEM classroom by ESS digital twins**

*Luise Theil Kuhn, Technical University of Denmark; co-applicants: Kim Lefmann, University of Copenhagen, Niels Bohr Institute and Jesper Bruun, University of Copenhagen, Department of Science Education; 3 years, DKK 7,988,223*

The European Spallation Source (ESS) in Lund (SE) is a future large-scale facility for neutron-based investigation of materials in the broad sense, from quantum materials and energy materials, over polymers and health-related materials, to biological materials. As host countries, Denmark and Sweden have a large interest in teaching and training students in the use of this world-class facility. However, access to instruments at ESS is highly competitive and little measurement time is set aside for training.

The use of digital twins of ESS instruments can replace hands-on training while keeping high quality learning. In a combined effort using the competences at DTU and University of Copenhagen in collaboration with ESS, we will develop digital twins of four of the first instruments to be operational at ESS, to be initially used for a neutron specialist course (at Physics and Nanoscience educations at the University of Copenhagen) and a broad-brush neutron/X-ray course for nonspecialists (combined offer from the Danish Technical University and the University of Copenhagen within all STEM).

### **CRAFT: Co-creating Responsible AI Frameworks for Teaching**

*Kirsten Jørgensen, University of Copenhagen, 3 years, DKK 4,189,979*

Artificial Intelligence (AI) is transforming how students learn, yet many university teachers lack the support needed to use these technologies effectively. The CRAFT project aims to help teachers at the University of Copenhagen integrate AI tools such as ChatTutor into their teaching in ways that are responsible, safe and pedagogically meaningful. CRAFT takes a collaborative approach, working closely with developers to adapt ChatTutor to real educational needs. This ensures the tool enhances students' critical thinking, understanding and academic integrity across a diverse range of subjects and disciplines.

CRAFT provides a framework for the inclusive and responsible integration of AI in higher education. The project brings together a unique combination of expertise— including leading scholars in didactics and cognitive psychology, software developers, practitioners, and the SCIENCE Learning Centre.

### **Didactic experiments in electromagnetism and quantum mechanics**

*Jakob Schiøtz, Technical University of Denmark; 2 years; DKK 2,200,000*

We propose to design novel student experiments in the two core physics courses Electromagnetism and Quantum Mechanics in the Engineering Physics program at the Technical University of Denmark. The experiments will clarify abstract mathematical concepts in these courses using tangible measurements.

Electromagnetism (EM) and quantum mechanics (QM) are absolutely crucial for developing new technologies for a sustainable future. However, they are also the courses that are most difficult for the students to master. The fail rates in the exams are too high throughout several Danish and foreign universities, even though physics students have strong academic backgrounds and are highly motivated to learn the physics. Carefully designed experiments can help learning the abstract mathematical concepts by making them more concrete.

### **Hands-on with Quantum – Next-Generation Teaching Experiments and Formats**

*Jonatan Bohr Brask, Technical University of Denmark; co-applicants: Jan Philip Solovej, University of Copenhagen, Mathematical Sciences, Kim Splittorff, University of Copenhagen, Niels Bohr Institute and Alexander Huck, Technical University of Denmark, Department of Physics; 3 years, DKK 6,932,275*

This project aims to create a paradigm shift in teaching of quantum physics and quantum technology at the BSc and MSc level by developing a set of portable, interactive experiments that can be directly integrated into classroom teaching without requiring dedicated labs, as well as a set of activities and teaching formats that activate students, enable hands-on experience, and maximise learning outcomes. This will facilitate inclusion of students with diverse backgrounds and produce graduates with strong intuition and improved understanding of quantum phenomena who are better able to connect abstract concepts with implementations and technology.

This will be achieved by designing and building three portable teaching-experiment setups, respectively harnessing squeezed light, a single quantum emitter in diamond, and quantum optomechanics, to demonstrate a wide range of ideas from fundamental concepts in quantum physics to applications in quantum technology.

### **VSLab - Virtual Software Laboratories as a Scalable Research Infrastructure for Higher IT Educations**

*Mikkel Baun Kjærgaard, University of Southern Denmark; 3 years; DKK 1,999,000*

Educators and students of the software engineering and computer science educations face significant challenges due to inadequate hands-on facilities for teaching and learning advanced IT subjects like Big Data, Cloud Computing, Machine Learning, Microservices, and Dev(Sec)Ops. Access to cloud-like environments is limited, and relying on commercial public cloud services is

neither sustainable nor feasible for iterative experimentation and teaching purposes. This project aims to address these challenges by designing, implementing, evaluating, and refining a scalable, Virtual Software Laboratories (VSLab) infrastructure, leveraging SDU's existing UCloud platform.

The infrastructure will be integrated into target courses with adapted teaching materials while assessing the students' technical proficiency and familiarity with the relevant technologies. The project will deliver prototypes of VSLab integrated into the existing UCloud platform at the University of Southern Denmark, including best practice roadmap for long term implementation.

### **BuddhAi - A multimodal Socratic AI tutor for novice programmers**

*Kasper Rodil, Aalborg University; 3 years; DKK 2,998,313*

Programming and algorithmic knowledge are foundational skills for students in technical fields, fostering problem-solving, computational thinking, and systematic reasoning in complex and dynamic environments. However, novice programmers often struggle with autonomy and decision-making, hindering the development of learner agency and self-efficacy. This challenge can lead to 'blank canvas paralysis' as students grapple with setting up environments, mastering tools, and debugging. Students increasingly turn to general-purpose LLMs like ChatGPT or Copilot. While these models provide fast, answer-driven support, they lack pedagogical grounding and offer limited scaffolding for thought and reflection. Meanwhile, teachers gain little insight into students' learning processes, limiting their ability to provide targeted support.

At Aalborg University (AAU), we believe addressing the problem can only be achieved as an interdisciplinary, collaborative effort between technical and educational staff working across three departments and integrating a programming LLM tutor into two relevant case educational programs spanning two faculties before further scale-up. The project delivers the final tool, a pedagogical framework with new course materials and exercises, and an AAU policy document will allow continuous use and scale-up.

### **Redesigning Classroom Instruction within University Mathematics Teaching: Building Student Engagement around Joint Problem-Solving**

*Steen Thorbjørnsen, Aarhus University; co-applicants: Louise Kobek Thorsen, Aarhus University, Department of Mathematics, Asger Hobolth, Aarhus University, Department of Mathematics; 3 years; DKK 1,736,692*

Theoretical exercise (TE) sessions have long been integral to teaching natural sciences at universities, offering students the chance to master theories from lectures in smaller, interactive classes. This project aims to redesign classroom instruction to be more problem-oriented and student-involving, enhancing relevance and engagement to boost participation and learning outcomes.

The project will implement the Building Thinking Classrooms (BTC) framework, based on a constructivist approach where learning occurs through active knowledge construction and social interaction. BTC encourages students to work on thinking tasks in random groups on non-permanent, vertical surfaces, with teachers providing hints and asking questions that promote deep understanding. The method supports active participation, cooperation, and in-depth understanding, which are crucial for students to thrive in a rapidly evolving world.

The project will initiate a pilot study in a first-semester course in mathematics. A teaching model will be developed from the pilot study and implemented in calculus courses for science students.

### **From knowledge to competence – Embedding practice in academic learning**

*Eva Harvald, University of Southern Denmark; 3 years; DKK 1,976,100*

A major challenge in life science education is the limited connection between academic teaching and its application in industry contexts. Research-focused teaching often leaves students struggling to see how subjects like bioinformatics translate to professional careers. This project will implement a bioinformatic focused, industry-integrated case-based learning model progressively across the bachelor's programs at the Department of Biochemistry and Molecular Biology, with the intension of broader application across the Faculty of Science. Cases, co-developed by biotech industry, health sector, and academic partners, will highlight the relevance of theoretical knowledge and digital skills, while stimulating students' critical and creative thinking in a practical context.

Outcomes will include a dynamic, online library of ideas and innovative challenges from industry and healthcare partners, case templates, and sharing of best practice and experiences of application. Faculty will be supported through tailored workshops, plug-and-play resources, and networking events, fostering a collaborative learning culture.