



VIDENSCENTER FOR DIGITAL TEKNOLOGIFORSTÅELSE

POSITION STATEMENTS FROM
THE INTERNATIONAL ADVISORY BOARD MEETING

AARHUS, DENMARK

3. APRIL 2025

14.00 – 14.10: Introduction to the talk-shop (*Professor Ole Sejer Iversen*)

14.10 – 14.40: Technology comprehension: Emerging technologies in K-12 education

- Technology Comprehension: A review of the field (*Lillian Buus*)
- Designing for empowering K-12 students (and other citizens) in an era of AI (*Marianne Graves Petersen*)
- Designing AI support for teacher trainers (*Camilla Balslev*)

14.40 – 15 20: Computing in Math, L1 & as an independent subject

- Technology comprehension & mathematics: How, what and why? (*Cecilie Carlsen Bach*)
- Computational literacy in L1 (Danish) (*Rasmus Fink Lorenzen*)
- Computational empowerment in technology comprehension (*Mikkel Hjorth*)

15.10 – 15.20 break

15.20 – 15.40 Technology Comprehension: Assessment & Diversity

Formative assessment of Computational Empowerment (*Christian Dindler*)

Technology comprehension for all (*Vibeke Schröder*)

15.40 – 16.00: How do we sustain findings in the Knowledge center?

- Impact and Scaling (*Roland Hachmann*)
- Dissemination and outreach (*Christian Johannessen*)

1. Technology Comprehension: A review of the field

Lillian Buus is Head of the Research Center for Didactics and Pedagogy (at VIA University College), which embrace research in various disciplines like science, literacy, language, mathematics, outdoor pedagogy, digital technologies, esthetics - all within a pedagogical approach. My own area of research is within methodologies on "How can we scaffold educators integrate digital technology in education?"

OUTLINE OF MY PRESENTATION

I will introduce some of the terminologies we have identified in the discourse of Digital Technological Comprehension, and it could be interesting to have a dialogue about further development in an international perspective.

PROJECT PRESENTATION

The Work Package A is to provide a whitepaper as a shared knowledge base for the Danish education system within digital 'Technology Comprehension' (TC) and with a special focus on computational empowerment. WP A will provide a baseline and follow up by an end line.

MAIN RESEARCH/DEVELOPMENT QUESTION

The research questions guiding the work in WP A is: "What characterizes translations and operationalizations of central concepts as they are expressed in findings and ambitions published in academic publications, reports and evaluations based on Danish projects and initiatives concerning Digital Technological Comprehension in Primary and lower secondary education, and upper secondary education?"

This will contribute to a mapping of central concepts in Digital Technological Comprehension and Informatics as interpreted and operationalized.

CASE DESCRIPTION

The purpose of WP A is to create a common knowledge base for the work of the Knowledge Center for Digital Technology Comprehension and for the actors who work with technology comprehension and informatics in the Danish education system.

WP A aims to shed light on scientific and conceptual developments and priorities, which can help provide an overview of the development of teaching in the form of concrete experiences and scientific publications that together have contributed to the professional practice, that gives a baseline for the knowledge center.

We have identified academic publications, reports and evaluation from 2011 till 2023, which have different perspectives on digital technological comprehension. Those are read and structured into categories.

Primary and lower secondary education • Danish • Mathematics • Arts • Science • As an independent subject in primary school	The four areas of competence • Computational thinking • Digital design and design processes • Technological competence • Digital empowerment
Upper secondary school • Biology • Social studies • Technology subjects (HTX)	Teacher education and Across the education chain

The challenges are that the readings contribute to a diversity of terms used and a difference in how teachers deal with integrating this into education.

2. Designing for empowering K-12 students (and other citizens) in an era of AI

Marianne Graves Petersen is professor at Computer Science Department, Aarhus University. Her areas of research include human computer interaction, embodied and tangible interaction, child computer interaction, human-centred AI. Together with Ole Sejer Iversen, she co-leads the interdisciplinary research center on Computational Thinking and Design at Aarhus University.

OUTLINE OF MY PRESENTATION

I will present examples of tools and activities which we have developed and present our rationales and lessons based on these cases.

MAIN RESEARCH/DEVELOPMENT QUESTION

This research project focus on exploring what children and teachers should know about AI and how we can design tools, frameworks and activities supporting this.

CASE DESCRIPTION

We have approached the design of learning tools and activities, through participatory design processes, collaborating with teachers and have developed tools and activities to Engage Students in Ethical Dilemmas in Machine Learning, allowing children to work with machine learning processes (constructing data, building models and evaluating these), allowing children to explore machine learning as a design material. We have worked with establishing strong dissemination partnerships, (e.g. micro:bit educational foundation), which has made it possible to disseminate the research tools into schools and teachers practices. There is still a lot to be done in terms of addressing GenAI, student AI collaboration and how AI can school subjects can come together in synergetic processes. Not to mention the challenges of teacher training.

3. Artificial Intelligence (AI) and Machine Learning (ML) in Teacher Education

Camilla Balslev Nielsen (Presenter) is project lead and program manager in the center within the for the K-9 education area. As an assistant professor she teaches computational literacy at the University College of Copenhagen. Her research interest is focusing on digital design, playful learning and pre- and in-service teacher training.

OUTLINE OF MY PRESENTATION

A brief presentation with some of the insights from the project at this stage and with a focus on:

How can we support the teacher educators' competencies with, so they can teach students about AI and ML in specific subjects in a critical and constructive way?

PROJECT PRESENTATION

It is essential that Danish children and young people receive critical and constructive technology education in AI and Machine Learning. Complex technologies require digital and transformative competences which must be learned by students at teacher education. The purpose of this project is therefore to contribute to a realistic and adapted AI literacy in school subjects and in courses at teacher education. The study takes place in the subject of Danish and general didactics and is a collaboration with nine teacher educators from four out of the six University Colleges in Denmark. The project is funded by the Danish Ministry of Education (2024-2026).

MAIN RESEARCH/DEVELOPMENT QUESTION

What content knowledge is important when teacher educators teach AI and AI literacy, and how is AI integrated into two subjects?

CASE DESCRIPTION

The overall research question is realized through three central initiatives which are being worked on simultaneously:

1. A structured survey conducting national and international experiences with teacher competencies and the competence development of teacher educators in technology understanding, with a particular focus on AI and ML.

Status: The literature has been collected based on three key frameworks: AI literacy, AI & learning, and AI & education, and is now being analysed.

2. An interview-based study with the nine teacher educators using a triangulation of methods.

Status: A baseline interview has been completed, and a co-creation workshop on prompting has been held. Following the workshop, a five-week prompting study is being conducted to investigate what characterizes teacher educators' experiences with the development and use of professional and generic AI competencies. This study focuses on how they practice prompting over time in ways that enable them to plan teaching using AI. The study began last week. There will be a final interview based on the data and insights gathered from the various initiatives in the project.

3. Interventions as co-designs between researchers and teacher educators with a particular focus on a) Teaching materials (digital tools) and learning resources, b) Pedagogy and didactics and c) Teaching guidelines for Danish and pedagogy and general didactics.

Status: Two out of three workshops have been developed and held. The teaching activities developed during the last workshop are currently being used (iteration) by the teacher educators and their students in their own context. The use of these developed teaching activities is being observed as they are implemented by the teacher educators and their students at the different University Colleges. The final workshop is being developed.

Results obtained:

We have experienced that although the teacher educators' competencies regarding the use and understanding of AI and ML in their work vary, they all have a high interest in learning about the technology, how they can use it in a constructive way, and why it makes sense to use it in planning their teaching.

Major challenges:

The dominant focus on AI in the educational system in Denmark is on how to prevent students from cheating. How can we change or add a perspective that allows us to discuss and investigate the possibilities AI can offer to students and the education system?

How can we support teacher educators' competencies on a larger scale when no funding has been allocated at this point?

How can we support the teacher educators' competencies on switching between different perspectives on technology (technology as tool, as subject matter, as a frame for reflection on societal impact)?

Opportunities:

- Creating more teaching materials and methods with teacher educators.

4. Technology comprehension and mathematics: How, what and why?

Cecilie Carlsen Bach, Postdoc, Departments of Computer Science, University of Copenhagen.
Bachelor of Education, master and PhD degree in Mathematics Education. Research focus:
Mathematical communication, mathematical competencies, and digital technologies.

OUTLINE OF MY PRESENTATION

In our presentation, we will begin by providing an overview of our teaching materials in relation to technology comprehension and its four subject areas: computational thinking, computational empowerment, technological efficiency, and digital design processes. We will then focus on the teaching design for facial recognition as an empirical case to explore its relevance within the Nordic building tradition.

PROJECT PRESENTATION

This project focuses on how to implement technology comprehension into mathematics teaching in K-12. Previous studies have shown that it is a difficult task. In our work, we focus on data literacy and how to implement technology comprehension in mathematics teaching – and how technology comprehension may fit in a Nordic ‘bildung’ tradition.

MAIN RESEARCH/DEVELOPMENT QUESTION

- *How may technology comprehension act as a component in mathematics teaching and vice versa?*
 - *What is the relationship between mathematical problem solving and computational thinking/computational literacy?*
 - *How may a focus on critical thinking in the context of mathematics teaching support computational empowerment?*
- *Which opportunities and obstacles may appear when implementing technology comprehension into mathematics teaching?*

CASE DESCRIPTION

Programming and technology are integrated into education differently across countries. In Sweden, programming is part of the algebra curriculum, whereas in England, computing is a separate subject (Tamborg et al., 2023). Research highlights a strong connection between

computational thinking and mathematics, emphasizing problem-solving and real-world applications (e.g., Israel & Lash, 2019; Weintrop et al., 2016).

To explore the integration of technology comprehension into mathematics, we have developed and tested instructional materials with K-12 mathematics teachers. A key focus is *data literacy* in teaching sequences about machine learning and students' computational thinking processes related to artificial intelligence. This work involves analyzing students' conceptual development of data and machine learning.

Additionally, we investigate how technology comprehension aligns with Nordic bildung traditions. *Technocritical mathematics education* (Misfeldt & Jankvist, 2020) helps reveal the underlying mathematics, as seen in a teaching sequence on facial recognition. This design also considers students' identities. Another perspective explores political empowerment through teaching materials, involving "tarot cards," that prompt discussions on the future of technology and education.

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5. Computational literacy in L1 (Danish)

Rasmus Fink Lorentzen (presenter) Leader of WP 2.2. L1 Danish and technological comprehension. Senior associate professor, PhD, VIA University College.

Marie Falkesgaard Slot Leader of WP 2.2. L1 Danish and technological comprehension. Senior associate professor, PhD, University College of Copenhagen.

OUTLINE OF MY PRESENTATION

Education develops slowly, and we know that things often only become a possibility when they are included in the curriculum (which technology comprehension is not at the moment). Based on a brief presentation of the above case, I focus on the following issue: The workshops are rich on resources and didactic ideas, but teachers are hesitant and insecure: How can we improve the teachers' sense of ownership and agency regarding the emerging expertise in CL in L1?

PROJECT PRESENTATION

Literacy and multimodality are considered fundamental in L1 Danish but are seldom related to digital forms. This research project focuses on the possibilities for computational literacy in L1 Danish as a creative and digital form of expression as well as a means towards critical thinking. The CL approach emphasizes a move from an instrumental and individual approach to computer use in schools towards a social and explorative way of engaging with powerful ideas in the world. Instead of focusing solely on how to code or build robots, CL should be seen as a way to offer opportunities for expression and engagement with the subject matter that involve computational media (Hachmann & Slot, 2024). Along with teachers we develop and integrate teaching-designs in CL in schools.

DEVELOPMENT/QUESTION

What is the significance of the workshop for teachers' professional development, and how does it equip them to independently develop and test CL in Danish, rather than merely implementing it?

CASE DESCRIPTION

Inspired by diSessa (2001), we approach coding with material, cognitive, and social aspects. This theoretical foundation underpins the testing of new analog and digital practices in L1 Danish. Our interaction with schools is guided by a Design-Based Research (DBR) approach and should be seen as a unified intervention at the K12 level. To date, our group of researchers and experts in subject matter has conducted a scoping review (which shows that CL is absent in Denmark) and 12 workshops with 10 K12 teachers from both secondary school (7th grade) and high school. Our

intervention is divided into three phases: 1) Data in social media etc.; 2) Visualizing data and computational thinking; 3) Data as expression (coding poems etc.). The focal point of the intervention is the workshops, where teachers engage in professional discussions, are introduced to resources and new didactic ideas and then design lessons for their students based on these insights.

Results obtained:

Results are preliminary: we have seen students engaged in activities about their own data, but we are still collecting and not analyzing data.

Major challenges:

- The entire work is radically new, and we constantly encounter the established professional norms within L1.-
Teachers need to undergo significant professional development, which is a major task
- Coding, AI, and data are new (and strange) phenomena in L1 education.

Opportunities:

Labs? - Perhaps develop a workshop format where students are also present? Maybe as Living labs.

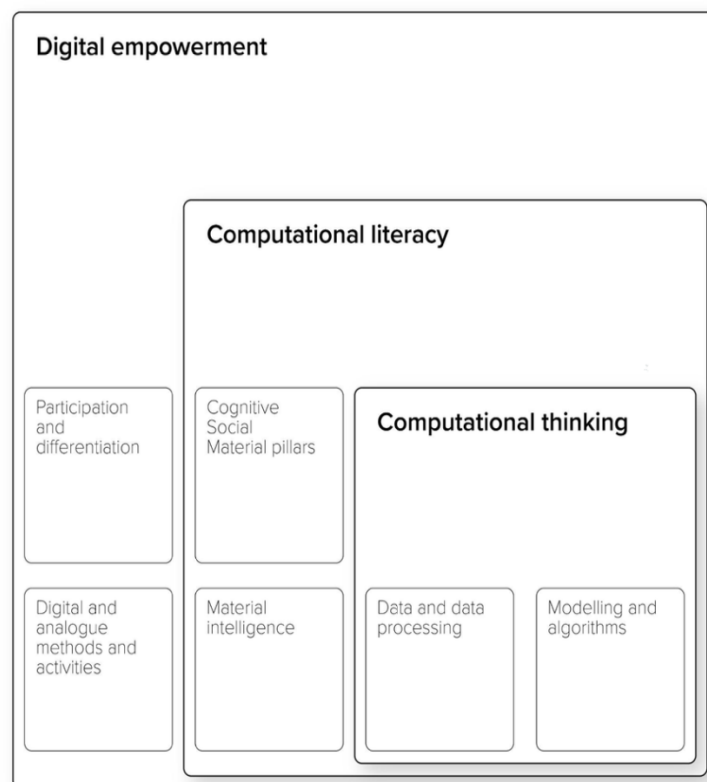


Fig. 2. Our conceptual model: Computational literacy seen as a bridge between computational thinking and digital empowerment.

6. Computational empowerment in technology comprehension

Mikkel Hjorth is a senior associate professor and head of VIA UCs research program for Learning and IT. His research focuses on computational empowerment and digital design in K-9 education as well as in pre- and in-service teacher training. He is especially interested in how a combination of creative-constructive and critical-analytical approaches to digital technologies in education can promote empowerment and agency.

OUTLINE OF MY PRESENTATION

The presentation will focus on strategies of introducing poor or broken technologies, teachers as a limiting factor, and the switches between technological and humanistic/social scientific perspectives.

DEVELOPMENT/QUESTION

The research in WP2.3 focuses on computational empowerment as part of technology comprehension as a subject in K-12. Here, we investigate a variety of strategies to teach for computational empowerment. These investigations are carried out as interventions co-designed with teachers and taught by teachers in-the-wild to provide answers to the question:

How can teachers promote students' computational empowerment and agency through creative-constructive and critical-analytical approaches?

CASE DESCRIPTION

So far, we have co-designed and tried three learning designs with teachers from three different schools. Each of these processes has been different, which when combined with the co-designs in WP1.2 has given us a rather wide range of teacher involvement in co-design: From very scaffolded by researchers (which promoted our ideas very precisely) to more hands-off approaches (which missed many of our central points). In other words, we have moved on a scale from more in-the-lab like conditions to investigating our questions more in-the-wild. The scale presents dilemmas of whether we research what is theoretically possible, what can be implemented tomorrow, or any step in between. Our preliminary analysis is that there (somewhat unsurprisingly) is a real need for competence development, before teachers can meaningfully be expected to prepare their own lessons in computational empowerment.

Regarding the teaching approaches, we have seen students become engagement by poor or broken technology in the form of a very skewed dataset that they were later asked to replace and modify. After themselves creating/modifying datasets as well as experimenting with temperature and n-gram settings for a language model, 8th-grade-students were able to explain possible reasons for the lackluster performance of iOS's recent language model. Our next step is to tweak this learning design to a grade 10 or 11 context.

Further, we have focused on combining analytical perspectives on (1) the technology in itself, and (2) its consequences or purpose. Often, it is left to students to make these combinations, but we view this as a transfer problem between domains: The technical domain and the more humanistic and social science domains. We are currently testing learning designs with this approach in cryptocurrency/ cybersecurity (6th grade) and input/output-technologies in schools and homes (2nd grade).

From a development perspective, our main obstacle is that teachers and students lack knowledge of the subject matter and self-efficacy with the technologies. From a research perspective, the main obstacle is to generalize from our very specific case studies.

7. Formative assessment of Computational Empowerment

Christian Dindler Associate Professor in participatory interaction design and appointed Distinguished Senior Innovator working at the intersection between research and innovation at Aarhus University

OUTLINE OF MY PRESENTATION

In my presentation I will focus on two main issues. **First**, CE is a distinct approach as it emphasizes the development of childrens' agency and taking action related to technology. Assessing these issues challenges us to think outside standard metrics and educational settings. **Second**, I will focus on the challenge of bringing formal and rigorous assessment elements into a Danish teaching practice that is highly situated, emergent and in many ways resists formalisation.

DEVELOPMENT/QUESTION

This WP addresses the issues of how to assess computational empowerment (CE) in primary education. While CE has gained traction as an agenda of empowering children to critically and curiously engage with technology and take action, little research has explored how this can be assessed in formal education. Since (formative and summative) assessment is an integral part of formal education, it is imperative to develop this aspect of CE.

How can develop rigorous formative assessment practices that promote CE within the reflective practice of teachers?

How can we assess the children's transformative agency as a central component of CE?

How can we support bridging technical-, design-oriented and critical approaches in CE teaching?

CASE DESCRIPTION

So far, the work in this WP has centered around four main issues: **First**, we have conducted a literature review to map existing work on assessing CE. The review revealed there very little work has been done with regards to assessing CE in terms of practice, theory and methodology. This work is currently under review in the Journal of Child-Computer Interaction (CCI). **Second**, we have conducted an interview study with teachers in Denmark who have experience in teaching issues related to CE to understand their conceptions, approaches and attitude towards assessment. **Third**, we have developed a potential theoretical foundation for assessing CE by bridging CCI research on CE with well-established concepts of assessment from the learning sciences which has materialised in a model taking into account the specific traits of CE. **Fourth**, we have conducted a series of

interventions in primary schools where we have focused on how we might translate the learning objectives around CE which are described in the Danish course on technology comprehension into learning practice and formative assessment in teaching practice. Collaborating with teachers, this has materialized in four teaching interventions across Danish schools where we have facilitated workshops with teachers, observed teaching and conducted pre- and post-interviews with teachers. Next steps in this WP is to analyse data from interventions to better understand potentials and challenges for formative assessment of CE in learning practice. Moreover, new interventions will be conducted focusing on bringing new assessment tools and practices into teaching.

8. Technology comprehension for all

Vibeke Schrøder, Lecturer, Teacher Education, University College Copenhagen. Her research is situated in educational practice and focus on how digital technologies co-produce pedagogical and didactical processes and on developing technology comprehension and computational thinking as an educational subject with a focus on inclusion and playful learning.

OUTLINE OF MY PRESENTATION

The presentation and the question for discussion will focus on the actual research and development, and on the forthcoming implementation of the results.

PROJECT PRESENTATION

The overall objective of the project is to explore how the learning environment in technology comprehension can be fostered to create space for diversity and multiple participation opportunities. The practical aim of the work package is to develop research-based tools to engage all children in the technology comprehension classroom.

MAIN RESEARCH/DEVELOPMENT QUESTION

- What pedagogical, didactic and material/technical strategies can contribute to a technology comprehension learning environment characterized by diversity and multiple paths of participation?

CASE DESCRIPTION

Our starting point is a systematic review on digital technology comprehension for all in the classroom. In the review we found the following means of action that sought to promote participation in the computer science classroom: plugged/unplugged, groupwork/peer-learning, pair-programming, collaborative programming, game-based learning and teacher professionalism

Pedagogically we have contextualized the model of Universal Design for Learning ([The UDL Guidelines](#))

In the autumn of 2024 we conducted our first school experiment comprising aspects of Universal Design for Learning and pair-programming as a single class case where the male students (half of the class) designed chairs for the future coding Lego spike in a maker space.

We found that it was possible to create participation in coding for all through an entanglement of 1) a number of ways to create engagement in the learning process (UDL); a) sense-based, b) competence-oriented, c) design-oriented, 2) student co-determination about selected pedagogical methods, 3) Many ways of organizing pair-programming. In other words, a complex and multi-dimensional classroom.

In the second experiment, we will revisit these findings and test them in a full classroom with both boys and girls and in a regular classroom. Further we will deepen the UDL perspective on engagement by organizing a children's workshop on their learning preferences and incorporate the results in the experiment.

For the time being the tools we plan to publish is a Nordic version of Universal design for Learning and how to grasp student's perspective on learning technology comprehension through children's workshop.

Discussion

The implementation of the new technology subject is a demanding and complex task for the teachers regarding the content and the computational practices.

- How do we prepare for inclusion of our pedagogical findings into the practice of the new subject?

8. Impact and scaling

Roland Hachmann, Ass. Professor University College of South Denmark. Roland Hachmann is a Danish educational researcher specialising in the role of technology in education. His work explores how technology shapes learning opportunities and constraints in primary and secondary schools, as well as in teacher training.

OUTLINE OF MY PRESENTATION

The key priority is to frame our current challenge in identifying relevant research and evaluations of other countries' experiences with implementing new and emerging subjects, that are not yet embedded within the established logic, routines, and subject traditions of

PROJECT PRESENTATION

This research project explores the potential for developing Technology Comprehension as both a new subject and a subject-specific area within existing subjects in primary and lower secondary education. The aim is to develop a model that facilitates implementation and scalability in relation to this emerging subject in primary and lower secondary schools. Technology Comprehension introduces new challenges in several areas, including:

- The construction of curricula
- The focus of publishers and developers of learning resources
- The foundation for learning objectives and assessment in schools
- A responsibility for school management and administration
- The development of professional capacity and capital in schools

MAIN RESEARCH/DEVELOPMENT QUESTION

What observable effects and underlying mechanisms (both inhibiting and promoting factors) can be identified as effective in developing Technology Comprehension as a subject and as a subject-specific dimension, with course materials and learning resources as the focal point?

CASE DESCRIPTION

Work Package 3.2 (WP3.2) is designed to operate in a staggered manner, progressing in alignment with the development of interventions in other work packages. In the first phase, we developed a design guide for the creation of learning resources. This guide was informed by existing research on the implications of learning resources and their impact on teaching and learning, translating this research into a practical framework.

Given the project's aim to explore an emerging subject in primary education, our intention was not to create a guide with rigid criteria for the production of learning materials to be directly implemented. Instead, the focus has been on developing design principles that serve as inspiration for the work carried out in other work packages.

The next step in WP3.2 is to prepare a state-of-the-art review, focusing on studies of other countries' experiences with scaling and implementing new subjects in primary education, particularly in relation to technology, computational thinking and computer programming. However, we are also interested in the implementation of other new subjects, as the focus is on identifying inhibiting and promoting factors in the scaling of an emerging subject.

Our core challenge is to explore how to introduce and upscale a new emerging subject and a subject-specific area within existing subjects that is not yet an established part of the traditional structure of schooling.

9. Dissemination and outreach

Christian Johannessen is a communications consultant at UCL Erhvervsakademi & Professionshøjskole. He has a research background in multimodal social semiotics with a focus on business communications.

OUTLINE OF MY PRESENTATION

I will share how our dissemination strategy is being built to support real knowledge exchange—not just communication.

PROJECT PRESENTATION

WP-C in the Danish Research Center for Technology Comprehension in K–12 Education aims to create meaningful connections between educational practice, educational research, and policy.

Our dissemination strategy includes a dual-purpose website and dynamic, in-person events. Accessibility, usability, and relevance across educational levels are central. We prioritize collaboration between educators, researchers, and decision-makers.

MAIN RESEARCH/DEVELOPMENT QUESTION

Which dissemination strategies best balance academic depth with practical relevance in disseminating technology comprehension across diverse audiences?

CASE DESCRIPTION

We have developed a dissemination strategy centered around a dual-purpose website and carefully curated events.

A key component of our dissemination efforts is a **dual-purpose website**, which is intended to function both as our public-facing communication hub and, increasingly, as a repository for the teaching materials, research publications, and other resources that result from work conducted in the centre.

We also prioritize **conferences and events** that foster dialogue and collaboration across different educational and research contexts. These gatherings are central to our strategy, offering spaces for shared reflection and exchange across institutional and disciplinary boundaries.

Two upcoming events exemplify this approach: (1) *AI i gymnasier (April 3rd, 2025)* – A one-day conference focused on the integration of artificial intelligence in upper secondary education, aimed at high school teachers, principals, and educational researchers. (2) *TekForstå 2025 (April 24th, 2025)* – An event dedicated to the *grundskole* sector (primary and lower secondary education, ages 6–15), bringing together educators, researchers, and school leadership to explore challenges and innovations in technology comprehension at this foundational level. This one-day event offers both keynotes, 6 talk sessions, 30 hands-on workshops and an Open Space for exhibiting and showcasing educational technology, showcase interesting approaches etc.