Forskningsprosjekter Nordisk Museologi 2014 • 1, s. 85–94

Expand – Research in Norwegian science centers

Dagny Stuedahl, Merethe Frøyland & Ingrid Eikeland

Abstract: *The research program Expand – Research in Norwegian Science Centers, (UtVite in Norwegian) was initiated as a collaboration between Inspiria Science Center, and three research partners in science education.[1] The project collaboration has as its main objective to understand the role of science centers for young people's engagement, interest and recruitment to science. Further, the aim of Expand is to explore research methods suitable for participatory action research approaches to design-based studies of learning in science centers. This is a presentation of the research design of Expand in the first funding period 2011–2016.*

Keywords: Science center education, science center exhibitions, engagement with science, reflective practice.

Why Expand?

In general, the discussion of the educational role of science centers relates to debates on science literacy and engagement with scientific issues that takes place in diverging research fields such as science education, media studies, science and technology studies (STS), environmental and sustainability, interaction design as well as in educational research on out-of-school learning. These diverging approaches to science education flag up a number of gaps between diverging perspectives and understandings of learning that might influence engagement and participation with science, in and across educational contexts and institutions. Expand is an interdisciplinary national research program that has as its main objective to address some of these gaps in a Norwegian context and to find pathways for development of education in science centers based on research. The project is managed by Merethe Frøyland, dr.scient in science education in museums, from the Norwegian Center for Science Education, in collaboration with Dagny Stuedahl, dr.polit and ethnologist in design and communication, and Ingrid Eikeland, Ph.D candidate, both from the Norwegian University of Life Sciences. From INSPIRIA Science Center in Sarpsborg, Christine Hassel Kristoffersen, head of education, and Bente Marie Jacobssen, head of societal issues, are participating in the

research project on a part-time basis. The program is financed by Statoil 2011–16.

Expand responds to the needs articulated in two evaluation reports initiated by the Norwegian Research Council (Quin 2006, Persson *et al.* 2009). These expressed a need for research on the role of science centers for stimulating engagement, interest and recruitment to science, and also to articulate the unique aspects of science centers as learning arenas supplementing schools and other learning sites in the Norwegian educational context. The questions that these reports raise adhere to discussions on the conceptualization and implementation of science learning in the age of open education and learning 2.0.

Expand responds to these evaluations by focusing on how research on science center education may be expanded in perspectives by combining qualitative and quantitative studies of young people's engagement with science, development of school programs in science centers as well as engagement in interactions with science center exhibits and installations. The project focuses on how learning interactions in science center exhibitions are designed and how science centers educators may be supported to develop their educational programs. The research is based on an applied approach with participatory action research and participatory design methods including science educators and science students in high school and university. By way of these methods and approaches the project seeks to address the following aspects;

1. *Science centers as learning arenas:* In what ways are science centers important supplementary learning arenas for learning in schools? What are the unique aspects of science centers as learning arenas? What role may installations in exhibitions hold for science learning?
2. *Science centers and recruitment:* How do science centers increase interest in science? In what ways do science centers contribute to increasing interest in science?
3. *Development of reflective practices:* How do science educators develop their practices? How should science centers continue their development in the future? How can science centers build a sustainable methodological grounding?

These focal points make up the three central topics of Expand, and include network-building activities and six subprojects of research crossing qualitative and quantitative approaches. The focus on learning and engagement with science is approached from different angles, such as interaction in physical exhibitions, inclusion of scientific controversies in educational programs, inclusion of young people in science centres, and continuing professional development for science centre staff. As part of this collaborative approach, the Expand program involves a national research network and a national conference serving to establish an arena for exchange between practice and research in science centre education.

What is Expand?

Expand is based on collaborative research, and involves all the nine regional science centers in Norway. These centers receive governmental funding yearly under the National Science center program which is related to the overall Norwegian strategy for raising standards in math and science in the educational system

(Soria Moria declaration). The research project is based at the INSPIRIA science center, which serves as a central case for our collaborative research approach. Several research activities are developed and performed in close collaboration with educators and students related to INSPIRIA. However, it is a central objective that observational methods and frameworks for assessment developed in the Expand program will be transferable to other centers. The project therefore involves science center educators from all centers in its research activities and in discussions of how science center pedagogy may relate to the design of exhibits and learning programs in general. This collaboration is arranged in the form of a *continuing professional development* (CPD) program giving ESCT points to course participants. Science center educators from nine science centers are involved in the CPD program 2013–14. The course participants gather data documentation of interactions in their science center as part of course activities. The gathered data constitute empirical material for the research in Expand as well, and course participants work in this way as co-researchers in Expand.

How will Expand work?

In this way, the Expand program is based on an emerging collaborative and participatory research methodology, which focuses on the added research outcome of user engagement methods in educational research (Rickinson, Sebba & Edwards 2011). Also, Youth Participatory Action Research approaches building on critical pedagogy and participatory approaches from social science (Freire 2007/1970, Cammarota & Fine 2008) are used to include young people. In this way the research project engages science educators and students on teacher training programs, on interaction design programs and at high school level in collaborative research activities with project researchers.

Expand builds on the emerging interest among museums and science centers in exploring participatory, practice-related and design-based research approaches to the development of educational offers across formal and informal settings. This methodological interest is especially related to exploring how the educational design experiment can be based on the participation of stakeholders. Design experiments have previously been used in design-based research approaches to learning sciences (Brown 1992, Collins 1992, Sandoval & Bell 2004). This experimental approach has been inspired by psychological research traditions and has traditionally involved conducting formative and test-based research in real settings. However, more recent approaches to using design experiments have developed with less focus on formative interventions and testing, and with a deep interest in the process of designing possible future solutions and visions as a component of investigating the process itself (Boling 2010). This methodological development supports emerging educational thinking in science centers, which directs attention toward social and cultural aspects. For example, studies have shown how visitors bring with them cultural assumptions and belief systems across visits to science centers and schools that constitute their participation and activity (Ash & Rahm 2012).

Previously, action-research based methods (Tal 2012) and hermeneutic research designs (Anderson 2012) have been combined with ethnographical approaches to capture these

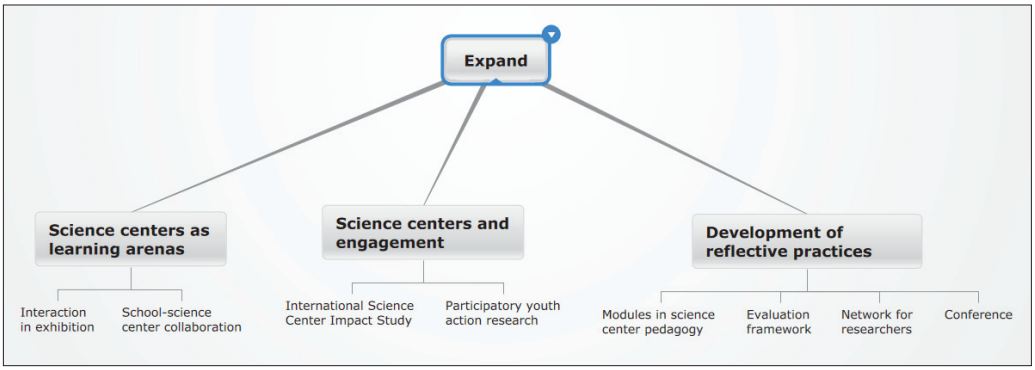

Fig. 1. Illustration of the structure and projects of Expand – Research in Norwegian Science Centers.

socio-cultural aspects of learning in science centers. Also, this participatory research approach has been shown to prompt science educator's reflections and improve their practice by participating in research projects (Tal 2012). Expand builds on these approaches, techniques and tools from participatory research methods and involves educators, experts, students and researchers across institutions and disciplines This user engagement and participatory approach is based on triangulation of research, education and practical development and innovation in science centers, and has professional development as an aim in addition to research outcome. This research design will be one of the main contributions of Expand to this field.

Expand and its focus areas

The structure of the Expand program is based on the three main focus areas and on perspectives on science centers as being part of the ecology of educational sources and resources (Bell *et al.* 2009, Falk et al. 2012). The program is divided into three focus areas with overlapping intersections: a) Science centers as learning arenas, b) Science centers as arenas for science engagement, and c) Development of reflective practices.

a) Science centers as learning arenas

This area focuses on two topics: The interactions in exhibitions and science center–school relations. We ask the following question: How do science centers work as learning arenas?

The *exhibition* plays a central role in establishing science centers as arenas for science learning: "Exhibits that do not provide learners with the means to construct the intended scientific understanding lack what for most museums is a fundamental characteristic" (Achiam 2012:2). The exhibition is the physical interface for learning in science centers, as it is where interactions take place, not only material interactions with objects, interactives and digital technologies, but also social interactions with other individuals. Several studies have concluded that interactive exhibits tend to attract more visitors and

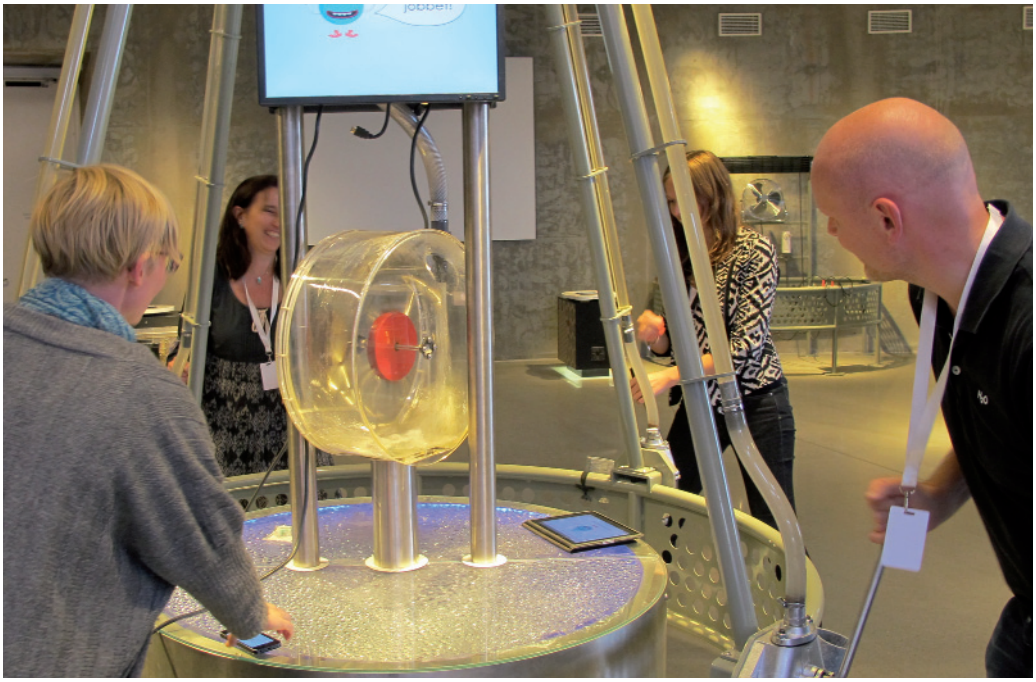

Fig. 2. Science educators attending the CPD course interact with the energy station at INSPIRIA science center, reflecting on learning outcome of installations. Photo: Dagny Stuedahl.

engage them for longer times than static exhibits (e.g. Brooks & Vernon 1956, Serrell 2001). At the same time, studies have also documented that exhibit designs that incorporate too many interactive features can lead to misunderstandings and to visitors feeling overwhelmed (Allen & Gutwill 2004). Several studies show how exhibitions often fail to support students in reflective thinking, to facilitate understanding of explanations and theories and even result in retention of misconceptions about scientific phenomena (Land 2000, Achiam 2012). More specifically, studies of interactive exhibits show that in some cases they actually seemed to *teach* misconceptions (Borun, Masey & Lutter 1993), and in other cases that visitors constructed knowledge that was not in accordance with canonical science (Anderson, Lucas, Gins & Dierking 2000, Achiam 2012).

Studying interactions in museum exhibitions is important in order to advance exhibition design and the design of interactives. In particular, there is a need to develop a didactic and systematic framework for analyzing and designing learning interactions with interactive installations in exhibition spaces. There is also a need for a shared terminology to articulate the relations between the designed features of interactives,

the learners' interactions and learning outcomes (e.g. what kinds of design features may support particular learning outcomes) (Mortensen 2011). There is a further need to develop a framework addressing how design processes can be planned and managed (Smørdal, Stuedahl & Sem 2014).

Expand focuses on the relation between exhibition design and learning design, and focuses on how object-based learning and its socio-cultural context may be conceptualized as part of the ecology of interactives in exhibitions. By involving science center educators in exploring how installations do or do not fulfill their learning aims, Expand explores methods beyond established front-end and formative evaluations. Two master students are currently studying interactions with installations based on ethnographic video analysis in combination with surveys. Rebekka Bjørneberg Castro, Department of Informatics, University of Oslo studies interactions with installations, focusing on engagement in play, and Hedda Kvaal Dunker, Section for Education, focuses on how prior knowledge affect young people's motivation to interact with installations.

b) The impact of science centers for science engagement

This focus area will address the overall research question: What impact do science centers have on the strategy for strengthening mathematics, science and technology in schools and in out-of-school contexts?

The Expand program is connected to the International Science Center Impact Study (ISCIS) initiated by the Association of Science-Technology Centers (ASTC) and The European Network for Science Centers and Museums (ECSITE). The ISCIS 2012–13 study is led by John Falk, Lynn Dierking and Mark Needham, and analyses the impact of science centers by determining the relative contributions that actual science center experiences may have on a range of desirable long-term science understanding, attitudes, and behaviors (International Impact Research Proposal). The focus of the ISCIS study is on a broader framework including four categories of impact: changed attitudes to science, social nature of the experience, career-related decisions, increased professional expertise in science centers and schools, and personal enjoyment. The survey is based on quantitative methods, and involves variables rooted in the assumption that public experiences at science centers improve the knowledge and understanding of science, and increase interest in and engagement with science. It is based on self-reports of learning, and has the goal of capturing visitors' articulations of the full extent, breadth, and depth of their knowledge and understanding of science resulting from experiences in science centers. Expand has conducted a survey based on a version of this instrument, focusing on young people in secondary and high school. In collaboration with the science centers in Norway the fall of 2013 the survey collected data from 850 informants. Marte Foss, Lillehammer College, will release the results of this survey after May 2014.

Expand also explores the role of science centers for science engagement by involving youth in a qualitative and participatory study. This subproject is based on youth participatory action research methods and earlier work focusing on involving young people in museum research (Cammarota & Fine 2008, Stuedahl & Smørdal 2011), and aims to achieve a better understanding of the

complexity of the development of aspirations. The project involves students in a science class in the upper secondary science program Greåker High School (2013–14). The school has an established partnership with Inspiria Science Center, and appreciates the practice-based approach of teaching the students basic research methods from social sciences. By way of their survey the students gain insight into young people's motivations for and interest in science, and define elements of science center experiences that young people prefer on their own terms. In this way an outcome of Expand will be to contribute to an understanding of science aspirations, but also how science centers can contribute to ongoing discussions of museums' role for general youth development and lifelong education (see e.g. Koke & Dierking 2007, Zipsane 2007).

c) Development of reflective practices

This focus area has a special interest in how science educators reflect on practice (Schön 1995/1983). The focus area concentrates on the following research question: How are arenas for reflection and professional practice development established and how can they be supported and shared in sustainable ways in science centers? The development of reflective practice arenas serves as a means to involve a broader community of science center educators in the research activities of Expand. The focus area on reflective practices spans a Ph.D project, developing a national network for science center research, developing a shared evaluation framework for science centers, and offering CPD modules to science center educators.

Science center educators' reflective practice in developing controversial socio-scientific issues (SSI) for school programs is a Ph.D. project, conducted by Ingrid Eikeland, Norwegian University of Life Science, that investigates how science center educators develop their professional knowledge and reflective practice during the design and testing of a new school program that focuses on controversial scientific questions. The focus on controversies in SSI is developed from the fundamental ideas of scientific literacy. Scientific literacy can be identified by the training of students' skills in using scientific information to make choices, engage in public discourse and debate that involves science and technology, and use scientific knowledge to think creatively and solve problems (National Research Council 1996). Controversial SSI is more specific as to engaging students in dialogue, discussion and debate by focusing on relevant controversial scientific topics such as cloning, GMO (gene modified organisms) or global warming (Zeidler & Nichols 2009). The PhD project will follow the development of a learning program focusing on controversies at INSPIRIA science center during 2014 and 2015.

The CPD module in learning with installations

The CPD module connects to ongoing discussion of the education of science center educators and the need to develop a shared language and shared practice (Tran 2007). While science center educators are involved in professionalization of their profession through associations and networks, sharing guidelines and thematic discussions, there still seems to be a need for initiatives that fill the gaps in educational development. Several initiatives for *continuing professional development* (CPD) have emerged to build a professional learning community. These initiatives are based on the

need to demarcate the knowledge and skills of the profession of science center educator. There are several studies on what museum educators do, but there is a limited body of literature on how educators do their work (Tran & King 2007). Studies show that while science center educators adapt to a higher level of complexity of student visitors' learning, for example in being attentive to students' prior knowledge, abilities and interests, their design of lessons is not very different from those given in school science classrooms (Tran 2007).

This forms the background to a CPD course developed as part of the Expand program and offered by the Norwegian University of Life Sciences. The CPD program has a special focus on methods and analytical frameworks for redesign of exhibition installations based on learning theories. The CPD course gives 15 ESCT points, lasts for a period of 9 months, and includes 4 workshops ending with a project report that will be examined. Each workshop presents a theme and a knowledge component that the science educators integrate into their practical work with an installation in their own center. During the workshops science center educators are involved in experimental and practical sessions to gain experience with different methods of documentation and observation of interactions in the exhibition. Different methods for studying visitors' interactions and learning from exhibits and installations are investigated collaboratively with the course participants, and evaluation needs and local conditions at the science center where the workshop is held is discussed in relation to need in other science centers. In between the workshops the course participants explore these methods in their own centers and report data and experiences with implementing the methods. The course participants' practical redesign of the installation in their own science center is based on implementation of the methods, theories and techniques gained from the course in the local context of their center. In this way, the CPD program engages science educators in research, and provides an arena where researchers and practitioners can share ideas and discuss implications based on practitioners' premises (Rickinson, Sebba & Edwards 2012).

Notes

1. Norwegian University of Life Sciences and Norwegian Centre for Science Education with Norwegian Research Council as associate partner.

Literature

Achiam, Marianne F. 2012. "A content-oriented model for science exhibit engineering." *International Journal of Science Education* 3:3, 214–232.

Allen, Sue & Joshua Gutwill 2004. "Designing with multiple interactives: Five common pitfalls." *Curator: The Museum Journal* 47:2, 199–212.

Anderson, David 2012. "A reflective hermeneutic approach to research methods investigating visitor learning." In Doris Ash, Jrène Rahm & Leah M. Melber (eds.). *Putting Theory into Practice. Tools for Research in Informal Settings. New Directions in Mathematics and Science Education.* Rotterdam/Boston/Taipei: SensePublishers, 15–27.

Anderson, David, Keith B. Lucas, Ian S. Ginns & Lynn D. Dierking 2000. "Development of knowledge about electricity and magnetism

during a visit to a science museum and related post-visit activities." *Science Education* 84:5, 658–679.

Ash, Doris & Jrène Rahm 2012. "Introduction: Tools for research in informal setting." In Doris Ash, Jrène Rahm & Leah M. Melber (eds.) *Putting Theory into Practice: Tools for Research in Informal Settings. New Directions in Mathematics and Science Education.* Rotterdam/Boston/Taipei: SensePublishers, 1–13.

Bell, Philip, Bruce Lewenstein, Andrew W. Shouse & Michael A. Feder (eds.) 2009. *Learning Science in Informal Environments: People, Places, and Pursuits* (Free Executive Summary). Washington DC: The National Academies Press. http://www.nap.edu/catalog/12190.html (accessed April 2014).

Boling, Elisabeth 2010. "The need for design cases: Disseminating design knowledge." *International Journal of Designs for Learning* 1:1, 1–8.

Borund, Minda, Christine Massey & Tiiu Lutter 1993. "Naive knowledge and the design of science museum exhibits." *Curator: The Museum Journal* 36:3, 201–219.

Brooks, Joyce A.M. & Philip E. Vernon 1956. "A study of children's interests and comprehension at a science museum." *British Journal of Psychology* 47:3, 175–182.

Brown, Ann L. 1992. "Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings." *The Journal of the Learning Sciences* 2:2, 141–178.

Cammarota, Julio & Michelle Fine (eds.) 2008. *Revolutionizing Education: Youth Participatory Action Research in Motion.* New York: Routledge Publishers.

Collins, Allan 1992. "Toward a design science of education." In Eileen Scanlon & Tim O'Shea (eds.). *New Directions in Educational Technology*. Berlin: Springer-Verlag, 15–22.

Falk, John, Jonathan Osborne, Lynn Dierking et al. 2012. *Analyzing the UK Science Education Community: The Contribution of Informal Providers.* Wellcome Trust.

Koke, Judy & Lynn D. Dierking 2007. *Museums and Libraries Engaging America's Youth: Final Report of a Study of IMLS Youth Programs, 1998–2003.* Washington, DC: Institute of Museum and Library Service.

Land, Susan M. 2000. "Cognitive requirements for learning with open-ended learning environments." *Educational Technology Research and Development* 48:3, 61–78.

Mortensen, Marianne F. 2011. "Analysis of the educational potential of a science museum learning environment: Visitors' experience with and understanding of an immersion exhibit." *International Journal of Science Education,* 33:4, 517–545.

Persson, Per-Edvin, Marianne Ødegaard & Sigurd S. Nielsen 2009. *Evaluering av Vitensenterprogrammet. Ekspertgruppens rapport.* http://www.vitensenter.no/files/091001-Evaluering.pdf (Accessed April 2014)

Quin, Melanie 2006. *Norwegian Regional Science Centers' scheme – assessment report.* http://www.vitensenter.no/files/Norwegian%20Science%20Centers%20Quin-report.pdf (Accessed April 2014)

Rickinson, Mark, Judy Sebba & Anne Edwards 2011. *Improving Research through User Engagement.* London: Routledge.

Sandoval, William A. & Philip Bell 2004. "Design-based research methods for studying learning in context: Introduction." *Educational Psychologist* 39:4, 199–201.

Schon, Donald A. 1995/1983. *The Reflective Practitioner: How Professionals Think in Action.* New York: Basic Books.

Serrell, Beverly 1997. "Paying attention: Duration and allocation of visitors' time in museum

exhibitions." *Curator: The Museum Journal* 40:2, 108–125.

Smørdal, Ole, Dagny Stuedahl & Idunn Sem, in print. "Experimental zones: Two cases of exploring frames of participation in a dialogic museum." *Digital Creativity* 25:2.

Stuedahl, Dagny & Smørdal, Ole 2011. "Designing for young visitors' co-composition of doubts in cultural historical exhibitions." *Computers and Composition,* Special Issue from Oslo, Norway 28:3, 215–223.

Tal, Tali 2012. "Action research as a means to learn to teach in out-of-school settings." In Doris Ash, Jrène Rahm & Leah M. Melber (eds.) *Putting Theory into Practice: Tools for Research in Informal Settings. New Directions in Mathematics and Science Education.* Rotterdam/Boston/Taipei: SensePublishers, 79–95.

Tran, Lynn & Heather King 2007. "The professionalization of museum educators: The case in science museums." *Museum Management and Curatorship* 22:2, 131–149. doi: 10.1080/09647770701470328

Zeidler, Dana L. & Bryan H. Nichols 2009. "Socioscientific issues: Theory and practice." *Journal of Elementary Science Education* 21:2, 49–58.

Zipsane, Henrik 2007. "Cultural learning as key word in transition from social client to learner." In *"The times they are a-changing" – Researching Transitions in Lifelong Learning – Conference Proceedings.* University of Stirling, Scotland.

Dagny Stuedahl, dr. polit, professor
dagny.stuedahl@nmbu.no

Merethe Frøyland, dr. scient, associate professor
merethe.frøyland@nmbu.no

Ingrid Eikeland, Ph.D. candidate
ingrid.eikeland@nmbu.no

Norwegian University of Life Sciences, Dept. of Mathematical Sciences and Technology
Box 5003
N-1432 Ås, Norway
http://utvite.org