THE MUSEUM OF THE FUTURE

TECHNOLOGY, SOCIETY AND SUSTAINABILITY LITERACY

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Jacob Thorek Jensen, Martin Aggerbeck,
Peter Bjerregaard and Birgitta Præstholm

danmarks tekniske museum

Danish Museum of
Science & Technology

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Foreword

I was five years old the first time my parents took me to the Danish Museum of Science & Technology. I remember thinking it was so much more fun than other museums. There were lots of things you could touch, and no one expected you to stand there just looking at the displays and speaking in a hushed whisper. That visit, my first encounter with fundamental scientific facts and methods, made me aware of the technological developments that these discoveries and inventions had made possible. I value such insight immensely, because it empowers us as human beings and helps us make informed choices about the future we all share.

Gaining insight into science and technology equips and enables us to develop new knowledge, to recognise solid facts and to think critically about the views and stances we encounter in our lives. But most importantly, insight into science and technology opens the door to the fascinating and wondrous world we are all a part of, and which we all have the opportunity to explore. The point is, we should not merely be users of technology. We should also be agents who shape it. This calls upon us to do even more to equip and enable individuals to live in an ever more technologically oriented society where the individual citizen needs to know about and understand the possibilities and potential risks that technology embodies. Success in this undertaking calls for a museum that is able to create relevant content for each individual citizen. A museum that can be enjoyed as an experience, and that speaks to the visitor's mind and heart.

A science museum should not only help citizens navigate capably through the constant stream of scientific and pseudoscientific information that flows around them every day. It can also address a modern society's need to build bridges between various disciplines and different types of knowledge. On the one hand, citizens are recipients of information; on the other, today they can themselves take part in producing content, thanks to new types of interaction and learning methods. The museum of the future will invite the public to become more co-creative. One precondition for this is a physical framework that can support the collective efforts of the museum, local citizens, curators, and scientists like me. By this I mean physical surroundings which can create value by fostering collaboration and community, and which host a living and forward-looking institution that can stimulate participation and creativity at all levels. A museum worth visiting often, and from an early age. A place we think of as part of our daily lives, just like cinemas, parks and supermarkets.

Anja C. Andersen,
astronomer and astrophysicist
Professor at Niels Bohr Institute, University of Copenhagen

Humankind is technological – towards a new Danish Museum of Science & Technology

Peter Bjerregaard and Jens Refslund Christensen

There is a widespread perception that technology is becoming ever more prominent in our lives. We are increasingly dependent on smartphones. We see artificial intelligence moving into areas that used to be exclusively the domain of human activity. And we hope technological solutions will save us from the climate crisis we have been pushing ahead of us for years. No wonder we feel obliged to rely more and more on technologies that few of us truly understand.

In a historical perspective, however, the question is whether our times really are as unique as we think they are. Imagine living in the early part of the twentieth century. In the decades around the turn of the century, the world witnessed a number of stunning innovations: moving pictures, automobiles, airplanes, wireless radios, electric lamps and electricity in the home, to mention just a few. It is not hard to see why many people felt either that the world they knew was collapsing, or that they stood on the brink of a bright technological future. This was also the age of the great World's Fairs – events that celebrated the technological advances of humanity – and the birth of many of the world's largest and finest technical collections. One of these would eventually evolve into the Danish Museum of Science & Technology.

Nevertheless, there is a fundamental difference between then and now. Looking across the modern technological landscape, it is obvious that we cannot cast caution and criticism aside and celebrate all we see. Humankind's achievements and tangible results are mind-boggling. We send people into space. We treat diseases with incredibly precise instruments. We build machines which, in a matter of seconds, process data volumes that exceed what humanity has produced over hundreds of thousands of years. Yet we also see that our technological capabilities continue to push the limits of what it means to be human, and we are not sure things are heading in the right direction. Rather, we know that not everything is heading in the right direction.

The science museum of the future – in a Copenhagen power station

The Danish Museum of Science & Technology, based in Elsinore, is currently working to set up a new museum in the buildings of Svanemøl-

leværket, a power station scheduled for decommissioning, built some seventy years ago in the northern reaches of the port of Copenhagen. Our plans for the coming museum basically revolve around recognising that as humans, we have views on and interactions with technology that are not only fabulously exciting, but fraught with dilemmas. For us, as museum professionals, it is precisely this tension between our own spontaneous fascination and all the problematic predicaments that makes it so incredibly exciting to be a science museum in this day and age. In recognising this contrast, we have found that it impacts our thinking about the coming museum in three different ways.

First, the history of technology is a central part of humanity's narrative. It is not meaningful to talk about technology without also talking about people. It all began when we found out how to use stones and bones as tools. Ever since then, technology has been a central aspect of being human. For better and for worse, our ability to develop and use technology has been absolutely decisive both for our individual daily lives and for the role humans play on Earth today. That is why science and technology are not (only) about great feats of engineering, but also about how we understand ourselves as human beings.

Second, while a museum of science and technology does not necessarily have the answers, it must be able to point to important issues that we all have to explore together. If technology is gaining ever greater significance in everyone's daily lives and affecting our options for acting in the world, then clearly no single group of professionals has a monopoly on being 'technology experts'. We want to use the museum to actively investigate the roles that science and technology play in our lives. Also, if possible, we would like to take a tentative look towards the future to evaluate both how we might use various technologies to create better lives, and how we can avoid their potential pitfalls. We want to do this through a broadly inclusive approach that involves scientists, researchers, companies, special-interest organisations and everyone who uses our museum.

Third, technology does not simply consist of stories and objects. Technology is a practice; something we do. To understand technology and its potentials, it is vital that we engage directly with the technologies we are discussing. That is why the bouquet of approaches offered in the new museum setting will include not only exhibitions and debates, but also workshops where visitors can gain hands-on experience with a variety of technologies and use them to create solutions. The future science and technology museum will also be a place where groups, associations and networks that work actively with technology will find a forum that allows them to reach out to a wider audience.

'Science – right where you are' and the new museum

The project entitled 'Naturvidenskab – der hvor du er' ('Science – right where you are') has been an important, indeed a defining element in our efforts to find our own particular role as the Danish Museum of Science & Technology among the wide range of science-related, technical and cultural history institutions in our country that reach out to the public. Through a number of experiments, large and small, we have examined what sort of role we can play as a museum, how we can engage with different groups around science and technology, and how we can work together. In this process we have benefited from having a broad-minded, candid and engaged advisory board, and the numerous professionals we have worked with outside the museum have opened new and sometimes unexpected doors. We thank you all for your support.

This book is not intended as a report on the work that has gone on under the 'Science – right where you are' project over the past two and a half years. On the contrary, our aim has been to compile a body of texts that can inspire further investigation along this important path. That is why we have asked some of the partners involved in the project to share their views on important issues here and now – at relevant museums, and in the field of science and technology education – and their ideas about potential paths ahead. We therefore hope that this book will also reach into the future, contributing ideas that are not only relevant to the new iteration of the Danish Museum of Science & Technology, but also more widely applicable in Denmark's teaching and outreach activities in these fields.


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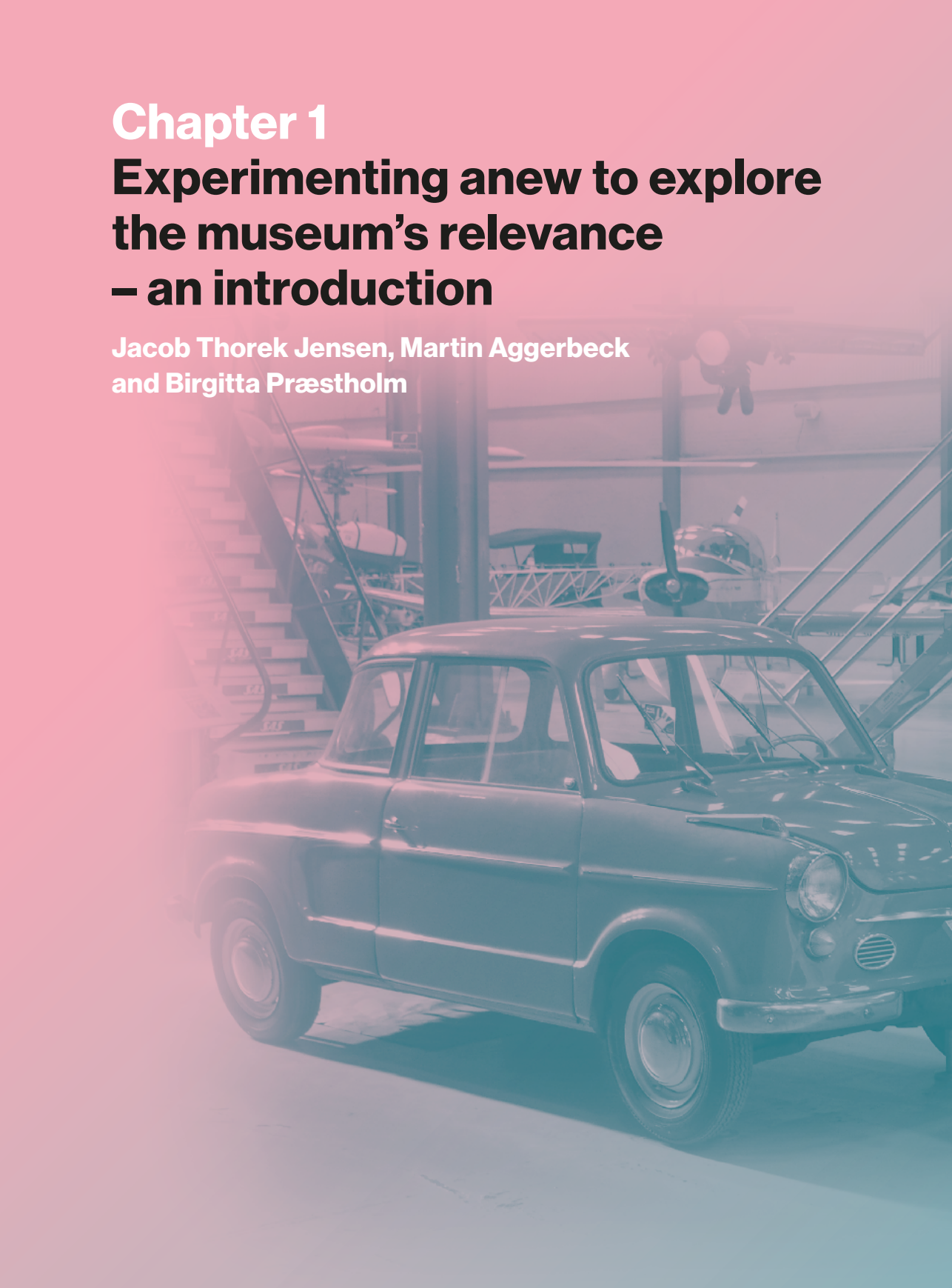
Part 1

Science – right where you are

Chapter 1
Experimenting anew to explore the museum's relevance – an introduction

Jacob Thorek Jensen, Martin Aggerbeck and Birgitta Præstholm



This chapter briefly outlines the project ‘Naturvidenskab – der hvor du er’ (‘Science – right where you are’), presenting learnings from the project and also introducing the book and its chapters.

'Science – right where you are' is a project carried out at the Danish Museum of Science & Technology between April 2021 and September 2023, investigating how the museum can communicate about science and technology in new ways. This project was made possible by a grant from the Novo Nordisk Foundation, and we take this opportunity to express our sincerest gratitude for their generous support. Without it, our plans and the project behind the book you are about to read would have come to nothing.

The aim of the project was to investigate how to develop the various ways our museum disseminates information, as we hope to encourage different types of visitors with varying backgrounds to relate to science and technology. Taking an experiment-based approach, the project has tested specific ideas and formats, thereby yielding insights on how to develop future exhibitions, public and educational programmes. These efforts have resulted in several concrete initiatives at our existing museum in Elsinore, north of Copenhagen. The project's results will also shape the future approaches, formats and practices we apply when communicating and teaching about technology and science – and the new home of the Danish Museum of Science & Technology is already on the drawing board, at the Svanemølleværk power plant in Copenhagen, which is scheduled for decommissioning in 2025.

The technological developments of the twentieth and twenty-first centuries stand on the shoulders of scientific discoveries and inventions. This makes science and technology extremely relevant, not only for professionals in these fields but for everyone, as these fields shape and give colour to our daily lives and the world we live in. That is why it is so important to include a wide range of perspectives in the way we communicate and teach about science and technology. This has become increasingly clear in recent years, with climate change and the ever more rapid digitisation of society giving rise to momentous shifts.

The chapters in this book can be read in sequence, in thematic parts or individually. Part 1 looks at actual experience and knowledge gained from the 'Science – right where you are' project, giving special attention to design and evaluation processes. Part 2 is about the museum's users and non-users, exploring different prospects of learning within the framework of the current museum in Elsinore and the new projected site in Copenhagen. Part 3 revolves around the museum's role in society, investigating how museums of industry, technology and science can promote the development of sustainable societies. Part 4 contains more detailed descriptions of the nine experiments scaffolding the project.

'Science – right where you are': structure, participants and partners

The project's aim was to develop and test tools, methods and practices by conducting nine different experiments. In the context of the project, an 'experiment' was defined as a specific initiative, either in an existing exhibit or as part of a newly developed exhibit, activity or educational programme. The first six experiments were standalone initiatives. After completing them, we spent a short time compiling our findings and sharing knowledge, then planned the last three experiments. All three had artificial intelligence as their theme. As noted, the individual experiments are described in Chapter 12.

The project team consisted of the three authors of this chapter, and the individual experiments were conducted in collaboration with internal and external colleagues and partners. In addition, the project had an advisory board consisting of postdoctoral fellow Katia Bill Nielsen, special consultant and programme manager Lene Christensen, associate professor Marianne Achiam, and director of learning and art interpretation Berit Anne Larsen. In Chapters 5, 7, 9 and 11 they share their own reflections about how the Danish Museum of Science & Technology and similar museums can communicate about technology and science in the future.

The project has also formally collaborated with the Science Museum Group in London. This resulted in a study trip to the United Kingdom and in two workshops held for all of the museum's staff by Science Museum Group representatives. We have also worked with the Danish body NEUC, The Evaluation and Development Centre for Science Education, developing evaluation tools to plan and evaluate the individual experiments.

On an ongoing basis we have involved the museum's staff in the project initiatives and held workshops where we have shared and discussed problematic issues, challenges and learnings. Finally, the project has investigated how the organisation as a whole can work towards changing its practice for communicating technology and science issues, and how we work with new initiatives at the museum.

Design methods

Museum exhibitions today are continuously growing larger and more costly. In step with this, their complexity is rising, not least because of the widespread use of scenography, soundscaping and digital and interactive installations. Therefore the need for thorough, well-structured processes and methods is also growing. That is why the 'Science – right where you are' project explored how a museum can work with an experimental approach in developing new exhibitions, activities and educational

programmes. The point of using experimentation is to open our eyes to blind angles and new perspectives as we move along in this process, at the same time gradually clarifying the framework and shape of each individual activity. Ultimately, our goal is simple: We want to become better at what we do.

At a practical level the project has worked with cyclical testing to gain good insights, within a relatively brief time span, into small projects or individual elements. We also applied design thinking to manage large and more complex projects, such as developing an entire exhibition. Chapter 2 explains the project's applied design methods in some detail.

Evaluation

We have had special focus on how to evaluate the project experiments, and on how to ensure that the experience and knowledge gained from our evaluations is integrated into the organisation as a whole, improving the way we develop new initiatives.

For each individual experiment, relatively early on we formulated a research question that would give direction to our development process and support us in planning and conducting ongoing evaluations and final evaluations for the given experiment. Before beginning the final three experiments, we formulated three principles that served both as a foundation for developing the experiments and as a framework for evaluating them. The project's evaluation elements, including the research questions and above-mentioned principles, are described in Chapter 3.

Making the museum relevant for a wider audience

Currently, the core group of visitors to the Danish Museum of Science & Technology consists of families with children, along with an over-representation of male adult users – the latter being an unusual sight in the Danish museum landscape. However, the Danish Museum of Science & Technology holds the potential to be, or to become, relevant for much wider sections of the public. Chapter 4 is about the museum's very real challenges in reaching new target groups, and about our work to develop new formats to gain relevance for some of the citizens who do not consider our museum as an option that appeals to them.

The project has found theoretical inspiration in the concept of 'science capital'. This concept was developed by researchers at King's College London, who studied why, despite having the same academic skills, some children and adolescents are more interested in pursuing a career in science than others. Their study showed that the interest felt by children and young people in these career paths is linked to their prior level of science capital.


Sven Viking

To briefly define the concept, a person's science capital is the sum of what they know about technology and science, how they think about it, what they do with technology and science, and people they know who are interested in technology and science. A person's science capital can be built up in various ways: through what they do in school, in the home and with family; at museums and similar external learning environments; through leisure activities; and through other experiences directly or indirectly linked to technology and science. There is also an element of thought and reflection, and of whether a person sees aspects of technology and science in what they do.

The Science Museum Group in the UK have studied how we can work concretely with science capital within the framework of a science museum. This group has developed tools and methods to make exhibitions, activities and communication less excluding, hoping to make more people feel they can link science and technology to their own lives. Science capital in general is explored in Chapter 5, both as a concept and as a framework for how people understand their surroundings, and it also shares observations that are based on a personal visit to the Danish Museum of Science & Technology.

The museum's learning potential

Learning is already a key aspect of the museum experience, and every year nearly 10,000 young people participate in teaching at, or use a materials package developed by, the museum in Elsinore. That is about one-sixth of an annual cohort of Danish pupils in, say, the seventh grade. Technological and scientific issues and devices exert an enormous influence on the daily lives of children and young people, adding to the importance of developing the museum's didactic and pedagogical practices as we look into the future. Our focus areas will include dialogue-based teaching, playful and exploratory approaches, and promoting critical reflection.

At the same time, museums need to develop a range of offerings that make them relevant to some of the educational institutions which, today, do not consider the museum as relevant to them. These include the country's vocational schools. At the Danish Museum of Science & Technology we spent several years examining (and will continue to investigate) how our museum can develop educational programmes and outreach services that are meaningful for vocational schools and their students, a group of citizens we have found to be significantly under-represented at museums. This is the topic of Chapter 6.

Teaching and learning at the Danish Museum of Science & Technology must take place in close interaction with the educational efforts that go on in society as a whole, and they must reflect the needs of Denmark's schools at various levels. This imposes new demands on the teaching and outreach activities that take place at museums, but it also opens opportunities to develop museums as external 'out-of-school' learning environments. Our educational efforts must actively play into the body of practice and knowledge that pupils know from their own school environment, while at the same time offering a learning space that goes beyond a conventional school framework. Chapter 7 develops and discusses these perspectives.

Interpreting and communicating about technology and science

The way we interpret and communicate about our fields at the Danish Museum of Science & Technology is based on our eminent collections of objects, accumulated over more than a century. Originally, the collection practices of the museum focused on material technologies and on the technical apparatuses and knowledge that had made a specific technology work. In recent years, however, we have focused increasingly on how technology affects individuals and society. The project 'Science – right where you are' has explored how the museum can work with science and technology going forward, not only to include and build upon our outstanding collections, but also to become clearer about our positions and approach to interpreting and communicating about science and technology issues.

The project is rooted in the fact that the museum's collections, which contain a wide range of objects from our daily lives, offer a firm foundation for conveying knowledge about technology and, consequently, about science. However, we also have the potential to work more freely with the science angle, cultivating science on its own merits and as a tool or lens through which to observe and understand the world.

The aim of this thinking is to pave the way for our visitors to more readily understand and participate in the public debate about science and technology issues. We also aspire to include themes such as artificial intelligence and climate change. This is a path the museum will pursue further in the years to come – both as we move towards setting up a new museum in Copenhagen, and after the new museum opens to receive visitors. Readers can find more in Chapter 8 about the reflections and perspectives associated with this transformation.

The Danish Museum of Science & Technology

is not alone in facing changes in the years to come. All over the world, science museums are working to find the best ways to serve as new frameworks for our common investigations and public debates about the role technology plays in our lives. Today, humanity faces a wide range of challenges, including climate change, increasingly digitised lives, and the possibility of modifying the genetic composition of people, plants and animals. Such topics make it abundantly clear that technological development is not merely increasing human capabilities by leaps and bounds, it is also propelling us towards ever greater dilemmas. Chapter 9 briefly outlines the history of such institutions and offers perspectives on their future.

The museum's role in society

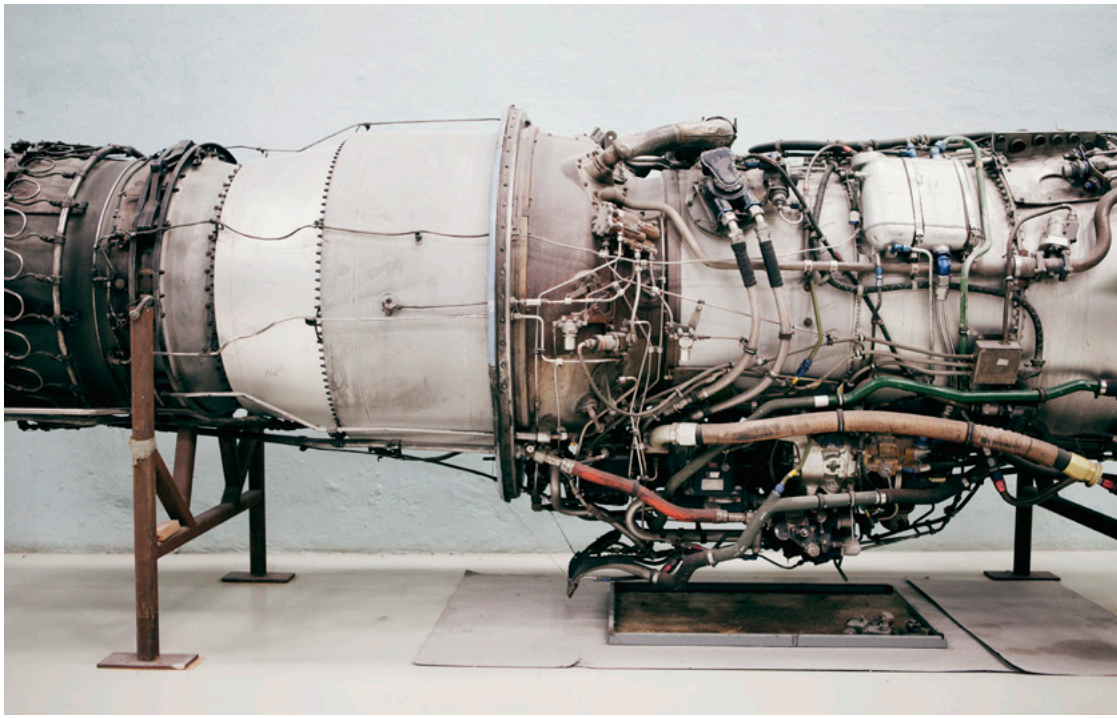
The project 'Science – right where you are' was part of a wider rethink of the Danish Museum of Science & Technology that arose with our plans to move, in the near future, to the buildings of a previous power plant in Copenhagen. On the one hand, this process is about how we want the museum of the future to look, sound, and feel, and about how it will find its place among other similar museums and institutions in Denmark. On the other hand, an equally important question is how the world around us regards us as a museum, not only in terms of our stakeholders and those who use the museum, but also in terms of the legal requirements set out in the Danish Museum Act.

The move from Elsinore to Copenhagen places the Danish Museum of Science & Technology in a unique position to rethink its role in society. With an excellent future location in one of Denmark's most iconic industrial structures, the museum will have a real opportunity to take on the role of a key actor in the national and international museum community. But important questions remain to be answered, such as: Which formats, methods and approaches should be the hallmark of an institution of this calibre? And how will the museum actively contribute to developing Danish society? These and other questions are discussed in Chapter 10.

Chapter 11 describes how the Danish Museum of Science & Technology is already using experimental formats in our existing museum to develop new formats that invite visitors to get curious, involving them in discussing and investigating some of the challenges that we – humankind – are facing. In specific terms this chapter deals with artificial intelligence and how we can create knowledge and learning processes by introducing new formats and initiatives at the museum.

Learning from our experimentation

Chapter 12 gives more in-depth descriptions of the actual experiments that made up 'Science – right where you are'. Short case presentations explain what we wanted to achieve with



the various initiatives, how they were developed, and what learnings we take with us as we move on towards the museum of the future.

We hope that, taken together, the contents of this book will inspire readers to draw from the variety of tangible approaches we offer in this publication to develop exhibitions, educational programmes, and activities at museums and other organisations that communicate knowledge. We also hope that the book will help readers understand the general challenges we face as science and technology communicators in a world where neither field can be captured as a distillation of neutral, objective facts. On the contrary, both fields lie at the crux of the great challenges we all face today.

We sincerely hope you will enjoy this book.

Experiments

Experiment 1

Newton i rummet (Newton in space)

EDUCATIONAL PROGRAMME, SINCE FEBRUARY 2022

Newton i rummet is an existing educational programme about Isaac Newton's three laws of motion and about gravity, on which we built to try out different ways of adapting the material to get more pupils to actively participate.

Experiment 2

Farlig viden (Dangerous knowledge)

ACTIVITY, SINCE APRIL 2022

Farlig viden is a free, self-guided riddle hunt in which teams of two or three visitors solve riddles together as they walk around the museum's various exhibitions. The riddle hunt was developed to create a facilitated, shared experience for young adults unaccompanied by children.

Experiment 3

The Future was Here

EXHIBITION, APRIL 2022 – AUGUST 2023

The Future was Here was a popup exhibition at Copenhagen Airport, allowing travellers to take a break and view some of the museum's objects. The aim was to reach out to some of those who would not normally visit the museum. More than 420,000 people visited this exhibition.

Experiment 4

Frihed på to hjul (Freedom on two wheels)

EXHIBITION, SINCE JUNE 2022

Frihed på to hjul is an updated version of the museum's bicycle exhibition, supplemented with three animated videos describing the historical evolution of the bicycle. The exhibition was intended to motivate visitors to take a more active approach to an everyday transport technology that is near-universal in Denmark.

Experiment 5

Opfind din drømmecykel (Invent the bicycle of your dreams)

ACTIVITY, SUMMER HOLIDAY 2022

Opfind din drømmecykel is a family activity where visitors can draw their own dream bicycle and afterwords 'ride' their own illustrated invention as they stand in front of a green screen. The activity was intended to motivate visitors to think more about an everyday technology they often take for granted.

Experiment 6

The Grand Departure

EDUCATIONAL PROGRAMME, MAY 2022

The Grand Departure is an educational programme developed specifically for students in vocational education programmes. The material was intended to reach out to visitors who normally do not visit museums and to show them that museums also offer topics and objects that are relevant for them.

Experiment 7, 8 and 9

Kunstig intelligens (Artificial intelligence)

EXHIBITION, EDUCATIONAL PROGRAM AND ACTIVITY, SINCE JUNE 2023

As the project worked with artificial intelligence as its theme, we developed a combined exhibition and learning space that contained board games designed to be used both for teaching and as a facilitated activity for holiday and weekend visitors. This arrangement explores the creation of a highly functional combined exhibition and learning space in which the objects on display are actively included in the teaching. The board games are an attempt to yield insights into, and spark discussions about, a topic that is both academically and philosophically difficult.

Chapter 2
Good processes: reining in, and running free

Martin Aggerbeck

This chapter presents specific examples and recommendations that are applicable to development processes in a museum context. While these are based on several well-known methods, including a learning cycle (Build – Measure – Learn) and design thinking, this chapter also discusses how to use research questions during the development process to give projects a direction.

As museum exhibitions continue to grow in scope, size and budgets, so does the complexity in their scenography, soundscapes and digital and interactive activities. This, in turn, calls for more thoroughly planned processes and methods. My aim in this chapter is to describe some of the guidelines we have used in developing the project 'Naturvidenskab – der hvor du er' ('Science – right where you are') at the Danish Museum of Science & Technology. Some we have already tried out; others describe directions we may pursue in the future.

The importance of good research questions

A research question aims to use keywords to set the direction for a test or a project. Using such questions in development processes can be extremely beneficial. The trick is to formulate a question that is open enough to allow freedom and open options in the design process, even while plotting a course that is sufficiently clear to enable design choices based on the question's focus points. One example of a research question, from the activity 'Invent the bicycle of your dreams' described in Chapter 12, is: 'How can we use playfulness and creativity to make people reflect on a near-universal, everyday technology?'

It is important that all members of the project group formulate the research question together. This gives rise to vital discussions, helping the group align their thinking and set a common direction for the process to come. If a research question leaves all doors open and closes none, it is not a good question. Its wording must reflect the decisions (to be) made about the direction a project will take. A further advantage in using a research question right from the start is that it can be used directly in a later evaluation process, by seeking to answer it.

Testing is crucial

Discussions may lead to many interesting ideas, but tests will tell you more. Some projects or sub-projects will offer obvious opportunities for testing to find the best solution. Here, an effective way of testing can be a cyclical design process in which one test gives input for the next. Such a cycle can, for instance, consist of three phases, as seen in the LEAN Startup model, which has three steps 'Build – Measure – Learn', as shown in Figure 1.[1]

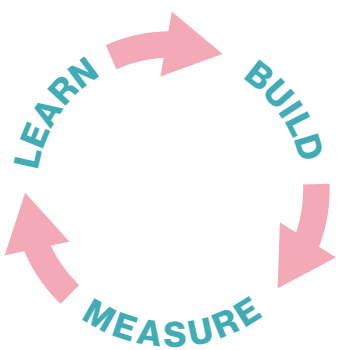


Figure 1. The test cycle from the LEAN Startup model

First, you set out a hypothesis or a specific idea you want to test (Learn). Next, you construct a prototype (Build), and finally you test and measure the results (Measure). Taking what you have learned from the test, you set out a new hypothesis (Learn) and follow the model towards your next test. The structure of this model is well suited to conducting many quick tests of partial elements, which is generally preferable to carrying out full-scale or final testing of an entire hypothesis or concept. If we put off testing until we have our final result, activity or display, it will be too late to make any major changes or adaptations at that stage. But if we test repeatedly as we go, the project can adapt or even change direction along the way. Visitors to the museum may miss a technical point that the developers find intriguing while fixating on other points elsewhere. This will enable the developers to consider a change of focus, or an alternative way to present their points.

Testing on colleagues and museum visitors

Many of us benefit from having our colleagues test out work-related input. We quickly show them an idea on the screen; have them read through an email before we send it to an external partner; try out an anecdote that may lighten up our next presentation. Such tests are extremely important, and they are a natural part of many people's work life. We seek advice from a colleague (an expert) who can rapidly form an opinion on our query.

Unlike professionals, visitors to the museum may find it hard to say how they would act in a specific situation if they are not actually confronted with that situation. Some visitors even think they are 'not doing what they're supposed to' at the museum when they don't read all the information panels and object labels in an exhibition, for example. That is why quite often as museum professionals we glean more information from observing visitors than from interviewing them with questions that go beyond specific details. If you do choose to interview visitors, you will often get more useful information from open questions such as 'What did you think of the film? And why?' than from questions like 'Did you read the information panels in this exhibition?'

'Dangerous knowledge' – a riddle hunt

As part of the project 'Science – right where you are' we developed a riddle hunt called *'Farlig viden'*, 'Dangerous knowledge', described in Chapter 12. When wording the research question, the team decided that the target group would be young adults unaccompanied by children, and that the aim of the riddle hunt was to frame a shared experience. Over time, our ideal users developed into 'a couple on a date', as we found this to be the situation in which young adults might have the most intense wish to share an experience. The research question gave this project a clear direction and defined our task: to design an

experiential activity that essentially requires at least two people.

The riddle hunters were to follow a route on a map of the museum, set out with numbered riddles and a narrative that develops as they go along. Each riddle has a 'riddle card' describing a specific task. During our development process the riddle cards made it easy to test riddles individually, and also in sequence. In this way, a single test could help us check and tweak the individual riddles and also study the suitability of the route through the museum. We tested twenty iterations, having made corrections large and small to the various elements. For some tests we used colleagues; for others we used visitors invited for that purpose.

We did our early prototypes in the easiest possible way: with riddle cards made using PowerPoint, riddle ideas indicated with a random piece of string, laminated paper clues, and a small cardboard box as a riddle station. This made it easy to adapt and change details for the next test run. The riddle hunt process was somewhat atypical in that some of the early tests actually required only one person, whereas later tests required two. In addition, the situation was comparable to that of a regular museum visitor who might want to solve the riddles while tracing their own trajectory around the museum. In other words, this differed from a test undertaken in one specific exhibition, where visitors might feel they were expected to read more object descriptions and spend more time than they would otherwise have done.

Meanwhile, we realised something important along the way: Our test-subject colleagues were at work and were therefore operating in work mode, task-delivery mode, get-things-done mode – and don't linger. This, however, is directly the opposite of the mindset we would expect in museum visitors. When they come to us, visitors are relaxed and have lots of time to look, listen, dive in and discover. Another obvious difference is that as museum professionals our colleagues might be outside the museum's primary target group, or possess specialist knowledge that our visitors don't have. That makes it important to be aware of what actually can and cannot be tested in each test scenario.

Designing exhibitions

Even though the 'Build – Measure – Learn' method is effective and results in a robust and thoroughly tested product, this type of testing is not possible or suitable for every kind of project. A museum exhibition, for instance, combines a cognitive experience with a bodily, sensory experience that occurs in a specific space and in a relaxed leisure situation. In this sense, testing specific elements of an exhibition may give the investigators a misleading impression of how they work in their exhibition context, and conversely certain elements may seem meaningless when tested out of context.

One way for designers to approach an exhibition in its entirety is to use 'design thinking'. This sort of process follows a model, for instance the Double Diamond, shown in Figure 2, which is quite well known and has four phases.

The Discover phase is used to study and research the problem or challenge at hand. The Define phase is used to delineate and describe problems and messages, thereby setting a direction for the solution. The Develop phase involves creating ideas and potential solutions. Finally, the Delivery phase is about selecting ideas and fleshing out the concept, and potentially also the solution. The model is iterative. This means that even though the model is drawn as a linear process, the activities will move back and forth among the individual phases. The two diamonds indicate visually how this process consists of 'opening' phases (Discover and Develop) where possibilities and options are created, whereas the 'closing' phases (Define and Deliver) call for decision-making.

Design thinking involves spending quite a bit of time on researching and defining the challenge before beginning to work on the solution itself. For instance, after the Define phase you may find yourself with a research question, a number of communication or teaching aims, or an outline that frames an exhibition. In this way, during the Define phase you find out what the aim of your process is, but you still have no indication of how to achieve it. Whether the project team formulates this as a 'goal' or a 're-

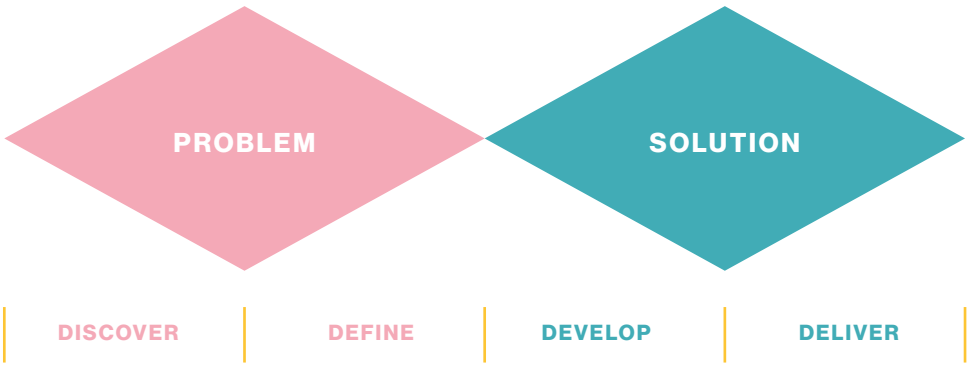


Figure 2. The Double Diamond model, published by the British Design Council[2]

search question' or an 'investigative question' is not crucial to the process. The most important thing is that the project team members all agree, giving the project a clear direction or path to pursue.

In the second diamond, ideas are created, hopefully an abundance of ideas. And hopefully a number of these will also be tested on users. One testing method could be the 'Build – Measure – Learn' cycle described above. In practice, you will be moving back and forth many times among and between the model's Develop and Deliver phases. When using design thinking for exhibition projects, it is often preferable to test individual elements and postpone the testing of large, assembled parts of the exhibition, or simply leave the latter out altogether.

Once the project reaches its actual production phase, the design thinking process will not be very useful. At this stage it is much better to use a production management method or system, such as Gantt charts.

An exhibition case: 'artificial intelligence'

When the museum developed the exhibition on artificial intelligence, also described in Chapter 12, our project team followed the Double Diamond model. We gave priority to a Discover phase spent exclusively on researching the topic through books, podcasts, news articles, and actual artificial intelligence applications such as ChatGPT and Midjourney. For the team members this – not having to think in terms of solutions from the outset – was a new way of working.

In the Define phase the team set out a clear framework for the points we wanted to convey to our visitors. As a result, three main areas emerged that we wanted to focus on: data, coding and intelligence. Figuratively speaking, coding is the engine that drives artificial intelligence, data is the fuel, and intelligence is (hopefully) the product. In this phase we also decided we would organise the available space to accommodate not only the exhibition, but educational programmes and activities as well. Needless to say, this did not reduce the project's complexity.

For the educational programmes and activities our aim was to have pupils, students and other visitors consider the philosophical aspects of artificial intelligence, using simple analog games as prompts. The project team therefore partnered with an external game designer, who was introduced to the task relatively quickly and easily based on the project team's research and the three main areas we had identified. Not long after, relatively speaking, the initial prototypes of the analog games were proposed and tested.

Dividing the exhibition topic into three main areas also gave the exhibition architect a framework, and the architect used these quite literally, structuring the space with clear delimitations that were easy to decode. The architect also used a simple design that matched the project's budget and fulfilled the project team's wish for a flexible space that could be reused for other themes at a later time.

Freedom and control

One of the greatest challenges in any large project is to keep your processes open long enough to explore a wide variety of options, yet at the same time to start making decisions early enough to define a direction for the project and find real solutions that are thoroughly considered and well executed. Not surprisingly, these two elements are contradictory, and achieving the right balance is no easy exercise.

At the Danish Museum of Science & Technology we work to strike a good balance with a process that has well-defined milestones along the way. At these milestones, we discuss the project's direction with colleagues and/or managers. Usually these milestones are scheduled in the process slightly after the anticipated transition from one phase to another. The aim of this timing is that usually the transitions are precisely the junctures where you discover important things you may have overlooked in the preceding phase.

I am by no means claiming in this chapter that the processes set forth above are the only way to manage an exhibition project. Nor am I claiming that an excellent exhibition cannot be made without tightly controlled planning. I would venture to claim, however, that good project management does ensure a minimum quality level; that it does reduce the mental strain on the project team; and that it does help you avoid major errors and unforeseeable pitfalls along the way.

At the same time let me emphasise that project management must never become a straitjacket that focuses the team's minds solely on ticking the right boxes, filling in all the documents, and taking the sure, straight and narrow path. There must be room to take chances and explore. There must be room to have fun, to take a playful approach – but yes, there are also times in a project planning cycle when these things are neither welcome nor beneficial. And in addition to creating a framework, a project model also gives the team a vocabulary to discuss the progress made, and the path forward, which can be just as important to a project as its actual content.

PROCESS TIPS

- Investigate your topic, and agree on the most important points you want to convey, both for the entire project/exhibition and for its various parts.
- Use your research question, findings list or a similar overview document to highlight the important parts of the project/exhibition.
- Test as many things as you can. It's better to run many small tests than a few large tests on the overall impression.
- Remember to be aware of when you are working in 'opening' phases of the process, and when you are in 'closing' phases. Frustrations arise quickly when one team member is trying to carry out and deliver on specific tasks (closing) while another is coming up with new ideas and tasks (opening).
- Stay aware of your process(es) and discuss, as and when needed, the things that are working and the things that are not working, either for the whole team or for your specific sub-team.
- Try to apply a method, such as design thinking, on a small project before scaling it up and applying it to a large project.

1 Ries, E. (2011). *The LEAN Startup*. New York: Crown Business.

2 https://www.designcouncil.org.uk/our-resources/the-double-diamond/.


How does AI work?


KETTEN


KOM
Føler du dig overvåget?


i starter her

Chapter 3
Building internal evaluation capacity

Majken Svendsen and
Karina Magnussøn Andresen

What is evaluation? What benefits does it bring? And how can an organisation build its own internal evaluation practice? These questions are addressed in this chapter, which is based on experience gained during process evaluations under the project 'Science – right where you are.'

All of us evaluate, assess and appraise, and we do it all the time. 'Does this dish need more salt?' We take a taste from the pot, add salt, stir and assess again. We could call such judgments or opinions 'everyday assessments'. In contrast, an 'evaluation practice' requires a systematic approach, delimitations, and parties who agree on both the definitions and the goals. The main aim is often to use the knowledge gained from the evaluation either to further develop the initiatives assessed, or to check them against certain criteria.[1]

One key difference between using one's own first impressions and gut feeling on the one hand and systematically evaluating on the other is methodology. Any systematic evaluation will be based on quality requirements for the methods used, one example being data reliability. How are the data to be assessed or analysed? When different people assess or analyse something, it is normal for them to do it differently and reach different conclusions.[2] In an evaluation process, however, the assessment criteria will be determined in advance, thereby increasing the reliability of the assessment. That is why, before conducting an evaluation, those involved must decide on its objective and what methods to employ. This is to ensure that the evaluation does not rely on everyday assessments, but on a systematic analytical effort within a framework of specified quality requirements.

Designing the evaluation framework for the project

With its project 'Naturvidenskab – der hvor du er' ('Science – right where you are') the Danish Museum of Science & Technology wanted to experiment on how to develop education and dissemination activities in different ways. At the same time, the museum wanted to learn from these experiments and from the processes used to develop them. The project evaluation framework was therefore designed as a process evaluation. Process evaluations are based on assessments of the processes used, and they link the various initiatives to goals. In doing this they can show what could be done to improve or develop the initiatives, and they also show how the interaction between the individual elements works.[3]

In addition, the museum wanted to develop its own evaluation practice, to learn more about data collection and analysis, and to become more systematic in collecting and analysing data.

The overall aims of conducting the evaluation activities were, therefore: (a) to help the museum evaluate its own dissemination activities in the future, and (b) to guide this particular project's development, adapting activities along the way and helping the museum to develop new dissemination tools.

An important aspect was that we, the two chapter authors, were not asked to act as operational evaluators. Our role was to help build in-house

evaluation skills at the Danish Museum of Science & Technology. We therefore chose to base our collaboration with the museum on the basic thoughts behind action research, experimenting jointly with various actions to foster development and change in the organisation.[4] For the same reasons, we also chose to structure our evaluation so it could be used as an instrument that would yield learnings, thereby supporting the development process that the project team and the museum were embarking on.

This set the guidelines for our role as external evaluators, which was to give the project group an opportunity to learn even as we ourselves learned which structural challenges (such as physical spaces and allocated resources) and opportunities the museum had. These were aspects that we had to incorporate and consider while developing appropriate evaluation tools. This, in turn, meant that as external parties we were still co-creating and facilitating the development of evaluation structures and tools.

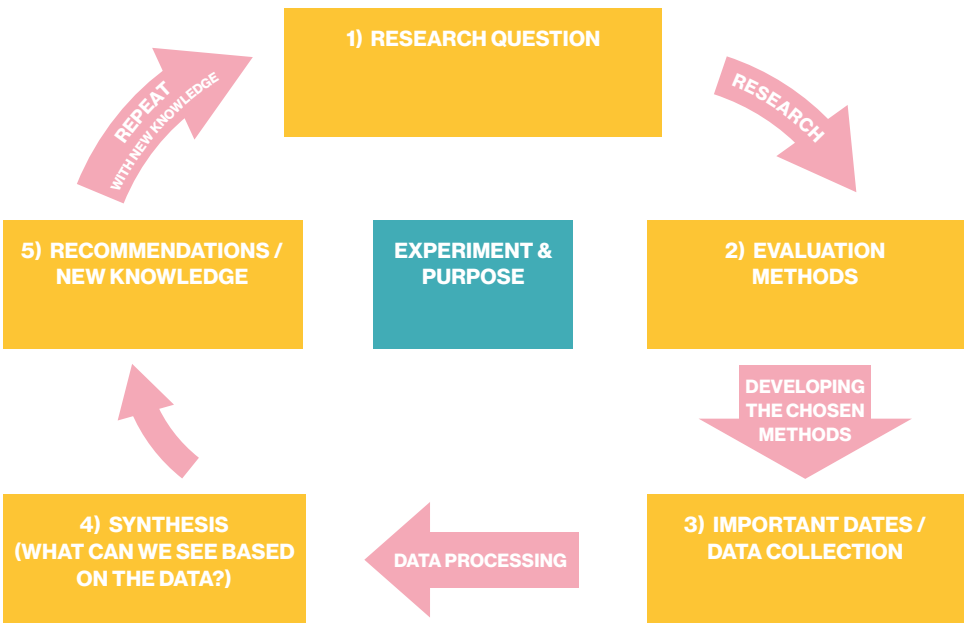


Figure 1. Circular evaluation model

In our practical work, we began by drafting an evaluation model to support the museum's own work in planning and conducting evaluations of its new dissemination activities.

We and our partners at the museum adapted this model together to make it meaningful for the project team to use at their museum, taking into account the challenges and opportunities of an out-of-school learning environment. The aim of the model was to guide the museum's team through the various evaluation phases.

The evaluation model – multiphase implementation

The following figure illustrates how we proceeded to implement the evaluation model. It visualises how, as external evaluators, we supported the museum's own subsequent implementation of the evaluation model, doing so in three phases. Each phase is described below in a separate section of this chapter. These explain which elements we, as external evaluators, paid special attention to supporting in the given phase, and they also include our reflections on the encounter between our intentions and real life.

PHASE A – Working hand in hand with the external evaluators

Evaluating a specific research question

A key part of implementing the new evaluation model was our role – in the capacity of external evaluators – in actively taking part in evaluating the museum's earliest experiments under the larger project. For one thing, we helped to shape the actual data collection tools, and to collect and process data. We also facilitated

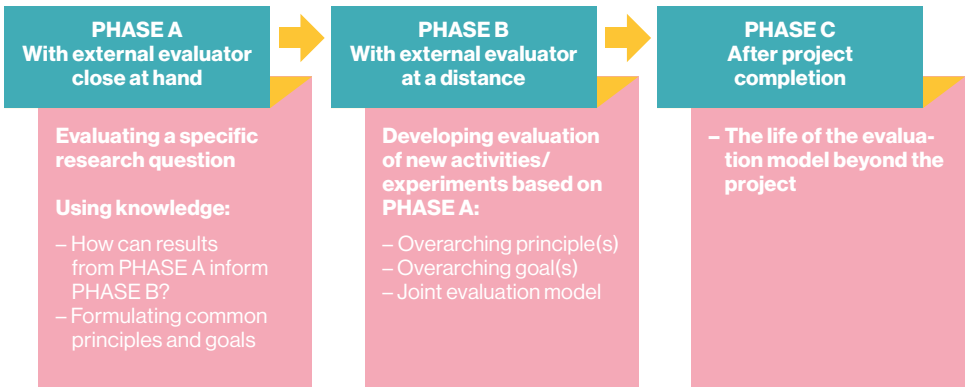


Figure 2. Implementing the evaluation model in several phases

processes for the museum's project team and support staff as they planned and carried out evaluation activities themselves. The aim of these hand-in-hand evaluation activities was to give the museum staff practical experience in systematically working their way through all three phases of the evaluation model. Step by step, during the initial stages of the project, this gradually equipped the museum's own staff to act as evaluators themselves.

General observations about using evaluation findings

The evaluation capacity of an organisation is not merely about being able to evaluate, or perhaps even being or becoming a skilled evaluator. It is also about being able to utilise the knowledge generated in the evaluation process – to improve the contents of an existing activity, for instance, or to develop entirely new activities.[5] As external evaluators, we therefore spent a good deal of time supporting the museum staff in working to translate the knowledge their evaluation produced into concrete learning points. To help create a common systematic framework for this work, we designed a 'self-evaluation tool' for use in the project. This tool consisted of a series of questions clarifying how members of the museum staff actually used the evaluation model. The aim of this was twofold: (1) to retain and document staff experiences in carrying out evaluations using the evaluation model, and (2) to stimulate staff members to actively think about what the evaluation results and findings meant, both for the *individual* activity/experiment and for the development of *other* activities/experiments.

Using evaluation findings to adapt the evaluation model

Throughout the 'Science – right where you are' project, the evaluation model was modified in dialogue with the project team. As it turned out, the project team did not find the circular model equally well suited to all their evaluations: From the outset the project was not designed to repeat all of the experiments developed during Phase A. The model was therefore changed to reflect a more linear-style, chronological evaluation model.

Using evaluation learnings to identify principles and goals for Phase B

As noted, not all of the project's experiments were meant to be repeated. As external evaluators we therefore chose to focus on supporting the project by investigating how knowledge acquired in Phase A could be used in developing new experiments during Phase B.

Once Phase A had been completed, we ran a workshop for the museum staff at which we introduced the concept of 'principle-focused evaluation'.[6] Based on learning points from Phase A, staff members were tasked with: (a) formulating an overarching *principle* for

Figure 3. Linear-style, chronological evaluation model

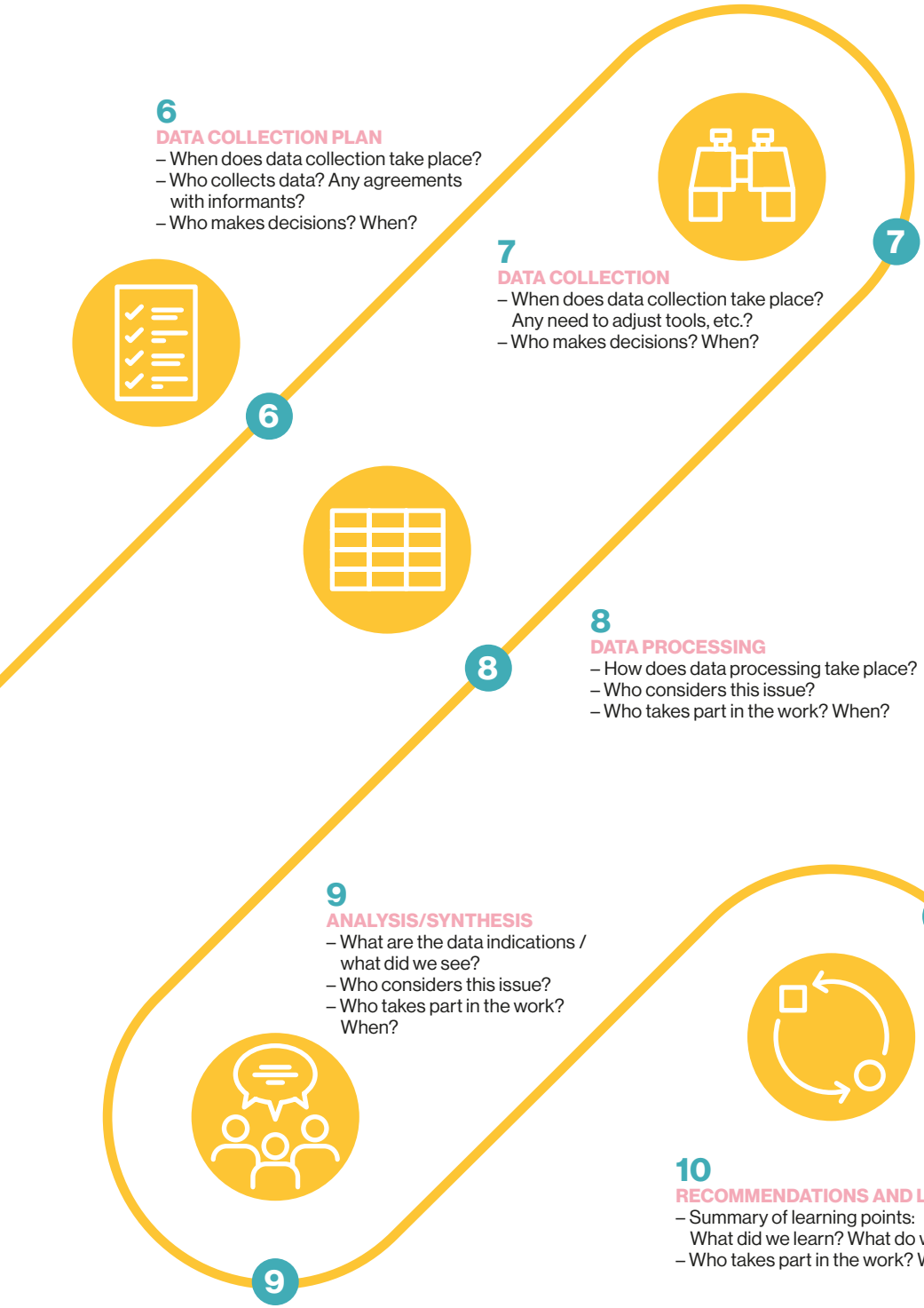
1
NAME AND PURPOSE
– What is the purpose of the experiment?
– Who makes decisions? When?

2
RESEARCH QUESTION
– Which research question is the evaluation intended to answer?
– Who makes decisions? When?

3
RESEARCH
– How are key concepts of the research question operationalised?
– Who makes decisions? When?

4
EVALUATION METHODS
– Which methods are relevant?
– Which methods are chosen?
– Who makes decisions? When?

5
DEVELOPING TOOLS
– Which data collection tools must be developed?
– Who makes decisions? When?



6
DATA COLLECTION PLAN
– When does data collection take place?
– Who collects data? Any agreements with informants?
– Who makes decisions? When?

7
DATA COLLECTION
– When does data collection take place? Any need to adjust tools, etc.?
– Who makes decisions? When?

8
DATA PROCESSING
– How does data processing take place?
– Who considers this issue?
– Who takes part in the work? When?

9
ANALYSIS/SYNTHESIS
– What are the data indications / what did we see?
– Who considers this issue?
– Who takes part in the work? When?

10
RECOMMENDATIONS AND LEARNINGS
– Summary of learning points: What did we learn? What do we take with us?
– Who takes part in the work? When?

developing new experiments, and (b) explicitly stating the overarching *goals* applicable to all new experiments in the project.

To support staff in formulating an overarching principle, during the workshop we introduced yet another tool in the form of a 'rubric'. And as follow-up after the workshop, staff members were encouraged to formulate another principle or two, based on the learning points and knowledge acquired during Phase A. The goal of these principles, along the lines of principle-focused evaluation, was both to support the project in establishing common, overarching evaluation criteria and to serve as drivers for the staff to develop new experiments during Phase B. In addition to this, they could form common ground, a foundation for the museum's evaluation efforts going forward.

Figure 4. Rubric for principle-focused evaluation

Principles The teaching/exhibition / dissemination activity		(Signs of) not adequate	(Signs of) adequate	(Signs of) good (mostly) / excellent
Principle 1: The activities are intended to stimulate the museum visitors to be active in actions, thoughts and dialogue.	**Visitors** (What does the visitor do?)			
	Facilitator (What does the facilitator do?)			
Principle 2: The initiatives should be based on recognisable everyday technologies, issues or experiences that are relatable for the target group.	**Visitors** (What does the visitor do?)			
	Facilitator (What does the facilitator do?)			
Principle 3: The initiatives should support shared experiences.	**Visitors** (What does the visitor do?)			
	Facilitator (What does the facilitator do?)			

IT IS IMPORTANT ...

- **to allocate time to, and make room for, reflection on staff members' own learning processes and competence development in connection with evaluation activities.**
- **to make a point of providing time for evaluation, given that planning, conducting and using evaluations requires time and resources.**
- **to develop an evaluation model that takes into consideration the practice or context in which it will be used, so as to ensure that the model is well suited to its purpose and that staff members feel a sense of ownership.**
- **to have staff members take part in the evaluation alongside the external evaluators, as this can give them new skills in evaluating, even as it helps to establish support systems within the organisation.**

FROM PHASE B (external evaluator at a distance) TO PHASE C (the evaluation model's life)

Developing and evaluating new activities/ experiments based on the findings from Phase A

Once they had completed the extensive task of systematically working through the phases of the evaluation model (as they evaluated the experiments in Phase A), the museum staff were on solid ground when embarking on Phase B. They had now acquired knowledge and experience not only in developing new experiments, but also in evaluating these experiments.

In order to retain and, if desired, subsequently examine and follow up on staff experiences working with the evaluation model and principles, we developed a joint tool: a self-assessment form. The idea was that for each completed experiment, the staff members would fill in a self-assessment form. This document would then serve both as a documentation tool for the project itself and as a way of conveying knowledge from the project to us – since, at this point, we were observing from the sidelines.

When the evaluation intentions meet real life

To create favourable conditions for a given body's evaluation capacity at an organisational level, there must be motivation, skills, and ancillary systems present to support the evaluation efforts in such a way that they become ongoing and reflexive.[7]

In the fact box, we share several of our observations after reflecting on which elements of this evaluation process could positively affect, first, the subsequent life of the evaluation model and, second, the ongoing efforts to build internal evaluation capacity at the Danish Museum of Science & Technology. These observations can also be seen as a sort of good-advice list for other external learning environments that may wish to build an evaluation practice of their own.

1 Andersen, M., Wahlgren, B. & Wandall, J. (2021). *Evaluering af læring, undervisning og uddannelse* [Evaluating learning, teaching and education], 229. Copenhagen: Hans Reitzels Forlag.

2 Dolin, J. (2020). *Evaluering på godt og ondt* [Evaluation for better and for worse], 23. Aarhus: Aarhus University Press.

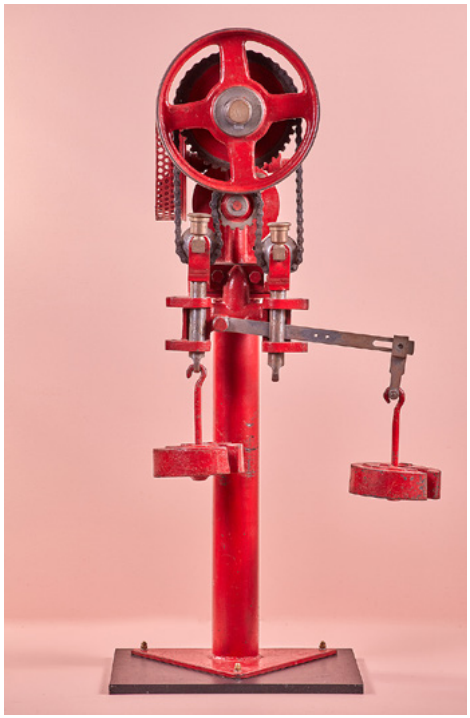
3 Andersen, M., Wahlgren, B. & Wandall, J. (2021). *Evaluering af læring, undervisning og uddannelse* [Evaluating learning, teaching and education], 175. Copenhagen: Hans Reitzels Forlag.

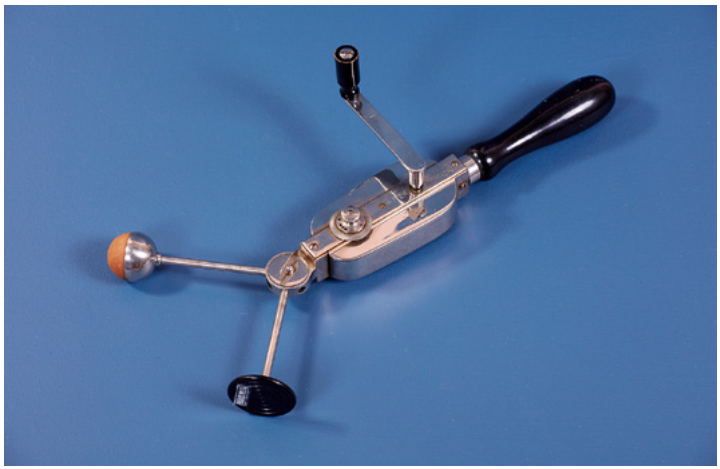
4 Frimann, S., Borup Jensen, J. & Sonne Kaa Sunesen, M. (2020). *Aktionsforskning – i et læringsperspektiv* [Action research – In terms of learning], 21–22. Copenhagen: Hans Reitzels Forlag.

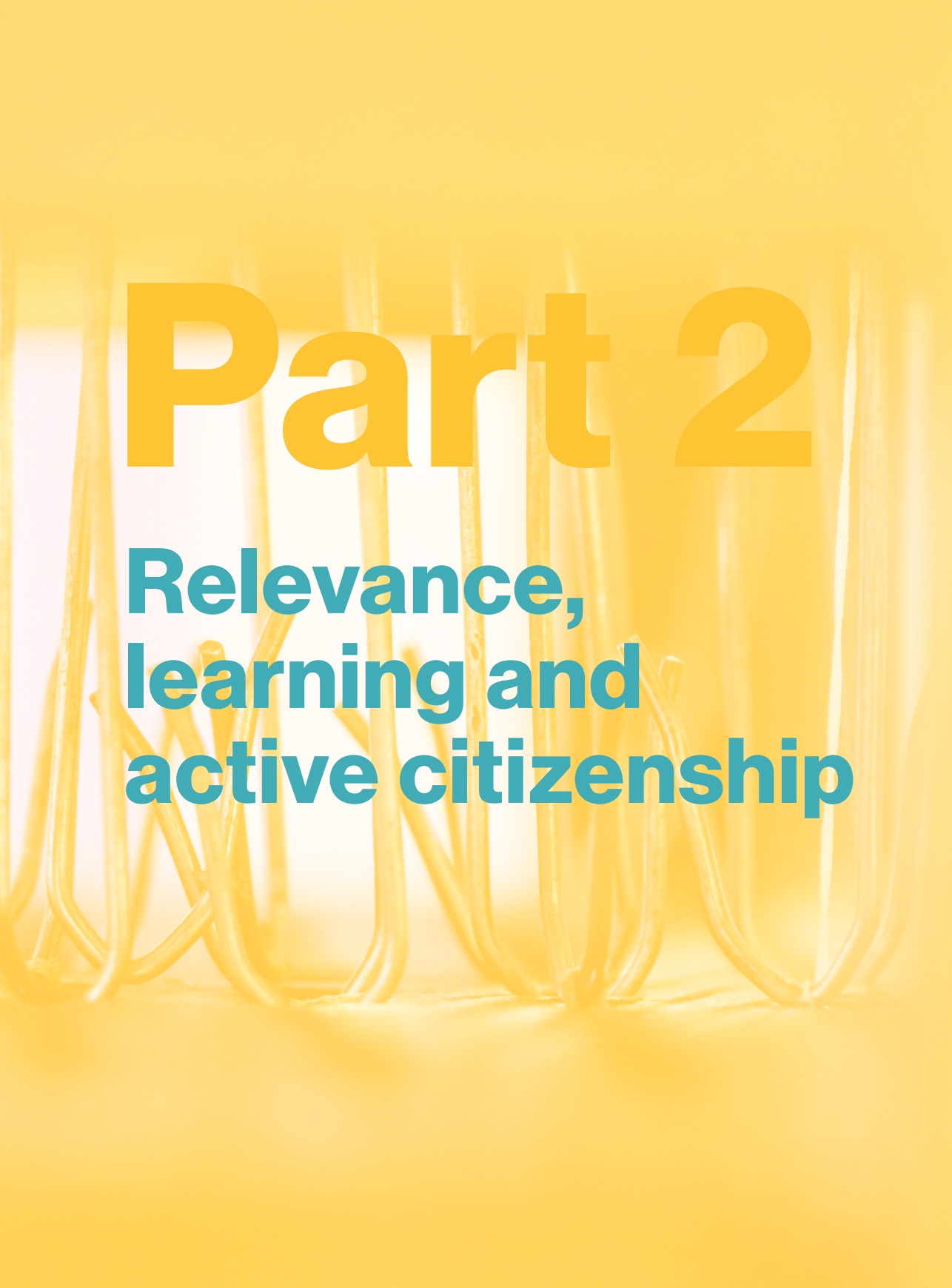
5 Dinesen, M. & Agerbæk A. (2015). *Realistisk evalueringskapacitet* [Realistic evaluation capacity], https://ineva.dk/realistisk-evalueringskapacitet

6 Patton, M. Q. (2018). *Principles-focused evaluation: The guide*. New York: Guilford Press.

7 Dinesen, M. & Agerbæk A. (2015). *Realistisk evalueringskapacitet* [Realistic evaluation capacity], 1.







Part 2

Relevance, learning and active citizenship

Chapter 4
‘I hate going to museums’

Jacob Thorek Jensen

There are very large differences among various social groups when it comes to who uses museums and how much they use them. But how can we open our doors to citizens who feel museums have nothing to offer them? To cater to these groups, we need to rethink our museum formats, communication modes, working cultures and self-perception.

In 2022, a grand total of 17.9 million visitors passed through the turnstiles of Danish museums. In a country whose population is just under 6 million, this number of unique visits corresponds to each Dane visiting a museum three times in one year, as Statistics Denmark and the Association of Danish Museums (ODM) optimistically wrote in their news bulletin on museum visits in 2022.[1] The question is, did every Dane actually go on three visits to a museum in 2022? The answer is, no, they definitely did not. Museums are good at attracting certain citizens, who go there often. For other segments of the population, which are quite large, you would have a hard time dragging them across the doorstep of a museum even once in their lifetime.

The skewed statistics for museum visitors and visits have been well known for years. Despite scores of initiatives to make museums relevant to a more diverse audience, the picture has hardly changed. But who are museum visitors really? And who are the people who never, ever go to a museum? Can museums do anything to become relevant and attractive to those who do not use them today? This chapter revolves around these questions, and it builds on experience and learnings from 'Naturvidenskab – der hvor du er' ('Science – right where you are'), a project at the Danish Museum of Science & Technology. The project goals included investigating how the museum can become relevant to some of the citizens who think that museums have nothing to offer.

The museum's users and non-users

A national Danish user survey conducted by the Agency for Culture and Palaces has documented that the core visitor segment at the Danish Museum of Science & Technology is families with children. In 2022, a remarkable 62 per cent of the groups visiting our museum included children aged 0–15. This is far above the corresponding proportion at other museums, which show an average of 20 per cent on this statistic.

Another prominent group at our museum consists of men, who in 2022 made up 57 per cent of our visitors. This figure is also remarkably above the corresponding statistic for other museums, where men, on average, make up 36 per cent of visitors. This puts the Danish Museum of Science & Technology among a small, select group of Danish museums with a preponderance of male visitors.[2]

At our museum we have a challenge in being relevant to citizens with short-cycle higher education qualifications, vocational training certificates and similar skills profiles. This is a paradox, because in so many ways our collections are linked to a wide range of crafts, trades and skilled jobs. One would therefore expect the museum to be capable of attracting more

It is important that museums in general become relevant for all citizens, given that culture and cultural heritage are things we share – things we produce together.

visitors with vocational training, rather than having such a massive over-representation of citizens with higher academic degrees.

However, this problem is not unique to the Danish Museum of Science & Technology. We see the same pattern in the vast majority of museums across Denmark, with citizens who left school around age 16 or completed vocational training being severely under-represented. In 2022, this group made up 25 per cent of visitors to our museum, and 19 per cent of visitors to Danish museums in general. Meanwhile, they make up a good 51 per cent of the Danish population aged 15–69.[3] In other words, our country has a very large group of people who do not use the Danish Museum of Science & Technology, or any other Danish museums.

Some citizens with short-cycle education also belong to a group that generally has a low level of cultural consumption – 'culture' in this context meaning museums, cinemas, libraries, sports matches and similar events. According to Statistics Denmark, the figure for low cultural consumption in people 16 years and up is 28 per cent.[4] This segment of the population generally perceives the classic or conventional cultural offering as irrelevant or unattractive.

The feeling of not belonging

One objective of our project 'Science – right where you are' was to investigate how the museum can become relevant to some of these citizens. Among other initiatives, we have developed a special educational programme for students in vocational training programmes (described in Chapter 12) to explore how we

can make the museum a place they perceive as relevant to them. The initial position was by no means encouraging.

Many of the students in this group said they found museums boring. One student even shouted out on arriving at the museum: 'I hate going to museums', and another said as he walked around the exhibitions in the museum: 'I can feel I'm not on my own turf.' It therefore quickly became clear that we had to think beyond our traditional formats to approach this group of students in a relevant way. The educational programme was designed to enable the students to be physically active along the way, including many changes of location, various tasks to solve, and many amusing stops and opportunities to have fun together. After the visit, several of them expressed that they did have fun, and that their visit had not been 'what visiting a museum is usually like'.

Our hope is that educational visits of this sort can change this group's perception of what a museum can *also* be. However, it will hardly make them frequent visitors at our museum or any other Danish museum. It will take substantial changes to make them feel that they (and other visitors) can use the exhibitions as more than a backdrop for a specifically tailored educational programme; to feel that the museum also anticipates and caters to their interests, behaviours and needs.

Thoughts on relevance: 'relevant' to whom?

I believe it is important that museums in general become relevant for all citizens, given that culture and cultural heritage are things we share – things we produce together. This means that there is a need to develop an open, inclusive object-collection practice at museums, precisely because they define what cultural heritage *is*, and what it *is not*, through their efforts to collect, register and preserve objects for posterity.

Museums have a legally defined task, namely (in my own translation) to work to 'create topical knowledge about cultural and natural narrative and to make this accessible and relatable' and to 'develop the utilisation and significance of cultural and natural heritage for citizens and society.'[5] This is a task that many museums handle well – for a select fraction of the population. I am not arguing that everyone ought to be forced to visit museums on a regular basis; but when such a large proportion of Danish citizens never use museums, then, generally speaking, the sector has a problem.

To put it bluntly, despite the innumerable inclusion initiatives we have seen in recent decades, museums have not been able to make themselves relevant to a significantly larger or more diverse part of the population. Instead, those who already use museums visit them more

often. Obviously, each museum must define the target groups to which it wants to be particularly relevant. However, as museums we must be much more prepared to look towards some of the groups in the population who never or very rarely use museums. One of these is the segment who have or are working towards vocational training. At any rate, this must be part of the ambition for the Danish Museum of Science & Technology of the future.

In my view, the Danish Museum of Science & Technology has a distinct potential when it comes to being relevant to some of the people who do not use museums. The point is that in a society like Denmark, technology and science are an integral part of living. We are all in touch with a wide variety of technologies every single day, and they are decisive to the way we live our lives – for better and for worse. That is why it is important that we exercise critical thinking in how to live with technologies in the future. This should be directed not only towards a small group with a special interest in or flair for technology. There must be an opportunity for everyone to participate in the democratic debate about the role technology should play in our society. This is where I see the Danish Museum of Science & Technology as a mental and physical forum that can scaffold meetings, dialogue, studies and investigations into how we can live with and alongside the technologies of the future.

The museum as an open house

If museums are to be developed into places where more people find themselves at home, or at least feel welcome, then we need to change the mindsets and practices of museums. There is an unspoken code of conduct, a certain way to behave when one visits a museum. Perhaps we need to challenge this code and start to think about how more people, and more different kinds of people, can use museums in new ways.

Museums must become even better at developing formats and physical spaces that people can use in various ways, thereby allowing them to meet different needs. In my opinion, we need to move beyond the conventional museum mindset, the silo thinking that characterises the museum community and the cultural sphere at large. A place like the Danish Museum of Science & Technology should certainly have staged, sensory-based exhibitions, but it should also serve as a framework for workshops catering to children and adults, for theatre performances, concerts, social dining events, literature events, debates, LAN parties and Fix-it-yourself cafés. There are countless opportunities to bring the museum's objects and expertise into play in new and innovative ways, thereby helping to generate new knowledge, insights, learnings and experiences that point towards new visions for the future.

This calls upon us, as museum professionals, to rethink our formats, communication, working culture and self-perception – at least if our aim is to succeed in becoming public places where many more people feel a sense of belonging or even ownership. To do this, we will need to do several things: to bring other skills into the museums' organisations; to develop new methods and practices for our curatorial work; to integrate the way we think about our space-specific and digital communications; and to be more accessible and appealing to the citizens we so desperately want to address as relevant and engage with in meaningful dialogue.

1 Statistics Denmark (2023). Museerne havde 17,9 mio. gæster i 2022 [Denmark's museums had 17.9 m visitors in 2022]. *Nyt fra Danmarks Statistik* [News from Statistics Denmark], 11 May 2023, 164; ODM – The Association of Danish Museums (2023). Nye tal: Museerne havde 17,9 mio. gæster i 2023 [New numbers: Denmark's museums had 17.9 m visitors in 2022]. *Nyt fra ODM* [News from ODM], 11 May 2023.

2 Jensen, J. T. & Lundgaard, I. B. (2015). Museernes brugere og brugernes museer [The museums' users and the users' museums], 18–57 in Jensen, J. T. & Lundgaard, I. B. (eds.), *Museer – borgere og bæredygtige løsninger* [Museums – citizens and sustainable solutions] (Copenhagen: Kulturstyrelsen [Agency for Culture and Palaces].

3 Ibid.

4 Tassy, A. et al. (2021). Tre ud af ti har et lavt kulturforbrug [Three out of ten have a low level of cultural consumption]. In *DTS Analyse* [DTS analysis], 13 October 2021, 2021:15.

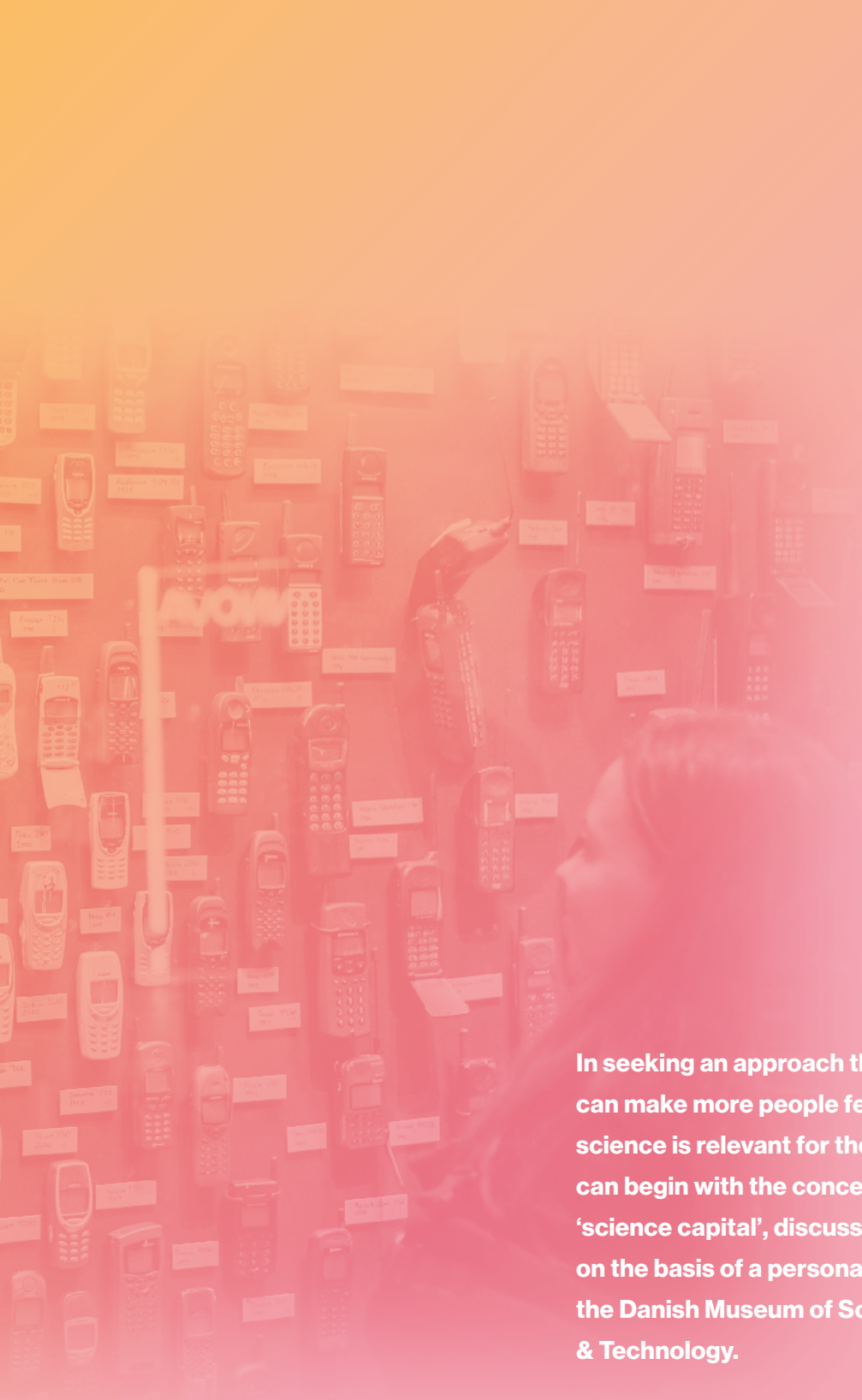
5 LBK nr. 358 af 08/04/2014 (Bekendtgørelse af museumsloven) [Danish Museum Act].


ZONE-R


DM i PAPIRFLY

Chapter 5
Who finds the museum appealing, and who does not?

Katia Bill Nielsen



In seeking an approach that can make more people feel that science is relevant for them, one can begin with the concept of 'science capital', discussed here on the basis of a personal visit to the Danish Museum of Science & Technology.

Stepping through the entrance to the Danish Museum of Science & Technology, one is met by an abundance of objects. A semicircle of vintage cars stands just where visitors pass into the large hall that makes up the first part of the museum. Behind the cars, a small passenger aircraft noses into the air. Several other airplanes are suspended from the ceiling, their long wings stretching out into the enormous exhibition space. The large hall has machines and objects everywhere, interspersed with partition walls that present information and screen off smaller spaces. There are also small object labels in front of the cars in the semicircle. But who are all these objects actually on display *for*? And what are visitors actually supposed to *do* with them?

According to the museum's charter, one of its objectives is to make knowledge relevant to and accessible for people; in other words, to interpret and communicate knowledge. I do research in the field of education, so for me it is wonderful to imagine museums as places where everyone, regardless of age, background or prior knowledge, can learn and experience new things. There are also a number of excellent arguments to support the importance of communicating and disseminating knowledge about technology and science. As a society, we need highly educated people who can fulfil the growing need for employees who possess such skills. On a personal level, it is important for individuals to become acquainted with these fields: they are a significant part of a well-rounded education, of a person's general knowledge of the world or, to use the German term, their *Bildung* or 'formation'.[1]

However, as just described in Chapter 4 ('I hate going to museums'), not everyone visits museums – far from it – and there are large differences among the groups who use Denmark's various museums. In this chapter, I introduce the concept of 'science capital' and reflect on how it can help us understand why some people may find it hard to imagine a museum, and the Danish Museum of Science & Technology in particular, as a place that has something to offer them.

Science capital, theoretically speaking

In the field of education, the issue of presenting people with opportunities to participate is a recurrent theme. Here, too, we see large differences and inequalities in who has access to, and who chooses to pursue, various educational programmes.

The entire school and higher education system has previously focused on the (lack of) interest among children and young people in disciplines that fall within the sphere we broadly refer to as STEM (science, technology, engineering and mathematics). Efforts have

mainly focused on under-represented groups, the general idea being that if only we could awaken an interest in these areas in children and adolescents, then more young women, for instance, would choose a STEM education or career path.

As recent research findings show, however, a lack of interest can by no means explain why young people reject STEM fields as a direction for their education or career. Instead, the British project ASPIRES found that social inequalities in such aspects as class, gender and ethnicity played a much more crucial role, and they developed the concept of 'science capital' as a theoretical approach that could help them understand these discrepancies.[2]

The researchers who developed this concept were inspired by the work of the French sociologist Pierre Bourdieu, who described capital as the resources a person can draw upon in various social contexts. He also believed there were three fundamental types of capital: economic, cultural and social. One way to understand this concept is by thinking of social inequalities as the differences between players in a card game. In this comparison, each player's capital can be seen as the cards in the hand they have been dealt. In the present context of STEM and science museums, science capital should not be regarded as a specific type of capital, but rather as a given person's total pool of science-related resources – what they know, what they do, how they think, who they know – because all these factors can contribute to their personal science capital.[3]

In Bourdieu's work, the concept of capital is closely linked to two other concepts: 'field' and 'habitus'. The first of these is particularly relevant to this chapter, as it refers to the social arenas in which we are active. We can compare a field to the rules of a game. There are a wide variety of social fields, each with its own set of rules. Although your cards may be the same, the rules of the card game will decide what you, as a player, can do with your cards in that specific game. Thus, the concepts of capital and field are intimately linked: the rules of the game (the field) determine whether the cards and the hand you have been dealt (your capital) have any value.[4]

The researchers behind the ASPIRES project use these concepts to explain why some young people find it easier to participate in science classes and see science as a field that has something to offer. Among other things, the project has pointed out that the resources young people have in their encounter with school situations give them different prerequisites – and discrepancies can easily be mistaken for different, or lacking, skills.

In that sense, the concept of science capital was not specifically developed for use in a museum context. However, it is an interesting

angle to apply as we try to understand why some people do not find museums appealing, or think museums have nothing to offer them.

A visit to the museum in Elsinore

On a cool day in April, my partner and I set out to visit the Danish Museum of Science & Technology. We both come from middle-class backgrounds, and while I have a social sciences degree, he has a degree in electrical engineering. I have been to this museum several times. For him, this is a first. We enter, and as we move through the museum among the many objects, I realise that his level of technical insight makes him notice very different things, compared to what catches my eye. For instance, we pass a display case filled with a large number of objects which, to me, are unidentifiable and look rather dull. Meanwhile, my partner sees what he later describes as perhaps the most prominent object in the entire museum: the actual apparatus used by the Danish scientist Hans Christian Ørsted when he observed electromagnetism – a groundbreaking discovery of immense importance to life in Denmark and all over the world.

One can easily think of the Danish Museum of Science & Technology as a treasure-trove of valuable objects, but taking a science capital approach one could also ask: What does it actually take for someone to be a visitor to the museum? What does it take for a person to participate and interact with the objects? What pool of capital are visitors expected to have when they step into the museum? And how does the museum support the use and development of various types or pools of science capital?

My own experience at the museum showed me that the knowledge and resources we bring with us as we enter a museum affect the way we look at its many objects. It also affects what we take home with us, and the way we link (or do not link) the visit to our daily lives. While my partner and I were visiting the museum, for instance, his technical expertise was what spurred us to have a conversation about the importance, to societies and to the world, of the many discoveries and inventions showcased by the objects on display.

If, following Bourdieu, we imagine the museum as a particular field, this enables us to view the museum as a place with a particular set of rules that frame how a person can act within its arena. Further, it enables us to see the museum as a place where certain types of capital can come into play and be acknowledged as valuable. This, in turn, prompts us to ask questions such as: What do we expect museum visitors to know in advance? Is it clear what people are expected to do when they visit the museum?

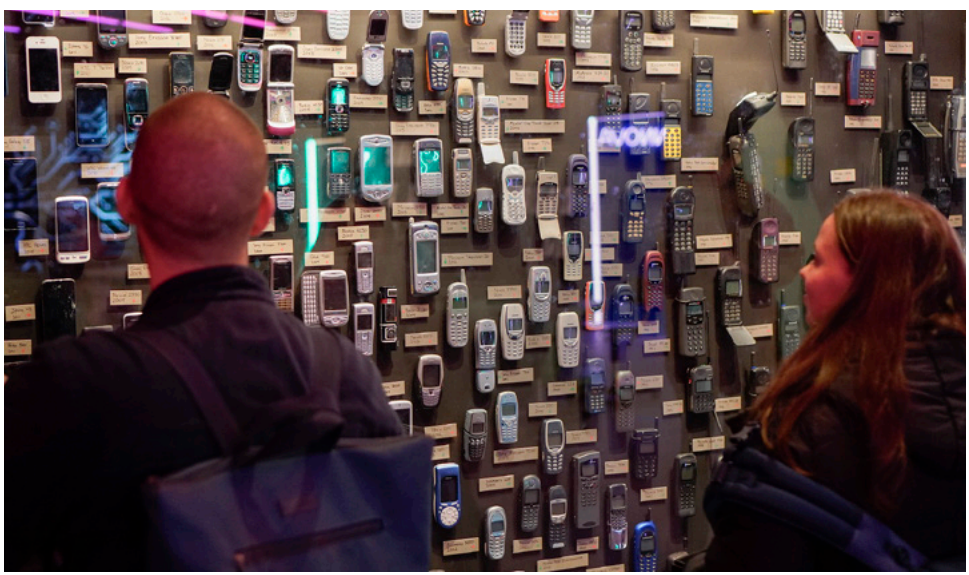
The concept of science capital does not readily answer the question of why some people do not visit the Danish Museum of Science & Technology. What this concept can do, however, is help us recognise some of the barriers that may lead some people to think the museum is not a place for them. Just as a lack of interest does not explain why more young people do not choose to pursue STEM degrees, it is easy to appreciate that a lack of interest does not explain why some people refrain from visiting the museum. Instead, taking a science capital approach, we might easily imagine that not everyone has the same preconditions for participating, and that some people may find it hard to see how the museum and its objects relate to them and their everyday lives.

1 Nicolaisen, L. B., Ulriksen, L. & Holmegaard, H. T. (2023). Why science education and for whom? The contributions of science capital and Bildung. *International Journal of Science Education*, Part B 0 (0), 1–14.

2 Archer, L., Moote, J., MacLeod, E., Francis, B. & DeWitt, J. (2020). *ASPIRES 2: Young people's science and career aspirations, age 10–19*. London: UCL Institute of Education.

3 DeWitt, J., Archer, L. & Mau, A. (2016). Dimensions of science capital: Exploring its potential for understanding students' science participation. *International Journal of Science Education* 38 (16), 2431–49.

4 Bourdieu, P. & Wacquant, L. J. D. (2009). *Refleksiv sociologi: mål og midler* [translated into English from the French original as: An Invitation to Reflexive Sociology]. Copenhagen: Hans Reitzel.

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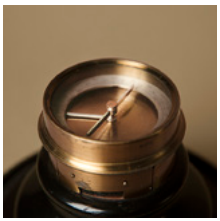


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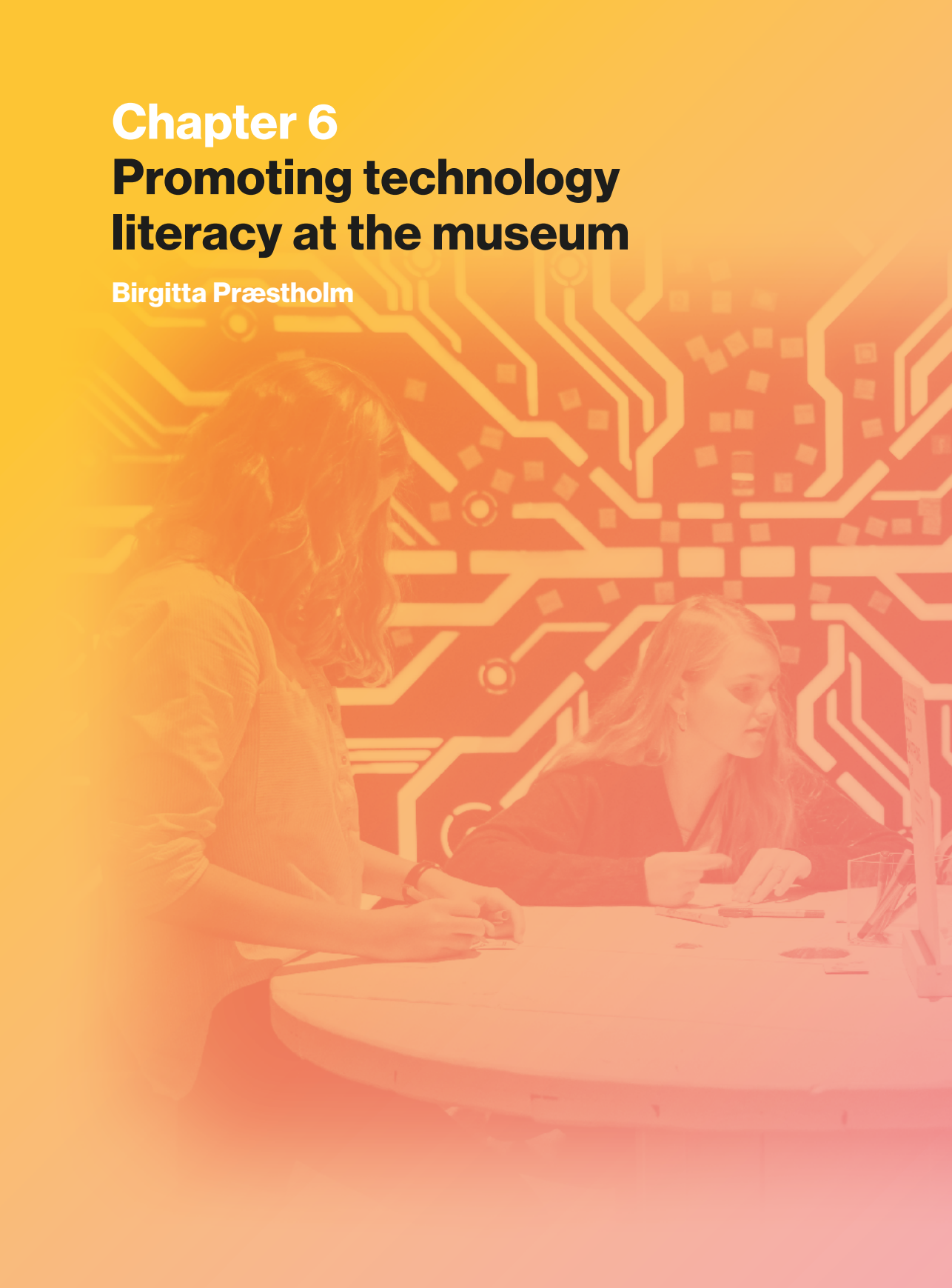
Chapter 6
Promoting technology literacy at the museum

Birgitta Præstholm



How should our museum organise and run its learning programmes in the new museum premises to be housed in the old Svanemølleværk power plant? And how can the Danish Museum of Science & Technology help more children and teenagers perceive technology and science as interesting – and as relevant to their own lives? These are the questions addressed in this chapter.

As the Danish Museum of Science & Technology continues its journey towards a new museum in the physical framework of a decommissioned power plant north of Copenhagen, the learning department explores what it will take to offer educational activities at a science museum for the twenty-first century. Where do our strengths lie? What is unique about our particular museum? What are the trends in society, and among politicians and educators? How can the museum offer children and young people memorable experiences they can carry with them as they move on in life?

This chapter is based on learnings and experience gained from the project 'Naturvidenskab – der hvor du er' ('Science – right where you are'), based at our own museum in Elsinore. Previously, our educational programmes revolved mainly around technological and industrial history. With this project, however, we wanted to investigate what role we, as a museum, can play in forming and educating young minds in science and technology. This chapter presents my own reflections, in my capacity as head of learning at the Danish Museum of Science & Technology, on how we can create more survey-based and relevant educational programmes, providing our young visitors with perspective and building on their spontaneous enthusiasm and engagement upon entering the museum. Our goal was to create a space where, during their relatively brief time with us, children and teenagers can investigate, be filled with wonder, play, and learn about the world's ingenious technical contraptions, scientific discoveries, inventors and inventions. We want to get them interested in the world and in the technologies that surround them – to arouse their curiosity and make them keen to learn more.

The need for skills that can create technological solutions for the future continues to rise. Specialist skills in the technical, scientific and digital fields are in demand among businesses and companies. Many initiatives have been launched, in Denmark and elsewhere, to create knowledge in STEM (science, technology, engineering, mathematics) fields and education programmes, and to make them more attractive – so far, with limited success. So where do things go wrong in our attempts to attract young people to scientific and technical subject matter? Numerous surveys and studies have looked into this. We know that the more children are exposed to science and technology through their family, friends, teachers who engage their interest, out-of-school learning situations and in their free time, the greater the probability that they will later choose a STEM path.

I remember my classes in physics – but nothing about physics itself

I recall my classroom lessons in physics and chemistry in the early 1980s – more clearly, in fact, than I can honestly say I want to. My teacher, Helge, always wore brown corduroy trousers and had a little leather book bag that he would smack down onto the table top, apparently to emphasise that the lesson was starting *now*. He smelt of pipe smoke and would puff away in class, eventually making a little cloud up under the ceiling. I remember the tiered classroom benches, the smells, the experiment area behind the partition. The glass-fronted cabinets full of bulbs and beakers and fluids. The Bunsen burners, cooker rings and valved gas lines, and the metal sinks spaced out along the pupil's workbenches. But I remember nothing of the subjects themselves. I had no clue as to why we were standing there heating glass beakers over an open flame. In short, I hated physics and I hated chemistry.

Today I think to myself: How can anyone hate the origins of the Earth? The elements, and Newton's laws of motion? Somewhere, something must have gone badly wrong. Somehow, Helge must have missed the mark. There were no hooks or pegs, no scientific coat-rack, no everyday examples to hang our topics from. There was nothing we were asked to investigate ourselves. All our activities were dictated from Helge's desk. My memory is intact. Oh yes, I remember Helge and our physics rooms well. I just cannot remember any of what Helge tried to teach us.

Children and young people need to be able to peg their knowledge to situations from their own lives, linking it to the world they live in. They must be able to somehow identify with the narrative. Children recall images and moods and good stories and knowledge that hooks onto something they know, say a leisure time activity. Another good device is to let them investigate things, wonder about things, find answers for themselves. In our own museum's educational programme *Newton i rummet* ('Newton in space', described in Chapter 12), school pupils investigate Isaac Newton's three laws of motion and also investigate gravity. They do this in exercises that use props they recognise from their daily lives, gaining an understanding of the subject matter because they can peg what they learn to everyday situations like playing ball, skateboarding, or riding a bus or a bicycle.

Seize the joy

It is fascinating to see what happens to young visitors when they enter our museum. They instinctively want to run. The objects simply draw them in – almost like the natural force that makes the Sun pull at the Earth. Several of our objects are large and represent technologies

young visitors know, even though many of these objects are older than their grandparents. There are also several objects they can physically walk into and touch. This fascinates them, motivates them, and it is precisely here we need to grab hold of them.

The museum has been working with dialogue-based teaching for many years. This means that educators base their approach on pupils' daily lives, coupling new knowledge with existing knowledge. Conventional one-way communication is not an option; the same teaching session may look very different in different scenarios. It all depends on what captures a specific group of pupils. The museum's own educators are trained to listen: What are the pupils saying? What do they bring with them? What is their view of reality? This may well mean that a set of teaching instructions cannot be followed to the letter. However, if a group of pupils are fascinated by a Tesla on their way to an educational programme in the museum's GAMER exhibition, then we stop and talk about the car and about Elon Musk. We catch hold of them where they are. Basically, we do all the things Helge never did.

Tech literacy at the Danish Museum of Science & Technology

In the Danish education and teaching system, technology literacy (or *teknologiforståelse*, which in direct translation means 'technology comprehension') is a new concept. Despite being interpreted in various ways, the point of tech literacy is to focus on the specific technological skills and competence profiles we need to promote in Denmark's education system.

Tech literacy, which may eventually end up as a subject on the primary school curriculum, covers several competence areas, mainly concerning digital technologies. This is obviously an area where our museum can contribute educational programmes that deal, for instance, with artificial intelligence, coding, robotics, smartphones and drones. In addition, however, we plan to make educational programmes that take a more analog approach to technology.

It is important for people to be competent at seeing through, and critically assessing, the many technologies that surround us, but it is also important to understand how they work. This would enable people, for instance, to repair some of the appliances and devices many of us use in our daily lives.

How does a piston in a combustion engine work? Why do scissor blades look like an X? How do you fix a punctured bicycle tube? Or fix the charger for your mobile phone? Skills like these are useful in terms of thinking sustainably and saving money.

In this context, as the Danish Museum of Science & Technology, we must also tap into

Quite often, the credit for a device will go to the engineer or inventor, but most of the objects at our museum would never have existed had it not been for the skilled craftspeople who made them.

the essence of tech literacy as a (potential) part of the school curriculum, allowing children to work with both analog and digital technologies on an equal footing. We can offer workshops on robotics and programming or artificial intelligence educational programmes, but such activities must also contain an analog element. These could include such themes as 'materials & craftsmanship' or 'product design', which would also enable us to differentiate our teaching and appeal to multiple types of skills and learning styles.

Focusing on vocational schools

As part of the project 'Science – right where you are', we have developed an educational programme designed for vocational students just starting secondary school on the Danish 'Basic introductory course, module 1' (see details in Chapter 12). Our main aim is to give them a fun, inspiring day. At the same time we wish to bolster their general knowledge by giving them a good idea of how their particular field arose, and how it fits into the bigger picture. This educational programme outlines technical and technological developments in Denmark, including some of the technologies that skilled craftspeople have helped to develop and construct – people who master a trade by virtue of the same type of training the vocational pupils are embarking on. Quite often, the credit for a device will go to the engineer or inventor, but most of the objects at our museum would never have existed had it not been for the skilled craftspeople who made them.

We hope to help restore the pride once associated with good craftsmanship and with learning a trade as a skilled professional. We

also hope that an educational programme like ours can make vocational school teachers and their students see the museum as a place that is relevant for them to visit, expanding the options in their classrooms.

'Green transition – your educational choice'

If we want to make science and technology more interesting than they were in the physics lessons of my youth, we must look at what is important to young people outside the physics classroom. Climate change is today's most momentous challenge, and many young people are worried about climate issues and their own future. Many are also committed to combating climate change. At the Danish Museum for Science & Technology, we decided to use this commitment as a linchpin. Our strategy was to pivot these concerns and take the opposite view, pointing instead to young people's opportunities to act, and showing them they can help combat climate change through the education they choose.

That is why, in 2021 and 2022, our museum hosted an education and career path event called *Grøn omstilling – dit uddannelsesvalg* ('Green transition – your educational choice'). Here, 55 certification and degree programmes in STEM, all focusing on sustainability, gave introductory presentations and hands-on demonstrations of what they had to offer. The target group was school-leavers from lower and upper secondary schools, and the two-day event attracted 1,500–1,800 young people in 2021 and in 2022.

At the green transition educational events we also sought to actively strengthen science and technology dissemination, hosting sessions that outlined the history of industrialisation and showed how development has improved living conditions in the Western world. But at the same time, we also zoomed in on how rising standards of living have impacted our planet and, not least, what is being done to address this.

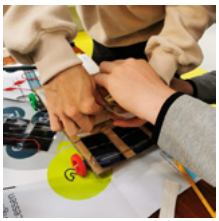
Arousing young people's curiosity

Our museum is an obvious place to help people understand technology, and to generate debates about how technology affects us. Our topics and objects are recognisable to young people and can give them a solid basic knowledge about technological progress and development. While visiting us, they can feel intrigued, curious and inquisitive, and they can explore and experience objects old and new.

We aim to support the curiosity and creativity of children and young people by taking a playful approach that makes history and science alive and relevant. We do not aim to teach them Newton's laws of motion by heart, but we do hope to forge links to their everyday lives and

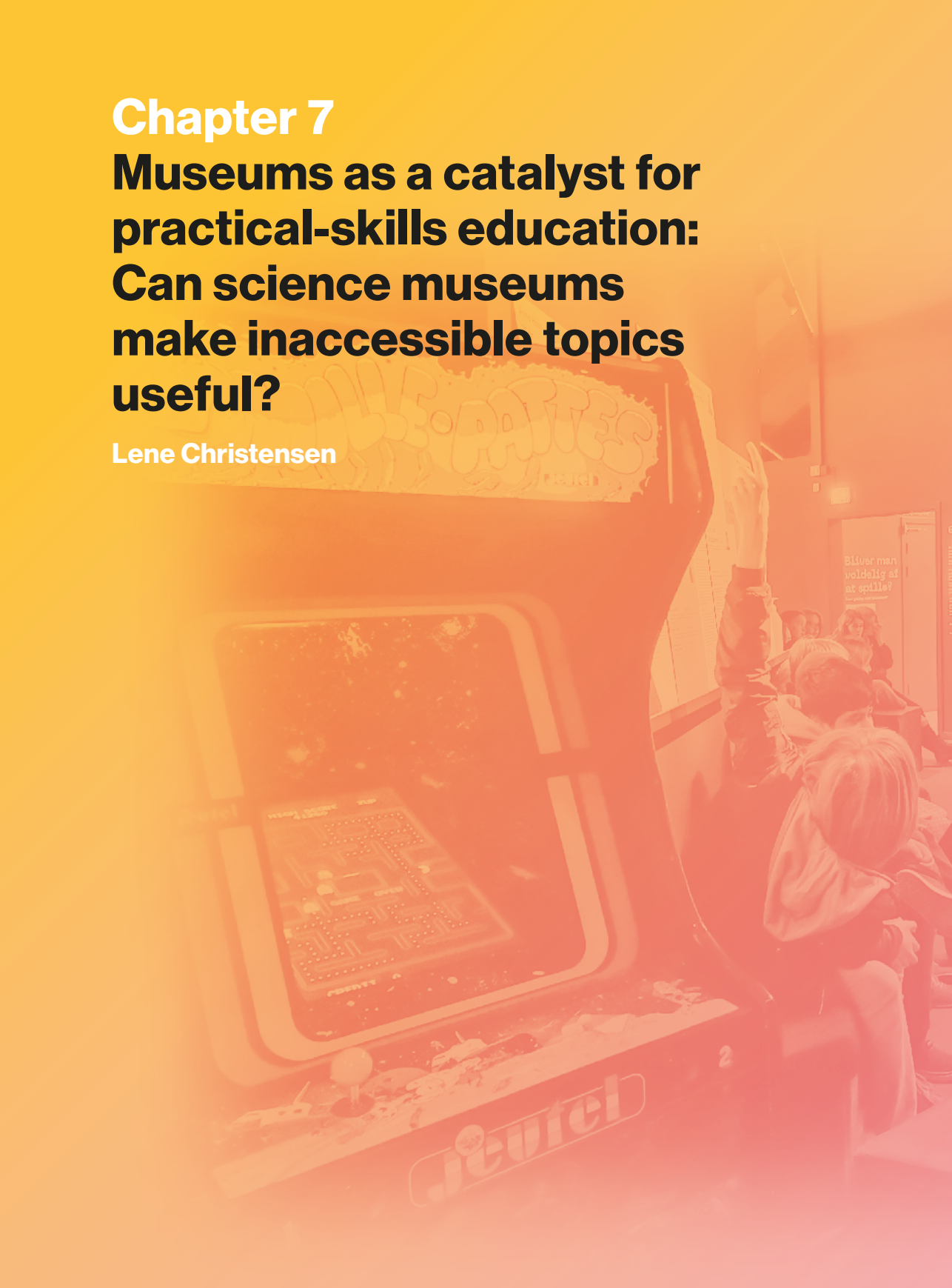
activities that make them curious about the world, make them want to keep on investigating after they leave us – whether they trip over a stone, see a satellite in the night sky or want to repair their own bicycle.

At the Danish Museum of Science & Technology, we want to create spaces where children and young people have a positive experience with technology and the scientific forces behind it. A space that offers a safe framework for learning, that builds bridges to the knowledge and experience they bring with them. A generous mental space, too, with ample room to wonder, reflect, make mistakes, try and try again, and play your way to reaching solutions and discovering new things for yourself.



Chapter 7
Museums as a catalyst for practical-skills education: Can science museums make inaccessible topics useful?

Lene Christensen



How can museums help children and teenagers learn about science and technology? And how can the Danish Museum of Science & Technology develop its unique position as an out-of-school learning environment? Addressing these questions, the author of this chapter focuses on dissemination and teaching practices that take a practical approach, bringing everyday utility value to the fore.

'We learned now to mount and fit an electric lamp, and I think that was pretty cool. It made me feel like I was a sort of "handywoman" myself.' This quote comes from Kia Børløs Isaksen, who is studying physical education at Viborg Idrætshøjskole, a folk high school in Jutland that specialises in sports. One of her fellow students there, Louise Nødebo Schwarz, agrees. For her, do-it-yourselfing holds an appeal all its own.

A number of Danish folk high schools – the country has about seventy of these live-in schools, a distinctly Danish type of privately run, formative learning environment with deep historical roots – offer a specific course called *Alt det, min far ikke lærte mig* ('Everything my father never taught me'). These courses typically highlight activities such as cleaning a clogged drain, hanging a picture straight and stopping a tap dripping. They are extremely popular, and are an eminent example of how young folk high school students from all walks of life are motivated by practical learning content that is genuinely useful. What does it take to help young people handle things on their own? And what does it take to enable them to be engaged, well-informed participants in debates about today's challenges?

Science museums (here: museums that deal with technical, technological, scientific and health themes) are good at putting public challenges on the agenda. Now more than ever, it is vital that museums focus on their role as cornerstones of society and conveyors of history, culture and general education (or *Bildung*, to borrow the German phrase for the Danish word *dannelse*, which literally means 'formation'). But could one role of science museums be to rewind, focusing on what is practical, basic, elementary, as part of the formative education we give children and young people? Can science museums take on a special role in this respect precisely because they have spaces, surroundings and objects that can serve as an excellent framework for practical, utility-oriented teaching?

Practical, applicable and real

A beloved child has many names, as a Danish saying goes. A popular term these days in Denmark is 'practical skills', often used by the country's current minister of education, Mattias Tesfaye (himself a skilled bricklayer) to describe what he and the current broad coalition government believe Denmark's schools ought to have more of – for instance, in announcing school reform plans in autumn 2023. Back in 2014, the previous reform of the country's public school system focused on concepts such as utility- and practice-oriented teaching. Across the system there are different terms and understandings of precisely what such terms mean. Examples are 'practical skills' and 'practicable/utility-oriented/reality-based' teaching, and it is

difficult to arrive at any uniform or collective understanding of them all. Each in their own way, various scholarly traditions and practice-based experiences are developing these concepts. Basically, however, they all agree that pupils are motivated by finding out how the topics taught can be used in various relevant contexts.[1]

Some teaching is already practical and utility-oriented. For example, pupils use their competences in algebra, geometry, reading or communication in their everyday lives. In contrast, science and technology subjects are sometimes challenged in this respect, with some teachers finding it hard to bring applied sciences into the classroom and use technology-based teaching methods themselves.

Motivation and formative education

One reason why practical skills are currently high on the Danish agenda is that studies point to rising pupil motivation when practical skills or utility orientation come into play. One study from 2023, published by the Danish Evaluation Institute, EVA, shows that a large majority of teachers (71 per cent) believe that practical-skills teaching holds the potential to increase pupil motivation (in my translation from the Danish):

Recent years have seen a growing focus on how teaching in the Danish comprehensive school system is typified by deskbound, result-oriented, written work. This sort of teaching is typically referred to as 'book-based' (see, for instance, the report *Undervisningspraksis i udskolingen* ['Teaching practices at lower-secondary level'], EVA, 2019), and it is held up in comparison to a more diverse and varied type of teaching, which contains more practical activities, including utility-oriented and reality-based elements. Both the stakeholders in schools and various professional educators have argued that compared to book-based teaching, practical-skills-based teaching can be a better way to motivate all pupils to participate actively in the teaching [situation] and thereby reap the greatest possible benefit from the teaching, both in terms of the subject matter and peer relations. Likewise, this type of teaching can help make the skills and knowledge pupils acquire at school easier for them to utilise – also outside a school setting.[2]

At the same time, a practical-skills approach can bring the formative element more into play, 'formative' understood here as a person's meeting the world through education, with the purpose of developing 'self-determination, freedom, emancipation, autonomy, authority, reason [and] self-activation.'[3] The formative element can sometimes seem rather abstract in school settings, but science museums can help pupils develop these qualities by letting them see and experience the practical utility value of their subjects, and by letting them

experience that learning and living as a citizen in their own society, Denmark, are two inseparable aspects of life. It is an advantage if their experiences at the museum are mediated, enabling them to clearly perceive links to the world outside the museum in the form of certain daily practices and issues on the public agenda.

What science museums can bring to teaching

Science museums have a very particular potential to offer teaching centred around difficult or inaccessible scientific, technical or technological topics, and also to strengthen the link between the topic itself and how pupils perceive its utility value outside the school setting. The museum's surroundings and collection objects are a perfect framework for this type of teaching or other interpretation and communication activities. This gives science museums a special opportunity to take a practical-skills approach and offer utility-oriented teaching, to raise the pupils' motivation levels and their understanding of complex scientific, technical and technological topics.

To give one example, the museum can present a topic such as 'the information society' by telling the story of the punch card. Here, the museum's teaching session guides learners on a journey from punch card to diskette, on to the CD and ultimately the microchip. By focusing on the practical-skills aspect (What do you use a punch card for?) and a taking a utility-oriented approach (How do you make a punch card, and use it?), the museum can foster an even better understanding of, and greater insight into, the opportunities and challenges of the information society. With teachers taking their cue from replicated original punch cards based on those made by Herman Hollerith – the first person to use punch cards to store and process information – the museum can also unfold the story of how, based on his inventions, Hollerith set up the company that would eventually become IBM.

Another example, seen at many science museums, is the tinkering lab, a sort of educational station or pitstop where children and families get a hands-on, utility-oriented introduction to a scientific topic. Such a topic could be light, with children and their parents going through activities that let them experience and understand what light is, and how light works. What they take away from the tinkering lab goes with them as they move through the exhibitions, increasing their understanding of the narratives in the displays. Some tinkering labs have an extra layer, featuring authentic objects that can be used for demonstrations. Such a high level of authenticity and immersion augments the experience as a whole and the person's understanding of the activity.[4]

The museum's potential to promote teaching and learning

The Danish Museum of Science & Technology has a unique potential for disseminating and communicating about technology, its topics ranging from the technical/mechanical field across basic and advanced analog technology to basic and advanced digital technology. These topics can seem not only far removed from people's daily lives, but also hard for both children and adults to understand. Based on the physical surroundings and the objects, the museum can create teaching and learning experiences that strengthen the understanding of how a technical process or apparatus works and what purpose it serves.

Kia Isaksen, the young student I initially quoted, felt like a real 'handywoman' after fitting an electric lamp. Surely she would think it was 'totally awesome' if she could produce and use her own punch card to store important personal information. And that is not all. She would also become better equipped to take part in well-informed discussions about the challenges and potentials embodied in today's information society.

1 Danmarks Evalueringsinstitut. (2019). *Praksisfaglighed i skolen – en forundersøgelse* [The practical-skills approach in schools – a preliminary investigation]. Holbæk: Danmarks Evalueringsinstitut [Danish Evaluation Institute, EVA].

2 Klafki, W. (2011) *Dannelsesteori og didaktik: nye studier* [Bildung theory and didactics: new studies]. Aarhus: Forlaget Klim.

3 Ibid.

4 Mehmetoglu, M. & Engen, M. (2011) Pine and Gilmore's concept of experience economy and its dimensions: An empirical examination in tourism. *Journal of Quality Assurance in Hospitality & Tourism* 12:4, 237–255.


GAMER
Bliver man voldelig af at spille?
JAGUAR

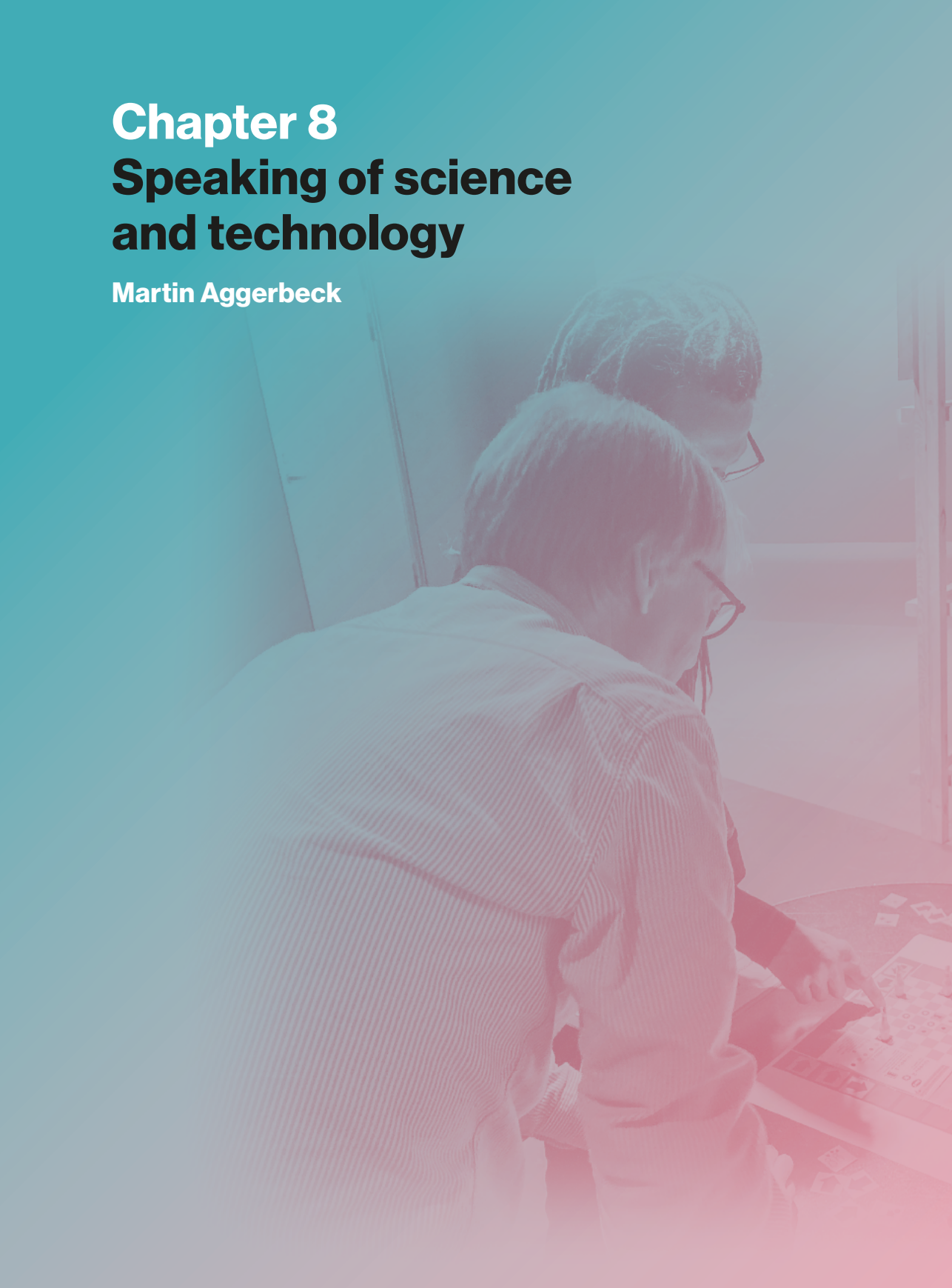

MAKERSPACE

Part 3

Transformation, sensory engagement and experimental practices

Chapter 8
Speaking of science and technology

Martin Aggerbeck



What role can, and should, science and technology play at the Danish Museum of Science & Technology? In this chapter, I propose a flower-shaped dissemination model in which the flower's stem is the objects, its centre is technology, and its petals are different fields, one of which is science. I also discuss the significance of museum objects, and how engaging and inclusive activities can involve visitors in debates about what technology means to individuals and to society in general.

As part of our project 'Naturvidenskab – der hvor du er' ('Science – right where you are') we have explored different ways for our museum to work with communicating science and technology. How the two relate to each other, for instance, and how they are weighted at the museum compared to, say, cultural history and inventions. These are some of the things I reflect on in this chapter.

Science and technology

An ongoing topic of discussion at the museum is our approach to technology and science. Our Danish name – Danmarks Tekniske Museum (literally 'the technical museum of Denmark') – implies mainly technical and technological history and objects,[1] while our official name in English – the Danish Museum of Science & Technology – implies that we deal with both technology and science.

The museum clearly distinguishes between technology and science: science makes technology possible, and we focus on science only when it is linked to technology. Personally, I envision the museum's communication and interpretation activities as a flower that has science as one of its several petals (see Figure 1).

The flower's stem consists of the objects. These are what visitors come to see, and they are the foundation of all that we communicate. The centre of the flower is the sum of technology embodied in the objects. Although we do not always explain in detail how a specific technology works, the very reason why a given object is at the museum is that it speaks about the development or perfecting of a specific technology.

The way the museum communicates can move from the flower's centre outwards, or inwards towards the centre. The capsule that carried the Danish astronaut Andreas Mogensen into space is one object that arouses immense interest. With the capsule as our starting point, we could tell multiple stories:

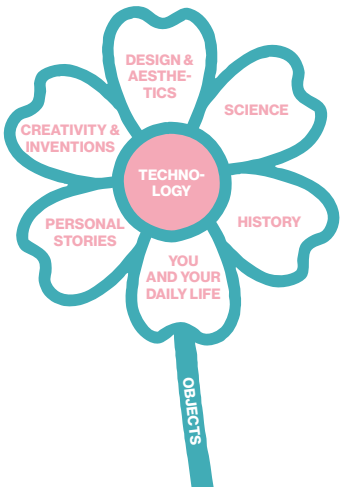


Figure 1. Communication and interpretation model at the Danish Museum of Science & Technology

about his long path to actually travelling into space, which he did in 2015 and 2023 (personal history); about the Cold War and the Space Race (history); about how driving directions on a mobile phone depend on satellites (you and your daily life); or about how rockets launch in stages, and about Newton's laws of motion (science). We could also focus on the space capsule's somewhat outdated appearance (design and aesthetics), and on the fact that the Soyuz capsule's design has not changed significantly since the 1960s, the space industry being cutting-edge, on the one hand, but extremely conservative on the other – once it has something that works (creativity and invention).

In other words, for us as a cultural history museum the stories relating to the objects can lead in many different directions – one of which is science. Basically, the museum's focus is more in line with its Danish name than with its English name. We do not cultivate science for its own sake, but we gladly treat science issues that are genuinely important to society through their significance to specific technologies.

Objects spark an interest

What does our museum have to offer compared to other types of knowledge dissemination? We are committed to collecting and preserving the technologies of the past and the present. That is why our objects are also the natural focal point for our dissemination activities. They are a perfect gateway to pique our visitors' curiosity and prompt them to visit all the petals of the flower model. As a visitor, suddenly you find yourself next to the space capsule, which you may have seen pictures of before. But it is only here, only now, that you truly understand how incredibly cramped a space it is for three adult astronauts in space suits. There is no doubt that the museum's physical objects are its strongest element. These objects can tell stories, explain technologies, and guide visitors to consider complex issues. They can also show historical developments right up to modern-day products, and even foster conversations and discussions that would not otherwise have taken place.[2] Our objects are physical, and they were designed to be used. This makes visitors curious to find out how they were, in fact, used – especially the really odd objects. On top of this, in aesthetic terms, several of our objects are quite beautiful.[3]

Physical objects have a purpose and appeal that is very different from, say, a YouTube video. A video can guide you very precisely through a specific story with clear focus points. Museum objects, on the other hand, give you freedom to decide where you want to look and what you find intriguing. You can look at the surfaces close up. You can smell the oil and the wood, whether you are examining the structures of the oldest wooden bicycle wheels or the earliest saddles, studying the peculiarities of

individual bicycles, or learning how bicycles have developed over time. There are countless stories to dive into, each one valuable in its own way.

Regarding our dissemination activities – teaching, learning, communicating and interpreting objects and technologies – our museum faces a big challenge. Visitors generally feel an urge to touch the objects, which is not permitted because we are committed to preserving them for posterity. Instead, we want to give visitors a sense of the objects without their having to touch the objects themselves. In an upcoming project, we will test the use of replicas for selected objects, or make modern versions of old technologies available that visitors can touch and try out. For example, visitors will be able to view actual historic balance bicycles and other velocipedes, then try out replicas on a small cycling track. In our outreach activities we will also be using more props that are authentic objects but not part of the museum's collection. Current examples of this are old-fashioned hand tools, typewriters, hand-powered sewing machines and mechanical calculators, all featured in our holiday activity *HUS – Helt Uden Strøm* ('House – totally unplugged)' in 2023.

Discussing new technologies through dialogue games

Our museum wants to help promote lifelong learning in Denmark, and we regard technology as a theme that every individual must reflect on throughout their lifetime, ranging from self-driving cars, to FaceID to open your mobile, to MitID, a comprehensive digital ID system that Danish citizens and companies use to gain access to everything from national health services to tax payments online. These are some of the new technologies everyone living in Denmark is forced to consider, whether they wish to use them in their daily lives or not.

We want our museum to play a dual role: disseminating knowledge, and also promoting public and private debates and knowledge-sharing as an accessible meeting place. We want to explain to children and adults how new inventions and technologies work, but we also want to encourage them to actively consider which inventions they want to use, and which ones they do not. Where is the limit for each individual? Are there pitfalls we fear? And where is the limit for new technologies for society as a whole? Our exhibition Artificial intelligence (described in Chapter 12) includes four analog games about coding, data, intelligence and new technology, respectively. These games also raise philosophical aspects, especially the two that address intelligence and technology.

In the game about intelligence, visitors must consider which of several items is the most intelligent. The selection of items includes a rat trap, a pendulum clock, a calculator and other items. This encourages players to discuss the fundamental nature of intelligence. Initially, many guests do not consider any of these objects to be intelligent, but they gradually come to understand the premise of the game and begin to play it as intended. What we are doing here is challenging our conception of intelligence to shed light on the concept of artificial intelligence. Are new technologies intelligent at all? And what does it take for us to perceive them as intelligent? The fact is, the way we think about what artificial intelligence actually is continues to change, as developers create new and ever more sophisticated solutions that can take over more and more human tasks.

In the game about new technology, we get players to vote on various dilemmas. Do you want artificial intelligence to plan your birthday, decide what you eat, or serve as a politician? Players must cast votes on these and many other suggestions, then discuss their answers among themselves. This process results in interesting discussions that prompt visitors to consider their own limits for using artificial intelligence. Isn't it high time Denmark opened the public debate on this particular topic? We do not wish to see opposing views clash, but we do hope to foster frank and open debate about the future – before it is overtaken by the present.

Technology and science at our future museum in Copenhagen

The current museum, based north of Copenhagen in Elsinore, plans to move into a soon-to-be-decommissioned power plant, the Svanemølleværk, in Copenhagen. This move will give us completely new opportunities, including a new setting as we transfer from an industrial estate on the outskirts of the modest town of Elsinore to a location in the Danish capital close to several Metro and local commuter-train lines. Taking on a new role in the Danish museum community, the museum will have to find its place among other major actors that disseminate science and technology. Personally, I believe our museum's focus will ultimately be technology and inventions. These are clearly key areas for our museum, for Denmark's industries and for the entire country. We obviously have a role to play in this context, and a commitment that we must continue to live up to in our domain.

At the same time, however, I believe the move presents a unique opportunity for the museum to eventually assume its place as a leading outreach institution and communicator of applied science for older children and adults. The Danish Museum of Science & Technology already exhibits or keeps several objects of crucial historical importance and interest to science. These include the compass used by the Danish scientist H. C. Ørsted when he discovered electromagnetism in 1820. Another

treasure is a cyclotron from the laboratories of the Niels Bohr Institute, used by the eminent Danish physicist himself and others to study atomic energy and nuclear medicine. It is my hope that in the long term the museum can build a firm foothold in science dissemination. As of today, I see no national champion in communicating science to older children, teenagers and adults – and this situation gives the Danish Museum of Science & Technology an unparalleled opportunity to assume and occupy this position with skill and conviction.

1 On 'technical' vs ' technological': While I know of no clear-cut boundary between the words 'technical' and 'technological', in this chapter I consistently use the latter. Originally, the words for 'technical' in Danish, *teknik/teknisk* (noun/adjective pair), refer to the concrete application of science to practical purposes, whereas the words for 'technological' in Danish, *teknologi/teknologisk* (noun/adjective pair), refer to the study of technical sciences. It is my distinct impression, however, that nowadays the former Danish word pair, as well as analogous words in other languages, are mainly used to refer to sprocket wheels, mechanisms and other traditional mechanical apparatuses, whereas the latter word pair (and also the short form 'tech') mainly refers to more recent technical and technological phenomena. This usage means that nowadays the word 'technology' has also come to mean concrete objects. This trend is also increasingly prevalent at the Danish Museum of Science & Technology, where we refer even to older objects as 'technologies'.

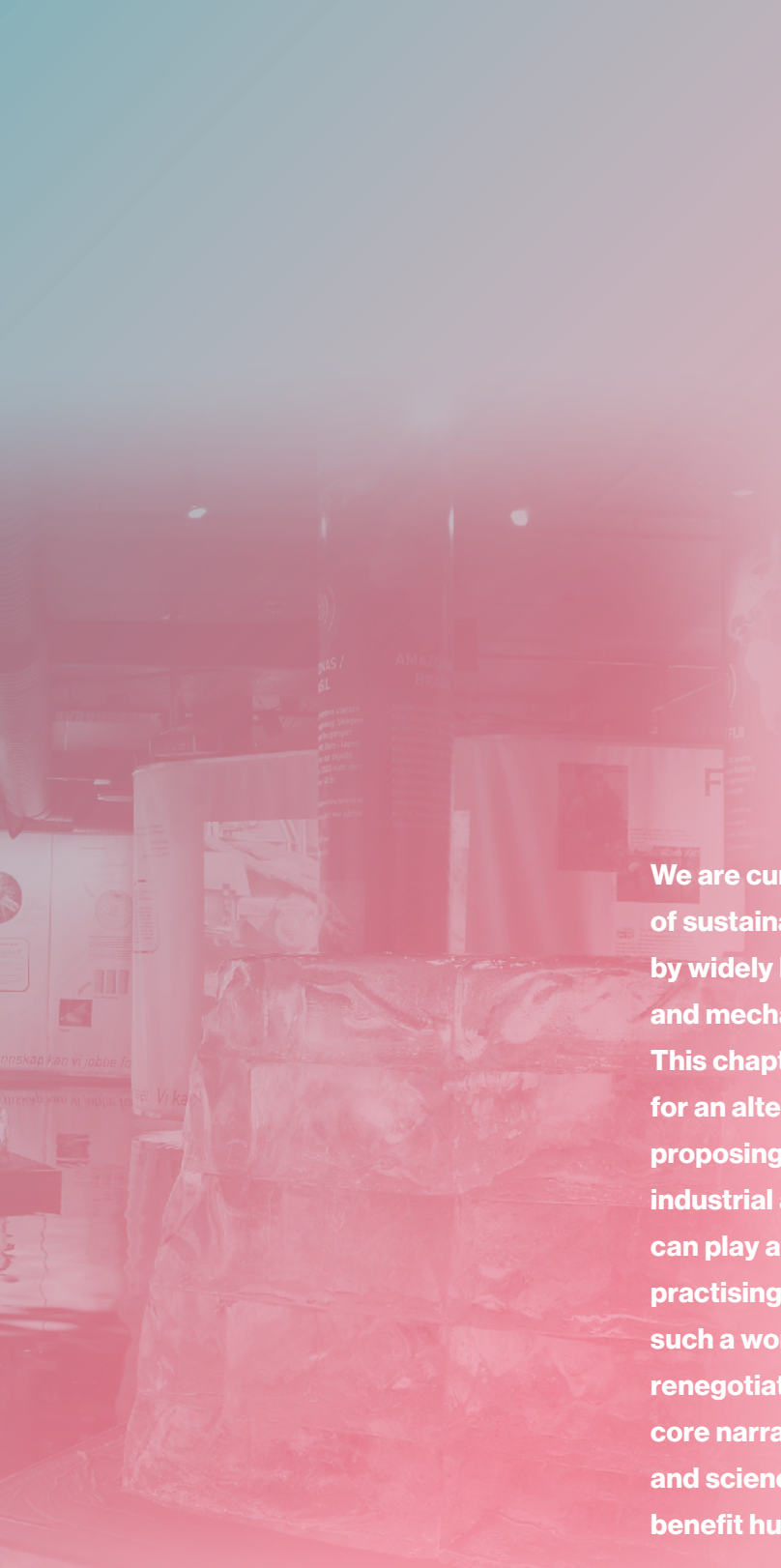
2 Alberti, S. J. M. M., Cox, E., Phillipson, T., Taubman, A. (2018). Collecting contemporary science, technology and medicine. *Museum Management and Curatorship* 33(5), 402–427.

3 Alberti, S. J. M. M. (2017). Why collect science? *Journal of Conservation and Museum Studies* 15(1), 1–10.


RUSSIA
RUMOBSERVATORIUM

Chapter 9
Museums of technology and industry need a new narrative

Marianne Achiam



We are currently facing a number of sustainability problems caused by widely held materialistic and mechanistic worldviews. This chapter argues the need for an alternative worldview, proposing that technical, industrial and science museums can play a crucial part in creating, practising and disseminating such a worldview. This requires a renegotiation of these museums' core narrative: that technology and science unambiguously benefit humanity.

Humankind is currently facing a number of problems stemming from a worldview that is both materialistic and mechanistic.[1] This worldview, allowed to dominate throughout recent history, is closely linked to Western modernity's ideals of free-market forces, constant growth, and the indisputable authority of science. The *materialistic* element has led to excessive and non-sustainable exploitation of the Earth's human and natural resources, the direct cause of the crises we face, which include climate change and deteriorating biodiversity. At the same time, the *mechanistic* view closely linked to this materialism has led to a fractured, reductionist way of looking at nature, which gives humans the misconception that we can dominate it.[2] That is why the sustainability problems currently confronting us are also described as a crisis in the forms of knowledge Western modernity has produced.[3]

Large numbers of people in the research community are calling for alternatives to the materialistic–mechanistic worldview. Refuting the technofix approach, which foresees technology delivering solutions without people having to change their behaviours, these researchers instead point out that what we need is to implement fundamental and lasting changes in the way we interact with the world. An essential component in bringing about such changes is to recognise that humanity, in its entirety, has an understanding of the world that stretches far beyond Western understanding. In other words, a precondition for such a transition is that we make room for non-Western, often marginalised forms of knowledge,[4] including non-human ways of being in the world,[5] and more democratic and inclusive ways of interacting are required to co-create the new knowledge needed to make a sustainable future.

The need for a new narrative

I use the phrase 'museums of technology and industry' in my title because it renders the expression in my own country, Denmark, for what English-speaking countries broadly call 'science and technology museums'. The subject field of these museums is scientific and technological heritage, and they can often trace their roots back to the great industrial exhibitions of the early twentieth century.[6] Such museums have the potential to be key players in the transition I just described. This can sound paradoxical, as today's science and technology museums build in many respects on modernist ideals: technological progress, growth, and the rationality and universal applicability of science[7] – the worldview that created the problems we face. But what these museums need is a new narrative. As the eminent museum scholars Robert Janes and Richard Sandell have pointed out:

More democratic and inclusive ways of interacting are required to co-create the new knowledge needed to make a sustainable future.

> The museum community must move beyond the doomed economy of industrial growth to the recognition that the connection between individuals, communities, and the natural environment is the key to our collective wellbeing. It is incumbent upon all museums to help envision and create this new narrative in partnership with their communities, and then deliver this story using their unique skills and perspectives.[8]

I propose this hypothesis: that science and technology museums have a unique opportunity to contribute to the green transition and to a more sustainable future, and that this opportunity calls for a renegotiation of their core narrative about the industrial revolution and technological progress. In the following, I present and substantiate certain elements of what such a renegotiation could involve, concluding with a few general comments about the potential museums have to put sustainability on the public agenda.

Shifting from interpretation and education to co-creation

The mission of science and technology museums includes communicating about 'the cultural heritage of science and technology, and the dissemination of knowledge of its development and importance to society.'[9] Historically, these museums have tended to use a rather one-sided perspective in their dissemination activities: the advances of industrialisation and technology were regarded as unquestionable; objects were seen as a sort of testimony to the authority of science; and museum visitors were seen as passive recipients of knowledge.[10] Over time, museums adopted other angles and communication methods, but they still did not break with the underlying perception that the status of science and technology was canonical.

In recent years, grassroots movements such as Black Lives Matter and #MeToo, along with a wave of decolonisation, have spotlighted the systemic inequities inherent in modern societies, institutions and norms. They have added

new layers to the conventional perception of industrialisation, technological development and science by pointing to various types of violation and marginalisation that have also been part of such progress.[11] This shift offers science and technology museums a unique opportunity to rethink the way they communicate and disseminate knowledge. By looking more critically at their fields of activity, for instance by giving marginalised groups a clear voice, these museums can create a richer and more inclusive shared understanding of technology's role in society.[12] However, this calls for a new paradigm in their dissemination activities: Instead of *presenting* canonical knowledge, science and technology museums must become much better at facilitating democratic *co-creation* of knowledge.

New formats and new target groups

The new dissemination paradigm I have outlined demands quite a lot from science and technology museums. For one thing, it will require a renegotiation of the elevated status traditionally enjoyed by the subject fields of these museums. For another, the renegotiation will have to take place through involving, for instance, individuals and groups who do not typically visit museums. But including hitherto unheard voices in the process is not merely a question of social justice. Researchers, scholars and decision-makers have emphasised the importance of having everyone contribute if we are to solve the environmental crises we currently face. In the words of António Guterres, Secretary-General of the United Nations, while addressing the high-level opening assembly at COP27: 'We need all hands on deck.'

Many findings suggest that aesthetic formats can be of decisive importance to the efforts of museums (and other institutions) to democratise knowledge. Aesthetic communication formats such as fiction and narratives, visual arts, performance and theatre employ their own ways of interacting with the world, which differ from the purely cognitive formats of science.[13] This enables such alternative formats to serve as an entryway to content that is inaccessible to many people, also promoting interpersonal connections based on empathy and equality.[14] What is more, several researchers emphasise the capacity of aesthetics and the arts to stimulate questions rather than presenting answers.[15] This puts aesthetic formats in a position to support collective investigative processes that not only strengthen citizens' capacity to make sustainable choices, but are also practical and applicable – which is not always the case for academic, hypothesis-driven research.

Although the practice of using aesthetic communication formats is not yet widespread at science and technology museums, several examples show how such formats can engage

visitors in new ways. One was the exhibition *KLIMA X*, on show in 2007–2009 at the Norwegian Museum of Science & Technology in Oslo. Visitors were given rubber boots to wear so they could wade through a 25 cm deep layer of water on the floor – a scenario illustrating the problem of ice melting at the poles.[16] Another excellent example, although not one from a museum, is the art installation *Pollution Pods* by the British artist Michael Pinsky, featuring five transparent domes that use harmless gases to simulate the air quality in Beijing, São Paulo, London, New Delhi, and the unpolluted Norwegian island of Tautra, respectively. As viewers move through the installation, they experience how the air quality in the domes visibly deteriorates.[17] In these examples, the exhibition or piece does not represent the sustainability problem 1:1. Rather, they are *meta-realistic* displays[18] that collapse time and space to bring relevance and urgency to climate issues.

A few concluding remarks

I began by framing the sustainability problems humanity currently faces as a crisis in the forms of knowledge that typify Western modernity. I then proposed that science and technology museums have great potential to address this crisis by developing, using and disseminating alternative forms of knowledge. Obviously, I do not claim that science and technology museums can handle this crucial task alone. My point is, rather, that the museum community as a whole has a critical and unique role to play when it comes to preparing people to address the problems at hand.[19] Museums enjoy considerable trust among the public – a position many politicians and journalists can only dream of – and this gives them an ideal position to put sustainability on the agenda, credibly and democratically.

This brings us to the question of how museums and science and technology can actually use aesthetic formats and transform them into inclusive co-creative processes. As a researcher, I am hardly the right person to answer this. One thing is clear, however. Museums are already expert at deconstructing abstract scientific and technical knowledge, then reconstructing it to fashion tangible, sensory, social experiences.[20] What I therefore propose here is not meant to disparage or detract from the expertise of museums, but rather to serve as a sort of epistemological and ideological rethinking or redirection of existing practices. Allow me to finish with another quote from Janes and Sandell's work: 'Everything that is required to fulfil the true potential of museums is here – now. There is nothing lacking.'[21]

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3 Santos, B.d.S. (2014). *Epistemologies of the South: Justice against epistemicide*. London: Routledge.

4 Freire, P. (1970/1997). *Pedagogy of the oppressed*. London: Penguin Random House; Santos, B.d.S. (2014). *Epistemologies of the South: Justice against epistemicide*. London: Routledge.

5 Benessia, A., Funtowicz, S., Bradshaw, G., Ferri, F., Ráez-Luna, E. F. & Medina, C. P. (2012). Hybridizing sustainability: Towards a new praxis for the present human predicament. *Sustainability Science* 7(1), 75–89; Haraway, D. J. (2016). *Staying with the trouble: Making kin in the Chthulucene*. Durham: Duke University Press.

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7 Ibid.

8 Janes, R. & Sandell, R. (2019). Posterity has arrived: The necessary emergence of museum activism, 1–22 in R. Janes & R. Sandell (eds.), *Museum activism.* London: Routledge.

9 CIMUSET. (n.d.). *CIMUSET. ICOM International Committee for Museums and Collections of Science and Technology: Our aims*. ICOM. https://cimuset.mini.icom.museum/about-us/our-aims/ (accessed 21 July 2023).

10 Pedretti, E. & Navas Iannini, A. M. (2020). *Controversy in science museums: Re-imagining exhibition spaces and practice*. London: Routledge.

11 Anderson, K. & Hadlaw, J. (2018). The Canada Science and Technology Museum. *Technology and Culture* 59, 781–786; Main, G. (2017). Food stories for the future, 171–180 in J. Newell, L. Robin & K. Wehner (eds.), *Curating the future: Museums, communities and climate change.* London: Routledge; Nicolaisen, L. B., Achiam, M. & Ibsen, T. (2021). Transforming astrophysics in a planetarium: 'We are part of the universe, the universe is part of us,' 167–183 in M. Achiam, M. Haldrup & K. Drotner (eds.), *Experimental museology: Institutions, representations, users.* London: Routledge.

12 Alberti, S. J. M. M., Cox, E., Phillipson, T. & Taubman, A. (2018). Collecting contemporary science, technology and medicine. *Museum Management and Curatorship* 33(5), 402–427.

13 Heinrichs, H. (2019). Strengthening sensory sustainability science: Theoretical and methodological considerations. *Sustainability* 11(3), 769. https://doi.org/10.3390/su11030769

14 Benessia, A., Funtowicz, S., Bradshaw, G., Ferri, F., Ráez-Luna, E. F. & Medina, C. P. (2012). Hybridizing sustainability: towards a new praxis for the present human predicament. *Sustainability Science* 7(1), 75–89; Heras, M., Galafassi, D., Oteros-Rozas, E., Ravera, F., Berraquero-Díaz, L. & Ruiz-Mallén, I. (2021). Realising potentials for arts-based sustainability science. *Sustainability Science* 16(6), 1875–1889. https://doi.org/10.1007/s11625–021–01002–0

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18 Ågren, P. U. (1995). Om museer och utställningsspråk [On museums and exhibition language]. *Nordisk Museologi* [Nordic museology] 1, 39–46.

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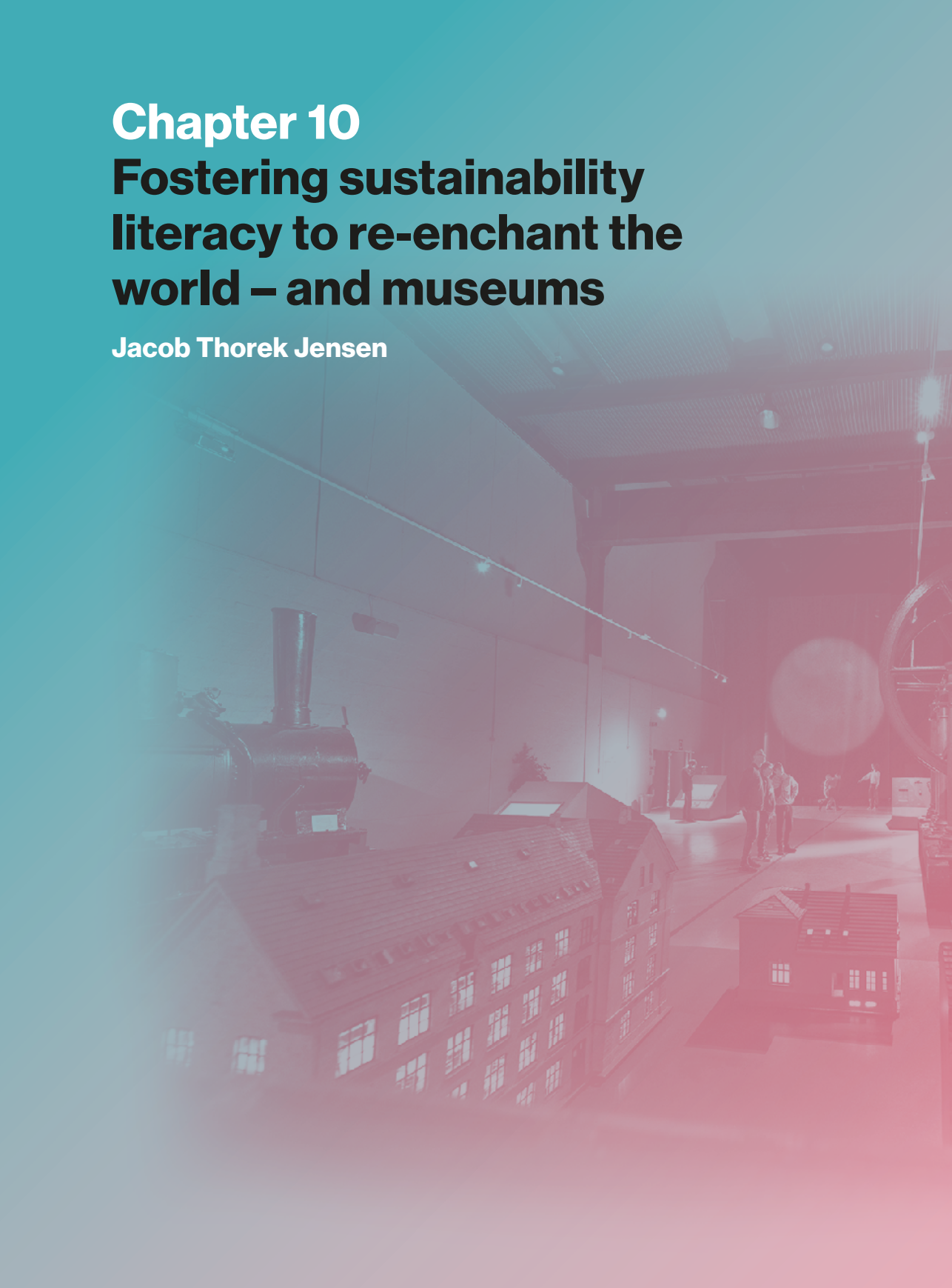
20 Ibid.

21 Janes, R. & Sandell, R. (2019). Posterity has arrived: The necessary emergence of museum activism, 1–22 in R. Janes & R. Sandell (eds.), *Museum activism.* London: Routledge.


Gamle løsninger

Chapter 10
Fostering sustainability literacy to re-enchant the world – and museums

Jacob Thorek Jensen



How do museums contribute to the development of a society? And what must museums do to fulfil their responsibilities – informative and formative – in helping citizens to learn and grow? This chapter argues that museums ought to review and plan their activities as part of a wider civic effort to foster literacy about sustainability. This involves developing new formats in which citizens actively participate and are invited into the museum's engine room – the place where new knowledge and visions for the future are shaped.

The most important task of museums that are run and/or subsidised by the state is to collect, register, preserve, study, and interpret and communicate about objects and heritage, and, through these efforts, to positively contribute to developing society and enlightening and educating citizens. This is reflected in the preamble of the law that governs such museums in Denmark, known as the Danish Museum Act. It is also clear from preparatory documents (quoted here in my translation), which supported proposed amendments to this act, adopted in 2012: 'the knowledge obtained by the museums must, to a greater degree, contribute to putting current developments and debates in society into perspective, and it must also form part of the foundation for solving tasks relating to [Danish] society'; and further, 'the societal role of museums must be strengthened, and the museums must contribute to the development of society, and to educational and formative activities that provide experiences, inspiration, learning, critical reflection and civic-mindedness.'[1]

But how do museums actually contribute to developing their societies? And what do a museum's educational and enlightenment tasks entail today? In light of the biodiversity crisis, climate change, technological challenges and the refugee situation – to mention just a few major issues today – it is now more important than ever for museums to focus on their role as a mainstay of society and a formative force. I discuss this topic in what follows, based on experiences and learnings from the project 'Naturvidenskab – der hvor du er' ('Science – right where you are'), which we conducted at the Danish Museum of Science & Technology. Further, I offer perspectives on developing the sustainable museums of the future. I argue that museums must profoundly reconsider their own practices with a critical eye, investigating the ways in which they are connected to their environments – human and natural, local and global. They must reassess how they are actually helping to foster social and cultural sustainability for all citizens in the societies they serve.

The museum as a formative institution

Although it lies in every museum's DNA to be a formative and informative institution for the public at large, different museums have different approaches to, and different understandings of, their own specific role in terms of *Bildung*. This German educational concept has an almost direct parallel in Danish: *dannelse*, a word that also means formation, shaping, and coming into being, and is very widely used in educational circles and elsewhere in Denmark, as discussed below. The Danish linguistics scholar Hans Arndt has pointed out that our concept of *dannelse* consists of two main elements: 'Partly some values or attitudes that have to do with other people and ways of relating to others, and partly a body of basic general

knowledge that enables us [to] understand the world around us, both the society we live in and the physical world.'[2] This is the context in which many museums, in Denmark and elsewhere, perceive themselves as places that encourage *Bildung* and lifelong learning. At museums you can learn about all sorts of different subjects, expand your horizons, have your own views confirmed or challenged and – at times – reflect on how you think society ought to develop.

Previously, the Danish Museum for Science & Technology mainly focused on conveying technical knowledge and facts about objects, the year of production and horse power of a steam engine, for instance, focusing less on how the steam power as a technology changed societies. Although steam engine technology is rarely used today, at our museum we can take an interdisciplinary approach and use this technology, for instance, to illustrate different perspectives on the evolution of modern society: on the one hand showing all the benefits many of us would hate to live without; on the other hand telling how this technology helped set in motion the climate changes we see today. Such a practice must necessarily entail developing a new approach to the museum's educational and formative activities – an approach that goes beyond the conventional one-way communication so typical of most dissemination activities at most museums.

Notions of *Bildung* abound

The Danish concept of *dannelse*, and other similar *Bildung* concepts in other languages, are a subject of ongoing debate, and definitions and boundaries are constantly being challenged: What is a 'formative education'? And what does being a 'well-educated citizen' really involve? Today, authors and public voices in Denmark are using the concept of *dannelse* about digital and technological literacy, creativity, science, mathematics, nature, sustainability, and practical skills.[3]

At the Danish Museum of Science & Technology we are continuously discussing and investigating how we can promote and develop science literacy among our visitors. This is the central question in our project 'Science – right where you are'. It grows from our conviction that we need to take a fresh approach to the roles that science and technology play in our society. It has been a prevailing view that knowledge about these areas is less important to a person's general *dannelse* than knowledge about fields like art and culture, or the workings of society. In other words, a person who can name winners of the Nobel Prize in literature is regarded as more accomplished than someone who can name Nobel laureates in physics or chemistry. A case in point from Denmark is that in 2006 our ministry of culture published a canonical collection of the most important Danish contributions to architecture,

film, music, literature, and other fields in the arts. However, we have yet to see a similar collection that showcases eminent Danish contributions to science, technology, engineering and mathematics.

No matter how many notions of *Bildung* and literacy we identify or introduce, they are all paradigms that scaffold the formation of what is often called a well-rounded person, in lay terms. Historically, notions of what makes for a well-informed, educated citizen have changed in step with how societies have developed. If we want to enable museum visitors to use what we offer in understanding and acting within the society that is theirs, we must add new dimensions to the concepts we use. *Bildung*, *dannelse*, literacy – they all need new dimensions which take sustainable development into account, and which take an active and interdisciplinary approach to addressing ongoing debates about sustainability

Building sustainability literacy – and a Danish notion of sustainable Bildung

One possible way to approach the formative role of museums is to think about how we can promote the relatively new concept of 'sustainable *Bildung*'. This concept, developed by the Danish leadership authors Lene Belling and Leif Frandsen, is defined as follows (in my translation): 'Sustainable *Bildung* is a holistic approach that expands a person's general formative education with science literacy, existential self-formation, and the moulding of a heart.'[4] Belling and Frandsen emphasise community, and a person's sense of community, as an important part of their general *Bildung*, also involving traditions, democracy literacy, cultural spheres and interpersonal relations. Existential self-formation, on the other hand, focuses on the individual, and it is about 'knowing oneself' and being rooted. Science literacy is our knowledge about the world and the universe, and about how we affect the Earth with our technologies, so this aspect notably encompasses the UN-defined concept of sustainability literacy. Finally, the moulding of the heart is our ethical compass, our feeling of connectedness with other people and with nature, and our capacity to empathise. Taken together, these four formative aspects point towards a sustainable notion of *Bildung*.

The concept of sustainable *Bildung* gives museums a framework they can use to rethink their roles and practices. This in turn paves the way for museums to take on new roles in society and become more active in sustainably transforming society. By virtue of their collections, knowledge and experience as formative institutions, museums are well positioned to frame their activities in terms of sustainable *Bildung*. The Danish concept also suggests interdisciplinary methods and approaches that ought to serve as a starting point for museums' creative and knowledge-producing work, more so than they do today.

Opening the doors to the museum's engine room

Expanding the Danish concept of *dannelse* with sustainable *Bildung* must and should challenge existing museum practices. This does not mean museums should distance themselves from their historical perspective when working to fulfil their formative role for the public. What it does mean is that museums should also help to frame collective processes in which, taking their cue from the museum's collections and knowledge production, people can imagine and conceptualise possible futures.

Museums must actively consider experiences, knowledge, views and feelings from citizens, across different cultures and social settings, and taking a local and global perspective. The point of this is to reach out to the wider public and acknowledge different people's cultural and social preconditions, and to frame the museum's knowledge in various contexts that are relevant and meaningful to people. Museums must present high-quality knowledge, but they must also lay it open to debate, inviting visitors into the museum's engine room where new knowledge and visions for the future are shaped.

In the 'Science – right where you are' project, our museum has worked to create a framework where we investigate with our visitors how we should use artificial intelligence in the future and what role we want it to play in Denmark. Among other things, we have developed a game where participants debate, reflect and vote on artificial intelligence in various spheres. Their votes indicate where they think artificial intelligence should be used, and where they find it important to maintain human relations and decision-making capacity. From a sustainable *Bildung* perspective, this game speaks not only to the players' self-formation but also to their heart-moulding, as players must consider ethical and moral aspects of using artificial intelligence in a society and how it will impact us as humans.

Artificial intelligence is associated with several issues that are sometimes referred to as 'wicked' problems because they are so elusive and hard to handle,[5] partly because there is no right or wrong way to solve the challenges technology presents. Also, technology is not developing in one specific direction. What museums can do is facilitate investigations of wicked problems such as artificial intelligence, climate change or pandemics by establishing an interdisciplinary practice in which various knowledge paradigms are recognised and included.

Prospects for museums of the future

If museums are to foster sustainability literacy and promote sustainable *Bildung*, their practices will need to be up to this challenge. This means we, as museums, will have to rethink

the experiences and activities members of the public meet when they visit us. Museum formats must achieve an even better balance between past, present and future, and in staging knowledge, views and perspectives we must ask both down-to-earth questions and existential questions. Museums must also be cross- and interdisciplinary and create secure, safe and inclusive spaces for co-creation and collective knowledge production, engaging visitors among themselves and alongside the museum's employees.

These are the seeds of a new, sustainable museology. A museology that helps museums to re-enchant the world, opening gateways to things unknown and magical – things we also find in nature and science. A museology that encourages museums to invite the public in, as we investigate questions and thorny issues together and find ways to move towards a more balanced world.

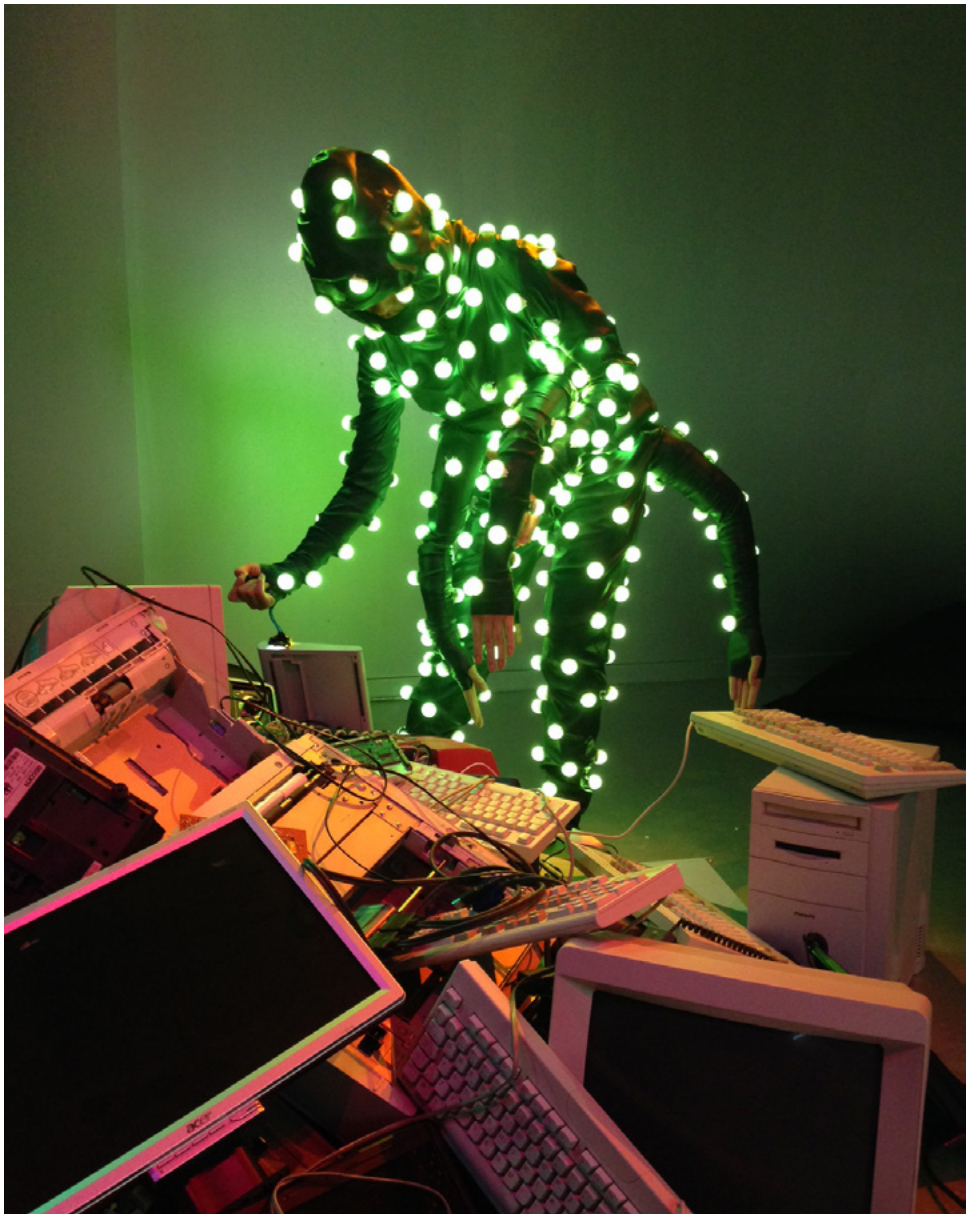
1 Consolidated Act on Museums, Executive Order No. 1505 of 14 December 2006 (translation in English), https://slks.dk/fileadmin/user_upload/kulturarv/english/dokumenter/Consolidated_Act_on_Museums_Executive_Order_No.1505.pdf; preparatory documents, in Danish, and later amendments adopted 19 December 2012 (in Danish), https://www.retsinformation.dk/eli/ft/201213L00024.

2 Arndt, H. (2002). Dannelse i sprog og sprogbrug [Bildung in (Danish) language and usage], 21–34 in Johansen, M. B. (ed.), *Dannelse* [The Danish concept of Bildung]. Aarhus: Aarhus University Press.

3 Examples include: Oettingen, A. V. (ed). (2016). *Almen dannelse – dannelsesstandarder og fag* [General Bildung – standards and formative subjects]. Copenhagen: Hans Reitzels Forlag; Johansen, M. B. (ed.). (2002). *Dannelse* [(Danish) perspectives on Bildung]. Aarhus: Aarhus University Press; Bundsgaard, J. (2017). *Digital dannelse* [Digital literacy]. Aarhus: Aarhus University Press; Hammershøj, L. G. (2012). *Kreativitet – et spørgsmål om dannelse* [Creativity – a question of Bildung]. Copenhagen: Hans Reitzels Forlag; Beck, L. & Ahlburg., N. V. (2021). *Naturdannelse – naturformidlerens håndbog* [Nature literacy – a handbook for nature educators]. Aarhus: Turbine.

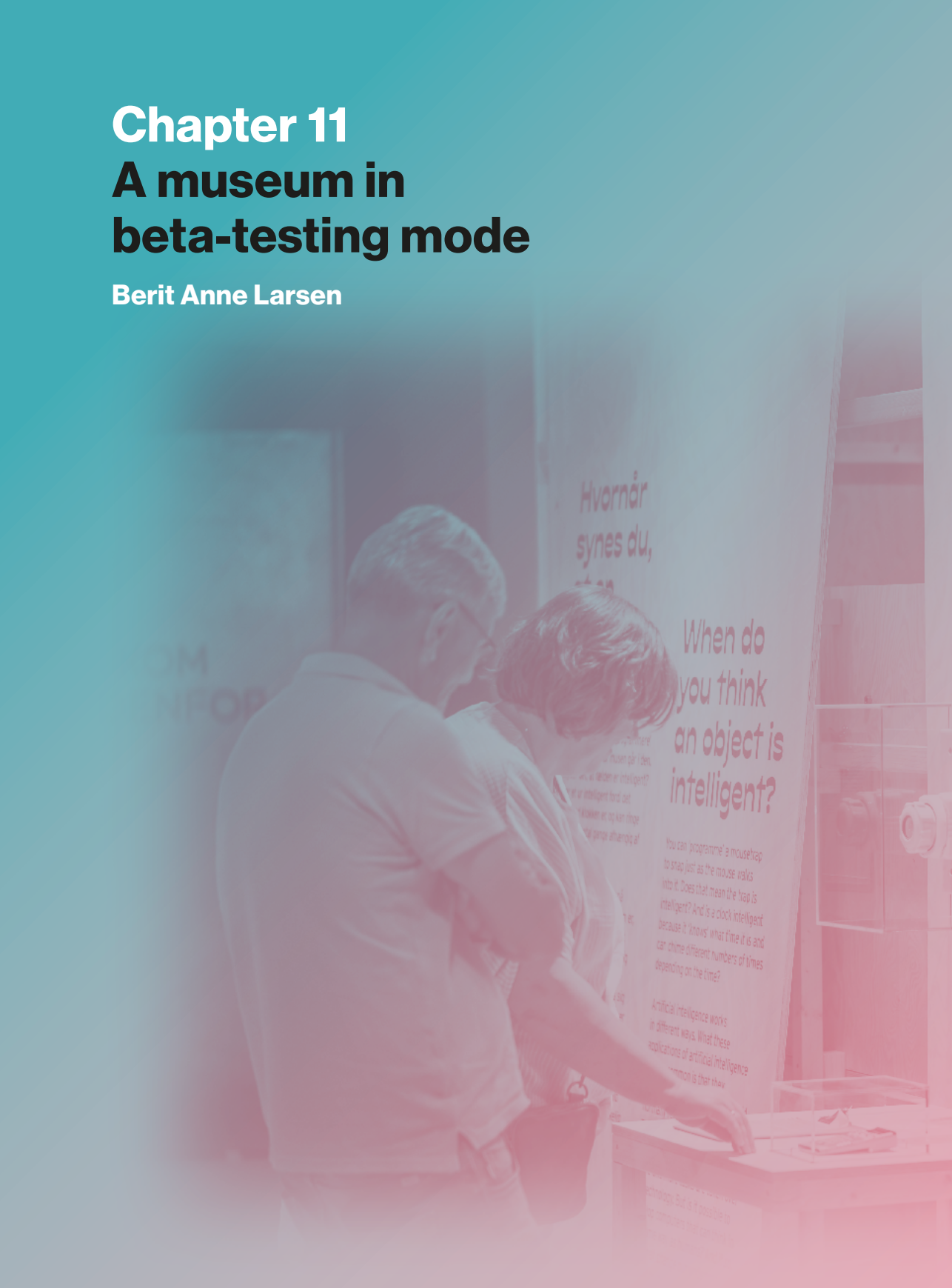
4 Belling, L. & Frandsen, L. (2017). *Bæredygtig dannelse. Skitser til en empatisk verden* [Sustainable Bildung: Sketching out a compassionate world]. Frederikshavn: Dafolo A/S.

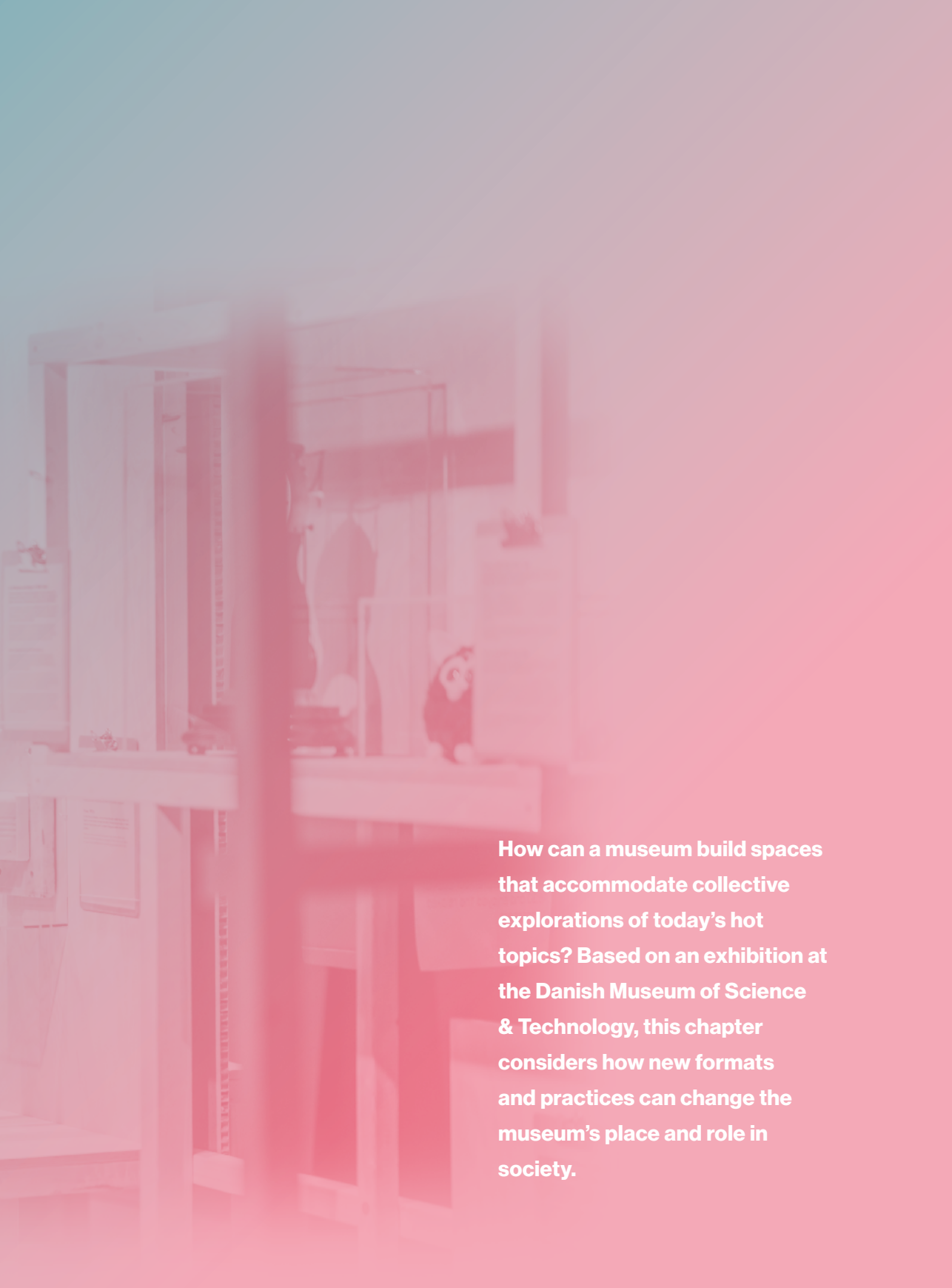
5 Achiam, M., Dillon, J. & Glackin, M. (2021). *Addressing wicked problems through science education: The role of out-of-school experiences*. Cham: Springer.



Chapter 11
A museum in beta-testing mode

Berit Anne Larsen





How can a museum build spaces that accommodate collective explorations of today's hot topics? Based on an exhibition at the Danish Museum of Science & Technology, this chapter considers how new formats and practices can change the museum's place and role in society.

Let me begin with an appeal embodied in the title of an exhibition by the Icelandic-Danish artist Olafur Eliasson: 'Y/Our future is now!' Museums too should seize the day and invite their visitors to take part in shaping the future, bravely and competently. Obviously, it is inherent in the nature of museums that they work to preserve and care for a collection, making it available to, and suitably interpreting it for, a contemporary audience today. The present is always balancing between the past and the future. But imagine what would happen if we brought the future and how we want to shape it more actively into our self-perception as museums with a mission and responsibilities to fulfil? Imagine if we thought of our museum as an institution that uses its collections as a lever to help people of all ages become better at navigating in the future and creatively imagining what Danish society and democracy can become.

Rapid relevance – and an exhibition about artificial intelligence

Many people regard artificial intelligence as the most groundbreaking invention since electricity. What if an eager journalist stopped you on the street for an interview and asked you what artificial intelligence is, and where you think it can best be used. You might initially find yourself stumped, then recall that artificial intelligence has something to do with processing enormous data volumes in a split second, and producing answers to all sorts of questions. Some might reply, 'Rapid relevance!' To be honest, personally I felt somewhat anxious in a similar situation. As part of a group exercise I was playing a traditional, analog board game designed by the Danish Museum of Science & Technology when I was asked the question: What do you think should be taken over by artificial intelligence in the future? My reaction was: Do I know anything at all about this topic? Can I be part of exploring answers, preferably sensible answers, to questions about such a newly emerging and difficult issue?

I was part of a group consisting of people from different academic fields: anthropology, history, biology, science didactics and art history. As a sort of alignment exercise, we were all asked to indicate our preferences for using artificial intelligence in a welfare society (such as our own country, Denmark). My experience was that during this exercise, within the given framework, it became possible to reflect on the questions we were given about where artificial intelligence ought to be used: When a rapid-response team arrives at the scene of an accident and the doctor must begin first aid immediately? For incoming emergency calls to 911? In caring for the elderly at a residential care home? Or when a politician wants a likeable and (highly) intelligent avatar as their alter ego on social media? Which public welfare services will artificial intelligence be able to replace? Which would it be able to support?

The simple framework we had, a board game, made it possible to reflect on difficult questions and dilemmas about an extremely relevant and complex issue that is high on the agenda today. Not surprisingly, our group found it hardest to envision artificial intelligence solutions taking over in care-giving situations. How can artificial intelligence enrich our lives? How can we use it to handle challenges and create positive change? And in what situations would we really prefer to have the decisionmaker be a genuine human being?

Experiment zones as small wins

Another alignment exercise asked us to arrange a small assortment of objects from the museum's collection on a scale ranging from 'least intelligent' to 'most intelligent'. The assortment consisted of a rat trap, a thermostat, a robotic vacuum cleaner, a responsive children's doll, and a children's book that reads aloud when the child passes an electronic device across a variety of bar codes. How do you think you would arrange these things? And can inanimate objects be smart?

The actual exercise was laid out on a table, around which we stood discussing the questions. Here we were, surrounded by similar objects from the museum's collection. They had informative texts with facts and information about their design and technological history that put them into context for us. These objects served as a sort of informative lifeline that we, the participants, were free to use. With its expansive patterning of objects from various times and contexts, the museum offers itself as an enormous analog database, a selection of reference works consisting of physical, real-time online-type searches.

This exhibition, an experimental zone wedged in among the museum's collections, opens an opportunity for rapid relevance – a museum in beta-testing mode. The basic idea behind this zone is to create a space to study and explore different dissemination initiatives without breaking up and altering the entire scaffolding of the exhibition within it. The experiment zone allows us to test and research on particular modes of staging, and to present and combine works and objects to reflect the hottest, most relevant topics. Furthermore, this zone enable us to study and explore the needs of specific target groups. What seems to be a small experiment gives us, as museum professionals, not only confidence in using the format but also learnings we can take away and use later in the museum's exhibition practice.

Small wins – a learning cycle

The American social psychologist David A. Kolb has developed a framework within which we can understand the fundamental processes of learning. In his experiential learning cycle, Kolb divides the learning process into four phases: experiencing, reflecting, thinking, and acting. Building on his work, two Danish

organisational theoreticians, Gitte Haslebo and Kit Sanne Nielsen, suggest combining the two different dimensions – an individual learning cycle, and an organisational/collective learning cycle – to obtain a change model, an action-based approach to implement change in an organisation.[1] This coupling of individual learning and organisational learning is rooted in their reading of Kolb combined with works by the American knowledge-transfer consultant Nancy Dixon.

The first step in Kolb's model is a concrete action and experience; Dixon likewise begins by generating knowledge and information. Kolb's second step is to reflect on the experience; in Dixon's step two, the gathered information and new knowledge must be integrated into the organisation. In the third step of Kolb's model, the individual draws conclusions from their reflections on the experience; in Dixon's organisational learning process, this third step of interpreting must take place collectively. Such a collective interpretation process is quite demanding for the organisation, as different and diverging views and perspectives must be able to interact playfully, ultimately becoming a collective interpretation. Once this has happened, the fourth and last step for Dixon, like the fourth step in Kolb's model, is to act on the basis of the interpretation – and here, to act means to test the interpretation. At the same time, the action generates new information, which in turn calls for new integration and interpretation, and so the cyclical process continues.

The exhibition – artificial intelligence as a topic of experiment

The Danish Museum of Science & Technology's experimental exhibition zone about artificial intelligence is laid out as a laboratory setting in which the question under scrutiny is examined and cross-examined from different angles and fields. The experiments result in new perspectives, new lenses through which to scrutinise the topic, and new gateways into the collection and the rest of the museum. The visitor becomes able to see new patterns and new lines that run across historical periods. As for our group, even though all members tended to rank the most recent digital inventions at the top, as the most intelligent, the anthropologist pointed out that of the assorted objects available, he definitely regarded the rat trap as the most intelligent invention. Not only was it a manifestation of a very intelligent culture, it was also a radically new part of an entirely new culture and way of organising society. By means of invention, humankind became able to catch or trap animals without being present at the site themselves. This innovation helped to shape a new future.

For visitors to the museum, it becomes clear that the artificial intelligence exhibition laboratory, while highlighting the archive, the col-

lections and the museum, also challenges the conventional narrative, which is fundamentally about the benefits of constant technological progress.

The living laboratory – asking questions about your own here-and-now

The exciting thing about having several activities revolve around one basic question – in this case: How intelligent is artificial intelligence really, and how does it work? – is that this format enables us to regard the museum as a living laboratory. In a laboratory you work with a question and a number of hypotheses, testing them in the form of prototypes that you can inspect, touch, examine and learn from. The advantages of regarding the museum as a lab is that good questions engage visitors and spark important reflections and conversations. If the basic question is compelling, it can engage and inspire at multiple levels: from the scientist who posed the question, it passes to the museum educator, guide or host, and from there to the museum's visitors and even to influential experts outside the museum. Interest in the issue can also seep out through personal communications and social media, reaching a wider audience as an interesting and relevant impulse for other people and public forums.[2]

The visitors eventually realise there is no final answer. They see that exploring the question is endless, and that the museum's researchers and educators are on a genuine journey of discovery alongside them. This makes them feel that there really is something at stake in getting involved. That they are being invited into an actual process of co-development. To ensure that this openness and truly exploratory aspect is clear to visitors and to the public in general, it is important to present and give access to hypotheses and prototypes, both in the museum's physical space and on its digital platforms. When we do this, we also need to clearly explain how we work with prototypes internally and in collaboration with selected external experts and our visitors. Ultimately, this means the next visit will always offer something new.

1 Dixon, N. (1994). *The organizational learning cycle: How can we learn collectively*. London: McGraw-Hill; Haslebo, G. & Nielsen, K. S. (1997). *Konsultation i organisationer – hvordan mennesker skaber ny mening* [Consultation in organisations – How people create new meaning]. Copenhagen: Dansk Psykologisk Forlag; Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Hoboken: Prentice-Hall Inc.

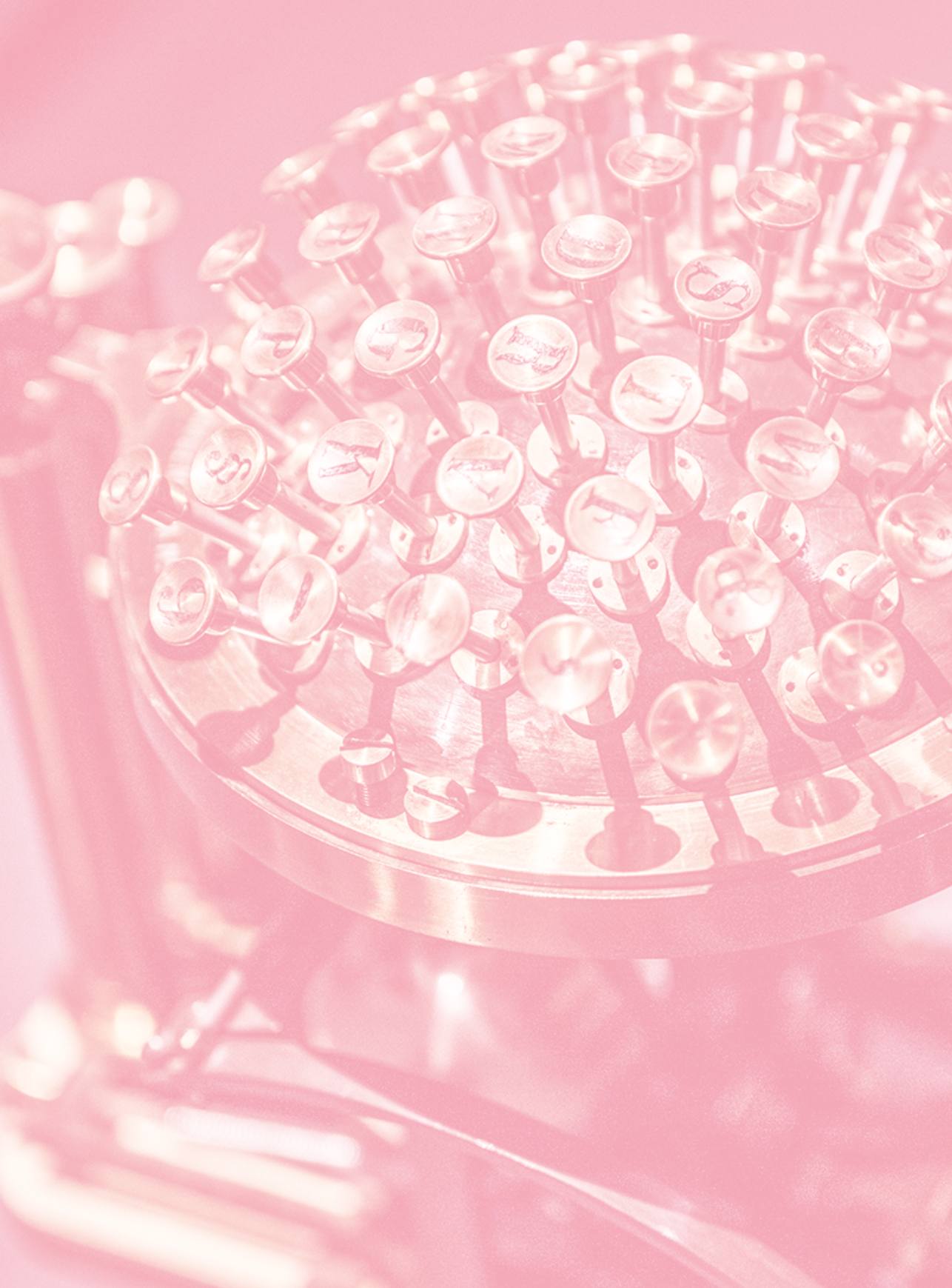
2 Through various conversation formats, Nadja Pass and Helle Solvang have rethought the salons of the Danish Golden Age 1800-1850 and identified the museum as a laboratory with a social calling.

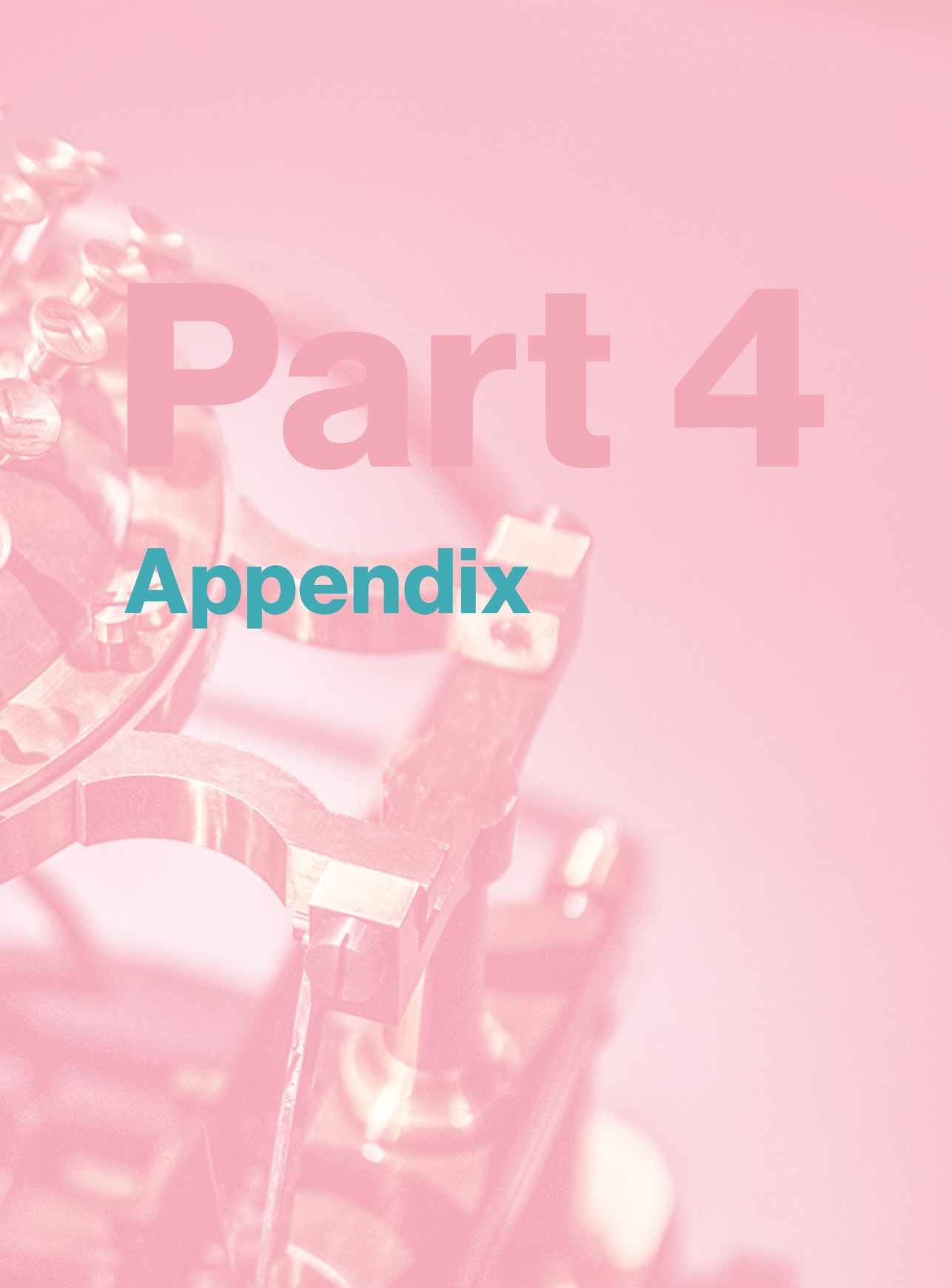

Føler
du dig
overvåget?
Do you feel surveilled?


Can things be clever?
How does artificial intelligence function?


robot


JA TAKI
NE TAKI





Part 4

Appendix

Chapter 12
Experiments

Jacob Thorek Jensen, Martin Aggerbeck and Birgitta Præstholm

This chapter describes the individual experiments that have been carried out in the project 'Science – right where you are' and presents key experiences and learning points.

Experiment 1
Newton i rummet (Newton in space)

Brief description, theme and type of initiative

Newton i rummet is an existing educational programme for the age group 14 to 16 that was further developed for the project.

Time and place

From February 2022, at the Danish Museum of Science & Technology.

Aim

To find good ways of getting more pupils to actively participate.

Primary target group

Groups/classes of pupils in the eighth, ninth, and tenth grade.

Research question

How can we get more pupils to participate actively in the educational programme?

Detailed description

The existing educational programme *Newton i rummet* was already popular among teachers and pupils. Originally, the first session started in the exhibition around the space capsule that transported the Danish astronaut Andreas Mogensen into space in 2015. Here, in dialogue form, the educator and the pupils discussed the space race and the Cold War, gravity, and Isaac Newton's three laws of motion. The class was then split up into five groups that rotated among five stations, including a fall experiment and an action–reaction experiment. We wanted to investigate how we could get more pupils to participate actively, since there were always some who stayed at the back or whose attention seemed to wander.

Using new elements, such as basing conversations on pupils' own reflections and including more physical props when explaining science aspects, we were able to activate more pupils. In particular, the dialogue-based element was inverted, in the sense that the pupils' own experiences and voices were given a more prominent role. At times the museum educator therefore seemed to be more like a mediator or facilitator of the group's discussions than a presenter.

Main learnings

- A good starting point is to begin with what the pupils investigate in the exhibition on their own and what they find most absorbing. Small tasks can be linked to their investigations, such as: 'Now let's look only at the space capsule. Do you notice anything in particular?'
- When there is a change of topic, the educator should also physically change to a new location in the exhibition, thereby shifting pupils in the back row to the front row and vice versa. This gives pupils whose attention is wandering a good opportunity to jump back in, and it helps everyone feel equally seen regardless of whether they were initially in a 'good' or 'bad' spot.
- Activity, chitchatting and fidgeting do not always indicate that pupils are not participating in the educational session.
- Physical props should be used to support scientific or educational points, preferably props that are recognisable and will activate the pupils.
- Having the pupils discuss in pairs before the full-class session allows them to practise using technical terms, and also bolsters less confident pupils in speaking out loud.

Experiment 2
Farlig viden (Dangerous knowledge)

Brief description, theme and type of initiative

Farlig viden is a free, self-guided riddle hunt in which teams of two or three people walk around the museum together, solving riddles in the various exhibitions.

Time and place

From April 2022, at the Danish Museum of Science & Technology.

Aim

To offer a fun and exciting shared experience for young adults visiting the museum.

Primary target group

Young adults unaccompanied by children; ideal for a date.

Research question

Can we use a riddle hunt around the museum to give young unaccompanied adults a positive, facilitated, shared experience?

Detailed description

The riddle hunt team is given a small box containing everything they need. They follow a map round the museum to find seven numbered riddle stations, each with a card detailing the riddle they must solve. All riddles are to be solved within the exhibition and are linked, to a greater or lesser extent, to the museum's objects. The riddle hunt begins with a personal letter, and the narrative it opens is carried forward by each new riddle solved.

The riddle hunt is an attempt to engineer an activity that is clearly a shared experience. For one thing, it includes two riddles that cannot be solved by one person alone. In addition, each riddle card contains a bonus question – such as 'Would you take a trip into space together if you could?' – intended to prompt conversations leading beyond the ordinary and supporting the shared experience.

The riddle hunt follows the style known from escape rooms and similar activities and games. The aim is to attract young adults, currently an under-represented group at the Danish Museum of Science & Technology.

Main learnings

- This sort of riddle hunt can be a fun shared experience for adults unaccompanied by children, and also for adults with older children.
- Incorporating the museum's objects or physical items in the riddle hunt increases dialogue and collaboration.
- New visitors make their way around and into all parts of the museum; repeat visitors see parts of the museum they have not seen or noticed previously.
- A riddle hunt gives visitors an opportunity to use the museum in a different way.
- Participants can, on the other hand, become so absorbed in the gaming element that they overlook parts of/the rest of the exhibitions.

Experiment 3
The Future was Here

Brief description, theme and type of initiative

The Future was Here was a popup exhibition in Copenhagen Airport, where travellers could stop and take a break while seeing some of the museum's objects.

Time and place

From April 2022 to August 2023, in Copenhagen Airport.

Aim

To reach some of the people who do not normally visit the museum.

Primary target group

Travellers in Copenhagen Airport.

Research question

How can we use a popup museum in Copenhagen Airport to create active actions, conversations, involvement in and signs of engagement with science and technology?

Detailed description

The Future was Here was a popup exhibition temporarily displaying a wide variety of objects from the museum's collection and giving a flavour of the experience visitors can expect at the Danish Museum of Science & Technology in Elsinore. There were information panels about the history of Danish aviation and about pioneering aviators, male and female. Other panels explained how an airplane can fly, and how we can achieve fossil-free air travel in the future.

With this exhibition we wished to reach a target group that does not normally visit our museum. We subsequently determined that some people had come to visit the museum in Elsinore because they had seen the popup exhibition at Copenhagen Airport. This exhibition, open for nearly a year and half, had more than 420,000 visitors.

Main learnings

- Well-known objects like a 'penny-farthing' velocipede, an antique telephone or a race car presented in fetching scenography can attract visitors' attention and prompt conversations about nostalgic memories of their own past, the good old days, and how the objects were used back then.
- Less well-known objects can then hold visitors' attention, make them wonder, and prompt associated conversations.
- In general, it is people who seem to feel at home with science and technology who naturally begin to talk about these issues in an exhibition.
- Visitors across genders and age groups found the exhibition's contents and aesthetics appealing.

Experiment 4
Frihed på to hjul (Freedom on two wheels)

Brief description, theme and type of initiative

Frihed på to hjul is a further development that builds on the museum's bicycle exhibition, using new modes of communicating and interpreting and adding contemporary bicycles.

Time and place

From June 2022, at the Danish Museum of Science & Technology.

Aim

To make visitors think actively about an everyday technology.

Primary target group

Non-professionals and people outside the cycling community, since our aim is to prompt people to reflect on a technology they do not think about in their daily lives.

Research question

How can we make technical knowledge interesting and accessible for non-professionals?

Detailed description

Frihed på to hjul displays part of the museum's unique bicycle collection. Bicycles hold a special place in Danish history and culture, and the vast majority of Danes can relate to the exhibition theme, as many use a bicycle daily or as basic transportation. Our exhibition highlights the intriguing and convoluted evolution of various bicycle types throughout the late nineteenth century. We use three stop-motion films to illustrate and describe how the bicycle developed from early balance bicycles without pedals through to their modern configuration. The films show, and directly link the information to, the bicycles on display.

The exhibition also contains special bicycles from the early 1900s as well as a collection of tricycles and professional tandem bicycle from the 1960s, juxtaposed with a state-of-the-art bicycle from Denmark's national track cycling team.

Main learnings

- Recognisable, iconic objects like an antique 'penny-farthing' velocipede or a cargo bike attract attention and are good at sparking conversations.
- Placing educational and communicative videos close to relevant objects creates a clear link for visitors.
- Linking multiple headphones to the same video enables visitors to share the experience.
- An exhibition about bicycles is relatable for visitors (at least Danish visitors) of all ages. Older models prompt grandparents to tell their own stories to their grandchildren.
- It can be difficult to maintain focus in a large space with many other audiovisual impressions.

Experiment 5
Opfind din drømmecykel
(Invent the bicycle of your dreams)

Brief description, theme and type of initiative

Opfind din drømmecykel is a workshop activity where visitors can draw their own bicycle, just as they dream it could be, and afterwards position themselves in front of a green screen and see themselves sitting on the bicycle they drew.

Time and place

Summer holidays 2022, at the Danish Museum of Science & Technology.

Aim

To prompt visitors to think about an everyday technology they often take for granted.

Primary target group

Families with children (although adults visiting the museum without children also participated in this activity).

Research question

Using play and creativity, how can we prompt new thoughts about everyday technology?

Detailed description

Opfind din drømmecykel is a workshop activity where visitors can have fun together drawing the bicycle of their dreams. They can then position themselves sitting on a stool or something similar in front of a green screen, which makes it look as though they are sitting on the bicycle they just drew. The system takes a picture that can be sent to the visitor.

The idea of drawing a bicycle from scratch is meant to stimulate visitors to think creatively about how one might design a bicycle – a technology many people take for granted. To enable small children to take part as well, the workshop has colouring sheets with preprinted bicycles available, and we encourage children to outfit their bicycles with extra features like booster motors, tassels on the handlebars, wings, or whatever takes their fancy.

Main learnings

- Visitors of all ages find this activity entertaining, and many stay for quite a long time.
- There is more creative thinking when people have a freer framework, compared to colouring in a preprinted drawing, for instance.
- Activities with an element of recognisability, in this case drawing, can motivate visitors to try out unknown elements, such as playing with a green screen.
- Offering activities that allow visitors to become absorbed and also to be active works well.
- Some visitors prefer to engage only in the drawing (absorption) activity; others prefer to engage only in the greenscreen (active) activity; and some have fun with drawings left behind by previous visitors.
- Combining analog and digital elements in a single activity offers new opportunities to be creative.

Experiment 6
The Grand Departure

Brief description, theme and type of initiative

The Grand Departure is a four-hour educational programme specifically developed for students at vocational schools who have just started on education programmes there.

Time and place

From May 2022 to October 2022, at the Danish Museum of Science & Technology.

Aim

To investigate whether we can make the Danish Museum of Science & Technology an attractive place for vocational school teachers and students, as our museum is in a unique position to develop inspiring, subject-relevant content for these students in particular.

Primary target group

Students from vocational schools, taking 'Basic introductory course, module 1'.

Research question

Can we design a targeted educational programme to give vocational schools an experience that makes them feel the Danish Museum of Science & Technology has something to offer them?

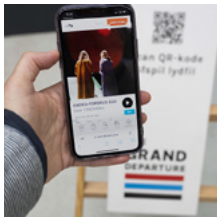
Detailed description

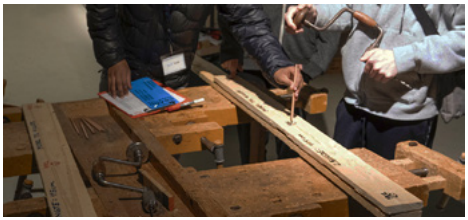
The Danish vocational school community has been looking for activities that can strengthen the general level of education among their students. The Danish Museum of Science & Technology would therefore like to contribute by making the first part of their school-based education more relevant and applicable. Further, we want to help students recognise that skilled workers also play an important role in society.

The students go on a relay race around the museum, visiting three stations dealing with industry and craftsmanship, space rockets, and energy and sustainability. These sessions are followed by a concluding full-class session. Here, students go through a teambuilding exercise where, in groups, they must build a bridge that can hold one student's weight. This educational programme contains various formats, including audio narratives, hands-on activities and quizzes. This variation aims to speak to different learning styles, to avoid uniformity, and to prevent students from becoming bored.

Main learnings

- The students should be told before they arrive at the museum what the day will be about and what will be expected of them.
- The students should be met with respect, interest and openness.
- Hands-on exercises and activities in which students investigate or construct something allow them to experience a museum as more than a 'boring', 'formal' place.
- Educational programmes become more relatable and more relevant for students when they are developed in collaboration with subject teachers from the schools.
- Objects should be included that the target group can recognise and may find fascinating, such as a Tesla, fighter jets or motorcycles.





Experiments 7, 8 and 9
Kunstig intelligens (Artificial intelligence)

Brief description, theme and type of initiative

We developed a combined exhibition and learning space with artificial intelligence as its theme. This space contains four board games that can be used both in teaching and as a facilitated activity for holiday and weekend visitors.

Time and place

From June 2023, at the Danish Museum of Science & Technology.

Aim

To investigate whether it is possible to design a highly functional combined exhibition and learning space in which the museum's objects are actively included in educational programmes. The games are intended to give visitors insight into a topic that is both academically and philosophically difficult, and also to prompt discussions about and reflections on the topic.

Primary target group

Pupils in the eighth, ninth and tenth grade, and other visitors aged 12 and up.

Research question

How can the museum's objects and gamified activities promote new perspectives and debates about a topic as complex as artificial intelligence?

Principles

For this experiment, the project group developed three principles to support development and evaluation of our dissemination initiatives. (The application of these principles is described in Chapter 3.) The three principles are:

1. The initiatives should stimulate visitors to be active in action, thought and dialogue.
2. The initiatives should be based on recognisable everyday technologies, issues or experiences that are relatable for the target group.
3. The initiatives should support shared experiences.

Detailed description

Kunstig Intelligens is an exhibition and learning space that encourages visitors and pupils to reflect on and discuss their attitudes to using artificial intelligence, both now and in the future. The space is divided into three areas. One is 'Coding', which can be regarded as the engine behind artificial intelligence; another is 'Data', which can be regarded as the engine's fuel. These two combine to create artificial intelligence. Then, as the third area asks: What is 'Intelligence'?

The Coding area shows older and more recent programmable machines, presenting the user with digital code lines, algorithms and digital programmes. In the game, participants code their own figure to move to a certain place on the board without bumping into the other players' figures along the way.

The Data area focuses on personal data. Do the participants share their data, and do they feel comfortable about doing so? In this game, players must guess the identity of a well-known figure by choosing among a selection of answers given to particular questions. The game is meant to make players reflect on the issue of good data and bad data, and on what data other people can find about the players themselves online.

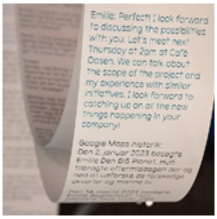
The Intelligence area treats the philosophical aspects of artificial intelligence. Here, visitors can explore their own perception of whether – and if so, when – something is intelligent. Here, they find everything from a rat trap to an old-fashioned telephone, a calculator and a robotic vacuum cleaner. In this game participants rank seven of the exhibited objects from the least to the most intelligent. There is no right or wrong answer, but players are stimulated to discuss the question of what intelligence is.

In the educational programme in this space, pupils play the games described above and explore the objects in the exhibition. The last session is a game where pupils discuss and then vote on what they would like to have artificial intelligence do in the future. Would they like to have a politician or teacher in the form of artificial intelligence? Or would they like to see artificial intelligence care for animals, or care for and entertain them when, someday, they themselves enter a residential care home for the elderly?

Main learnings

- Dialogue-motivating games work well to produce shared, activating and debate-generating experiences revolving around philosophical topics.
- Games should be extremely simple and intuitive, so participants can play them without reading any rules.
- Games can compel players to take a position on complex topics which, as museum visitors, they may previously have felt they could not do because the topic had nothing to do with them.
- A debate-generating exhibition activates all visitors, enthusiastic and sceptical alike.
- The museum's collection can be brought into play in other ways, by exhibiting objects in new constellations that reveal surprising perspectives on a current topic in the public debate.
- As a general rule, schoolchildren do not read information panels and object labels in exhibitions unless they are specifically instructed to do so.


Føler du dig overvåget?
Do you feel surveilled?
ting være kloge?
Hvordan fungerer kunstig intelligens?
How does AI work?


Emilie: Perfect! I look forward to discussing the possibilities with you. Let's meet next Thursday at 2pm at Café Oasen. We can talk about the scope of the project and my experience with similar initiatives. I look forward to catching up on all the new things happening in your company!
Google Maps historik:
Den 2. januar 2023 besøgte Emilie Den Blå Planet.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JAKOBSEN

Contributors

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Martin Aggerbeck was a curator at the Danish Museum of Science & Technology from 2021 to 2023. He holds a degree in design engineering and a PhD in materials technology. He was part of the museum's project 'Naturvidenskab – der hvor du er' ('Science – right where you are'), which developed new ways to communicate about science and technology issues. He was also involved in the exhibitions *Sort energi & grønne håb* (Black energy & green hope) and *Niels Bohr* (about the Danish physicist Niels Bohr). Martin has previously worked with the dissemination of science, and with creativity and design processes at Aalborg University and at the Experimentarium in Copenhagen. He now owns and runs his own company, Idefu, based in Copenhagen.

Karina Magnussøn Andresen is a consultant with the Danish body NEUC, The Evaluation and Development Centre for Science Education (run collaboratively by the Department of Science Education, University of Copenhagen, and Astra, The National Centre for Science Education). Here she provides guidance and evaluations for teachers and educators working with science development projects. Karina has a background in teaching mathematics and science, and she has conducted practical and theoretical work to promote the development and assessment of science teaching in Danish primary schools. She holds a master's degree in educational science.

Peter Bjerregaard is programme manager at the Danish Museum of Science & Technology. His PhD specialisation was the modern ethnographic exhibition. He has previously worked

as an exhibition consultant at the Museum of Cultural History at the University of Oslo as part of the team that renewed the entire museum's exhibition spaces. He has edited several anthologies, including *Materialities of passing: Explorations in transformation, transition and transience* (Routledge, 2016); *Kollaps: På randen av fremtiden* [Collapse: On the brink of the future, in Norwegian] (Dreyers Forlag, 2018); and *Exhibitions as research: Experimental methods in museums* (Routledge, 2020).

Lene Christensen is a special consultant with the Danish body Astra, The National Centre for Science Education, where she is the programme manager for *Masseeksperimentet* ('The mass experiment', a series of Danish citizen-science projects for primary school pupils) and *Testoteket* ('The testo-thèque'). She also acts as didactic consultant for crossdisciplinary projects, including projects about the interplay between out-of-school learning environments and education in primary and secondary schools. Lene has previously worked in the outreach department at the Copenhagen Zoo and has been the head of outreach activities at the Esrum Abbey and Millyard medieval centre.

Jens Refslund Christensen, director of the Danish Museum of Science & Technology, runs the museum in its current form in Elsinore, North Zealand, and is responsible for developing the new museum, which will be housed in the buildings of what is now the Svanemølleværk power station, in the northern part of the Port of Copenhagen. He has previously played a leading role in major transformation processes: at the Royal Theatre, as production manager while the Royal Opera House and the Royal Playhouse were under construction; and as head of construction development and commercial manager during the building of the new Natural History Museum of Denmark. He has also previously been production manager and commercial manager at Østre Gasværk Theatre and at Teater Republique, both in Copenhagen. He holds a degree in production management from the Danish National School of Performing Arts.

Jacob Thorek Jensen is a curator at the Danish Museum of Science & Technology, where he has worked since 2016. He has organised exhibitions there on various topics, including the smartphone and digital media, gaming, artificial intelligence, and human bases in space. He heads the project 'Naturvidenskab – der hvor du er' ('Science – right where you are'), in which the museum has been developing new ways to communicate about science and technology issues. Jacob has previously worked at the Workers Museum and with the Agency for Culture and Palaces. Since 2022 he has also been the vice-chair of CIMUSET, ICOM International Committee for Museums and Collections of Science and Technology.

Berit Anne Larsen is the director of learning and art interpretation at SMK, The National Gallery of Denmark, Copenhagen. She has previously worked at the Danish modern art museums ARKEN and Louisiana, and has also been an assistant professor teaching art history and film and media sciences at the University of Copenhagen and Aalborg University. She holds a master's degree in modern culture and cultural communication from the University of Copenhagen, as well as a master's degree in public governance from CBS, Copenhagen Business School. She is currently working towards the 2025 opening of SMK's new branch museum at the opposite end of Denmark, in the North Jutland region of Thy.

Katia Bill Nielsen is a postdoctoral fellow at the Department of Science Education at the University of Copenhagen. She has a degree in anthropology and a PhD in university-level didactics. Her main research topics are students' choices of university programmes, and perspectives on science. She is part of the research project SCOPE, which aims to investigate how children and young people view and relate to science as a school subject and an academic field, and on how this develops over time.

Birgitta Præstholm is the head of learning activities at the Danish Museum of Science & Technology, where she has worked since 2019. The project 'Naturvidenskab – der hvor du er' ('Science – right where you are') is one of the many projects in which she has been involved. She previously worked for DR, the Danish Broadcasting Corporation, for 16 years, beginning her apprenticeship there in 2003 as a graphic web designer. She moved on to the position of web editor for DR Kultur (at dr.dk/bog/film/teater), then joined the team behind the cultural programme *Den 11. Time* ('the eleventh hour'). In 2008 she joined the educational department, DR Undervisning, developing teaching materials with a variety of partner institutions such as Frederiksborg Castle (now a national history museum), SMK, The National Gallery of Denmark, and *Sex og Samfund* (a sexual and reproductive health education portal).

Majken Svendsen works as a special consultant with the Danish body NEUC, The Evaluation and Development Centre for Science Education (run collaboratively under the Department of Science Education, University of Copenhagen, and Astra, The National Centre for Science Education), where she works with the assessment of projects in science development in the field of education. Majken has several years of experience with development and evaluation projects relating to social intervention programmes and education. She holds a master's degree in political science.

The Museum of the Future – Technology, society and sustainability literacy

The Danish Museum of Science & Technology
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3000 Elsinore
Denmark

Editors: Jacob Thorek Jensen, Martin Aggerbeck, Peter Bjerregaard and Birgitta Præstholm

Graphic design and layout: Mark Gry Christiansen
Translated from the Danish by Avanti Gruppen
Original Danish title: Fremtidens museum – teknologi, samfund og bæredygtig dannelse

Photo credits
Page 7-11: The corporation for development of City and Port
Page 90-91: The Norwegian Museum of Science and Technology
The remaining photos belong to the Danish Museum of Science & Technology

Printed in Denmark by Kandrups Bogtrykkeri A/S
Danish edition: 200 copies in print
English edition: digital version only

ISBN
Paperback in Danish: 978-87-87034-07-4
E-book in Danish: 978-87-87034-08-1
E-book in English: 978-87-87034-09-8

We are grateful to the Novo Nordisk Foundation for supporting this publication and the project 'Naturvidenskab – der hvor du er' ('Science – right where you are').

novo nordisk fonden

We also thank the following people for valuable input, fruitful deliberations and help along the way: Jeppe Sand Christensen, Martin Exner, Lars Volf Jensen, Helle Madsen, Lise Dissing Møller, Mette Posselt, Simon Reinhardt, Ane Dorte Riis, Anne Schnettler, Mikael Thorsted, Brit Ross Winthereik and all our colleagues at the Danish Museum of Science & Technology.

‘Who controls the past’, ran the Party slogan, ‘controls the future: who controls the present controls the past.’

George Orwell

Technology is a central element in humanity's narrative. For better and for worse, our ability to develop and use technology has been decisive in shaping our lives as individuals, and indeed in the role humans now play on Earth. But the opportunities that technological progress has given us also mean that in today's world we depend on technologies that few of us understand at a deeper level, or find transparent.

In these changing times, science and technology museums around the world are grappling with hard questions. What themes, methods and formats are needed if technology is not merely the story or history of how machines developed, but also a question of democratic rights, climate issues and ethics? And how do science and technology museums address and engage with their visitors given that, fundamentally, their target group should not merely be people interested in technology, but a wider public who use technology every day?

This publication presents a series of reflections on how museums can actively serve as fruitful forums where technology can be explored and debated. We hope it will contribute new perspectives on the role that science and technology museums can and should play at a juncture where technology is saturating and affecting our lives more than ever.

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