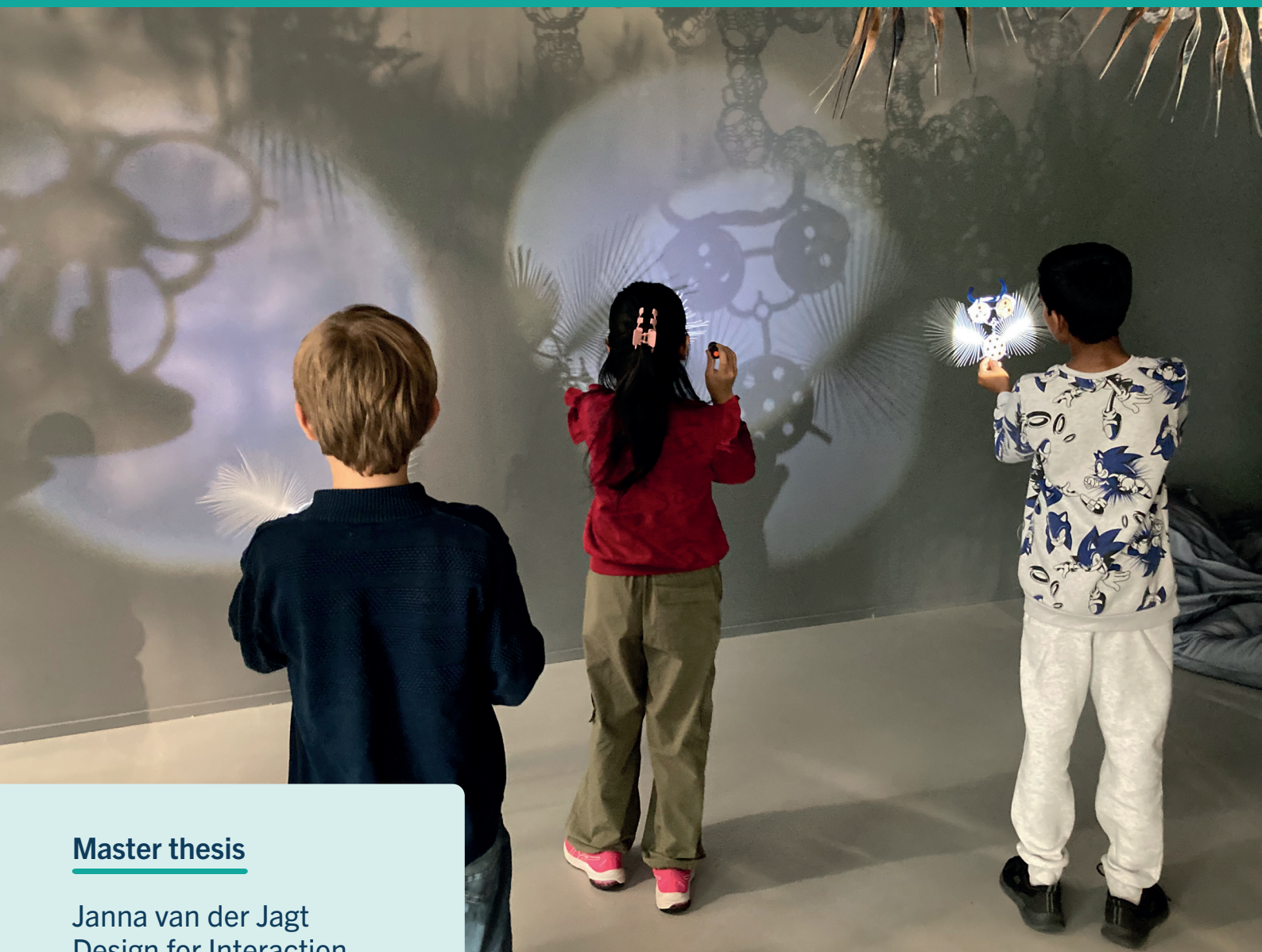


Supporting the development of meaningful STEAM-based workshops for children aged 8-12 years

Designing a practical guidance tool through a case study



Master thesis

Janna van der Jagt
Design for Interaction
June 2025

Colophon

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Designing a practical guidance tool through a case study

Master thesis

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10 June 2025

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Preface

This thesis is the final project of my master's degree in Design for Interaction at the Faculty of Industrial Design Engineering at TU Delft. I dedicated the final months of my studies to this project, from December 2024 to June 2025.

Throughout the master I have developed my interest for designing for playful learning, human centred design, and sustainability. Choosing this study felt natural, I was looking for a place where I could combine both my creativity and my interest in technology. Doing both the Bachelor and Master at Industrial Design Engineering has proven to be the right path for me. Ending this journey with a project that asks me to bring together creativity and technology for young learners feels like a perfect conclusion, closing the loop.

One thing I had been missing in my curriculum was the experience of working within a real organisation and a real project. I am happy I have had the opportunity to do exactly that with the TU Delft Science Centre. Special thanks to Tanja and Simon, who have helped to find the balance of 'fun' and 'seriousness' I was looking for in this project.

I would also like to express my thanks to my supervisors at IDE, my chair Arnold and mentor Aadjan. Our meetings helped me navigate and define the direction of this project and helped bring my final result to a higher level.

It was a great opportunity to meet and collaborate with Philip Beesley and his team. The communication and openness have been beneficial for both our projects.

In addition, I would like to thank everyone who has been part of my graduation project. The children and their parents who took part in the workshops, the facilitator of the workshops, all experts I have interviewed and anyone else involved.

Lastly, I want to thank my girlfriend, friends, family and fellow students for their support during the process.

I am proud to present my thesis to all of you!
Enjoy reading!

Abstract

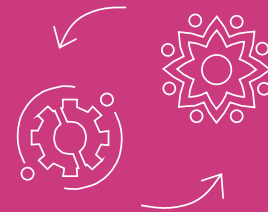
The TU Delft Science Centre is currently renewing its programming, including the development of new workshops for children aged 8 to 12 years, named Techniek Studio. The Science Centre's main goal is to create fun experiences that spark a lasting interest in technology and innovation. However, how to achieve such meaningful engagement remains unclear. This design research project responded with the following design challenge: "Discover how to develop a STEAM-based workshop that provides children 8 - 12 years old with a meaningful experience at the TU Delft Science Centre"

Using a Research Through Design approach, the project combined literature review, expert interviews, and observations to formulate 14 initial design guidelines. These guidelines were organised across the three experiential phases: before, during, and after the workshop. They included initial actionable points and instructional support. It also incorporates the on literature-based designed 'experience layers model', which guides goal setting and evaluation.

A case study was performed, which included the development and testing of the 'Experiencing with Art' workshop. Through this case study, the guidelines and supportive elements were refined. This process led to the design of 'The STEAMingful Design Tool', a detailed, practical booklet for workshop design. Evaluation of the test workshop with the 'experience layers model' indicated that participants gained meaningful insights on both the topic and the use of the materials of the workshop. However, the longer-term impact on sustained interest remains uncertain.

Expert reviews on the tool suggest that the tool effectively supports novice designers but recommend adapting the tool for more experienced users.

Ultimately, this project delivers both a tested STEAM-based workshop and a research-informed design tool that holds promise for fostering meaningful STEAM-based out-of-school learning experiences. Future research by independent workshop developers is recommended to examine the long-term effects of using the tool on children's level of experience. This will also further validate the applicability of the tool outside the Science Centre.



The STEAMingful Design Tool

Practical guidance for developing meaningful STEAM-based workshops for children aged 8 -12 years.

Reader's guide

The main goal of this graduation project was to offer design guidance on how to develop meaningful STEAM-based workshops for children. A large part of this was explored through a case study: the design of a workshop for the Science Centre at TU Delft. This was the initial request from the Science Centre and served as the starting point for this project.

This project lasted from December 2024 to June 2025. Throughout this report, several projects at the Science Centre will be discussed that were still in development. Some of these projects evolved in parallel with this graduation project. As such, the process involved close collaboration with Science Centre staff to stay aligned with ongoing developments. These changes were considered where relevant, but did not influence the main direction of the project.

It is important to note that the project was approached from a 'Design for Interaction' perspective rather than an educational science background. This means that the design process was shaped by principles such as user-centered thinking, iteration, and experience design, rather than by formal pedagogical theory.

Path of the project

This report describes the process followed, including researching, designing and testing. This is summarized in the accompanying diagram in Figure 1.

Used abbreviations

SC - Science Centre

STEAM - Science, Technology, Engineering, Art and Math

LASG - Living Architecture System Group

PB - Philip Beesley

DG - Design Goal

Terminology notes

In this report, the term 'parents' is used as an inclusive term referring to all primary caregivers, including parents, guardians, and others responsible for the care and upbringing of children.

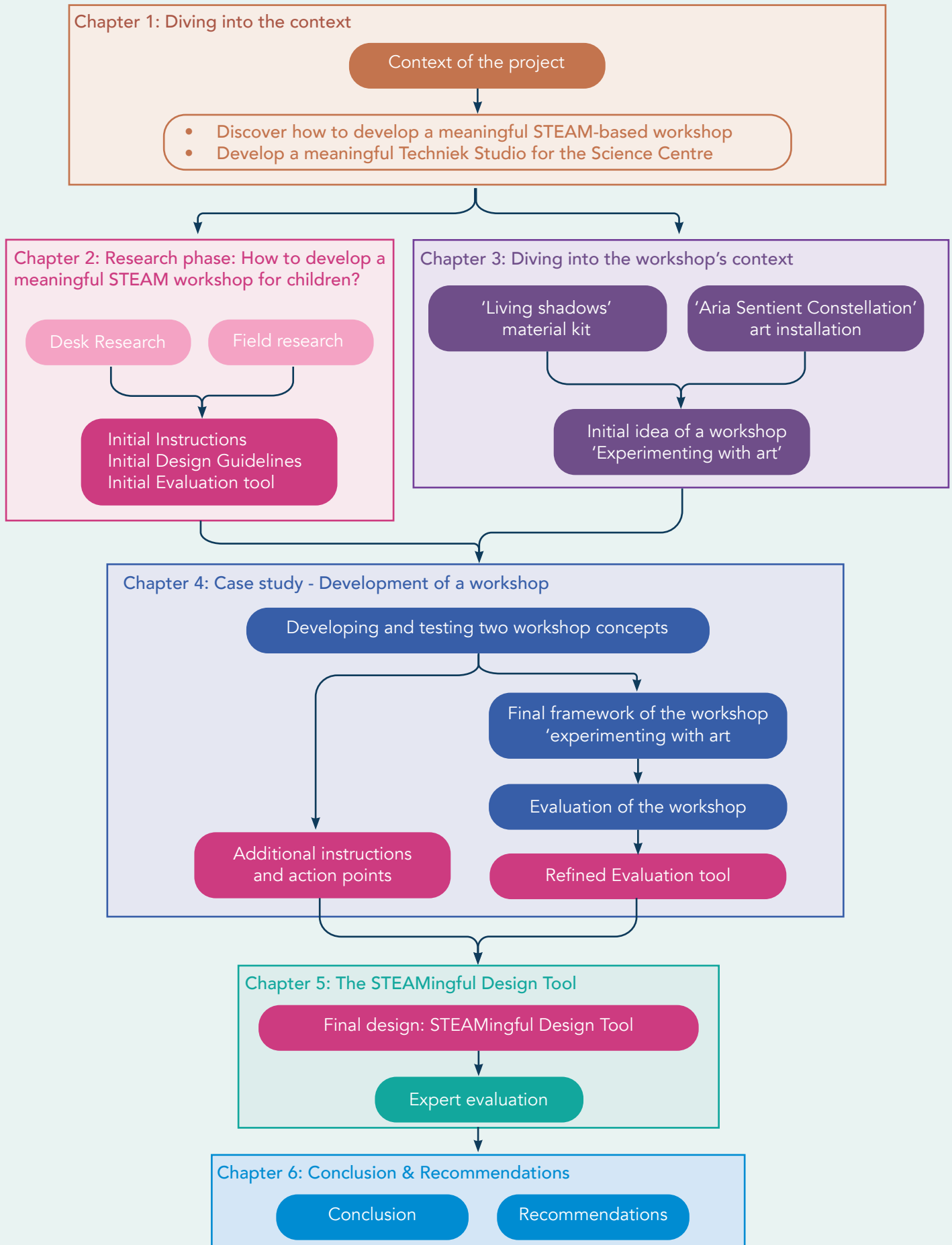


Figure 1: Overview of this projects process, explained throughout the chapters

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Chapter 1

Diving into the context

This chapter serves as the foundation for this master thesis. The first section introduces the project context, the research direction and the projects approach. Thereafter, each section takes a closer look at one of the key aspects within the context and highlights the found research and design opportunities. The chapter concludes with the main takeaways that launch this project.

- 1.1 Introduction
- 1.2 TU Delft Science Centre
- 1.3 Techniek Studio
- 1.4 STEAM in education
- 1.5 STEAM at the Science Centre
- 1.6 Meaningful Experience
- 1.7 Conclusion

1.1 Introduction

TU Delft Science Centre is a place where visitors of all ages get the chance to explore the world of technology, research and innovation. For young visitors they offer the possibility to discover new skills, use their curiosity in a hands-on way and get the chance to step into the shoes of a researcher. With diverse activities the Science Centre inspires a new generation of creators and problem solvers of the future. As an organisation that offers a combination of both out-of-school learning experiences and educational activities towards the future, they recognise the importance of renewing and researching their way of conveying knowledge and skills to the visitors.

Currently, the Science Centre is renewing their entire program, which gives the perfect chance to research design opportunities around the development of new activities.

A STEAM workshop line is part of this renewed program and deserves some attention in its development. STEAM (Science, Technology, Engineering, Arts, and Mathematics) integrates creative methodologies with technical disciplines. This will be offered in the new 'Techniek Studio', a hands-on STEAM workshop designed for children 8-12 years old. The goal is to help children develop an interest in science and technology through a playful interaction with art. The workshops are part of the out-of-school learning experience and will be held during the weekends and on holidays.

Research direction

One of the goals for the Science Centre, is to impact their visitors in a way that the experiences trigger a lasting interest in the world of technology and innovation. Until now, the Science Centre developed many activities for all kinds of target groups to achieve this. All of them are developed with good reasoning behind the use of themes and materials. Nevertheless, there is a lack of research on reaching this lasting interest, or any validation of the workshops' impact. Moreover, there is no focus in the workshop development to achieve this.

This leads to the aim of this study, which is to discover how these STEAM workshops can be designed for the participants to have a meaningful experience. This means that an activity not only triggers emotions which make it a memorable experience, but also involve reflection,

leading to insights that are connected to one or several sources of meaning that makes it meaningful (Bastiaansen & Duerden, 2024). In other words, to enable the development of workshops for the Science Centre that foster this lasting interest with visitors. Figure 2 illustrates the accompanying projects scope, showing the main aspects of this project.

Design challenge

With this context and a clear direction of the research, the design challenge is formulated as follows:

“Discover how to develop a STEAM-based workshop that provides children 8 - 12 years old with a meaningful experience at the TU Delft Science Centre”

Project approach

This project will go through several phases and follows a Research Through Design approach, in which design activities play a central role in generating knowledge. The focus lies on learning through the process of designing and testing in real-world contexts (Stappers & Giaccardi, 2017).

The **exploration phase** aims to create a deeper understanding of the key aspects related to the design direction. This will be done through researching existing literature and conducting field research.

In the **development phase**, an initial form of design guidance, a tool, will be created based on the insights gained during the exploration phase.

During the **test phase**, the initial tool will be applied and evaluated through a case study. This case study will be about the use of the initial tool to develop a Techniek Studio for the Science Centre. Evaluating this case study will provide new insight.

In the **refinement phase**, the initial tool will be improved using all the insights from the case study. This will result in a final design of the guidance tool and a final reflection.

Opportunities

The main goal of this project is to design for the support of future development of workshops at the Science Centre, with the aim of making them more meaningful for visitors.

Within this project, additional opportunities emerged. Firstly, as part of the design process, the design will be applied in practice as a case study. This gives the opportunity to directly develop a useful workshop for the Science Centre.

Secondly, when this project's goal is reached, the final design could also be used by the Science Centre to revise and redesign existing workshops to make them more impactful.

Thirdly, outside the projects scope, this project result could be used by other organisations who are interested in developing STEAM-based workshops to have more impact on their young participants.

Challenges

One of the biggest challenges this project faces, is to find the balance between on the one hand seriousness as the goal is for visitors to learn something new and on the other hand for them to have fun, as the workshop will be an out-of-school learning experience for children.

Furthermore, within the target group of children 8-12 years old there will be a difference of cognitive development and skills. Within this project, it is important to design for the participating children so they can all be challenged on their own level.

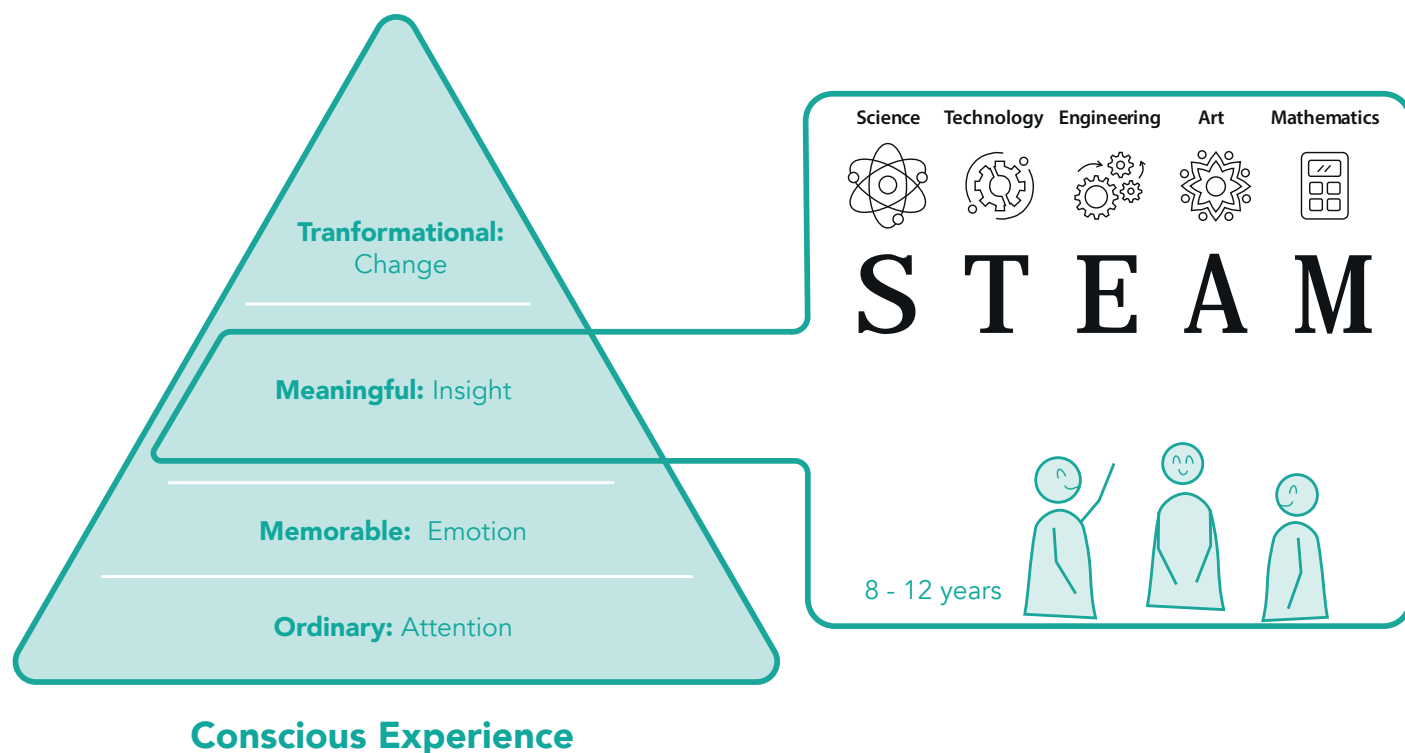


Figure 2: Scope of the project

1.2 TU Delft Science Centre

TU Delft Science Centre is the place on the TU Delft campus where science, technology and society come together. To understand its role in this project, this chapter will look at how the Science Centre has evolved over time and what research and design opportunity it offers as a start for this project.

Development over the years

TU Delft Science Centre is a registered museum and descends from the 'Technical Exhibition Centre' founded in 1976 by a group of engineers who wanted to present engineering to a wider audience (Geschiedenis Van Het Science Centre Delft, n.d.).

Nowadays, the TU Delft Science Centre is a way for the TU Delft to connect the public to science and technology. They aim to engage the wider society with scientific issues and technological challenges. What makes it unique is that, as part of the university, it is directly linked to education and research at TU Delft. They organise a wide range of activities such as science events, workshops, lectures, exhibitions and tours. This gives the visitors the change to come in contact with scientists and their research.

Visitors

The Science Centre is part of 'communications' of the TU Delft and has the function to connect the university with society. Therefore the target audience of the Science Centre is very broad. Going from students being able to use facilities for their research projects, to both primary and secondary schools that visit as a school excursion. Starting in early 2026 families too are welcome to visit the Science experience.

Renewing the Science Centre

In 2022 the Science Centre opened on a new location on the TU Delft campus. While this master thesis is carried out, the construction and renovation process of the TU Delft Science Centre is in full progress. Figure 3 shows the look of the new entrance area where the visitor will start their Science Centre experience.

Since the opening, there are several labs installed where a mix of research, education and open public visits can make use of them. This provides the visitors with the right

equipment and help to experiment with and learn about a certain topic and ask critical questions. Examples of labs are: a makerspace with lasercutters and 3D printers, a Microbiology laboratory and a Swarming lab with drones.

Renewing the Science Centre, also means the development of new projects and programs for the public. Offering a broad audience new activities for both education and out-of-school learning.

Project focus

The following three projects the Science Centre has planned, will play a key role in this graduation project.

Techniek Studio

The Techniek Studio will offer visitors the opportunity to participate in hands-on workshops on various topics. It will be held during weekends and school holidays for children 8 to 12 years old. More explanation will be given in Section 1.3.

The Science Centre plans to make some of these Techniek Studio STEAM-based. STEAM adds the arts to science and technology, more is explained in Section 1.4. According to Simon Aerts, project leader and program curator public presentation at the Science Centre, science suffers from a somewhat outdated and 'dusty' image. This is something that can be change by offering visitors engaging, hands-on experiences in the Techniek Studio. To enable them in recognising that there is a lot of creativity involved in scientific research (Van Oosten, 2025).

Entrance area

The new entrance is designed by artist Philip Beesley Studio Inc. & Living Architecture Systems Group (Philip Beesley Studio, n.d.). A big installation, Aria Sentient Constellation, immediately emerges visitors in art and technology and will be the start of every visitor's Science Centre experience (Beesley, 2024). Further explanation is given in Chapter 3.1.

Material kit

Besides this installation, Philip Beesley (PB) and his team have also created a material kit titled 'living shadows'. The kit is designed to introduce children to technology through creative, tactile exploration using materials recognisable from the installation itself. More details about the kit can be found in Chapter 3.2.



Figure 3: Impression of the new TU Delft Science Centre entrance area (TU Delft Science Centre, 2024).

Role in the project

Together, these three projects offer valuable opportunities this graduation project in terms of research and development.

The Science Centre has identified the ‘living shadows’ material kit as a good starting point to develop a first STEAM-based workshop that aligns with the Techniek Studio concept. Using these materials also presents a promising opportunity to create a meaningful link with the new artwork at the entrance. Together, this formed the initial challenge, proposed by the Science Centre, at the start of this graduation project.

Diving deeper, this project discovered that the development of this workshop could serve as a valuable case study. Through this case study, the outcomes of the research phase can be tested, applied, and refined into a final design.

Altogether, this project sees the opportunity to do both: to design a useful product that supports the development of STEAM-based workshops that offer a meaningful experience, and to use this project’s process to deliver the framework of a useful Techniek Studio for the Science Centre.

Value of the project

This project aims to be valuable for the Science Centre in several ways.

Firstly, conducting the case study aims to result in a concrete framework for a STEAM-based Techniek Studio, which can be further developed for implementation.

Secondly, this research aims to deliver an initial form of design guidance, that allows the Science Centre to easily offer future staff or even students guidance in developing new Techniek Studios.

Lastly, it can add credibility and depth to the public image of the Science Centre. They can communicate to their audience and stakeholders that their workshops are not just fun, but also designed with the intention to leave a meaningful and lasting impression on children.

1.3 Techniek Studio

The 'Techniek Studio' is one of the new projects of the Science Centre which will be opened in May 2025. It will be a fixed program for the young visitors aged 8-12 years. The program will be held on the weekends and in school holidays (Wij Bouwen Aan De Toekomst, n.d.). Here participating children will have a hands-on experience with equipment and items that you will only find at a technical university. Examples of workshops are working with bioplastics in the biolab or learning robot programming in the robot lab.

Program goal

The main goal of this program is for the young target group to have the realisation discover what technology can mean and how it connects to their world. They should not only be inspired, but also get an understanding of how technologies work. Nevertheless, this program is part of the out-of-school learning experiences offered by the Science Centre, and not the educational activities specifically designed for schools. So, the workshop design aims for the children to have a lot of fun while working with technology. The visitors should have a hands-on experience which allows them to explore a complex subject in a concrete, engaging way. Helping them feel empowered, curious, and more connected to the topic.

Target group

The Science Centre's target audience for the Techniek Studio is children aged 8 to 12. In their weekends or holidays, they can visit the Science Centre to take a first step into the world of technology and innovation at the TU Delft. The workshops offered have their own theme that fits the interest of children and will serve multiple skill levels within this target group. With the aim to trigger their curiosity and help to discover the world around them.

Set-up

For the Techniek Studios, the Science Centre has already decided on a few basic elements of the overall set-up. The Techniek Studios will be a 3-hour long workshop within one of the labs, for groups of 12-15 children. Here the children will be introduced to the lab's topic by the workshop giver, in most cases a student of the TU Delft. Figure 4 gives an impression of this setting. The further detailing of the workshop is topic dependent. One of the

overall topics of the workshops used in Techniek Studios are STEAM-based workshops. This will be explained in the following Section 1.5. At the end of the workshop they finish their project and have learned something new about technology and innovation.

The tickets that are sold, are combination tickets. Meaning it includes the entrance of a child between 8 and 12 years old, and that of its parent/caregiver. This results in a workshop room with around 12 children, 12 adults and 1 workshop facilitator. An example situation is shown in Figure 5.

Role of the parents

The parents of the children also play a part in the experience of a Techniek Studio. Firstly, they are important for the recruiting of the children. The audience of the current Science Centre program is mostly found through their website and on their social media. Parents will be responsible for telling about, signing up, and communicating information about the activity to their children. They will receive an email with information about the workshop beforehand. Secondly, the parent is asked to join the workshop with their child. In some workshops, the parents can play a small role. For example, they can be asked to help their child with more complicated tasks. The four most important steps are shown in Figure 6.



Figure 4: A facilitator explaining the materials to children in a Techniek Studio.

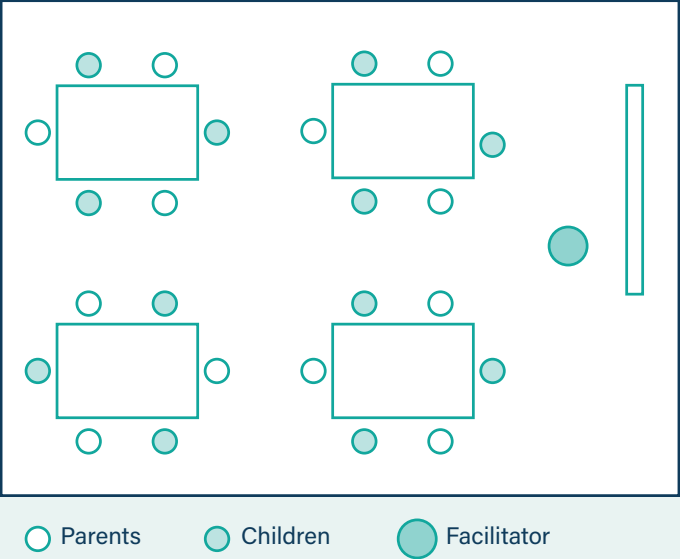


Figure 5: Schematic overview of the workshop room set-up.



Figure 6: Most important steps in which the parent plays a role within the workshop experience.

1.4 STEAM in education

One of the opportunities for the Science Centre's Techniek Studios is to offer a line of STEAM-based workshops to the audience. This concept is already partially present in several activities as the Science Centre but has never been in the centre of it.

Definition

STEAM is the abbreviation of Science, Technology, Engineering, the Arts and Mathematics, see Figure 7. It builds on the more familiar STEM education, by adding the A of Art to it. In general, it aims to integrate these disciplines encourage students to learn through exploration, hands-on experiences, and through this, foster creativity, critical thinking, and student engagement (Perignat & Katz-Buonincontro, 2018).

Research shows that there is no agreed-upon way to add the arts into STEM education. Perignat and Katz-Buonincontro (2018) did a literature review of 44 publications on STEAM education (2007–2018) and found a wide variety of interpretations of the "A" in STEAM and multiple approaches to combining the disciplines.

Building on a similar conclusion, Liao (2019) explored what current STEAM education practices look like. To illustrate this, a map was created that visualises the different approaches and objectives between current

STEAM education practices (Figure 8 presents the two-dimensional map.) According to the research, there are many ways of STEAM practices all fitting in this map (Liao, 2019).

The two main opposites, also placed within the map, are explained as:

A. "Practices that proceed from the idea of using STEM knowledge to create art" (Liao, 2019).

and

B. "Practices that proceed from the idea of creating art to learn, understand, represent, or demonstrate STEM content" (Liao, 2019).

In whatever way art is integrated, for this report the following phrase from McKeown (2018) is seen as important for all workshops "STEAM places value on the arts for their creative methodologies, ways of knowing the world and tangible modes of knowledge production." In other words, art is so much more than just making something look nice. How the Techniek Studio is placed will be explained in the following Section 1.5.

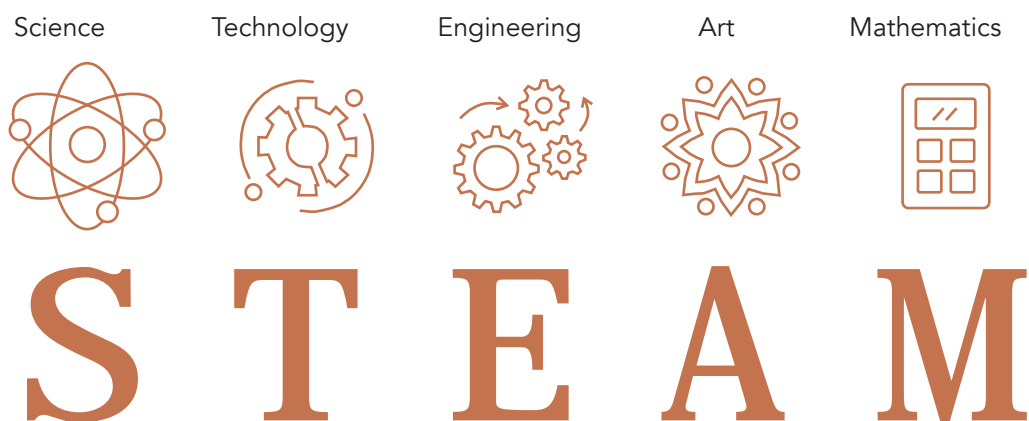


Figure 7: STEAM explained

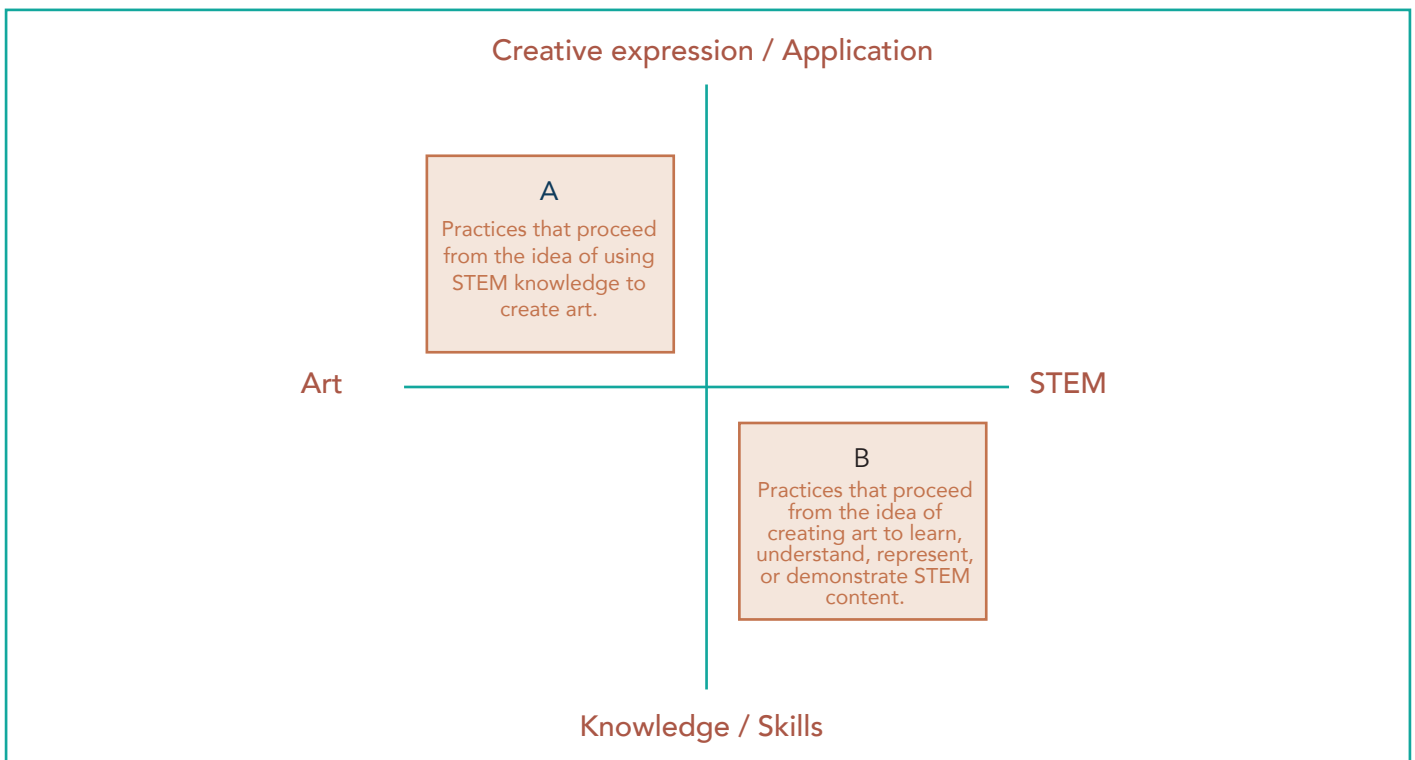


Figure 8: Mapping STEAM education practices (adapted from Liao, 2019). The horizontal axis represents the relationship between ART and STEM. The vertical axis shows the spectrum from creative expression to knowledge and skill building.

Historical reasoning

Looking into historical characters, it was very common to combine science, technology and art. A great example is Leonardo Da Vinci (1452–1519), who is well known as a great painter of the Mona Lisa and the Last Supper for example. In his artistic work, he used scientific knowledge, like the anatomy of the human body. Furthermore, he used his invention and mathematical skills together with the observation of birds to create things like an aerial screw, that looks like a early helicopters (see Figure 9)



Figure 9: Aerial screw, model by Leonardo da Vinci (ca. 1485), reconstruction on display at Leonardo3 Museum, Milan.

(Hobbs, 2018). Many more came after him fitting this artist-scientist archetype. Here, history shows that art, science, and technology go perfectly together and can even enhance each other.

Future reasoning

“The separation between art and engineering came only after the Renaissance as our scientific knowledge grew more powerful.” (Blockley, 2018). This resulted in the educational system we know now, where it is very common to only have a focus on either STEM or the arts, but not both. The downfall of this way of educating is that it focusses on the hard skills in nowadays technologies, although in 10 years there will be a demand in jobs that use technology that has not even been invented yet (Hobbs, 2018). This leads to changing skill requirements on the job market. On top of this, soft skills become appreciated more as careers progress. For example, the soft skills, like a problem-solving mindset, decision-making and critical thinking needed for leadership and management are increasingly valued (Aguilar, 2021). Here, it can be concluded that STEAM in education can be the creator of a good balance.

1.5 STEAM in the Science Centre context

STEAM beyond education

During the research phase of this project, most of the papers found about STEAM primarily focused on 'STEAM education'. Whereas for the Science Centre, these workshops will not be part of the educative program but belong to the out-of-school learning experience named 'Techniek Studio'. Meaning there are no core objectives with which they have to comply. However, the Science Centre does aim at a hands-on learning experience for all visitors. The aim thus is that the children get in contact with the STEAM disciplines in a hands-on and fun way. Therefore, the theory around STEAM cannot be directly applied and needs to be adapted to fit the Science Centre's out-of-school learning environment.

Positioning the Techniek Studio

With the new concept of the Techniek Studio's the Science Centre sees an opportunity to implement the theory of STEAM. The first step in integrating this in the right way, is understanding what direction of STEAM fits best. It is not the goal to use art as just a decorative tool to make something tangible. The aim is to use art as its own discipline including the process of critical reflection, creativity, and understanding what you are making (Liao, 2019). So, when looking at the STEAM map explained in Section 1.4, the Techniek Studios are more leaning towards building knowledge and skills within the STEM disciplines. Thus, in Figure 10 it is positioned in the lower right corner. The aim is to use a hands-on, artistic processes as a tool to deepen understanding of STEM concepts among the participants.

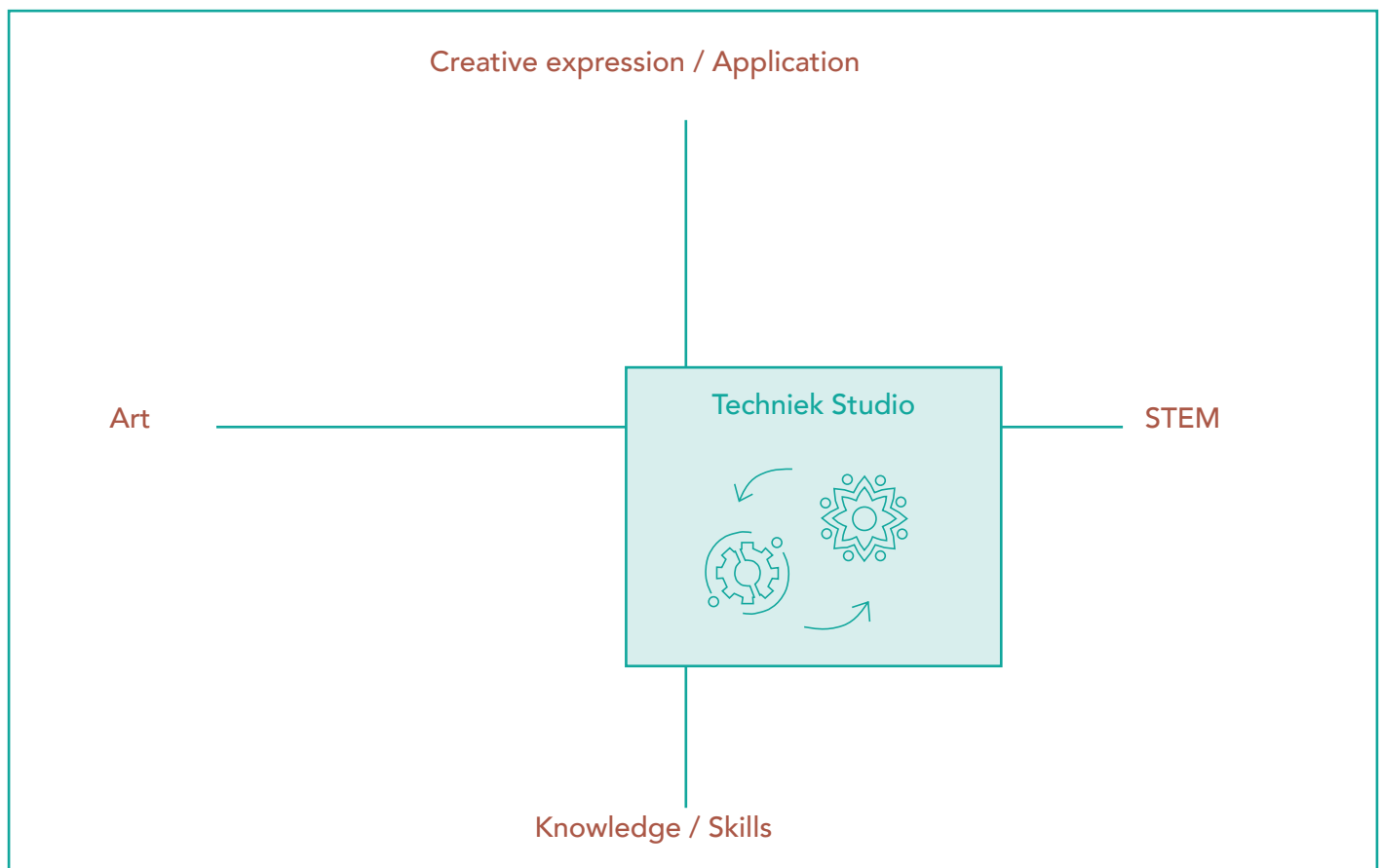


Figure 10: STEAM education practices map with the Techniek Studio positioned in the STEM - Knowledge area.

“To develop a complete mind: Study the science of art; Study the art of science. Learn how to see. Realize that everything connects to everything else.”
~Leonardo Da Vinci

Goals for the Science Centre

For the Science Centre there are several reasons to implement STEAM in their range of activities. The following five points were identified during a conversation with T. Klop, team leader of education at the Science Centre.

1. Broadening interest in technology

For the Science Centre the aim is to use STEAM-based workshops to make technology and innovation attractive to a bigger group of visitors. Students who look at the STEM disciplines as dull and boring can be transformed to a broader view on them. Broadening their horizon will help them to recognise that technology and innovation are not just hard science with electronics. In this way, not only children that already have an interest in tech will be attracted, but also those who might see technology as something scary or too complicated. Showing the creative side, may help them grow more confidence.

2. Applying technology in real-life

STEAM allows theory to be applied in tangible ways, giving the opportunity to experience how technology can be used in a realistic setting. Whereas sometimes STEM only explains the technology, how it works and its theory. The advantage of STEAM is for the theory to be directly applied and learn how to do this in a hands-on way. This helps the participants to understand how the new theory can be used outside of the workshop.

3. Gender balance

There are few women among young technicians relative to men, and these women are also less likely than men to enter a technical profession. In research, it was found that using STEAM has a positive effect on female students, and women remain more interested in the pursuit of STEM (Wajngurt & Sloan, 2019). So, a STEAM workshop at the Science Centre can show girls, or anyone more attracted to the arts, a bit of technology through creativity. On the other hand, STEAM can also help to show the opposite group who now have a big interest in technology, in what way creativity can be beneficial for a project.

4. Enhancing soft skills

Adding art to STEM activities can help explore and develop the use of soft skills. Soft skills are seen as a combination of interpersonal and social skill that are developed through personal experience and reflection (Dixon et al., 2010). For example, thinking outside the box or critical thinking are important skills that can be used in many fields. Whereas technology learned now will change rapidly in the coming decades, soft skills will remain useful and important over time (Aguilar, 2021).

5. Taking a leading role

For the Science Centre, it is also interesting to take a leading role in the development of activities connected to technology for children. Since STEAM is still an upcoming way of education, they could set a great example towards their visitors.

1.6 Meaningful experience

The development of a new workshop gives the opportunity to consider its intended outcomes. For the Science Centre, this means creating an experience that provides the visitors new insights into the workshop's topic and sparks a lasting interest for technology and innovation in general. This can be called a 'meaningful experience'.

Looking at various sources, it becomes clear that the term 'meaningful experience' has been used with a range of different explanations. It can be seen as a broad, subjective concept. For this report, the article of Duerden et al. is used to reach a clear understanding (2018). They introduce a framework of experience types. This framework is shown in Figure 11.

Firstly, a workshop is a structured experience since it is conceived and performed by a provider. Secondly, a workshop can be seen as a conscious experience because it involves participants actively paying attention to what is happening around them and triggers a subjective reaction like personal thoughts, feelings, or insights. Thirdly, as something that does not happen every day, a workshop belongs to the extraordinary experiences. This is further defined as something that may hold an individual's attention and "an experience that is characterised as highly emotional, meaningful, unique, and having the power to transform." (Duerden et al., 2018).

As a last step in this framework, extraordinary experiences can be divided in three specific subtypes: memorable, meaningful, and transformational.

The first type, at the bottom of the framework, is a memorable experience, in which an activity holds a person's attention and results in having strong emotions which helps creating memories.

One level higher, are meaningful experiences. These do not only involve emotions, but also discovery. This can be achieved by direct engagement and being actively involved. When both emotions and the senses are engaged, this will lead to a deeper experience. If this is relevant for the person's life, so for example matches their interests, it results in a greater impact on the participant. After this, reflecting on the experience will help discovering new insights. And finally, when these insights are connected with one of the four sources of meaning, the experience will be perceived as meaningful (Bastiaansen &

Duerden, 2024). These four sources of meaning are social connection, goal fulfilment, contribution and growth and will be discussed in detail in Chapter 2.2.

Beyond meaningful experiences, there are transformative experiences. These experiences often result in lasting changes in behaviour or attitude because they lead to personally relevant insights.

The pyramid shape of the framework shows this hierarchy in the depth of experiences. As one moves from memorable to meaningful and ultimately to transformative experiences, the likelihood of participants reaching each level decreases. In other words, the higher up the pyramid, the rarer and more impactful the experience becomes.

Important to note:

- An experience is personal, so individuals in the same activity may experience this at different levels (Duerden et al., 2018).
- There is only a fine line between a meaningful and a transformative experience. For example, if an experience leads to an insight that causes a temporary change in behaviour, it goes beyond being meaningful, but may not be fully transformative.

Contextual value

The focus of this project will, as Figure 11 shows, lay on the meaningful type. Within the context, a meaningful STEAM workshop experience can be very valuable for the Science Centre, the children they are targeting and their parents.

Attending a workshop should be a fun experience, but with the curiosity of children, a workshop that brings new insights can help them understand and discover new things about the world around them. Inspiring them to ask questions, explore further, and connect with the topic makes the experience more impactful. As for the parents, it is presumed that it makes a workshop more appealing when it has more educational value and goes beyond just enjoyment.

For the Science Centre it is found very valuable to provide their visitors with meaningful experiences. It helps creating a stronger connection to the topic and encourages curiosity and critical thinking. Where an only

1.7 Conclusion

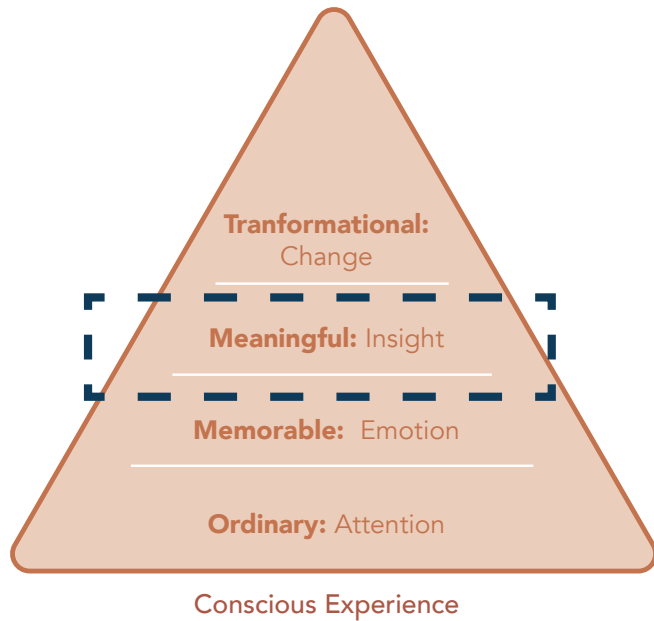


Figure 11: A framework of experience types (Duerden et al., 2018)

memorable experience could lack depth or impact. This impact of new insights that fit the participant's interest is far more powerful and perfectly fits the Science Centre's mission. In the best case scenario, the workshop will plant a first seed, and grow a child's interest for innovation and technology.

Research and design opportunity

Although the Science Centre acknowledges the importance of meaningful experiences in its workshops, it has not yet actively explored how this can be achieved through design. There is a lack of knowledge on how to approach this which makes it a valuable opportunity for this project to research and design for more meaningful workshops.

A first literature review indicates a lack of direct information on how to design a workshop to be a meaningful experience. The question "how to create a workshop that not only triggers emotions, but also provides insights and maybe even starts of a future interest in technology and innovation?", should therefore be researched more deeply prior to the designing phase.

Here, it should be recognised that such experiences are unlikely to resonate with every child in the same way. However, if the top of the model can be expended, meaning more children experience the workshop as meaningful, it will already be considered a valuable success.

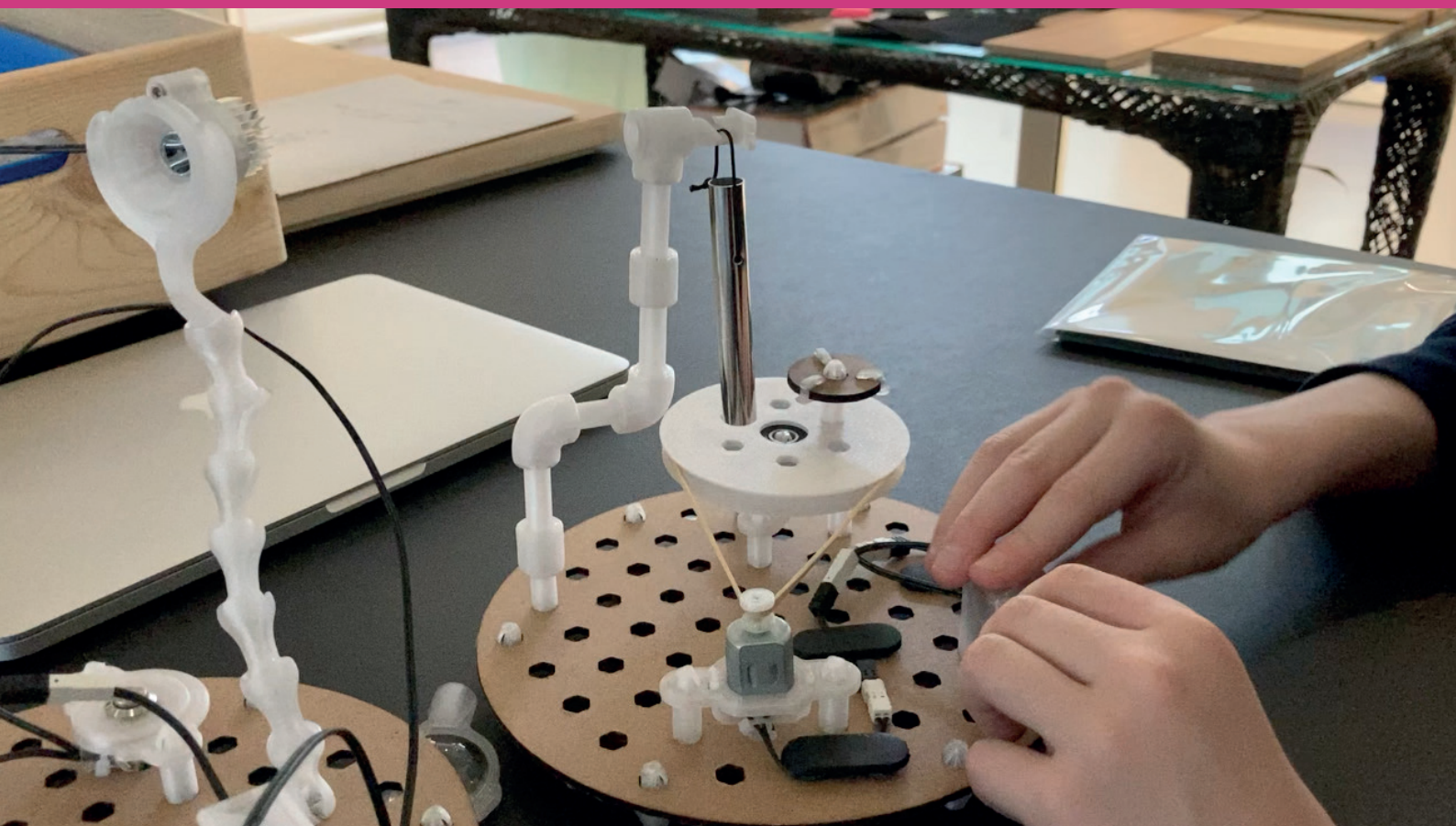
This chapter has introduced the context and motivation behind this study, highlighting the opportunities presented by the renewal of the TU Delft Science Centre's programming. With the development of the Techniek Studio and the integration of STEAM, the Science Centre aims to inspire a new generation of creators and problem solvers through playful and creative interaction with science and technology.

While previous activities have been thoughtfully developed, there remains a lack of understanding on how to create experiences that not only engage but also foster lasting insights and can be a first trigger for a lasting interest among young visitors. This has led to the central aim of the study: to discover how to develop a STEAM-based workshop that can be a meaningful experience for children 8 - 12 years old at the TU Delft Science Centre.

Chapter 2 will research all areas within this context and gather insights on it. These will inform the creation of an initial form of design guidance, a tool that can support the design of future workshops aimed at providing meaningful experiences.

Besides this, the opportunity was found to make use of three new projects, launched at the Science Centre. The new installation Aria Sentient Constellation at the entrance, the Living Shadows material kit and a Techniek Studio that combines these two. These projects will be addressed in detail in Chapter 3. Together they provide a concrete starting point for a valuable case study (Chapter 4) through which the research findings can be applied, tested, and refined.

Ultimately, this project aims to deliver both: a STEAM workshop prototype and a design tool that can support the Science Centre in creating meaningful experiences.



Chapter 2

Exploring the design challenge

In the previous chapter, the context and goals of this project were outlined: highlighting the Science Centre's ambition to develop STEAM-based workshops that offer children a hands-on and meaningful experience. This comes with the need to get a better understanding how to develop such a workshop.

This chapter extends the research phase of this project. The focus is on exploring how to design for the different aspects of this goal, further clarified in Section 2.1. Through literature studies, field research, and expert input, this chapter will analyse existing strategies and other valuable discoveries. Chapter 2.5 will combine these strategies into design guidelines. These design guidelines will be tested and refined in the chapters that follow.

- 2.1 Aim of the research
- 2.2 Designing for Meaningful experience
- 2.3 Designing for children 8 - 12 years old
- 2.4 Designing for a STEAM workshop
- 2.5 Initial design guidelines
- 2.6 Conclusion

2.1 Aim of the research

The aim of this research phase is to identify relevant insights and existing strategies for designing meaningful STEAM-based workshops for children aged 8–12 and translate them into an initial tool that offers guidance during the design.

To achieve this, several key research questions were explored, each focusing on a specific area relevant to the design context. A combination of research activities was used to answer these questions, including literature reviews, expert interviews, and qualitative field studies. The short studies and their findings from these activities are presented in Chapters 2.2 to 2.4, answering the following questions:

- 2.2 How can a meaningful experience be achieved?
- 2.3 How to design for children 8 - 12 years old?
- 2.4 How can a STEAM workshop be designed?

Throughout these sections, effective design strategies and other useful findings are highlighted in pink. In Section 2.5, these insights are brought together into clusters and translated into a first try at a useful tool for design guidance. The chosen format of this tool, design guidelines, will be explained including why they are in line with the scope of this project. These initial guidelines will be tested with a case study, described in Chapter 4. The insights gained from this case study will result in a refined version of the design guidelines, presented in Chapter 5.

2.2 Designing for a meaningful experience

The first step in discovering how to achieve this project's goal, is researching 'how to design for a meaningful experience'. This subchapter elaborates on the activities, field research and literature studies that were carried out to answer this question.

Theoretical foundation

The main theoretical foundation for this part is the work of Bastiaansen and Duerden, as introduced in Section 1.6. In their research "Conceptualizing Meaningful Experiences" they outline several strategies for designing meaningful experiences (2024). They explain that the first essential step is to create a memorable experience. This involves designing to capture the participant's attention and evoke strong emotions. These emotional moments help anchor the experience in memory, building the foundation for further layers in experience.

As previously mentioned, the key component that transforms a memorable experience into a meaningful one is reflection. This is, because reflection allows us to remember memories of the experience and draw insights from those memories (Thorne et al., 2004, cited in Bastiaansen & Duerden, 2024). Bastiaansen and Duerden, further explain "if individuals connect these insights to sources of meaning, they perceive the experience that the insights are associated with as meaningful" (2024). In other words, just reflection is not enough. Experiences should be designed to connect insights to one or more of the following four sources of meaning:

Social connection

Sharing an experience and the reflection on it together with others, like friends or family can enhance its meaning. For example, the pros and cons in a discussion making process could be discussed. Also, reflecting on how the collaboration can be part of a design strategy for a meaningful experience through social connection.

Goal fulfilment

The fulfilment of goals, wishes or desires are seen as concrete sources of meaningfulness. These can be both assigned or participatory goals. Usually, goals focussed on learning and (personal) growth are more effective than goals focused on performance. Important in goal setting, is that they should matter to the participant and resonate with their values. Receiving feedback about their

participation towards their goal is also important. At the end of an experience, receiving feedback and sharing stories about it will be valuable to the meaningfulness.

Contribution

For participants this means it is important that they feel like they contribute to something bigger than themselves. When an activity shows the need of a participants help, they should have the needed skills to help and receive positive feedback about their efforts. Again, connecting their need for contribution to their own values will help them recognise how they are part of a larger story.

Growth

It is important for people to acknowledge and to be acknowledged in, their (personal) growth. Preflecting on previous successes and accomplishments can be a first step in this. 'Preflection' is a method which involves thinking and discussing in advance what might happen and what can be learned from it (Falk, 1995). During an experience, reflecting on achievements while the activity is ongoing, can be stimulated. Reflecting during the activity is most useful when the feedback is given regularly, timely, and when the feedback is tangible and constructive. Also, keeping track of the progress of skill development is important. At the end, participants can reflect on their own growth through assessments or self-evaluations. This enhances the meaningfulness of the experience.

Field research

To explore whether these theoretical findings resonate with real-life experiences, a qualitative field study was conducted with 15 participants who are either master's students at the TU Delft or have recently started working in a technical field. This group was deliberately chosen because, as advanced students or recent graduates, they have made a conscious decision to pursue a career in technology, which suggests a lasting interest in the field. Participants were asked a few open-ended questions through WhatsApp or in face-to-face conversations. An overview of the interview answers can be found in Appendix A.

Firstly, they were asked if they could recall any activities from their childhood (aged of 8 to 12 years) that may have triggered their first interest in science and technology. Most of them talked about an excursion they had done with their primary school, or moments where they helped their (grand)parents with a small task at home.

Secondly, they were asked why they believed can be the reason that this specific activity stood out to them when

looking back at their path going towards technology. Some pointed to the sense of being challenged for the first time; others mentioned taking something home from the activity, which helped keep the memory alive. Several participants expressed a sense of proudness, either in their own achievements or in how they talked about the results afterwards.

When analysing the answers, many similar responses were discovered (see Appendix B). These were grouped into nine clusters, which are shown in Figure 12. Some clusters include a quote, which are participants answer to the question 'Why do you think you specifically remembered this memory?'

These clusters offer valuable insights. However, it remains difficult to clearly separate the elements that made the experiences memorable from those that made them meaningful. Since both dimensions are essential to the workshop's intended impact, all identified clusters will be considered during the design and implementation phase.

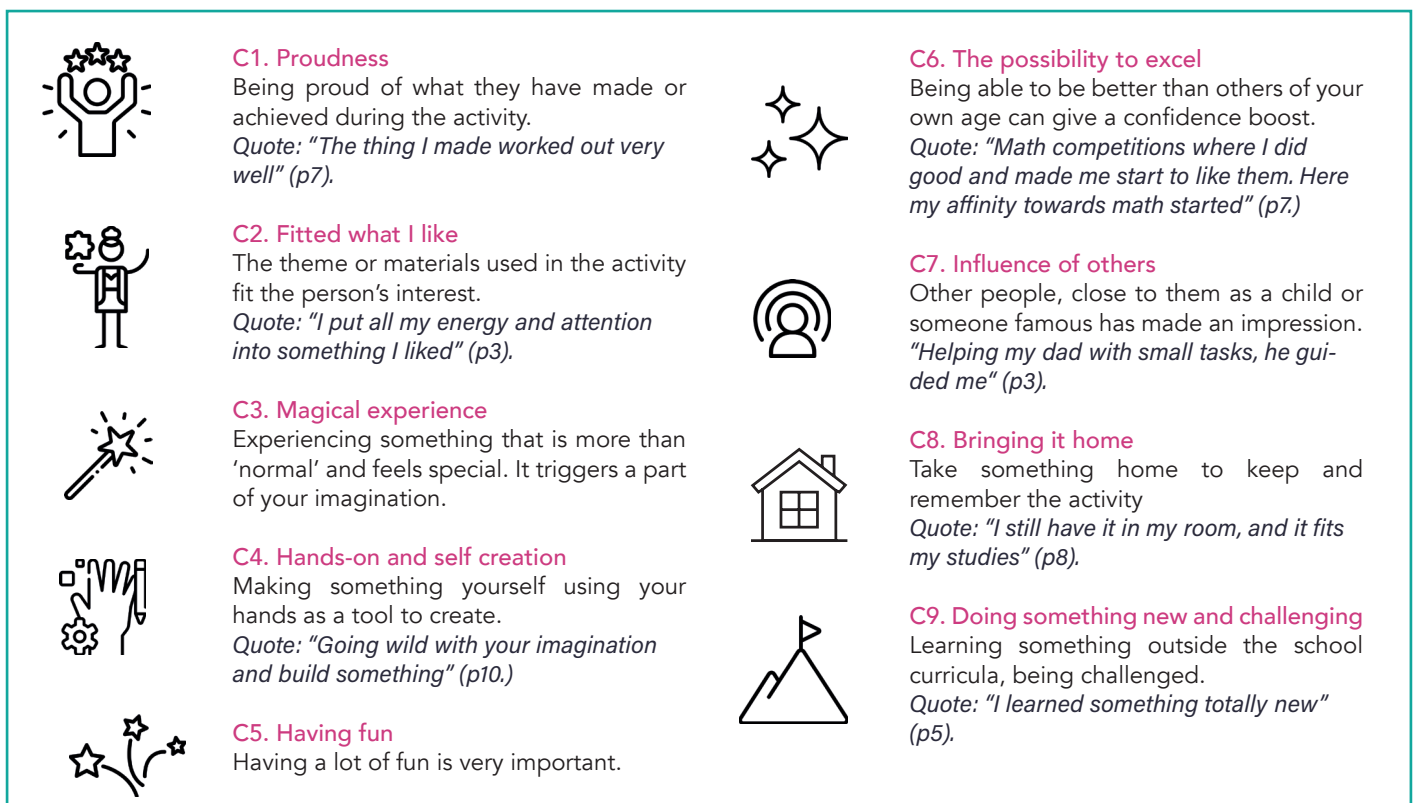


Figure 12: Nine clusters of participant responses on childhood experiences that may sparked their interest in technology.

Designing for proudness

Most of the clusters are practical and relatively straightforward to design for. However, 'proudness' stands out as a more emotional and complex theme, therefore it was chosen to further research this. Here, a fitting paper was found. Little et al. wrote about 'designing for proudness' (2024). The aim of the paper is 'to increase the likelihood of proud moments in science courses.' According to the paper, the following design principles are important to use when designing for proudness (Little et al., 2024):

- **Challenging achievement**

The assignment should feel challenging to do or even outside of your comfort zone.

- **Improvement**

There should be room for growth and iteration.

- **Reflection**

It is important to look for opportunities to recognize progress, such as comparing early versions of work to later ones.

- **Tangible**

It really helps if the final product is tangible. To have a final result to be proud of.

- **Personal Alignment**

It is beneficial for the participant when the activity aligns with their interests or personal goals.

- **Responsibility**

Let the person have some feeling of being in charge of a part of the project.

- **Community**

This is about having interactions with other people within their community, being other participants, friends or a facilitator. The following are found important for proudness.

- **Constructive feedback**

This can be given by people in the person's own community. When this happens, they should feel comfortable asking further questions about it. This should fit the community

- **Cheer squad**

Celebrating with others will enhance the feeling of proudness. Storytelling with or to peers will help this.

- **Public and positive sharing**

Have the opportunity to share work with others in a positive and public way.

- **Giving back**

The work helps others in some way.

Going over the findings, it can be concluded that most of the insights about 'meaningful designing' align very well and elaborate on each other. Therefore, they will be clustered together in Section 2.5. Before doing so, it is essential to let these strategies fit with the target group of 8-12 years old and with the theme of STEAM workshops. Which will be done in the following sections.

2.3 Designing for children aged 8 - 12

Designing for children comes with a set of challenges and opportunities that is different from designing for adults. Their way of thinking, learning, and interacting with the world is different. They all develop on their own pace and have different skills and interests.

In a discussion with Mathieu Gielen, assistant professor at the Faculty of Industrial Design Engineering, with expertise in 'Design for children's play' it was found that even though these in '1.2 Designing for a meaningful experience' discussed strategies are based on general literature, they can still be applied. With a clear understanding of children aged 8-12, the guidelines can be adapted to meet their needs, values and ways of thinking. Therefore, it is important to obtain a better understanding on where they are in their development and how they learn. To achieve this, literature studies were conducted.

Development stage and skills

There are many ways to categorise children on their developmental stage. Looking at the work of Piaget, who is considered the founder of many later research on children's thinking, the cognitive stage of children 7 to 11 years old is called 'concrete operational' (Kohnstamm, 2009). This stage means the child starts thinking systematically and logically. "They become able to deal with complex problems about concrete objects and events" (National Research Council, 1984). Terms such as quantity, length, weight and substance are mastered and applied. This is an important part of what the expected level of the children is and what can be used in the workshop's themes.

Within this group there will still be a big variety of skills. Therefore, **the level of difficulty should be adjustable** based on what the children can handle, so that they can be constantly challenged on their own level.

How children learn

Although it is not an educational track, knowing how children learn is important since this is part of making an experience meaningful. Interesting here is John Dewey (1859–1952), who has been an influential philosopher in education. His approach to learning emphasises the importance of experience. With his concept of '**Learning by doing**' he suggests that knowledge is gained through active engagement rather than passivity (McRaine & Russick, 2016). Explaining by adults and older children

is less important for the development of inner logic than **experiencing and discovering it themselves** (Kohnstamm, 2009). This perfectly fits with the context of a children's hands-on workshop. To help the children in holding on to this new knowledge, **repetition** can be very valuable. A basic strategy needed for almost all types of learning (Kohnstamm, 2009).

There are many varieties within the target group. A group of children aged 8 to 12 years old will consist of diverse learners that learn in different ways. **All children have their own strengths and interest**. On top of this, it should be realised that children understand the world in a different way than adults (McRaine & Russick, 2016).

According to Lev Vygotsky (1896–1934), **the role of parents and friends** can be important since social interaction with adults or peers influences how well someone performs (McRaine & Russick, 2016). Since parents possess more sophisticated skills, they can stimulate children's learning.

Field research

Throughout this project, the following was noticed: where theory can say a lot, in means of designing for a target group like this, it is highly recommended **to have a better understanding of the children in the real world**. For this reason, field research was done by attending several workshops with children, followed by conversations with the workshop giver. The observations done during the workshops helped in understanding the children's level of thinking and creating. It also helped to get a feel for the communication between children and their interaction with the facilitator. Appendix C goes further into detail about the observations and conversations.

The first attended workshop was at a primary school. A lesson organised by ZH Mad Science, given by 'professor Ootje' a pseudonym used to engage children in a playful manner. The workshop was a 45 min lesson to children aged 7-9 years in a class, about the solar system. Ootje, was talking most of the session, his frequent use of questions directed at the children, along with the use of physical models to illustrate the solar system as shown in Figure 13, helped capture and maintain their interest. Figure 14 shows a final hands-on activity to let the children play around with imaginary planets. Also, the enthusiasm of the facilitator was observed as a key requirement to hold



Figure 13: Children holding the planets in the right order of the solar system during the workshop (St. Augustinus, 2021)



Figure 14: Children blowing bubbles that are imaginary planets. (OBS De Schuthoek - Nieuws, n.d.)

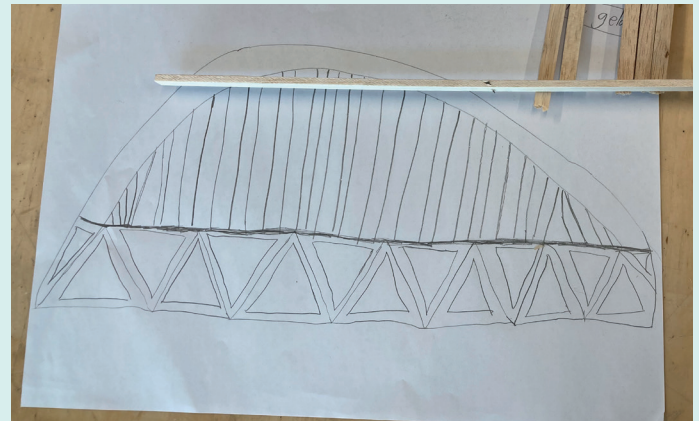


Figure 15: Drawing of a bridge after the theoretical explanation.

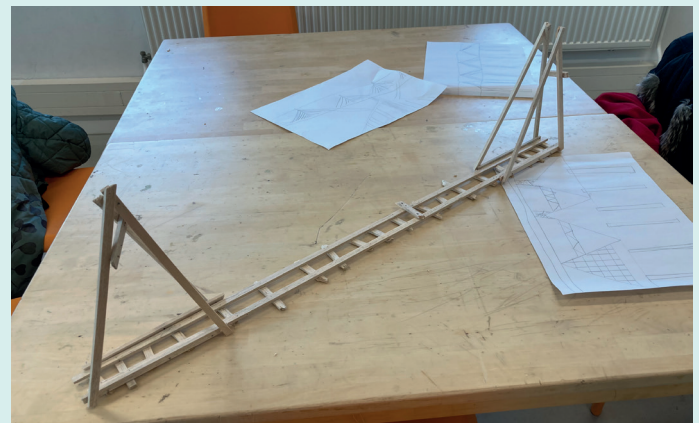


Figure 16: Final result of a bridge by one group.

the children's attention. In the conversation afterwards, these observations were confirmed by the facilitator himself. Other important requirement for a smoothly running workshop that he mentioned, is repeating the new knowledge throughout the workshop and always keeping the key objectives in mind.

The second workshop that was observed, was at the Science Centre, called 'balsa bruggen'. Here, a class of 25 children learned about building bridges. Firstly, they learned the theory of how bridges can be built from several structures. This workshop is much more hands-on. The children got 15 minutes to draw their own bridge (Figure 15), and after 70 minutes to build a bridge with balsa wood and nails in a group of 5 children. Working hands-on turned out easy for some, but difficult for others. This had influence on the attention span of the children. A final result from one group is shown in Figure 16.

Both workshops that were observed, were attended two times with different children but the same facilitator. This made clear that every class / group of children responds differently. Thus, it is important for the facilitator to be able to adjust to the situation.

All these observations and conversations after the workshops led to the following take ways that are important to know during the design of a workshop for children:

- T1. **Having a lot of fun** is the most important factor for children.
- T2. The influence of the **enthusiasm of the facilitator** on the children is key.
- T3. **Working hands-on** should be the biggest activity.
- T4. Children who are eager to learn, especially about technology, mostly from highly educated parents will be the ones mostly interested in these types of workshops.
- T5. **Repeating the new knowledge** several times helps in remembering it.
- T6. The children get enthusiastic when the facilitator asks questions about the topic that they can **answer themselves**.
- T7. Facilitators will not fully adopt the workshop's instructions in detail.
- T8. Children have a short attentions span, so any **theoretical explanation should not be too long**. On the other side, for hand-on activities some children can do the same for a very long time.

2.4 Designing for a STEAM workshop

Designing a STEAM workshop comes with a few challenges. To design for it, it is important to gain a deeper understanding of how to use the disciplines and how to make the children feel encouraged to participate and explore.

STEAM disciplines

The workshop can be designed with any of the STEAM disciplines. There is no need for all of them to be used. It will be at least one STEM discipline and Arts. However, it is important that in this, the Arts is used as an equal to the other discipline. For example, if the topic of the workshop is determined by a STEM discipline, the materials to explain and explore it, can be used for the creative side.

STEAM knowledge

There will also be a difference in knowledge on the STEM disciplines. Some might already know more about technology, and play with e.g. Lego Technic at home. Others might not be familiar with these types of toys or feel no interest towards it. If so, it can be a big step or seem too difficult when looking at toys or school assignments that involve technology, such as small computers, wires or other technical components they are not familiar with. Therefore, there should be **a smooth mixture of at least one of the STEM disciplines and art**. According to Riley, from the Institute for Arts Integration and STEAM, it should be possible for the workshop to go from **STEM content to the arts back and forth** as Figure 17 shows, so it will have a natural balance (n.d.).

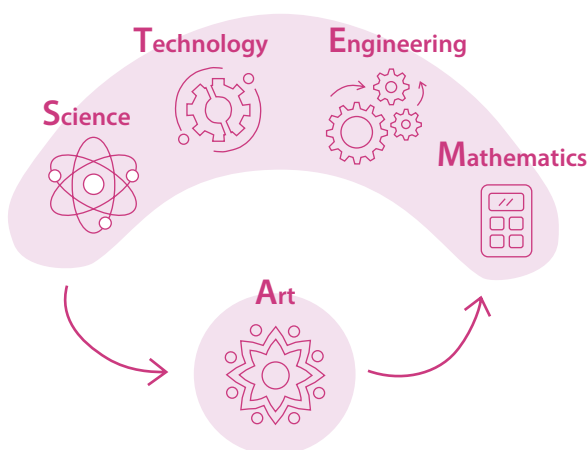


Figure 17: Connecting STEM and Art

Balance between fun and serious

There is a lot of literature on how to design for STEAM, and most is focused on STEAM education. However, it is important to know that for people to be willing to learn something new in their free time, there should be a combination of an **intrinsic motivation and a high level of having fun** (Packer, 2006). As the Science Centre is aware of this, they aim with their STEAM workshop-line to teach visitors something about technology and innovation, and simultaneously offer them with an engaging and enjoyable workshop. In other words, to balance fun and seriousness, as shown in Figure 18. In Packer's research about 'learning for fun', the following four key conditions that contributed to experience learning as an enjoyable activity were found (2006):

- **A sense of discovery or fascination**
Visitors found learning enjoyable when it sparked curiosity through surprising, new information that evoked a sense of discovery or rediscovery.
- **Appeal to multiple senses**
Engagement was enhanced when exhibits stimulated multiple senses such as sight, touch, and sound.
- **The appearance of effortlessness**
It helps when learning is perceived as easy, natural and informal, without the pressure or structure of traditional education.
- **The availability of choice**
When the experience can be personalised and experience on their own pace about their own interests.

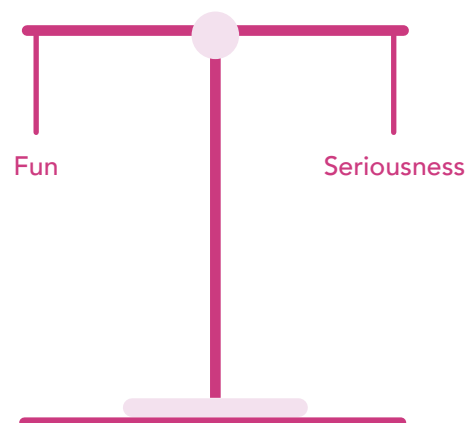


Figure 18: Balancing fun and seriousness



2.5 Initial Design Guidelines

The research phase of this project led to the identification of relevant design strategies that address all the key areas around this project's scope. Going over the insights, it was discovered that many overlap and fit well together. This resulted in clustering the insights into 14 initial design guidelines (DGs) and instructions to use them.

Approach

The found insights cover all the aspects of the context that together answer the question: 'how to develop a meaningful STEAM-based workshop for children?'. These key insights have been highlighted in pink in the previous sections.

As the strategies were reviewed, similarities and overlaps were found. Therefore, they have been brought together in an overview, shown in Table 1.

The table is divided over three phases of the workshop experience: before, during, and after the workshop. This structure follows the approach described by Bastiaansen and Duerden (2024) in their model for designing meaningful experiences. Their framework is one of the core references that contributed to the gained insights. Dividing the workshop experience into three stages, helps to cover the whole timeframe of an experience (Bastiaansen & Duerden, 2024).

In the table, each main resource used in the research, is listed on top with the found insights placed underneath. The strategies that match or complement each other, are put on the same row. This resulted in a total of 14 rows, and thus 14 clusters.

These 14 clusters are used as the initial design guidelines, which will be presented in the next section. The term 'initial' is used because these guidelines are only based on the insights found in the exploration phase. Which consisted of researching existing literature, conducting short interviews and doing observations. The practical effectiveness of the guidelines has not yet been tested.

Format

To provide design guidance to workshop developers the format of 'design guidelines' was chosen. This was considered most fitting for the Science Centre, or any organisation that wants to develop a new STEAM-based workshop. This is mainly because design guidelines can translate the more abstract research insights into actionable points that can directly support the development of a new workshop. In addition, it fits this project aim to give the workshop developer accessible guidance in the design process, rather than give fixed rules or definitive methods. Additionally, the flexible nature of design guidelines allows them to be applied not only in the creation of new workshops, but also in adapting existing ones to make the experience more meaningful for participants

To ensure the guidelines can be used effectively and understood as a practical tool, additional supporting information seems required. Because developing a workshop is a step-by-step process, it is helpful to provide users with instructions that include an explanation of how to use the guidelines, and what to prepare beforehand. Therefore, initial instructions, presented in section 2.5.1, are included to the initial DGs. These instructions were also informed by the insights gathered during the research phase.

In addition, a significant part of the research insights relates to the importance of establishing clear learning goals and an overall workshop goal. These are both essential for the workshop developer to make design decisions during the process to create a meaningful experience. Therefore, the workshop developer should first define these goals clearly. To support this, an initial model is developed to help the user formulate this goal. This is further explained in section 2.5.2.

After the instructions and use of the model, the user should be ready to understand and use the guidelines. These are presented in 2.5.3

Table 1: Overview of all research insights. Each row presents matching insights.

		Meaningful experience (Bastiaansen & Duerden, 2024)	Field research (9 clusters)	Design for proudness (Little et al., 2024)	How children learn (literature on education, observations)	Learning for fun (Packer, 2006)
Before	1. Sharedness	Share the experience and reflect together	C7. Influence of others			
	2. Communicating the goal	Set clear learning goals that fit with values	C2. Fitted what I like			Increase intrinsic motivation with fun
	3. Topic of the workshop	Prerequisite level of knowledge differences	C2. Fitted what I like	Personal alignment	Differences in more STEM or Arts preference (riley, n.d.)	
During	4. Personal Value	Feeling of contribution	C3. Magical experience C5. Having fun		T1. Having a lot of fun	Discovery and fascination
	5. Preflection	Preflection on previous successes & what they hope to learn			T7. Facilitator don't use instructions in detail	Increase intrinsic motivation with fun
	6. Skill development	Keep track of progress & Positive feedback	C9. Doing something new and challenging	Constructive feedback & opportunity to improve	Repetition of knowledge (T5; Kohnstamm, 2009) Answer questions themselves (T6)	
	7. Make it new but relatable	Prerequisite level of knowledge differences	C9. Doing something new and challenging		Offered to learn something new (Gielen, personal communication, 2025)	
	8. Achievable and challenging goals	Learning goals should fit abilities	C9. Doing something new and challenging	Challenging achievement	Challenge needed to feel success (Kohnstamm, 2009) Progress on own pace (Ootje, personal communication, 2025)	Learning should not take effort & Availability of choice.
	9. Creative process & hands-on	Meaning is created when playing an active role	C1.Proudness C4.Hands-on & self creation	Tangible outcome	T3. Working hands-on Learn by doing (McRainey & Russick, 2016)	Appeal to multiple senses
	10. Teamwork	Reflect on benefits of teamwork	C6. The possibility to excel	Together with friends & Feeling responsibility		
	11. Concluding the work	Receive summative feedback & remind mistakes are natural part of growth			Repetition of knowledge (T5; Kohnstamm, 2009)	
After	12. Physical reminder		C8. Bringing it home	Public and positive sharing		
	13. Reflection	Reflect on own growth with tools		Reflection		
	14. Sharing Achievements	Receive feedback & share stories	C1. Proudness C7. Influence of others	Public and positive sharing, Cheer squad		

2.5.1 Initial design guideline - Instructions

Before using any guidelines, the workshop developer will need some instructions to get started. These can explain which guideline to use, how to use them and what to prepare beforehand.

During the research phase, several instructions were already gathered. These were found valuable to inform the user about. The following instruction aim to support the practical application of the initial design guidelines.

Instructions: Getting started

As explained before, the guidelines will not give strict instruction, but will serve as a tool to give guidance to the workshop developer. This is because it is assumed that most organisations that plan to use this tool, already have their own standards for the outlines of a workshop. When a new workshop is developed, the designer should be aware of this. This leads to the following instruction:

Organisational standards

Start by identifying the existing workshop standards within the organisation. Knowing how workshops are usually developed and delivered will help to apply these guidelines more effectively.

The workshops designed using these guidelines will have the intention to be a practical STEAM-based workshop. It is obvious that this will involve materials that the workshop's participants can play with. These materials can be pre-determined, or they can be totally unknown at the start of the workshop design. The guidelines should be explained so they can be adaptable for both options. This leads to the following instruction:

Understanding the materials

Since the workshop will be hands-on, it is obvious that materials will be used. The kind of materials does not necessarily need to be set when starting to design the workshop.

However, if the workshop is designed with materials as a starting point, it is very important to understand them. You should know: How do they work? What can you do with them? Moreover, you should know how children use the materials. Do they understand how it works? Is it safe? Do they need guidance?

One of the challenges that was found at the beginning of this project is finding a balance between fun and seriousness. On the one hand, the workshop will be a recreational activity, but on the other hand, the aim is to give the children insights through learning new things. While developing the workshop, it is important to be reminded of this.

Balancing fun and seriousness

The guidelines should contribute to both the enjoyment and the overall purpose of the workshop. Especially since the focus is on out-of-school experiences, making it important for the children to not focus on the learning goals all the time.

In addition, a user can consider how many guidelines fit the purpose of the workshop. Since the tool is only meant to guide the developer, it is not necessary to use every guideline strictly. This was also found in one of the main sources used before. Explained in the following guideline:

Amount of design guidelines

As Bastiaansen and Duerden mentioned, there is not a minimum amount of constellations or strategies needed to reach a meaningful experience (2024). It is suggested to apply a certain amount of guidelines that help to design the workshop in a way that integrates fun and learning naturally. Moreover, it is important that the guidelines chosen should complement each other.

Lastly, when looking into children, many sources explain that designing for children can be a challenge since they are all so different. This is important to mention to the user with the following instruction:

Designing for children

Since children have a unique mindset and way of viewing the world, it is expected that the outcome can sometimes be quite different than the theory was expecting. The designer should anticipate on this by not designing too strictly, and test and adjust the workshop multiple times. Or when the design is already set, communicate with the facilitators they should remain flexible, observe how children respond to different elements of the workshop, and adjust if needed.

2.5.2 Initial experience layers model

Besides starting with the instructions, it is also important to have a clear goal in mind regarding the kind of workshop being developed. While the overall aim, to create a meaningful experience for children, is already established, further defining this goal will support the user in applying the design guidelines more effectively. Therefore, this section presents an extended model about the experience levels. For the user, this will come after the instructions explained in the previous section and comes right before the use of the guidelines themselves.

As explained before, the guidelines aim to support the process, but throughout the development, design decisions still need to be made. To do this, the developer should clearly understand the workshop's main goal. To support this, a model is created that can be used during the process of the workshop development. This model combines the found theory that grounded this project's goal and the insights found in the research phase.

Experience layers in workshop design

Chapter 1.6 introduced the framework of experience types introduced by Duerden et al. (2018), which describes three levels of experience. Based on the new insights gathered during the research phase of this project, a more detailed version has been developed to better suit the specific context. In this version, the middle part of the original framework, shown with a dotted line in Figure 19, will be divided into multiple layers.

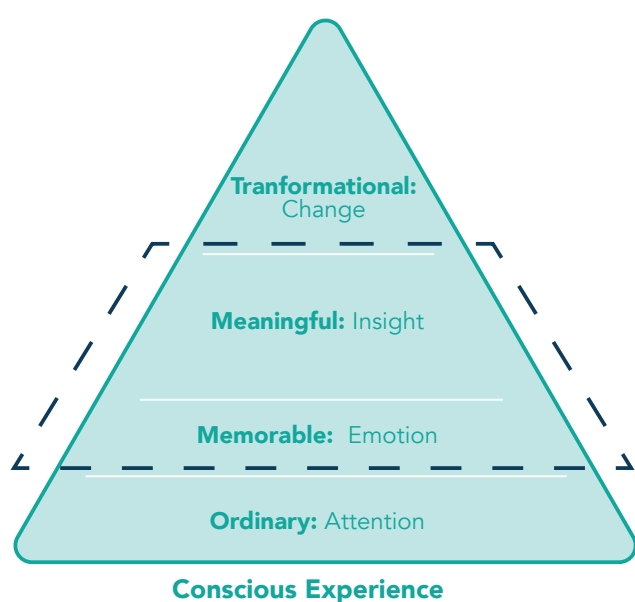


Figure 19: Framework of experience types with a dotted line highlighting the Memorable and Meaningful stages.

The new model, zooms in, and shows how the three types memorable, meaningful and transformational are divided into more layers (see Figure 21). As in the original framework, a pyramid shape is used. Firstly, this structure helps to illustrate how the different types of experiences build upon each other in terms of complexity, depth, and impact. Secondly, it shows that when you move up the pyramid, experiences become rarer and thus fewer people may reach the top where the most meaningful experiences lay.

The clusters converted into design guidelines shown in the next section, Section 2.5.3, are intended to support the creation of such experiences, helping more people reach the meaningful layers higher up in the pyramid.

The research that was the base for the guidelines, was not specifically done per layer, but it gathered interesting insights throughout all layers. This is because all the layers are interconnected and an experience is personal. So, individuals in the same activity may experience this at different levels (Duerden et al., 2018). Again, this fits with the fact that this tool only 'guides' the user, since it cannot tell what guideline to use to reach a certain level.

It should be noted that meaningful experiences can still occur without explicitly using these guidelines. However, using the guidelines is recommended, as it can help expand the top of the pyramid, as shown in Figure 20. In other words, designing with these guidelines will likely increase the number of children who experience the workshop as meaningful.

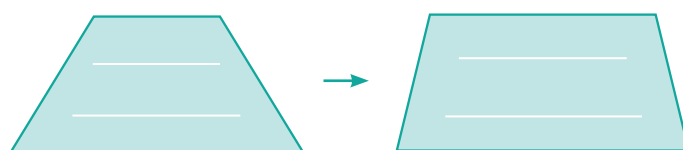


Figure 20: Section of the pyramid. Pointing to the aimed version where the top expands.

On the next page, the initial model is presented along with an explanation for users of the design guidelines. This explanation serves to bridge the theoretical framework and the practical guidelines. The aim is to clarify for the user why they should use the design guidelines and what they can expect to achieve by applying them.

Experience layers model

Before using the guidelines, it is important to understand the overall aim of the workshop. Which is to develop a meaningful experience. This 'meaningful' designing comes from the following theory:

There are three different levels of experiences that range from simple and memorable to deeply meaningful and even transformational (Duerden et al., 2018). These layers build on each other: the higher you go, the more impactful, but also the rarer the experiences become.

An extended version of this model, shown in Figure 21, gives a deeper explanation about these experience levels for the specific context of a hands-on workshop for children. They go from triggering the participants emotions, through making them feel proudness, to make them have more insights and maybe even trigger an ongoing interest.

The goal of the workshop design is to create the conditions that make these meaningful experiences more likely. That's where the design guidelines come in. They are designed in such a way, that going to a higher level in the model is fostered.

When to use?

This model can be used as a preparation before using the guidelines by understand what the overall aim is of designing the workshop. Later in the process, when testing the workshop, it can be used as a checkpoint, to evaluate if the aimed effect of the workshop is reached.

How to use?

The model has 'to fill in' gaps. Here, 'the topic of the workshop' can be filled in. This is the topic about which the participants will gain insights about.

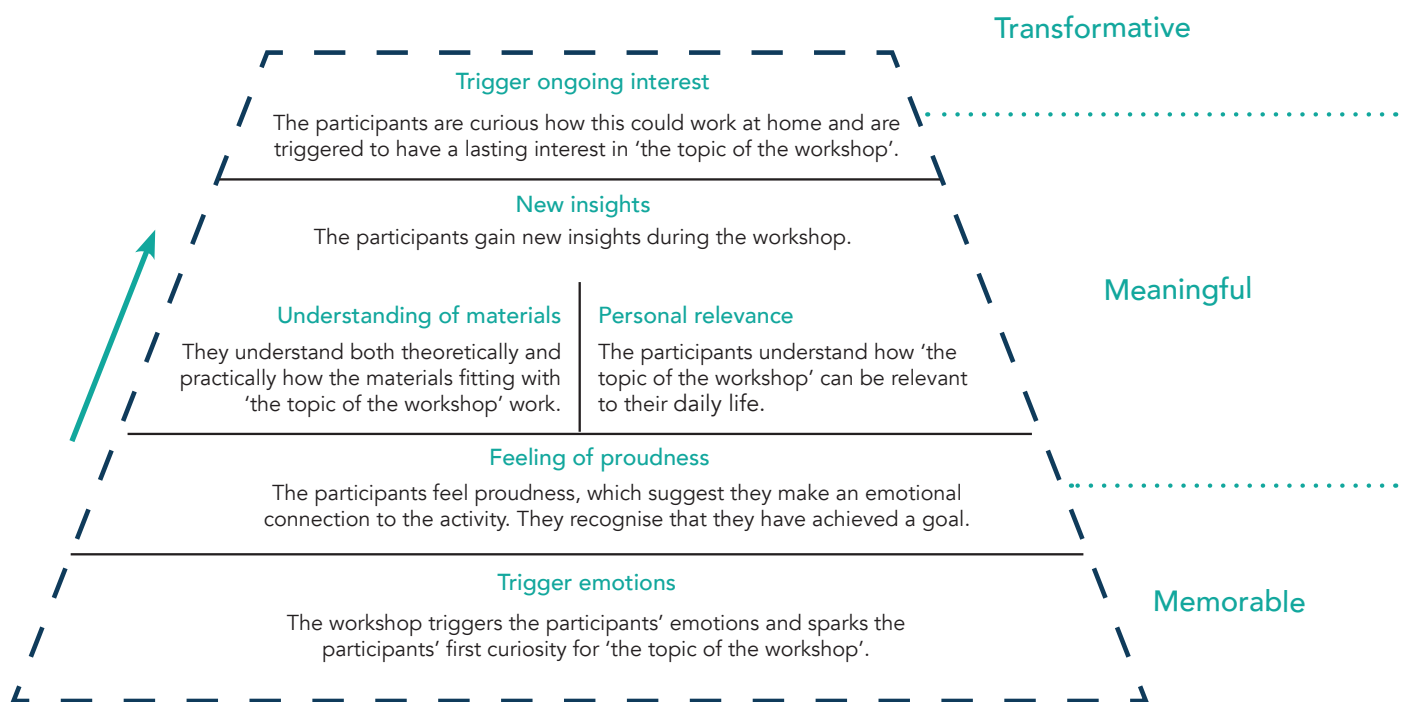


Figure 21: Expanded version of the middle section of the original framework of experience types. Fitting with this project's context.

2.5.3 Initial design guidelines - Overview

Overview of the 14 design guidelines

Before

1. Topic of the workshop

2. Sharedness

3. Communicating the goal

After

12. Physical reminder

13. Reflection

14. Sharing achievements

During

4. Personal value

5. Preflection

6. Skill development

7. Make it new but relatable

8. Achievable and challenging goals

9. Creative process & hands-on

10. Teamwork

11. Concluding the work

Reading the guidelines

The guidelines are made with all the insights, drawn from both desk and field research, that were clustered together. To ensure they are clear and practical for workshop development, additional explanatory sentences were added. Insights that should trigger concrete actions, were translated into actionable points to guide the design process. These should foster the guidance.

The order that is used, follows the expected flow of steps in a typical workshop. The steps that belong to the workshop's stages (before, during and after), are shown with a small storyboard on top of each page.

The guidelines will include the accompanying resource from the found insight. Insight that resulted from the field research, will be referred to with a letter.

- The insights from clustered answers from the experience interviews with students will be shown as (C.no.).
- The insights from takeaways of observations from several workshops will be shown as (T.no.).

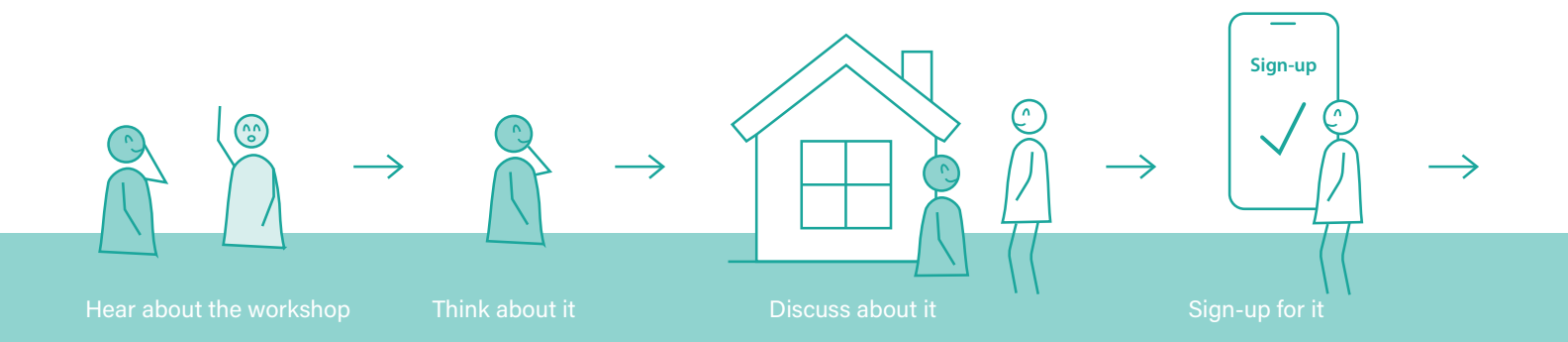


Figure 22: Steps taken by the participant before the workshop.

Before the workshop

The journey of this meaningful experience already starts at home, see Figure 22. The children will hear about the workshop, think about the workshop, subscribe for the workshop, maybe prepare for the workshop and finally travel to the workshop.

In this part, it is all about prefection and interest. Preflection means, thinking ahead and preparing your mindset, goals, or expectations for what's about to happen (Bastiaansen & Duerden, 2024). This can include images or videos about the upcoming experience, discussions at home or setting your own goals.

1. Sharedness

Fostering social connection before the workshop like being able to sign up together with friends or family will enhance the experience.

Action points:

- Allow your participants to share the experience with others they already know (C7. Influence of others). For example, make it possible to sign up together with friends.
- Design for shared anticipation among the participants, so there can be a collective expectation and excitement about the workshop (Bastiaansen & Duerden, 2024).



2. Communicating the goal

The participants of the workshop will benefit from knowing what they can expect. This allows them to mentally prepare for what they will learn.

Action points:

- Set clear learning-goals for the workshop. Growth- and learning-oriented goals are often more effective than performance goals (Bastiaansen & Duerden, 2024).
- Communicate the learning-goals to increase their impact during the workshop (Bastiaansen & Duerden, 2024).
- Communicate them in a way that fits the purpose of 'having fun', and does not feel too educational (C2. Having fun).
- Find a way to also communicate these with the facilitator. Enabling them to understand the aim of the workshop.

3. Topic of the workshop

The topic of the workshop is what will draw the attention of your audience and should interest them to apply. Therefore, the start of a workshop design is understanding your target group. Knowing their interest, knowledge and skill level.

Action points

- Choose a topic that fits the participants' personal interests and/or goals (Little et al., 2024; C2. Fitted what I like). This will trigger intrinsic motivation (Packer, 2006).
- Understand the prerequisite level of knowledge about the topic of the participants (Bastiaansen & Duerden, 2024). Consider that this can differ per participant on the STEAM disciplines (Riley, n.d.).
- Make clear the topic is about one or multiple of the STEM disciplines in a combination with Arts to appeal a broader range of participants (Riley, n.d.).

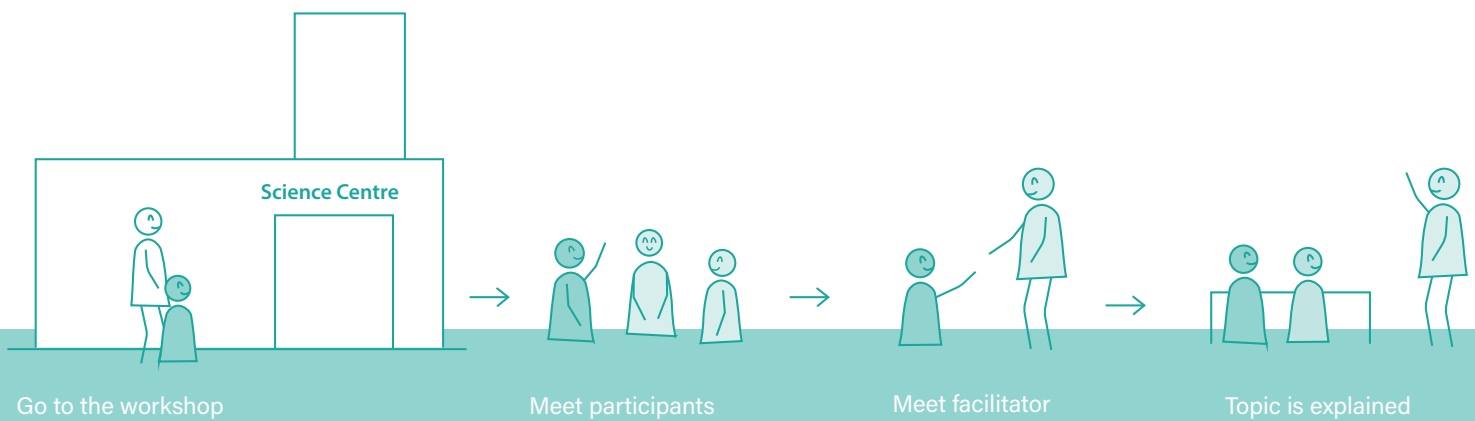


Figure 23: Steps taken by the participant during the workshop.

During the workshop

Arriving on the location will be where the activity starts, see Figure 23. In this case, a workshop at the Science Centre. Here the participants will be getting to know each other. They will be introduced to the facilitator who will explain the topic and the hands-on working principles. They will start with the activity, have in between breaks and discuss and reflect on the results together.

Creating meaning in this part is all about what the participants do, how they do it and the reflection on it. Here, reflection-in-action, during the experience can also be seen as savouring, looking into the positive feelings of the activity. This requires time and a conscious thought (Bastiaansen & Duerden, 2024).

4. Personal value

The workshop should be designed to align with the participants values (Bastiaansen & Duerden, 2024). Therefore, these should be framed before the design of the workshop. To do this, it is important to know what values belong to the workshop's target group. Three main values are highlighted, but it stays important to design for your target group's specific values.

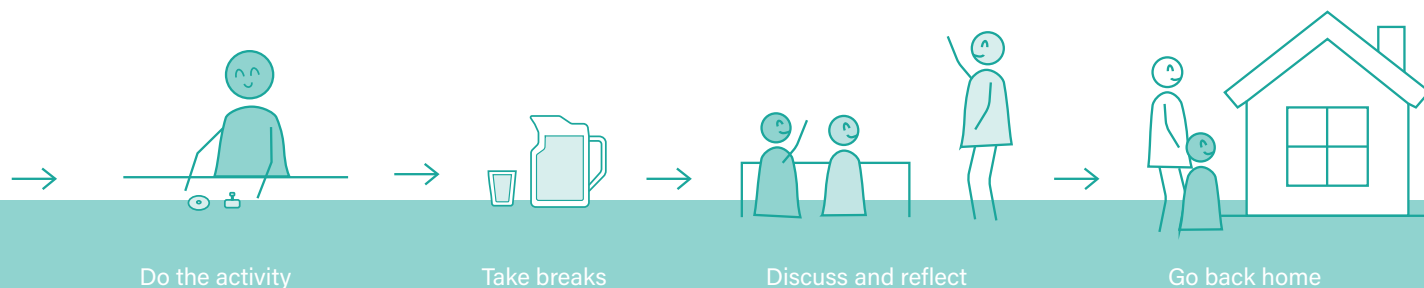
Action points:

Having fun

- Use a topic that fits all the children you aim for (T1 & C2. Having fun).
- Let the facilitator ask simple answerable knowledge questions (T6 Answer questions). This gives some children the opportunity to answer and excel above others (C6. The possibility to excel).
- Find or design a way for the facilitator to get excited about the topic as well (T2. Enthusiasm of the facilitator).

Magical experience

- Give the children a magical experience through the workshop (C3. Magical experience).
- Design for a surprise moment or effect.
- Design for the children to have a sense of discovery and fascination (Packer, 2006).



Contribution

- The participants should feel like they can contribute to something bigger than themselves (Bastiaansen & Duerden, 2024).
- The purpose of contribution should match their personal value (Bastiaansen & Duerden, 2024).

5. Preflection

Having a central start of the workshop, with a short introduction from the facilitator gives the opportunity to prelect. This is about discussing the learning goals of the workshop to align expectations and increase motivation before the workshop starts (Bastiaansen & Duerden, 2024).

Action points:

- Translate the learning goals into a non educative perspective. Making it fun to talk about to increase intrinsic motivation (Packer, 2006).
- Have a way to present the steps of the workshop, giving the children a clear overview.
- Let the facilitator take some time to discuss these goals and new skills. This will encourage participants to think beforehand what they hope to learn (Bastiaansen & Duerden, 2024).
- Design for the facilitator to be supported in discussing learning goals with the children (T7).

6. Skill development

Receiving positive feedback is always useful. Making new learning point insightful, will happen when the participant recognises their ability to develop new skills in the past and present. Giving them the opportunity for improvement (Little et al., 2024).

Action points:

- Acknowledged that the strengths and values are different for every child.
- Make sure to repeat what they are learning several times throughout the workshop. Repetition of their new knowledge is valuable (Kohnstamm, 2009).
- Design so the participants can easily track their progress over time and are encouraged to do this (Bastiaansen & Duerden, 2024).
- Have a way for the facilitator or other participants to give positive feedback (Little et al., 2024; Bastiaansen & Duerden, 2024).
- Design the guidance for reflecting on new skills and a way to understand how these can be used in other situations (Bastiaansen & Duerden, 2024). For example, what can they do with this skill at home?

7. Make it new but relatable

Most participants will join a STEAM workshop to learn something new. Nevertheless, it is important to make this new topic or skill relatable to something the participants are already familiar with in daily life.

Action points:

- The participants should be offered to learn something that is new for them (C9. Doing something new).
- Use examples from daily life to explain new information (M. Gielen, personal communication, 2025). This will catch their attention and help them understand the main theme of the workshop
- Let the facilitator ask simple questions about prior experiences / familiar topics as a start that is connected to new workshop's topic. Being able to answer will give a confidence boost (Ootje, personal communication, 2025).

8. Achievable and challenging goals

It is important for a child to feel some sort of challenge in an achievable task, to have a feeling of success (C9. Doing something challenging; Kohnstamm, 2009; Little et al., 2024). This will support meaningful learning. The following action point will help balance the difficulty and accessibility.

Action points:

- Get an understanding of the variety of skills and knowledge level within the target group.
- Keep in mind that some children are more skilled in the STEM disciplines and less in arts, or the other way around.
- Go back over the learning goals set in a previous phase. Do the goals fit the target group, are they achievable within the participants abilities? (Bastiaansen & Duerden, 2024).
- Use scaffolding: break down challenges into smaller steps - to offer varying skill levels and allow each participant to progress at their own pace (Ootje, personal communication, 2025).

- Design for the availability of choice. This gives the participants the opportunity to personalise and provide themselves with the right level (Packer, 2006).
- Make sure it does not take effort to learn something new during the workshop (Packer, 2006).

9. Creative process & hands-on

One of the most important parts of a STEAM workshop for children is directly applying new knowledge in a hands-on way. This will make it fun and help them with insightful learning. Meaning is created when participants can play an active role in the experience (Bastiaansen & Duerden, 2024).

Action points:

- Let the participants work hands-on and try out what works for themselves (T3. Working hands on; C4. Hands-on). They will learn by doing (McRaine & Russick, 2016).
- Make sure the workshop focusses on the children's process of making and not the perfect outcome of what they make.
- Although the focus is not necessarily on the final result, having a tangible outcome will help reach a feeling of proudness among the participants (Little et al., 2024; C1. Proudness).
- Explaining new theory, should be followed by a hands-on way of learning to make connections between the two (Eason & Linn, 1976).
- Appeal to multiple senses. Think about not only seeing the materials, but also feeling the materials (Packer, 2006).
- Keep going back and forth from the chosen STEM topic(s) of the workshop to the arts, and connect the two through the activities (Riley, n.d.).

10. Teamwork

Working in teams is a big benefit for the participants, making them feel part of a community. Here it is important to reflect on how teamwork helps their project (Bastiaansen & Duerden, 2024). Having this experience with friends can fit their personal values. There are three important things to note here:

- When children don't know each other yet, it might not go smooth if they are forced to work together. Testing will help discover what will be a moment in the workshop for children to be able to work together. But don't force it. (M. Gielen, personal communication, 2025)
- Within a group, each participant should have the opportunity to feel they are responsible for a part of the project. In this way they can feel proud of having contributed to the group (Little et al., 2024).
- The participants should have the possibility to excel. The participants benefit from the feeling they perform better than others (C6. Possibility to excel).

11. Concluding the work

With all these new learnings and insights, it is important to have a small reflection moment at the end of the workshop.

Action points:

- Give participants the opportunity to receive summative feedback about their work (Bastiaansen & Duerden, 2024).
- Support the participants in going over the activities of the workshop again. Once again repetition can help in strengtening their insights (Kohnstamm, 2009).
- Look back at the tool that will show the steps of the workshop in the preflection phase. It will be beneficial to go over them and find out if they understood the key aspects of the workshop (Riley, n.d.)
- Give the participants space to discuss about their failures and be reminded of how mistakes are a natural part of growth (Bastiaansen & Duerden, 2024).

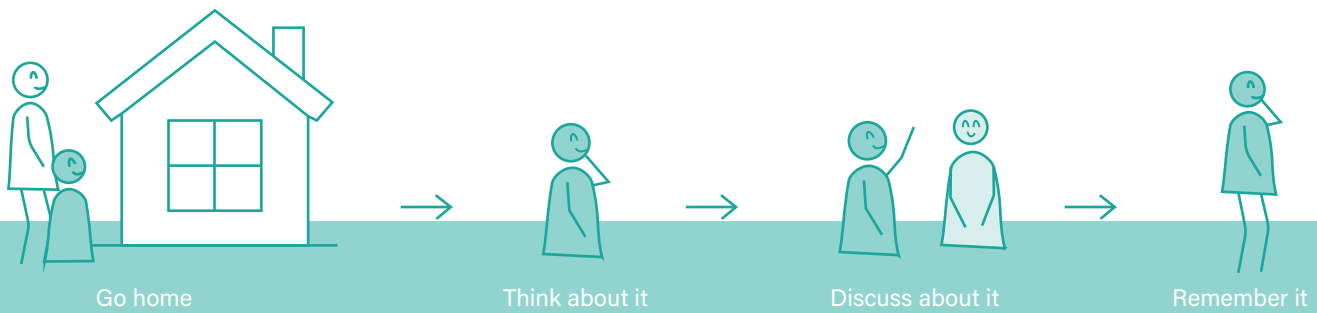


Figure 24: Steps taken by the participant after the workshop.

After the workshop

The moment the workshop ends, the experience continues, see Figure 24. The participants will go home with their parents, process their thoughts about the workshop, alone or with others and maybe at a later moment in life they will be interacting around the same topic and be reminded of this workshop.

12. Physical reminder

Providing participants with something tangible to take home after the workshop helps revisit the experience and reflect at moments later.

Action points:

- A physical reminder, whether it's a self-made object, a small prototype, or even a piece of material will be fun for the children to take home (C8. Bringing it home).
- When deciding on what it is, think about how it might trigger conversations with others, extending the impact of the workshop into the participant's personal environment.

13. Reflection

Give the participants the opportunity to reflect after the workshop has finished to mentally reengage with the experience (Bastiaansen & Duerden, 2024).

Action points:

- Give the participants the tools to reflect on what they have done and achieved during the workshop. This can be through communication channels or a tool they bring home.
- Think about in what way they can share stories about their growth. And on how this can again be some sort of repetition of their new knowledge as a learning strategy.

14. Sharing achievements

It is important to celebrate the achievements. This can be with other participants or people at home. Little et al. calls this the cheer squad (2024).

Action points:

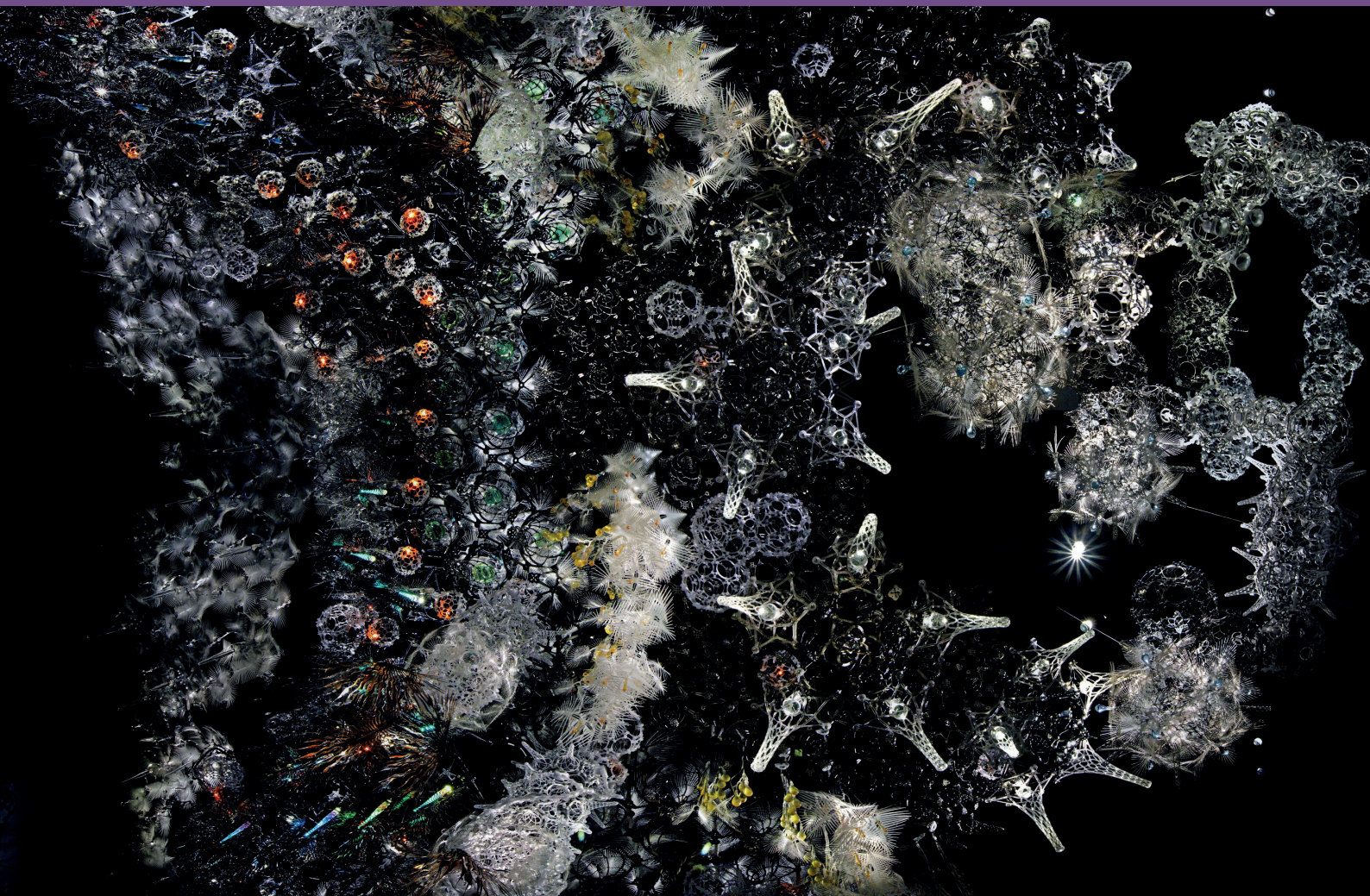
- Think about a way the participants can share their work with others. This can facilitate as a moment of proudness (Little et al., 2024; C7. Influence of others).

2.6 Conclusion

This chapter has outlined the research phase in which many key insights were found that all support the development of meaningful STEAM-based workshops for children. Through a combination of literature review, interviews, and observations, 14 initial design guidelines (DGs) were derived and organized into clusters based on their overlap and alignment. These clusters are structured across the three experiential phases of a workshop: before, during, and after.

To ensure these DGs are useful for real-world application, accompanying instructions and a model that helps formulation clear workshop and learning goals have been developed. This was also done through the research's findings.

While these guidelines remain 'initial' and untested in practice, the next phase of this project, will be about the implementation in a realistic context. Specifically, the guidelines will be applied in a case-study within the Science Centre's Techniek Studio. This is done to evaluate the initial design guidelines and refine them into a more practical tool. It will also help evaluate the usefulness of the instructions and the model, and discover if other instructions are needed to effectively begin developing new workshops.



Chapter 3

Diving into the workshop's context

In the previous chapter, the research phase, design strategies were discussed and clustered into initial design guidelines. In Chapter 4, these guidelines will be evaluated through a case study. In this case study the initial design guidelines are used for the development of a new workshop for the Science Centre. This chapter will provide all the needed information about the new projects of the Science Centre that lay the foundation for this workshop.

Section 3.1 will elaborate on the new installation, 'Aria Sentient Constellation', at the entrance of the Science Centre. Section 3.2 explains the 'living shadows' material kit. Section 3.3 describes how these two will be brought together in the workshop.

- 3.1 ARIA Sentient Constellation
- 3.2 Living shadows - material kit
- 3.3 Experimenting with art

3.1 ARIA Sentient Constellation

In this project, the design of a STEAM workshop for the Science Centre will be used as a case study to discover the use of the initial guidelines. Before going into the design process, it is important to first understand the specific context in which the workshop will take place. The main goal of this workshop is integrating Art in STEM through hands-on activities.

The Science Centre has identified the 'Living shadows' material kit, designed by Philip Beesley (PB), as a good starting point for this workshop. Using these materials also presents a promising opportunity to create a meaningful link with the new artwork at the entrance called 'Aria Sentient Constellation' also designed by Philip Beesley. To get a better understanding of this specific context, this first section looks at the artist, the design and purpose of the new artwork.

Philip Beesley Studio Inc. & Living Architecture Systems Group

This workshop is a collaboration between the Science Centre, Philip Beesley Studio Inc. and Living Architecture Systems Group (LASG). This is an interdisciplinary design firm located in Toronto, Canada. Beesley specialises in architectural design of public buildings, public art and experimental installations. On the website, Philip Beesley Studio explains its work as following: "The most recent generations of these works feature interactive sound, light and kinetic mechanisms with distributed control systems. Studio research focuses on aesthetics, technology and craft of responsive envelope systems including digital fabrication of extremely light-weight, flexible component arrays containing embedded sensors and actuators" (n.d.).

Living architecture testbeds are one of the systems the LASG designs. These are sculptural systems that are both an art installation on itself, and a learning environment. With this, they also support STEAM learning on location (Beesley et al., 2023). They have been installed on universities where "they have been integrated into courses and research projects for undergraduates in design, technology, and engineering" (Philip Beesley Studio, n.d.).

Aria Sentient Constellation

LASG and Philip Beesley Studio have been in collaboration with the TU Delft and the Science Centre for several educative projects already. With the opening of the Science Centre on a new location, the opportunity was found to have a permanent sculpture hanged at the entrance. An overview photo is shown on the next page in Figure 29. It will immediately emerge visitors in art and technology at the start of their Science Centre experience. This sculpture is not just designed to be an artwork, but also serves as one big testbed (Beesley, 2024). It will be a multi-year project which brings together, artists, researchers, educators and students of all levels and ages. Figure 25 shows an overview of how research streams around the installation are imagined by LASG.

The artwork is called '**Aria Sentient Constellation**' (ARIA). The installation was officially unveiled during the Highlight Festival on 14 February 2025 and is now permanently open for all visitors of the Science Centre.

ARIA brings together art and technology. It consists of more than 500.000 components that are connected

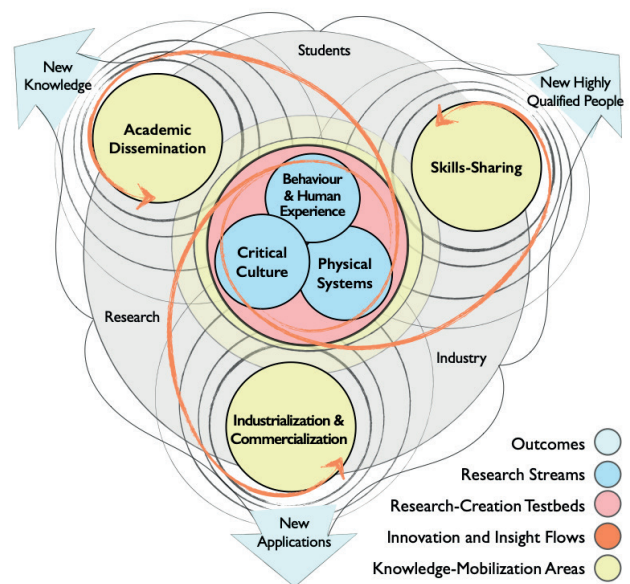


Figure 25: Overview of ARIA's research streams and stakeholders

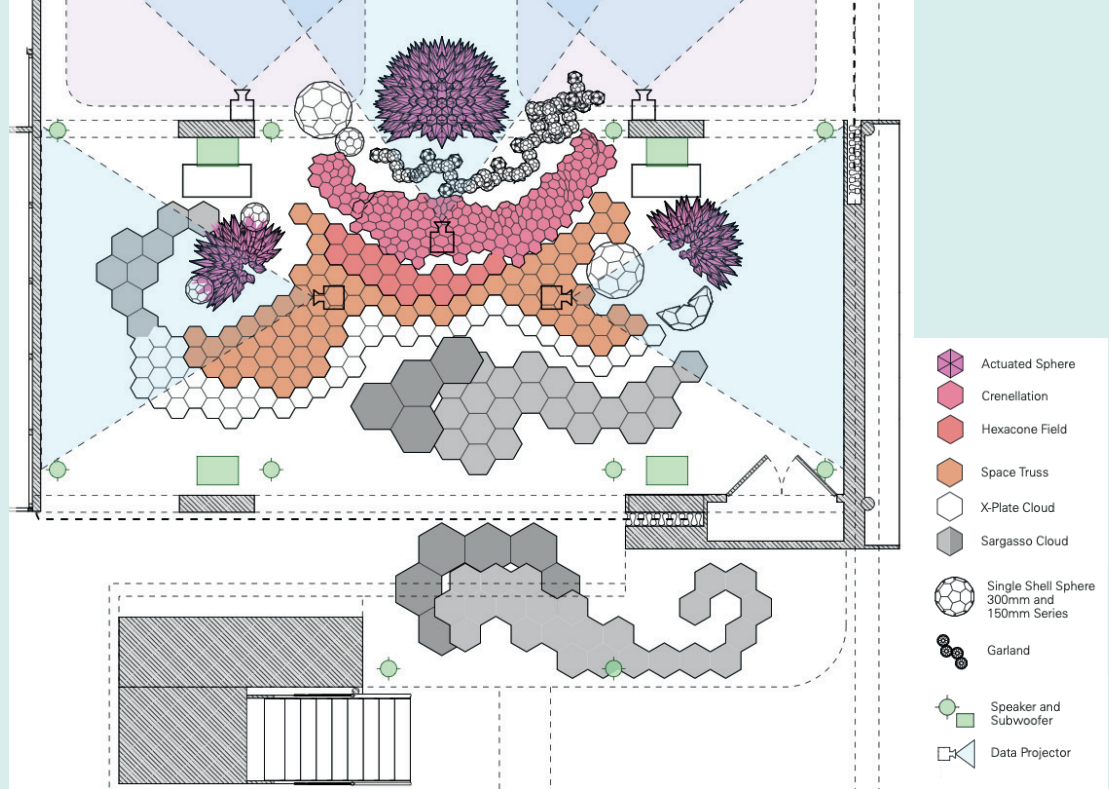


Figure 26: Schematic top view of ARIA at the Science Centre (Beesley, 2024).



Figure 27: Sargasso cells while they were being produced



Figure 28: Installation 'Poietic Veil Tilburg' (Beesley, 2023)

to each other. The artwork can respond to its visitors in different ways, when they are coming nearby or touching it. The way it responds is not a one-to-one interaction. Someone's appearance sets off a whole movement of parts reacting to it and to each other. Just like the wind blowing through the grass. Moreover, if there is no one interacting, ARIA will still be alive. It can think and feel because of the small computers that are connected all through the sculpture (Aria Sentient Constellation, 2025). Besides this interactive mode, there is also a show programmed into the sculptures' computer. This can be started remotely and starts a pre-set eight-minute program. This includes sounds, and different colours of light and movements that together tell a story.

The artwork is a combination of several structures that LASG has used in many other works, this can be seen in Figure 26. In Aria, '**Sculpture components cluster together like constellations of stars in the sky**' (Aria Sentient Constellation, 2025). All structures have been created with inspiration drawn from nature at different scales. For example, sargasso cells, shown in Figure 27, are explained as 'These spiral hexagon forms are similar to the skeletons in tiny living animals called diatoms.' (Aria Sentient Constellation, 2025).

Not only the structures, but also the materials themselves are reused. For example, it makes use of parts from the temporary artwork 'Poietic Veil Tilburg', that was staged at the TextielMuseum in Tilburg until April 2024, as shown in Figure 28.



Figure 29: ARIA from the side (Beesley, 2024)



3.2 Living shadows - Material kit

The 'Living Shadows' material kit, designed by Philip Beesley (PB), has a strong connection to ARIA and it offers a strong foundation for a hands-on STEAM-based experience for children. That is why the Science Centre has selected it as a good starting point for the new workshop. More information about the kit is essential for a better understanding about the case study, described in Chapter 4. This section looks at the materials goal, its use and the development.

Objective of the Materials

The structures and materials of the sculpture in a testbed, as ARIA was explained in the previous section, are a perfect way of supporting STEAM-based programmes. However, having the opportunity to take part in a hands-on activity would even be better to immerse students, and so foster STEAM-based activities. Therefore, PB and LASG are also developing material kits that use similar materials and components as the sculptures are made from. With these kits they want to offer playful materials to participants in learning environments, where they can make their own sculpture 'instruments'.

Altogether it is explained as "They will learn about how we perceive and evoke life through structure, movement, sound, and light using Shadows and Whispers kits. Students can quickly and easily create their own instruments for exploring concepts that bridge science and expressive art." (Dream Worlds, 2024).

The kits components

Knowledge of these materials has been obtained through various tests, conversations with Philip Beesley and browsing through the folio's (small booklets) PB and LASG have published about it (Beesley et al., 2023).

The kit includes many different parts. Because of their modularity, these materials allow for endless possibilities in building instruments. The four main aspects are:

- Electrical components that create light or motion
- The components can be activated and played with, using wires, buttons and knobs
- 3D-printed, semi translucent building components like ring shaped parts to build structures with.
- Base plates, to attach components on and bring them together as one assembly.

Many parts, particularly the electrical components and 3D-printed parts are derived versions from the artwork. In Figure 30 these four elements are pointed out in an example assembly. A very simple assembly is shown in Figure 31. Assemblies can also be extended with new structures and components and become more advanced, as shown in Figure 32.

The users can keep experimenting and refining their creations with several materials. In this way they are exploring sound, light, structure, motion, and simple controls. Through this playful experimentation, their creations can be brought to life.

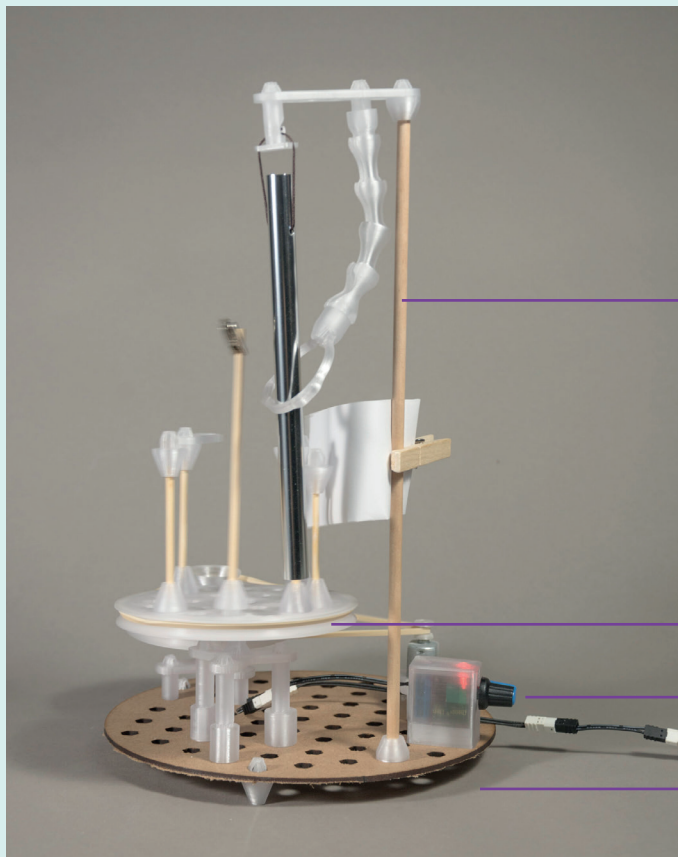
Development of the kit

The Living shadows kit is part of a multi-year STEAM Kit development project which is being carried out in phases by PB and the LASG, in collaboration with the Science Centre.

It is important to note that during this graduation project, the development of the project was ongoing. Which means that throughout the course of this project, different versions of the kit have been used. At the beginning of this project, the basic kit that was delivered by PB in December 2024 was named 'Shadows and Whispers'. With this version, the first tests of the workshop were done. These tests will be discussed in more detail in Subsection 4.3.2, where the materials are evaluated as part of the case study.

After some testing and meetings with PB, the SC team and me, the project researcher, some improvements were made in February 2025. Among which eliminating some elements and choosing for specific assemblies. Here, the decision was made to mainly focus on the light and movement assemblies and all creative materials. Although audio is also important, this will be discovered in a later stage of the kit's development, which will happen after this project.

Finally, this led to the final version named 'Living shadows' kit, with which the final tests were done. This is also the version ordered by the Science Centre and will be used in the planned Techniek Studio. Figure 33 and 34 provide an overview of all the components from the final version.



Building materials

Actuator (a small spinning motor is placed underneath the installation)

Controllers

Pegboards are the baseplates all the components can be attached to.

Figure 30: Rhythm assembly (Dream Worlds, 2024). Arrows point to and label the key components of the kit.



Figure 31: Vibration assembly. A vibration motor is connected to an on-off switch. (Dream Worlds, 2024)



Figure 32: Cellular assembly. Many rings connected create a sphere with a light on top. (Dream Worlds, 2024)

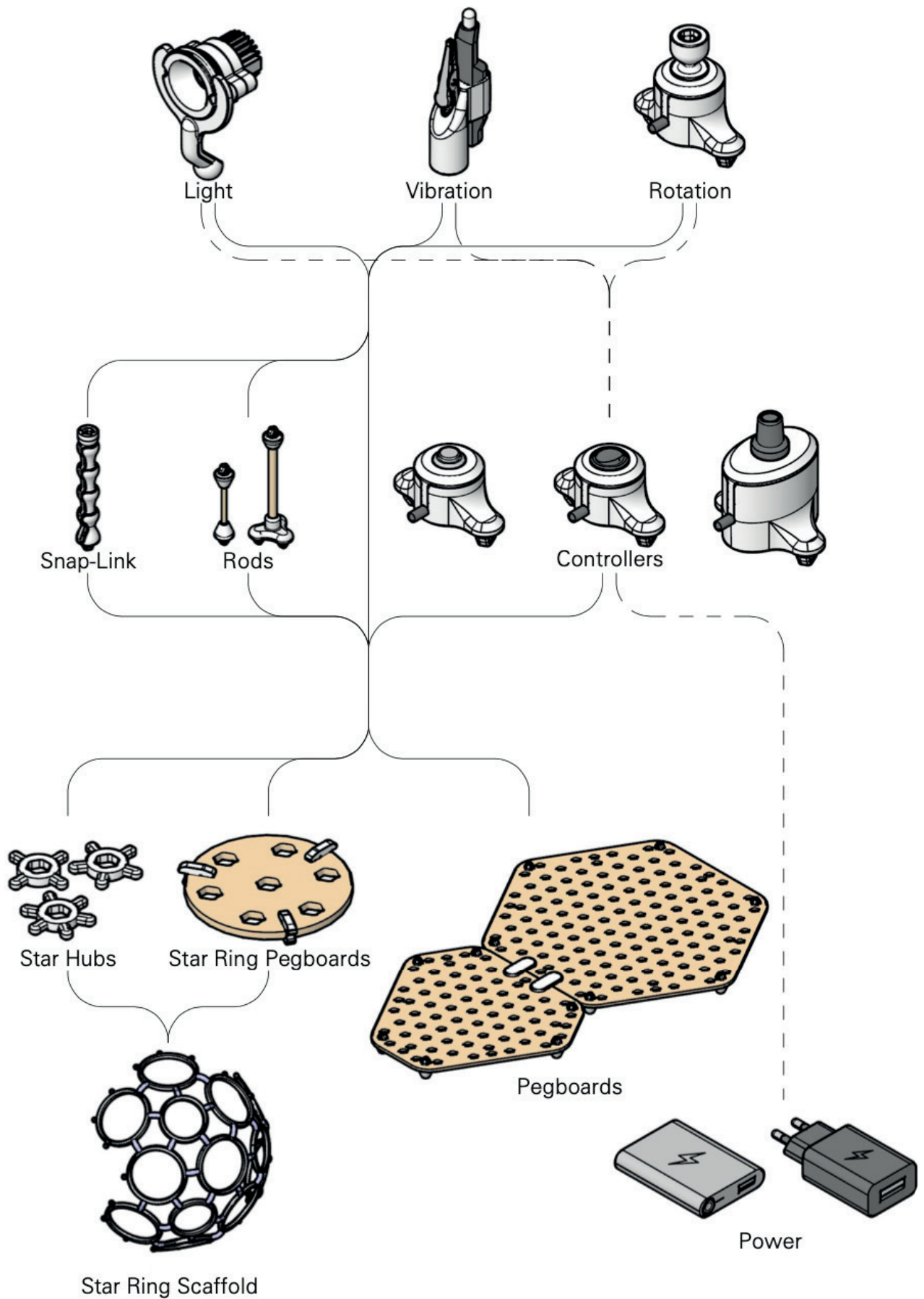


Figure 33: Kit system diagram. The parts that can be used to make a full assembly. (Philip Beesley Studio Inc. & Living Architecture System Group, 2025)

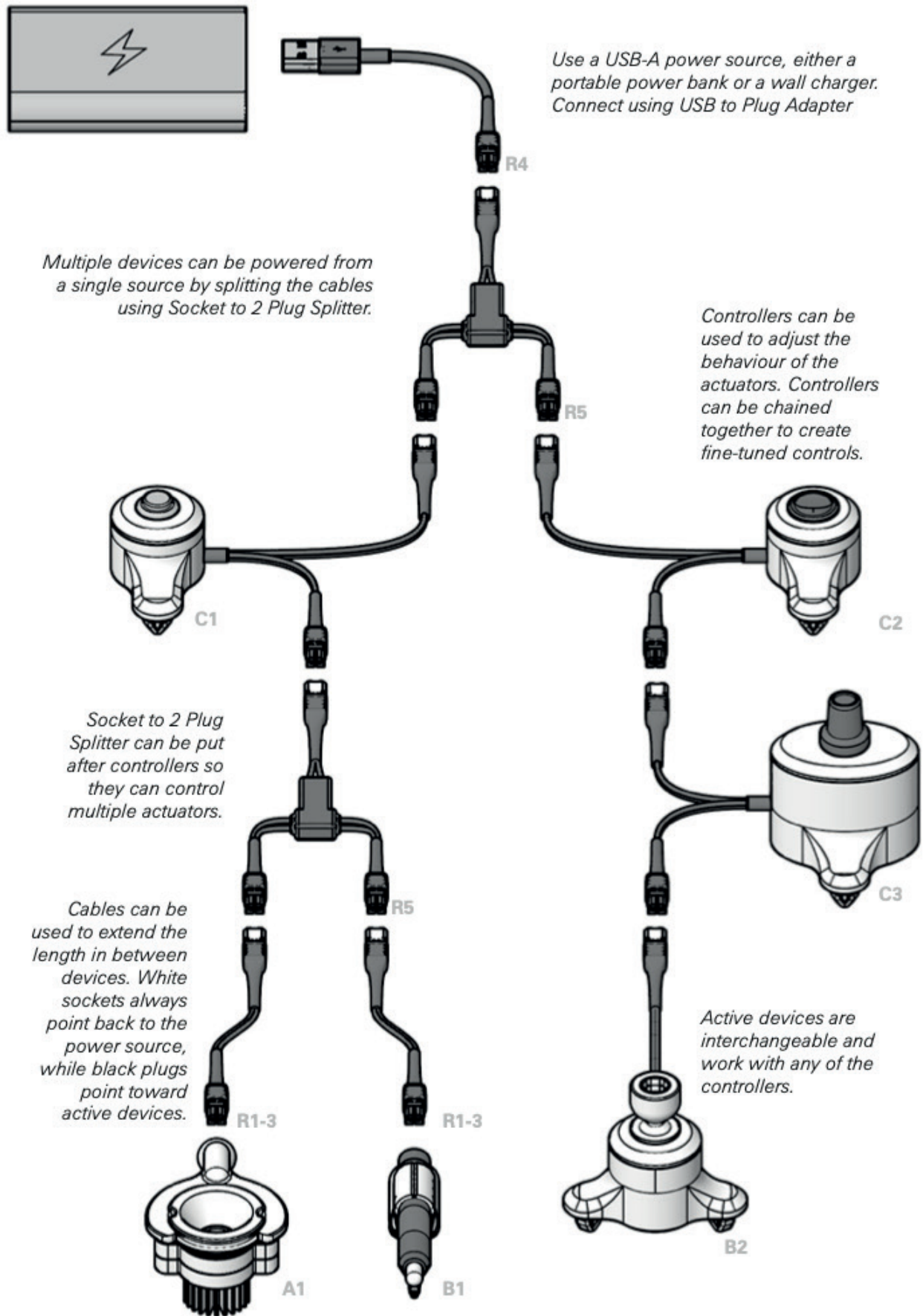


Figure 34: Cable system. Schematic overview of how the technical components can be attached to each other and to a power source. (Philip Beesley Studio Inc. & Living Architecture System Group, 2025)

3.3 Experimenting with art

The materials from the 'Living shadows' kit and the artwork integrate the elements of the STEAM disciplines in a way that makes it accessible for experimenting, for students of all ages. Using this kit, gives the Science Centre the opportunity to create a STEAM workshop fitting their mission for the 'Techniek Studio's'. This workshop will be called 'Experimenting with art'. This section introduces the main goal and overall concept of the workshop. The detailed workshop design will be explained in Chapter 4.

Main goal of the workshop

The need for development of this workshop, gives this project the opportunity to test the initial design guidelines in a realistic setting. When designing the workshop, it is essential to align it with the Science Centre's intended goals for the workshop. The most important requirement is to bridge the 'living shadows' material kit with the artwork itself, as Figure 35 shows. In this way the participating children get to experience that it is possible to be creative and work with technology at the same time. This explains the name 'experimenting with art', designated by the Science Centre. How this name is used as the topic of the workshop will be explored during the design process.

Using the materials

As the previous section about the materials has explained, structures and components can be easily combined and extended, encouraging many cycles of exploration. Using these kits, children can quickly and easily create structures and working models. However, to make the workshop STEAM-based and meaningful, it needs more foundation.

Making it STEAM-based means using a combination of one or multiple of the STEM disciplines and Art. With an understanding of the materials, it is found that they can easily be divided into technical materials (electrical components and wires) and creative materials (rings and connecting tubes). Only the implementation of those two into a workshop format had to be found. This will be discussed next, as separate phase. However, in the development process this happened simultaneously.

Implementing the creative materials

When looking for an overarching theme for the workshop, the 'interests of children' were held as the highest requirement. This also comes back in initial guideline 4. Personal value. Which was found during the research phase. While looking into children's interests and values,

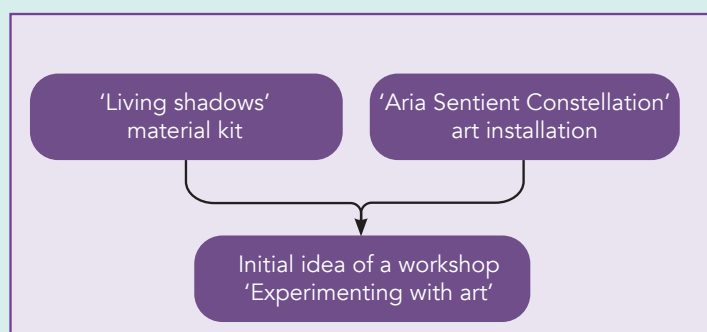


Figure 35: Schematic overview showing the two projects that lay the foundation for the workshop 'Experimenting with art'

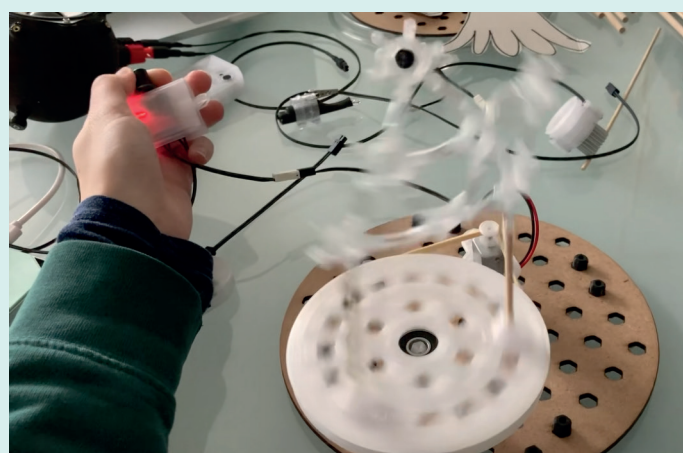


Figure 36: A first test with the material kit, at home.



Figure 37: Creature made by students during the Interactive Environment course.



Figure 38: Creatures made by young children during science day at the Science Centre

fun and magical were discovered to be important.

Figure 36 shows a first test of the materials, here it was not yet clear how this feeling could be achieved. Appendix D and E present an overview of the insights gained from the tests. The joints, rings and connections tubes and more 3D-printed parts, have been designed for all kinds of variation, supporting curiosity and open-ended creative play (Beesley, 2024). However, without assignment, they did not spark a creative feeling, or need for creation.

Looking into earlier workshops done at the Science Centre with similar materials, it became clear that the making of 'creatures' could be the right way. In several activities facilitated for different groups of young participants similar topics were seen as successful by the Science Centre. Figure 37 and 38 show two examples. To better understand the course of an activity with a similar age group, a conversation was held with one of the organisers of the workshop 'creatures in a reef'. An activity held during a science day at the Science Centre. Here children could use see-through tubes and small connectors to make creatures (Figure 38). This conversation concluded that the children had a lot of fun but did not really learn anything from the activity. **"Making little creature friends was something all the children liked to do"** (workshop

facilitator, personal communication, 2025). So, making creatures was found as a good opportunity for the creative part of the workshop in which children can make something they like.

Implementing the technical materials

Besides the creative part, the use of the technical materials is important. This will be the part of 'learning something new', which is important to make the workshop meaningful.

By making an assembly with the technical materials, the children can make their creature come to life. To achieve this, and to keep it simple for the children, it was decided to continue with the two most obvious themes:

- Simple spotlights can be combined with lenses and filters. With this, vivid projections can be made including shadows and storytelling.
- Kinetic motion like spinning and vibrating assemblies, can be brought to life using hand-powered or motor-driven mechanisms. This will add movement to the children's creations.

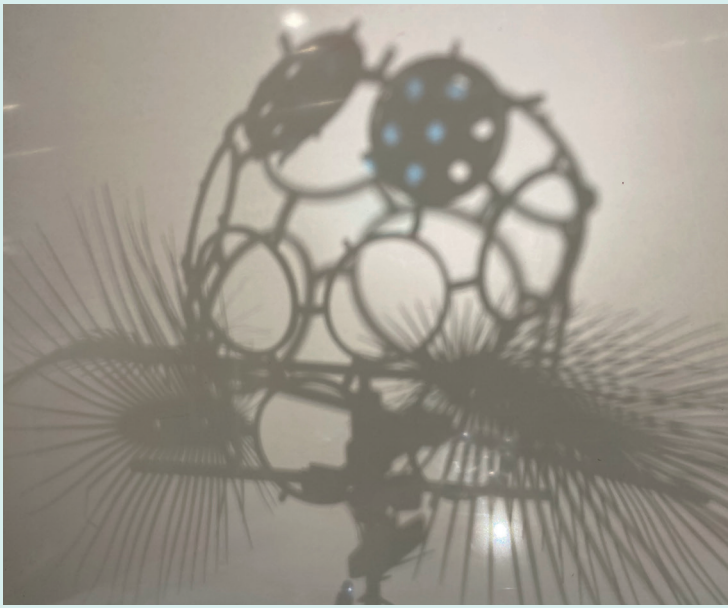


Figure 39: Droomling try-out 1

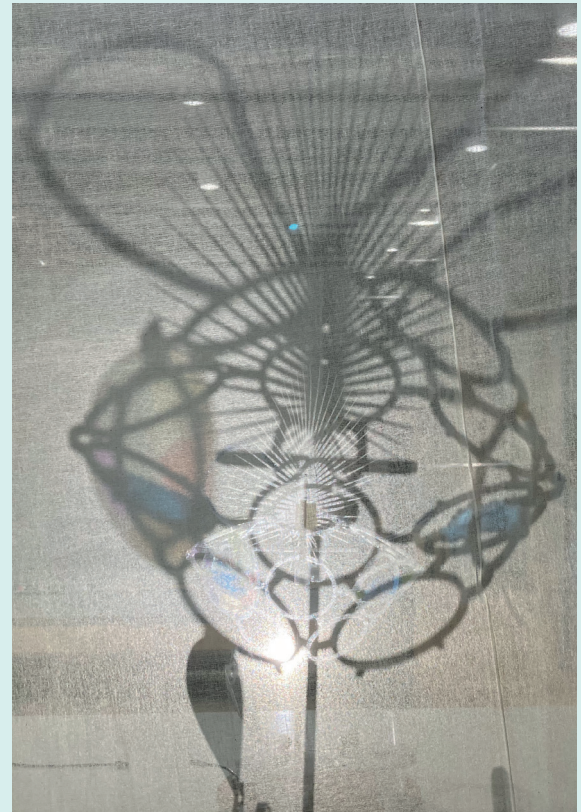


Figure 40: Droomling try-out 2

Connection to ARIA

With both the technical and creative part covered, the only thing missing is a better connection to ARIA. To find a way to do this, conversation with Philip Beesley and members from the LASG team helped to discover more about the artwork. The artwork itself is sometimes referred to as 'a dreamworld'. Within this dreamworld, the shadows of the artwork play an important role. The shadows are an extra projection layer behind the artwork, a part is shown in Figure 41. They can move differently than the actual shadows of the artwork.

When looking closely at the shadows, there are already some sort of creatures moving through the artwork. PB explains it as 'vivid shadow-play appearing', as can be seen in Figure 42.

This playing with shadows and the making of creatures was seen as a good overall activity for the children during the workshop. The creatures the children will make, will be called a 'droomling'. This is a made-up Dutch word, loosely translated as 'dreamlike creature'. Figure 39 and 40 show the result of some tests that were done by playing with the materials while trying to make some creatures. In Appendix F, a more elaborated version of these test can be found. From this, it was concluded with confirmation of both PB and the Science Centre, that the making of 'creatures' is an interesting approach for the Techniek Studio. From this point, the material kit was named 'Living Shadows Kit'.



Figure 41: Shadows projected behind the installation on the wall

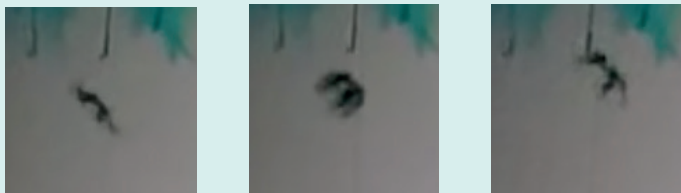


Figure 42: Three snapshots of the projection, where a small flying creature appears.



Figure 43: Final design of the screen and its frame. Allowing easy shadow play for the kit's users.

Collaboration with Philip Beesley

Throughout the development of the workshop's several meetings with Philip Beesley took place. This collaboration has been crucial in understanding the materials and adapting them to fit the specific needs of the workshop. Especially meetings at the beginning of the workshop design process, made it possible to tailor the components and assemblies to support the workshop goals effectively.

With the feedback of tests, PB and his team can continuously test and improve the materials. These improvements benefit not only this project for the Science Centre but also future projects where the materials will be used in other settings.

Shadow screen

A great example of this collaboration is the development of the screen assembly. To support shadow play, it was found needed to have a blank canvas to project the shadows on. Every workshop room is different and white walls are not expected to be available everywhere. An alternative was found by trying out shadows on some hanging cloth as a test. PB and his team found this very fitting, so they designed modular screens that can easily be set-up and moved within the room. In Figure 43, the final design is shown in use.



Chapter 4

Case study - Development of a workshop

In the previous chapter, the context of the 'Experimenting with art' workshop was explained. Building on this foundation, the present chapter examines the development of the workshop as a case study. This aims to understand what information is needed for a workshop developer to get started and use the guidelines. Through this case study, new insights will be found and used to develop a more practical and refined version of the initial design guidelines proposed in Chapter 2. The final design of the refined design guidelines will be presented in Chapter 5.

Section 4.1 outlines the process that this case study followed. To provide a reference point for the analysis that follows, Section 4.2 introduces the final framework of the workshop. Then the initial guideline's instructions are applied in Section 4.3. Section 4.4 presents the actual design process and reflects on the role of the initial guidelines within it. The workshop is then evaluated using the initial Experience Layers Model in Section 4.5, which also includes a critical assessment of the model itself. Finally, Section 4.6 concludes the chapter by summarizing key findings and implications.

4.1 Case study - process

4.2 The workshop's framework

4.3 Applying the initial guideline's instructions

4.4 Applying the initial design guidelines

4.5 Applying the initial experience layers model

4.6 Conclusion

4.1 Case study - process

This projects' research phase (Chapter 2) resulted in 14 initial design guidelines, including instructions and an evaluation model. The Science Centre's need for the development of the Techniek Studio 'Experimenting with Art' presents the opportunity to apply the proposed initial design guidelines in a real-world context, as a case study. The aim of this case study is to gain a better understanding of the DG's practical use and to refine them into a more useful set of design guidelines.

Evaluating all these elements of the initial design guidance tool will be done through an iterative process consisting of multiple phases. It should be noted that this design process has not been linear, but this chapter will explain everything step-by-step for clarity as visually summarised in Figure 44.

Starting, the framework of the workshop that emerged from this design process will be presented through a storyboard. This is necessary to understand the detailed steps that follow.

Then the use of the initial instructions is explained in Section 4.3. These have helped to get started with the design.

This next step is the test phase, which will be introduced with the method used to test the steps and the flow of the workshop in Section 4.4. This is followed by a detailed explanation on how each initial design guideline was applied in Workshop Test 1 and 2. This will lead to many takeaways which will be translated into new action points.

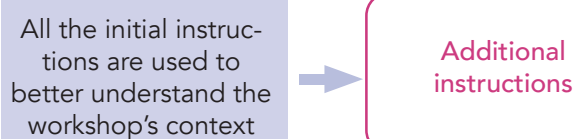
Then, an evaluation of the workshop using the 'initial experience layers model' is done in Section 4.5. Aiming to answer the question: Did the participating children have some level of a meaningful experience? Thereafter, the use of this 'initial experience layers model' is assessed.

Finally, all initial elements of the design guidance tool can be refined. This leads to a final design presented in Chapter 5.

4.2 The workshop's framework

The developed workshop is presented in 22 steps.

4.3 Following the guideline's instructions



4.4 Implementing the design guidelines

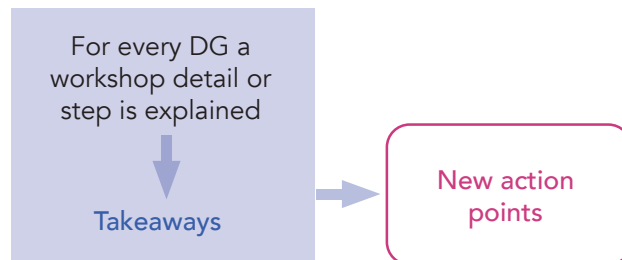
4.4.1 Test approach

An explanation about how the tests are performed.

4.4.2 Overall research outcome

Explanation how results have led to refined DGs.

4.4.2 Refining the DGs one by one



4.5 Applying the initial experience layers model

4.5.1 Evaluation part 1

The level of experiences of the participants in Workshop Test 2 is evaluated.

4.5.2 Evaluation part 2

The course of the evaluation is assessed.

Refined 'Experience layers model'

Figure 44: Overview of steps of the case study.

4.2 The workshop's framework

To provide a clear overview, this section presents the final framework of the workshop through a storyboard. Understanding the overall story and structure helps to contextualise the following sections. Since the process was non-linear and iterative, presenting the final workshop first serves as a useful reference point. Subchapter 4.3 will elaborate on how this framework resulted from the design process.


Overall story

With a clear vision for the workshop goal of 'experimenting with art', as outlined in Chapter 3.3, the overall story of the workshop is as follows:

Visiting the large artwork ARIA, at the entrance of the Science Centre and watching the show can feel like being emerged in a dreamworld of movement, lights and shadows. The overall story of the workshop will connect this interpretation to the 'living shadows' materials kit. During this workshop, children will first learn step-by-step how to use the technical materials with their own kit. Thereafter, they will get creative using the structural elements, inspired from the artwork, to create their own dream creatures that could live in the artwork.

Readers guideline

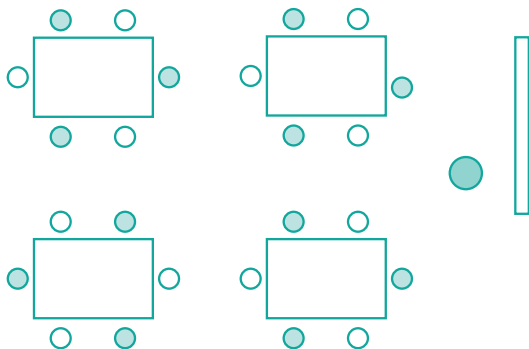
The storyboard is divided over 22 steps. Every step shortly explains what happens. Some elements within the storyboard are intentionally left open (highlighted with a green border). These parts are described very generally and are filled in in different ways within the workshop tests.

Step explanation	The step of the story shortly explained with text.
	'Open elements' Different content is given to these in the concepts of the workshop.

Storyboard - Basic structure

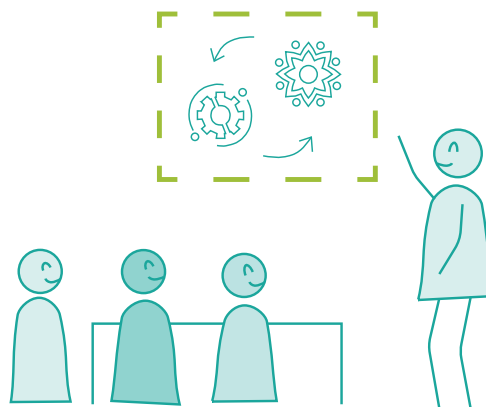
1

The workshop starts in the workshop room. All 12 children and their parents find a spot around the tables.



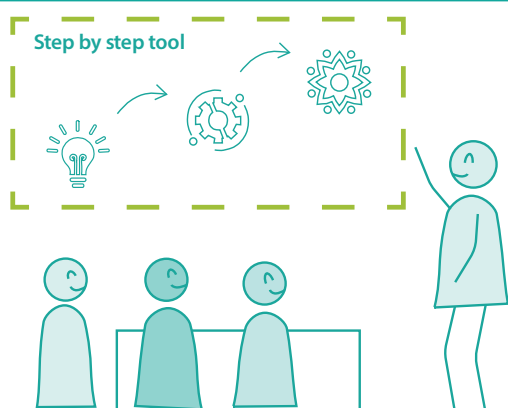
2

The facilitator explains **the main topic** and asks what the children already know about this.



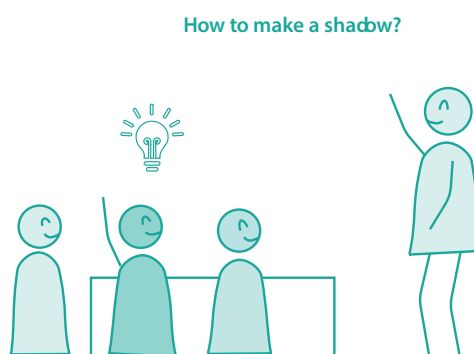
5

The facilitator clarifies what they will be making their own creatures with shadows. **The tool** is introduced to show the step-by-step process.



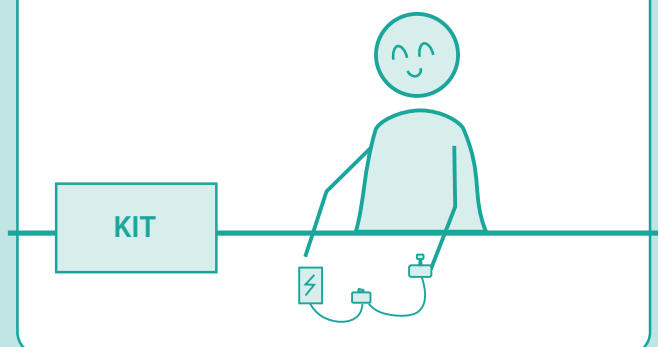
6

The facilitator asks if they already know how to make a shadow and explains how they work. With the first step being shining light.



9

Using their powerbank to try out other components from the kit. Like a spinning and vibration motor.

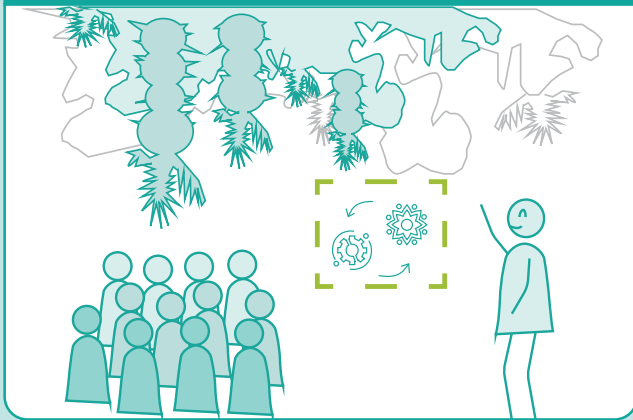


10

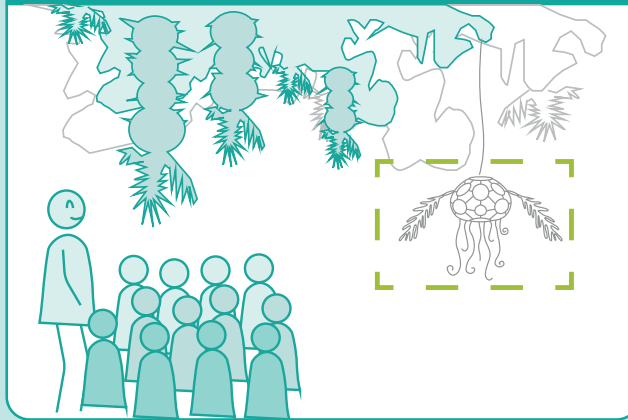
They discuss from what devices at home they recognise these components.



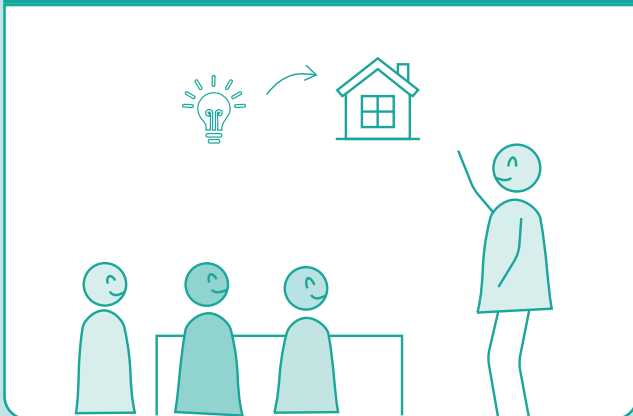
- 3 The groups visits ARIA. They interact with it and they discuss aspects of **the main topic** in the artwork.



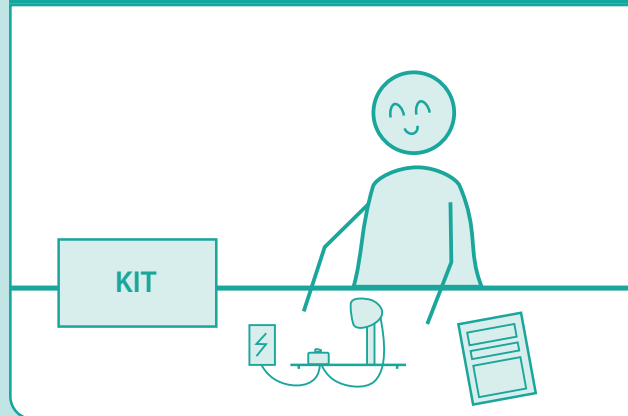
- 4 Ariana appears in the shadows and asks the children for help through **the story** of the workshop.



- 7 The facilitator explains how electricity works. Like at home, a switching on will closes the loop and makes the electricity run to make the light go on.



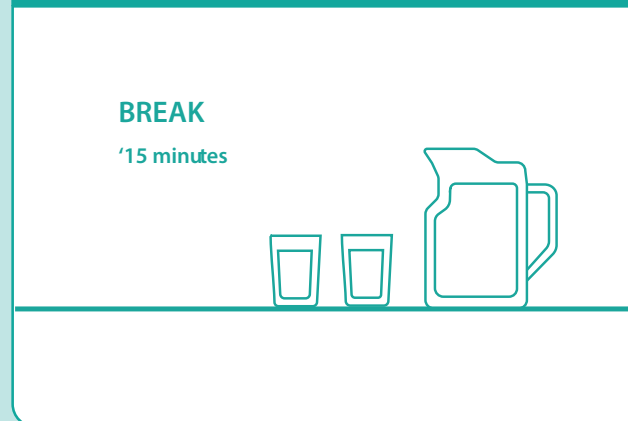
- 8 Use a simple manual to use the materials from their kit to build their own light.



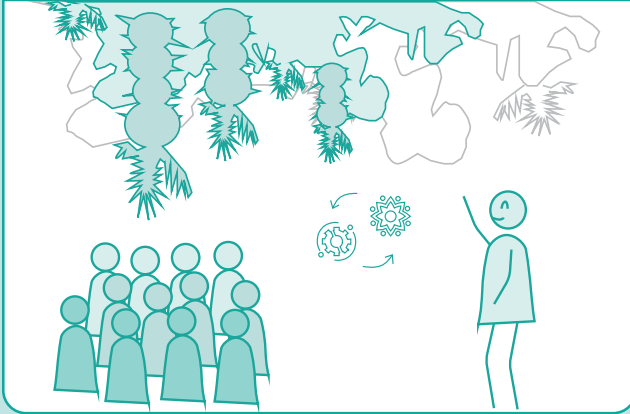
- 11 They choose one of the manuals, and build their own assembly with the materials from the kit. The parents help where needed.



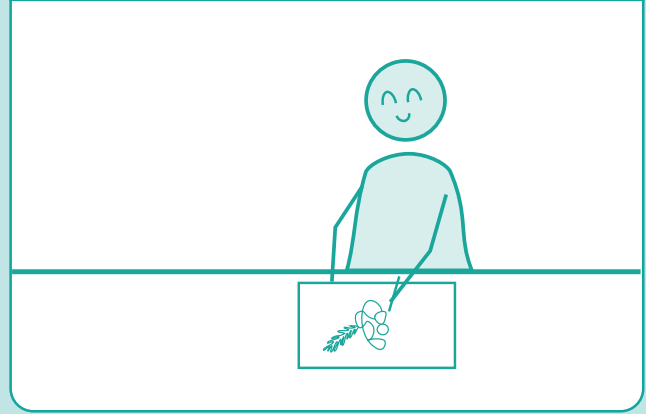
- 12 They have a 15 minute break.



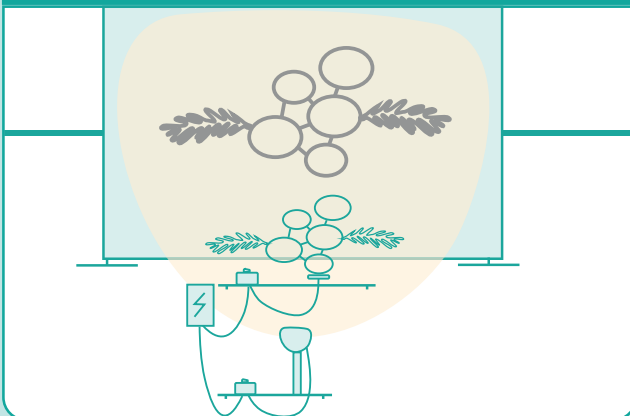
- 13 After the break they gather under ARIA. They discuss where in the artwork they see the elements they have been using themselves.



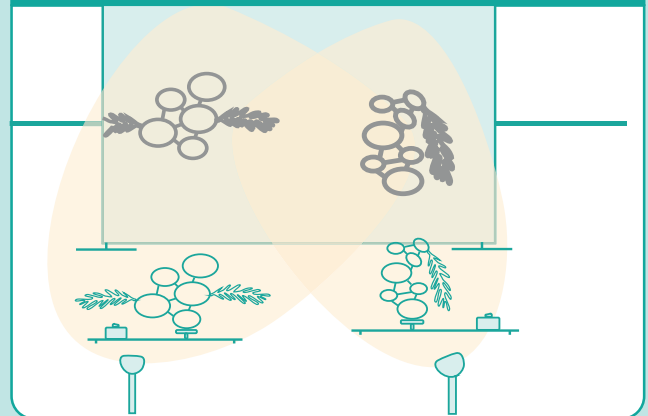
- 14 They will draw their idea of what their creature will look like.



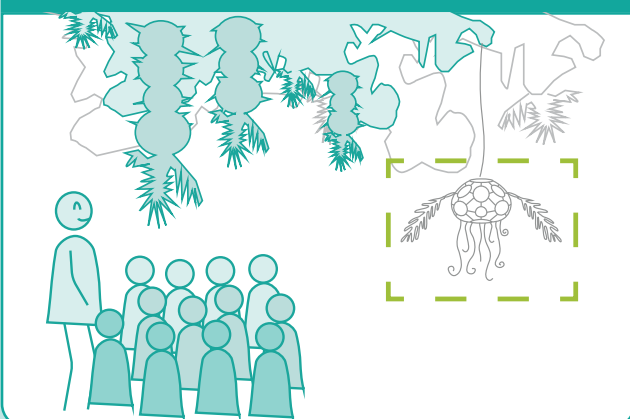
- 17 The shadows of the moving creatures are tested on the screen. They have the opportunity to change their creature to the shadow they like best.



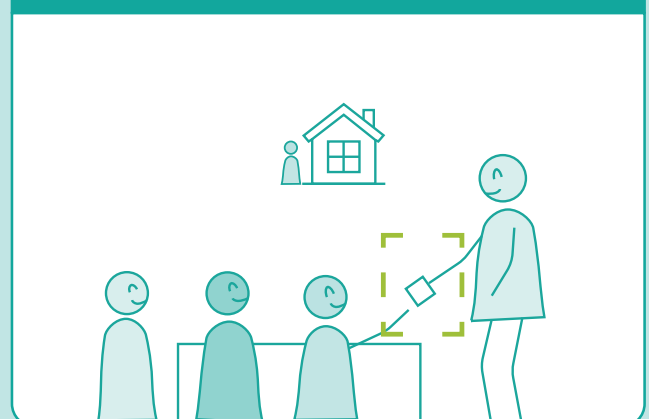
- 18 If everything is finished, they show the shadows all together on a few screen in the workshop room.



- 21 They finish the workshop as a group at ARIA. Here **the story** comes to an end.



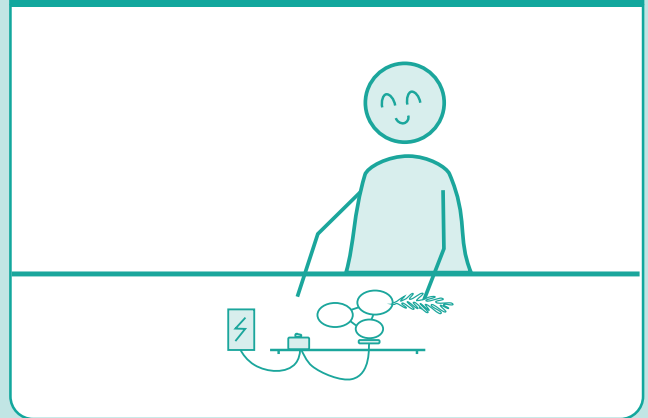
- 22 As a small 'thank you' they get a **'take home gift'** after the workshop.



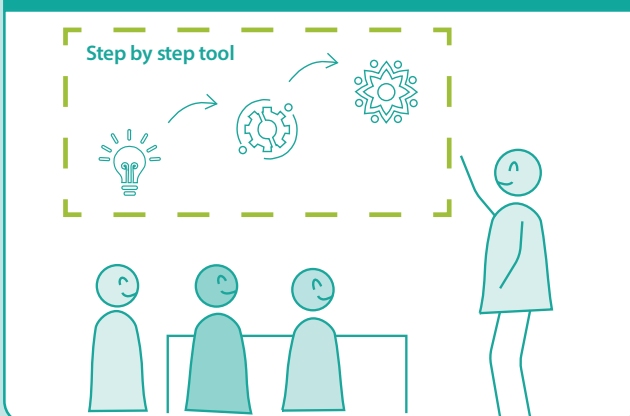
15 It is time to build their creature, using all the materials they want.



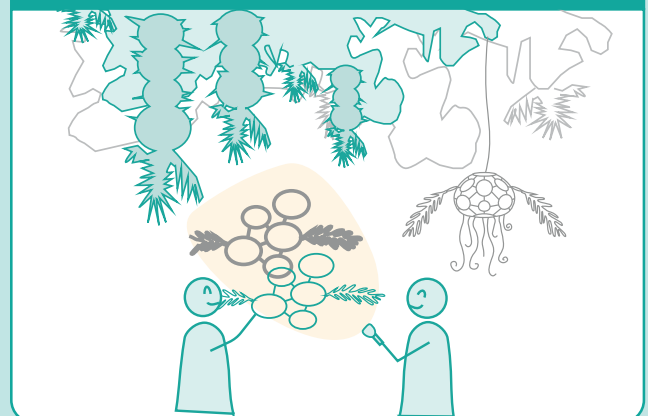
16 They attach their creature to their mechanism and see how they work together.



19 The facilitator uses **the tool** to discuss and reflect on what they have done and learned.



20 At the end of the workshop, they take their creature to ARIA and play with it in the shadows.



4.3 Applying the initial guideline's instructions

This section provides a detailed description of how the initial design instructions were applied in practice and how their implementation laid the foundation for the presented workshop.

The initial instructions are intended to provide a clear understanding of the workshop's context and the initial objectives envisioned by the organisation. The instructions are essential for effectively applying the 14 design guidelines and represent a key step in the development process. The instructions are formulated to either pose reflective questions to the developer or present straightforward tasks. During the workshop design process, answers to these instructions were explored through various tests. Besides designing the workshop, this also helped identify additional instructions that may be valuable for the designer.

A total of six initial instruction were proposed in Subsection 2.5.1. Of these, three were actively implemented in the design of the workshop leading to additional instructions. They are discussed in detail in the following subsections:

- **4.3.1 Organisational standards**
- **4.3.2 Understanding the materials**
- **4.5 Experience layers model**

The remaining three instructions, shown on the right, do not require immediate action but serve as important considerations to keep in mind throughout the design process. These will be integrated into the final design as guiding principles.

Guiding Principles

Read through the following information before moving on to the next step.

Balancing fun and seriousness

The guidelines should contribute to both the enjoyment and the overall purpose of the workshop. Especially since the focus is on out-of-school hands-on learning experiences, making it important for the children to not focus on the learning goals all the time.

Amount of design guidelines

As Bastiaansen and Duerden mentioned, there is not a minimum amount of constellations or strategies needed to reach a meaningful experience (2024). It is suggested to apply a certain amount of guidelines that help to design the workshop in a way that integrates fun and learning naturally. Moreover, it is important that the guidelines chosen should complement each other.

Designing for children

Since children have a unique mindset and way of viewing the world, it is expected that the outcome can sometimes be quite different then the theory was expecting. The designer should anticipate on this by not designing too strictly, and test and adjust the workshop multiple times. Or when the design is already set, communicate with the facilitators they should remain flexible, observe how children respond to different elements of the workshop, and adjust if needed.

4.3.1 Organisational standards

The goal of the following instruction 'organisational standards' is to help the workshop developer to better understand the context and the boundaries of the workshop.

Organisational standards

Start by identifying the existing workshop standards within your organisation. Knowing how workshops are usually developed and delivered will help you apply these guidelines more effectively.

For this project, finding the organisational standards was done through several discussions with this project's supervisors from the Science Centre. The following standards were found:

Science Centre Standards

Workshoproom

Within the Science Centre, multiple workshops are given during a day, and the spaces for this are limited. Therefore, the workshop should be independent of the room where it will be given. So, no materials should be fixed to the room.

Duo-ticket

The tickets are sold as duo tickets. Meaning the attendance of the children should always be in the presence of one of their parents.

Facilitator

The facilitators are students from the TU Delft. They are trained by the Science Centre. This training is outside the scope of this project. So, the design should be in line with their current abilities.

Sustainability

Sustainability is one of the focus points in renewing the Science Centre's program. This leads to boundaries such as limiting the use of disposable materials and materials to bring home.

Inclusivity

A theme the Science Centre is currently working on. Meaning workshops should be accessible and welcoming for everyone. For example, having all text written in B1 Dutch language is an important requirement.

Realising the need to understand these specific organisational standards, resulted in additional instructions, shown below. The instructions provide the user with a range question that will support the user in knowing what kind of organisational standards may be important.

Additional instructions

Organisational standards:

Does your organisation use:

Standard workshop rooms?

This tells you if the materials you use can be fixed to the room or should be transferable to another room

Standard facilitators?

This tells you who your target facilitator can be. Are they experienced? Close to the target group? Inside education? Do they need/ get training?

Does your organisation already work on:

- Sustainability
Think about the use of materials, the development of tools, printing of information sheets.
- Inclusivity
Think about the facilities used, the senses needed for the activities, the way you address your audience.

4.3.2 Understanding the materials

The goal of the following instruction ‘understanding the materials’ is to help the workshop developer to better understand how the target group can use the materials and how the materials can serve the workshop’s goal.

Understanding the materials

When the workshop is designed with materials as a starting point, it is very important to understand them. How do they work? What can you do with them?

Moreover, it is important to see how children from your target group use the materials. Do they understand how it works? Is it safe? Do they need guidance?

Approach

For the development of the workshop, the materials were already chosen. The living shadows kit presented in Section 3.2, lays the foundation for the workshop. Understanding the materials was therefore found essential before the development of the workshop. Thus, several activities were done:

Conversations with Philip Beesley and his team

When ARIA was built at the Science Centre, there was a need for volunteers. This gave the opportunity to get in contact with the development team of ARIA. Connecting to the team was a very valuable activity that helped to get a better understanding of the artwork.

On top of this, discussions with Philip Beesley and Adrian Chiu were done about the ‘living shadows kit’ and the development of the workshop.

Interview with expert

A facilitator of a previous workshop using similar materials helped understanding what kind of materials are interesting for children, about their main takeaways and issues.

Exploration sessions with earlier versions of the kit

Short test sessions were done giving participants time to explore the materials and doing simple assignments. For example ‘Try to turn on a light with a switch?’. In these sessions, the participants were adults.

Also, a short test with an eleven year old child was done. Here, also some examples were laid out to see his response to the materials.

The most important findings from these tests can be found here, in the examples. A more elaborated version of the tests can be found in Appendix D and E.

Material kit test 1 - Participant 1



Figure 45: Participant 1 trying out the materials

Excluding kit components

PB’s team explain that the materials offer an infinite amount of possibilities to build and play with. However, several participants mentioned that all the materials together were too overwhelming. It was concluded that using all materials will be too much for a workshop that only lasts 3 hours.

Quote: “There are too many materials in this box, I don’t know where to start.” ~ Participant 1 (Figure 45).

Material kit test 1 - Participant 2



Figure 46: Participant 2 trying out the materials

Kit guidance

According to PB, the kit should be intuitive for the user, so they can without much explanation explore with the technology and create their own imaginary worlds (Personal communication, 2025). However, tests show that this effect is not always reached. The participants would have liked some extra information or guidance when playing with the kit. **Quote: "I need more guidance in building something with these materials" ~ Participant 2.**

Material kit test 2



Figure 47: Participant 3 trying out the materials

In need of a story

In a conversation with Participant 3, it was concluded that for a very technical child, it will be like playing with Lego. Only for a child who is more hesitant about technical materials, a more creative assignment and a background story could be useful.

"To trigger my creativity, I would need a story to the materials" ~Participant 3 (Figure 47).

Workshop step - test 1

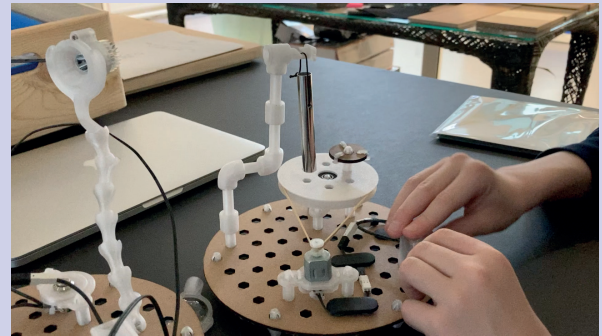


Figure 48: 11 year old participant playing with an example assembly

Example assemblies

Looking at how a 11 year old child was playing with the materials (Figure 48), it was observed that exploring was much easier when some examples assemblies were standing on the table already.

Realising the time and effort it takes to understand the materials gave the insight that users could benefit from additional instructions. These can help with quickly and effectively understanding the materials. The takeaways from the tests helped to write additional instructions.

Additional instructions

Understanding the materials

Amount of materials

Are there enough materials for children to explore? Is it possible they get bored? Is it possible they get overwhelmed?

Intuitive

Are the materials intuitive? Will the user know what to do with them? Is there a need for guidance?

Fitting the target group

Are the materials more STEM? Consider if they still fit the children more drawn to the Arts. And the other way around.

Test with your target group

Any test will give insights. However, testing with your target audience will likely give the best insights.

4.4 Applying the initial design guidelines

Now that all instructional steps have been completed, the next step is applying the design guidelines. This section provides insight into the development process of how this was done. It shows how the ideation process together with the implementation of the initial design guidelines informed the development of the workshop's steps. And with it, how it helps to propose additional action points valuable to refine the final design guidelines.

Generating ideas

The implementation of the initial guidelines has been done through an iterative process of designing and testing ideas. The guidelines were not yet fully defined at this point, but they were kept in mind throughout the process and provided a general sense of direction during decision-making steps. Several methods were used to generate ideas and come to first and second workshop concept.

Used methods are: individual brainstorms, how to's, mind mapping, sparring with friends and family and storyboard drawing. Moreover, friends and family were also used in exploring the materials, explained in Subsection 4.3.2. Also chat-gpt was used several times as a brainstorm buddy. By discussing with supervisors of both Industrial

Design Engineering (IDE) and the Science Centre, and a workshop facilitator, decisions were made to best fit the context and helped ensure that the concept was considered feasible within the Science Centre's context.

The few key activities that contributed to shaping the workshop concepts are shown in Figure 49. A more extended version can be found in Appendix G1 and G2.

Testing the guidelines

With a clear framework of the guidelines in place, the workshop could be tested in its entirety. Two test sessions were organised in which children participated. The main goals of these sessions were to assess the overall flow of the workshop, identify structural issues, and observe the impact of the detailed elements. The approach used for these tests is described in Subsection 4.4.1.

Although refining the initial guidelines was not the primary objective of the tests, and they were not directly targeted, testing still revealed many valuable insights. Indirectly, the sessions highlighted gaps in the guidelines and provided useful feedback on their implementation. This process is discussed in detail in Subsection 4.4.2.

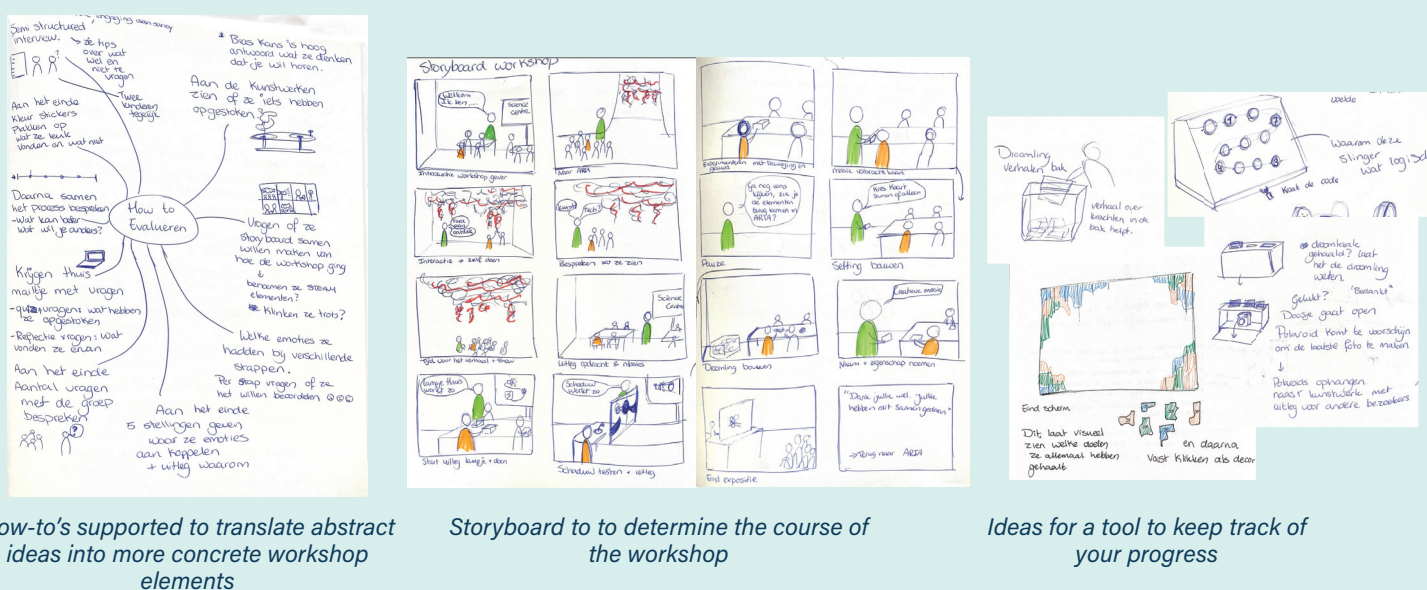


Figure 49: Overview of the used design methods.

4.4.1 Test approach

This subsection outlines the approach used to organise and conduct the two test sessions. It describes how the tests were set up, the context in which they took place, and the methods used to observe and evaluate the workshop. While the tests were primarily focused on evaluating the structure and flow of the workshop, attention was also given to participant reactions, facilitator involvement, and practical challenges. These insights were essential for understanding how the workshop functions in practice and identifying areas for improvement.

Context of the test

Two tests were conducted as part of the iterative process of developing the workshop. Both sessions were held with small groups of children aged between 8 and 12 years. The workshops were designed to last approximately 2.5 to 3 hours and took place in a dedicated workshop room at the Science Centre. The set-up of Workshop Test 1 and 2 can be seen in Figure 50 and 51. An explanation about the concepts of these workshops is given on the next page.

Each session was facilitated by one workshop leader and observed by me, the project researcher. To gather useful insights, various evaluation materials were used before, during, and after the sessions.

Test goal

The goals for these test workshops were:

Flow of the framework

The main goal was to see whether the activities logically built upon each other and how the story guides the workshop. Moreover, the time management of the steps is considered

The details

The second goal was to understand how the details, the interpretation of the open elements, were perceived by the participants.

This comes with the following **evaluation questions**:

- How do the participants perceive the storyline?
- Is the workshop well connected with the artwork?
- Is the timing of the steps right?
- Do the steps of the workshop have a logical order?

Set-up - Workshop Test 1

Participants:

2 children, aged 9 and 10 together with their parent.

When:

12 March 15:30 - 17:30



Figure 50: Workshop room set up for testing concept 1

Set-up - Workshop Test 2

Participants:

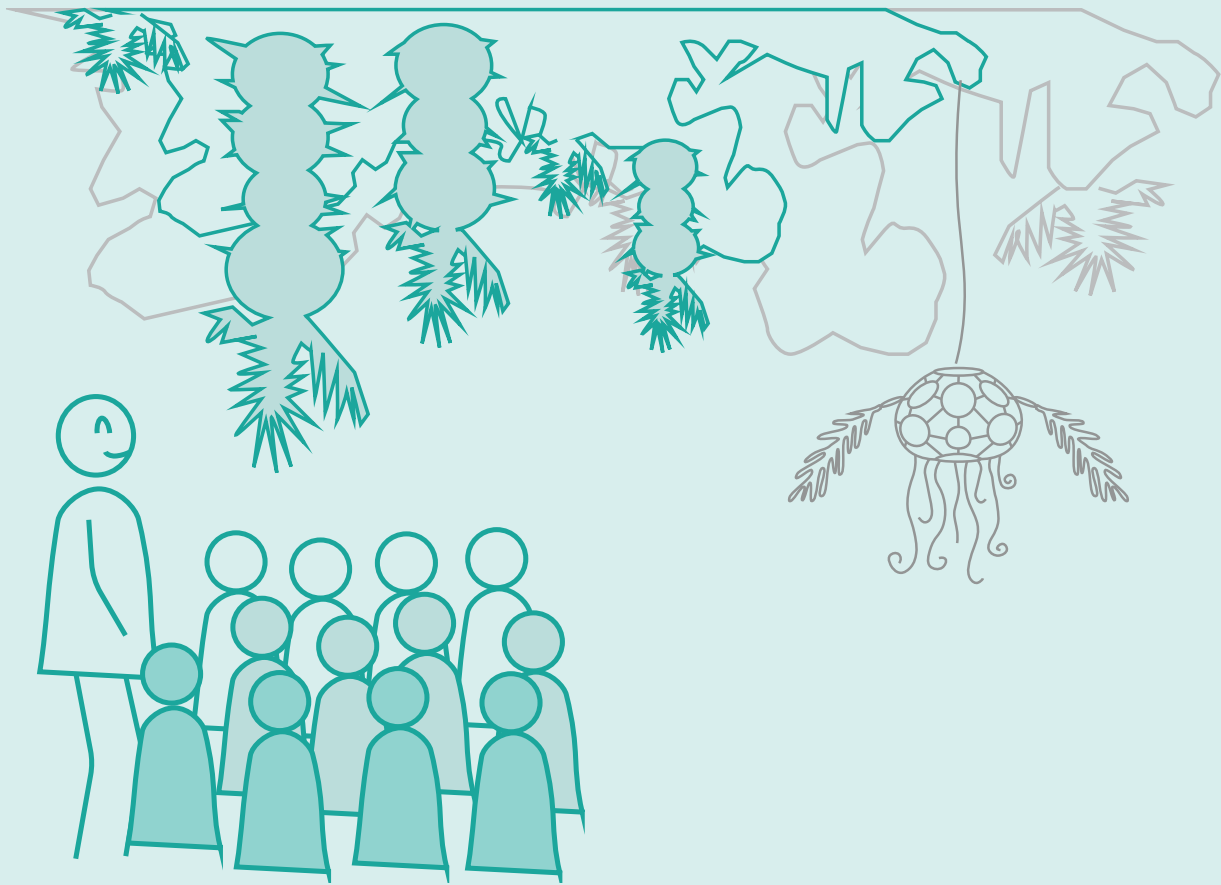
4 children, aged between 8 and 11, together with their parent.

When:

16 April 14:00 - 17:00



Figure 51: Workshop room set up for testing concept 2



Concept 1 - Restore the energy!

The main topic of the workshop is about the combination of 'art' and 'technology' and how they complement each other. During the workshop the story is told by the main character Ariana who lives in the shadows. While watching the show of the artwork, it suddenly stops moving. She asks the children for help to help restore the energy of ARIA. To do this, they have to build new creatures using art and technology. The children have to do the tasks and receive a card if they complete it. They can put this card in the 'toolbox' in the workshop room. If they put all these cards into the 'toolbox' the box opens. This shows a camera with which they can take a picture at the end of the workshop. They can take this home after the workshop.

Concept 2 - Help to build friends

The main topic of the workshop is about 'being creative with technology'. The story in this concept is also led by Ariana. She asks the children to build creatures to make sure she does not feel alone anymore. To reach this goal, they will follow the steps as shown in presentation slides and explained by the facilitator. Every time the children finish a step, the facilitator gives them a token. They can use this token to show Ariana they have completed a task. Then, Ariana gives them a compliment and tells what the next step is. When they have finished all steps, and created their creature, they show this to Ariana and receive a final token they can take home.

Preparation

After understanding the aim of the test, a test plan was made. This includes all the preparation steps for the researcher, like organising the set-up, involving a workshop facilitator, designing evaluation materials and recruiting participants. The key aspects of this preparation will be explained. For a full overview of the preparation steps of testing the workshop, see Appendix H.

Facilitator

The workshop will be given by a facilitator. This is chosen by the Science Centre because they play a role model for the children. For both test sessions, a facilitator from the Science Centre was invited to lead the workshop. This was done for several reasons:

- It allowed the researcher to take on the role of observer and focus on the workshop as a test environment
- The facilitator had experience working with children and was familiar with guiding similar activities.
- The experience of the facilitator made it possible to compare the test sessions with ongoing workshops at the Science Centre and identify key differences or opportunities.

To prepare the facilitator, a complete walkthrough of all the workshop steps was conducted prior to the first full workshop test (see Figure 52). This walkthrough served as

a valuable pre-test to identify and solve unclear parts and find gaps in the workshop design.

To guide the facilitator, a manual including a script was provided, see Figure 53. The facilitator was explicitly encouraged to adjust the text freely to his own words. However, he should follow the steps. Here it was assumed that if the facilitator uses his own expertise, this could reveal opportunities for further refinement.

The 'Initial instructions', explain the importance of knowing what kind of facilitator will give the workshop. While preparing the workshop, it was realised that some additional instructions could be helpful for the workshop developer. Therefore, this is added to the instructions.

Additional instruction

Know the facilitator

A workshop will be given by a facilitator that will guide the participants throughout the workshop. It is important to know what kind of facilitator will oversee the workshop you are designing.

- What kind of facilitator will give the workshop?
- A professional who knows a lot about education? Or a student as a role model?
- How might their background influence the design and tone?



Figure 52: The workshop facilitator exploring the materials during the briefing

Techniekstudio "Experiënteren met kunst en technologie" studentinstructie

Logistiek
Duur: 3 uur
Hoeveel begeleiders: 1
Hoeveel bezoekers: 10-12
Doelgroep: 8 t/m 12 jaar, met ouders

Inhoudelijk
Doel: Kinderen door hands-on en creatief aan de slag te laten gaan met simpele technologie hen interesseren om zelf creatief te experimenteren met materialen en techniek.

Verloop: het hele programma duurt 3 uur, grofweg bestaat dit uit:

- Eerste deel workshop (60 a 70 minuten)
 - Introductie & Interactie kunstwerk
 - Introductie verhalen
 - De basis – Een simpele aanpak
 - Uitdaging – Experimenteren met bewegingen en geluiden
- Pauze (20 minuten)
- Tweede deel workshop (80 a 90 minuten)
 - Setting bouwen
 - Droomingen bouwen
 - Expositie klaarzetten
 - Expositie + (in)scannen / foto ?)

Wat moet je klaarzetten

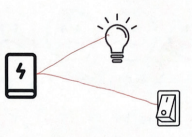
Benodigheden

- 1 Licht kit (incl. powerbank)
 - Met inhoud voor 4 licht installaties
- 9 Beweging kits
 - 9 voor de kinderen
 - 1 reserve
- 6 Voorbeeld bouwsets (per tabel 2 voorbeelden)
 - 2 Mechanisch
 - 2 Mechanisch draaiend
 - 2 Tellen
- Drooming onderdelen
 - 1 bak met ringen in alle maten
 - 1 bak met kleine ringen
 - 2 Zachte verbindingsstukjes (2 maten)
 - Verbindingsmateriaal + schaar (alleen voor de begeleider)
 - 1 bak Vormende elementen (verkenbaar uit kunstwerk)
 - Scharen
 - Pipetraggers

Figure 53: Instructions for the workshop facilitator

Deelnemer #3.

12. Weet jij al hoe een lampje werkt? Verbind de onderdelen.



Na de workshop
9. Ik vind techniek ...

13. Wat voor cijfer?

14. Zou je de techniek Aan wie?

15. Wat zou je thuis maken?

10. Wat is er leuk aan techniek? Kies er 2.

11. Heb je iets nieuws ontdekt?

Wat heb je ontdekt?

Dat kunst + techniek heel mooi kan werken

Figure 54: Questionnaires used in test 2

Droomling bouwen
Aan de slag

Overall

Snappen ze wat ze moeten doen? Hoe?

Ja / Nee

Verzinnen van wat ze moeten maken is moeilijk

Bouwen makkelijk

Doen ze het samen? Hoe?

Ja / Nee

Maar wel naast elkaar gaan zitten door ouders

Totaal niet met elkaar bezig

Geven ze antwoorden? Hoe?

Ja / Nee

Paar vragen over wat ze maken maar gaat moeizaam

Wel bij verzinnen van naam

Stellen ze vragen? Hoe?

Ja / Nee

Ze het goed doen mag ik al bouwen

Hebben ze plezier? Hoe?

Ja / Nee

Moeilijk te zien, maar wel fanatiek bouwen.

Figure 55: Tool to guide the observations

Ik wil mijn droomling graag verder bouwen.

17. Omcirkel de stap die je het leukst vond.

Wat was dan zo leuk?

Om te experimenteren dan kun je zien wat de resultaat is

Figure 56: Used in interviews to ask about feelings and specific steps

Evaluation methods

To evaluate, several methods were used. At the start and at the end of the workshop, the children were asked to fill in a list of questions. During the test, observations were done by the researcher. Additionally, at the end of the workshop the children were asked to participate in a short interview. Tools made to assist in these evaluation methods. A detailed overview of the tools can be found Appendix J. Such as: observation forms, questionnaires, and interview prompts.

Pre- and post-questionnaires

At the start and end of the workshop, the children were asked to fill in a short list of questions individually. An example is shown in Figure 54. These aimed to get an idea of their expectations beforehand and their reflections afterward. Discovering their answers was meant to clarify observations, get feedback in their own words, and ask about specific moments or elements from the workshop.

Observations

Throughout the workshop, the researcher acted as an observer. Notes were taken on how the children interacted with the materials, other participants and their parents. A format was made to guide the observations, see Figure 55. It was observed how engaged they were during different phases, and where moments of confusion or enthusiasm occurred. Most importantly, attention was given to the workshop's flow.

Short interviews

At the end of the session, the children were asked to participate in a brief and informal interview. The questions focused on their feelings, understanding of the topic, and overall experience. To assess the children's emotions, the Premo tool was used several times (Desmet, 2018). An example of a filled in questionnaire and the selected Premo can be found in Figure 56.

Conversation with facilitator

After each workshop session, a conversation with the facilitator was held as part of the evaluation method. This provided valuable insights into their experience of giving the workshop, including what worked well, what could be improved, and how the workshop compared to other sessions they had facilitated.

Reviewing the creations

Lastly, at the end of the workshop, the final design of the participants were also looked at. The technical assemblies and creative creatures also clarify whether the children understood the assignments.

4.4.2 Overall research outcome

The initial goal of testing the workshop was to evaluate its flow: to see whether the activities logically followed one another. As a result, the workshop's structure could be finalised. However, the most valuable outcome of the testing turned out to be the opportunity to refine the design guidelines. When evaluating the workshop tests, this exposed practical gaps in the initial guidelines. This allowed the guidelines to be critically examined, validated, and, where needed, adjusted to a more refined version.

Workshop improvement

Workshop test 1 used concept 1: *Restore the energy*. Important takeaways from this test helped to improve the workshop itself. This resulted in concept 2: *Help to build friends*, used in Workshop Test 2.

The main framework (see Section 4.2) remained almost the same in both. The biggest difference between these tests was the content of the frameworks 'open elements', highlighted as green areas within the storyboard.

Evaluating the more practical parts of the workshop (such as the use of scaffolding or the influence of parents), were improved ones and did not need to be improved after Workshop Test 2.

From evaluation to takeaways

In the following section, 4.4.3, the guidelines will be discussed individually. Here it will become clear what content was used for the 'open elements', and most importantly what takeaways resulted from it. For each takeaway it shows the evaluation method they came from:

- [Questionnaires]
- [Observation]
- [Interview]
- [Conversation with facilitator]

From takeaways to action points

Looking at these specific takeaways from a more abstract level, they could often be translated into more abstract action points. These action points are added to the initial guidelines, resulting in refined guidelines. This set of final guidelines is presented in Section 5.2.

Limitations

Focus of the tests

Because the initial guidelines were not the original focus of the test, they were not systematically evaluated or targeted during the sessions. This is seen as a limitation, but also helped to test in a more natural, realistic way. Helping to understand how the design functioned in practice.

Size of test group

Because of unfortunate reasons, like planning and no shows, only two and four children showed up to Workshop Test 1 and 2, respectively. Therefore, it was not always possible to draw strong conclusions. Therefore, some action points are phrased more suggestively to account for the limited size of the test group. Example:

- Observation: Two children did not read the compliment cards.
- Takeaway: Explaining a compliment through text might not be the most effective approach.
- Action point: When designing a tool for giving compliments, consider what medium fits best with the target group.

Limited Testing Rounds

Only two iterations of testing were possible within the project timespan. As a result, some of the refined guidelines were not tested again, leaving their practical applicability somewhat unverified.

Subjective Evaluation Methods

Many takeaways were based on observations and informal conversations with the facilitator. While valuable, these methods are more subjective and may be influenced by personal interpretation or bias.

There were also some limitations that made improving the workshop itself more difficult. This can be found in Appendix I.

Opportunities

Conducting the first test provided valuable insight into how to best carry out a workshop evaluation. It also confirmed some of the findings from the research phase, highlighting the importance of the design guidelines.

4.4.3 Refining the DGs one by one

In this section, the refinement process of each design guideline will be explained through their implementation in Workshop Test 1 and 2. However, not all guidelines have the same priority in this project.

Some design guidelines were applied across multiple steps of the workshop. In this chapter, each guideline is presented in the step where it was most clearly visible and had the most impact, particularly where changes occurred between the two tests.

Setting priorities

Given this project’s timespan, priorities needed to be set to help focus the design process. Logically, the highest priority is given to the children. After that, the workshop’s facilitator and the parents of the children also play relevant roles. The role of the communication between the Science Centre and their audience, was set to a low priority. This decision was made because the project’s primary focus is on the workshop experience itself, rather than on external communications.

Figure 57 presents a timeline of the workshop, indicating the moments in which the stakeholders are expected to play a role. This timeline was used to clarify which stakeholders are relevant in each guideline. As a result, some guidelines were identified as less relevant in this case study and therefore will not be implemented.

These guidelines are visually represented with a lower saturation of pink and are accompanied by brief explanations for their low priority in this case study. Consequently, these guidelines will lack actionable takeaways, limiting the possibility to improve these in further steps. This results in the following overview of the initial guidelines:

1. Sharedness	81
2. Communicating the goal	81
3. Topic of the workshop	82
4. Personal value	84
5. Preflection	88
6. Skill development	90
7. Make it new but relatable	92
8. Achievable and challenging goals	93
9. Creative process & hands-on	96
10. Teamwork	98
11. Concluding the work	99
12. Physical reminder	100
13. Reflection	101
14. Sharing achievements	102

Highly relevant Less relevant

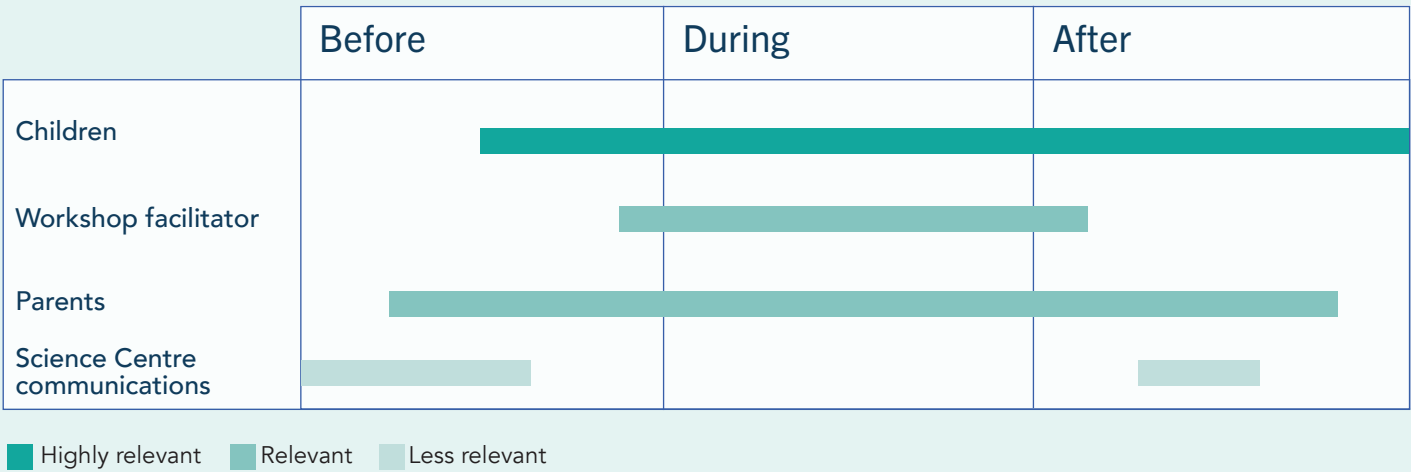


Figure 57: Schematic overview of the relevancy of stakeholders in the phases of the workshop experience.

Science Centre communications

The design guidelines that are about the before stage of the workshop, are mostly about pre-event materials that will be communicated to the outside world through different channels to reach the target audience. Therefore, it was decided that the following two guidelines, DG1. Sharedness and DG2. Communicating the goal are outside of this projects focus. So, they will not be taken into account while developing the workshop or testing the workshop. They are shown in light pink, because of this. How the action points would work for the Techniek Studio is shortly explained for both DGs on this page.

1. Sharedness

Fostering social connection before the workshop like being able to sign up together with friends or family will enhance the experience.

Action points:

- Allow your participants to share the experience with others they already know (C7. Influence of others). For example, make it possible to sign up together with friends.
- Design for shared anticipation among the participants, so there can be a collective expectation and excitement about the workshop (Bastiaansen & Duerden, 2024).

A Techniek Studio standard will be to sign-up for the workshop with one child and one parent. Signing up together with friends is the participants responsibility and will not be promoted by the Science Centre.

2. Communicating the goal

The participants of the workshop will benefit from knowing what they can expect. This allows them to mentally prepare for what they will learn.

Action points:

- Set clear learning-goals for the workshop. Growth- and learning-oriented goals are often more effective than performance goals (Bastiaansen & Duerden, 2024).
- Communicate the learning-goals to increase their impact during the workshop (Bastiaansen & Duerden, 2024).
- Communicate them in a way that fits the purpose of 'having fun' and does not feel too educational (C2. Having fun).
- Find a way to also communicate these with the facilitator. Enabling them to understand the aim of the workshop.

Communicating the learning goals beforehand, would be a part of the communication with the parents before the workshop. Here the Science Centre communications section has a big influence and it involves at home activities that are very time consuming to follow. This was not further explored for this project.

Although the DGs were not tested, reading them gave the insight that the designer will be in the need of some more instructions before being able to use these two guidelines. This resulted in the following new instruction.

New instruction

Communication

Be aware of your communications channels and its range. They will play an important role in reaching your potential participants.

What channels will reach them? Social media, papers, poster, word of mouth?

3. Topic of the workshop

Description

The topic of the workshop is what will draw the attention of your audience and should interest them to apply. Therefore, the start of a workshop design is understanding your target group. Knowing their interest, knowledge and skill level.

Action points

- Choose a topic that fits the participants' personal interests and/or goals (Little et al., 2024; C2. Fitted what I like). This will trigger intrinsic motivation (Packer, 2006).
- Understand the prerequisite level of knowledge about the topic of the participants (Bastiaansen & Duerden, 2024). Consider that this can differ per participant on the STEAM disciplines (Riley, n.d.).
- Make clear the topic is about one or multiple of the STEM disciplines in a combination with Arts to appeal a broader range of participants (Riley, n.d.).

Like the first two guidelines, this guideline is about the communications phase. However, the workshop's topic will of course stay important throughout the whole workshop.

In the first few steps of the workshop, the topic is introduced to the children. Together with the facilitator they will discuss about it. One of the goals of this workshop, is for the children to get insights about this topic and get an understanding about it through hands-on learning. In Workshop Test 1, a first attempt is made to achieve this.

Workshop test 1

2

3

Art and Technology

The first try was done based on the title the Science Centre has given the workshop 'Experimenting with art'. With 'art' they aim to broaden the group of children interested in 'technology'.

At the beginning of the workshop this topic is introduced with the goal to connect the workshop's activities to the artwork ARIA.

The topic was explained as learning about how 'Art and Technology' can complement each other. The children are asked if they can explain what 'art' is, and secondly what they think 'technology' is.

In the next step, when visiting the artwork the facilitator asks if they can point out components that fit 'art' or 'technology'.

Takeaways

Fit to level

Discussing "art" was found a bit too challenging. Answering the question "what is art" was difficult. [Observation]

Fit to activity

Making 'art' is about much more than using creativity to build something. What the children will make is not directly 'art'. So, art might not be the correct framing (A. van der Helm, this project supervisor, personal communication, 2025)

Difficulty

Since the participants have not yet used the materials themselves, it was too difficult to recognise them in the artwork. [Observation]

Doing a test was very useful in getting to know the interests and level of knowledge of the target group better. With the key findings from the first test, a more suitable topic, 'experiment with technology in a creative way' is tested in the second workshop test.

Workshop test 2

2

3

13

Experimenting with technology in a creative way

The facilitator introduces the topic 'being creative with technology' and gives a few examples of familiar products or activities that fit (e.g. designing with a 3D printer). The facilitator asks the children if they can give more examples where they recognise this.

In the next step, when visiting the artwork, the facilitator explains how the artist has used his creativity to make this installation and points out the technical parts.

For repetition, step 13 was added. Here the group comes back to ARIA after the break. They now better understand the materials since they have been working with them hands-on, which makes it easier to point them out in the artwork as well.

13 After the break they gather under ARIA. They discuss where in the artwork they see the elements they have been using themselves.



Takeaways

Fit to level

It was easier for the children to come up with examples they are familiar with. Which is an improvement of discussing the more difficult theme 'art' in the previous concept. [Conversation with facilitator]

Revisiting ARIA (step 13)

When they were asked if they could recognise the elements they had been working with, joy was observed in recognising the elements they have been using, like lights and vibration motors.

All the takeaways from both workshop tests, resulted into the following new action points:

New action points:

- The terminology used to explain the topic, should be directly linked to the activity of the workshop.
- Make sure the topic of the workshop is not only discussed at the beginning but is repeated multiple times throughout the workshop.
- A first try out will help understand whether the children understand the topic. Does it fit their level and interests?

4. Personal value

The workshop should be designed to align with the participants values (Bastiaansen & Duerden, 2024). Therefore, these should be framed before the design of the workshop. To do this, it is important to know what values belong to the workshop's target group. Three main values are highlighted, but it stays important to design for your target group's specific values.

Action points:

Having fun

- Use a topic that fits all the children you aim for (T1 & C2. Having fun).
- Let the facilitator ask simple answerable knowledge questions (T6 Answer questions). This gives some children the opportunity to answer and excel above others (C6. The possibility to excel).
- Find or design a way for the facilitator to get excited about the topic as well (T2. Enthusiasm of the facilitator).

Magical experience

- Give the children a magical experience through the workshop (C3. Magical experience).
- Design for a surprise moment or effect.
- Design for the children to have a sense of discovery and fascination (Packer, 2006).

Contribution

- The participants should feel like they can contribute to something bigger than themselves (Bastiaansen & Duerden, 2024).
- The purpose of contribution should match their personal value (Bastiaansen & Duerden, 2024).

Designing for the children to have fun, is something that is kept in mind throughout every step of the process. For the magical experience, the artwork itself, that the children visit during the workshop, already includes this in the workshop design.

Aiming for 'the feeling of contribution' is more challenging. The children should be given a reason to make something with the materials, which contributes to something bigger than themselves. Using a story, and a voice that asks the children for help, was thought of as a way to fit 'contribution'. On top of this, it can help bring this magical feeling from ARIA into the workshop room.

In the first workshop, a story was used as a try out. To discover how the children would react to it.

Workshop test 1

Storyline - Restore the energy!

The story starts after the workshop facilitator has explained about the topic of the workshop.

How does it work?

The facilitator tells it is time to watch the show together and see how the dreamworld comes to life. The facilitator turns on the installation which starts the pre-programmed movement and lights. The group watches the show together. Suddenly, after a few minutes, the show fades out, the volume is turned down and ARIA becomes inactive.

Ariana, a creature from the world of ARIA talks to the children through a speaker. A creature in this world is called a 'Droomling'. This is a made-up Dutch word, loosely translated as 'dreamlike creature'. Ariana asks if the children notice that the energy in the dreamworld is fading. As a droomling, it is her task to restore the energy, but she cannot do it alone. She asks the children for help. By creating new droomlings, each with a unique ability they can restore and strengthen ARIA's energy through their movements. The full text of this story can be found in Appendix K1.

Takeaways

Connecting the story

After hearing the story from Ariana, coming back into the workshop room, the children did not connect the goal of the assignment as told by Ariana to the activities in the workshop room. The children forgot about their task to help Ariana. [Conversation with facilitator]

Storyline

The story is about something 'magical' having an influence on the energy the artwork receives. Given that the Science Centre and this workshop want to give the children realistic insights about technical topics, this story seems not fitting. [Observation]

After the realisation that writing a fitting story also comes with some iterations, an extra test was planned. This test was used to try out three different stories and find the best one.

Story test

Ideating towards a new version, led to three different versions (Appendix K), all having the same purpose. To find the best one, a test was conducted.

Approach

The evaluation session was conducted with three students, all with a non-designer background. It lasted one hour and was carried out in Dutch. The test consisted of a different story for each participant. All stories were recorded with the same voice in the same style. They all had their own headphones to listen to the audio while looking at Ariana (see Figure 58).

A question form was provided, the same for each participant. During the test, notes were taken about the observation. The test was concluded with a short interview. Altogether, this was used as qualitative data to understand what story is perceived best.



Figure 58: The three participants listening to their own story while watching Ariana

Results

In the form, various questions were asked to identify the most important differences between the stories. In hindsight, it became clear that these questions were derived from the Design Guidelines. In Table 2, the final result is shown by the amount of green tick marks representing if it was perceived by the participant.

They all filled in the question forms very differently. For example, question 8. asked "Do you already understand what you will learn?". Participant 2 answered with "I am going to make droomling friends", which is not the goal of learning, but only

the activity. Participant 3 answered with "How to make something fun with different materials and techniques". Which is much closer to the aim of teaching the participants how creativity and technology can complement each other.

Table 2: The three different stories with for every important takeaway the amount of green tick marks representing how much that point was perceived by the participant.

	DG	Restore the energy!	Lonely droomling	Ideas from nature
Know what you will learn	5 + 6	✓		✓✓
Creativity & technology	9	✓		✓✓
Magical story	4	✓✓	✓	
Feeling of contribution	4	✓✓	✓	
Believable	Instruction		✓✓	✓✓

In the final interview, which was more of an open conversation with the participants it was concluded that all stories have their own qualities important for the workshop.

The magical texts are much catchier and stick much better through the workshop. But in the somewhat more boring text, the learning goals come out better. So that part has to be reflected in the more magical stories.

Conclusion

Doing an in-between test for just the story was very useful. It gave many insights and helped to better develop the final version that fits with the design guidelines.

For the story, it can be concluded that not one of the stories is a perfect fit. All have some positive and negative points. Therefore, it was chosen to combine the best of all stories. This leads to the story that will be used in the second test of the workshop explained on the next page.

Workshop test 2

4

21

Storyline - Help to build friends!

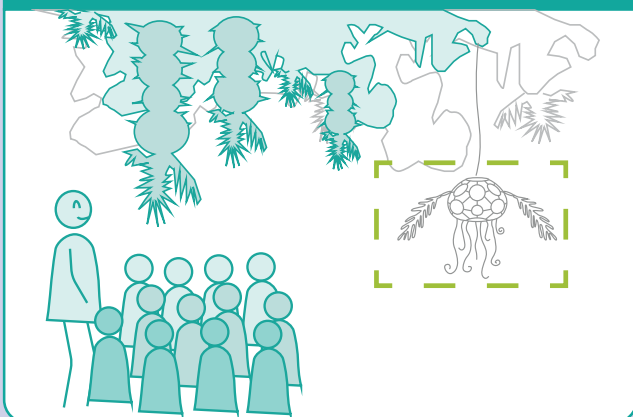
This time, the story is divided over two fragments. The first is played during the introduction of the workshop.

The facilitator shines a light on the creature hanging next to ARIA. A shadow appears and starts talking (a voice audio starts playing). Ariana, a creature called a 'droomling' from the world of ARIA talks to the children. She tells them she is the only creature in this dreamworld. She feels a bit lonely. She asks the children if they can use their creativity and use technical elements from the artwork to make her friends that can also live in the shadows. She explains that she will help them step-by-step in the workshop room.

In step 13 of the storyboard, a sidestep is added. Here the story continues to remind the children of their 'contribution' and to help them start the next workshop activity. This is done through a new audio fragment from Ariana. The full text can be found in Appendix K3.

13B

ARIA. Ariana continues her **the story**. She explains how she thinks the children can help.



In step 13B, the facilitator shines the flashlight on the creature and Ariana starts talking again. She gives some more information about the artwork being inspired on nature. And tells the children she wants them to use their inspiration from nature to make her new friends.

Takeaways

Connecting the story

After hearing the story from Ariana, coming back into the workshop room, the children did connect the goal of the assignment as told by Ariana much better. [Conversation with facilitator]

Nature as topic

Looking at the children's final results on the following page, the influence of the 'nature' part of the story is obvious. In the second workshop test, the creatures the children created are more animal-like. The results shown in Figure 61 to 63 show more inspired on nature than Figure 59 and 60. It was also observed that it was much less difficult for the children to start making their droomling than it was in the first workshop test. [Observation]

Voice

Observing the children showed that the voice was sometimes interpreted as a bit too childish.

New action points:

- Reflect on the way you want to convey this 'magical' touch. It should fit with the intentions of the organisation and the target group itself.
- Find a way to ensure that this sense of 'having contributed to a bigger purpose' stays with participants throughout the workshop.
- The use of a storyline could be a good way of giving a magical experience and telling the children they are contributing to a bigger purpose. Iterating on this story by testing and adjusting it will help reach something fit for the target group.
- Use a topic that fits all the children you aim for. (E.g. Nature is a good topic that fits all children in which they can use their own inspiration and imagination.)

Results Workshop Test 1



Figure 59: Droomling result from Participant 1 in Workshop Test 1.



Figure 60: Droomling result from Participant 2 in Workshop Test 1.

Made by the participant who joined the workshop tests both times

Results Workshop Test 2

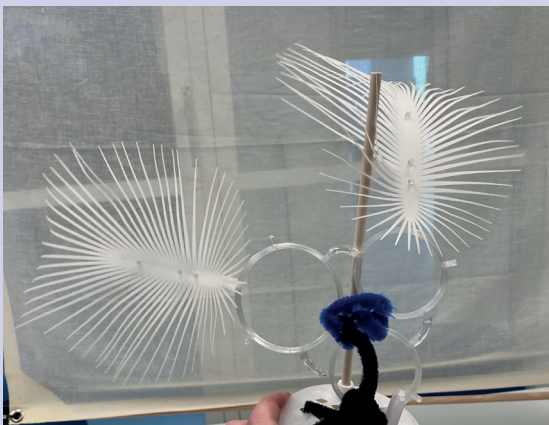


Figure 61: Droomling result from Participant 1 in Workshop Test 2.

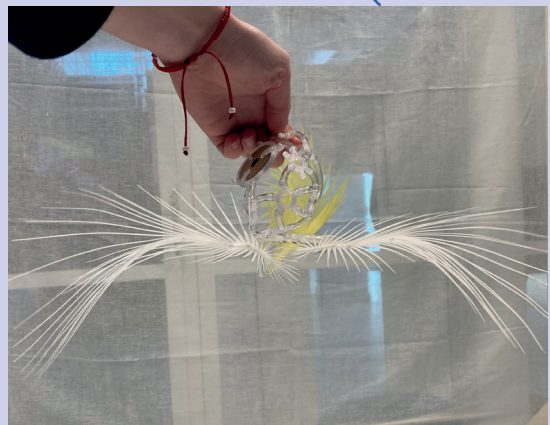


Figure 62: Droomling result from Participant 2 in Workshop Test 2.

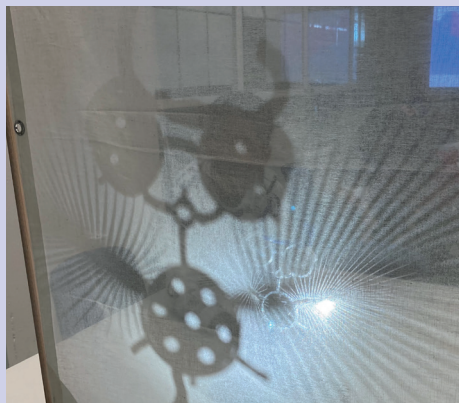


Figure 63: Droomling result from Participant 3 in Workshop Test 2.

5. Preflection

Having a central start of the workshop, with a short introduction from the facilitator gives the opportunity to preflect. This is about discussing the learning goals of the workshop to align expectations and increase motivation before the workshop starts (Bastiaansen & Duerden, 2024).

Action points:

- Translate the learning goals into a non-educative perspective. Making it fun to talk about to increase intrinsic motivation (Packer, 2006).
- Have a way to present the steps of the workshop, giving the children a clear overview.
- Let the facilitator take some time to discuss these goals and new skills with the children. This will encourage participants to think beforehand what they hope to learn (Bastiaansen & Duerden, 2024).
- Design for the facilitator to be supported in discussing learning goals with the children (T7).

To use this guideline, the user should first have determined what the learning goals of the workshop are. This is not yet explained in the instructions and should therefore be added to the manual. This is done as follows:

Additional instruction

Learning goals

Think about the overall goal and the learning goals of the workshop. Try to make a list. What do you want the children to learn? What do you want them to get insights about? This should fit the workshop's topic and main goal.

Using this instruction beforehand, helped to set some learning goals that fit the topic 'Experimenting with technology in a creative way'. They are about learning about some theory behind the material, like 'how can you turn on a light' and about getting an understanding that creativity and technology can enhance each other.

The next step was to implement the learning goals into something fun. In the research phase, several workshops were observed. Here it was found that not all facilitators take the time to prepare and read the workshop's manual.

So, just designing a manual with 'mandatory' explanation is not expected to be used. Therefore, a tool is introduced into the workshop to give the facilitator the needed guidance.

This tool was chosen after some ideation and how to's. Since the learning goals go together with the steps of the workshop, they are combined within the tool. To every sub activity of the workshop belonged a learning point that the children will hear about through a toolbox.

Workshop test 1

5

19

The dreamworld toolbox



Figure 64: The toolbox as it looks at the end of the workshop filled with cards.

After visiting ARIA, the group comes back into the workshop room and finds the toolbox (see Figure 64). The toolbox consists of an explanation text on top, read aloud by the facilitator. Telling the children to go through all the steps covering the main theme. For each step they can receive a 'task-card'. On top, they visually see that the goal is to fill all three gaps with the cards to complete the workshop's tasks.

Takeaways

Connection story and toolbox

The tool was not really blended into the story and the activities. Therefore, not much attention was put to it. The function of the tool should be clearer through the design. [Observation]

Visual process

Visually it was not clear what the steps were. It was difficult for the facilitator to use this box to show the steps of the workshop. [Conversation with facilitator]

Since the tool was not well blend in with the story, the children did not pay much attention to the toolbox. Using more audio to connect the tool with the story and a more central point in the workshop room was used in the second test. A powerpoint on the screen, that helps to visually show the steps in a clear way.

Workshop test 2

Step by step path

A powerpoint on the screen that stands in the middle of the classroom, helps to visually show the workshop's steps in a clear way.



Figure 65: The screen in the workshop room

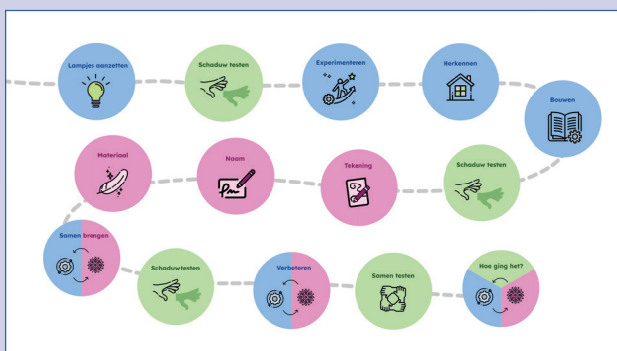


Figure 66: The first slide of the powerpoint showing the full process of the workshop.

A powerpoint shows the steps of the activities the workshop will go through (see Figure 65 and 66). This should better guide the children in following their learning path, fitting with DG6. Skill development. Each step has its own slide. The colours within the path clearly show the difference between blue 'technology' and pink 'creativity' steps with in between green for testing of the shadow. The slides are introduced. The facilitator shows the slide and explains the steps the workshop will go through. Every new activity is introduced by a new slide, showing on what part of the path they are on.

Takeaways

Amount of steps

In the last part, too many steps are shown. In the test, the facilitator did not use them, and the children went through an iterative process themselves. [Observation]

Inclusiveness

With the facilitator it was discussed that for colour blind people the difference in colour might not be so clear. Using different shapes could work better. [Conversation with facilitator]

Digital slides

In school, digital slides are often used. To give the children a new experience, the Science Centre would like to stay away from this format (S. Aerts, personal communication, 2025).

The takeaways from both tests, have helped to create the following new action points for the design guideline 4. Preflection:

New action points:

- Make sure the way this overview is presented blends in with the workshop activities and style.
- Make the steps visually clear and keep it simple. Use it to focus on the main elements.
- Consider the medium through which the steps will be presented (e.g. slides, poster, hand-outs). It should fit with the participants.
- This design guideline is directly linked to DG6. skill development.

Besides, it also helped with realising a general tip. When designing it is important to including all users, and some have specific needs.

New General tips

Design for inclusiveness: Think about the use of colours and shapes. E.g. colourblind people should also be able to understand if a colourgradient is used to define something.

6. Skill development

Receiving positive feedback is always useful. Making new learning point insightful, will happen when the participant recognises their ability to develop new skills in the past and present. Giving them the opportunity for improvement (Little et al., 2024).

Action points:

- Acknowledged that the strengths and values are different for every child.
- Make sure to repeat what they are learning several times throughout the workshop. Repetition of their new knowledge is valuable (Kohnstamm, 2009).
- Design so the participants can easily track their progress over time and are encouraged to do this (Bastiaansen & Duerden, 2024).
- Have a way for the facilitator or other participants to give positive feedback (Little et al., 2024; Bastiaansen & Duerden, 2024).
- Design the guidance for reflecting on new skills and a way to understand how these can be used in other situations (Bastiaansen & Duerden, 2024). For example, what can they do with this skill at home?

To use these actions points, the opportunity was found to process them into the tool that is used for DG 5. Preflection. There, the steps are about the learning goals and the steps. To explain children they have finished a step and learned new skills, the idea was found to use this tool again throughout the most important steps.

So, both the workshop tests, use the tool explained before, but in their own way. This is explained in the following examples.

Workshop test 1

The task-cards

The dreamworld toolbox explained in test 1 of DG5. Preflection uses 'task card' to show the process. On these cards the activity they have completed is presented (see Figure 67).

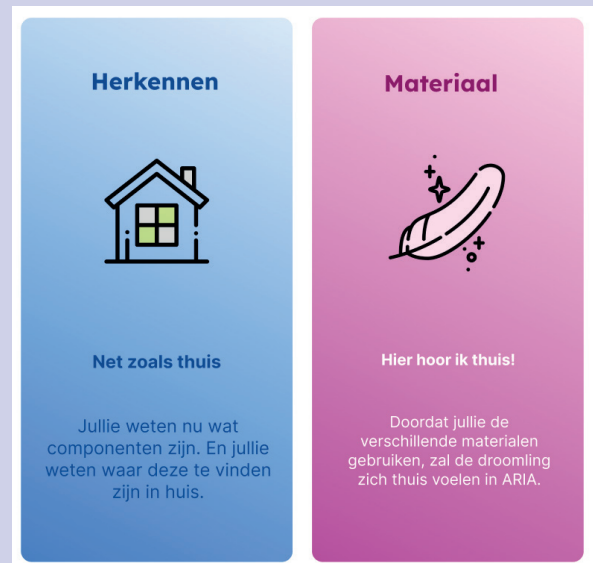


Figure 67: An overview of the four most important task cards

How does it work?

Every time the children complete an activity like 'building the lamp' together, they receive one 'task-card' from the facilitator. Next, the child reads the card aloud. Through the text, the whole group receives positive feedback and an explanation about their new skills. Now, the child can put the card into the box. Visually the toolbox shows that they should fill all three gaps to complete the workshop's tasks. When all cards are in the box, it can be opened. What they find is a small surprise, which can be used in the last step. Explained in 'polaroid photo' of DG12. Physical reminder.

Takeaways

Textual cards

The children did not read what the cards explained. It might have been too textual. [Observation]

Feedback

Putting the cards into the box did not give any direct visual feedback. It is unclear if they do it right and why they do it. [Observation]

How did it go?

Getting compliments through a standardized card did not seem believable and was too quickly done for it to have an impact. [Conversation with facilitator]

With these takeaways, and a replacement of the toolbox by the step-by-step path, a new way to use the DG was needed. This was done in the second concept.

Workshop test 2

Confirmation token

This concept is about receiving tokens which go together with the step-by-step path explained in test 2. of DG5. Preflection. To better connect this 'step-by-step path' to the story of the workshop, shadow play is used to show the children they have completed a task. This is done through tokens shown in Figure 86:

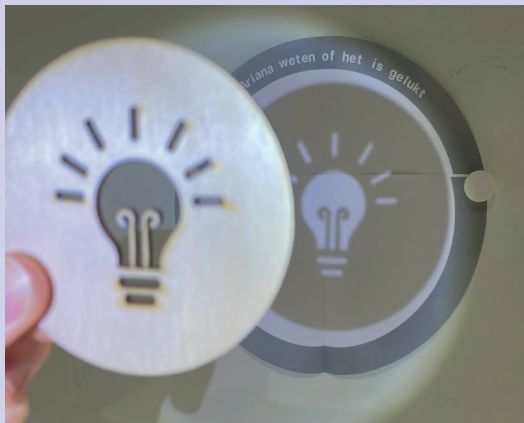


Figure 88: The first confirmation token 'light' shown in use

How does it work?

The group gets a token every time they finish one of the main tasks. The facilitator hands out the token to one child and a flashlight to another. Within the slides there are open spots to aim the shadow on.

When they aim right (see Figure 68), the whole group receives positive feedback and an explanation about their new skills. This is done through audio with the same voice fitting the story that is told throughout the workshop.

Takeaways

Fun to do

The children like to do it. Two of them put up their hand if the facilitator asks "who wants to show Ariana that we finished?". [Observation & interviews]

Structure

There is no clarity to the structure of the steps or to when a token should be used. This makes it difficult for the facilitator to remember when he has to use this slide. Easier if it is always at the same moment.

Voice

As in the story, the voice might have been too childish as it is used now. [Observation]

Little attention for the story

Not enough visual feedback about that they are 'entering it well'. The children now kept holding the token all the time instead of showing it briefly. This resulted in little attention on the audio that was giving them the compliments. [Observation]

All the takeaways from these two tests, resulted in the following new action points that will be added to the refined version of DG6.Skill development.

New action points:

- Consider the medium through which the positive feedback and an explanation about their new skills can be communicated. (e.g. reading text, audio, video)
- The moment of receiving feedback should not be too short, the children should have the chance to have a moment of reflection.
- Standardised feedback might not have much impact. Remind / guide the facilitator in giving personalised compliments as well.
- Make a clear structure with repeating moments so it is obvious for the facilitator when the tool should be used.

Besides, it also helped with realising a general tip. When designing it is important to including all users, and some have special needs.

New General tips

Design for inclusiveness: When using audio, also give the option for children to read the text.

Design for the right age-group: With a first try-out of the workshop, try to discover whether the tools and assignments you have made, fit with the age group. Is it too childish? Is it too difficult?

7. Make it new but relatable

Most participants will join a STEAM workshop to learn something new. Nevertheless, it is important to make this new topic or skill relatable to something the participants are already familiar with in daily life.

Action points:

- The participants should be offered to learn something that is new for them (C9. Doing something new).
- Use examples from daily life to explain new information (M. Gielen, personal communication, 2025). This will catch their attention and help them understand the main theme of the workshop
- Let the facilitator ask simple questions about prior experiences / familiar topics as a start that is connected to new workshop's topic. Being able to answer will give a confidence boost (Ootje, personal communication, 2025).

For this design guideline, the implementation in the first test already went smoothly. The materials offer enough possibilities to learn the children about something new. Within the facilitator's manual, text explains what the facilitator should discuss with the children about it. In this manual, only some small adjustments were done to smoothen the flow. This was tested in the second workshop test. How this works, and how the children respond is explained in the following example.

Workshop test 2

7

10

Instructions for the facilitator

In the first few steps of the workshop, the children get to know the materials. To explain the function of the materials, the facilitator uses a slide and explanation written in the manual. The first explanation tells how the spotlight works. To clarify, the facilitator explains how a light bulb at home works with a light switch on the wall. This is connected to an explanation of how the spotlight in the material kit should be connected and how the current flows through the small wires.



Figure 69: Slide the facilitator uses to ask about the use of components at home.

In a later step, the facilitator explains what “electronic components” are. The accompanying slide is shown in Figure 69. For this slide, the manual suggests the following text:

“These are the small parts that work together to make an electrical device work. There are lots of different kinds, in many different sizes. Today you are working with some examples.

Who can name a product from home that also make a motion like this? Examples:

- Mixer, spinning motor
- Washing machine, spinning motor
- Electric toothbrush, vibration motor
- Mobile phone, vibration motor

But, without electrical components, we can also make motion.

Namely, mechanically. Who can give an example?

- Bicycle
- Windmill

Takeaways

It was observed that the children really like to answer questions from the facilitator. After the facilitator provides them with an example, they easily name more elements that work in the same way.

Not much needs to be changed, since these materials really offer the children something to learn about on the right level, with the right kind of examples fitting. For the facilitator, having some examples to use really worked. Therefore, the following action point is added.

New action points:

- Make sure the facilitator has the needed examples in the manual to use in the explanation to the children.

8. Achievable and challenging goals

It is important for a child to feel some sort of challenge in an achievable task, to have a feeling of success (C9. Doing something challenging; Kohnstamm, 2009; Little et al., 2024). This will support meaningful learning. The following action point will help to balance the difficulty and accessibility.

Action points:

- Get an understanding of the variety of skill and knowledge level within the target group.
- Keep in mind that some children are more skilled in the STEM disciplines and less in arts, or the other way around.
- Go back over the learning goals set in a previous phase. Do the goals fit the target group, are they achievable within the participants abilities? (Bastiaansen & Duerden, 2024).
- Use scaffolding: break down challenges into smaller steps - to offer varying skill levels and allow each participant to progress at their own pace (Ootje, personal communication, 2025).
- Design for the availability of choice. This gives the participants the opportunity to personalise and provide themselves with the right level (Packer, 2006).
- Make sure it does not take effort to learn something new during the workshop (Packer, 2006).

As explained in Section 2.3, in the discovery phase of this project, several workshops have been observed. Observations helped to get a first understanding of the knowledge and skill level. With this, several decisions were made on the implementation of the materials and the structure of the workshop. The action points do not follow each other in one step of the workshop but are scattered over multiple steps.

The following pages show some examples. Since not much changed between the first and second test of the workshop, the examples show results from 'Workshop Test 2'. Every example is accompanied with some final takeaways.

Workshop test 2

8

Personal Kit

One takeaway explained in Subsection 4.2.2 Understanding the materials was: all the materials together are overwhelming for a user to see together. One kit per participant was preferred by the testers. This would mean they could start with having just a few options to build with. After deciding on what materials fit the children and workshop best, a kit was prepared per participant. See Figure 70.



Figure 70: A preparation of the individual kits.

These kits will be handed out at the beginning of the workshop to every child. This contains every element needed for the technical part of the workshop. It helps to get an understanding of how the materials work without getting overwhelmed by options.

With this kit the children build their own mechanism. When they are familiar with the materials, it is time for the more creative part. This is done through bigger boxes including materials for everyone.

Takeaway

Build up

It really helps the children if they have some time to get to know the materials with their own kit. This helps them not to get overwhelmed by the options. [Observation]

Scaffolding

While testing the materials a few technical components were found with different functions. A rotation motor, a vibration motor and a light.

With the instruction to use 'scaffolding', using one component in the first step to explain the materials was found as a good first challenge. The user test with an 11-year-old, explained in Subsection 4.3.2, confirmed this insight.



Figure 71: A light assembled with the materials.

With some guidance (explained in the next example) the children can easily assemble the light (see Figure 71). Understanding how this light works, will help in the next step. Where they figure out themselves how the other components work.

Takeaway

Time management

Some children finished a small assignment much faster than others. Here the facilitator had to think about extra assignments. [Conversation with facilitator]

The manuals

One takeaway explained in Subsection 4.3.2 was: the participants are in the need of some guidance before understanding what they have to do with the materials. Therefore, it was decided to develop guiding manuals. Using the documents Philip Beesley send to communicate the materials and possible assemblies.

As a test, two different manuals were made: One manual showing the final result and a list of materials needed. The other showing a step-by-step explanation. Figure 72 shows how it looks.

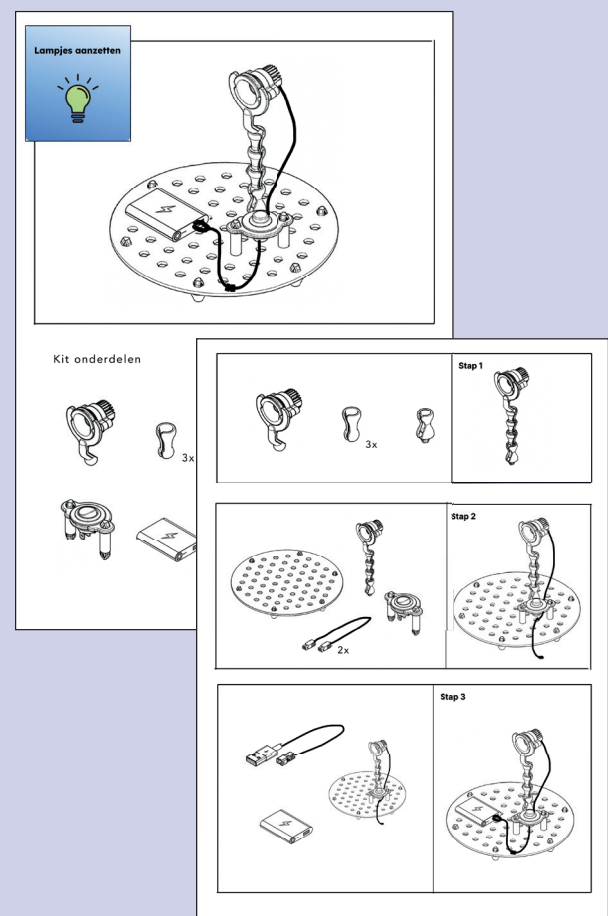


Figure 72: Manuals for building the light assembly

The manuals are handed out together with the individual kits and are well used by the children.

Takeaway

Availability of choice

It was found that providing several options so a child can choose, works best. This allows every child to work at their own level. [Observation]

Parents

During both workshop tests, the parents were also observed. There was no task or explanation for the parents. They joined the workshop by watching their children work and help them where needed. See Figure 73 for an example of Workshop Test 2. This also made sure all the children could work on their own level without getting stuck. Since the facilitator cannot help all 12 children at the same time.

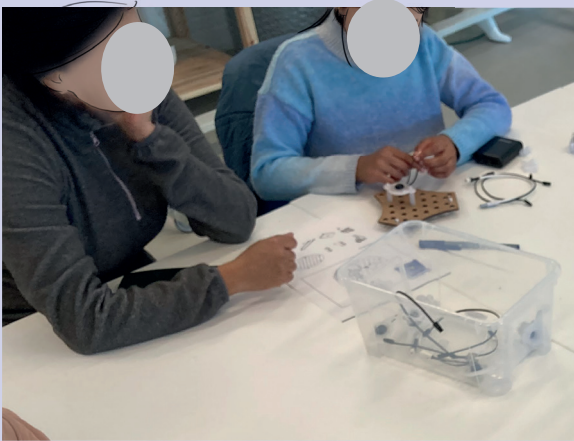


Figure 73: A mother helping her daughter to read the manual.

Takeaway

Use of help

It was found that they can be of good help for the children in the difficult parts. Especially in the building phase, when they make the more complex assemblies. [Observation]

Drawing

Drawing is found to be useful in thinking ahead of what kind of creature the children want to make.

In the first workshop test, a blank A3 paper was handed out. This was found the most difficult part of the workshop by both participants. Since they had no idea of what they were going to make yet. Therefore, a paper with a grey pattern with some example creatures as background layer was made. The use of these papers seemed quite useful in the second test, see Figure 74.

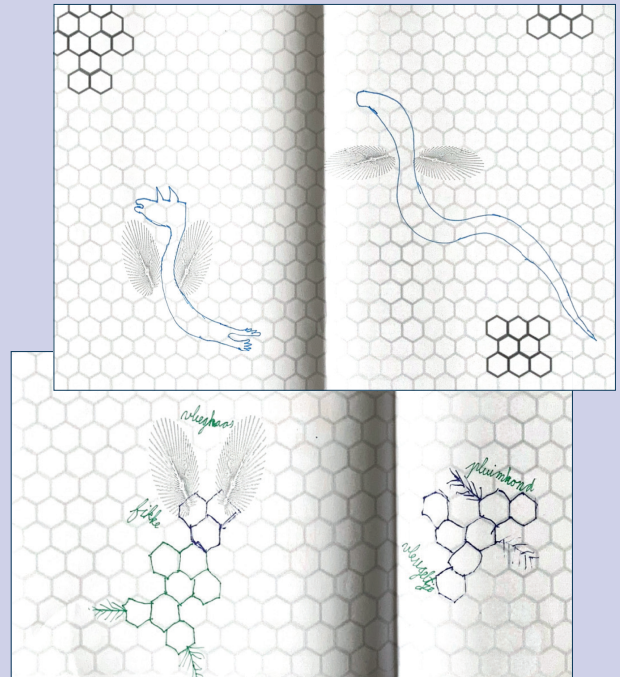


Figure 74: Final results of drawings from two participants in Workshop Test 2.

Takeaway

Extra tool

Drawing on a blank paper can be difficult, but with some extra guidance in turned out to be a useful step in the workshop. [Observation]

New action points:

- Consider that some children will finish much faster than others. A facilitator will benefit from a list of extra tasks they can give the children.
- Think about how, in the difficult parts, the children can help each other. Or if the workshop is set-up with the presence of a parent, they can help the children with difficult activities.
- When participants are given a broad assignment, think and test if there is a need for more guidance. This guidance can be done in through the facilitator or through the design of extra tools. (e.g. Drawing ideas on a white A3 paper is more difficult than a paper with hints printed on it)

9. Creative process & hands-on

One of the most important parts of a STEAM workshop for children is directly applying new knowledge in a hands-on way. This will make it fun and help them with insightful learning. Meaning is created when participants can play an active role in the experience (Bastiaansen & Duerden, 2024).

Action points:

- Let the participants work hands-on and try out what works for themselves (T3. Working hands on; C4. Hands-on). They will learn by doing (McRaney & Russick, 2016).
- Make sure the workshop focusses on the children's process of making and not the perfect outcome of what they make.
- Although the focus is not necessarily on the final result, having a tangible outcome will help reach a feeling of proudness among the participants (Little et al., 2024; C1. Proudness).
- Explaining new theory, should be followed by a hands-on way of learning to make connections between the two (Eason & Linn, 1976).
- Appeal to multiple senses. Think about not only seeing the materials, but also feeling the materials (Packer, 2006).
- Keep going back and forth from the chosen STEM topic(s) of the workshop to the arts, and connect the two through the activities (Riley, n.d.).

All these action points are about the use of materials. For this workshop, the materials that are used were already set. That using these materials involves hands-on activities and a creative process was therefore inevitable.

While designing the workshop, the above actions points were kept in mind. The steps in which they are most obvious are explained here. They explain the small changes that were made from the first to the second workshop test and again result in a few takeaways.

Creative box

After understanding the technical materials, the children will start making their own creature, a 'droomling'. This should be an activity where they can make whatever they imagine. Therefore, it would be good if they can dig through the materials and feel like there are infinite possibilities. In this step this is done with the creative box. One big box, including all the fun materials that can be attached to each other so they can make anything they like. Since they already know the materials, they will not get overwhelmed anymore.



Figure 75: An overview picture of the creative materials

When testing the materials in the earlier stages, it was found difficult to make something that looks like a creature that resonates with ARIA. Concluding there was a need for more materials, including some colourful materials too (see Figure 75).

Materials that were included after this:

- Feathers in white and multiple colours
- Pipe cleaners in multiple colours
- See-through sheets & whiteboard markers

Takeaway

Sustainability

Think about sustainability when choosing and organising all the materials. Are they used multiple times, or do they need to be thrown away after?

Materials fitting the goal

In the first test the goal was to make creatures, but the children found it a bit difficult to imagine creatures with these materials. [Interview]

Creative time

The first test only lasted 2:30 hours. Here the creative part was shortened to 25 minutes. Testing the flow was most important. As feedback, both the participants and one parent gave said that the time of the creative part, was way too short here. They would like to work much longer on their 'droomling'. Also, since finding the right shape they had in mind using the rings can take some time. Figure 76 shows how this is done. In the second test of the workshop, the creative part was much longer, around 50 minutes for this part. The participants seemed more satisfied and finished when this activity ended.

Quote participant's parent: "I saw that my daughter really liked the creative part. Unfortunately, it was way too short."



Figure 76: A participant building a droomling with the building rings.

Takeaway

Time management

Some participants would have liked more time on the creative part. Some better liked the technical part. So, it would be good to find a balance or give the option to work on what they like best. [Interview]

New action points:

- When testing, try to discover the need for open creative activities from the children. How big is their attention span to work?
- Try to realise that in a STEAM workshop, there will be children more interested in one of the STEM disciplines, and some more on the creative part. Discover what is the right balance for your target group and enable personalised focus.

Besides, it also helped with realising a general tip that could be useful for the workshop developer.

New General tips

Design for sustainability:

Think about sustainability when choosing and organising all the materials. Are they used multiple times, or do they need to be thrown away after?

Concluding, a closer look at the creative activities of the workshop have helped to find the following new action points for this guideline 'creative process & hands-on' and a new general tip about considering sustainability.

10. Teamwork

Working in teams is a big benefit for the participants, making them feel part of a community. Here it is important to reflect on how teamwork helps their project (Bastiaansen & Duerden, 2024). Having this experience with friends can fit their personal values. There are three important things to note here:

- When children don't know each other yet, it might not go smooth if they are forced to work together. Testing will help discover what will be a moment in the workshop for children to be able to work together. But don't force it. (M. Gielen, personal communication, 2025)
- Within a group, each participant should have the opportunity to feel they are responsible for a part of the project. In this way they can feel proud of having contributed to the group (Little et al., 2024).
- The participants should have the possibility to excel. The participants benefit from the feeling they perform better than others (C6. Possibility to excel).

The dynamics of teamwork, especially with children, is considered a complex topic. Therefore, it was decided not to address this aspect directly within this project. The DG is shown in light pink because of this. However, if teamwork spontaneously occurs, it will of course be allowed.

During both test workshops, one of the observational points was to see if any teamwork occurred. This rarely happened between two children. This was mainly because the parents were most of the time sitting in between two children. This made it difficult to reach out to one another and there was less need, since the parents could always explain the difficult parts.

At the end of Workshop Test 2, an interview was done. Here, the following question was asked: "Would you have liked to have more activities within the workshop where you had to work together with someone else?". To this, all three children answered they would like that, but could not easily point out where. One explained she thought it was funny that she played a little bit together when they were showing their creatures.

In one step in Workshop Test 2, a little bit of teamwork did occur. This was also the goal of the design, explained in the following example.

Confirmation token

The only place where deliberately teamwork was designed in, was in the use of the confirmation token. First, the facilitator hands out the token to one child and a flashlight to another. Second, the children together try to aim for the spot on the board to show Ariana they have finished their activity. Like shown in Figure 77.

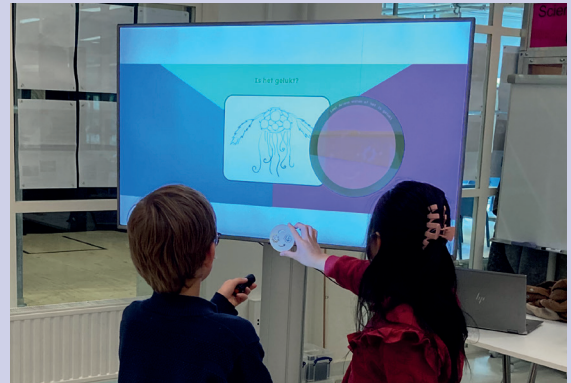


Figure 77: Two participants using the token

The reason for only two children to do this, is because than they can feel responsible for that part of the project, and finally proudness for their contribution. Whether this worked is hard to tell from observations only. However, the following takeaways were found.

Takeaway

No spontaneous teamwork

If it is not a task, teamwork among children does not easily happen spontaneously. [Observation]

Dependent on assignment

Just having to do a small assignment together, does not mean they are working in a team.

With these takeaways, the following new action points were added:

New action points:

- For teamwork, find tasks where the children have to discuss together about their plan. Do not just give each participant another task they can do next to each other.
- Do not expect for teamwork to occur spontaneously, really think and try out moments in which participants can do a task together.

11. Concluding the work

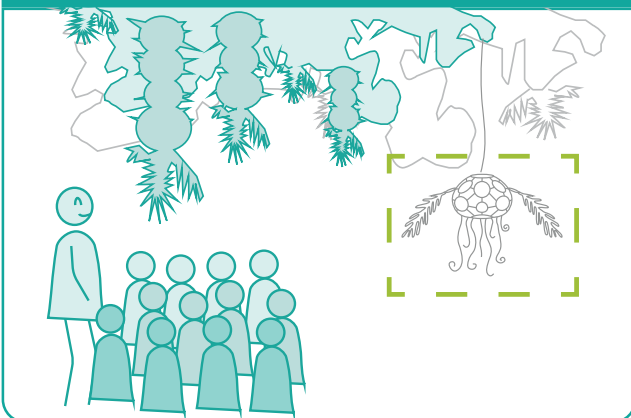
With all these new learnings and insights, it is important to have a small reflection moment at the end of the workshop.

Action points:

- Give participants the opportunity to receive summative feedback about their work (Bastiaansen & Duerden, 2024).
- Support the participants in going over the activities of the workshop again. Once again repetition can help in strengthening their insights (Kohnstamm, 2009).
- Look back at the tool that will show the steps of the workshop in the reflection phase. It will be beneficial to go over them and find out if they understood the key aspects of the workshop (Riley, n.d.).
- Give the participants space to discuss about their failures and be reminded of how mistakes are a natural part of growth (Bastiaansen & Duerden, 2024).

For the first full workshop test it was not planned but spontaneously found that the children expect to be able to take their creature to ARIA as a final assignment. This was considered a good opportunity for the children to receive feedback about their work. Therefore step 21 was added as a workshop step where Ariana tells through audio that the children have really helped and thanks them for this.

21 They finish the workshop as a group at ARIA. Here **the story** comes to an end.



This was found very valuable since the children are reminded of their 'contribution' of their work to the overall workshop / story. This connects this DG to DG4. Personal value.

To follow the other action points of this DG, the following was found in Workshop Test 2:

20

Workshop test 2

Step by step path

As explained in the facilitator's manual, the final slide showing the steps (Figure 78) can be used to reflect at the end of the workshop together with the children. However, this was not really done by the facilitator who skipped this step and proceeded with step 21.

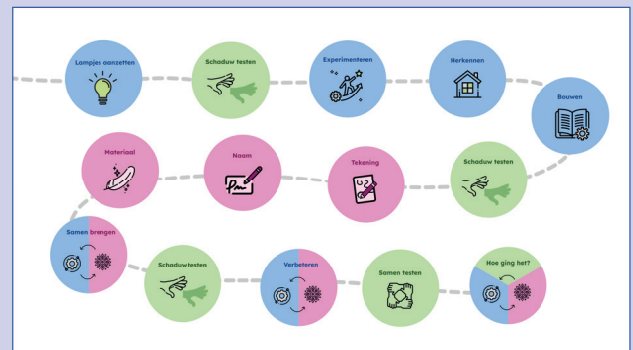


Figure 78: The final slide of the powerpoint showing the full process of the workshop again.

Takeaway

Facilitator's manual

The slide was skipped by the facilitator. The manual was probably not clear enough. [Observation]

Order of steps

After closing the story, the children remain in the magical feeling, it would be unfortunate to break this by a reflection moment. The reflection part should take place before the closure of the story.

With these takeaways, the following new action points were added:

New action point:

- Provide the facilitator with examples of what to discuss about the workshop's learning points.
- If you use a story, try to conclude it in the very last part of the workshop. Any reflectional moment can be done before that to keep the magical and fun experience high.

12. Physical reminder

Providing participants with something tangible to take home after the workshop helps revisit the experience and reflect at moments later.

Action points:

- A physical reminder, whether it's a self-made object, a small prototype, or even a piece of material will be fun for the children to take home.
- When deciding on what it is, think about how it might trigger conversations with others, extending the impact of the workshop into the participant's personal environment.
- The item they bring home, should be valuable enough that they will not throw it away at home and small so it does not take up too much space.

With this design guideline in mind. An element was thought of that allows children to take a tangible outcome home. Due to several reasons, as costs and sustainability, the children are not allowed to bring home the 'living shadows' materials.

For the surprising effect of action point of DG4. Personal value, the first concept made use of a box holding a surprise. This toolbox, explained in the example in DG5. Preflection, could be opened by the children after they had done all the activities.

Workshop test 1

22

Polaroid photo

When the toolbox opens after all the tasks are finished, the children find a polaroid camera. Capturing the creations with a camera was found fitting all the before mentioned criteria.

The facilitator tells the children to put all their creatures, 'droomlingen' together. The facilitator takes a picture of each child with their own creation. They receive the picture as shown in Figure 79 and take it home.



Figure 79: The two participants on the polaroid photo.

Takeaways

Fitting the story

It was not clear that taking a picture was part of finishing the story. [Conversation with facilitator]

Time

In this test, only two pictures had to be made. However, for a facilitator it will take up some time to make pictures of the total group of 12-15 children

After this test, it was clear that taking a picture was well received by the participants, but actually not convenient for the story or the facilitator. The second workshop design gave the opportunity to find something more fitting with the story itself. The tokens, explained in the examples of DG6. Skill development offers a great opportunity for this. As shown in the following test:

Workshop test 2

22

Thank you! - Token

To stimulate and remind the children they can play with shadows at home, they receive a token at the end of the workshop. This token has a cut out figure of Ariana (see Figure 80). With a flashlight they can see what this looks like. They know how this works since they have used the same tokens during the workshop.

The token also serves as a physical reminder of the workshop itself and as a simple tool to start the conversation about the workshop afterwards with others.



Figure 80: The token in use, showing the shadow of Ariana on the wall

Takeaways

Enthusiastic

They showed joy receiving the token. This was just for a short moment. [Observation]

Contribution

Not totally clear if they feel that they have achieved something or contributed to something. [Questionnaires]

Facilitator

This token is very easy to hand-out by the facilitator. [Conversation with facilitator]

Unfortunately, it remains unclear what happens with the token after the workshop. Doing research into this was outside of the scope of this project. However, it is assumed that they will know how the token works since they have used similar tokens during the workshop already. If it contributes to the meaningfulness for the children through reminding them of the workshop cannot be concluded.

Using the takeaways from both tests, has concluded into the following additional action points for this design guideline.

New action points:

- Incorporate some of the learning goals or overall workshop goal into the item, so when looking back, the knowledge is once more repeated.
- Make sure it does not take too much of the facilitators time to hand out, or explain the physical reminder.
- The physical reminder should fit with the workshop, the story and the activities.

As explained before, this project has its focus on the workshop experience during the workshop itself. The part of the experience that happens at home, is not designed for and is therefore not tested as well. Just like for the before part, the Science Centre communication channels would be of influence here and that is outside this project's scope.

Therefore, it was decided that the DG13. and DG14 are outside of this project's focus. So, they were not taken into account while developing the workshop, or testing the workshop. They are shown in light pink, because of this.

13. Reflection

Give the participants the opportunity to reflect after the workshop has finished, and in this way mentally reengage with their experience (Bastiaansen & Duerden, 2024).

Action points:

- Give the participants the tools to reflect on what they have done and achieved during the workshop. This can be through communication channels or a tool they bring home.
- Think about in what way they can share stories about their growth. And on how this can again be some sort of repetition of their new knowledge as a learning strategy.

Reflection after the workshop will be done at home. It is expected that the Science Centre will send a 'thank you' to the parents. This can be the start of a conversation with their child about their experience. However, it is not expected that the children will work on repeating their new knowledge on their own without any guidance in this.

Something that can occur, is that a child will try out to work with materials at home, to replicate something they did in the workshop. To encourage this, the following action point should be added.

New action point:

- Make sure the facilitator can explain to the children, how they can use their new learned skills at home. What materials can they use? Are there examples?

4.4.4 Overall takeaways

Also in the following DG, will take place at home after the workshop has finished.

14. Sharing achievements

It is important to celebrate the achievements with others. This can be with other participants or people at home. Little et al. calls this the cheer squad (2024).

Action points:

- Think about a way the participants can share their work with others. This can facilitate as a moment of proudness (Little et al., 2024; C7. Influence of others).
- In what way can the facilitator play a role in explaining this and putting them to the task to share their work with others?

Although there is not really designed for 'sharing achievements', it is expected that a conversation between the child and parent occurs when they are going home or arrive at home. Talking through their day or telling someone else what they have done will be part of sharing their achievements. It is expected that this will help in both reflection and stimulate the feeling of proudness about what they have created and learned during the workshop.

When the children or parents are sharing about their experience with others, the Science Centre will probably benefit from this as well. This is because they also rely on word of mouth to reach out to other participants. This will probably be the case for many other organisations.

Mentioning this in the guidelines, can stimulate the workshop developer to actually put some effort into applying these 'after' design guidelines.

Explanation of the 'after' guidelines

Be aware that a part of these guidelines will be about the communication the participants have after the workshop with others about their experience. If your organisation depends on word of mouth, make sure you keep this in mind while using these final design guidelines.

Although it was not the initial goal, the evaluation of both workshop tests, have resulted in a variety of useful takeaways. With this, the guidelines could be improved a lot. Besides this, also some overall takeaways were found about the use of the guidelines in general. **These can be used in designing the final tool that includes the guidelines, done in Section 5.1. There, the final design will also be presented.**

Hierarchy level

It was discovered that the guidelines are not on the same hierarchy level. Some are more specific about what steps to take, some are broader and ask the user reflective questions. The user should be made aware of this.

Connected guidelines

Some of the guidelines are connected and can support the development within another guideline.

Type of action points

The action points give different type of actions. Some are about testing the workshop beforehand, some are about what the facilitator should do or tell. A small icon to the action points could help the user understand this.

4.5 Applying the initial experience layers model

Workshop Test 2 not only allows for refining the workshop's flow and design guidelines, but also provides insight into how effectively these guidelines contribute to participants' experiences. It offers an opportunity to evaluate whether the designed workshop achieves a degree of meaningfulness. This process involves preparing evaluation materials, conducting the test, and analysing the outcomes.

Research Questions

Although the underlying theory of the design guidelines suggests that the workshop's design provides the right conditions for such an experience, it was valuable for this study to assess whether this goal was achieved in practice. This leads to the following research question:

RQ1 Has the workshop's design successfully created the conditions for participants to have a 'meaningful experience'?

To support this evaluation, the initial model of layered experience could be used. This model provides a framework to assess whether a part of the participants experienced deeper levels than simply "memorable". It also recognises that not every child will reach the highest level of meaning. Whether this model is useful should be assessed. This leads to the following research question:

RQ2 Is the 'experience layers model' a useful tool for evaluating participants' experiences in the workshop?

Evaluation strategy

To answer the research questions, the evaluation is divided into two parts.

Part 1: Will use the initial 'experience layers model' as a checkpoint after Workshop Test 2, to evaluate whether the desired meaningful experience is achieved.

Part 2: Will examine how the 'experience layers model' was applied in the evaluation of the first part.

These will be explained in this chapter's Subsections 4.5.1 and 4.5.2, respectively.

Short recap of the model

The aim of the 'experience layers model' is to support the design of meaningful workshop experiences for children. It builds on the original framework by Duerden et al. (2018), which shows three levels of experiences, from simple and memorable to deeply meaningful and transformational. An extended version is developed in this project specifically for hands-on workshops, adding more layers within the meaningful stage. The layers are triggering emotions, feeling proudness, gaining insights, and sparking ongoing interest. A workshop developer can use this model in two ways:

- The model helps to define the workshop goal in the preparation phase of the workshop design.
- The model can be used as a checkpoint to evaluate whether the desired meaningful experience is achieved.

Participants

The evaluations will look at how the children experienced the workshop. In total, data from four participants could be used here.

In Workshop Test 2, four children participated. Participant 1 chose not to be part of the research and is excluded from the evaluation.

Workshop test 1 was a trial for the evaluation materials. Since only minor adjustments were made for test 2, data from test 1 could still be used. The two participants from test 1 are included in this evaluation. One of the two participant joined both tests and is labelled as Participant 3 (P3).

4.5.1 Evaluation part 1

Evaluation part 1

This section will try to answer research question 1. Therefore, it will use the initial 'experience layers model' as shown in Figure 81. It is used as a checkpoint to evaluate whether the desired meaningful experience is achieved.

It is important to note that the design guidelines do not directly align with the stages of the model, so the meaningfulness of the experience cannot be evaluated per guideline.

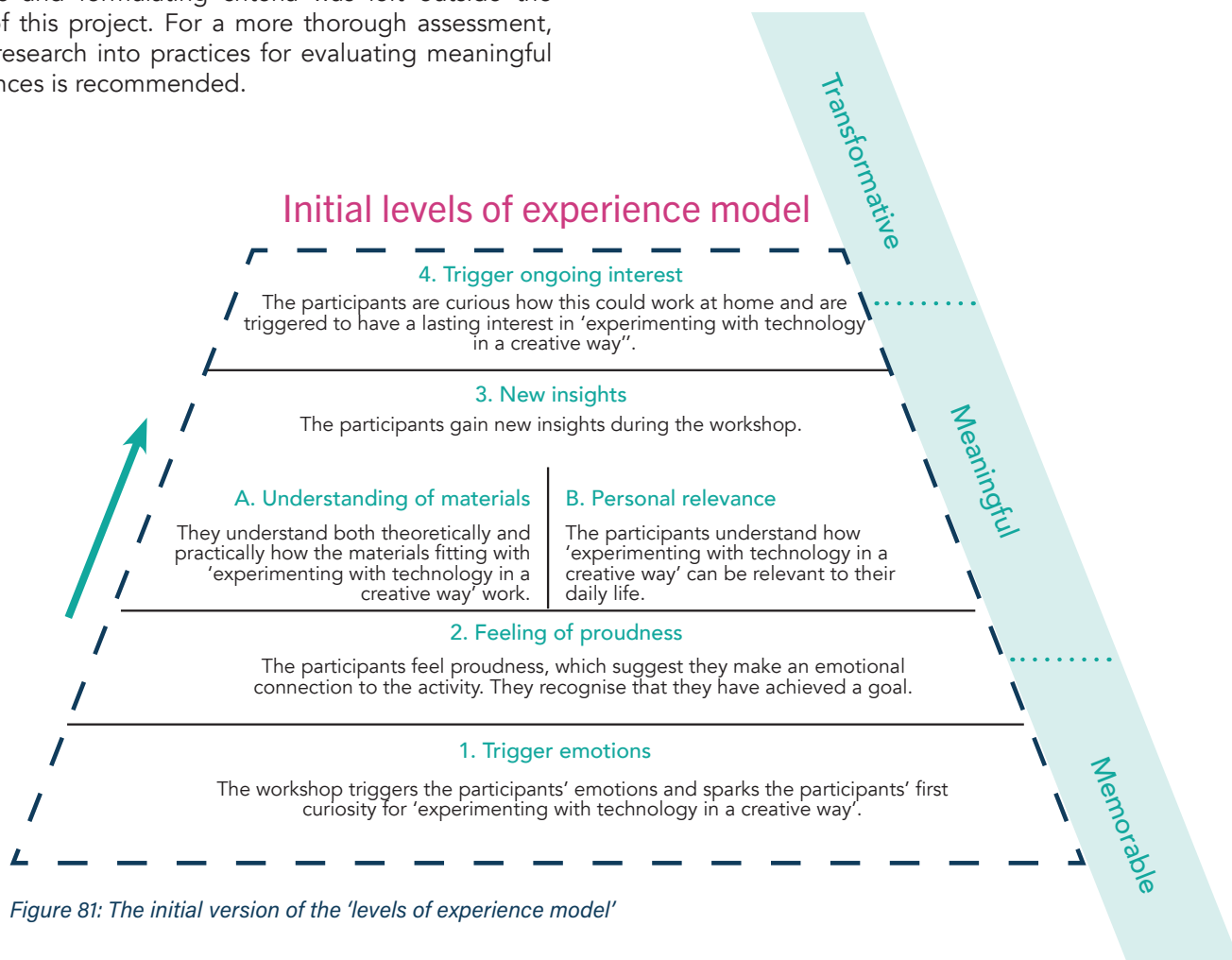
Instead, each layer of the model is examined individually. To do this, the same evaluation methods as in Section 4.4 are used, especially question forms and the interviews played an important role here. For each layer, dedicated questions were formed within the evaluation materials.

It should be noted that doing research on evaluation methods and formulating criteria was left outside the scope of this project. For a more thorough assessment, further research into practices for evaluating meaningful experiences is recommended.

Expected outcome

The stages of experiences are shown in such a way that allows for each participant to reach its own stage. Ultimately the workshop could be meaningful for all children, but this is not expected.

As the steps become more in-depth, the number of children reaching them are expected to decrease. How a child will experience the workshop depends on several factors, such as prior knowledge, learning style and, above all, the personal value the child attaches to the topic. However, it is expected that the use of the guidelines will effectively result in an expansion of the top of this model. And thus, more children will experience higher levels of meaningfulness.



Preparing the model

Before use, the topic of the workshop needs to be filled into the 'fill-in' gaps of the model. In the evaluation of initial guideline 3 the following topic was chosen: 'experimenting with technology in a creative way'.

Going over the layers

Next, each layer of the model will be discussed separately to evaluate to what extent the workshop succeeded in reaching each level of experience.

For each layer, the following is explained:

- The approach, with a short explanation about the expectations and what evaluation method was used. More details from the tools made to assist in these activities can be found Appendix J.
- Outcome. A short summary of the results from the test is discussed.
- Conclusion. A very short conclusion is drawn, answering the question of the layer.

1. Trigger emotions

Did the workshop trigger the participants' emotions and spark the participants' first curiosity for 'experimenting with art in a creative way'?

Approach

Discover what their overall impression of the workshop was, how they felt after the workshop, and if they would recommend it to anyone else. [Questionnaire: Q3, Q9, Q14, Q13] & [Interviews: Q1].

Outcome

They all filled in they had 'a lot of fun' as shown in Figure 82 and gave a high grade to the workshop. Two of the three children chose the Premo saying they had a lot of fun. One of them also chose 'I want to continue building' (see Figure 83). The children playing with their creative outcomes also showed this.



Figure 82: Answers from Participant 2 and 3



Figure 83: Answers from Participant 2: having a lot of fun (left) and p3: I want to continue building (right)

Unexpected, but affirmative for this was the participation of Participant 3, who had already participated in test 1.

Quote: Researcher asks "Why did you want to come again? Participant 3 says "Because I enjoyed it last time"

Conclusion

It clearly triggered the emotion of enjoyment since they showed and explained they had a lot of fun during the workshop and liked the materials. The materials triggered their curiosity because it prompted them to experiment with it.

2. Feeling of proudness

Do they feel proudness? Do they recognise that they have achieved a goal? This would suggest they make an emotional connection to the activity.

Approach

Observe if they show any positive feeling towards their own work, and if they communicate this to others, about what they have made. [Observations], [Questionnaire: Q13].

Outcome

The parents and facilitator told several times they like what they had made. The children seemed satisfied with what they made and wanted to shortly play with it afterwards. Additionally, they did not want to take their creatures apart at the end of the workshops. However, they do not directly use the word 'proud' or 'proudness' during the workshop.

None of them deliberately said they have achieved a new goal, but two of the three children did choose this premo with the sentence 'I wasn't expecting I could make this' (see Figure 84).



Figure 84: Answers from Participant 2 and 3.

Conclusion

They were surprised about creating these cool things and were very happy with their final result, which suggest a feeling of proudness. However, the participants were not very expressive about their feelings next to 'having fun'.

3A. Use of the materials

Do they understand both theoretically and practically how the materials of the workshop work?

Approach

Observe if they practically understand the materials after hearing the theoretical explanation. See if there is a difference between what they knew before and know after the workshop about the technical part. [Observation] [Questionnaire: Q8, Q12]

Try to understand if they can give words to what they have learned from the materials, and if they can explain it to someone else. [Interview: Q8a+b]

Outcome

All of them managed to build the assemblies. For three participants, the answer on a theoretical question changed (see example in Figure 85). Some of them already understood this theory before the workshop.

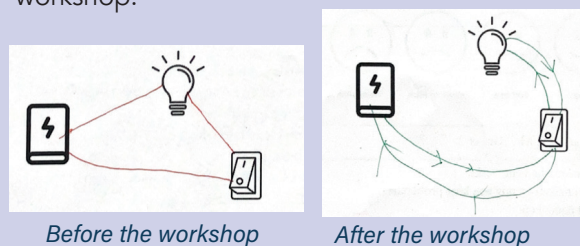


Figure 85: Answer from Participant 2 on the question 'Do you know how a light works?'

Two of the participants managed to explain what they had made to the researcher. One had remembered the names of the assemblies clearly. "First I made the mechanical turning assembly, and secondly the electronical turning."

Participant 3, who was participating for the second time, was much faster in building assemblies and started to try out things herself. Showing she had learned from last time and she feels more comfortable using technical materials.

Conclusion

All participants built the assemblies, showing practical understanding. For one, even more confidence in the use of materials was found. Improvement in theoretical understanding in the long-term is hard to tell, but in the moment, they were able to explain their new learnings.

3B. Personal relevance

Do they understand how 'the topic of the workshop' can be relevant to their daily life?

Approach

Discover what they have learned in the workshop and what they explain about this. Do they name specific aspects of something connected to the workshop's topic? [Interview: Q11, A18]

Understand if their opinion about 'technology' has changed. [Interview: Q4 +Q10]

Outcome

All mentioned something different about what they had learned. Two of them mentioned something about creating, the other two about using technology. Participant 3 mentioned "That you can recognise the things at home", which was one of the activities, that had made an impression. Participant two said "how you can use electricity in diverse ways"

Before the workshop, all four children said they liked technology because 'you can craft with wires, lights, and devices.' Afterward, none of them chose this answer again. Two changed it to 'you can make something that really works,' while the other two chose, 'you have to work hands-on.' Here they move from an association of technology with just materials to a focus on the appliance and process (see Figure 86).

10. Wat is er leuk aan techniek? Kies er 2.

<input type="checkbox"/> Je kan iets maken dat echt werkt.	<input type="checkbox"/> Je kan fouten maken en nog een keer proberen.
<input checked="" type="checkbox"/> Je moet hard nadenken.	<input type="checkbox"/> Je kan iets met je handen doen.
<input checked="" type="checkbox"/> Je kan iets laten bewegen.	<input type="checkbox"/> Je kan knutselen met draadjes, lampjes of apparaten.

Wat is er leuk aan t

<input type="checkbox"/> Je kan iets n	<input type="checkbox"/> _____
<input type="checkbox"/> Je kan foutei	<input type="checkbox"/> _____
<input type="checkbox"/> Je moet hard nadenken.	
<input type="checkbox"/> Je kan iets met je handen doen.	
<input checked="" type="checkbox"/> Je kan iets laten bewegen.	
<input checked="" type="checkbox"/> Je kan knutselen met draadjes, lampjes of apparaten.	
<input type="checkbox"/> _____	

Figure 86: Answer from Participant 2 on the question 'Why do you like technology? Before (left) and after (right).

Conclusion

All of them found some insights about either the materials or the topic of the workshop. Their understanding of technology deepened. Whether they realise how the topic can be applied to their own lives remains unclear.

4. Trigger ongoing interest

Are the participants curious about how this (what they have learned), could work at home? Are they triggered to have a lasting interest in 'Experimenting with technology in a creative way'.

Approach

Understand how they feel about the workshop afterwards, and see if they mention they would like to 'continuing working'. [Interview: Q2]

Or if they want to discover what they can do with this as home. [Questionnaire: Q15]

Outcome

While building the mechanism, Participant 3 says to his mom: "it is a pity that we are not allowed to bring this home"

One of the four children chose the premo that says "I want to know how I can use this at home" (see Figure 87).

In the interview when asked what they could do with it at home, it was difficult to answer. Participant 2 discusses with his mom: "maybe we can make shadows with Lego".



Figure 87: Answer from Participant 2 on the question 'how do you feel right now?'

Conclusion

It is difficult to say if the workshop has triggered an ongoing interest. Only one participant said he wanted to see what the possibilities are for working with this topic at home. More research is needed to follow up on this, after the workshop is over.

Overall conclusion

RQ1: Has the workshop's design successfully created the conditions for participants to have a 'meaningful experience'?

Several conclusions can be drawn from the evaluation to answer this question:

First, the design guidelines proved to be very useful in developing a STEAM-based workshop for this target group with the pre-arranged material kits. A final workshop framework was successfully created using them. Besides, after the improved workshop concept (concept 2) the children have expressed to have a lot of fun participating.

Second, the evaluation suggests that the workshop design, guided by the design guidelines and all found take aways after Workshop Test 1, has the right conditions for the participants to have a meaningful experience.

According to the experience layers model, all children were engaged and enjoyed the activities, indicating they reached the 'memorable' level. For some participants proudness was observed and some children were able to explain what they had learned, showing signs of reaching the lower layers of meaningfulness. Whether the highest layer, ongoing interest, was reached remains unclear; further research is needed to assess that.

Finally, without a control group, (i.e., a version of the workshop without the guidelines) it is difficult to determine to what extent these experiences were directly caused by the design choices. Still, the positive outcomes and enthusiastic responses indicate that the guidelines contributed to a meaningful learning experience.

Limitations

Based on the results, several conclusions can be drawn. Before using these conclusions to make a final design, it was found important to consider the following limitations that may have had an influence on the results:

Evaluation methods

The interviews and questionnaire that were used as evaluation methods, were not based on any research. Creating more reliable evaluation materials would require in-depth knowledge of educational measurement and validated tools. This was outside this projects' scope.

Test group

Again, the size of the group, with only four children makes it hard to draw strong conclusions. Besides, talking with children has been found a real challenge. This was done without any expertise of research about specifically testing with children.

Question forms

Within the test, the children were tasked to fill out the forms, which were part of the evaluation materials. It should be considered that answering these questions could have influenced their experience. It may have:

- primed the children about the topic
- made them reflect on the workshop
- helped repeating the theory

These three, are also used in the action points of the DGs and therefore realistic factors to influence the results.

After part

To be able to conclude properly, it would have been interesting to know more about the last phase of the experience. This takes place at home. Due to this project's timespan, this was left outside of the scope.

Influence of observer

Knowing they were taking part in research and they were observed might have altered how the children behaved or filled out the question forms.

Opportunities

Evaluation methods

Although not based on research, some evaluation methods concluded to be useful for evaluation. The following can be written in the final design:

In the practical tool's test section, consider briefly highlighting the possibilities of different evaluation methods, especially when working with children.

4.5.2 Evaluation part 2

Now that the initial 'experience layers model' has been applied to evaluate the kind of experience the children had during the workshop, its effectiveness as an evaluation tool can also be assessed. And with this, look for improvements or any additional information for the user.

Approach

This evaluation is limited to exploring how the researcher applied the model. Due to the project's time constraints, assessing how others might interpret and use the model falls outside the scope. Therefore, a thorough evaluation is not possible.

Within this limited scope, a few key aspects are considered to help improve the model.

From evaluation to improved model

Questions were shaped to evaluate the way the model was used. With the questions a short evaluation follows. **New takeaways for the final version of the model are highlighted in pink.**

1. Did using the model help draw firm conclusions about the experience of the participants?
As Subsection 4.5.1 has shown, it proved helpful in recognising different experience levels among participants. Although the use of 'evaluation tools' seems very important here. Without, it can be hard to use this model.
2. How was the format and text of the model perceived?
 - **During the workshop's evaluation, it became clear that the model would be more useful if presented in a question-based format.**
 - Before using the model, it is useful to know that **DG3. can be used to determine the topic of the workshop.** Then the 'topic' gaps can be filled in.
3. Is the information given with the model enough for users to understand it?
Workshop developers are unlikely to fully grasp the model without background information. To address this, **a more complete summarized explanation of the theory behind the model will be added to the instructions.**

4. When can the model be used?

This model was developed alongside the design of the workshop. So, the content was kept in mind during the process which was helpful in using the guidelines and developing evaluation materials:

1. **This model can be used in the preparation before using the guidelines. The layers of the model will help understand what the overall aim of the workshop is.**
2. **Before testing the 'experience level' of the participants, this model can help in the development of evaluation materials.**

Since it was helpful to test, this is recommended:

3. **Later in the process, when testing the workshop, it can be used as a checkpoint. It helps to evaluate if the aimed effect of the workshop is reached.**

Overall conclusion

In this assessment of the evaluation tool, the research question was as follows:

RQ2: Is the 'experience layers model' a useful tool for evaluating participants' experiences in the workshop?

No strong conclusions can be drawn, as the assessment was limited to the researcher's own use of the model. However, it proved very useful in both developing the evaluation materials and conducting the evaluation itself. Therefore, it is decided that the model will be included in the final design of the tool. Minor adjustments are suggested to improve clarity and usability. Further testing with external users is recommended to validate and refine the model.

4.6 Conclusion

This chapter has shown how the initial design guidance tool, comprising the 14 design guidelines, instructions, and the experience layers model, was tested and refined through the real-world case study of the Techniek Studio 'Experimenting with Art'. The iterative design process allowed for a practical exploration of how each element functioned in the workshop setting.

The application of the initial instructions provided a solid starting point and showed what instructions should be added for a better start for the user.

Two workshop tests were done. Workshop test 1 used concept 1: 'Restore the energy', out of an iteration with new findings, concept 2: 'Help to build friends' emerged. Here, the overall framework remained the same, but open elements (e.g., the story, take home gift) changed significantly. These tests offered valuable insights into the workshop's flow and its specific steps. Most insights came from observations and facilitator conversations, with additional input from interviews and questionnaires.

The overall flow of the workshop was noticeably improved in the second concept. The children were visibly engaged and mentioned they enjoyed it in the interview afterwards. Also seen in their active participation, spontaneous reactions, and creative outcomes. Some photos of this second workshop are included in Figure 88 and 90 to

illustrate the atmosphere and outcomes of creations of the children during the workshop.

Although the workshop tests were not aimed at this, the real value of testing turned out to be revealing gaps and opportunities in the initial guidelines. This is because the found takeaways were abstracted into broader action points that were added to the guidelines and transformed them to be more refined and practical.

Additionally, the evaluation using the 'experience layers' model confirmed that some children reached the meaningful layers. Although it is difficult to determine definitively whether this was because of the use of the guidelines, due to the absence of a control group for comparison. However, using the design guidelines is strongly recommended. Firstly, because the use of the guidelines showed very valuable for the development of the workshop itself. Secondly, they support more intentional choices during the design process which most likely improve the chances of creating a meaningful experience for children. The use of the experience layers model has proven useful and will be part of the final tool.

Altogether, these findings support the refinement of the tool into a more practical and user-friendly version. The final version of the design guidance tool is presented in Chapter 5.

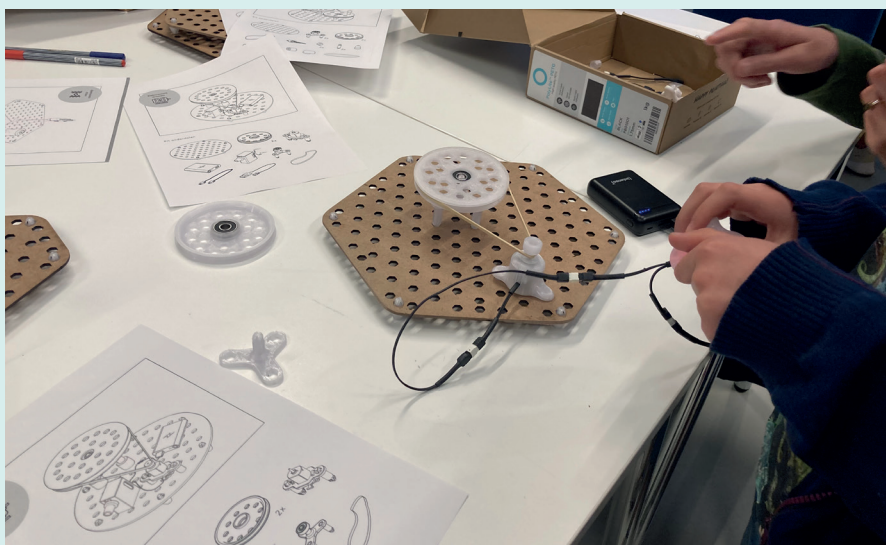


Figure 88: Participant 1 using the manual to build his first assembly.

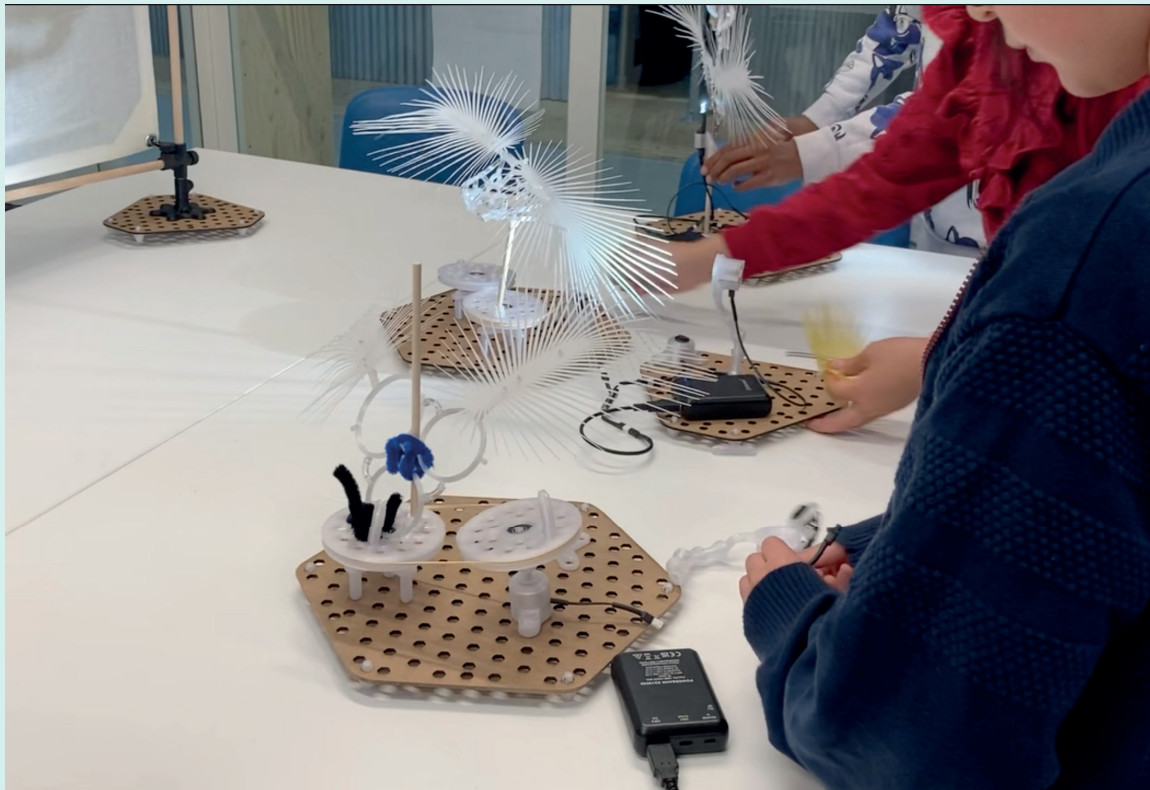


Figure 89: The three participants trying out the movement of their assembly with their creature attached to it.



Figure 90: Participants 1, 2 and 3 playing with the shadows of their final 'Droomling'.



Chapter 5

The STEAMingful Design Tool

This chapter presents the final design: **The STEAMingful Design tool**. It is a refined and more practical version of the initial guidelines, developed and tested through the case study discussed in the previous chapter. Afterwards, Section 5.3 discusses the expert evaluation conducted with three reviewers, each with a different background. They provide some practical suggestions for refinement and future implementation. Section 5.4 examines how the Science Centre has implemented the workshop and its steps and tries to understand the reasoning behind any changes. The outcomes of these evaluations are summarised in Section 5.5.

- 5.1 A practical tool for the user
- 5.2 The STEAMingful Design Tool
- 5.3 An expert view on the final design
- 5.4 Launch of the workshop
- 5.5 Conclusion

5.1 A practical tool for the user

Now that the guidelines have been proven applicable through a case study, it is time to present them in a user-friendly format. This allows anyone who wants to develop a STEAM-based workshop for children to use them as a guiding tool. The format chosen is a small, physical booklet, named 'the STEAMingful Design Tool'. It will include all the findings that were discovered during this project.

Name

The name 'The STEAMingful Design Tool' combines "STEAM" with "meaningful," reflecting the central aim of this tool: to help create the right conditions for the participants of the STEAM-based workshop to have a meaningful experience.

Format

The format of a physical booklet is chosen because it is practical and visible. A booklet is easy to grab during the design process of a new workshop, or simply during a first brainstorm session. It can be kept on a desk, shared with colleagues and used without distractions. The guidelines are presented step-by-step which helps the user to work through the content logically.

Although the content of the guidelines has been carefully designed, it is outside this project's scope to dive further into the format that is used to communicate the guidelines. See Section 6.2 for recommendations on this.

Composing the booklet

This final booklet integrates all insights gathered during the research and case study, including new action points and supporting instructions. In some cases, additional sentences have been added to provide flow and clarity for the user. Giving a bit more instruction on how or why a specific guideline should be applied. To understand how to use this booklet, it includes an introductory explanation of what this booklet is and its purpose.

Some design decisions have been made to enhance the readability and practical usefulness for the reader. Each guideline is presented on its own page using the same designed layout, including:

- A clear title
- A short introduction to the guideline
- Action points the user can apply to the design process
- An example showing how the could be applied in practice. These come from the case study of this project)

Figure 91 shows the designed template with more details. A few layouts were tried out to find the right visual hierarchy for guiding the reader's attention and supporting usability (Appendix L).

A key revision from the initial version is the order in which the guidelines are presented. There, the guidelines followed the timeline of the workshop experience: before, during and after. However, evaluation of the case study, gave the realisation that the order in which the guidelines are presented should align with the logical sequence of a workshop design process. This is a layered approach.

Zooming in the first steps:

1. Define the overall goal and flow of the workshop.
2. Divide the flow into distinct steps
3. Design each step in detail

Zooming out in the final step:

4. Address practical and organisational aspects. E.g., designing the workshop manual for the facilitator and the communication information for the organisation can be thought out.

This new structure is explained to the user at the start of the booklet. It is supported by a visual overview page listing all the guidelines, each marked with a small icon to show which part of the workshop experience it relates to (before, during, or after).

Target user

Although the case study was done for the Science Centre, and the original brief came from them, the booklet is designed to be broadly applicable. In this way, it can be used by anyone looking to develop or improve a STEAM-based workshop for children. And thus, also other organisation could make use of this booklet.

Moreover, it is also designed in a way that it can be used both as a tool for creating new workshops and as a reference for improving existing ones.

To make the content more engaging and accessible, the booklet uses a second-person instructional tone. It uses "you" to directly address the reader, making them feel like they are part of the instruction. This will help to adapt the guidelines to their own context.

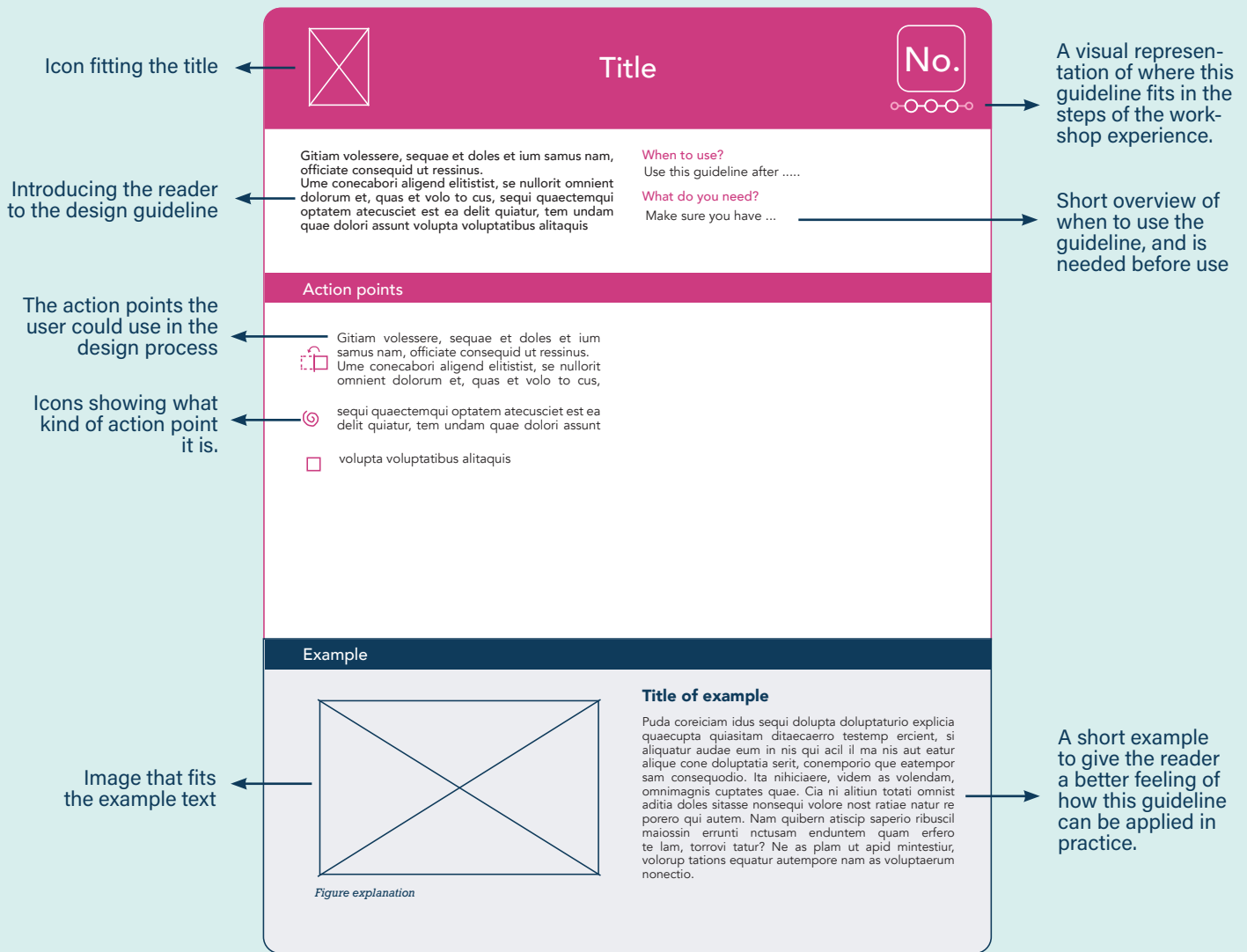
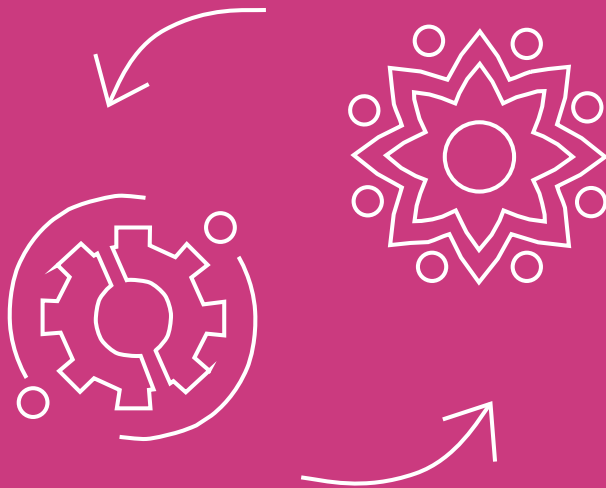


Figure 91: Detailed overview of the used layout for the design guidelines

5.2 The STEAMingful Design Tool

On the following pages, this project's resulting booklet will be presented in its entirety. The goal of presenting the full booklet, is to give a complete and concrete view of the final design outcome. A short evaluation with expert workshop developers will be provided in Chapter 6.



The STEAMingful Design Tool

Practical guidance for developing meaningful STEAM-based workshops for children aged 8 -12 years.

J.C.van der Jagt

Introduction

Organising a STEAM workshop for children? While the workshop should be fun and engaging, you also would like the children to learn something new. But how do you ensure that the children gain valuable insights, while still having a great time?

This booklet will help you to get started. Step by step, it will guide you through a process of shaping your workshop. First, assisting you to understand what kind of workshop you want to set up and which target group you want to address. Then, presenting 14 guidelines that will help you develop the workshop and make thoughtful design decisions. All together this will support you in creating the right conditions for your workshop to be a meaningful experience for the participants.

The 14 guidelines cover the entire workshop experience, including the before and after phase. Each guideline consists of a short explanation, action points and an example to clarify. These guidelines are developed to be used as an addition to organisational standards or even an existing workshop format. They are therefore formulated flexible so that you can give them your own interpretation.

Who are these guidelines for?

These guidelines are designed for anyone who is planning to develop an out-of-school learning experience * STEAM based workshop for children around 8 to 12 years old. Whether you're an experienced workshop developer, a professional educator or designing your first STEAM workshop. They are applicable for any organisation interested in STEAM-based activities.**

How to use these guidelines?

Are there any elements in your workshop that are already fixed, such as the materials or the room in which it is given? It is likely that some organisations regularly organise workshops for children and therefore already follow a standard approach. You may already have your own facilitators, preferred materials, use of space, or perhaps even an existing framework to rely on.

For that reason, these design guidelines do not aim to explain every step of designing a workshop from the ground up. Instead, they are intended as a complementary tool that could fit with any organisation.

In case you do not have any standards yet, the steps and examples will guide you with questions. They help you reflect and work on your own basic set-up.***

How were they developed?

These guidelines are originally the outcome of a master's thesis for the Design for Interaction program at TU Delft. They were developed using a Research Through Design approach, combining literature review, field research, and real-world testing within a case study. The case study involved the development of a workshop itself within the context of a science centre.

Disclaimers

*These guidelines were developed using a case study. The workshop within this case study was primarily focused on out-of-school, informal learning experiences. Where having fun and learning something new are balanced. When you are applying them to a more formal, curriculum-based or school-related educational contexts, these guidelines may need further adaptation.

**While the tool was tested in the context of a science centre, its applicability in other cultural or linguistic contexts has not yet been evaluated. Further testing may be required before implementation in significantly different settings.

*** The workshop in the case study that informed these guidelines made use of existing materials. Therefore, this booklet does not go into detail about the making of new workshop materials.

Getting started

There are some key instructions that should be followed before using the design guidelines. The goal of this instruction is to help gain a better understanding of your workshop's context and its boundaries. This prior knowledge is essential because you will use it across multiple guidelines.

I. Overall

When designing a new workshop, it is very important to firstly have an overall understanding of what kind of workshop it will be. Nothing has to be set in stone yet.

Try to roughly answer the following question before moving on to the next step.

1. Define the goal of the workshop:

Start by understanding the purpose of your workshop.

- What do you want the participants to learn? In a later step, V. Define the workshop's goal, will help you detailing out the goal with criteria.
- What do you want participants to experience?

2. Know your target group

These guidelines are built around children aged 8–12, but you may aim for a more niche target group.

- Who is your target group?
- What is their level of knowledge?
- What are their soft and hard skills?
- What topics suit them?
- What pace within activities suits them?
- What will they expect from a workshop?

3. Know the facilitator

A workshop will be given by a facilitator that will guide the participants throughout the workshop. It is important to know what kind of facilitator will oversee the workshop you are designing.

- What kind of facilitator will give the workshop?
- A professional who knows a lot about education? Or a student who is close to the children?
- How might their background influence the design and tone?

II. Organisational standards

It's helpful to identify whether your organisation already follows a standard process for developing and delivering workshops. This prior knowledge will help you apply the guidelines more effectively and ensure they complement existing practices.

If no standard process exists, this step will still help you understand your context better.

Try to roughly answer the following question before moving on to the next step.

1. Workshop location & facilities

- Where will your workshop take place?
- What kind of facilities are in the room?
- Can your materials be fixed to the space, or do they need to be mobile and adaptable for different rooms?

2. Time & Participation Constraints

- How much time is available?
- How many children can participate at once?
- At what time of day will the workshop take place (morning, afternoon)?
- Are there specific time constraints or scheduling considerations?

3. Style

- Is there a particular tone, atmosphere, or educational style that aligns with your organisation's identity?
- In what way is the workshop communicated with the facilitator? Will there be a manual?

4. Sustainability

- Are there any set sustainability constraints?

5. Inclusivity

- Does your organisation have inclusivity standards for workshops?

III. Guiding principles

Before you start selecting and applying the guidelines, consider the following principles. They will help to ensure the guidelines you select work well together and support your overall workshop goals.

Read through the following information before moving on to the next step.

Amount of design guidelines

As Bastiaansen and Duerden mentioned, there is not a minimum amount of constellations or strategies needed to reach a meaningful experience (2024).

Tip: Apply an amount of guidelines that helps to design the workshop in a way that integrates fun and learning naturally. Moreover, it is important that the guidelines chosen should complement each other.

Balancing fun and seriousness

The guidelines should contribute to both the enjoyment and the overall purpose of the workshop. Especially since the focus is on out-of-school learning experiences, making it important for the children to not focus on the learning goals and reflection all the time.

Tip: Don't force reflection, allow insights to emerge naturally.

Designing for children

Because children have a unique mindset and way of viewing the world, it is expected that the outcome can sometimes be quite different from what theory had expected. The designer should anticipate on this.

Tip: Do not designing too strictly. Keep testing and adjusting the workshop multiple times.

Tip: Explain to the facilitators they should remain flexible and observe how children respond to different elements of the workshop. Then they can make adjustments if needed.

IV. Understanding the materials

The workshop you will develop using this booklet focuses on learning about the STEAM disciplines through hands-on activities. Obviously, this means participants will engage with tangible materials throughout the workshop. Therefore, it's needed to know whether you will be using materials that already exist or that the development of these materials are part of the workshop design. In second case, read VII. Designing the materials.

If the workshop materials are already identified, please read through the following information before moving on to the next step.

It is important to take a moment to understand the materials before starting the design process. This will help you gain a solid grasp of them, both theoretically and physically, so you can apply them effectively and find the right fit for your target group.

Explore the materials yourself

- How do they work?
- What can you do with them?

Observe how children interact with them

Test with your target audience!

- Do they understand how it works?
- Is it safe to use unsupervised?
- Do they need instruction to get started?

Quantity vs. Variety

- Are there enough materials to explore?
- Is it possible the children get bored?
- Is it possible they get overwhelmed?

Intuitive use

- Are the materials intuitive to use?
- Is there a need for guidance?

Fitting for STEAM

- Can you already tell what forms the theoretical basis, and what could be used as a creative extension?
- Are STEM and the arts balanced?
- Are the materials more STEM? Consider if they still fit the children more drawn to the Arts. And the other way around.

V. Define the workshop's goal

When using this booklet, your overall aim with the workshop design is to create a meaningful experience for children. Further defining this goal will support you in applying the design guidelines more effectively and help in making focused, relevant design choices during the process.

First, some background information about 'meaningful' designing is needed to understand and establishing your workshop's goal.

There are three different levels of experiences that range from simple and memorable to deeply meaningful and even transformational (Duerden et al., 2018). Figure I shows this original framework of experiences. The layers in this model build on each other: the higher you go, the more impactful, but also the rarer the experiences become.

An extended version of this model, shown in Figure III, is developed for this booklet. It has more layers within these experience levels for the specific context of a hands-on workshop for children. They go from triggering the participants emotions, to making them feel proudness, to make them have

more insights and finally maybe even trigger an ongoing interest.

The goal of the workshop design is to create the conditions that make these meaningful experiences more likely. That's where the design guidelines come in. They are designed to enhance the chance of going to the next level in the model.

It should be noted that meaningful experiences can still occur without explicitly using these guidelines. However, using the guidelines is recommended, as it can help expand the top of the pyramid, as shown in Figure II. Thus, designing with these guidelines will likely increase the number of children who experience the workshop as meaningful.

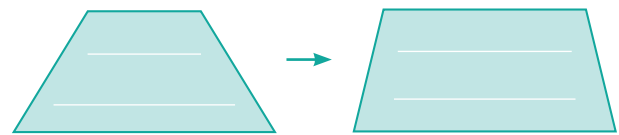


Figure II: Section of the pyramid. Pointing to the aimed version where the top expands.

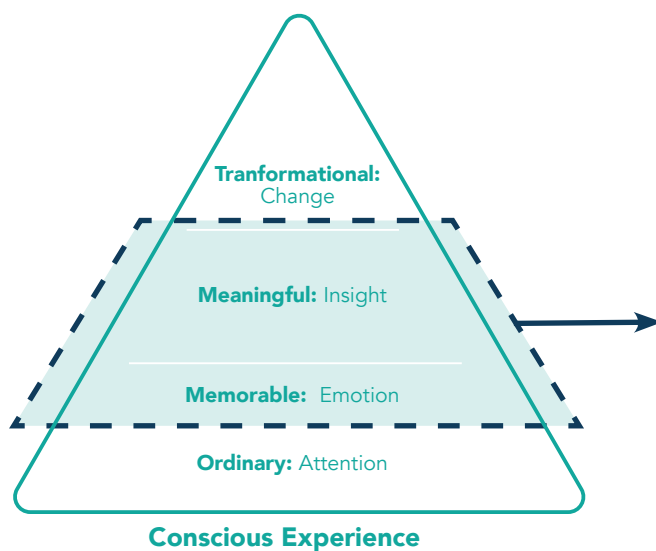


Figure I: Original framework of experience types from Duerden et al., with a dotted line highlighting the Memorable and Meaningful stages (2018).

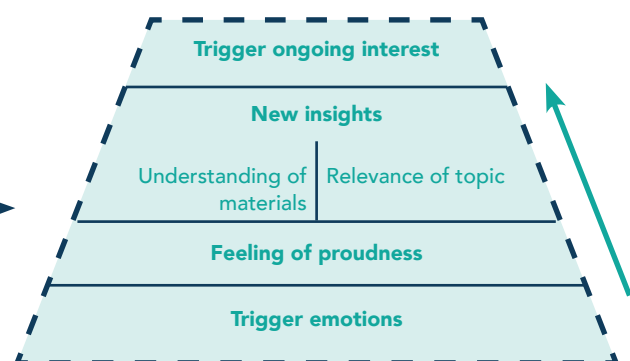


Figure III: Extended framework with multiple levels specific for the context of a hands-on workshop for children

Now you understand the background of this model, it is time to apply the detailed version, shown in Figure IV, to your own workshop.

When to use?

1. This model can be used as a preparation before using the guidelines. They will help you understand what the overall aim of your workshop is.
2. Later in the process, when testing the workshop, it can be used as a checkpoint. It helps to evaluate if the aimed effect of the workshop is reached.

How to use?

The model has 'to fill in' gaps. Here, 'the topic of the workshop' can be filled in. This is the topic about which the participants will gain insights about.

If the topic of the workshop is not defined yet, use design guideline 1.Topic of the workshop.

If the topic of the workshop is defined, fill in the workshop's topic into the gaps and read through the layers of experience.

From this point on, the guidelines can be used to develop a new workshop and reach these layers.

It should be noted that it is not expected that the more guidelines you use, the higher level of experience people will have. Whether someone has a higher level of experience is dependent on a broad range of factors that also go beyond the design process and these guidelines. However, the better you make the design guidelines fit with your target audience, the more likely the workshop's participants will reach a higher level within this model.

Levels of experience model

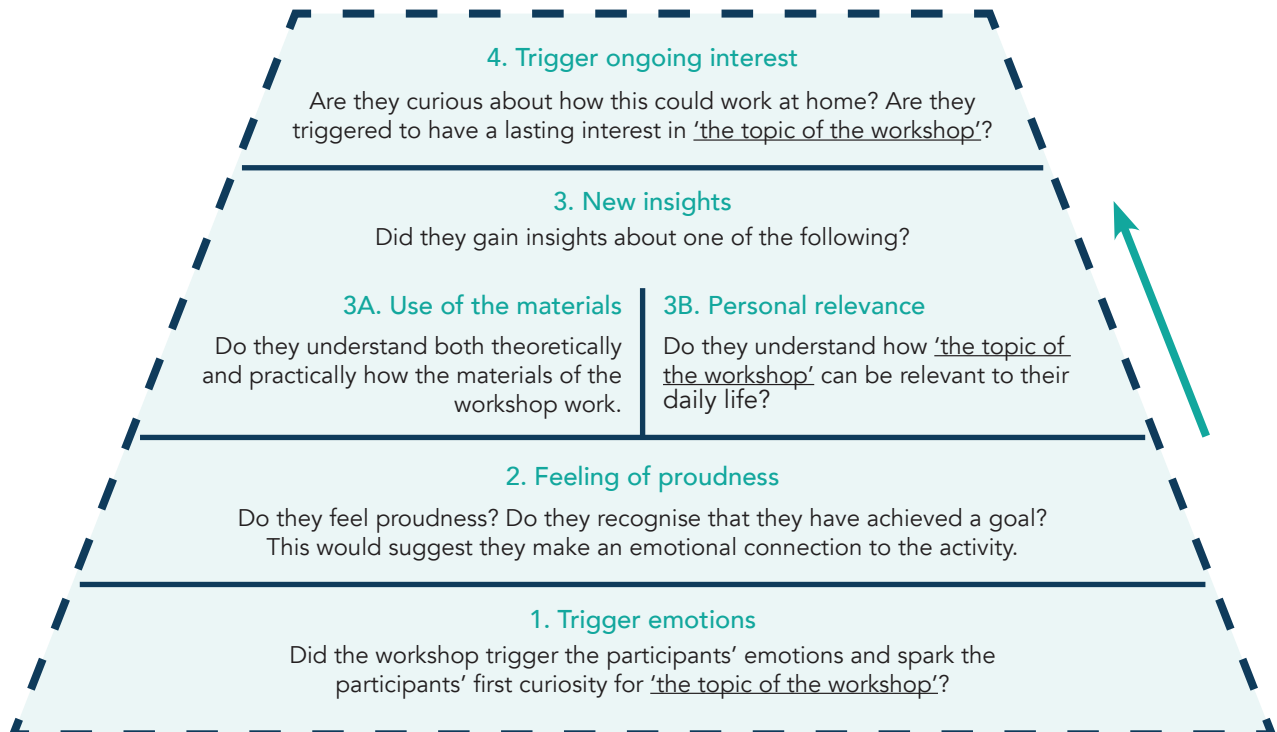


Figure IV: Extended framework with multiple levels. Including questions to understand the aim of the workshop

VI. Define the learning goals

With all the gathered information and a clear overall goal of the workshop, you will be able to set-up a few learning goals. These learning goals are about what you aim for the children to learn by participating in the workshop. This is important since they will be needed within the use of a few design guidelines. Having clear learning goals not only helps you design the workshop but also helps you evaluate its success afterward.

Take a moment to make a list of the learning goals before moving on to the next step. You can use the following questions:

- What do you hope the children will learn?
- Are there specific skills, insights or attitudes you want them to develop?
- Do you want them to learn about the materials, or only use the materials?
- What kind of learning goals align with your organisation's overall mission?
- What do you think the children and their parents expect to learn during the workshop?

Note: You don't need many goals, just a few strong ones can guide your design effectively.

VII. Designing the materials

If the materials for your workshop still need to be selected or developed, start by looking at your overall workshop goal and the learning goals. What kind of materials would help children explore these ideas in a hands-on, engaging way?

Important note: This booklet is composed through the use of a case study. In this case study, the materials were already known. Since the development of materials comes with a whole process, the guidance within this section does not provide a full step-by-step approach for developing new materials from scratch. Instead, it offers reflection questions and considerations to help you choose or shape materials.

You can use the following questions to guide your material selection or development:

- What should the materials help the children understand or do?
- Do the materials invite for exploration or creativity?
- Do they support a balance between STEM and the Arts?
- Are the materials age-appropriate and safe for independent use? Is it not too childish?
- Do they encourage trial-and-error, problem-solving?
- Can children make their own choices with them?
- Do they allow for the process of making to be more important than the final result?

Whether you are designing materials yourself or use existing materials, make sure to test early and often with your target audience. **You can use 'IV. Understanding the materials' when testing.**

General Tips

There are some general tips to consider regarding sustainability and inclusiveness when designing a new workshop. These can be especially useful if your organisation does not yet have established standards in these areas. **You can revisit these tips throughout the design process.**

Design for inclusiveness:

Design with inclusiveness in mind by considering the diversity of children and parents who may attend the workshop.

- Are the workshop activities accessible to children with different physical, sensory, or cognitive abilities?
- Are the instructions and communication styles inclusive and age-appropriate?
- When the participants are addressed, is it in an inclusive way?
- Use diverse examples and visuals (people, places, stories) to help all children feel represented

Design for sustainability:

Think about sustainability when setting up the workshop and choosing and organising all the materials.

- Are the materials used multiple times?
- Can you minimise single-use?
- Do they need to be thrown away after?
- Is there a more sustainable way?
- Where do the materials come from? Can you source them locally
- Can leftover materials be repurposed in future workshop.

Using the guidelines

With your goals defined and materials considered, you are ready to move on to the next step: using the design guidelines. These guidelines are here to support your process and help you make thoughtful design decisions that increase the amount of children that experience the workshop as meaningful.

You don't need to apply every single guideline. Instead, select the ones that best match your goals and context. They are there to guide, while still leaving room for your own creativity, expertise and intuition.

The following page gives an example framework overview of a workshop. Here you can see that the workshop experience you will be designing is not just the workshop itself. It already starts before and may end long after the actual workshop itself. For example, signing-up and receiving information before the workshop are also part of the experience. The guidelines include these phases as well.

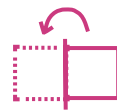
How to read

An overview of all design guidelines, including their corresponding experience stage and page number, can be found after the example. This makes it easier for you to navigate and find the guidelines you need. The order of the guidelines follows the general steps you are likely to take when designing the workshop.

Each guideline starts with a brief introduction explaining when and how to use it, along with any requirements before applying it. Following this, the action points are clearly summarized and accompanied by a small icon. This icon indicates the guideline's role in the design process. This will help to understand when it can be applied best.

Lastly, each guideline concludes with either a real workshop example using the guideline or an important note.

Legend



Do this, prior to the main activity point of this design guideline.



Main activity point.



Consider this detail, when working on the main activity point.



Use this when setting up the workshop's steps



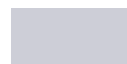
Go over the workshop's steps. Consider if you have already done this.



Use this when developing the facilitator's manual.

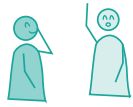


Do this, after the main activity point of this design guideline.



Example matching the guideline.

Example framework



Hear about the workshop



Think about it



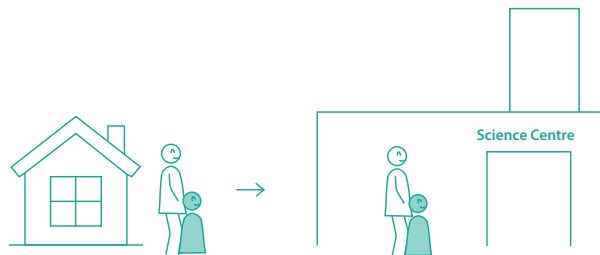
Discuss about it



Sign-up for it



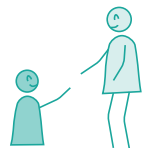
Receive more information



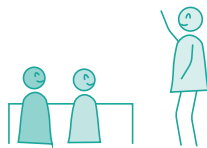
Travel to the workshop



Meet other participants



Meet facilitator



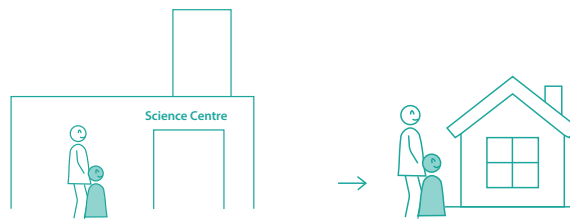
Topic is explained



Do the activities



Discuss and reflect



Go back home



Reflect at home














Tell others about it



Remember it years later

Overview of the guidelines

Timeline	Guideline	Page
	1. Topic of the workshop	12
	2. Personal value	13
	3. Sharedness	14
	4. Make it new but relatable	15
	5. Achievable and challenging goals	16
	6. Creative process & hands-on	17
	7. Teamwork	18
	8. Preflection	19
	9. Skill development	20
	10. Concluding the work	21
	11. Physical reminder	22
	12. Communicating the goal	23
	13. Reflection	24
	14. Sharing achievements	25



Topic of the workshop

1



The topic of the workshop will draw the attention of your audience and should interest them to apply. Rather than focusing on concrete skills, like learning to work with new materials, the topic can be framed more abstractly or thematically. Through hands-on engagement with the materials, the participants can naturally develop a better understanding of both the topic and the tools.

When to use?

When you are setting the overall goal of the workshop and are ready to decide on the workshop's topic.

What do you need?

An overall idea of the workshop's goal

Action points



Understand the prerequisite level of knowledge about the topic of the participants (Bastiaansen & Duerden, 2024). Consider that this can differ per participant on the STEAM disciplines (Riley, n.d.).



Choose a topic that fits the participants' personal interests and/or goals (Little et al., 2024). This will trigger their intrinsic motivation (Packer, 2006).



Make sure the topic of the workshop is not only discussed at the beginning but is repeated multiple times throughout the workshop.



Make clear the topic is about one or multiple of the STEM disciplines in a combination with Arts to appeal a broader range of participants (Riley, n.d.).



The terminology used to explain the topic, should be directly linked to the activity of the workshop.



A first try out will help understand whether the children understand the topic. Does it fit their level?

→ **Linked instruction:** V. Define the workshop's goal

Example



Figure V: The picture communicated on the Science Centre social media fitting the topic 'experimenting with technology in a creative way'.

Experimenting with technology in a creative way

On social media the following is communicated: "You will creatively work with technical elements, taken from the artwork, to create your own dream creatures that could live in the artwork." Including the picture in Figure V.

In the workshop the facilitator introduces the topic 'experimenting with technology in a creative way'. With it, a few examples of familiar products or activities that fit (e.g. designing with a 3D printer). The facilitator asks the children if they can give more examples from daily life where they recognise this. This was found very joyful for the children, being able to tell the facilitator about their own experiences at home or at school. The topic is revisited throughout the workshop as they reflect on their creations.

12



Personal value

2



The workshop should be designed to align with the participant's values. Three main values are highlighted in this guideline. These fit with the general age group of this booklet, children aged 8-12 years. However, if you have a more niche target audience, it is important to find their specific values.

When to use?

After you have defined the overall goal and the workshop's topic and you are about to set the outlines of the workshop.

What do you need?



Know the values of your target audience.

Action points

Target group specific values

- ☐ Think about how to take these values into account while developing the workshop.

Having fun


- ☐ Use a theme that is perceived as fun by the target group you aim for.
-  Let the facilitator ask simple answerable knowledge questions. This gives some children the opportunity to answer and excel above others.
-  Find or design a way for the facilitator to get excited about the topic as well.

Magical experience


- ☐ Give the children a magical experience through the workshop.

-  Design for a surprise moment or effect.

-  Design for the children to have a sense of discovery and fascination (Packer, 2006).

-  Reflect on the way you want to convey this 'magical' touch. It should fit with the intensions of the organisation and the target group itself.

Contribution

- ☐ The participants should feel like they can contribute to something bigger than themselves (Bastiaansen & Duerden, 2024). This contribution should match their personal value (Bastiaansen & Duerden, 2024).
-  Find a way to ensure that this sense of having contributed to a bigger purpose, stays with participants throughout the workshop.

Example



Figure VI: The magical creature that is used to show how you can use inspiration from nature.

Storytelling

The use of a storyline is how the example workshop uses a magical experience and telling the children they are contributing to a bigger purpose. Iterating on this story by testing and adjusting it helped to reach something fitting for the target group.

Children design and build creatures inspired by nature. Nature is a good theme that fits all children in which they can use their own inspiration and imagination. Figure VI on the left, is the example that is shown to them. This taps into children's natural curiosity about animals and the environment. In the creative part of the workshop, they engage with materials like 3d-printed rings, pipe cleaners, and motors, in a playful, hands-on way.



Sharedness

3



Fostering social connection before the workshop like being able to sign up together with friends or family will enhance the experience.

When to use?

When deciding on the base of the workshop and filling in the steps further.

What do you need?

Know the target group

Action points

- ☐ Allow your participants to share the experience with others they already know. For example, make it possible to sign up together with friends.
- ☒ Design for shared anticipation among the participants before the workshop starts. In that way, there can be a collective expectation and excitement about the workshop (Bastiaansen & Duerden, 2024).

→ [Linked guideline: DG7. Teamwork](#)

Note

For this guideline, the use of the communications functions within your organisation will play an important role. Within the test workshop, this was not tested.

It is therefore recommended that you interpret the guidelines in the way that best aligns with your workshop.



Make it new but relatable

4



Most participants will join a STEAM workshop to learn something new. Nevertheless, it is important to make this new topic or skill relatable to something the participants are already familiar with in daily life.

When to use?

When setting up the outline of the workshop and when detailing out the steps.

What do you need?

- Set of learning goals
- An overview of the workshop's steps

Action points



Understand the participants level of skills and prerequisite knowledge.



The participants should be offered to learn something that is new for them.



Use examples from daily life to explain new information. This will catch the children's attention and help them understand the main theme of the workshop



Let the facilitator ask simple questions about prior experiences / familiar topics as a start that is connected to the workshop's topic. Being able to answer will give a confidence boost.



Make sure the facilitator has the needed examples in the manual, of what you should recognise from at home. These can be used in the explanation to the children.

→ **Linked guideline:** DG 12. Communicating the goal

Example



Figure VII: The slide showing the components the children will work with.

Comparing with home

To explain the function of the materials the children use in the workshop, the facilitator uses the accompanying slide. The first explanation tells how the spotlight works. To clarify, the facilitator clarifies how a spotlight works at home with a light switch on the wall. This comes with an explanation of how the workshop's spotlight should be connected and to make the current flow. Later also other components are mentioned, see Figure VII. The children are asked if they can name devices from home that use those components. E.g. Mixer, spinning motor; Washing machine, spinning motor; Electric toothbrush, vibration motor.



Achievable and challenging goals

5



It is important for a child to feel some sort of challenge in an achievable task, to have a feeling of success (Kohnstamm, 2009; Little et al., 2024). This will support meaningful learning. The following action point will help to balance the difficulty and accessibility.

When to use?

When designing the steps and looking at their details.

What do you need?

Understanding of the materials

Action points

Skill levels



Get an understanding of the variety of skill and knowledge level within the target group. Do the set learning goals fit within the participants abilities? (Bastiaansen & Duerden, 2024).



Keep in mind that some children are more skilled in the STEM disciplines and less in arts, or the other way around. Try to find the right balance for every individual participant.



Consider that some children will finish much faster than others. A facilitator will benefit from a list of extra tasks to give the children.

Break it down



Use scaffolding: break down challenges into smaller steps to offer varying skill levels and allow each child to progress at their own pace.



Make sure it does not take effort to learn something new during the workshop (Packer, 2006).



When using a lot of new materials or information that is new to the children, make sure they do not get overwhelmed by this. For example, don't introduce all the new materials at the same time, but over a wider time span.

Personalise



Design for the availability of choice. This allows participants to personalise and provide themselves with the appropriate level (Packer, 2006).

Guidance



Think about how, in the difficult parts, the children can help each other. Or if the workshop is set-up with the presence of a parent, they can help the children with difficult activities.



When participants are given a broad assignment they may need more guidance. This guidance can be done through the facilitator or through the design of extra tools.

Example

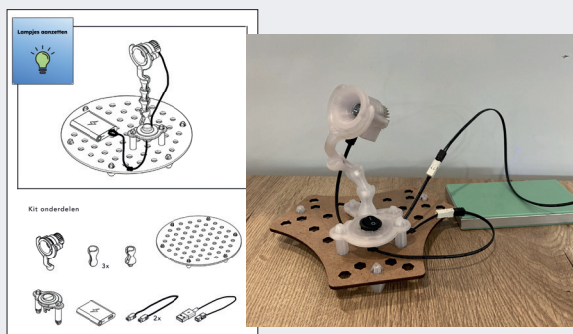


Figure VIII: On the left, the manual on building a light. On the right, a light assembled as explained.

Steps of the workshop

In the example workshop, children are challenged to use several technical materials to build their own assembly.

Here, scaffolding is used. The children will firstly learn how the light component works. In this step, they can use a guiding manual showing how to do this. This is shown in Figure VIII on the left.

Secondly, they can figure out themselves how the other components work. Some more difficult than others. Again, they can use a manual to do it.



Creative process & hands-on

6



One of the most important parts of a STEAM workshop for children is directly applying new knowledge in a hands-on way. This will make it fun and help them with insightful learning. Meaning is created when participants can play an active role in the experience (Bastiaansen & Duerden, 2024).

When to use?

When designing the steps of the workshop. Especially the ones in which the materials are used.

What do you need?

Understanding of the materials

Action points

- Let the participants work hands-on and try out what works for themselves. They will learn by doing (McRaney & Russick, 2016).
- Make sure the workshop focusses on the children's process of making and not the perfect outcome of what they make.
- Although the focus is not necessarily on the result, having a tangible outcome will help reach a feeling of proudness among the participants (Little et al., 2024)
- Explaining new theory, should be followed by a hands-on way of learning to make connections between the two (Eason & Linn, 1976).
- Appeal to multiple senses. Think about not only seeing the materials, but also feeling the materials (Packer, 2006).

STEAM

○ Keep going back and forth from the chosen STEM topic(s) of the workshop to the arts, and connect the two through the activities (Riley, n.d.).



Realise that some children will be more interested in one of the STEM disciplines, and some more on the creative part. Find the right balance for your target group and enable personalised focus or use of time.



When testing the workshop, try to discover the children's need for open creative activities. How big is their attention span to work on them?

Example



Figure IX: Children making their own creature using the creative materials

Creative activity

In the example workshop, after understanding the technical materials, the children will start making their own creature. Figure IX shows how this is done. This should be an open activity where they can make whatever they imagine. Therefore it is found fitting if they can dig through the materials and feel like there are infinite possibilities. This is done with the creative box. One big box for each table, including all the fun materials that can be attached to each other so they can make anything they like. Since they already know the materials, they will not get overwhelmed anymore.



Teamwork

7



Working in teams is a big benefit for the participants, making them feel part of a community. Here it is important to reflect on how teamwork helps their project (Bastiaansen & Duerden, 2024). Having this experience with friends can fit their personal values.

When to use?

When filling in the steps one by one.

What do you need?

Know the target group

Action points

- ☐ Consider whether and where teamwork could be useful for the children. How can it be implemented into the workshop's steps?
- ☒ For teamwork, look for tasks that require the children to discuss their plan together. Do not just give each participant a task they can do next to each other.
- ☐ Do not expect for teamwork to occur spontaneously, really think and try out moments in which participants can do a task together. And clearly explain this to the facilitator.

Important to note:

- ☒ When children do not know each other yet, it might not go smooth if they are forced to work together. Testing will help discover what will be a moment in the workshop for children to be able to work together. But don't force it.
- ☒ Within a group, each participant should have the opportunity to feel they are responsible for a part of the project. In this way they can feel proud of having contributed to the group (Little et al., 2024).
- ☒ The participants should have the possibility to excel. The participants benefit from the feeling they perform better than others.

Note

For the following guideline, teamwork did not play a role and was therefore not assessed. It is recommended that you interpret the guidelines in the way that best aligns with your workshop.



Preflection

8



This design guideline helps to design a good and clear introduction of the workshop, where preflection plays a central role. Preflection is about discussing the learning goals of the workshop to align expectations and increase motivation before the workshop kicks off (Bastiaansen & Duerden, 2024).

When to use?

When the outline and the steps have been set-up and the start of the workshop can be designed.

What do you need?

- Set of learning goals
- An overview of the workshop's steps

Action points

Learning goals



Translate the learning goals into a non-educative perspective. Making it fun to talk about which will help to increase the children's intrinsic motivation (Packer, 2006).



Design for the facilitator to be supported in discussing the learning goals with the children. This can be done through the manual or a tool they can use.



Let the facilitator take some time to discuss these goals and new skills with the children. This will encourage participants to think beforehand what they hope to learn (Bastiaansen & Duerden, 2024).

Overview of the steps



Have a way to present the steps of the workshop, giving the children a clear overview.



Consider the medium through which the steps will be presented (e.g. slides, poster, hand-outs). It should fit with the participants.



Make sure the way this overview is presented blends in with the workshop activities and style.



Make the steps visually clear and keep it simple. Focus on the main elements.

→ **Linked guideline:** DG9. Skill development

Example

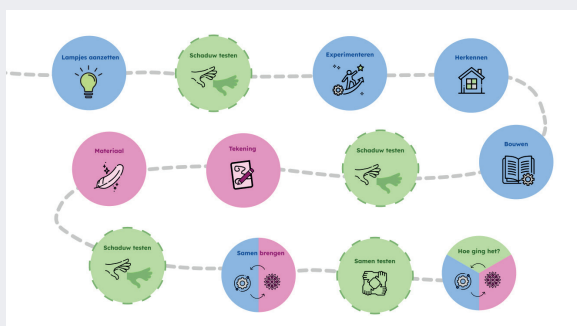


Figure X: Slide showing the step-by-step path.

Step by step path

The example workshop makes use of slides that show the steps of the activities in the workshop, like shown in Figure X. This helps to better guide the children in following their learning path. They are named 'activities' or 'workshop goals' to make it non educative.

The colours within the path show the difference between topics: blue 'technology' steps and pink 'creativity' steps with in between green for 'testing their creations'. This helps to clarify the structure of the workshop, making the balance between creative and technical phases more visible and help to identify the different learning phases.

It also guides the facilitator in explaining the steps. Each step has its own slide with more explanation on it.



Skill development

9



It is time to boost the participants' confidence. Receiving positive feedback is always useful. Making new learning points insightful, will happen when the participant recognise their ability to develop new skills in the past and present. Giving them the opportunity for improvement (Little et al., 2024).

When to use?

When you are detailing out the workshop's steps.

What do you need?

Optional to use the outcome of 4. Preflection in the following action points.

Action points



Acknowledged that the strengths and values are different for every child.



Make sure to repeat what they are learning several times throughout the workshop. Repetition of their new knowledge is valuable for remembering later (Kohnstamm, 2009).



Design so that participants can easily track their progress over time and are encouraged to do this (Bastiaansen & Duerden, 2024).

Reflecting



Design for guidance in reflecting on new skills and a way to understand how these can be used in other situations (Bastiaansen & Duerden, 2024). For example, what can they do with this skill at home?



Have a way for the facilitator or other participants to give positive feedback (Little et al., 2024; Bastiaansen & Duerden, 2024).



Make a clear structure with repeating moments so it is obvious for the facilitator when the tool should be used.



Consider the medium through which the positive feedback and an explanation about their new skills can be communicated. (e.g. reading text, audio, video)



The moment of receiving feedback should not be too short, the children should have the chance to have a moment of reflection.



Standardised feedback might not have much impact. Remind / guide the facilitator in giving personalised compliments as well.

Example



Figure XI: The light token with the shadow behind on the designated spot.

Feedback token

Creating shadows is one of the activities within the example workshop. By using 'shadow making' to receive feedback as well, this activity is linked to the workshop.

The group gets a token, as shown in Figure XI on the left, every time they finish one of the main tasks. The facilitator hands out the token to one child and a flashlight to another.

Within the slides there are open spots to aim for to show they have finished. When the children aim right together audio starts playing. In this way, the whole group receives positive feedback and an explanation about their new skills. The audio uses the same voice that tells the story throughout the workshop.

20



Concluding the work

10



This guideline will help to think about how the workshop can be concluded. With all the new learnings and insights, the participants have gained during the workshop, it is important to have a small reflection moment at the end of the workshop. This will help to strengthen the insight.

When to use?

When detailing out the final steps of the workshop.

What do you need?

- Steps of the workshop
- Overall idea of what the children will learn

Action points

- Give participants the opportunity to receive summative feedback about their work (Bastiaansen & Duerden, 2024).
- Let the participants look back at the tool that will show the steps of the workshop in the reflection phase. It will be beneficial to go over them and find out if they understood the key aspects of the workshop (Riley, n.d.) Once again, repetition can help in strengthening their insights (Kohnstamm, 2009).
- Give the participants time to tell about their failures and be reminded of how mistakes are a natural part of growth (Bastiaansen & Duerden, 2024).
- A simple way to give feedback is talking about 'strengths and improvement points' on what they have made during the workshop. This can be done by other participants or the facilitator.
- If you use a story, try to conclude it in the very last part of the workshop. Any reflectional moment can be done before that, to keep the magical and fun experience high.
- Provide the facilitator with examples of what to discuss about the workshop's learning points.

Example



Figure XII: Slide showing the step-by-step path.

Step by step path

In the example workshop, the slide (Figure XII) was used to explain the steps to the children during the workshop. This is also the final slide, which can be used by the facilitator to reflect at the end of the workshop together with the children.

Questions can be asked like:
 What was your favourite step?
 In what step did you learn something new?
 What step was the most difficult one?



Physical reminder

11



It can be very meaningful for the participants if they are provided with something tangible to take home after the workshop. This helps them to revisit the experience and reflect on it at moments later. It is also something they can show others to tell about the workshop they did.

When to use?

When detailing out the final steps of the workshop.

What do you need?

- Steps of the workshop
- Overall idea of what the children will learn

Action points

- A physical reminder, whether it's a self-made object, a small prototype, or even a piece of material will be fun for the children to take home.
- When deciding on the item, think about how it might trigger conversations with others, extending the impact of the workshop into the participant's personal environment.
- Incorporate some of the learning goals or overall workshop goal into the item, so when looking back, the knowledge is once more repeated.
- Make sure it does not take too much of the facilitators time to hand out, or explain the physical reminder.
- The physical reminder should fit with the workshop, the story and the activities.
- The item they bring home, should be valuable enough that they will not throw it away at home and also small that it does not take up too much space.

Example



Figure XIII: The 'take home' token with the shadow on the wall.

Take home token

Making shadows is one of the activities within the example workshop. To stimulate and remind the children they can play with shadows at home, they receive a token.

This token has a cut out figure of a creature that has been telling the workshop's story to the children. With a flashlight they can see what this creature's shadow looks like. This is shown in Figure XIII. They know how this works since they have used the same tokens during the workshop.

In this way, the token serves as a physical reminder of the workshop itself. It is also a simple tool that can trigger the conversation about the workshop afterwards with others.

22



Communicating the goal

12



Now you have almost finished the workshop and know its learning goals, it is time to let the participants know too! The participants will benefit from knowing what they can expect from the workshop before it actually starts. Not only about what they will do, but also about what they will learn. This allows them to mentally prepare for what they will learn beforehand.

When to use?

When the learning goals are clear, and it is time for sending publicity about the workshop to reach the target group.

What do you need?

- Learning goals
- Decision on the use of type of media

Action points



Set clear learning-goals for the workshop. Growth- and learning-oriented goals are often more effective than performance goals (Bastiaansen & Duerden, 2024).



Communicate the learning goals before the workshop to increase their impact during the workshop (Bastiaansen & Duerden, 2024).



Communicate them in a way that fits the purpose of 'having fun' and does not feel too educational.



Find a way to also communicate these with the facilitator. Enabling them to understand the aim of the workshop.

Note

For this guideline, the use of the communications functions within your organisation will play an important role. Within the test workshop, this was not tested.

It is therefore recommended that you interpret the guidelines in the way that best aligns with your workshop.



Reflection

13



Give the participants the opportunity to reflect after the workshop has finished, and in this way mentally reengage with their experience (Bastiaansen & Duerden, 2024).

When to use?

When detailing out the final steps of the workshop.

What do you need?

Know the target group

Action points

- ☐ Give the participants the tools to reflect on what they have done and achieved during the workshop. This can be through communication channels or a tool they bring home.
- ☒ Think about in what way they can share stories about their growth. And on how this can again be some sort of repetition of their new knowledge as a learning strategy.
- ☐ Make sure the facilitator can explain to the children how they can use their new learned skills at home. What materials can they use? Are there examples?

Note

For this guideline the use of the communications functions within your organisation will play an important role. Within the test workshop, this was not tested. It is therefore recommended that you interpret the guidelines in the way that best aligns with your workshop.



Sharing achievements

14



It is important to celebrate the achievements with others. This can be with other participants or people at home. Little et al. calls this the cheer squad (2024).

When to use?

After the workshop has been designed, and the before and after communications are developed.

What do you need?

Know what the children will create

Action points

- ☐ Think about a way the participants can share their work with others. This can facilitate as a moment of proudness (Little et al., 2024).
- ☐ In what way can the facilitator play a role in explaining this and putting them to the task to share their work with others?

Notes

For this guideline the use of the communications functions within your organisation will play an important role. Within the test workshop, this was not tested. It is therefore recommended that you interpret the guidelines in the way that best aligns with your workshop.

Since this is about the communication the participants have after the workshop with others about their experience. If your organisation depends on word of mouth, make sure you keep this in mind while using these final design guidelines.

Testing

Testing your workshop is essential. It helps you spot what works, what doesn't, and why. By observing participants and gathering feedback, you gain insights to refine your workshop and ensure it delivers meaningful, engaging learning for your target group.

Why test:

- **Improve your flow.** Do the steps flow over in each other and is the order logical?
- **Spot practical issues.** Do the materials work as planned? Are instructions clear?
- **Discover how the children experience the workshop.** Do you reach your goal?
- **Is it doable for the facilitator?** Is the manual understandable?

If you have never tested a workshop before, you can use the following recommendations:

Recommendations

Before the test:

Test group

Find a group of children to participate.

Tip: To evaluate the flow, you don't need a big test group. A workshop with 3–5 children can offer valuable feedback. If you want to evaluate the experience, a bigger test is recommended.

Facilitator

Find a facilitator who can give the workshop and closely represents the real facilitator you plan to use. So, you as a designer can observe and discuss details with the facilitator later

Tip: To prepare the facilitator, a complete walkthrough of all the workshop steps prior to the first test is recommended. This serves as a valuable pre-test to identify and solve unclear parts and find gaps in the workshop design.

Evaluation materials

If you want to specifically evaluate the experience of the children, it is recommended to use evaluation materials.

Examples are:

Pre- and post-questionnaires These can show differences in feelings and knowledge between for and after the workshop.

Simple interview questions. Conduct simple interviews with the children afterward. Keep your questions short and open-ended, such as:

- What did you enjoy the most?
- What was new for you?
- What was the most difficult?

Note: Evaluating with children can be challenging, but not impossible. In fact, many children enjoy filling out questionnaires.

Tip: Take another look at the 'Experience layers model', this will help in the development of evaluation materials.

During the test:

Observation

The most important thing is observing the workshop. Watch how the children interact with the materials, each other, and the facilitator. Are they engaged? Confused? Excited? These cues reveal a lot.

Tip: Write down some observational points you deliberately want to look at.

Tip: Encourage the facilitator to use the manual as they see fit, trusting their expertise. Any changes can be discussed afterward.

After the test:

Evaluate

After the test, write down what you noticed.
What went well?
What could be improved?

Keep in mind: above all, it's important that the children have fun! Use this reflection to adjust your workshop before the next and maybe real run of your workshop!

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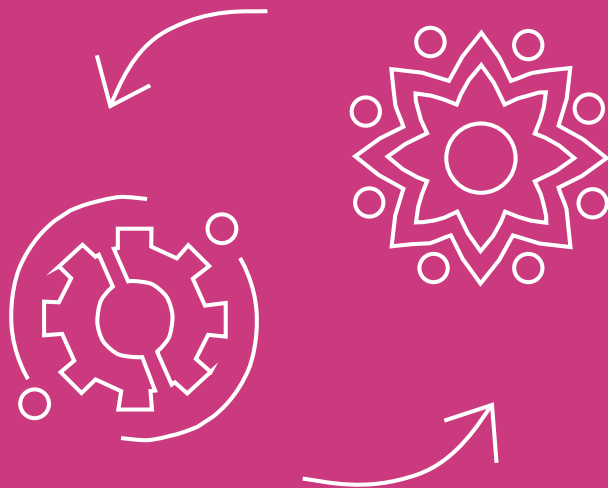
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Use this booklet when your aim is not just to design 'any' STEAM workshop, but to create a workshop that offers children a meaningful experience. It's about designing the right conditions to make an impact. A workshop where children feel curious, engaged, proud, or inspired, and where the experience stays with them even after the workshop ends.



5.3 An expert view on the final design

The content of the STEAMingful design tool was examined through a case study. To also evaluate the usability of the designed booklet, a final review was conducted with three individuals, each having a different expertise. This section explains the evaluation approach and key outcomes.

Goal

The goal of this evaluation was to gain insight whether the booklet can effectively function as a support tool for developing STEAM-based workshops. Particularly if they are adaptable for any workshop, taken the fact they have been designed using only one case study.

Approach

It was reviewed by three individuals from different fields:

- Reviewer 1: Experienced workshop developer.
- Reviewer 2: STEAM specialist.
- Reviewer 3: Team leader of education at the Science Centre (only did a brief scan through the booklet).

The reviewers had varying levels of prior knowledge. Reviewer 1 and 3 were already familiar with both the workshop used in the case study and had some understanding of the guidelines. Reviewer 2 an external reviewer with no prior knowledge of the case study.

They were given the full version of the booklet in advance and asked to read through it. A one-on-one meeting was planned with every reviewer individually. The meetings were done in person or by phone.

The conversations were very open, asking the reviewers about their main insights. All reviewers had taken notes while reading the booklet, which supported a smooth discussion. The goal of the conversation was explained to them as 'a need for an expert's perspective on the design'.

Guiding questions

About the booklet:

- Is the introduction, including the purpose, clear?
- Is it flexible and open to interpretation?

About the guidelines:

- Are the guidelines easy to follow and feasible?
- Which ones were confusing or not useful?
- Is there anything essential missing?

Key insights

Several positive aspects about the concept and structure emerged from the meetings, as well as consistent suggestions for improvement across all reviewers. Detailed notes from each conversation can be found in Appendix M, including detailed aspects of the design guidelines.

In addition to these insights, some minor issues were identified, such as unclear explanations or small errors. These have already been adjusted in the final version of the design.

Target user

According to all reviewers, the booklet is written general enough and can be used in any kind of STEAM workshop. "The booklet is very complete" (Reviewer 1) which makes it particularly helpful for those new to workshop design or without a pedagogical background. However, as Reviewer 3 explains, for a more experienced developer, e.g. someone who is trying out STEAM but has developed many workshop before, it is too much.

All reviewers suggest adding a "quick-start guide" (Reviewer 2) or an "overview" (Reviewer 3) to support users who are already familiar with workshop design but are specifically interested in STEAM integration. Who already know much about the pedagogical side but are interested in adding technology for example.

Overview Tool

So, although the booklet encourages selective use of guidelines, some reviewers found the number of choices overwhelming. "How do I make a choice?" (Reviewer 2). A visual overview or roadmap would help users decide where to start.

Reviewer 1 says "Imagine I get this booklet, I would very much like to have a quick overview of the most important things. Then, I can take a look at what I think is interesting to use. And I don't have to read the whole booklet." In that case, with the academic point of view the tool could be a very useful reference book when looking into details.

According to Reviewer 1, adding an overview will be like offering "another way of working". With this it will be like an IKEA manual. You can easily use it when you want to follow everything step by step. But you can also start

developing a workshop from the overview and use the booklet whenever you are stuck.

Reviewer 2 noted: “Think - Do - Share, this is what STEAM is all about, and this is very well reflected in your booklet. Maybe it can also be used for the overview.”(translated from Dutch).

Using these phases:

- Think: Process and reflection
- Do: Hands-on creation
- Share: Communication and collaboration

STEAM

According to Reviewer 2, the STEAM specialist, the booklet is well-aligned with STEAM principles. It shows to that the booklet was developed with knowledge about STEAM in the right way. However, it is missing a clearer explanation of what STEAM is for first-time users.

Additionally, it is important to recommend to the developer to begin the workshop with technical familiarization. And from this basic knowledge, the creative application of the materials can follow.

Structure of the booklet

The reviewers agree that the structure is logical. A remark from Reviewer 2, is to use the introduction to explain just a little bit more and try to give less action points. “Right now it feels like I have to make decisions about what I will do, however the booklet should have made these decisions for me” (Reviewer 2).

Icons were helpful to Reviewer 1 but overlooked by the others suggesting their function could be clarified.

Examples

Examples, currently based only on the case study, were sometimes hard to relate to. Especially for Reviewer 2, (with little background information) who could name optional examples for each DG (see Appendix M2). Also for the DGs that now only have a ‘note’.

Reviewer 1 explicitly mentions the usefulness of ‘example question for the facilitator’ given in the example in DG12. This could be done in more examples.

Learning objectives

Although designed for out-of-school contexts, the tool could also be valuable in formal education. Teachers would benefit from guidance on integrating learning objectives while using the tool. Making the tool useful for this target group, will also increase the number of users.

5.4 Launch of the workshop

During the final phase of this project, the Science Centre began implementing the workshop independently and has already launched the first few sessions (see Figure 92). The first official workshop was held on April 27th. Early feedback suggests that the children enjoy the experience, which already makes the workshop a valuable addition to the Science Centre's programme.

The launched version of the workshop was compared to the recommended version used in Workshop Test 2. It is part of the evaluation to assess whether the key steps, especially those closely linked to the design guidelines, were implemented, and to understand the reasoning behind any changes.

While most of the steps of the main framework were adopted, some of the 'open elements' parts such as the take-home element, the tool to show the steps of the workshop, or the story itself, were simplified or skipped. These changes were made for various practical reasons, specific to each element (e.g., time constraints, design capacity).

Although the adjustments are understandable, they also mean that the design guidelines were only partially applied, which may reduce the intended depth and meaningfulness of the experience.

Reflecting on these choices offers several new insights. Appendix M provides a detailed overview of the guidelines that were not fully implemented, what step they relate to, and what the consequences are for each.

A short evaluation conversation was done with two facilitators who had given the workshop two times. They also pointed out several missing elements that align with the findings of this comparison.

Example

In the launched workshop, the step-by-step path was left out. However, the facilitators mentioned that they would like some guidance in explaining the workshop activities to the children and having a clear overview (Student facilitators, personal communication, 2025). This aligns with what DG5.Preflection identifies as an important need. The Science Centre chose to leave this tool out for two main reasons:

- There was not enough time to finalise it into a design that fit the Science Centre's visual style.
- They preferred not to use a digital presentation during the workshop.

Key insights

Understanding the Science Centre's choices and knowing the guidelines values, key insights were found useful for future improvement of the tool:

- If developing a new workshop tool is too time-consuming or does not align with the workshop's goals, developers should remember: it doesn't have to be complicated. For example, a tool like the step-by-step path could simply be visualised in a single slide to offer a clear overview.
- The way certain elements are explained to facilitators matter. The facilitator manual should be extremely clear, practical, and easy to use during the session. It may help to clearly highlight which elements are essential to discuss with the children.
- If changes are made to the workshop after testing, it should be considered that some design goal may be compromised. Alternative ways could be explored to still achieve the intended effect.



BEZOEKERS - 8 tot en met 12 jaar

Techniekstudio: Experimenteren met kunst

Tijdens deze workshop maken kinderen hun eigen kunst en droomwereld geïnspireerd op het grote kunstwerk in de entree [ARIA](#). Je gaat creatief aan de slag met technische elementen, die uit het kunstwerk komen, om je eigen droomwezens te maken die in het kunstwerk zouden kunnen leven.

→ Koop kaarten

Figuur 92: The website's explanation about the workshop, as it is launched.

5.5 Conclusion

This chapter has presented the final design 'The STEAMingful Design Tool'. A booklet designed to support the development of STEAM-based workshops in a practical useful way. The name combines "STEAM" with "meaningful," reflecting the central aim of this tool: to help create learning experiences that are not only fun but also insightful and relevant to young participants.

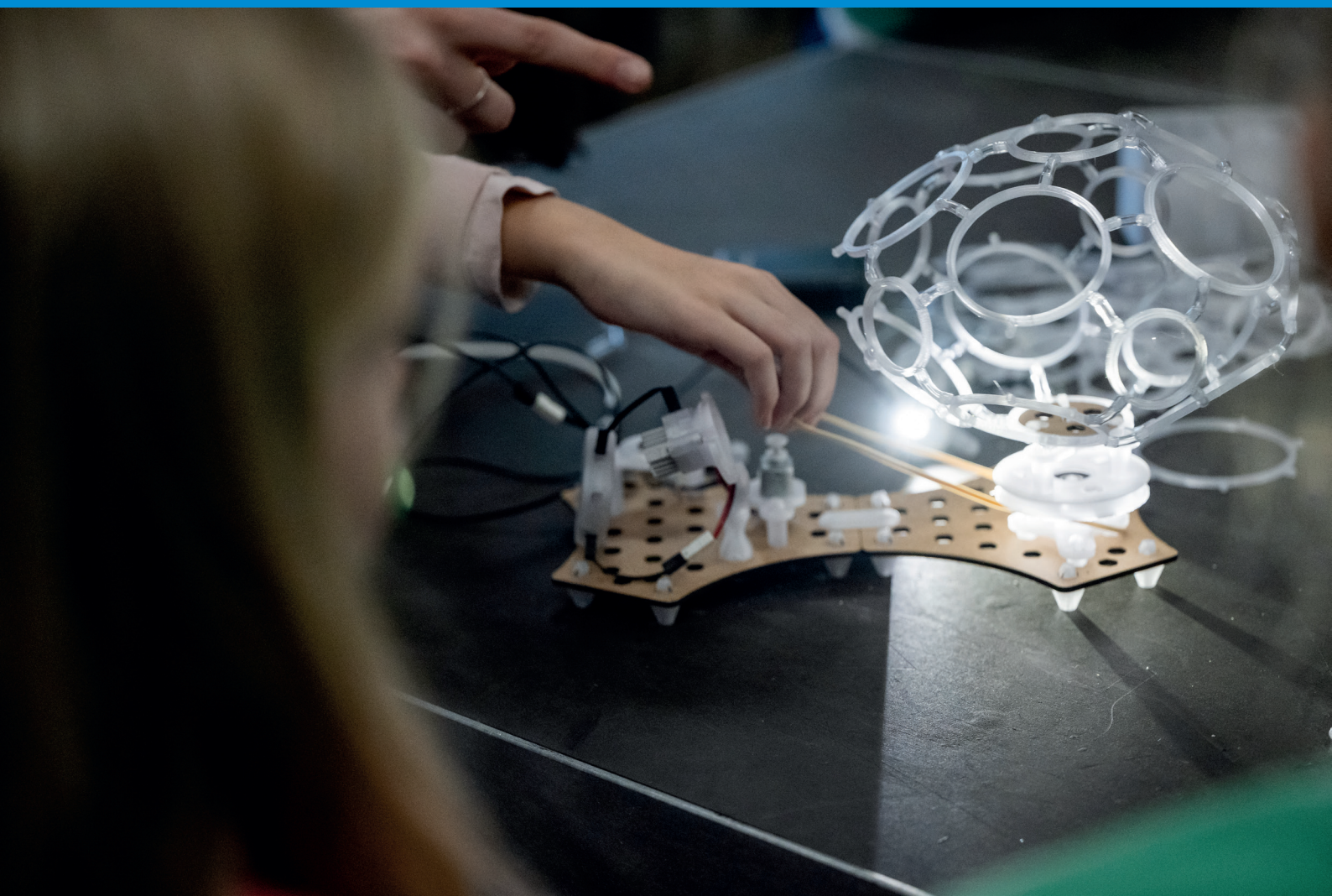
The final evaluation with three individuals, each having a different expertise, has provided important insights for future iterations of the booklet. Most important insights:

- The booklet is a valuable tool particularly for users who are new to workshop design or lack a pedagogical background.
- For more experienced users, the current format can feel too detailed and overwhelming. To address this, all reviewers recommended adding a visual overview or quick-start guide. The booklet can then be used as detailed reference.
- The structure of the booklet is generally seen as logical, and its alignment with STEAM principles is strong.
- The examples could be improved including more varied and relatable examples

These insights show the booklet can reach a wider audience if a few adjustments are made to suit different experience levels and needs.

Furthermore, a short comparison with the already launched workshop has resulted in a few insights that could help with small adjustments that can support clarity and impact. Highlighting the use of simple workshop tools and clear communications with the facilitator.

After these evaluations, the best way to further improve the tool is by letting real workshop designers use it in their own context.



Chapter 6

Conclusion and recommendations

Section 6.1 presents the concluding insights of this research, while Section 6.2 offers recommendations for the further development of the design guidelines.

6.1 Conclusion

6.2 Recommendations

6.1 Conclusion

This research project explored how to develop STEAM-based workshops that provide children aged 8–12 with a meaningful experience at the Science Centre. This resulted in the creation of the STEAMingful Design Tool. This practical booklet supports workshop developers with 14 research-based design guidelines, accompanied by instructions and examples. It also incorporates the through research designed 'experience layers model', which is used for goal setting and evaluation. The booklet is structured around the experiential phases of a workshop: before, during and after.

The tool was developed and iteratively refined through a Research Through Design approach, which combined literature review, expert input, observational studies, and a real-world case study at the TU Delft Science Centre. Testing it through the development of the 'Experimenting with Art' workshop demonstrated that the tool can be effectively applied to the design of a Techniek Studio. The use of the 'experience layers model' helped identify signs of children reaching layers of meaningfulness, although the longer-term impact on sustained interest remains difficult to measure during the workshop itself.

Final evaluations with experts from different fields indicated that the tool is especially useful for novice workshop developers that need step-by-step guidance. To better serve experienced designers, an additional quick-start visual would be very beneficial. Furthermore, including varied examples would improve clarity for all users. With a few adjustments, the tool can meet the needs for a broad range of users.

Ultimately, this project delivers both the framework of the already launched Techniek Studio and a research-informed design tool with potential for broader application. With further validation in diverse informal learning settings, the STEAMingful Design Tool could contribute to the development of future STEAM-based workshops at the TU Delft Science Centre and beyond.

6.2 Recommendations

The defined scope and timeframe of this project imposed some limitations. Throughout all phases of this project, especially the evaluation, many new questions and opportunities emerged. This section provides recommendations for potential future research and further development of the design. Some specific recommendations on further development of the workshop are presented in Appendix N.

Focus on the target user

The key goal of this project, to design a useful, practical tool, emerged throughout later stages in this project. Therefore, this project did not have any focus on the target user of the tool itself. For further development, it is highly recommended to investigate the needs of the target user. Research should explore what kind of tool would be most useful to them and how much time workshop developers are willing or able to invest in the design process. (E.g. to see whether users will take the effort to use the 'experienced layers model' or find it to time consuming.) Such research will likely result in a detailed list of user requirements.

With these new insights, the tool could be redesigned accordingly. Reviewer feedback (see Section 5.3) suggested the following improvements:

- Introducing a 'quick overview map' for easier navigation, focussing on experienced users.
- Adjusting the format of each design guideline (DG) to present more general information and fewer action points for clarity.
- Including examples beyond the current case study, such as the GROOW toolkit, which helps children track their learning process (Steamlabs, 2023). Additional examples are provided in Appendix M2.

It is recommended to test the new design with potential users for validation.

Developing the materials

For some of the design guidelines, the design process was relatively straightforward because the materials were predefined. However, if workshops are developed without predefined materials, research is needed to determine what instructions users need for this.

The case study started with a focus on the materials and then developed a suitable topic. Starting with a topic instead, brings different challenges and may require additional strategies to ensure materials support the intended experience.

Use on an existing workshop

To extend the booklet's reach, it would be valuable to support users who want to apply it to existing workshops. The booklet should guide user in a different way, for example by highlight sections that help make small, efficient adjustments to their workshop.

It is recommended to make a prototype of this and then test it on an ongoing workshop and its developer.

Education Design Research

During a later stage in this project, it was discovered that a lot of research exists on developing educational solutions, known as 'Educational Design Research'. Defined as 'a genre of research in which the iterative development of solutions to practical and complex educational problems provides the setting for scientific inquiry.' (McKenney & Reeves, 2013). It was outside this project's timeframe to look into this, however for further development of the tool, this would be recommended.

Format

During this project, not a lot of research was done into the format of the design tool. A booklet seems to have many advantages. However, other formats, such as a website, could also be useful. A website is very accessible and always at hand. Or maybe a website can be additional to the booklet. Prototypes could be made to discover the preferences of potential users.

Broadening the target group

This project focused on children aged 8 to 12 as the target audience of the workshop developer. However, expanding the age range to 12 to 18 could broaden its use. Further research and testing would be needed, as some elements, such as the values in DG4: Personal Value, are now targeted at the younger group.



Chapter 7

Reflection

Looking back at the total project, I really enjoyed working on it and I am proud of the final outcome! As expected with a design project, it had its ups and downs, but each phase contributed to a new learning experience.

It all started with a box filled with materials and the assignment to develop a STEAM workshop for the Science Centre. This gave me a lot of freedom to explore and define my own direction. Using this materials kit as a starting point was fun, but also quite challenging. The first exploration sessions did not spark much creativity and I felt unsure about where the project was heading. However, after talking to my supervisors, I was encouraged to take another look.

This was right at the time the ARIA was being installed. As a volunteer helping to build the installation, I had the chance to connect with Philip Beesley and his team. They helped me better understand both the artwork and the kit materials. The enthusiasm that Philip and Tanja expressed about my findings gave me a real confidence boost to continue.

What I felt was missing in my curriculum was real-world experience, so I'm especially grateful that the Science Centre offered me the opportunity to develop my graduation project there. It provided a place where I could come to work, have conversations about my project and get help in organising user tests. At the beginning, I explicitly explained (a bit outside my comfort zone) that I could not guarantee to deliver a full developed workshop, because I did not know where the project would take me.

However, I discovered that aligning with the needs and wishes of my client and users, in this case the Science Centre and the children, is something that really motivates me as a designer. This perhaps has also been my blind spot, since I lost sight of my initial goal: to provide the Science Centre with a practical tool to help develop more meaningful workshops.

My Greenlight moment was a moment to look back and discover that the outcomes I had found were of much higher value than I realised. The tested workshops could be used as a case study, which was important to finish this project with a more desirable outcome. This was, after all, the initial goal of my project. In the meantime, the framework I had developed was already being implemented as a real Techniek Studio, with a lot of positive feedback.

Although it took a bit longer than expected, I am very glad I took the time needed to develop a useful guidance tool. While The STEAMingful Design Tool still needs some refinement before it can be used, the final result of this project is something I can be proud of.

I am very grateful for all the help I got throughout this project. From my supervisors at both IDE and the Science Centre and everyone else who contributed along the way. The guidance and feedback, supported to reach the outcome of this project.

Writing was part of this project, on which the use of ChatGPT as a supplementary tool should be mentioned. Used to explore alternative formulations and clarify certain parts of text. I critically reviewed all AI-generated suggestions and adapted them to fit my personal writing style.

At the start of the project, I identified project management as an area in which I felt under-experienced. Involving activities like: preparing meetings with experts, keeping everyone in the loop and planning ahead. Looking back, I can say this experience has shown me that I am capable of independently managing and executing a project from start to finish.

Concluding this master's phase, I can say that this study has shaped my way of viewing the world, teaching me to think logically, creatively, and with a user centred perspective. This project was the final piece of the experience I was looking for as a student and has helped me get ready for whatever is coming next.

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