Key factors to consider in guided tours in STEM subjects for years 6 to 9

A study about successes and failures in guided tours and field trips for middle school students

Master's thesis in Learning and Leadership

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Cover: The visitors centre, two of the telescopes and one of whisper discs at the space observatory in Onsala.

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Abstract

There are several important factors to consider when creating guided tours or field trips at out of school learning sites. When these visits are constructed to suit students in the Swedish School years 6-9, some factors seem to be particularly important. The aim of this thesis was to, through a literature review as well as qualitative data collection, extract these key factors to consider. The key factors were also used to create a concept for guided tours at the space observatory in Onsala, which aimed to be an example of how the key factors can be translated from theory to practice.

The result consisted of two main parts. A total of 13 key factors to consider in guided tours or field trips were created with the support of interviews with guides and educators at out of school learning sites. These key factors range from what the role of the visiting school teacher should be to what content should be covered, the importance of building relationships and more. A recommended concept for the guided tours at the Onsala Space Observatory was then created through an iterative process where the key factors were considered. This also resulted in a collection of activities with a negative outcome. This concept can be seen as an example of how to implement the key factors and as a package for the observatory to use in the future.

Keywords: Outreach program, STEM, Guided tours, Field trip, Astronomy, Middle school, Out of school learning site, Research infrastructure, Science capital.

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Glossary

In the report, the following terms and acronyms are used:

Guided tour and field trip	Throughout the report, these terms will be used together and/or interchangeably. These terms refer to the procedure that happens at and around an out of school learning site, specifically during visits that involve some level of arranged activities and/or guiding.
Out of school learning site	A place where guided tours or field trips take place. In the context of this thesis, this can be a museum, science centre, research facility or a relevant workplace.
Outreach program	A broader term referring to the activities, tours and trips that an organisation conducts to inform and engage e.g. a school.
Participant, student, visitor	Throughout the report, these terms are used interchangeably since the focus is on participants or visitors in school years 6 to 9.
Research infrastructure	A tool used by researchers. This can range from physical research sites to digital databases and more (Vetenskapsrådet, 2018).
School curriculum	Can refer to the more general plan of education throughout all subjects (Läroplanen), or specific plans for education and contents within subjects (Kursplaner), and is developed by the Swedish National Agency for Education (Skolverket).
Science capital	A term covering the extent of cultural and social knowledge in science as well as scientific behaviours and practices. It is frequently used for describing what participating students gain from a guided tour or field trip within STEM subjects (Archer et al., 2015).
Science centre	An interactive museum or exhibit focusing on science education.
STEM	The term STEM includes subjects within science, technology, mathematics and engineering. As this thesis focuses on the Swedish school years 6 to 9, the subjects are more specifically biology, chemistry, physics, technology and mathematics.

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1
Introduction

1.1 Background

The space observatory in Onsala, a part of Chalmers University of Technology, regularly conducts guided tours for varying age groups showcasing their research infrastructure. The tours include a presentation in their seminar room, a few telescopes and a visit to their recently built visitors centre. Due to the employment of a new guide and more resources used towards guided tours, there has been an increase of guided tours at the observatory from 2025. At the same time, the observatory has had difficulties finding research papers regarding what makes a guided tour, at a place with research infrastructure such as the observatory, a good guided tour. Due to this, and a lack of resources, it is uncertain whether the current concept for guided tours is the most effective one. Furthermore, there are challenges in strengthening motivation, interest and learning at visits by students in years 6 to 9 (ages 12 to 15). Therefore, there is a demand to investigate factors to consider in guided tours both at Onsala, at research infrastructures and at other places where guided tours within STEM subjects take place.

Even though not much research has been done directly relevant to the context of the observatory, guided tours in general within STEM subjects have been analysed by several researchers. Some prominent researchers are DeWitt and Storksdieck (2008) and Cox-Petersen et al. (2003), who mainly focus on learning during field trips. Research has also largely been done about the importance of social interaction during field trips (Falk and Dierking, 2012). This thesis aims to build on this (and other) previous research, combined with experiences from people in the field, to create a more comprehensive collection of key factors to consider during guided tours and field trips.

1.2 Aim

The aim of this thesis is to, through a literature review as well as qualitative data collection, extract key factors to consider during a guided tour or field trip. The hope is that these key factors will portray a more nuanced view of what works well during a guided tour or field trip and what does not. For out of school learning sites, these factors will hopefully function as a guide for a successful guided tour or field trip and result in better support for guides and teachers, better engagement from participating students, more effective use of time during the visits and more.

Another aim of the thesis is to use the extracted key factors to create new recommended materials and concepts for how the guided tours at the Onsala Space Observatory can be done. This will create a base for the observatory to conduct more structured and engaging tours with their new resources and visitors centre in the future.

1.3 Specification of issue investigated

The thesis investigates key factors to consider during a guided tour, conducted within the STEM subjects for visitors in the Swedish school years 6 to 9.

More specifically, this is split into:

- What possible key factors to consider exist?
- Within those key factors, how is the outcome of the guided tour affected by different strategies and implementations?
- Finally, how can these key factors be realised and implemented at the space observatory in Onsala?

1.4 Delimitations

This section covers the delimitations of the investigated issue.

- The thesis mainly focuses on Swedish school years 6 to 9, although results from the literature review and data collection regarding younger and older students have been included if deemed appropriate.
- The school and education is mainly based on the Swedish system throughout the thesis.
- The participating out of school learning sites are all in the geographical area surrounding Gothenburg, Sweden.
- In the early stage of the thesis, the data collection has mainly been done at out of school learning sites in the form of interviews with guides or teachers working there. Students and regular teachers were not involved until later in the thesis, during the testing phase, by being observed and giving feedback on the concepts tested at the space observatory in Onsala.
- The key factors were tested at the Onsala space observatory where the possibility for a representative sample of students and teachers was limited.
- Since the main data collection was done to extract key factors, the evaluation of the implementation at the space observatory in Onsala was not done as rigorously as the main data collection.
- Today, many out of school learning sites also visit the schools and conduct programs within the classroom, or virtually. This is not considered in the thesis, which solely focuses on physical field trips and guided tours.

2

Literature review

The aim of the literature review was to identify key factors to consider during guided tours or field trips in current research. For this, papers were found using keywords such as *outreach*, *guided tours* and *field trip*. After discarding irrelevant papers, a systematic qualitative textual analysis was done (Esaiasson et al., 2017, pp. 213–214), where 11 themes were extracted. The 11 themes provide a baseline for the later analysis, and can be considered a preliminary version of the ”key factors”.

Aside from the 11 themes, some general background about the connection between guided tours and outreach programs as well as the ”science capital” concept is covered in this section.

2.1 Guided tours and field trips in outreach programs

There is a need to bridge the gap between higher education and STEM with the community, schools and the general public. This can be done through outreach programs (Vollbrecht et al., 2024, p. 1). The term ”outreach program” is a general term covering both in-classroom and out-of-classroom activities. In the context of this thesis, outreach programs are conducted at the space observatory in Onsala through guided tours and public events (Chalmers University of Technology, 2025). One reason for this program is the mission of Chalmers University of Technology. A part of the mission is to ”educate and conduct research so as to create and disseminate knowledge, skills and solutions based on scientific evidence that benefit both individuals and society in both the short and the long term” (Chalmers University of Technology, 2024). To gain a broader perspective on outreach programs, this section will now cover a few different views on and ways to conduct outreach programs.

Outreach programs can be conducted both within the classroom and outside the classrooms. One example of outreach within a classroom was the program ”Brain Explorers” where medical students, at Western Michigan University Homer Stryker M.D. School of Medicine, conducted lessons about biomedicine and neuroscience for middle school students (Vollbrecht et al., 2024, p. 2).

At the Sanford Underground Research Facility in South Dakota, USA, outreach programs are done through physical and virtual field trips but also through the creation of curriculum units, a focus on career exploration and professional development

for teachers (Horn and Woodward, 2023, p. 3). It was also argued that school field trips may not always be the best option for outreach as creating curriculum models have a stronger long term impact (Horn and Woodward, 2023, p. 4). Furthermore, it is important to put a focus on schools usually not reached by the outreach program, such as schools with younger students in rural areas. To involve students who belong to groups that are under-represented in outreach programs, a meta study by Ní Chorcora et al. (2023, p. 16) suggest combining disciplines (cross-collaboration) rather than regular guidance, perhaps by gamifying a concept.

There are several positive consequences from outreach programs. Outreach activities that are carried out by researchers (as opposed to teachers) can help students re-evaluate misconceptions about science, such as chemophobia (Sáez-Hernández and Ballesteros-Garrido, 2024, p. 1639). One reason found is that it engages students to have conversations about scientific matters that concern them (Sáez-Hernández and Ballesteros-Garrido, 2024, p. 1640). Outreach programs also seem to have a positive effect on students' sense of wonder and topic knowledge, while critical thinking is not affected to the same extent (Richard et al., 2022, pp. 15–16). For outreach programs to still be effective, it is important that they keep the schools and their students in mind, and address their needs and goals when designing activities (Luecke et al., 2023, p. 6).

2.2 Science capital

The concept of science capital goes further than knowledge or skills within science. It builds on the concept of cultural capital which originally captured opinions, taste and practices within art (Archer et al., 2015, pp. 925–926). Archer et al. (2015, pp. 929–932) created an initial framework for science capital consisting of scientific *cultural capital*, scientific *behaviours and practices* and scientific *social capital*. The first (*cultural capital*) part includes scientific literacy, but also the insight that science can help you in your daily life or in your career. Meanwhile, scientific *behaviours and practices* include consumption of science-related media and visits to museums, science centres and other relevant sites. Finally, the scientific *social capital* include science identity, discussing science with others, your background, knowing a researcher and more. All these factors build the science capital in a person.

Archer et al. (2015, pp. 933–934) measured the degree of science capital of students by using variables connecting to the above framework. This resulted in a "science capital score". A few of these variables were:

- Future science aspirations.
- Attitudes to science.
- Valuing museums.
- Valuing science.

2.3 Key factors to consider according to current research

From a range of papers and books regarding outreach, guided tours and field trips, a total of 11 themes were extracted. These themes each contain the most prevalent aspects in current research, and can therefore be seen as a baseline for what factors to consider during a guided tour.

The key factors found in the literature review are shown in figure 2.1, and are considered preliminary key factors. Each key factor is illustrated with descriptive examples to clarify its content.

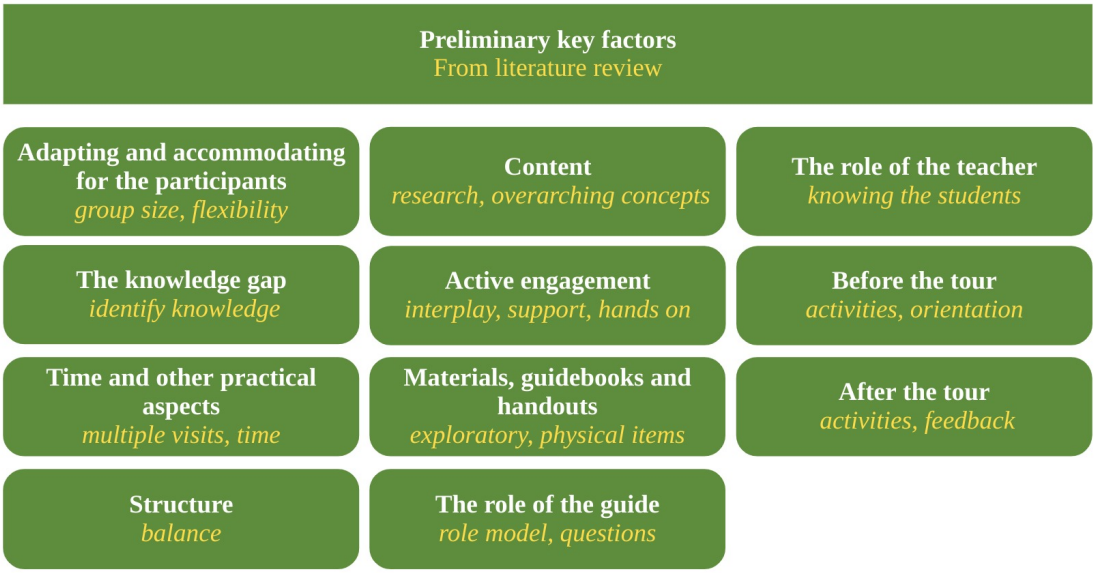

Figure 2.1: Preliminary key factors found in the literature review in white, with descriptive examples in yellow.

2.3.1 Adapting and accommodating for the participants

One aspect regarding the participants is the size of group during the tour. Smaller group sizes are associated with better outcome, which is also possible to achieve by splitting larger groups into smaller (Powell et al., 2022, pp. 345, 349; DeWitt and Storksdieck, 2008, p. 185). If the group is larger, Cox-Petersen et al. (2003, p. 212) suggested that students should be divided into smaller groups during a guided tour, in order for the students to be able to actively participate in the activities. In order to make this possible, not only the main guide but also other adults (teachers etc.) need to be prepared for this in advance to be able to support all student groups.

It is also important to be flexible and be able to adapt the tour to suit different learning styles and specific needs (Acut, 2024, p. 10). Different needs regarding

culture, language and disability should be considered by the tour guide during a guided tour. The content and language used during the tour should be adjusted with regards to these aspects (Cox-Petersen et al., 2003, pp. 206, 215). The content should be adapted to the age and interest of the participants (Cox-Petersen et al., 2003, p. 214). One way to use the right language and vocabulary is by laying out a list of terms that are appropriate for a specific audience with a certain background. This makes sure that they understand the content and can engage in the activity (McKee et al., 2019, p. 3). For younger students, only a few more complex words was suggested to be used (Cox-Petersen et al., 2003, p. 212).

When creating a guided tour with inclusion in mind, it is still important to maintain the academic rigorousity (Gilley et al., 2015, p. 2). By keeping the subject relevant and at the same time adapting the tour to suit the abilities of the participants, the main focus can be the subject at hand instead of physical or psychological hindrance.

2.3.2 The knowledge gap

For a guided tour to be successful, the tour guide should identify what the students already know and don't know, and then adjust the tour from that (Chitima, 2024, p. 11). Not only prior knowledge, but also the agendas and interests that the students have before a field trip or a guided tour have an impact (DeWitt and Storksdieck, 2008, p. 185). Working with the gap between knowledge from school and content covered in a field trip or outreach program can be challenging, since this gap can be large (Broß et al., 2021, p. 5). A possible strategy to bridge the gap is to utilize the teacher (Krange et al., 2019, p. 257). Krange et al. (2019) has shown in their study that teachers are better at encouraging students to use their prior knowledge to draw new conclusions and framing activities in a manner that the students understand than tour guides. Broß et al. (2021, p. 4) also mention context and framing to be an important aspect for utilising students prior knowledge. They suggest using doctoral students in addition to teachers.

2.3.3 Time and other practical aspects

Of course, also practical aspects need to be considered when preparing for a tour, field trip or similar (McKee et al., 2019, p. 3). These include the setting type (formal or informal), budget, type of audience and more.

The time of the tour/visit as well as the number of visits conducted with the same group is a recurring practical aspect. According to Haddad et al. (2024, p. 8), only one field trip is insufficient to assimilate what the students have learned previously in the classroom. Several visits to a museum makes it easier for students to remember the museum later (Falk and Dierking, 2012, p. 159). DeWitt and Storksdieck (2008, p. 183) also argue that multiple visits are beneficial. However, it is not impossible to have a great impact from only one visit. It is also beneficial if the tour guide does not rush the students through the tour (Chitima, 2024, p. 13), and shows consideration to the limited attention span of the students. A prolonged monologue

is not a good idea (Chitima, 2024, p. 15).

In general, time is an important aspect for museum visits and alike, since not only the time for the visit matters but to understand the entire experience from a visit it is necessary to pan out and analyse a longer time frame (Falk and Dierking, 2012, p. 29).

2.3.4 Structure

The degree of structure can have an impact of the success on field trips. There is a balance between structure and free exploration, and while structure may increase cognitive learning, it can also decrease interest (DeWitt and Storksdieck, 2008, pp. 185–186). Blanchard (2017, p. 3) argues that the program, tour or similar should be very structured but still flexible. Further, the use of smooth transitions between program elements are also associated with better outcome (Powell et al., 2022, p. 345).

2.3.5 Content

There are several aspects concerning the contents of the tour, outreach program or similar. One such aspect is the need to connect the contents of the tour to the real world and the classroom curriculum. It may for example help students connect more complex concepts to more hands on objects and ideas (Blanchard, 2017, p. 2) and make the tour or trip more memorable (Falk and Dierking, 2012, p. 159). This connection can be created by constructing the content and pedagogy from a student perspective (Cox-Petersen et al., 2003, pp. 207, 215). To create a beneficial connection with the classroom and curriculum, it is also necessary to be sensitive to the needs of the teachers regarding objectives, aims and practice (DeWitt and Storksdieck, 2008, p. 188). They often know what kind of things students want to investigate and how to make the content understandable through analogies (Warwick et al., 2020, p. 3).

During a guided tour, focus should be on overarching concepts rather than on facts, to create a deeper understanding and to encourage open-ended questions and discussion (Cox-Petersen et al., 2003, pp. 214–215). The same study suggested that the education of museum educators might be problematic, since a lot of focus is put on facts (Cox-Petersen et al., 2003, p. 211). Behrendt and Franklin (2014, p. 239) suggested that a common mistake when designing a tour is that the exhibition simplifies the content too much and therefore hides the real science.

Other strategies for effective use of content during a tour is to let students experience the content through a different medium such as art (Raaijmakers, 2022, pp. 51–52), establishing strong connections to the local community and environment (Horn and Woodward, 2023, p. 4) and learning about the typical day-to-day work of scientists (Broß et al., 2021, p. 9). It was shown that students were motivated by the latter.

2.3.6 Active engagement

Active engagement is a broad term, and during guided tours or field trips it can occur in many ways. Active engagement can occur through the interplay between peers or between students and adults. It also requires some degree of freedom from the students. Active participation leads to deeper engagement by the students, especially when the activities are associated with real science (Acut, 2024, p. 6).

Higher level of verbal engagement with students is associated with better outcome, according to Powell et al. (2022, p. 345). Further, a higher number of visitors seems to reach a state where they are fully engaged with the learning opportunities presented when a guide is present and interactive (Corral et al., 2021, pp. 3, 6). It is important to ponder how the interactions are constructed. Students often need support, or scaffolding, of some kind to be able to comprehend some exhibits and activities (Krange et al., 2019, pp. 258–259). It is important to give students the right amount of support. Too much support tend to lessen interest, while too little support leads to demotivation (Broß et al., 2021, p. 10). Falk and Dierking (2012, pp. 158–159) discussed the importance of social interaction between students during a museum field trip. During those social interactions, students are able to explain their knowledge to others which increases learning. However, when students only rely on their peers to grasp a concept, they might not get a complete understanding, if they can't frame the activity to fit their prior knowledge (Krange et al., 2019, pp. 258–259).

Students tend to prefer learning environments where they have some choice and control over their learning (Coll et al., 2018, p. 21; DeWitt and Storksdieck, 2008, pp. 190–191) They generally feel more comfortable in an informal learning environment, since activities are often voluntary (Behrendt and Franklin, 2014, p. 237). Some amount of free exploration during a museum field trip also creates a sense of choice for the students, which creates opportunities for discussion about exhibit objects with peers (Falk and Dierking, 2012, pp. 159–160). It's also important that teachers involve their students and take their ideas into consideration, as lack of involvement can have a negative impact on their sense of freedom and their learning (Coll et al., 2018, p. 25).

The active participation of students during a guided tours leads to better engagement and focus (Chitima, 2024, p. 11). Chitima suggests for the students to actively participate in the tour by using and working with the objects on show, by discussing, role playing and interacting. Hands-on activities where students are prone to engage also have a positive impact on students' interest, attitude, and motivation, according to Kerzmann et al. (2016, p. 18) and Behrendt and Franklin (2014, p. 235). Active participation was also a suggestion by Cox-Petersen et al. (2003, pp. 214–215). The engagement from students can be on two different levels - overall engagement and multimodal discussion indicative of deeper understanding (Hauan and DeWitt, 2017, pp. 170–172). In order to actively engage the audience in an outreach activity, a lesson plan model could be used. This could be the 5E model (Tanner, 2010) but McKee et al. (2019, pp. 2–3) suggest that the ABC-CBV-RAL model could be used

instead. In this model a subject is introduced with an activity, then follows the concept and important vocabulary. Finally, the ”reading” takes place.

Tasks where students get to partake in the real science are more successful, as the students take ownership of their own learning and thereby increase their intrinsic motivation (Acut, 2024, p. 6). Partaking in real science through interviews with scientists during a field trip resulted in a higher desire for students to work in and study science in the future (Mills and Katzman, 2015, p. 206).

2.3.7 Materials, guidebooks and handouts

The types of handouts and worksheets have an impact on student engagement, understanding and social interactions (Hauan and DeWitt, 2017, pp. 173–175). According to DeWitt and Storksdieck (2008, p. 186), these can either be of a more unstructured type, with more open questions or a survey-type structured worksheet. The latter relates to a more structured field trip in general. The handouts with the strongest effects were however the ones of the GEL-type (guided exploratory learning), where the students are guided through their own exploration (Hauan and DeWitt, 2017, pp. 173–175). These types of handouts resulted in deeper understanding and higher levels of engagement, and can be seen as a middle ground between the open and survey-type handouts suggested by DeWitt and Storksdieck (2008, p. 186). If the handouts were in a paper format rather than digitally, the students tended to invite their peers into their groups and collaboration more often (Hauan and DeWitt, 2017, pp. 173–175).

The handouts can also be constructed in the form of a guidebook, which lays out the steps for the entire field trip including aims, methods, activities, and the equipment to be used (Haddad et al., 2024, p. 9). A complementing teachers guide was also discussed as something positive (Haddad et al., 2024, p. 10). The usage of clear aims and instructions in handouts and observation sheets was also supported by Blanchard (2017, p. 1) who claimed that it resulted in better enjoyment and learning.

The handouts can even include physical items. Cox-Petersen et al. (2003, pp. 212–213) suggested a handout package containing question cards but also some items similar to ones in the exhibit which the participants can touch and feel.

2.3.8 The role of the guide

What type of person should the guide be, and what should the guide do? These are questions that are important to consider during a field trip, guided tour, outreach program or similar. Mills and Katzman (2015, p. 207) discussed the importance of *role models* in the context of a field trip. If students met STEM role models, it strengthened their science identity. A tour guide in an educational context should also take the role as a facilitator of knowledge, where the students can explore the knowledge themselves. This can be done by focusing on questions, inquiry and discourse (Cox-Petersen et al., 2003, p. 210).

This implies that the type of questions asked by the guide is of great importance. According to Powell et al. (2022, p. 345), high quality questions that lead to provocation are associated with better outcome. The types of questions asked by a guide or museum educator can differ. On one hand, the question can be open, where the answer from the participants or the students can be a range of answers (Tigert et al., 2021, p. 2). On the other hand, the question may be closed, where the possible answers are limited and where the length of the answer generally is shorter. Open questions also leads to a dialogic discourse rather than a triadic discourse, where the conversation between educator/guide and participant/student follows a pattern of closed question, short answer and a follow up (Tigert et al., 2021, p. 3). During a study in an industrial history museum, it was found that a majority (around two thirds) of the questions were of the closed type (Tigert et al., 2021, p. 6). Using more open questions leads to better learning and makes it possible for the participants or students to be in the zone of proximal development (ZPD) (Tigert et al., 2021, p. 8). Open-ended questions are also advocated by Cox-Petersen et al. (2003, p. 206), for example in the usage of question cards in smaller groups. The questions should also be adapted to the participants of the tour (Chitima, 2024, p. 11).

Scaffolded support can be implemented in order for a guide to feel comfortable conducting an outreach program. This could be done by having another guide support them when creating or joining the program (Blanchard, 2017, p. 2). This means that both the teacher and the guide play important roles during guided school tours.

2.3.9 The role of the teachers

The teachers involved in field trips or guided tours can have many roles. Aside from joining the tour itself, they can help improve their students' attitudes or even help plan the layout of the visit. It can be useful to consider what support teachers need before a guided tour.

It can be advantageous to involve teachers when planning the layout of a field trip or guided tour (Abramowitz et al., 2024, p. 1844). Teachers often have extensive knowledge of their students abilities, and their input can ensure that the guided tour contains activities that are suitable (Harris et al., 2020, p. 25184). Teachers also have a unique opportunity to know of different learning styles, which guides might not have. (Pompea and Russo, 2020, p. 324). Lack of collaboration between teachers and staff at guided tours may have a negative impact on students learning (Coll et al., 2018, p. 25; Warwick et al., 2020, p. 3). The importance of having dedicated staff working with teachers was also supported by Falk and Dierking (2012, p. 167).

It has been shown that the positive attitude of the teacher before a field trip has a positive effect on the field trip (DeWitt and Storksdieck, 2008, pp. 184, 187). Teachers that have a more positive attitude are more likely to conduct pre- and post-visit activities as well as prepare themselves and the students for the trip (DeWitt and Storksdieck, 2008, pp. 184, 187).

As with the guide, scaffolded support for teachers through support from other teachers or guides is beneficial (Blanchard, 2017, p. 2). Another way to support teachers is by creating a teacher guide (Haddad et al., 2024, p. 10), or by offering professional development for teachers (Falk and Dierking, 2012, p. 167).

2.3.10 Before the tour

Before a guided tour, two aspects need to be taken into consideration. The first is the *pre-visit activities*, where the students prepare themselves for the content covered in the guided tour. The second is the *pre-orientation*, where the students are prepared for what will happen during the tour. The importance of teachers taking time to plan the visits, both regarding how the subject is prepared and taught and what the aim and goals of the visit are, was highlighted by Coll et al. (2018, p. 25).

With a suitable guide for teachers, the students can partake in activities before the guided tour that both fit with the curriculum and enhances learning at the site of the field trip (Lee et al., 2020, pp. 999–1000). It is easier to facilitate such preparations in collaboration with the host organisation (Lee et al., 2020, p. 1003). DeWitt and Storksdieck (2008, pp. 183, 187) also discuss the advantages of pre- and post-visit activities. However, another study based on interviews with teachers and tour guides show that field trips should be able to be held as stand alone activities, and not demand that the participants have undergone the preparing activities (Harlow et al., 2021, p. 7). Further, Harlow et al. emphasise that when preparing activities are issued, it is important that they are designed with the classroom and its ordinary setup and material in mind. Finally, it's noted that preparing activities that are similar to the setup of the guided tour itself is favourable.

Furthermore, giving students pre-orientation before a museum visit prepares them for the learning ahead (Chitima, 2024, p. 14). This refers in part to the practical orientation, as the degree of organisation of the participants upon arrival is associated with better outcome of the visit (Powell et al., 2022, pp. 345, 349). It also refers to process orientation, where students can learn how to better understand and learn from the exhibits (Chitima, 2024, p. 14). The use of process orientation was also promoted by Cox-Petersen et al. (2003, p. 214) who recommended that students should be prepared for how to use a museum or similar as a learning tool and opportunity.

2.3.11 After the tour

Post-visit activities were correlated with more successful and memorable field trips (Falk and Dierking, 2012, pp. 159, 167). They could also enhance the learning (Lee et al., 2020, pp. 999–1000). Post visit activities also make it possible to assess the learning during the event. Vollbrecht et al. (2024, pp. 3–4) suggested three different

ways to access learning from an outreach event. This included post-event assessment, pre- and post-event assessment and spaced pre- and post-event assessment. Vollbrecht et al. (2024, pp. 3–4) suggested the simple post-event assessment approach when the possibilities for post visit activities was scarce. This can often be the case in an outreach event.

There should also be a possibility for teachers to give feedback regarding the field trip or guided tour. An example of how this has been done is brief 90 second interviews (DeWitt and Storksdieck, 2008, p. 191). Several types of feedback should be collected, including surveys and interviews (Broß et al., 2021, p. 10).

3
Methods

This section outlines the methodology used in the thesis. Firstly, key factors to consider during guided tours or field trips were created through interviews with knowledgeable people within the subject. This is covered in section 3.1.

Secondly, a recommended concept of new activities, content and arrangements for guided tours at the Onsala Space Observatory was created. This concept was supported by the extracted key factors. Different variations of the concept were evaluated through a simple data collection consisting of observations and short surveys with teachers, to create one refined concept for the observatory. Section 3.2 covers this.

Finally, delimitations (section 3.3) and ethics (3.4), taken into consideration in the thesis, are discussed in this section.

3.1 Initial collection and analysis of data

During this part of the thesis, key factors to consider during guided tours or field trips were extracted. Together with the preliminary key factors extracted from the literature review, two different sets of key factors were created in this thesis. This chapter concerns the process of extracting key factors from interviews.

Relevant people from organisations where guided tours or field trips within STEM subjects take place (out of school learning sites) were interviewed in a semi-structured manner. The interviews were then analysed through a thematic analysis. While the questions asked during the interviews were partly based on the literature review, the thematic analysis was inductive and therefore a fully separate process from the literature review.

3.1.1 Participants

In total, 19 different professionals at 15 different organisations were interviewed. At two occasions, two people from the same organisation participated during the same interview. 16 of the participants have occupations where they arrange or conduct guided tours or field trips (Educator / guide or Communicator), while three have a larger role with an overview of schools and learning (Person with overview of education). The organisations mainly included research infrastructures, science centres,

museums, industries and treatment plants connected to STEM.

In general, the interviewees were found by contacting a suitable person at a suitable organisation, such as someone responsible for education. Sometimes this person themselves later participated in an interview, and sometimes they forwarded a contact to someone else within their organisation. Almost every organisation that was contacted agreed to an interview.

All participating organisations are Swedish, which differs from the more global representation in the literature review. Furthermore, all organisations are located in, or in close proximity to, the city of Gothenburg. This choice was made to simplify the process of the interviews. It was also considered valuable to conduct the interviews on-site with the interviewees when possible.

Since the issue of the thesis was to find key factors to consider during guided tours in all STEM-subjects, there was a need for the participants to reflect this width. While biology, technology, engineering and physics are widely represented in the interviews, both chemistry and maths are more weakly represented, although not completely missing.

The number of places where interviews could be held were limited. Since it was of interest that the organisations had some degree of STEM focus, not all organisations that held guided tours were suitable. This created difficulties in following the principle of maximal variation, where interviewees are chosen to maximise variation with regards to characteristics such as social status and ethnicity (Esaiasson et al., 2017, p. 271).

3.1.2 Interviews

In total 17 interviews were conducted in the time span of three weeks. In general, the interviews were between 40 and 60 minutes each. The majority of interviews were held on-site, while a few were done remotely. Most were conducted with one interviewee. However, in some cases there were two interviewees in a single interview. For simplicity, the two interviewees in those interviews were regarded as one interviewee throughout the later analysis. For this reason, the number of interviews was less than the number of participants.

Since the purpose of the interviews was both to get a widened perspective and to understand the different viewpoints of guided tours and field trips that the participants have, the interviews were constructed as a mix of key informant and respondent character. Therefore, the interview questions were partly constructed to receive information and partly to initiate discussion about different aspects, opinions and viewpoints regarding field trips and guided tours (Esaiasson et al., 2017, pp. 272–273). Mixing two distinct types of interviews might cause problems to arise, such as the difficulty knowing whether a statement by an interviewee is a fact or a viewpoint. It might also be difficult to know whether an answer arises from the cul-

ture of the interviewer or the interviewee (Gabor, 2017, p. 3). However, due to the time constraint and the need for both types of answers, this was deemed the best solution. Throughout the interviews and analysis, the mixing did not cause any issues.

A few of the questions of informational character were as follows:

- *When a class visits your site, explain what generally happens.*
- *Explain the prerequisites and knowledge the students usually have before the visit. How do you work with this? Do you have strategies and in that case, what kind of strategies?*
- *How do you cooperate with the teachers that arrive with the class?*

On the other hand, questions of respondent character were, for example, as follows:

- *What do you think is a successful guided tour or field trip?*
- *Think about the materials, activities and exercises you have. Is there anything that you do that you think works extra well?*

An interview guide was constructed with the purpose to have a guideline of what should be covered in the interviews. Several of the questions in the interview guide were based on the findings from the literature review. The interview guide can be found in appendix A. However, this guide was simply a suggestion since the interviews were semi-structured (Lantz, 2013, p. 41). As such, the interviews were adapted to the answers from the participants, their backgrounds and the nature of the site. In some cases, very few of the questions in the interview guide were actually asked during the interviews since they were irrelevant and there were other questions more suited to the participant and their organisation. This was especially the case when the interviewees did not conduct any tours or visits themselves. Since the analysis was done as an overview of all answers the formulation, order and choice of questions was not deemed as a problem.

The interviews were recorded and transcribed using the transcription tool in either the Google Recorder app or Microsoft Word. After this, the transcription was manually compared with the audio file and then revised.

3.1.3 Analysis of interviews and extraction of key factors

The interviews were subject to a thematic analysis, based on the process described by Säfsten and Gustavsson (2023, pp. 211–212). A great advantage of implementing a thematic analysis was that the result, the themes, corresponded directly to the key factors which are the main issue of investigation in the thesis. The process of the analysis was as follows:

1. Familiarisation with the transcribed interviews through reading the transcripts.
2. Finding of initial interesting aspects in the material, and coding all data through finding key-words based on the interesting aspects and the issue of investigation.
3. Gathering of codes to create themes by seeking similarities and patterns, and

finding quotes representative of the themes.
4. Reviewing and refining of the themes to confirm that they reflected the gist of the data.
5. Clearly defining and labelling themes.
6. Finishing analysis, presenting themes as written summaries.

An inductive approach for finding themes was deemed most suitable (Säfsten and Gustavsson, 2023, pp. 211–212). This was done through creating themes based solely on the interviews, separate from the findings in the literature review. An important aspect of an inductive thematic analysis is that codes are added continuously, as opposed to creating all codes beforehand. The inductive approach therefore created an opportunity to begin the process of the analysis before all interviews had been conducted. The first two steps of the analysis were therefore conducted parallel to the interviews themselves.

3.2 Implementation of key factors

In this section, the key factor implementation process is described. During this process, several new concepts for the field trips at the space observatory in Onsala were created, conducted and evaluated. The aim was to create a final recommended concept for the space observatory in Onsala where the key factors were implemented.

3.2.1 The implementation process

During the spring of 2025, several field trips were conducted at the space observatory in Onsala where one of the purposes was to implement the extracted key factors from the literature review and interviews. In total, this was done during five field trips with one or two visiting groups each.

The aim was to create realistic and usable plans and arrangements for the field trips where the key factors were considered. This in combination with the constraints of the site meant that not all key factors could be implemented.

Firstly, three different concepts for the guided tours at Onsala space observatory were created in regards to the key factors. Not all key factors were considered in every concept. Since each key factor can be interpreted differently, one purpose of the three concepts was also to evaluate different interpretations of the key factors. The creation of the concepts was done both deductively and inductively. This meant that a combination of key factors, constraints of the site and new activities and ideas unrelated to the key factors together created the new concepts. To anchor the concepts in the key factors, the finished concepts were analysed again before they were implemented to show how the key factors tied to a concept.

In general, the emphasis was on changing the following aspects of the field trips:
- Structure and in which order the activities were done.
- New activities.

- Using the resources of the site in new ways and in other contexts.
- Re-considering the roles of the guide and accompanying teacher.

These aspects do not necessarily directly correspond to the key factors.

The three concepts were then evaluated and reshaped to one new main concept. This concept was once again evaluated to create a finalised concept. This final concept, which can be seen as a recommendation of how to implement the key factors at the space observatory in Onsala, is presented in section 4.2.2. The implementation process can be summarised as follows:

1. Conducting concept 1.
2. Conducting concept 2.
3. Conducting concept 3 (with two groups).
4. Evaluating concepts 1 to 3.
5. Conducting improved concept.
6. Evaluating improved concept.
7. Conducting final concept.
8. Evaluating final concept.

The evaluation process is described in section 3.2.2.

3.2.2 Evaluation of implementation

The effects of the implemented changes were evaluated in two manners: Observations by guides and short surveys with attending teachers.

The observations were partly done by the authors conducting the visits, and partly by other guides from the observatory whose main task was to observe. The observations also included communication with students and teachers in a relaxed manner without recording or notation. All attending guides were informed about the key factors found in the initial collection of the thesis, and could therefore use them as a framework when analysing the activities and students behaviour. The collective observations and opinions of the attending guides were compiled shortly after each visit.

To emphasise the visitors perceptions of the guided tour, as opposed to only using the observations from the guides, one teacher from each visit was asked to participate in a short survey. The survey chosen to be text-based, through e-mail, to better accommodate the teachers. The questions asked varied considerably as they were adapted to the specific activities and phenomenons at specific visits. The opinions of the teachers were considered along with the observations of the guides to determine how the visits would be adapted forward.

The main purpose of the analysis was not to thoroughly confirm whether the key factors found in the initial collection were true or not. Instead, it was meant to be a practical way to iterate a realistic and usable plan for the field trips at Onsala space observatory, with the key factors as a framework. Therefore, observations were chosen over more structured interviews with students, to promote a more hands-on

evaluation process.

3.3 Delimitations

As previously mentioned, not all STEM-subjects are equally represented in the interviews. It will not be investigated how a different choice of interviewees in regards to the subjects within STEM would change the result. Further, it will not be investigated how the key factors would be impacted if the interviews were to be held in other parts of, or outside of, Sweden.

No students or school-teachers were interviewed or subjected to any kind of data collection during the initial part of the thesis. Instead, the opinions of school-teachers were collected directly in connection to the implementation. The opinions of students, although not directly collected, were perceived through the surveys with their teachers and through observations.

3.4 Ethics

For the initial data collection there were several ethical concerns. Since the interviews were recorded and transcribed, a form of consent was prepared for the participants to sign, which can be found in appendix B. Among other things, the form stated that the recordings and transcriptions were to be deleted after a certain time. Furthermore, no names were attributed to any citations in the report, to make the participants more comfortable in the interviews and for them to remain anonymous. At the same time, there was a concern that the interviewed organisations would not like to share information with a ”competing” organisation, such as the space observatory at Onsala. Therefore, the purpose of the thesis was clearly stated to the participants leading up to, and directly before, the interviews. Unless otherwise agreed, the organisations also appear in the ”Acknowledgements”-section in the report.

For the implementation at Onsala, ethical considerations included how to handle the issue of privacy and sensitive information when conducting interviews with adolescents. This was one factor in the decision of only doing short surveys with teachers. Since a survey is not recorded, the ethical risks were deemed low.

4
Results

In this section the results from the thesis are presented. Firstly, the main result is presented which consists of 13 key factors to consider in a guided tour in STEM subjects for school years 6 to 9. These key factors are mainly based on the interviews conducted with professionals knowledgeable in the subject. Secondly, a recommendation for how the key factors should be implemented at guided tours at the space observatory in Onsala is described. The results of the evaluation process of these recommended guided tours are also presented. It should be noted that all interviews were held in Swedish, and therefore all quotes in this section has been translated.

4.1 Key factors to consider during guided tours in STEM subjects

The following section outlines the key factors extracted from the interviews held with professionals within the field of guided tours and field trips in STEM. These factors can be considered the final key factors in the thesis. Some of the factors coincide with the preliminary key factors from the literature review in section 2.3, such as *Content* and *Structure*. However, other key factors differ. The difference and connection between the preliminary key factors in the literature review and these final key factors is further discussed in section 5. The key factors based on the interviews are shown in figure 4.1, and are considered final key factors. Each key factor is illustrated with descriptive examples to clarify its content.

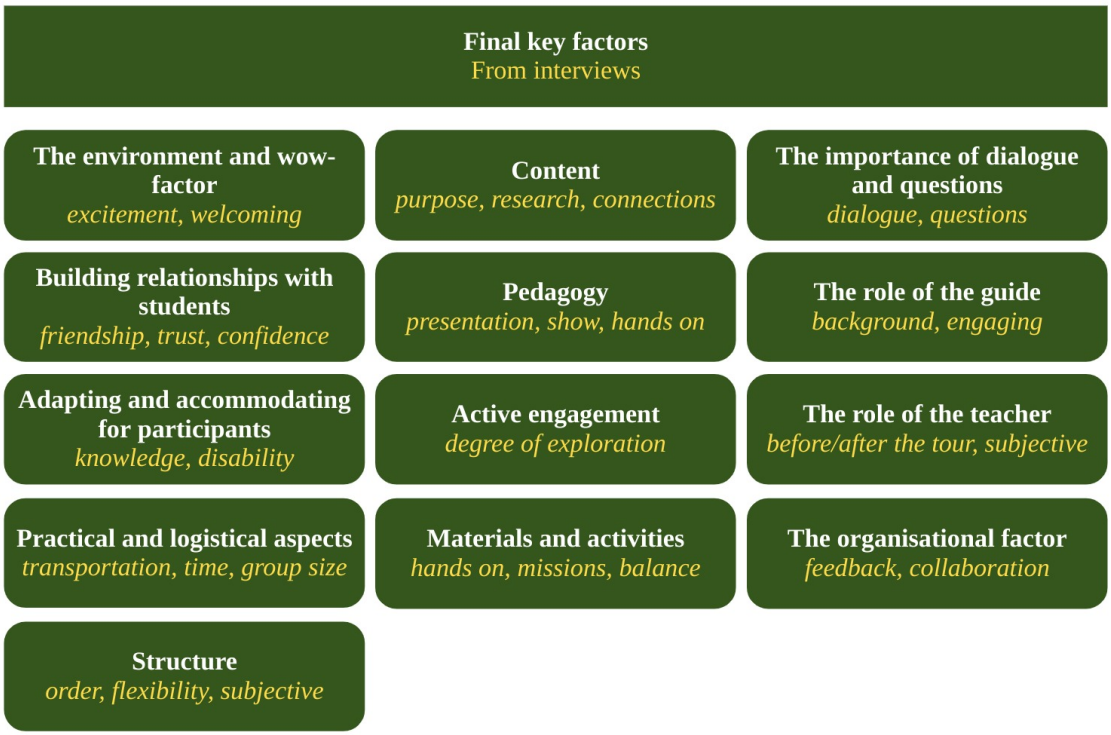

Figure 4.1: Final key factors based on the interviews in white, and descriptive examples in yellow.

4.1.1 The environment and wow-factor

The first factor, which was not prominent in the literature review, is the importance of creating "wow-factors" and environments which are welcoming and support interest and learning. Several interviewees stated that field trips themselves offer something different than a regular classroom. As such, already from the get go, field trips come with unique learning environments not found in school.

> *It's something that differs from a normal schoolday. It's something special that happens.*
>
> Educator / guide no. 1

> *Going away on a field trip, being somewhere else. That's something really valuable.*
>
> Educator / guide no. 2

Some interviewees, however, stated a different approach. For an optimal learning environment the goal should be to incorporate the field trip into the school day. This signals that the place for the field trip is also a place for learning.

> *They came together with the teachers and now they are here with us. This is a normal school day, we are just in a different place.*
>
> Person responsible for guided tours / field trip programs

An exciting environment can be a result of the nature of the site, but is also some-

thing that many out of school learning sites work actively on. Creating an environment both welcoming and open for exploration, but also not too overwhelming, is key for a successful field trip or guided tour, according to several interviewees. A part of creating the environment is of course working with the exhibition itself to create a place where learning can happen even without a guide or educator present.

> *Building a field trip program is made easier by the nature of the site itself.*
>
> Educator / guide no. 3

> *When we are here, in the mathematics part [of the exhibition], there is a cosy room where you want to be.*
>
> Educator / guide no. 2

Finally, an important aspect is the ”wow”-factor. This gets the participants engaged and interested. It also supports the idea that the field trip is something special. Sometimes a ”wow”-factor is already present, while sometimes it has to be created. It can be something big and impressive, but it can also be something less visible, like a story.

> *I’ve got a cupboard with some unusual and rare pieces of garbage which the students think is really exciting. Sometimes I have stories to tell about these items.*
>
> Communicator no. 1

> *We then visit the [part of exhibition], which may be the most spectacular experience we have.*
>
> Communicator no. 2

4.1.2 Building relationships with students

> *From the perspective of my role, I have worked here for 20 years, it is very much about creating relationships.*
>
> Communicator no. 1

This was the very first thing one of the interviewees said. Many also highlighted the importance of creating a good relationship with the participants/students at the beginning of the tour or field trip. For this to happen, every student should be seen and feel welcome. One interviewee stated that in the context of a guided tour it is possible to create more of a "friendship" relation with the students than in the context of a teacher/student relationship. It is also necessary to create a sense of trust in the students already in the beginning for the rest of the visit to be purposeful. The participants should, for example, not be afraid of asking questions.

> *The focus is to create an environment where people feel that they can ask any questions they like about...*
>
> Communicator no. 2

Throughout the visit, the students should therefore feel comfortable. The importance of creating the feeling that ”we’re in this together” was also highlighted. Also important is to increase the confidence of the students throughout and after the

visit. Several interviewees expressed that students, especially in years 6 to 9, feel that they aren't competent enough to complete the activities or that the activities "are not for them".

> *You should end the day by feeling "Damn, I can do this".*
>
> Communicator no. 3

> *When they [the students] have accomplished something, that is something you should highlight.*
>
> Educator / guide no. 2

Strengthening their confidence in a field trip or guided tour setting is easier than in the classroom since there is less pressure on the students to perform. A unique aspect of the field trip setting is that the educator or guide doesn't know the relationships within the group and between the group and their teacher beforehand. The students might be shy towards each other or there might be tensions between the students in the group. In one case, the key was to engage the one student, the "queen" of the class. After that, the atmosphere became more relaxed.

> *She is the queen of the class. She hasn't approved of this field trip... And this queen of the class finally puts her hand into the water and touches a starfish called a red cushion starfish which is smooth and a bit slimy. And then we have another starfish... It has more spikes.... And then she says "This one is freaking soft, and this one is freaking hard"... Finally, she allowed herself to experience something, but above all she said it to her friends...*
>
> Educator / guide no. 1

Finally, the interviewees also mention that a field trip seems to be more successful if the students trust each other and their teacher.

4.1.3 Adapting and accommodating for the participants

Throughout the interviews the importance of considering the participants and their prerequisites and knowledge was highlighted. These prerequisites can differ greatly within one class as well, which might be a challenge. Firstly, there may be background factors affecting how the participants approach the guided tour or field trip. One such factor is the socio-economy. Due to this factor, some schools might visit a site more frequently than other schools. The importance of creating a more equal visitor-base is highlighted by several interviewees.

> *It is an equality thing as well. Often, more wealthy families are the ones owning VR headsets and such. It is nice that everyone gets to try them.*
>
> Educator / guide no. 4

The students can also have different abilities to participate in the activities due to disabilities. To adapt the tour or field trip to specific needs, experts should be consulted, according to one interviewee. A majority also stated the importance of clear communication with teachers beforehand regarding disabilities. Some adaptations might be easier than others.

> *It is very easy to understand that you should have an accessible restroom, but it is a bit harder to understand that you should adapt an installation in an exhibition to participants with ADHD.*
>
> Educator / guide no. 5

The age of the participants should also be considered. Several interviewees expressed challenges with students in years 6 to 9. Scheduling issues and resources hinder the amount of field trips during those year, and during that age, many other things also happen in their lives. This often make them more unfocused, and maybe even less interested, during the field trip than younger or older students. Still, one interviewee argued that this fear is unjustified.

> *It is very difficult to create "wow-effects" for this audience, when you have TikTok and such... But I think there is an unnecessary fear in that. It is of course much easier to discipline someone at the age of 7. But at the same time, you can gain so much more...*
>
> Person with overview of education.

In general, adapting the visit to the age, knowledge and background of the participants is key. This was highlighted by almost all interviewees. The adaptation can be done in many ways, from choosing which guide should host the visit to lowering the bar if the knowledge gap is too big and adapting the progress of the tour or visit in the moment it happens.

> *The right guide for the right group.*
>
> Communicator no. 1

> *The more you know your target audience, the easier it is to create a successful visit.*
>
> Educator / guide no. 5

> *I watch, listen and then adapt.*
>
> Educator / guide no. 6

The interviewees also expressed that the knowledge of the participants differ greatly, but that this generally isn't a problem since they are used to adapting the tours or visits to different audiences. Still, many argue that the outcome of the visit is often greater if the students come prepared.

> *The best visits are when they are prepared and the students are proud of their knowledge.*
>
> Communicator no. 1

Finally, the students are still students. There might be distractions, tensions in the class or simply students too curious to stay focused. To know how to work with these aspects is key. Distractions should be worked with, not around. One interviewee mentioned that in a new situation they let the students get comfortable before starting the main task. If there is time, students with many questions can get extra attention between activities. To retain a general sense of order among the participants, most wish for the teachers to cooperate with them.

> *I am a bit limited in that regard, because it is not my job to raise them even though I sometimes try. So I have to turn to the teachers...*
>
> Educator / guide no. 3

4.1.4 Practical and logistical aspects

There are many aspects of the practical nature to consider, such as time and transportation. This also included group size, where the interviewed organisations almost never welcomed groups larger than 30 and some even set the limit around 15 to 20. The possibility of dividing them into smaller groups depended on the nature of the activities and the number of guides.

> *No, we don't [divide them into smaller groups]... I usually work alone, so it's not possible.*
>
> Educator / guide no. 7

The practical aspects also included the length of the visit, often around 45 minutes to two hours. During what part of the day the visit happens is also key, especially for years 6 to 9 where there are many scheduling issues.

> *For middle school it is a jigsaw puzzle, maybe Thursday at 10 o'clock doesn't work for them... So we squeeze them in at 12:55 because that's when they can come.*
>
> Educator / guide no. 7

The distribution of breaks and safety aspects should also be considered. One organisation set an age limit of 15 years for one of the activities due to safety reasons.

The main issue regarding logistical aspects throughout all interviews was the one about transportation. Due to distance and economic reasons, many schools don't afford to rent buses. This means that some organisations are more frequented by geographically closer and more wealthy schools while other organisations pay for the bus so all schools have the same opportunity to come. Even if the distance is not that great, teachers might still be hesitant to do the visit if it includes public transportation.

> *It is difficult to get here because it takes maybe an hour, and you have to rent a bus and there is no bus money.*
>
> Educator / guide no. 8

However, some argue that the journey to and from the site is just as important, especially if it involves public transportation since this gets the students used to getting around.

> *Well, many field trips for younger students are just as much about how to use the tram to get there.*
>
> Person with overview of education.

One solution to this, mentioned in the interviews, are mobile visits. One organisation reached out to the schools furthest away by doing a visit at the school instead. Another solution is digital field trips, which the interviewees had varying opinions

on.

4.1.5 Structure

The word ”structure” is subjective, and what it entails was different throughout all interviews. One meaning was the difference between a tour where the participants explore freely and one where the stops and activities are well defined. In this regard, many promoted tours and field trips with a higher degree of structure, albeit for different reasons. Some sites have safety precautions, demanding a higher degree of structure, while other times it can depend on the nature of the subject in question. A few argued that learning is more effective when there is a high degree of exploration and independence. The degree of exploration and freedom is further discussed in section 4.1.8.

> *It is not the teacher's job to push down facts or skills down the students' throat, instead you need to get the students to want to learn... In our case, the most important thing is to create fascination for the ocean by serving our smorgasbord...*
>
> Educator / guide no. 1

Another aspect of structure is what and in which order things happen. A clear structure with an introduction and conclusion was highlighted as important. The purpose of the introduction was often to build relationships with the participants but also to establish and explain the agenda and structure to them.

> *We try to gather everyone as fast as we can so that everyone can see and hear, and then it's also good to explain the itinerary of the tour.*
>
> Educator / guide no. 7

A conclusion to wrap things up was also a good idea according to the interviewees. The difficulty level and degree of exploration can also vary throughout the visit. One interviewee mentioned that in some of their programmes they start easy and end with more activities for exploration.

> *Our programming programmes are often very basic. Everyone can do it, and those who like it and are fast can often continue by themselves... In the end of the programme we usually add more freedom like ”Now you get to try, change and so on”.*
>
> Educator / guide no. 4

Being flexible about the structure and adapting to different groups is also key, as well as having variation in the type of activities.

> *We have over 30 programmes. And we have... great variety.*
>
> Educator / guide no. 4

4.1.6 Content

Throughout the interviews, a recurring theme was the importance of knowing what the guided tour or field trip should convey. Having a clear aim or purpose was key.

What the aim was of course differed between the organisations, where some wanted to promote behavioural changes among participants (e.g. promote recycling) while others wanted to spark interest in STEM subjects. Showing a greater perspective and increasing the science capital among participants was also mentioned several times.

> *For me personally, the purpose is to increase the science capital among all kids.*
>
> Communicator no. 2

Connecting the content in the tour to society and the daily lives of the participants was also highlighted. This can be done through connecting to history, the backgrounds of the participants and what the participants themselves can do at home. Having a connection at all seems to be key.

> *It is difficult when there are areas or subjects which few people can relate or connect to.*
>
> Educator / guide no. 5

Most interviewees discussed the connection between what happens at the tours or visits to what happens in the classroom. Many stressed the importance of using the school curriculum to shape the programmes. This supports the idea that the field trips or tours should complement the classroom.

> *We think that we support the school and therefore it's also important that everything we do is connected to the curriculum.*
>
> Communicator no. 3

A few also mentioned the possibility to combine different subjects which might usually not be possible in the classroom, like history and mathematics. It also seemed that the content should cover what actually happens at the site, such as current research.

> *It would be pretty pointless if you didn't show something that has to do with the site.*
>
> Educator / guide no. 5

Finally, a few of the interviewees argued that the subject itself makes for interesting content, while others argued that the subject itself is not crucial for a successful field trip.

> *The subject is irrelevant. Instead it is about how to create content which fits your participants.*
>
> Communicator no. 1

4.1.7 Pedagogy

Many interviewees highlighted thought out pedagogical ideas to increase learning. When asked about if they create activities for different kinds of senses, almost everyone said that they do. It seems that doing things with your hands or body is most prominent, partly because of the lack of kinaesthetic activities in school.

When you finally get to visit you'll actually get to touch things for real.

Educator / guide no. 4

It also seems to be important to create a willingness to learn, mainly by making the subject itself interesting. This can be done through creating a framework where students can connect their previous knowledge and their every-day life with the subject at hand. Several people mentioned how it's important to attain the students' focus. Some ways that were mentioned for doing this is creating movement, repetition and getting the students involved.

We can't just sit in a chair for an hour.

Communicator no. 4

Finally, multiple means of presenting the content was mentioned. Some use more classical means of presentation, such as a video or a slide show. Important to mention is that when presenting like this, the interviewees stressed that they strive for active engagement. Some educators use different forms of interactive theatre instead, and see their presentation much like a show. This is mostly present at sites where education - not research - is the main focus. During the shows, and sometimes in absence of shows, some educators execute experiments together with or in front of the class.

4.1.8 Active engagement

The majority of the interviewed educators and guides expressed how they prefer tours where students get to be active participants. This is either attained by letting the students walk freely between activities or stations, or by creating more regulated activities to be executed together. It's important, however, to make an actual decision about the degree of freedom, one educator claimed:

The person designing the tour must keep in mind if you should be able to move freely about the area and, in that case, it should fulfil the purpose of the visit.

Educator/guide no. 5

While giving the students opportunity to roam freely can increase their curiosity and ability to try things themselves, a more regulated activity can ensure greater opportunity for asking questions or seeing the bigger picture of a subject, which is also valued by interviewees. It seems to be important, however, to still create some sort of movement or transfer when having less free exploration. Whichever you choose, many stressed that getting the students involved is key. It does not seem to matter if you use multiple short activities, or a few more extensive ones. One example of involving students is handing out materials to use during the tour:

We have tried activity cards which have been an attempt to give mini-missions to the students, so that they can experience the tour themselves without much contact with adults.

Communicator no. 2

The most occurring form of activity throughout all interviews is having the students ask questions or partake in discussions. This seems to create a more fluid or live experience. The goal of activity-based learning during guided tours seems to be to

create a learning opportunity highly adapted to the students, and get them to own their learning:

> *Well, this... experience! Push! Pull!... Be responsible for your own learning.*
> Person with overview of education

4.1.9 Materials and activities

Since the interviewees work in vastly different spaces, the type of activities also differ. Some use paper-based activities, such as bingo, mission-cards, or a walking quiz. Others have different stations with experiments or exercises, or build things with Lego. It is also common to walk around to look at the research equipment or at the site at large.

In general, the goal seems to be to create activities that are more hands-on.

> *Here you get to squeeze, touch, draw and cut. Ask, ask, and have fun! And break things, you're almost supposed to break things.*
> Person responsible for guided tours / field trip programs

> *They get to try and do something, not just look at things but also really do something as well.*
> Educator / guide no. 9

It's common to present different kinds of missions, where the students get to solve problems. Some take this as a chance to also work on collaborations within the group of students, through competitions or teamwork. It's also mentioned that the missions don't have to be overly complicated:

> *You can ask something like "What color is the car", and by doing that you get them to look at the car and explore the car. You don't have to ask a complicated question about something advanced to do with the car.*
> Educator / guide no. 5

The division of time spent between learning theory and doing practical exercises should also be considered.

> *The combination of a lecture with us, which can be very theoretical, with a visit to the exhibition is usually quite good.*
> Educator / guide no. 10

4.1.10 The importance of dialogue and questions

Almost all interviewees agreed that the type of interaction between the guide and the participants is important. Rather than in the style of a lecture, they promoted dialogue and conversations in an open environment where the participants shouldn't be afraid of asking questions or expressing their viewpoints.

> *Previously we had a slide show with old grey photos, and that's something I wanted to remove.*

Communicator no. 4

Learning happens through conversations and meetings and relationships.

Communicator no. 3

According to several interviewees, the dialogue should still be on the level of the participants, use language they understand and have a good balance of humour and seriousness. Irony is something to be avoided.

A bit of fun and a bit of seriousness.

Educator / guide no. 2

The usage of questions is key to creating a dialogue. This is something almost all interviewees mentioned. However, the type of questions asked differs between the interviewees. Some promote simple or trivial questions to start the dialogue, while others agree that questions which make the students think and reflect are key. They might be open questions where the answer includes explaining something. A few of the interviewees used leading questions instead. They might also be used to find out the knowledge gap and what the students have done in school beforehand.

Open questions where you don't give too complicated explanations but rather ask a small question that pushes them to explain by themselves.

Person responsible for guided tours

The questions from the participants are equally as important as the ones from the guide or educator, argue several interviewees. In general, these interviewees agree that all questions are welcome and that these always should be answered. It is an important part of creating a dialogue. Embracing their questions is of course also a type of adaptation, discussed in the previous section 4.1.3.

We talk all the time, but we... everything is built upon their questions, even though we lead them.

Educator / guide no. 7

4.1.11 The role of the guide

One of the most influential parts of a guided tour is the guide itself. There are divided opinions among the interviewees regarding the educational background needed to be a guide. Some are determined that every guide needs to have studied teaching, while others see advantages in using guides with no pedagogical background. Some also claimed that it is more important to choose a guide that fits the group and the experience; if that's a teacher, biologist, or just an enthusiast is less important. Instead it seems more important that they are able to create engagement within and a connection to the group of students. It is also important to be genuinely curious and interested, along with being flexible and willing to listen and answer questions. One interviewee added the importance of creating a guided tour whose success isn't completely relying on the type of guide present; the outcome should always be somewhat satisfactory.

Many ways to create engagement are present throughout the interviews. It seems

to be important to choose the right balance between fun and serious, and also to show interest in the subject at hand. Further, it's important to try to understand what within the subject the students will actually find interesting.

> *Not the kind of teacher that stuffs knowledge or skills down the students' throats, you have to get the students to want to learn.*
>
> Educator / guide no. 1

However, it was also mentioned that you have to accept that not all students will have great interest, but that the guided tour can be a suitable gateway.

> *Our goal and purpose is to, well, create joy and curiosity in the understanding that nature is fun, because not all students think it's that exciting.*
>
> Educator / guide no. 7

It was also mentioned by several people that representation matters, and that everyone should be included in the same kind of tour regardless of parameters such as gender and ethnicity. Including guides and other personnel of different gender and ethnicity can help create a more open climate where students can imagine themselves as future employees.

Another way to create engagement is to try to connect to the students, which was mentioned as important by several interviewees. Some ways to connect are hard to affect, such as the age or gender of the guide, while others, such as using words that the students understand and creating connections to things they are interested in, are available to everybody.

Finally, some interviewees see a guided tour as very similar to a show or performance. From that point of view, it seems to be important to be mindful about the energy needed to perform. Several educators explained how they choose to offer fewer visits per day to ensure greater quality, while others don't have that option. One educator explained how this is usually a struggle:

> *Sometimes, there are like 7-8 visits on the same day, and then you have to try to... Well, you get tired.*
>
> Educator / guide no. 10

Another educator explained that when this kind of thing happens, they try to find support and energy from their colleagues.

4.1.12 The role of the teacher

The teacher seems to have a role of utmost importance before, during, and after guided tours. Few interviewees have planned activities for the students to complete beforehand, and for those who do these seem to be simple (look through a list of important terms), informational (watch a video about what will happen during the tour) and highly optional. Several educators mentioned that it doesn't seem to be very requested by teachers to have material to complete before the tour. Instead, they said that they trust the teachers and that they will prepare in a way that they find suitable.

> *It depends fully on how much the teacher has committed to the tour.*
>
> Educator / guide no. 11

> *The teachers that do this as a part of their teaching, they know how they want it done.*
>
> Educator / guide no. 4

The discussion around activities to complete after the tour is similar. While most interviewees leave it up to the teachers to handle as they please, some stressed that it can be good to offer some kind of help to create a suitable conclusion in the classroom.

Some interviewees explained that they instead find communication with the visiting teachers important. This communication seems to usually take beforehand, or at the beginning of the visit. This kind of communication ensures that both educators and teachers know about the general level of knowledge, and eventual specific needs for individuals or for the group as a whole. It also gives the opportunity for teachers to ask questions while designing their own introduction or conclusion to the subject.

A recurring theme is the experienced luxury of creating long-lasting relationships with teachers. A communicator explained that,

> *The meetings that feel most satisfactory are the ones you have with people you know, or people who are returning.*
>
> Communicator no. 2

It seems to be very common for teachers to return to the same organisations several times but with different sets of students. Several interviewees claimed that this is advantageous to everyone involved, as these relationships ensure better communication and realistic expectations. In fact, many interviewees agreed that it's almost completely up to the teachers' ambition and interest if a class of students get to partake in a tour, especially if the tour itself is popular and quickly gets fully booked.

> *They know that the programme is released at 7 o'clock. It's like they are logged in to get tickets to Bruce Springsteen.*
>
> Person with overview of education

There are widespread opinions about how a teacher should act during a guided tour. While most agreed that they don't expect more involvement from the teacher than being an extra adult in the room, most also agreed that the success of the visit highly depends on how excited or committed the teachers are. Some interviewees expressed that they think that it's important to give opportunity to the teacher to claim a more active role, but in a way where the outcome of the visit isn't dependent on the teachers commitment. An important aspect that was recurring throughout the interviews is that the teachers most often know the students better than the guide or educator. In that way, they can be of more use as an informant of specific needs or as a one-on-one teacher for students who might need extra support. Finally, it seems to

be important to have clear communication about expectations. One communicator, for example, expressed how they sometimes don't get along with teachers' degree of discipline.

> *I got rather angry with a teacher who was more interested in disciplining its students than letting them participate in the discussion.*
>
> Communicator no. 2

4.1.13 The organisational factor

Some more organisational aspects need to be taken into consideration while designing a guided tour. Many interviewees stressed the importance of collecting and using feedback to improve the tour. Several people mentioned that collection of feedback often occurs through observations and internal discussion within the group of educators. A lot of educators also speak to teachers and students during or after the visits. The importance of daring to test different solutions was also mentioned, but as some expressed fear of removing concepts that guests appreciate, this should probably be done with care. One interviewee added that feedback can also be collected through observing behaviours:

> *I think you have to see it as a proof that if they choose to come back, then... well, then they feel satisfied.*
>
> Educator / guide no. 6

Another way to improve guided tours is through collaboration. Several kinds of collaborations were mentioned throughout the interviews: collaborations within the group of educators and collaborations with other organisations. While few seem to be offered further pedagogical education (outside of different programs to increase accessibility), the learning that occurs between guides working together seems to be prominent. Some see it as a strength when educators have different gender, background and education, while others prefer every guide to be highly pedagogically trained. When reaching outside of the organisation, some interviewees mentioned that collaborations with other organisations can give a deeper connection to real science which might catch some students' interest. Collaborations with universities also seem to be used to create deeper connections and to attract future teachers.

4.2 Implementation of key factors

Through an iterative implementation process, a recommended final package and concept for guided tours at the space observatory in Onsala was created. This is outlined in section 4.2.2. Throughout the implementation process, the concepts were evaluated, the results of which are presented in section 4.2.1.

4.2.1 The results of the implementation process

To evaluate the new concepts at the observatory, new ideas and activities were tested. This was done through observations and surveys with teachers after the

tour. The recommended package for Onsala (section 4.2.2) is made up of the activities and ideas deemed successful.

Some ideas and activities suggested from the interviewees and others were not successful when implemented. Some ideas tested during the visits that did not always have a positive outcome therefore included:

- On one guided tour, the visitors were prepared for the 20 metre telescope (location 6 in figure 4.2) by being handed out helmets before they entered. This only worked since the number of guides was higher than usual and therefore this idea was discarded.

- In the recommended concept (section 4.2.2) real data from an actual researcher is presented. Initially, this activity was significantly longer and included more time for discussion. Since this resulted in reduced interest later in the activity and since it was more focused on mathematics than astronomy, the activity was reduced and refined.

- The teachers now receive information to share with their pupils on the bus to the observatory. It is uncertain whether this has a positive or negative outcome since limited observations were done regarding this. Still, one teacher expressed unease in using the microphone on the bus. Therefore, this is now recommended as something voluntary.

- To support the division of the class into groups and roles, identity cards originally meant for school years 2 to 5 were tested. With these, the students know which group they are in and which role they have in different activities. The conclusion was that this, unlike for younger students, created problematic group dynamics when certain pupils were divided into certain groups. The recommendation for school years 6 to 9 is therefore instead to make use of the teacher when dividing into smaller groups.

- On one occasion, the students received a single mission to complete in the visitors centre instead of an entire sheet of missions. When this mission was completed, they received a new one. The purpose was to create more interaction between the guide and students that usually do not interact. However, based on the observations, a higher engagement was achieved when the students themselves chose which missions to do.

- Finally, one guided tour made use of the guide taking on a theatrical role. The purpose was to make the guide a co-explorer and also engaging the participants. However, the guide not acting as themselves made it more difficult to build relationships with the visitors and also made it confusing for the participants who the guide actually was. This idea was suggested by one of the interviewees in the early parts of the thesis, but will not be a part of the recommended concept for the space observatory in Onsala. The idea of the guide taking on a role is further discussed in section 5.2.

4.2.2 Recommendation of how to implement key factors at Onsala Space Observatory

The final recommendation for the space observatory in Onsala was created in the form of a package of concepts, materials and activities for a two hour guided tour with students in years 6 to 9. The recommended concept uses both existing and new activities. The concept is divided into seven different parts, all conducted in different locations at the observatory, according to figure 4.2. The concept was created with the key factors in mind, and the connection to these is discussed in section 5.2.

The main aspects changed from the previous used concept at Onsala is a new order of activities, an experiment, a new activity in the visitors centre and the usage of actual research data.

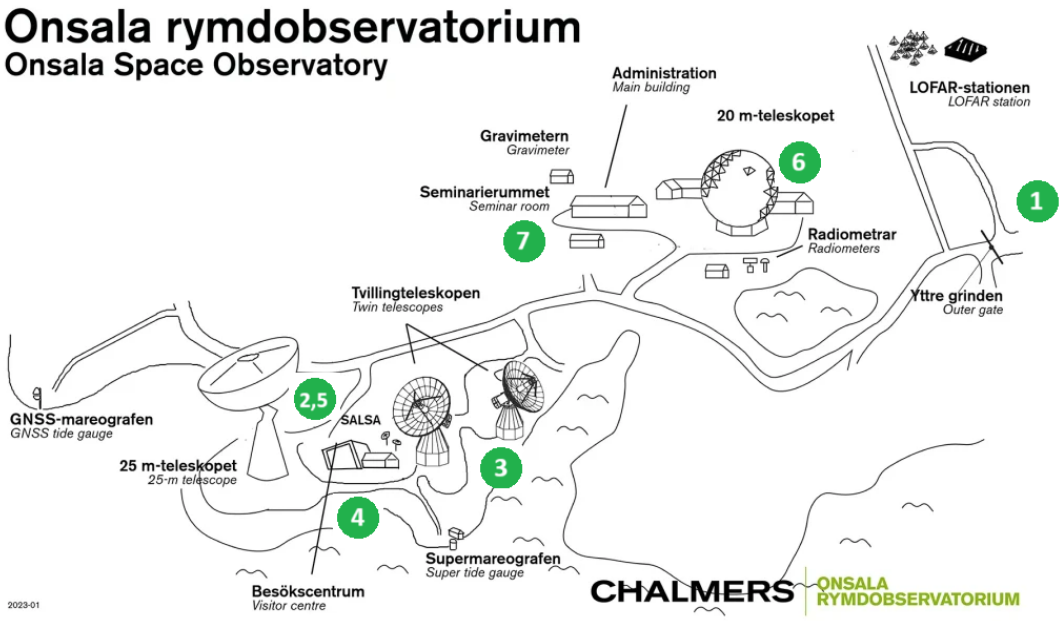

Figure 4.2: A map of the Onsala Space Observatory with all locations marked out. (Chalmers University of Technology, 2023). Edited with permission.

At each location, the recommended concept is as follows:

1. **On the bus to the observatory.** The teacher shares some introductory information with the students according to the teacher information sent to them beforehand (see appendix C). The information includes some practical information, the agenda of the visit as well as a question to discuss for the students. This is a voluntary activity.

2. **At the 25 metre telescope, circa 10 mins.** The students meet the guide by the bus. The guide welcomes them to the observatory, explains the agenda and, if applicable, follows up on the discussion in the bus. The guide also briefly presents the 25 metre telescope. In this part of the visit it is important to build a relationship to the students and make connections between the observatory,

the daily life of the students and their previous experiences. Remember to explain why no phones are allowed at the site.

3. **At the twin telescopes, circa 10 mins.** The guide explains what a telescope, and specifically the twin telescopes, do. The guide should emphasize that the students later in the visit will see actual data from these telescopes.

4. **In the visitors centre, circa 55 mins.**
   - The visitors and guide gather in a conference room. An experiment is conducted with them according to the instructions in appendix C. The purpose of the experiment is to show that there are certain things in the universe which you can not see with your eyes, but instead measure in other ways.
   - The visitors and guide move to another gathering point in the middle of the exhibition. The group is divided into two groups (1 and 2).
   - Group 1 gets taken aside and are prepared for a planet game (an already existing game where they ”travel” to another planet and guess which planet it is) before they enter it. Appendix C contains the information the group receives. One of the teachers is handed an instruction (see appendix C) and conducts the game with the students.
   - While group 1 does the planet game, group 2 gets to do a ”space bingo” in pairs of two, consisting of a set of missions for them to complete in the exhibition.
   - After 10 minutes the groups once again gather and switch activities.
   - Time for lunch or free exploration of the exhibits.

5. **At the whisper discs, circa 10 mins.** The visitors and the guide gather outside. The guide briefly explains the GNSS mareograph visible from the spot, to highlight the connection between earth and space. The ”whisper discs” is a new name for an existing activity, where the name change highlights what you should do with them. The group is divided into two where the students one by one get to talk to the other group over a significant distance with the help of parabolas. Clear markings beneath the parabolas show where the students should stand.

6. **At the 20 metre telescope, circa 25 mins.**
   - The guide clearly presents the purpose to the visitors before they enter, and discuss why they should wear a helmet inside. The guide also makes it clear that it is a real research facility, and that the visitors therefore should be careful. They then enter the telescope building.
   - The control room is shown.
   - A piece of the roof similar to the one around the telescope is handed around the students.
   - A photo from inside the telescope is shown.

7. **In the seminar room, circa 10 mins.** If time is limited, the tour ends

before the seminar room. If not, the group gathers inside.

- The guide follows up on what happened at the 20 metre telescope.
- The guide initiates a discussion with the visitors about what is possible to see with the telescopes.
- The visitors are introduced to an actual researcher, with a recorded greeting from them. Actual data from the researcher (measured with the twin telescopes) is presented. The visitors are encouraged to discuss the reasons behind the trends in the measured data.
- If time allows, the video "The Known Universe" is shown, where the viewers travel from Earth to far away in the universe and back.
- The visit ends and the visitors leave the observatory with the bus.

5
Discussion

In this section it is discussed how the results relate to each other and to previous research as well as the literature review. The choice of methodology and its advantages and disadvantages is also discussed. Finally, future research and how the results can be used in other organisations is suggested.

5.1 The connection between the literature review and the final key factors

There are several similarities between the preliminary key factors from the literature review and the final key factors after the interviews. While some final key factors, such as *Structure* and *Content*, essentially correspond directly with their preliminary namesakes, other final key factors, such as *The role of the teacher*, include aspects from several preliminary key factors. A detailed chart over how the preliminary and final key factors are connected is shown in figure 5.1.

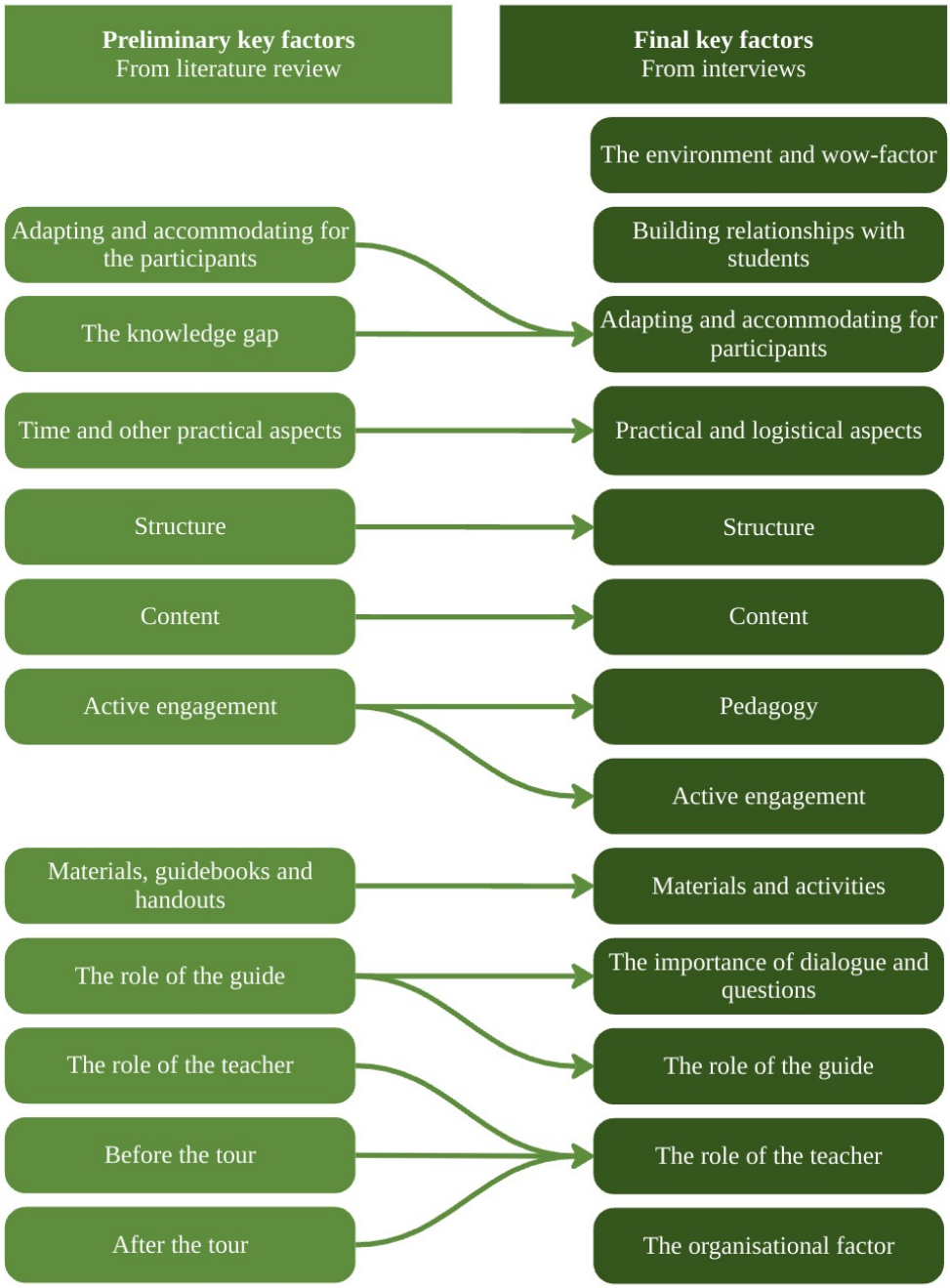

Figure 5.1: Overview of how the preliminary key factors from the literature review relates to the final key factors after the interviews.

One notable difference is the division of the preliminary key factors *Active engagement* into *Pedagogy* and *Active engagement*, and *The role of the guide* into *The importance of dialogue and questions* and *The role of the guide*. Both preliminary key factors were divided in two such that the initial key factor remained, and a new, more specified, key factor was added. While some aspects of all four new key factors were found in the literature review, they were further pronounced in the interviews,

hence why they were considered individual final key factors.

Another notable difference is the convergence of the key factors *Adapting and accommodating for the participants* and *The knowledge gap* into *Adapting and accommodating for the participants*, and *The role of the teacher*, *Before the tour*, and *After the tour* into *The role of the teacher*. The aspects from preliminary key factor *The knowledge gap* were mostly mentioned in connection to *Adapting and accommodating for participants* during the interviews, hence why they are combined in the final key factors. Further, most interviewees considered teachers to be responsible for work done with the class before and/or after the tour, why *Before the tour* and *After the tour* are considered part of *The role of the teacher* in the final key factors.

Yet another notable difference is the additional final key factors *The environment and wow-factor*, *Building relationships with students*, and *The organisational factor*. The aspects brought forward from the interviews concerning these key factors were not found at a great extent in the literature review. It's possible that previous research on the subjects has been done, but that it has not appeared within the searches for literature. In general, it's possible that there are key factors that are important to consider that have not appeared in the literature review or from the interviews.

While the research found in the literature review was global, with a main focus on North America, the geographical focus during the interviews was the region in and surrounding Gothenburg, Sweden. This may explain some of the differences between the two sets of key factors.

The degree of similarity between the two sets of key factors was expected, especially since the results from the literature review was used as a foundation when designing the interviews. The complete interview guide can be seen in appendix A. This choice in design is also the motive for considering the key factors from the interviews final, since the data gained from the literature review is already implicitly included in them. One risk of using the literature review as a foundation for the interviews is that some existing aspects may have gone unnoticed in the interviews if they were absent in the literature review. To counteract this effect, a number of more open questions were included. The interviews were also held in a semi-structured manner, which gave opportunity for the interviewees to answer with a focus on their own experiences.

Since the literature review was executed before the interviews and the thematic analysis, the level of knowledge about the subject before the thematic analysis was high. This might also have affected which themes (referred to as final key factors) were found. The advantages of being able to construct research-based interviews was considered more important than being able to be more neutral when constructing themes. Therefore, the approach was not fully inductive.

5.2 The connection between the final key factors and the recommended concept

In this section the connection between the recommended concept in section 4.2.2 and the final key factors in section 4.1 is discussed. Throughout the implementation, all key factors were at least partly considered. However, some key factors are more pronounced in some activities and in the recommended concept. Therefore, the examples of each key factor described in this section should be seen as one example of how the key factors and concept relate. Furthermore, due to limitations in what changes could be done to the guided tours at the observatory, not all key factors have been implemented.

The first key factor, *The environment and wow-factor*, is already present at the observatory, with the impressive telescopes. The concept amplifies the wow-factors in several areas, for example by delaying the 20 metre telescope to a later part of the tour. *Building relationships with students* happens mainly in the beginning as well as in the visitors centre and in the seminar room, for example when building upon previous experiences of the students. *Adapting and accommodating for participants* is done throughout the guided tour, but is most prominent in the visitors centre where the students choose which missions to do and to what degree they want to explore freely. This is also an example of the *Structure* and *Active engagement* factors.

The *Content* factor has been considered in many ways, but mostly by tying the research at Onsala closer to what the visitors experience on the guided tour. They now gain a greater understanding for the telescopes through the experiment and get to see actual data. The hope is also that the new concept increases the science capital (Archer et al., 2015, pp. 925–934) among the visiting students. Cultural capital is created by showing that science is connected to many aspects of daily life and other subjects such as geography. Meanwhile, scientific behaviours and practices are hopefully promoted through hands on activities and the experiment. Simply travelling to the space observatory and meeting the guide and an actual researcher at the end of the visit hopefully also increases the scientific social capital.

One new example of *Pedagogy* is the new approach to the whisper discs while *Active engagement* is present in all *Materials and activities* including the new experiment and space bingo. Even though *The importance of dialogue and questions* should be considered throughout the visit, the recommended concept highlights the importance of questions, discussion and dialogue in several of the activities.

Another example of *Pedagogy*, which was tested but did not become a part of the recommended concept, was the guide taking on the role of a character. The purpose of this was to create engagement and reduce the gap between the guide and the students. The hope was that this would create more active participation from the students. However, the trial resulted in less discussion and more difficulty in creating engagement. For this work, significantly more preparation and training of

the guide would be required to make the guide feel comfortable and for the students to want to participate in the ”show”. While this currently is unfeasible at the space observatory in Onsala, it might be a good pedagogical trick to use at other out of school learning sites. In general, it might be problematic to create a concept very dependent on the guide and their skills.

> *I don't think the outcome should be dependent on the guide.*
>
> Educator / guide no. 5

Finally, an effort has been made to make *The role of the guide* and *The role of the teacher* more clear. The information to the teachers before the tour and in the visitors centre explain what their role is. The two factors *Practical and logistical aspects* and *The organisational factor* have been difficult to consider since these require more significant changes in which groups visit the observatory and how they visit it as well as how the organisation is structured.

Since a focus of the implementation process was to create a useful package for the observatory, many activities were created before they were connected to a key factor. A consequence of this is that the connection to the key factors could have been stronger if they would have been the starting point in the creation of the concept. However, the chosen method allowed for a more iterative process, with a more useful and realistic package for the observatory, while still maintaining a connection to the key factors.

5.3 Limitations of the chosen methodology

One issue when using qualitative methods such as interviews and thematic analysis is that the results are somewhat dependent on the researchers. This is especially true in semi-structured interviews, which give a considerable amount of freedom during the implementation. However, it also creates opportunity for interviewees to highlight specific aspects that reflect their experience.

One delimitation mentioned in section 3.3 is that no students or teachers were interviewed during the initial part of the thesis. It is probable that teachers and students would have a different view of what aspects are important during a guided tour. It was however considered more efficient to interview people who had actively considered different aspects of a guided tour, and who had extensive experience of participating in guided tours. It would of course be preferable if extensive data collection was done with all target groups.

While the implementation of the key factors was thoroughly designed, with the final key factors as a foundation, the testing and evaluation of the implementation was limited. The main method of data collection was through observation. A minimum of three guides were present during each tour, of which at least one guide was not responsible for participating in the guiding. This gave opportunity for thorough observation, including dialogue with students and teachers. Some teachers were also chosen to answer some questions about their experience at the visit through e-mail.

To better grasp the opinions of students and teachers, more thorough interviews or verbal questionnaires could be held at the site of the visit. This would entail more trustworthy results. However, it would also create a large increase in the time and resources demanded.

It should also be noted that while the recommended implementation for Onsala Space Observatory (see section 4.2.2) has been tested and are satisfactory for the observatory, it is unsure in what extent each key factor contributes. Since the goal of this later part of the thesis was to create a well-working concept, in contrast to testing the effects of the key factors, the design was not constructed as to test each key factor separately. While this creates problems with the evaluation of the research at large, it also creates a more realistic example of a guided tour. This was preferable, as it can be used by people within the work field to realise the key factors for use in their own organisation.

5.4 The age group

The issue studied in this thesis includes "... key factors to consider... *in the Swedish school years 6 to 9*". However, the findings in the literature review, interviews and implementation mostly cover guided tours and field trips for schools in general. Therefore, there is a need to discuss what distinguishes this age group from younger or older students.

Of course the knowledge level of the students differ from those older or younger, but one aspect highlighted in several interviews was the difficulty with middle school students in the sense that their focus is on something completely different, and that the social aspects are even more important.

> *Middle school is the most difficult audience... A lot happens with the students... There are so many other things that drain their energy with hormones and growing and so on...*
>
> Communicator no. 1

Even though the key factors can apply to all age groups, some are of even greater importance in years 6 to 9. This does not only include *Adapting and accommodating for participants*, but also *The environment and wow-factor* and *Active engagement* in order to retain their interest. *Building relationships with students* is also extra important to create a comfortable and welcoming environment to the students. As mentioned in section 5.1 these are factors that were more prominent in the interviews than in the literature review. Since the interviewees knew that the focus of the thesis was on years 6 to 9, this might be the reason why these key factors were emphasised in the interviews.

Of course, the key factors and recommended concept are to a large extent also applicable to other school years. For younger and older students some of the key factors might be less or more prominent than others. Regarding the concept from section 4.2.2, the general structure and order of the tour should work well also for

younger and older visitors. However, the specific activities, such as the planet experiment and space bingo, will likely be too complex for younger students and too simple for older students. For younger students, these activities can be replaced with other existing activities in the visitors centre adapted for the age group. For older students, more time for discovering and discussing the research equipment on site is suggested. Still, it would be possible to adapt the new activities for other age groups if needed, which could be part of a future project.

5.5 Implications for out of school learning sites

In this thesis, the positive effects of using the key factors has mostly been exemplified by the recommendations for the guided tours at the space observatory in Onsala. However, the key factors can also be of great use at other out of school learning sites such as science centres, museums and research infrastructures. The key factors can hopefully be viewed as a tool when creating guided tours, outreach programs or field trips, to create a well thought out experience. Other organisations can also use the recommended package for Onsala and apply similar activities in their guided tours. These insights can also improve the, already well functioning, collaboration between learning sites around Gothenburg and further.

In general, this thesis highlights the importance of research in the field. There is already some research, which this thesis summarises and builds upon. One effect of the thesis might be that it incentivizes out of school learning sites to further their tours and programs in research, and leads to more future research within the field.

5.6 Future research

There are several interesting aspects of guided tours that have not been thoroughly investigated in this thesis. Within the limits of the issue investigated, the biggest opportunity in future research is to apply more thorough testing. It would be interesting to include students and/or teachers to a greater extent, but a methodological progress can also be attained by doing further interviews with guides with the thematic analysis and testing at Onsala Space Observatory as a foundation. This could open doors to creating more specific concepts, easily applicable to guided tours in society at large. It can also be of interest to design the evaluation of the key factors in a manner where only one key factor is tested at a time, as to confirm their credibility.

When expanding the research outside of the issue investigated, there is essentially no limit to the amount of options. It would, for example, be interesting to investigate how the key factors could be implemented at other out of school learning sites. It would also be interesting to look beyond the key factors and investigate how aspects such as the layout of the site itself could be adapted to increase success. Research regarding guided tours have yet only scratched the surface of the actual mechanisms beyond out of school learning sites, which gives an almost infinite opportunity for future researchers to contribute to the field and, in extent, to society.

6
Conclusion

There are several key factors to consider during guided tours conducted within the STEM subjects for visitors in the Swedish school years 6 to 9. These include *The environment and wow-factor*, *Building relationships with students*, *Adapting and accommodating for participants*, *Practical and logistical aspects*, *Structure*, *Content*, *Pedagogy, Active engagement*, *Materials and activities*, *The importance of dialogue and questions*, *The role of the guide*, *The role of the teacher*, and *The organisational factor*.

Most key factors have been tested in several designs, and while some strategies and implementations seem to work well, others have been rejected for various reasons. One tested strategy to increase active engagement, for example, was for the guide to take a theatrical co-exploring role. This was rejected since it created problems with building relationships with students. Instead, active engagement seemed to be more easily achieved by creating smaller tasks and activities throughout the visit. Active engagement during the tour is also key to increase the science capital among the participating students.

By creating a recommended concept for the Onsala Space Observatory, the key factors could be exemplified. However, not all key factors could be implemented. This concept also serves as a suggestion for other out of school learning sites of how to use the key factors. Above all, the new concept has been an improvement to the previous concepts for guided tours at the observatory and a way to increase the science capital among the participants in their guided tours. Not only can the concept be seen as an example of the key factors, but all or parts of it will also be of use for the space observatory in Onsala for many guided tours to come.

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A

Interview guide

Below follows the interview guide used in the initial data collection. Note that the interview guide is in Swedish.

Intervjuguide för intervjuer

Information före intervju

- Våra namn
- Och vår utbildning (MPLOL)
- Presentera våra roller under intervjun
- Presentation av undersökningen.
    - Ta fram framgångsfaktorer för studiebesök inom NO/teknik år 6-9.
    - Vi gör detta genom intervjuer med olika guider/pedagoger, litteraturstudie samt en testningsfas senare i vår på skolbesöken på Onsala Rymdobservatorium (Chalmers)
- Intervjun kommer ta cirka 1 timme.
- De svar vi presenterar i rapporten kommer ibland kunna knytas till typen av verksamhet, ibland inte. Men vi kommer inte tilldela citat och resultat några namn.
- Även andra namn på exempelvis skolor och personer kommer censureras i rapporten.
- Verksamhetens deltagande kommer presenteras i början och/eller slutet av slutrapporten. Om detta inte är något ni vill så säger ni till.
- Samtyckesblankett.
- Intervjun spelas in och transkriberas. Inspelningen tas bort efter genomförd studie.
- Man svarar på hur många eller hur få frågor man vill.
- Det finns inget rätt eller fel svar.
- Har du några frågor?

Frågor

Tema 1: Uppvärmningsfrågor och allmänt om verksamheten samt dess skolbesöksverksamhet

1. För någon som aldrig hört talas om er verksamhet, vill du beskriva vad ni arbetar med på XY generellt?
2. Beskriv din roll i verksamheten och på era skolbesök.
3. I hur stor utsträckning tar ni emot skolklasser?
    a. Har ni någon huvudsaklig målgrupp?
    b. Har ni identifierat någon/några målgrupper som inte brukar besöka er verksamhet?
        i. Arbetar ni med att försöka få dessa målgrupper att besöka er verksamhet?
        ii. Hur väl fungerar det arbetet?
    c. Under resten av intervjun, tänk på målgrupp XY i dina svar.
4. När en skolklass kommer på besök, beskriv vad som brukar hända då.
    a. Hur lång tid tar besöket?
        i. Är detta tillräckligt lång tid?
        ii. Brukar de komma vid flera tillfällen?
    b. Hur stora brukar grupperna vara?
        i. Görs det någon form av gruppindelning under besöket?
5. Vad är syftet med era skolbesök?
    a. Finns det något krav på er från annat håll att genomföra skolbesöken?
    b. Vad vill ni att eleverna ska få ut av skolbesöken?

Tema 2: Framgångsfaktorer i skolbesökens upplägg

1. Beskriv ett skolbesök som varit framgångsrikt
    a. Vad var det som gjorde skolbesöket framgångsrikt?
    b. Vad är ett framgångsrikt studiebesök för dig?
2. Tänk på de aktiviteter, rutiner och material ni har för skolbesöken.
    a. Finns det några/något ni gör som fungerar extra bra?
        i. Varför tror du att just dessa/detta fungerar extra bra?
    b. Samma fråga, fast specifikt gällande material, handouts, stenciler m.m.
    c. Tänk dig en skala från 1-10 i struktur, från väldigt fritt där eleverna går helt fria runt till något väldigt strukturerat där eleverna lyssnar på en guide hela besöket. Vart skulle du placera er skolbesöksverksamhet på en sådan skala?
        i. Varför?
        ii. Varför har ni valt att ha den graden av struktur?
3. Tänk tillbaka på ett skolbesök som inte har fungerat.
    a. Beskriv detta skolbesök kortfattat. Vad var det som hade gått snett?
    b. Vad tror du att ni hade kunnat göra annorlunda om samma grupp elever besökte igen?
4. Hur arbetar ni tillsammans med de ordinarie pedagogerna eller lärarna?
    a. Får lärarna någon information innan besöken?
        i. Vad är syftet med den informationen?
    b. Har lärarna någon särskild roll under studiebesöken?
        i. Hade du velat utnyttja lärarnas kompetens på något annat sätt?
    c. Arbetar ni utifrån läroplanen?
        i. Beskriv arbetet med läroplanen och hur det fungerar.
5. Hur arbetar eleverna förberedande inför skolbesöken?
    a. Vad tror du hade varit ett optimalt upplägg?
        i. Varför?
6. Vad händer efter skolbesöket?
    a. Hur arbetar eleverna och klasserna med vad de upplevt efter skolbesöken?
    b. Vad tror du hade varit ett optimalt upplägg?
        i. Varför?

<u>Tema 3: Hur arbetar ni med eleverna?</u>

Här är viktigaste frågorna att ställa 1a, 1b och 3.

1. Beskriv elevernas förkunskaper och förutsättningar (kunskapsmässigt, socialt m.m.) innan de kommer på besök.
    a. Brukar detta vara tillräckligt för att förstå och ta till sig era skolbesök?
    b. Hur arbetar ni med detta? Har ni strategier? Vilka då?
        i. Praktiskt i utställningen
        ii. Hur guiden arbetar
        iii. Hur ni involverar lärarna.
    c. Alla elever lär sig på olika sätt. Hur tar ni hänsyn till detta?
        i. Har ni aktiviteter som kopplar till visuellt, ljudligt, läsande och rörlighet?
2. Hur arbetar ni för att inkludera elever med olika funktionsvariationer, språkliga hinder med mera?
    a. Hur fungerar det?
3. Arbetar ni med att få eleverna att ta initiativ eller utforska anläggningen/utställningen själva?
    a. Hur arbetar ni med detta?
    b. Har ni andra sätt att få elever att aktivt delta i skolbesöket?
    c. Ser ni att detta har någon effekt?

        i. På lärande
        ii. På engagemang
        iii. Socialt
4. Beskriv om ni under skolbesöken gör några kopplingar mellan er verksamhet och elevernas vardag.
    a. Hur fungerar det?

Tema 4: Om guiden

Här är viktigaste frågan 3

1. Beskriv hur situationen med guider/pedagoger ser ut.
    a. Hur många är ni?
    b. Arbetar guiderna/pedagogerna även med något annat inom verksamheten?
2. Hur skulle du beskriva dig själv som guide/pedagog?
3. Brukar du ställa frågor till eleverna?
    a. Hur ser dessa frågor ut?
        i. Hur svarar eleverna på frågorna?
    b. Har du någon baktanke kring hur du ställer frågorna, och i så fall vilken?
4. Har de guider/pedagoger som finns i verksamheten någon utbildning eller erfarenhet?
    a. Vad finns det för möjlighet att få utbildning som guide/pedagog?
    b. Tycker du att den utbildning och erfarenhet du har är tillräcklig?
        i. Om inte, vad ser du för utvecklingspotential?

Tema 5: Avslutande frågor

1. Har ni gjort någon undersökning av vad som fungerar bra eller dåligt vid era skolbesök?
    a. Brukar ni samla in återkoppling från elever eller lärare?
        i. Hur arbetar ni med den återkopplingen?
2. Beskriv var tyngdpunkten kring det ni förmedlar ligger.
    a. Är det på det verksamheten arbetar med eller något annat?
    b. Är det på fakta eller större koncept?
    c. Varför har ni valt att lägga fokuset där ni lagt det?
3. Tack för intervjun. Finns det något mer du vill tillägga, som du ännu inte fått säga?

Information efter intervju

- Vi tackar för oss
- Vi dubbelkollar att det går bra att vi använder dina intervjusvar i vår analys.
- Information om hur och när de blir delgivna rapporten. Fråga hur de vill ha den.
- Tack för deltagande.

B

Form of consent

In this appendix the form of consent for the interviewees in the initial data collection can be found. Note that the form of consent is in Swedish and uses the standard template for these types of forms at Chalmers University of Technology.

CHALMERS

Samtycke och information om behandling av personuppgifter i studentarbete

Jag samtycker till att mina personuppgifter i form av

För- och efternamn, mailadress samt organisation. Inspelning av intervjusvar och utplockade citat därifrån får behandlas av Chalmers tekniska högskola för studien:

”Key factors to consider in guided tours in STEM-subjects, years 6 to 9”

Information

Personuppgifterna kommer att hanteras på följande sätt:

- Uppgifter ämnade för kommunikation mellan studenterna och organisationen samt ljudfiler och transkriberingar raderas senast 2025-08-31. Innan dess kommer enbart studenterna, samt vid enskilda tillfällen, handledare Robert Cumming ha tillgång till uppgifterna.
- Enskilda citat som kopplas till typen av organisation kan komma att finnas med i slutrapporten som kommer publiceras på Chalmers arkiv för examensarbeten.

Ditt samtycke gäller tills vidare. Du har rätt att när som helst ta tillbaka ditt samtycke. Detta gör du genom att kontakta sihlbom@chalmers.se eller registrator@chalmers.se. Om du återkallar ditt samtycke kommer vi upphöra att behandla personuppgifter vi samlat in med stöd i ditt samtycke. Vissa uppgifter kan komma att sparas pga. Chalmers skyldigheter enligt svensk arkivlagstiftning.

Chalmers tekniska högskola, 412 96 Göteborg, med org. nr 556479-5598 är personuppgiftsansvarig. Du hittar Chalmers integritetspolicy på www.chalmers.se.

Som registrerad har du rätt att få information om hur dina personuppgifter behandlas. Du har rätt att få felaktiga uppgifter rättade, överflödiga uppgifter raderade, begära att behandlingen begränsas och uppgifter överförda till en annan aktör. Du har även rätt att lämna klagomål till Integritetsskyddsmyndigheten (IMY). Har du frågor rörande Chalmers behandlingar av personuppgifter kan du kontakta Chalmers dataskyddsombud på dataskydd@chalmers.se.

Jag samtycker till att Chalmers tekniska högskola behandlar personuppgifter om mig i enlighet med ovanstående.

Ort	Underskrift
Datum	Namnförtydligande

C

The recommended concepts, materials and activities for the space observatory in Onsala

This appendix contains the developed materials, concepts and handouts for the recommended guided tour at Onsala. Since the language used at these tours is Swedish, most documents below are in Swedish. These documents include:

- A plan for how to conduct the guided tour in Swedish. An English version is presented in section 4.2.2.
- The information given to the teachers before the visit. This document is in Swedish and also contains the information the teacher is encouraged to give to the students on the bus to the observatory.
- The information for the guide conducting the tour regarding how to set up the planet experiment. This document is in Swedish.
- An example of the space bingo handed out to the visitors. This activity was created in Swedish and English. Therefore, the example shown is in English.
- The information about the planet game to be shown before the students enter the room. This document is in Swedish.
- The information given to the teachers conducting the planet game. This document is in Swedish.

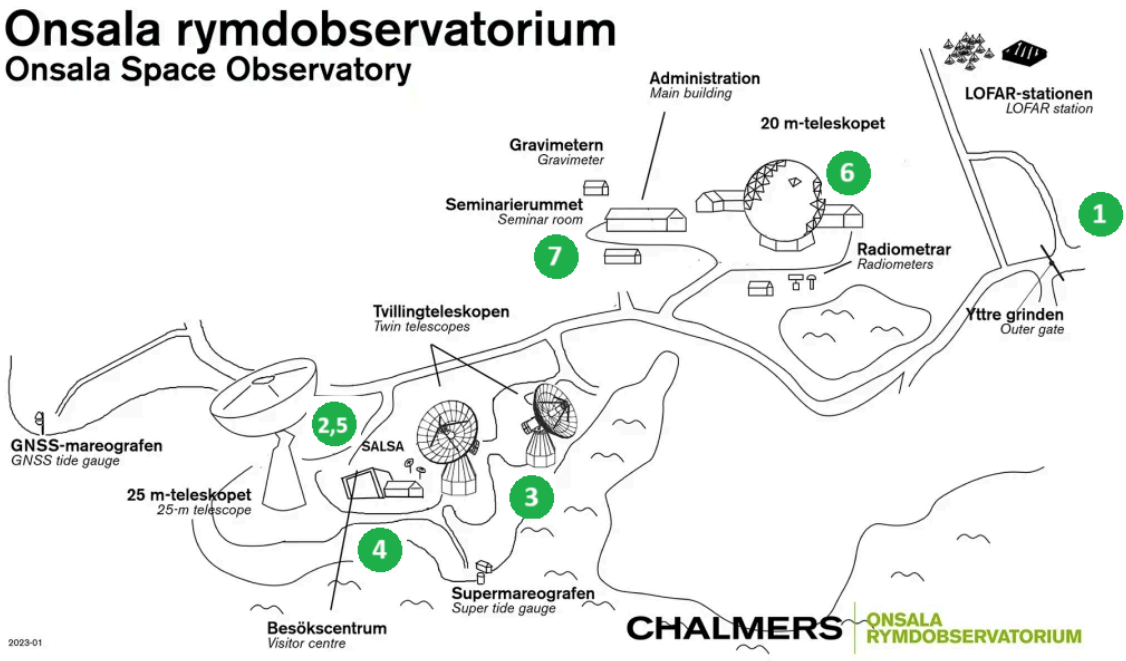
Rekommendation - Studiebesök Onsala för åk 6-9

Nedan följer den slutgiltiga rekommendationen för genomförande av studiebesök på Onsala år 6 till 9. Besöket är två timmar långt och bygger på att det är en grupp på ca 15-30 elever. Se figur 1 för karta av observatoriet samt vart varje moment genomförs. Utöver detta dokument tillkommer även följande dokument/instruktioner:

- Lärarinformation inför studiebesök på förmiddagen.
- Lärarinformation inför studiebesök på eftermiddagen.
- Powerpoint-presentation för användande under moment 4 och 7.
- Instruktion för genomförande av laboration under moment 4.
- Skylt till dörren till rymdäventyret under moment 5.
- Lärarinstruktioner till rymdäventyret under moment 5.
- Rymdbingo (svenska samt engelska) för moment 5.
- Bild på insidan av 20m-teleskopet att visa upp under moment 6.

1. Läraren ger eleverna förberedande information på bussen enligt lärarinformationen (frivilligt för läraren). Informationen består av en kort introduktion, praktisk information och besökets agenda.
2. **Introduktion (10 min):** Guiden möter gruppen vid bussen vid besökscentret. Guiden hälsar dem välkomna, berättar översiktligt vad observatoriet gör samt om upplägget för besöket. Här är det viktigt att göra relevanta kopplingar mellan Onsala, vardagslivet och elevernas tidigare erfarenheter. Här presenterar också guiden kortfattat 25m-teleskopet. Kom ihåg att prata om varför man inte får ha telefonen på Onsala.
3. **Tvillingteleskopen (10 min):** Promenad till tvillingteleskopen. Presentera vad ett teleskop gör, och specifikt vad tvillingteleskopen gör. Här är det viktigt att trycka på att om vi har tid så kommer vi få se data från tvillingteleskopen senare.
4. **Besökscentret (55 min):** Gruppen förflyttar sig till besökscentret:
    a. Samling i Hasselbladsrummet. Genomförande av laboration enligt separat instruktion. Syftet är att ge en förståelse för att det finns egenskaper på objekt i universum som vi inte kan se men som vi ändå kan mäta.
    b. Samling vid en samlingspunkt mitt i utställningen. Dela in gruppen i två (grupp 1 och 2).
    c. Grupp 1 sitter kvar medan guiden går med en lärare och grupp 2 till dörren för rymdäventyret. Där introduceras de till upplägget enligt skylten på dörren, och läraren får en utskriven instruktion om hur spelet ska genomföras med eleverna.
    d. Förklara kort hur man spelar ett bingo för grupp 1 och dela ut rymdbingot. Se till att eleverna huvudsakligen gör detta två och två.
    e. Efter ca 10 min samlas båda grupperna vid samlingspunkten igen och grupperna byts av, och gör den andra aktiviteten i ytterligare cirka 10 minuter.
    f. Tid för lunch, fika alternativt fritt utforskande i utställningen. Lunchen bör ske senast 1 timme efter besöksstart.
5. **Viskparabolerna (10 min):** Samling utomhus vid viskparabolerna. Berätta om GNSS-mareografen som syns härifrån, och tryck på kopplingen mellan satelliter och mätningar på jorden. Introducera därefter viskparabolerna. Se till att det sitter fotmarkeringar på trädäcken där eleverna ska stå. Dela in dem i hälften, låt grupperna gå till varsin parabol och låt dem gå upp en i taget. Var tydlig med att kalla dem “viskparaboler”.

6. **Promenad samt 20m-teleskopet (25min)**: Gruppen förflyttar sig till 20m-teleskopet:
    a. Presentera upplägget tydligt utanför teleskopet. Förklara varför de kommer ha på sig hjälmar inne i radomen och att det sker riktig forskning därinne. Syftet är att eleverna ska förstå att det inte är okej att röra vid saker eller göra vad som helst där inne. Öppna dörren efter introduktionen.
    b. Visa kontrollrummet.
    c. Visa och skicka runt takbiten från den gamla radomen.
    d. Visa själva teleskopet. Ta med en bild från insidan av teleskopet och visa den.
7. **Seminarierummet (10 min):** Om det är ont om tid avslutas besöket här med en kort uppföljning utomhus. Annars förflyttar gruppen sig till seminarierummet:
    a. Uppföljning om vad de såg inne i radomen. Koppla till likheter och skillnader till tidigare teleskop.
    b. Diskussionsfråga om vad man kan titta på med teleskopet. Syftet är att skapa en övergång till nästa moment.
    c. Berätta om doktoranden Alva med hjälp av bild och hälsning eller film.
    d. Visa upp mätdatan från tvillingteleskopen och förklara sambandet. Be eleverna diskutera varför ljuset förändras.
    e. Om tid finns visa filmen "The Known Universe". Tryck på kopplingen mellan de enskilda saker Onsala forskar på och allt som är upptäckt i universum.
    f. Besöket avslutas.



Figur 1. Karta över Onsala Rymdobservatorium. (Chalmers tekniska högskola, 2023). Omarbetad med tillstånd.

Lärarinformation under bussresan

Välkommen till ett studiebesök på Onsala rymdobservatorium!

Vi hoppas att ni ser fram emot ert besök ute hos oss på Onsala rymdobservatorium. Under de två timmarna besöket varar kommer ni både att få nya perspektiv på rymden i allmänhet, och få en närmare titt på några av våra radioteleskop. Dessa radioteleskop kan hjälpa oss observera saker i rymden som inte går att se med våra egna ögon - de är alltså inte som vanliga optiska teleskop.

Ungefär halva tiden kommer vi spendera utomhus, och halva tiden inomhus. Ta därför med kläder efter väder. Efter halva tiden kommer det finnas tid för medhavd lunch eller fika. Tänk på att det inte finns mikrovågsugn.

OBS: Glöm inte att stänga av eller samla in elevernas mobiltelefoner. Lärarnas mobiler ska sättas i flygplansläge, men får användas för fotografering. **Påslagna mobiler inne på anläggningen stör utrustningen och förstör forskarnas mätningar.**

Vi vill också be dig som lärare att berätta lite om observatoriet och besöket redan under bussresan till Onsala. Du väljer själv när du berättar informationen, förslagsvis när det är ca 10 min kvar av bussresan. Nedan följer ett förslag på vad du som lärare kan säga. Använd gärna bussens mikrofon/ljudanläggning.

Vi är på väg ut till rymdobservatoriet på Onsala! Ni kommer märka att det blir färre och färre hus när vi närmar oss observatoriet. Observatoriet ligger långt ifrån bebyggelse för att prylarna som finns där är väldigt känsliga, och störs av saker som finns i helt vanliga hus. Det är också därför ni inte får använda telefoner på observatoriet. Forskarna ute på Onsala tackar för hjälpen!

Först kommer vi åka igenom en grind, det är då vi kommer in på observatoriets område. Om ni spanar ut till höger efter grinden kommer ni kunna se en första glimt av teleskopen! Till vänster kommer ni kunna se havet, vi har faktiskt åkt hela vägen ut på en halvö!

Bussen kommer parkera längst in på området, bland flera av teleskopen. Vi kommer titta på några av dem, och kommer sedan gå in i "besökscentret" där vi kommer göra flera rymdiga aktiviteter. Där kommer vi också äta lunch. Vi kommer avsluta besöket uppe vid den stora vita bollen som vi kommer att se när vi åker in på området. Under besöket kommer en guide följa med oss, och guiden svarar gärna på frågor. Kom ihåg att alla frågor är bra frågor!

Under sista delen av bussresan vill jag att ni passar på att prata med någon ni sitter nära. Vad tror du att man kan kolla på med ett teleskop? Hur tror du att ett teleskop ser ut?

Låt eleverna diskutera frågan tills ni är framme eller tills de känner sig nöjda med frågan.

Chalmers tekniska högskola och Onsala rymdobservatorium hälsar er varmt välkomna!

Instruktion för planetexperiment

Syfte: Skapa en förståelse för att vi kan mäta saker som vi inte ser med ögonen.

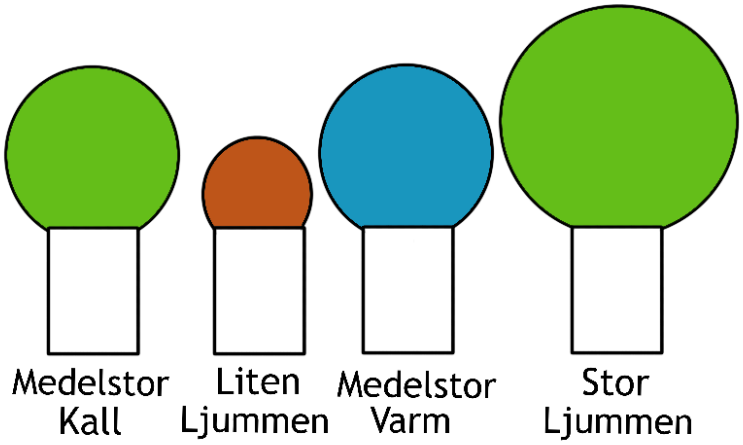
Ramar: Övningen sker i Hasselbladsrummet. Eleverna har fått introduktion till Onsala och tittat på tvillingteleskopen.

Material:

- 4 ballonger i olika kulörer
- Stativ för ballonger, t.ex. glas
- Värmekamera
- Förberedda slides med bild på ballongerna tagen med värmekamera, alternativt värmekamera med livefunktion
- Vatten med tre olika temperaturer

Förberedelser:

- Fyll ballongerna med vatten med tre olika temperaturer enligt figuren. Du kan välja kulörer fritt eller följa förlaget i figuren.
- Placera ballongerna i glasen enligt figuren på en lämplig plats i rummet.



Genomförande:

- Se till att eleverna sitter så att det fungerar att ha diskussioner dem emellan.
- Presentera ballongerna som planeter man upptäckt i ett nytt solsystem. Du har i uppdrag att undersöka dem.
- Dra igång powerpoint där frågorna finns med.
- Ställ diskussionsfrågorna, låt dem gärna tänka själva först innan de får diskuteras i par. Sammanfatta i helklass.
    - Vad har planeterna för egenskaper/utseende?
    - Vilken/vilka planeter tror du det kan finnas liv på?
- Ta fram värmekameran och låt eleverna kolla på planeterna genom kameran. Låt alla elever som vill prova. Ta fram bilden från värmekameran på powerpointen. Använd alternativt en kamera med livefunktion.
- Ställ nästa diskussionsfråga, låt dem även här tänka själva först innan de får diskuteras i par. Sammanfatta i helklass.
    - Kan vi dra någon ny slutsats om vilken planet det finns liv på?
- Avsluta med att förklara att det finns saker vi inte ser, och att vi på observatoriet också mäter saker vi inte kan se.

SPACEBINGO!

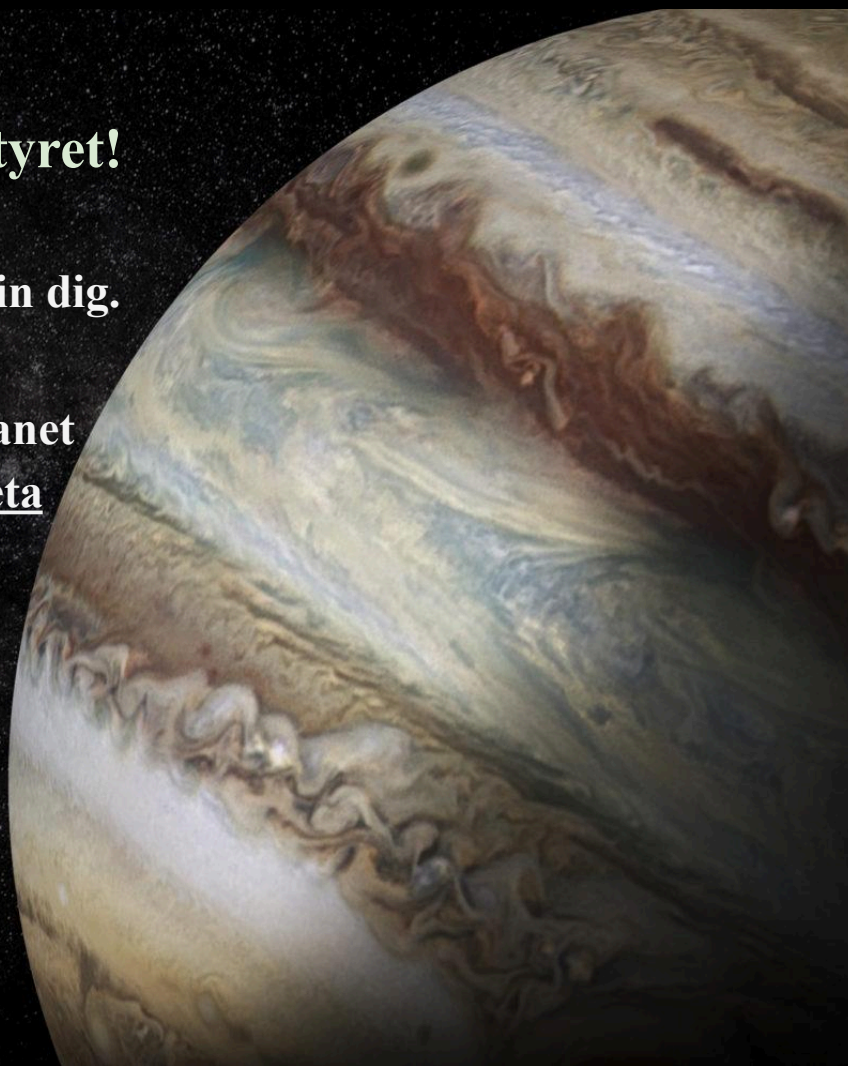
Largest and smallest Discuss with a friend and think of the smallest thing you can and think about the largest thing you can.	**Another space observatory** Find a photo of another observatory than Onsala. Think about what differences and similarities there are to the observatory at Onsala.	**Photo of an astronaut** Find a photo of an astronaut.	**Mirror your self** Go to the parabolic reflector (mirror) near the entrance. Ask someone who has a camera to take a picture of you in the mirror. Can you find the focal point of the mirror?	**Become astronaut** Wear the orange space suit. Walk around the exhibition and look at the pictures. Find a place in a picture where you would need a space suit. Return the space suit to where you found it.
Twins Look outside and find two telescopes that look the same.	**Your space secret** What is the spaceiest thing you've done or experienced? Tell it to a friend or an adult.	**Look at space** Look around in the exhibition, can you find a stargazer?	**Find a cool photo** Find the big photo taken by the space telescope James Webb.	**Where can you find life?** Find the photo of Mars. Discuss with someone else: What do we have on earth that makes it livable? What is most important and what can we live without?
Look outside Look through the windows and see if you can spot 3 different telescopes.	**Becoming an astronaut** Ask your friends and find someone who wants to become an astronaut.	**Big or small?** Find a picture of something that is much larger than yourself, and a picture of something that is much smaller than yourself.	**Planet or star?** Ask a friend: what do they think is the difference between a planet and a star?	**Find satellites** There are two satellites in the exhibition - MATS and Odin. Find a friend or adult and share one difference and one similarity between the satellites.
Solar panel Find a solar panel. What role does the solar panel have?	**The dog in space** Ask other people in the room and see if anyone knows what the first dog in space was called.	**The picture of a nebulose** Find a picture of a nebulose.	**Make a planet from pegboards** Go to Hassebladsrummet and find the pegboards. Make something that looks like a planet!	**The speed of light** How long does it take for the sunrays to reach earth? Can you find someone who knows?
Rocketship or satellite? There are multiple satellites in the room. Look at them and find one difference between rocketships and satellites.	**Become a scientist** What would you like to discover about space if you were a scientist? Discuss with someone in the room.	**Your own satellite** If you were to build your own satellite, what would it look like and what would it do? Tell an adult!	**Find earth** Find the picture of earth from space. Do you know which continent is shown?	**Jump high** Find the buckets with planet-names and lift them. On what planet do you think you can jump the highest?

Välkommen till Rymdäventyret!

Vänta här tills en vuxen släpper in dig.

I detta spel ska ni gissa vilken planet ni hamnat på genom att samarbeta - så var schyssta mot varandra!

När du kommer in - sätt dig direkt på golvet eller en pall.



Lärarinformation Rymdäventyret

1. Be en elev trycka på den gröna knappen vid ingången.
   Titta på filmen.

2. Be en elev trycka på knappen till höger om bildskärmen.
   Ni kan trycka flera gånger.

3. Lyssna på telefonsamtalet i telefonen bakom pallarna.

4. **Diskutera gemensamt vilken planet ni hamnat på.**

5. Gissa planeten tillsammans med hjälp av planetknapparna.

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