AR in the Wild
Designing an Outdoor Augmented Reality Tour for Preschool Children

Charlotte Tsz Wing Ho

Thesis Supervisor: Björn Lyxell
Thesis Examiner: Rachel Ellis
Copyright

The publishers will keep this document online on the Internet – or its possible replacement – from the date of publication barring exceptional circumstances.

The online availability of the document implies permanent permission for anyone to read, to download, or to print out single copies for his/her own use and to use it unchanged for non-commercial research and educational purpose. Subsequent transfers of copyright cannot revoke this permission. All other uses of the document are conditional upon the consent of the copyright owner. The publisher has taken technical and administrative measures to assure authenticity, security and accessibility.

According to intellectual property law the author has the right to be mentioned when his/her work is accessed as described above and to be protected against infringement.

For additional information about the Linköping University Electronic Press and its procedures for publication and for assurance of document integrity, please refer to its www home page: http://www.ep.liu.se/

© Charlotte Tsz Wing Ho
Abstract

The goal of this research was to create an educational, outdoor Augmented Reality tour for preschool children using Minnesmark editor and mobile application. It started with an ethnographic pre-study which aimed understand the children’s abilities, characteristics and interests. It was followed by a bodystorming session which allowed the children to contribute to the design process together with the designer. Based on all the findings, a context scenario was created which showed the concept of a practicable tour. All the functional and data requirements were specified before creating the tour. The design was intended to be user-centred and to have positive effect on the children’s learning of sustainability and biodiversity. The tour was refined and created as a final product. 10 children participated in the tour which was executed in a forest behind the preschool and the preschool garden. The tour was evaluated which identified the design problems and their possible solutions.

Keywords

Augmented reality, outdoor learning, user-centred design, preschool children, bodystorming, ethnographic pre-study, interest, motivation and learning.
Acknowledgement

I would like to express my greatest gratitude to everybody who have helped contribute to the completion of this project.

Many thanks to Björn and Mattias for your help and guidance throughout the project. A special thanks to Mattias who allowed me to be a part of the Minnesmark development.

Thanks to Eva, Maria and all the children at who took part in the study for your time and patience. You have always been friendly and made me feel welcomed. It has been an invaluable experience that I will never forget.

I would also like to thank Josefin for being an exceptional colleague. I appreciate your support and all the productive discussions we have had.
# Table of Contents

1 Introduction .................................................................................................................. 1

1.1 Research Question ..................................................................................................... 1

1.2 Delimitations ............................................................................................................... 2

1.3 Background .................................................................................................................. 2

1.3.1 Augmented Reality ............................................................................................... 2

1.3.2 Minnesmark .......................................................................................................... 3

2 Ethnographic pre-study .................................................................................................. 5

2.1 Interview ..................................................................................................................... 6

2.2 Participant observation ............................................................................................... 7

2.3 Data analysis ............................................................................................................... 7

3 Design ............................................................................................................................ 11

3.1 User-centred design ................................................................................................. 11

3.2 Visual search ............................................................................................................ 11

3.3 Interests, learning and motivation ............................................................................ 12

3.4 Bodystorming ........................................................................................................... 14

3.5 User requirements ..................................................................................................... 18

3.6 Context scenario ....................................................................................................... 19

3.7 Functional and data requirements ............................................................................ 21

3.8 The tour .................................................................................................................... 21

3.9 Evaluation of the tour ............................................................................................... 25

3.10 Design alternatives and improvements .................................................................... 26

4 Discussion ..................................................................................................................... 27

4.1 Methods and procedure ......................................................................................... 27

4.2 Results and analyses ............................................................................................... 28

4.3 Design and evaluation ............................................................................................. 29
5 Conclusion .................................................................................................................. 31
Reference .................................................................................................................. 33
Appendix .................................................................................................................... 35
Appendix: Interview questions ............................................................................. 35
1 Introduction

This thesis project aims to contribute to the learning of sustainability and biodiversity for preschool children using mobile Augmented Reality (AR). Earlier researches show that mobile AR can contribute to outdoor pedagogy, which provides a starting point for this project in creating a design for a group of preschool children in Linköping, Sweden. The project goal is to design an user-centred, interactive educational tour for the children to learn about a certain new topic in the nature, using an application called Minnesmark. The concept is based on location-based storytelling which can be seen as a roundtrip. The target participants of the tour are four- to five-year-old children at a preschool which applies the “I Ur och Skur” concept as the basis of their school curriculum. The preschool supports outdoor pedagogy and interactive learning. It strives to provide better education of the nature and promote the understanding of the relationship between human and nature. By participating the tour, it is hoped that the children will gain a deeper understanding on topics regarding the nature and environment.

1.1 Research Question

Based on the purpose of the study, the below research question is proposed:

*How can an interactive outdoor augmented reality tour be designed to contribute to the learning of sustainability and biodiversity at a preschool?*

This main question is supplemented by the answers of the following sub-questions:

- What pedagogical approaches do the preschool employ that are useful for creating the tour?
- What topics are the children most interested in?
- How do the children contribute in the design of the tour?
- Does the tour help the children to learn?

To answer the questions, an ethnographic pre-study is first conducted to understand the children’s interests, abilities and characteristics. Its results help to decide the context of the tour, namely the types of information and the theme to be presented. It is followed by a bodystorming session as the children co-design with the researchers. Details are put in studying the children’s interactions with the physical environment, leading to the presentation of the tour. The tour is then created and refined based on all the findings. It is evaluated which demonstrates its learning effect and strengths and weaknesses. Design alternatives and further improvements for future tours are also provided.
1.2 Delimitations

This thesis report focuses primarily on the design of the product, which is an interactive tour with the use of a mobile AR application called Minnesmark. Although the effect goal of this project is to expand the children’s knowledge on a certain topic, the study of learning effect is not documented in detail in this report.

The quality of the tour was affected by the usability of the application to a large extent. However, it was not investigated due to time constraints, which made it hard to justify when listing the quality requirement of the tour. Therefore, only the functional and data requirements were analysed. Furthermore, the lack of time allowed only one preschool to engage in the study and the tour was evaluated once.

1.3 Background

The following chapters provides the overviews of the target technique (Augmented Reality) and the application (Minnesmark).

1.3.1 Augmented Reality

Augmented Reality (AR) is a technique that creates an experience using various computer-generated sensory inputs such as visual and audio information (Kipper & Rampolla, 2012). It supplements our real-world environments with digital elements, presenting information that is otherwise hard to detect or temporarily unavailable in real life.

The use of smartphones and tablets are arguably the most common devices for using AR nowadays since they have almost become necessities in our daily lives. There are also increasing number of mobile AR applications available to the general public for various purposes such as entertainment and education. Smartphones and tablets are easily portable and they are equipped with the basic setups required for AR such as a camera, a display monitor and GPS, making them very convenient tools for both designers and users. AR has been used for mobile learning and it has been shown in various researches that it has positive effects on users’ learning experience and/or school performance. Examples include Explorez\(^1\) (Perry,

\(^{1}\) Explorez is a quest-based mobile application created for students who study French at University of Victoria, B.C.
2015) and *OcuClass* (Casati et al., 2016) which were shown to be helpful to users’ learning and attention.

There are different signals or elements that can bring out the AR components in mobile platforms, for example GPS positions, AR markers and image recognition, depending on the features and purpose of the application. However, they are in fact susceptible to the technical challenges mentioned by Kipper and Rampolla (2012), namely object recognition and sensor accuracy. Imagine an application that specifically uses AR markers, if the camera fails to register the AR markers correctly and/or the application cannot recognise them, then it cannot function at all. Functionality is, among other things, one of the most important aspects that determent how users experience the AR application. More on user experience will be discussed in Chapter 3.1.

### 1.3.2 Minnesmark

Minnesmark is a mobile AR application developed by Mattias Arvola and Umapathi Tallapragada. It aims to provide learning experience for school children in outdoor settings by participating in a treasure hunt or a round trip, using an iPhone or iPad. Minnesmark has a web-based editor for teachers to create and edit a tour. They can locate a number of stations in a designated area by their GPS positions (Figure 1) or AR markers (Figure 2), and connect them to different media files. An AR marker is the medium that triggers the interactive, digital component in the surrounding environment and thus augmenting the reality.

---

2 *OcuClass* resembles museum visits in classroom settings, which helps to provide an efficient and functional learning environment.
When a tour is created, the children can download and open it in the mobile application. They can explore the area and eventually arrive at the stations. Some media files are played automatically when the children arrive at a station with a specific GPS position. The application supports a navigation function which helps the children to find the GPS-activated AR components (Figure 3) by pointing at the direction to the closest station. If they found an AR marker that was placed by the teacher prior to the tour, they can simply turn on the camera by tapping the button at the bottom-right corner and scan the marker to activate the AR component.
Figure 3. Screenshot of the Minnesmark application on an iPad, displaying the navigation function. Children can turn on the camera by tapping on the camera icon at the bottom-right corner of the screen.

2 Ethnographic pre-study

As the design of the tour adapts a user-centred approach, it is naturally important to get a description of the user’s needs, desires, and/or thought processes (Hanington, 2003). Hanington (2003) explained some of the methods acquired in understanding users are originated from ethnography (i.e. the study of people and cultures). Typical methods in ethnographic studies include semi-structured interview and participant observation (Howitt, 2013), which are used in the pre-study to answer the aforementioned research questions of what pedagogical approaches the preschool employ, as well as what topics the children are most interested in.

According to Howitt (2013), a semi-structured interview is a lengthy interview that intends to obtain detail information from an individual on a certain topic. The interviewer often prepares a set of open questions prior to the interview which aims to encourage the interviewee to talk in-depth. Since the interview is semi-structured, the interviewer does not have to follow the prepared question strictly and they are free to add other questions during the interview when necessary. Howitt (2013) describes participation observation as a form of fieldwork, which requires the researcher to take part in particular situations to witness and observe personally what is going on. The researcher can decide at what degree they wish to engage as a member
of the observed group, depending on the situations and the opportunities of taking notes while observing.

Fieldnotes and voice recordings are the usual methods of data documentation which should be made during and after each interview and observation session. The researcher should bear in mind to separate observation and speculation in their notes as it affects how readers interpret the data.

2.1 Interview

An in-depth semi-structured interview with an experienced teacher at the preschool was conducted which creates an opportunity for the researcher to get to know the children’s abilities, characteristics and interests. The interview data was determent to the types and content of media files to be presented in the tour. A set of fourteen questions and the informed consent document were prepared in advance. The researcher explained the purpose of the interview to the teacher and asked for consent to record the conversation. When permission was granted, the researcher started recording using a mobile phone application called Smart Recorder.

The prepared questions were in Swedish and they were translated as follows, the original questions were attached in Appendix.

- Do the children read a lot of books? Do they like to read?
- We want to know about how much the children can read, can you suggest some book that they have recently read?
- We are wondering where we can execute the tour, where are the places that are the most convenient and easiest for you/us to keep an eye on all the children?
- For how long can they stay focused? What do you usually do to encourage them to continue with an activity?
- Do you have any tips on how to give instructions to the children?
- How do you describe new phrases and concepts to the children, for example, what a water molecule is? (Verbal descriptions? With gestures? With the surrounding objects?) How do the children react to new ideas?
- Can you describe how creative they are? When you built the bird feeder with the children, what did you do to inspire them?
- Which day/activity in the week do the children look forward the most? What can this be due to?
How often do the children work in pairs or groups? Does the cooperation work well?
Is there anything we should account for when we hold the workshops?
Does anyone have special needs?
Can you suggest some themes that can be the most motivating for the tour?
There can be media files in the tour that present information for the children, in the form of texts, sound clips and films. What types of media files will the children learn the most from?
If we have the parents’ approval, can we take pictures during the tour? That is to say, the children’s faces will not be shown in the reports.

The interview took around twenty minutes. It was selectively transcribed and translated, meaning that only the key points were extracted from the recording.

2.2 Participant observation

A week after the interview, the researcher returned to the preschool and observed the children’s behaviour in an educational setting. The children gathered in a Sami tent and the teacher introduced the researcher so everybody understood the purpose of their presence. During the observation session, a teacher told a story about recycling and they went on an excursion in the forest afterwards, to which the researcher was invited. They went to the forest behind the preschool and played a game. The game required roleplaying as the children pretended to be marine animals looking for a home in the increasingly contaminated ocean. The purpose of the game was for the children to learn the importance of respect and environmental protection. Since the researcher took part in the game, notes were taken directly after instead of during. The duration of observation was between one and two hours.

2.3 Data analysis

The collected data need to be structured and analysed, and one of the methods of analysis is to use an Affinity Diagram, which is a tool that helps the researcher to sift through large volumes of data by putting them into categories/themes (Arvola, 2014). The finished affinity diagram should entail information about the users and create insights on design concepts.

The data obtained from the interview and observation are summarised in the following parts of an affinity diagram (Figure 4a-4c). All the phrases were generated or directly extracted from the interview recording and observation field notes, as evidenced by the translated selective transcripts and related observations. The phrases are sorted in three categories, summarising
the children’s abilities and characteristics (Figure 4a), the pedagogical approaches employed by the preschool (Figure 4b), and the topics of interests (Figure 4c).

<table>
<thead>
<tr>
<th>Children's abilities and characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like to listen books</td>
</tr>
<tr>
<td>Good at listening</td>
</tr>
<tr>
<td>Children can stay focused for half an hour</td>
</tr>
<tr>
<td>Love to go to the forest</td>
</tr>
<tr>
<td>Play a lot together</td>
</tr>
<tr>
<td>Help each other a lot</td>
</tr>
<tr>
<td>Cannot read</td>
</tr>
<tr>
<td>Good at expressing themselves</td>
</tr>
</tbody>
</table>

**Figure 4a. An overview on the children’s abilities and characteristics.**

“The children like to read (listen) to books. […] They are good at listening, they can stay focused for half an hour with no problem. […] The older children (5-year-olds) recognise some letters and can write their names, but they cannot read. […] The children are very good at expressing themselves. […] I think they very much look forward to go to the forest, they love it! […] The children do not often work in pairs or groups, but they play a lot with each other and they always help each other. I think it should work well and we can try to do group activities. “

The observation fieldnotes agreed with the interview that the children liked to listen to stories. They stayed quiet and kept their eyes on the teacher during story time, which showed a great deal of attention. After the story, one teacher said an alphabet and the children whose name begin with that alphabet could leave the tent, showing that they had somewhat learnt to recognise certain alphabets (at least verbally). They expressed excitements as they were told to line up to put on their vest before going to the forest. On the way to the forest, the children walked in pairs and held hands. They seemed to get along very well. They were also very helpful and friendly during the game when they were asked to share small space with each other.
“We read them books every day, usually a few times a day. We encourage the children to discuss what they have learned in each story. [...] I use my body and voice a lot when I want to draw attention from the children. [...] When I give them instructions, I tend to keep it short and clear. [...] We use models to demonstrate new phrases and concepts to the children. And use simple words with examples or metaphors so they understand better. It is important to use different modalities like gestures and senses. Repeat a lot, get them to discuss, and try to associate the new concepts with the nature and environment, and use what is available at hand for demonstration. [...] It is important to get them interested and just go from there. When they made the bird feeder together last year, they did some sketching first, which allowed them to use some fantasy. Then they got to build their own model in paper, and discuss a lot. Why did they build them that way? Can it look like this instead? We encourage them to look for different answers. [...] We want them to be able to think independently, so asking open-ended questions are important. “

It was observed that the teacher asked many questions when they told the story. It got the children to think critically, such as whether the actions of the character in the story was correct and why. They quickly came to the conclusion of what the message or the moral of the story
might be, due to active discussions. The children were keen on sharing their personal experiences with the class as an example to relate to the story or their discussions. The teacher made big gestures and used a dynamic voice to keep the children focused as they were telling the story. The children also learned through games and roleplaying, which allowed them to see things from other’s perspectives.

<table>
<thead>
<tr>
<th>Topics of interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds</td>
</tr>
<tr>
<td>insects</td>
</tr>
<tr>
<td>Features</td>
</tr>
<tr>
<td>Living environment</td>
</tr>
</tbody>
</table>

*Figure 4c. A list of topics in which the children were the most interested.*

"The children have been learning a lot about birds, insects and fishes through books. [...] They have worked mostly on birds and insects, they built a birder feeder and an insect restaurant during the last school year. I think they can look for insects and birds in the tour. What feature they have, how they look like, what environment do they live in, etc. Associate with their living environment like what they eat and where they live."

No related observational data was obtained regarding this category. However, it was obvious that the children had learned a lot about birds and insects because of the books, bird models and the products of their building projects that were found at the preschool.

To summarise, knowing how to draw their attention and keep them interested were important aspects that needed to be considered when designing the tour. All the activities should be kept around thirty minutes so that the children can stay focused throughout the session. Since the children were good at expressing themselves, active discussions were preferred to keep them engaged. Working in groups were not a regular act in the preschool, but the children were open to allow others to play with them and they often helped each other. Therefore, putting them in groups and sharing an iPad during the tour should not be a problem. The children had learned a lot about birds and insects recently. As the tour is aimed to be educational, it is essential to use materials that are not too easy nor too difficult for the children. They were too young to read so texts should be avoided. Instead, pictures, sound recordings and videos were considered more inviting. The content of the tour should be relevant to nature, especially birds and insects which the children were familiar with yet not proficient in.
3 Design

This chapter documented the design process of the tour.

3.1 User-centred design

It has already been mentioned in the introductory chapter that user experience is an important aspect in designing Augmented Reality. To create desirable user experience, the design ought to concern the user’s perspective. It should ensure that the design is based on the needs and interests of the user (Norman, 2002). It is essential to make the design usable and understandable. The design should help the user to reach their goal with ease, and without burdening their cognitive load in perception, memory, attention, etc.

The process of creating a design is divided into four activities (ISO 9241-210, 2010):

1. Understand and specify the context of use.
2. Specify user requirements.
3. Produce design solutions.
4. Evaluate design against requirements.

These activities help the designer to create insights, generate ideas and to realise the ideas through the design. It should also be constantly compared with user’s requirements to make sure that those requirements are fulfilled. The first activity has already been achieved. To recapitulate the context of use, the tour applies a mobile Augmented Reality technique to help a group of preschool children to gain deeper understanding of certain topics related to the nature. The user requirements are specified in Chapter 3.5, which captured the most important issues that the researchers had learned about the children after the pre-study and the bodystorming. A context scenario is created in Chapter 3.6 to describe a possible tour, leading to a functional and data requirement analysis in Chapter 3.7 that specify what needs to be prepared in order to create the tour. The children participated in the tour and the researchers evaluate the tour in Chapter 3.8 and 3.9 by comparing it with the all the requirements and uncovering the design problems that occur during the tour. Design alternatives and improvements are suggested in Chapter 3.10.

3.2 Visual search

A desirable design should help the user to achieve their goal with ease (Norman, 2002). In the case of Minnesmark which uses AR markers, user can activate an AR component by scanning a marker using the camera on the device. However, in order to do so, they must find the marker
first. Searching for a relatively small object in an outdoor environment can be a challenge. A search by definition is to engage in an active search for a particular stimulus (Sternberg & Sternberg, 2011), in this case the AR marker. Normally, the user needs to ignore or deemphasise the distractors in the visual field to locate the visual target. However, if the user recognises the features of the marker (Figure 2 in Chapter 1.3.2), they can conduct a feature search, meaning that they can simply select their attention to the features in the environment (Treisman, 1993; Weidner & Mueller, 2009). If the features are distinctive from the distractors, it is unnecessary to look through every detail in environment, hence less effort is required. Apart from the salient features of the marker, the search can also be aided by expectancy, as people tend to pay attention to places where they expect to see changes or anomalies (Wickens et al., 2012). For that reason, correct expectations help us to find the target more effectively even though its detectability remains unchanged.

3.3 Interests, learning and motivation

The ethnographic pre-study showed that it is important to keep the children interested when introducing new concepts. Deci & Ryan (1985) described interest as “an important directive role in intrinsically motivated behaviour in that people naturally approach activities that interest them”. Since the early 19th century, German philosopher Herbart (1906/1965, 1841/1965) brought out the close relationship between interest and learning. He believed that the development of interest is one of the primary goals of education as it leads to meaningful, memorable and motivational learning. There are two types of interests, namely individual and situational. Individual interest develops slowly and tends to have long-lasting effects on an individual’s knowledge, while situational interest is usually temporary and triggered spontaneously by an object or activity. It is relatively less influential to an individual’s knowledge (Hidi, 1990). In Hidi’s (1990) study, it shows that both kinds of interests have profound effect on learning in different ways. She claimed that individual learning plays a strong role in intentional learning, while situational learning is apparently more relevant to knowledge acquisition.

Schraw, Flowerday & Lehman (2001) supported the claim that situational interest is important for learning. They believed that emphasising the relevance and value of the learning information may increase student interest in class. They offered a guideline of six suggestions to help promoting situational interest, which are to:

1. Offer meaningful choices to students.
2. Use well-organised materials.
3. Select materials that are vivid.
4. Use materials that students know about.
5. Encourage students to be active learners.
6. Provide relevance cues for students.

Deci & Ryan’s description of interest suggests that interest goes hand in hand with motivation, which according to Price & Harmon-Jones (2011), is reflected by bodily movements. They explained that body postures are indicative to one’s motivation based on the psychophysiological perspective. For example, leaning forward is an action that demonstrates approach motivation as organisms lean towards desired object, such getting closer to the table (where the food is) when one is hungry. On the contrary, leaning backward suggests low approach-motivated states, usually after a goal has been achieved and the desire for the object no longer exists, such as sitting back when one has had a satisfying meal.

In this study, an exploratory workshop was conducted which aimed to help the children to grasp the concept of augmented reality, so that they had an idea of what to anticipate in the tour. According to Schraw, Flowerday & Lehman’s (2001) guideline, providing relevant cues for the children would help them to develop situational interest. Since AR was a new concept to the children, it was important that they understood what this technique was and how it looked like before they went on the tour to avoid the possible frustrations.

Due to the outdoor curriculum, the workshop took place in the forest rather than in a classroom. First, the researcher explained briefly what augmented reality was, its application and how it could be incorporated in the tour. The children were divided into groups of three and each group experienced Augmented Reality using an application called Augment, with which 3D models were visualised in the real world presented in the mobile phone monitor through the camera. The children were asked to choose an animal model and “interact” with them. Each group had around fifteen minutes to play with the AR components as well as to discuss what they had learned. At the end of the workshop, the children were told how this technique would be implemented in the tour they were about to participate in the next couple of weeks. This workshop did not generate any data as its sole purpose was to demonstrate the AR technique to the children. However, this workshop ought to create some interests and excitements for the coming bodystorming session and the tour.
The children had never heard of phrases such as reality, augmented reality nor digital elements. However, once the researcher had explained each phrase briefly using examples, the children quickly learned and started pointing at different objects to demonstrate their understanding. Some of the younger children were slightly confused with all the new phrases but they understood immediately once the researcher showed them the Augment mobile application.

The children reacted on the AR technique very positively. They showed grave interest and motivation in testing the application as they each wanted to “hold” an animal on their hands as shown in Figure 5 below.

![Figure 5. A child “holding” a cow in their hand using the mobile application Augment.](image)

The reactions suggested high level of acceptance towards this brand-new concept. As the workshop came to an end, the children could verbally explain those new phrases using richer vocabularies without any assistance. They also referred to the animals in the application to exemplify their understanding. The workshop was considered a success in introducing AR to the children.

### 3.4 Bodystorming

Bodystorming is a design technique that is based on interaction and movement of the body (Oulasvirta et al., 2003). The idea is to imagine as if the product already existed and it should take place ideally “in the wild”, where the product will be used. Oulavirta et al. (2003) pointed out that successful bodystorming enables participants to get up and move, which helps sharpening focus and generating ideas. It allows them to use their bodies to externalise their
ideas so others can see. They suggested that bodystorming is best for designing activities that are accessible and unfamiliar to the researcher. Besides, according to Smith (2014), designers of location- or place-based mobile computing experiences have used bodystorming as it helps them to explore the relationship between the product’s intended uses and the environment.

Although bodystorming is not a method that is as common and simple as sketching, it is indeed a better way to co-design with children (Hemmert et al., 2010), for the reason that bodystorming provides a more enjoyable experience and helps children to express their ideas. One important factor that is missing from the activity of sketching is the opportunity to interact with other children and the environment. In this sense, bodystorming allows for more detailed verbal and embodied descriptions of the emerged concepts. Oulavirta et al. (2003) believed that this embodiment allows participants to externalise and visualise their mental models and thoughts, and reduces their cognitive workload, allowing them to reallocate their mental resources from speech production to other tasks.

The bodystorming technique acquired in this study was slightly different from what Oulavirta et al. (2003) explained. It was customised according to the children’s understanding. Since the concept of AR was new to them, it might be hard to imagine how it could be applied to other contexts in detail. Instead, the children were asked to first create a story using their knowledge and creativity, and then recreate it immediately after by roleplaying as the main character and placing pictures on relevant objects in the forest. Allowing the children to create a story on their own brought them the opportunity to use their imagination and fill in the details. The researcher tried to avoid interfering with the creation of the story unless the children were out of ideas. The reason for creating a story beforehand was that the children might have trouble focusing on the telling and the acting of the story at the same time.

The bodystorming session was documented by written notes and photographs. Five four-year-old children participated in the bodystorming in the forest. Their parents or legal guardian had signed a consent document stating, among other things, that the researcher had the permission to report the findings. Since the number of children attended preschool that day were fewer than expected, all five children participated in the same group. They sat in the wind shelter as they created the story together. The researcher showed the children an idea picture for the children to begin the story with. Since the results of the ethnographic pre-study showed that the children were interested in birds, a picture showing a frightened bird fleeing from a tree that was being cut down by a man was chosen. The researcher prepared a set of other related pictures that were predicted to be relevant or included in the possible events or scenes in the
story to be created. The children described what they saw in the idea picture and developed it both backward and forward as they tried to figure out what had happened and what would happen next. They were also asked to describe what the characters in the story might feel due to the events.

The refined version of the story is presented below:

“Once upon a time, there was a little blue bird named Neo. Neo was a song bird who lived in a tree in a beautiful forest.

One day, Neo heard some loud noises and he flew out to see what was going on. Suddenly his world was turning upside down, he flew out of his home and saw a man cutting down the tree he was living in! He was frightened and he fled immediately. He tried to look for a new tree and rebuild his nest, but all the trees in the entire forest had disappeared. “What should I do now?” thought Neo.

He remembered that there was another forest just a little further away. He hoped for the best and got to the forest. To his expectation, he found trees – lots of trees! Neo inspected the forest as he needed to find a few things before he could decide to live there or not. “I need water, food, and material to build a new nest!” said Neo. He flew across the forest and discovered a pond. He rested in a tree nearby and realised he started to get hungry. He flew onto the ground and started looking for worms. Neo realised that this is the perfect place to live in as he could easily find food and water. Then he gathered some tree branches to make a nest. He found himself a new home!

The story finished as Neo built a family and became a father a year later. “

As the story came to an end, they went out in the forest and started to act on the story. The researcher retold events of the story from start to end, and gave the children a related picture related to each event with a piece of double-sided tape attached. The children were asked to imagine as if they were the character, Neo, in the story, and they took turn to put the picture up on wherever the object in the picture they thought it should be found. The acting allowed the children to indirectly create a tour on their own as they roleplayed as Neo, who had a mission to find different object at different places in the forest. The target places were comparable to the stations in a tour.
The purpose of asking the children to put up pictures in the nature was due to the resemblance of actions. If the children were to place a printout of a worm on the ground, this placing action mimicked the scanning action in the use of the Minnesmark application. Therefore, the printout acted as an iPad, the located printout as the target (the AR marker) and the placing action revealed whether the children had the tendency of matching their expectations with the reality already at this young age, such as birds fly above them in the sky and worms crawl in/on the ground below their eye levels. This understanding is essential to determent where the AR markers could be placed in the tour.

The children (acting as Neo) were asked to find food, water and material for building a nest (which were equivalent to station 1, 2 and 3, respectively). They were able to find places where it was possible for a bird to find worms, such as on the ground and inside a tree trunk with holes. As shown in Figure 6 below, a child created the first station by attaching a paper with an image of a worm on the tree trunk. Initially, the child wanted to put it slightly below their eye level as it was more near to the holes and to the ground. They also naturally placed it at just below shoulder height due to convenience. However, due to strong wind, the child was hardly able to hold the picture in place and they needed assistance from their teacher, who slightly altered the position and the angle of which the child intended to place the picture.

*Figure 6. A child holding up a picture with the help of their teacher.*
A better approach to continue with bodystorming under that weather was to ask the children to point and use their body to express their thoughts. The next scene was to find a water source (station 2) for Neo. One child ran to a relatively empty space, where they were not as many trees around, and told the researcher that they had found water “over here” as they looked on the ground. They made a horizontal arm spreading gesture to imply that there was a pond. The last scene required the children to find the best tree around that could provide Neo with the safest home possible. They agreed that the tree had to be big and full of leaves, so it would provide shelter and avoid the risk of falling during bad weather. All children targeted one tree which seemed to be the strongest and greenest, making it station 3. They pointed forward and upwards at the tree as they said “that one” and started moving towards it. They were asked to collect materials for building a nest. Some of the children pointed downward at the broken tree branches on the ground, and some picked them up from the ground and tried to show the others what they had found.

The acting activity showed that the children had the concept of locating objects in relation to themselves as they pointed at relatively distant or hard to reach objects (e.g. a tree) and referred them as that, while they approached objects that are nearer to them (e.g. an imaginary pond) without pointing at them, and they used words such as over here. In the scene where the children looked for an imaginary water source (station 2), the child made a large gesture for the water at where they stood at, suggested they were aware that objects would appear larger at shorter distance. Furthermore, the child chose a rather empty space where there were less trees around. Given that trees do not usually grow on water and the fact that the other children agreed with their choice of space, it proposed that the children had the capacity of matching their expectations with their surroundings.

3.5 User requirements

The ethnographic pre-study helped the researchers to figure out what to present, while the bodystorming helped to find out how information should be presented. The list below summarised the most important findings that are helpful to the designing of the tour up to this point:

- The tour should be no longer than 30 minutes long.
- The tour should maintain active discussions.
- The theme of the tour should be consistent with the topics that the children had recently learned, i.e. Birds and insects.
• The media files should contain graphic, video, and/or audio information, and they should **not** contain texts.
• The children can work together and share an iPad.
• They should be able to utilise the objects and resources in their surroundings to help them gain deeper understanding of the nature and environment.
• All instructions should be kept precise and concise.
• The children had the concept that distant objects appear smaller and near objects appear larger.
• The children had the tendency to match their expectations with the reality.
• The children used their expectations to locate objects, and those expectations were originated from their knowledge and/or experience.

### 3.6 Context scenario

A context scenario describes an action sequence in form of a diagram or text (Arvola, 2014). It shows how a user can achieve their goal or solve their problem step-by-step based on the concept of the designed product. It also provides detailed information of the sub-tasks of each step, creating a complete picture of the task from start to end.

The following context scenario (Figure 7) was created based on the user requirements. Because spring was coming at the time the tour was designed, the theme of the tour was decided to be the nature in spring. Children would see the seasonal birds that were coming back, the caterpillars that were growing and transforming into butterflies, and the trees that becoming green again during that time. Each of these three categories contained at least two examples.

To accommodate the knowledge test which aimed to study whether the children had learned from the tour (Olsson, 2017), at least two relevant pictures of each example were presented, so that the children could pair the pictures of the same kind. Birds of both genders, the lifecycles of butterflies and two features of trees (buds and leaves) were the preferred contents of media files.

The scenario was presented in form of a task flow which demonstrate an outline of an achievable tour. The bolded texts represented all the objects (nouns) and the italicised texts represented all the actions (verbs) in Station 1, 2 and 3.
Figure 7. Context Scenario showing an outline of the tour.
3.7 Functional and data requirements

Context scenario helped defining the functional and data requirements for realising the design (Arvola, 2014), which specified what the children could do and what data should be contained for each function.

The purpose of highlighting the verbs and nouns in the scenario was to help identifying the functional and data requirements of the tour, which were summed up in the below table. The functional requirements presented the actions to be carried out while the data requirements helped the researchers to prepare for the materials.

<table>
<thead>
<tr>
<th>Functional requirements</th>
<th>Data requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruct the children about the tour</td>
<td>List of instructions of the tour</td>
</tr>
<tr>
<td>Locate AR markers</td>
<td>AR markers</td>
</tr>
<tr>
<td>Open media files</td>
<td>Media files of:</td>
</tr>
<tr>
<td>Learn about the media contents</td>
<td>Information about each media file:</td>
</tr>
<tr>
<td>Find markers on the trees (that correspond with the media contents) in the forest</td>
<td>Trees in the forest with buds and leaves</td>
</tr>
<tr>
<td>Find marker on bird feeder</td>
<td>Bird feeder</td>
</tr>
<tr>
<td>Find marker on insect restaurant</td>
<td>Insect restaurant</td>
</tr>
<tr>
<td>Find marker on a tree in preschool garden</td>
<td>A tree in preschool garden</td>
</tr>
</tbody>
</table>

Table 1. Functional requirements and data requirements of the design.

3.8 The tour

Two researchers created the tour together. One of them was mainly responsible for the implementation and the other for a knowledge test. The knowledge test and the presented information in the tour were interdependent, therefore it required both researches’ input.
The creation of the tour followed the context scenario as shown in Chapter 3.6. Eighteen pictures and one video clip were found on the internet. There were pictures of a male bullfinch, a female bullfinch, a male sparrow, a female sparrow, a male blue tit, a female blue tit, a birch leaf, a birch leaf bud, an aspen leaf, an aspen leaf bud, a brimstone butterfly and a tortoiseshell butterfly (eggs, caterpillars, pupae and adults for both butterflies). There was also one short footage of a tortoiseshell butterfly extracting nectar from a nettle flower. All media files are found on the internet. They were not presented in this report due to copyright protection.

Bullfinches, blue tits and sparrows were the usual visitors at the preschool area during summer time so the children were familiar with these species. The choices of aspen and birch was due to their presence in the forest. The researchers believed that the children might be able to learn more if they could refer to real life examples. The choices of butterfly species were due to the accessibility and quality of the pictures and the footage.

Since there were only eight AR markers available in the Minnesmark editor and each AR marker could only show one media file, the pictures of the same kind were merged together. The male and female birds were paired together to become one picture. The same applied to the leaves and leaf buds. As there were four pictures for each of the butterflies, two slideshows were made. Each picture in the slideshow was shown for four seconds. The slideshow with the tortoiseshell butterfly was also merged with the footage as the end of the cycle. These three categories made three stations for the tour, with AR markers of the same station being placed closer together. The widths of all pictures were adjusted to 350 pixels and the heights were adjusted proportionally. After editing, there were seven media files in total (three for bird, two for butterflies and two for trees). Each of them was assigned to an AR marker in the editor. The tour was published, downloaded into the application in the iPad and the AR markers were printed out. The markers were wrapped in plastic and attached on a cardboard stand to avoid damage in rain and wind.

A set of instructions was prepared for the teachers who led the tour. The original thought as shown in the context scenario was that the researchers could give out instructions before the tour but since the teachers were better communicators, they were asked to take on the leading and explaining role instead. The instructions included some general information and the researchers’ expectations about the execution of the tour. There were specific instructions for each station as well, providing the teachers an idea of what information they could give to the children.
A plot study was not possible during the time of visit, therefore the researchers only demonstrated the media files to the teachers a week prior to the tour, to ensure the correctness of the chosen material. Three picture were replaced for clarification purposes.

Ten children of age between four and six participated in the tour with permission from their parents or legal guardian. The participation was completely voluntary and the children were free to discontinue their participation anytime without any consequence.

The children were divided equally into two groups. Each group was guided by one teacher and the tour started as the children put their safety vests on at the preschool. Before the tour began, the children were asked to perform a knowledge test, which was a picture-mapping task that evaluated their knowledge regarding the media contents.

Group one consisted of four five-year-old and one six-year-old children, guided by teacher A. Two researchers were present in the tour as one took notes and the other took photographs and provided technical support when needed. Group two consisted of five four-year-old children with teacher B as the guide. Only one researcher was present and responsible for documentation and solving technical problems.

As the tour started, the researcher led the group and the teacher to the forest where the first station was located. The teacher and the researcher explained on the way what the children were about to do in the forest. There were four AR markers hidden in the forest and three in the preschool garden (Figure 8 below).

![Figure 8. A map of the tour presenting the stations (in dotted line) and locations of markers (the coloured objects).](image-url)
As they arrived in the first station, the researcher brought the children to an AR marker so that they learned how a marker looked like. The researcher demonstrated how to use the iPad to scan the marker and see the AR content, then the children got to take turn and hold the iPad (Figure 9).

![Figure 9. A child watching the media content of the brimstone butterfly marker.](image)

There were two markers at the first station, which showed the lifecycles of a tortoiseshell butterfly and a brimstone butterfly. Both the AR markers were placed on the ground in the forest as butterflies were more likely to be found near the ground. The markers were tilted at an angle so that they could be scanned easily from a natural standing position. They were placed at a short distance from each other so that the children could focus on only one marker at a time but with no problems finding the next one. The teacher initiated a conversation and discussion with the children and explained how the butterfly transformed through different stages. When they had learned about the butterfly, they spread out and looked for the second marker and the same process proceeded.

The researcher directed the children to Station 2, which was among the trees right behind Station 1. The AR markers were placed on the corresponding trees, meaning that the marker for aspen was placed on an aspen, and birch on a birch. The AR markers were slightly above the children’s heights and tilted downward so the children would have to look up as they normally would when they looked at a tree. When the children found the markers for the birch and aspen, the teacher showed the leaf buds to the children directly from the tree. Teacher B
asked the children in group two to touch a sharp aspen leaf bud so that they would remember it better.

After Station 2, the researcher guided them back to the preschool garden to continue with the last station. The children were more free to run around as it was an enclosed area where they could not get lost. The children had previously built a bird feeder and an “insect restaurant” as school projects and put them in the garden, therefore it was considered as fun and relevant place for this station. The children found the bullfinches on the tree, sparrows on the bird feeder and blue tits next to the insect restaurant. The teacher explained how they could tell the differences between the male and the female of each species. The tour ended as they have found and learned from all seven of the AR markers. The children then left the garden to perform the knowledge test again which was similar to the one they did before the tour.

3.9 Evaluation of the tour

A few problems were observed during the tours. The AR markers at Station 2 (trees) were placed slightly too high for the children to scan with an iPad. The researcher had to adjust them accordingly for each group. The iPad seemed to be too heavy for the children to carry above shoulder level, and this was a general problem for the younger participant in Group 2. Teacher B suggested the researcher to hold the device throughout the tour. At Station 1 (butterflies), the time for each picture in the slideshow was too short. The teachers could not fully explain the picture before it changed. Besides, the children needed time to process the information they received from the teacher at the same time they look at the pictures.

The children looked very interested at the beginning of the tour. Most of them actively requested to hold the iPad and test for themselves. The children tend to put the iPad as close to the marker as possible when they were excited, but then it created a problem that the markers could not be captured by the screen and read by the application. As the tour proceeded, some technical problems in the application emerged that were not manageable by researchers. The only solution was to restart the application. Some children became impatient and started to lose interest every time they were asked to wait.

Other than the issues with the application, the weather condition was also a factor in maintaining the quality of the tour. The execution of the tour took place when it was sunny. The iPad screen therefore reflected a lot by the sun, which made the media contents hard to see even when the brightness was set to maximum.
The purpose of the tour was to help the children to acquire new knowledge, although it was not the focus of this report. The results from the knowledge tests and the additional interview with Teacher B were obtained from the other member of the research group (Olsson, 2017).

The knowledge tests showed that the children performed significantly better after attending the tour \((N = 10, \text{average score from 2.20 to 5.30, } z = -2.50, p < .05, r = -.79)\). Teacher B revealed in an interview one week after the tour that they were positive towards the outcome. They believed that the AR markers were placed in appropriate locations, which allowed them to demonstrate real life examples to the children at certain stations and helped the children to learn more. They observed that the children had shown a lot of interests on the tour and that they had fun during the tour. They believed that the children had learned a lot as they recognised the birds, butterflies and trees when the teachers brought up for discussions after the tour. They also believed that the children learned more from the AR technique than the usual learning methods because it was interesting and completely new to them. The children seemed more attentive and curious, which implied that the learning experience was enjoyable.

Teacher B expressed that they wish to keep using the AR technique in the future. The only negative comment that teacher B pointed out was the technical problems with the application. The children quickly became bored as they waited for it to work.

### 3.10 Design alternatives and improvements

Some of the design of the tour aimed to accommodate the limitation of the application as well as the knowledge test. The following design suggestions tackle the problems that have occurred during the tour and provide potential improvements both regarding and regardless of the accounted constraints.

A more thorough investigation of the station areas could be carried out before the next tour. Although the feedback regarding the locations of the markers were positive, it was later found that there were more relevant features in the forest, such as a small nettle patch that could have been used for the tortoiseshell butterfly marker. It is suggested to consult someone that is familiar with the area and/or has knowledge about the subject of the tour.

The heights of the AR markers and the weight of the iPad can be interrelated since the children had less problem scanning the markers downward on the ground than upward on the trees. Therefore, either the heights of the markers at Station 2 can be lowered, or a smaller and lighter device can be used instead. The latter option changes the way the children share the device. It is not optimal for the same number of children to share a smaller screen such as a mobile phone.
as it may be hard for everyone to see. It also carries the risk that someone may feel left out. If the children go on the tour in smaller groups, the teachers’ workload may consequently be increased. For that reason, changing the heights of the markers is perhaps an easier option. The original thought was to place the marker where its content was spatially compatible to the stimulus in reality, such as butterflies fly closer to the ground and tree leaves grow higher up in the tree. Since the children were directed to a specific area at each station and the markers were not located far away from each other, they only focused on looking for the markers. For example, in Station 2, they were told that there were two markers for trees, so they started searching among the trees nearby. They did not know or notice the different kinds of trees because all they knew was that they were trees, which suits the purpose of the tour completely and allows the children to learn. Therefore, the compatibility is rather irrelevant. Accessibility, however, is more important as they should easily get to the information of which they learn from. The optimal height is where the children can stand up and point the iPad downward at the marker. This position helps the children to hold the iPad for longer duration. It is also easier for other children who are not holding the iPad to look at the AR effects together.

If more AR markers could be used or added into the tour, the effort and time required for editing the media files may be reduced. The children may have more fun as well since they will get to scan more markers. They may, as a result, gain a higher sense of contribution, allowing them to engage to the tour even more. Furthermore, if one marker contains only one picture or film, the teachers may not have to rush through their speeches like they did to keep up with the slideshows at Station 1. If the modification is not possible, each picture in the slideshows should be displayed for a longer period, about 10 to 15 seconds, so the teachers have enough time to explain.

The problem with the reflection of the screen was not a big issue since the children could still complete and learn from the tour, but it can easily be solved by applying an anti-glare screen protector if necessary.

4 Discussion

This chapter refers to the related theories in this report and presents ideas for future tours.

4.1 Methods and procedure

Due to the availability of the preschool teachers, the researchers only got a few hours in total to do the ethnographic pre-study. If there was more time, it is recommended to conduct the
same interview with other teachers and to spend more time with the children. The researchers
did not have a lot of experience in working with children, which made them less confident in
being around them, therefore taking the time and getting to know the children will help them
to communicate with each other. Besides, the children may feel more relaxed if they were asked
to take part in activities with familiar adults than with strangers.

The exploratory workshop was considered more meaningful than expected as it provided the
children an idea of AR and its applications. There were instant reactions as the children were
excited about the workshop and the activities that were coming onwards. This follows one of
the suggestions by Schraw, Flowerday & Lehman (2001) that promotes situational interest,
namely to provide relevance cues for students (suggestion 6). Knowing what is relevant to the
learning task and to be prepared for it in advance increases interests in learning as they now
understood the value of the information.

It is not common to conduct bodystorming with children at such young age so modifications
of method were necessary. There was a risk of framing when the researcher and teacher asked
them questions that might have affected the children’s answers and actions. The researcher
tried to avoid this problem by asking open-ended questions (e.g. What do you think Neo should
do?”) instead of close ended questions (e.g. Do you think Neo will find another forest?). It is
essential that the researcher makes sure they do not control the bodystorming process too much
so that the children can express their own ideas and thoughts.

There might be potential data lost in the bodystorming session and the tour as the researcher
was not able to take notes or photographs during those events as planned. Even if they were
possible, it was still difficult to observe all the children at the same time. They were enthusiastic
about joining in a discussion, which often resulted in cross talking. Fortunately, there was
enough data for producing the design.

4.2 Results and analyses

The results and analyses were obtained by the four activities of design process (ISO 9241-210,
2010). The researchers understood and specified the context of use (activity 1) by conducting
an interview with a teacher. They hoped to create a tour that fitted the preschool curriculum
and principle. As the preschool supports outdoor education and they emphasised the
importance of learning of sustainability and biodiversity, the theme of the tour should adapt to
this requirement. The interview also helped specifying the user requirements (activity 2),
together with the observation and bodystorming session. They were however only the teacher’s
and the researcher’s interpretation of what the children needed and knew. The children were very young and they had inadequate amount of vocabularies to express their feelings, thoughts and ideas. Design solutions were produced (activity 3) with the use of a context scenario, which was also a draft of how the tour would look like. The design was evaluated against all the requirements in Chapter 3.5 and 3.7 (activity 4), which resulted in slight modification during the creation of the tour.

Although the exact scenario and stations created by the children were not applied in the tour, it created an opportunity for the researcher to study the interaction between the children and the environment. It showed that the children had expectations of where different objects should be, based on their spatial knowledge of the objects. Furthermore, the children made various gestures during the bodystorming session which helped them to explain their ideas. As already mentioned, the children had limited vocabularies to express themselves. Therefore, gestures were very helpful actions that externalised their thinking using their hands and bodies (Oulasvirta et al., 2003). The children sometimes demonstrated their understanding of the world without being aware of doing so, such as the concept that near objects appear larger and distant objects appear smaller. This understanding had yet no influence on the decision on the size of the markers as the size of the media contents were also affected by how close the children were standing in front of the markers.

4.3 Design and evaluation

The researchers aimed to make the tour as interesting as possible for the children as they believed that it would make the learning experience more positive. They borrowed idea from some of Schraw, Flowerday & Lehman’s (2001) suggestions to increasing situational interest. Apart from providing relevance sues for students as aforementioned in Chapter 4.2, the researchers followed suggestions 2, 3, 4 and 5 as well. The reason that the researchers did not follow the first suggestion (i.e. offer meaningful choices to the children), was because the tour was designed as a group activity. It was hard to satisfy everybody’s preference but the researchers decided to use three different categories of media files to increase the children’s interests without having to make choices. The children were familiar with all three of the categories (suggestion 4) before the tour as they had already learned a lot about birds and insects in the school year. They were used to being in the nature and learning about the environment. The AR technique allowed for deeper learning as the children could see animals and insects that they knew about but perhaps never seen or noticed in the nature. The advantage of putting the tree markers on the corresponding trees was that the children (in group B) got to
touch the aspen leaf buds with their fingers. This tactile together with visual perception helped consolidating their memory regarding the characteristics of aspen trees.

Suggestion 2 and 3 stated the use of well-organised materials and materials that are vivid. Since the children could not read, they received information in dialogues so they listened to the researchers and their teacher instead of reading. The researchers gave the children a brief introduction of the tour and what they were about to do, providing some background information of the activity. The researcher also reminded the children about the AR technique that they learned in the first workshop, creating a frame of reference for the children. The teachers who led the tour were excellent communicators who explained everything in ways that were easy for the children to understand. They received a list of information (refer to which suggests what information they could give to the children. They were also welcomed to provide other information that was relevant. The teachers encouraged the children to be active learners (suggestion 5) as they initiated a lot of discussions about each media content. The children also liked to share their own experience and thoughts about what they saw and learned.

The researchers believed the tour did raise some interests, which was observed by the children’s bodily movement during the tour. At the beginning of the tour, the children often approached the markers as closely as they could even after the researchers and teacher told them that the screen needed to display the entire marker for it to work. As much as it was problematic, it was a positive indication of motivation. Children brought themselves closer to the marker implied that they were interested and motivated to find out what would see. It matches Price & Harmon-Jones’ (2011) claim that organisms lean towards the objects that they desire. Herbart (1906/1965, 1841/1965) postulated that interest is closely related to learning, which can be agreed due to the improved performance in the knowledge test after the tour.

The researchers considered the possibility of using different types of media files, such as pictures, video clips (with and without audio) and audio clips. Linköping is a windy city so it would be hard to listen to the narratives. Besides, the children need to share an iPad and so using earphones were not ideal either. Having the teacher as the narrator allowed for more interactive conversations and discussions among the group. More video clips were preferred but it was harder to find videos that could be implemented in the editor. Moreover, due to the time constraint, the researchers were not able to make their own videos.

Another consideration regarded the use of GPS in triggering the AR components. The researchers decided not to use GPS because the tour took place within a small area. It would
require extremely sensitive GPS and accurate positioning. The children were too young and they might become tired and lost interests if they had to walk for long distances. Therefore, only AR markers were used.

Throughout the tour, the children had no problem searching for the AR markers in the forest and school garden as they recognised how an AR marker looked like. It is consistent with Treisman’s (1993) and Weidner & Mueller’s (2009) explanation of a feature search as the children directed their attention on the distinctive features of the markers in the environment without spending tremendous effort in looking for them.

The most problematic issue in the design was the heights of the markers but it was manageable during the tour. The original thought was to place the markers close to where their media contents can be found in environment, so that the children’s expectations of the objects could help them to find the markers (Wickens et al., 2012). However, the children could not easily scan the markers that were above shoulder height. The researcher later learned that accessibility was more important than the spatial relations between the media content and the environment.

5 Conclusion

This report documented the design process and the creation of an outdoor Augmented Reality tour for preschool children based on the research questions:

➢ What pedagogical approaches do the preschool employ that are useful for creating the tour?

The affinity diagram displayed the results from the ethnographic pre-study that teachers often asked open-ended questions to encourage active discussion, so that the children could learn to think independently. They tend to use different modalities to help the children to understand new concepts. They often guided the children to associate those new concepts to the nature and environment. These approaches were embedded in the flow of the tour to help the children learn. Roleplaying and using resources that were available in the environment were also important approaches, which were applied in the bodystorming session that contributed to the creation of the tour.

➢ What topics are the children most interested in?

The affinity diagram showed that the children were the most interested in birds and insects. The teacher believed that the children would like to learn about their living
environment and style. This answered to the what aspects of the tour, providing a content for the tour.

➢ How do the children contribute in the design of the tour?

The children created a tour without realising it through bodystorming. They cooperated and made a story, for which they roleplayed and assigned different object for different “stations” according to their expectations of the world. The bodystorming session allowed the researcher to understand the interactions between the children and the environment, responding to the how aspects of the tour.

➢ Does the tour help the children to learn?

A knowledge test revealed a significant improvement after the participation of the tour, suggesting that it has a positive effect on the children’s learning.

All the results and analyses provided answers to the main research question of how an interactive outdoor augmented reality tour can be designed to contribute to the learning of sustainability and biodiversity at a preschool. The content of the tour was customised according the children’s requirements. The tour itself was partly created with the children through bodystorming, which helped the researcher to generate ideas in the presentation of information.

Future tours can be made with a storytelling approach as it is found that children like to listen to stories. They may be even more interested if they can experience a story themselves. They can, for example, act as the characters in the story as the teacher narrates. Apart from learning the moral of the story, the children can also understand the story from the characters’ perspectives, possibly leading to social developments such as theory of mind. This study showed that the applied methods were practicable in creating a tour, but it only focused on one group of children. It implies that it may not be possible to generalise all the design ideas to create tours for all children since every child is unique. It is hard to make assumptions on what an individual child knows and prefers. It may be simpler to design a tour for a specific group of children with common social background such as a play group or a class, but the tour need to be customised for each and every group accordingly.
Reference


Appendix

Appendix: Interview questions

1. Läser barnen många böcker? Gillar de att läsa?
2. Vi vill veta ungefär hur mycket de kan läsa, kan du föreslå någon bok som de nyligen har läst?
3. Vi funderar på vart vi kan göra rundvandringen senare, vart är de ställena som är enklast för er/oss att hålla koll på barnen?
4. Hur lång tid kan de hålla uppmärksamheten? Vad brukar ni göra för att uppmuntra de att försätta med en aktivitet?
5. Har du några tips på hur man ger instruktioner till barnen?
8. Vilken dag/aktivitet i veckan längtar barnen mest efter? Vad kan detta bero på?
9. Hur ofta jobba barnen i par eller grupp? Funkar samarbetet bra?
10. Finns det något som ska betraktas när vi gör workshops med barnen?
11. Finns det något barn som deltar i studien har specialbehov?
12. Kan du föreslå några tema som kan vara mest motiverande för rundvandringen?
13. I rundvandringen kommer det finnas mediafiler som presenterar information för barnen i form av texter, ljudklipp och filmer. Vilken eller vilka typer av mediafiler kommer barnen lära sig mest av?