UNIVERSITY OF TURKU

Using Low-Tech Prototype to Study Children's Preferences for UI Components

Case KidNet

University of Turku
Department of Computing
Master's Thesis
Interaction Design

Author:
Mirva Tapola

Supervisors:
Assistant Professor Tuomas Mäkilä

July 2023

Master's Thesis
Department of Computing, Faculty of Technology
University of Turku

Subject: Interaction Design
Programme: Master's Degree Programme in Computer Science
Author: Mirva Tapola
Title: Using Low-Tech Prototype to Study Children's Preferences for UI Components
Number of pages: 100 pages, 7 appendix pages
Date: July 2023

Children are spending more and more time on the internet. Although children grow up surrounded by technology, they still lack the skills to distinguish advertisements from the real content and have issues evaluating the reliability of websites. KidNet is a closed online learning environment developed for teaching children these important skills needed online.

User interfaces are a significant part of websites, but even when websites are targeted at children, the UIs are designed by adults. Adults do not remember what it is like to be a child, yet the children have usually been excluded from the design process, even when they are the main user group.

The main goal for this thesis was to find a way to include 6th graders in the design process, find out what kind of UI elements they like, how their likes differ from adults' likes and is there a need for two different UIs if KidNet was used by adults as well.

The goal was accomplished by organizing short design sessions where children and adults got to choose their favorite elements from different design alternatives and use them to build a low-tech prototype of a UI.

The results showed that the biggest differences were in the layout, children and adults made similar choices concerning chosen elements and colors and that there is no need for separate UIs in the case of KidNet.

Keywords: user interfaces, participatory design, child-computer interaction.

Abbreviations and Acronyms

CCI	Child-Computer Interaction
CD	Contextual Design
GUI	Graphical User Interface
HCI	Human-Computer Interaction
ID	Informant Design
LCD	Learner-Centered Design
PD	Participatory Design
UCD	User-Centered Design
UI	User Interface
UX	User Experience

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1 Introduction

Being a mother and watching my daughter grow up in a very different environment to what I grew up in, got me interested in the topic of children and computers. Today's children learn to use smartphones before they learn to walk. They can use computers before they can even read, and computers are used even in schools. Despite being a big user group for computers, websites and programs, children are rarely included in the design process for the new technology [1].

I have been working on the KidNet project first as a trainee and now as a research assistant for over a year now. One of my main duties has been designing and developing the user interface for KidNet. KidNet is an online learning environment where users can learn online inquiry skills which will be introduced more thoroughly in Chapter 5. The main user group for KidNet is 6^{th} graders. In order to design a good UI for our child users, I needed to gain knowledge on how children users differ from adult users. To be honest, I was in 6^{th} grade almost thirty years ago when computers were not everywhere.

The goal for this thesis was born out of my motivation to understand children as users and give them a chance to participate in the UI design, after all, they would be the actual users of the UI, instead of me. I also wanted to deepen my knowledge of users in general and gain understanding why something should be designed in a certain way.

I tend to question certain rules and I desire to understand why certain rules exist. In this case, I wanted to understand what is behind the recommendations made for UI design. I found a book written by Jeff Johnson called "Designing with the Mind in Mind" ([2]) which opened up a door to the users' minds and made me better understand the recommendations and rules concerning UI design. Chapter 4 is based on this book.

Allison Druin wrote an article called "The Role of Children in the Design of New Technology" [1]. Because of this article, I wanted to somehow give children a chance to get their voices heard, after all, they were the main user group of KidNet, not the adults developing it. Participating children in the design process became a key objective for this work. I started to wonder how children could take part in the UI design, what kind of UIs the children would design if they had a chance and how much the UIs would differ from the UI that I had designed for KidNet.

1.1 Research Questions and Research Methods

The researcher questions started to take form after reading about children's role in the design process and I ended up having the following research questions:

RQ1. What kind of user interfaces are good for children? How should the age of children be considered when designing user interfaces for them?

RQ2. What are the differences between children's and adult's user interfaces? Is it possible to create a user interface that all age groups like?

RQ3. How can user interfaces be designed with children? What kind of role children can have in the UI design?

RQ4. What kind of user interface would children design for KidNet? What kind of UI elements address the target group?

With these goals in mind, I started to think about different ways to include the children in the design process. I wanted to organize a design session that would be fun, beneficial and would not take too long, so that the children would not get bored. It was important that children would be able to express their likes and dislikes in a way that they would be comfortable with. I came up with this UI "puzzle" idea where children get to choose the components, they like the most from different alternatives and create their own version of a UI by placing the components the way they wanted to.

I did not think about any research methods while planning the UI "puzzle" and I consider it to be a good thing. Thinking about different research methods might have limited my creativity and forced me into a box where I might have not thought about this approach at all. Although the research methods were not around in the beginning, it is safe to say that this thesis has two parts, theoretical and empirical, which had multiple research methods.

I started the theory part with a literature review to gather information about child-computer interaction, children as users, user interfaces and users in general. The empiric part of this thesis was implementing the design sessions with participants and analyzing the data gained from the design sessions. Because the research made was limited to KidNet and the goal was to find out users' preferences, it can be seen as a case study and user study. On a more practical level, the design sessions were a combination of an interview, observation and participatory design. More about the research methods in Section 5.2.

1.2 Structure of the Thesis

The structure of this thesis consists of two parts. The first part is the theory part which is discussed in chapters two, three and four. Chapters five, six, seven and eight are more about the empirical part of this thesis.

Chapter 2 is based on theory about human-computer interaction, child-computer interaction and user interfaces. The end of the chapter tries to define the characteristics of a good UI and how to design one.

Chapter 3 is a theory chapter focused on children as users. The chapter begins with a short introduction of children's cognitive and physical development. The chapter also answers "How should the age of children be considered when designing user interfaces for them?" by describing how the age of children impacts the user interface designed for them. The chapter introduces different design theories used with children and answers "What kind of role children can have in the UI design?" as well.

Chapter 4 is about humans as users based on the book "Designing with the Mind in Mind" by Jeff Johnson [2]. It goes through the limitations and demands that humans have and how certain factors like memory and vision should be considered when designing user interfaces for humans. The chapter is primarily about adults, the differences between children and adults have been highlighted.

Chapter 5 is about the case description. KidNet is introduced more thoroughly. The research methods used in this thesis are also introduced together with a small ethical consideration.

Chapter 6 is an introduction to the design sessions held with the participants. The components used in the sessions and the theory behind the components are introduced in this chapter. The protocol used for design sessions is also introduced.

Chapter 7 presents the results from the design sessions. The chapter begins with a description of how the design sessions went with children and adults. Interfaces made by children and adults are introduced after small statistics about the choices they made. The chapter ends with a statistical summary about the choices made by the participants.

Chapter 8 begins with an introduction of the existing UI of KidNet and how things learned during the theory part influenced the design. It has visualizations about the choices made by participants and introduces a sketch that could be used as a new UI for KidNet.

Chapter 9 is the conclusion chapter where the research questions are answered and the ideas for future research are introduced.

2 Human-Computer Interaction, Child-Computer Interaction and User Interfaces

This chapter discusses human-computer interaction, child-computer interaction and user interfaces. Section 2.1 is about HCI and CCI and Section 2.2 is about user interfaces and characteristics of a good UI.

2.1 Human-Computer Interaction and Child-Computer Interaction

Human-computer interaction is a field of study that focuses on the design of computer technology and how humans interact with computers [3]. Child-computer interaction is HCI's subfield. CCI focuses on the design of computer systems made for children, how children interact with computers and the impact that computers have on children [4]. Both HCI and CCI are multidisciplinary fields ranging from computer science to psychology[1] and design [5],[6].

The obvious main difference between HCI and CCI is that research in HCI is concerning adults while research done in CCI is concerning children. The main difference between an adult user and a child user is that the child is still developing, and the technology used can have bigger impact on the child user, for good as well as for bad.

HCI has three elements: human, computer, and the interaction between the two elements. Humans have evolved during hundreds of thousands of years while computers have existed only few decades. Computers have changed drastically during these decades while humans have changed very slowly if at all [7]. More about human development in Chapter 4.

A few words about the interaction part before moving deeper into HCI and CCI. Humans expect the same things from interaction with computers as they do from interaction with humans. E.g., our time demand for response time from a computer (discussed more in Section 4.6.) is based on the expectation that if we were speaking to another human the human would answer within a second. Because a human would answer within a second, we assume that the computer will answer us in same time as a human would.

2.1.1 Human-Computer Interaction

In 1946 the first computer called ENIAC was announced. It had vacuum tube technology, was about three meters high, occupied 167 square meters of space and

[1] especially developmental psychology in CCI's case

consumed energy as much as a small town. It required a team of scientists, engineers, and programmers to work. Loading a program could take days because switches, dials and cable connections had to be set manually. Transistor-based computers became available commercially in 1958. They were very expensive, so they were mainly used for scientific and engineering tasks, but they did not require a lot of staff like the vacuum tube computers, so they had lots of potential. Minicomputers became available in the mid-1960s. They provided word-processing, spreadsheets and email and were marketed as office systems. In 1980, IBM prepared to launch the PC or Personal Computer making computers available for "everyone". [7]

HCI existed before the PCs but became more popular after PCs started to appear in the 1980s. The first articles focused on ergonomics since the computers were big and needed manual labour from workers. A British researcher Brian Shackel published "Ergonomics for a Computer" in 1959 and "Ergonomics in the Design of a Large Digital Computer Console." in 1962. In 1973, James Martin published "Design of Man-Computer Dialogues", which became the first popular HCI book. In the 1980s, the subject started to move more to psychology as the role of the user started to change: "The user is not an operator. He does not operate the computer, he communicates with it." [7]

Computer technology has changed massively after the eighties. The way we use computers have changed. The UIs have changed. The reasons why we use computers have changed. Today computers are everywhere. We can interact with them using voice and gestures beside the more traditional ways. We do not use computers only for work, we use them for entertainment and games as well. As the technology has changed and the relationship that people have with computers have changed, also HCI has changed. It has "expanded from desktop office applications to include games, learning and education, commerce, health and medical applications, emergency planning and response, and systems to support collaboration and community" [5]. Its "initial focus on individual and generic user behaviour" has changed to include social and organizational computing, accessibility for all people and "the widest possible spectrum of human experiences and activities" [5].

2.1.2 Child-Computer Interaction

Seymour Papert started to investigate how children could use computers and benefit from computing in the 1960s. He was working together with Jean Piaget developing a theory of learning called constructionism[2]. He also created Logo programming

[2] "A core element of constructionism is to support children to become authors and creators, rather than passive recipients, of educational content, and by extension, other media for children." [5]

language and Lego Mindstorms product line[3]. His work had an enormous influence on CCI. [6]

> In the 1990s, CCI research produced a steady flow of work stemming largely from the field of Human Computer Interaction. As a multidisciplinary research community CCI is directly connected with several research areas (e.g., psychology, learning sciences, interaction design, engineering, computer science and media studies). [8]

Although Papert did his pioneering work already in the 1960s, CCI became steadier in the 1990s. The early research focused on interactive technology and how well children performed using mainstream technologies designed for adults revealing that children had special design needs. At the same time, researchers were studying methodology on "how to design and evaluate products with and for children". CCI grew very fast like HCI did, in just a decade the diversity of research had grown to include games, communication technologies, educational multimedia, drawing programs etc. [6]

Today, the research in CCI is includes participating children in the design process, cybersecurity, augmented reality, 3D printing, using modern technologies for learning, potential harms to children from using new technologies etc. The list would include all new technologies that children can use and how they could harm children or can children benefit from the use of these new technologies. [9]

In my opinion, CCI research is needed now more than ever. Technology has been making giant leaps during the past decades. When I was a child in the 1980s, there were no smart phones, no internet, TV had only two channels, and we mostly played outside using our imagination to come up with new forms of play. Today the internet is everywhere. Smart phones, tablets, laptops, smart TVs and streaming services have an endless supply of programs, videos and games. The development has been so fast that we cannot possibly know how this entertainment flood will affect our next generation. Rapid development can make long-term research difficult. It is impossible to compare tests made on children born in the 1990s with children born in the 2010s because technology has evolved so much, and today's children are growing up surrounded by it.

2.2 User Interfaces

User interfaces are everywhere! In our cars, ovens, phones, computers... the list would go on and on. Basically, a user interface is anything that lets the user use anything. On interactive systems, this can mean graphical user interfaces (GUIs), voice-controlled interfaces (VUIs) and gesture-based interfaces used in VR and AR systems

[3] "A toy construction kit which allowed children to build and program their own robots" [5]

[10]. Since the topic of this master's thesis is an online learning environment, we will be focusing on graphical user interfaces.

A GUI lets humans and computers interact with each other. The GUI makes communication easier by presenting functions visually, often imitating real-life objects. Creating a mental model from a GUI is easier than creating a mental model from an abstract, text-based UI. The GUI elements are event-driven, which means that they are activated by the user using mouse. E.g., a program starts when the user clicks on its icon. [11]

2.2.1 History

The history of GUIs can be traced to 1945 when Vannevar Bush published an article about a tool called memex.

> He envisioned a tool that combined technologies such as high resolution microfilm, multiple graphical screen viewers, cameras, and keyboards, with the goal of storing data in such a way that it is accessible and linkable. This memex laid out ideas that have become reality today with the advent of personal computers and the World Wide Web. [11]

A man-machine graphical communication system called Sketchpad was another early GUI concept. The Sketchpad was created by Ivan Sutherland in 1963. [11]

> Sutherland's Sketchpad system allowed the human and computer to communicate using line drawings created on a CRT screen with a light pen. He also included the ability to zoom in and out on the display and to store objects in memory for later recall. [11]

Although there had been these early GUI concepts, the first usable GUI was Xerox Star. It was developed in 1977 by researchers at the Xerox Palo Alto Research Center. Steve Jobs learned about this development and hired researchers to work for the Apple Computer. Lisa Computer – a predecessor to Macintosh was launched in 1984. [11]

> This computer initially had a command line interface but was soon converted to a GUI interface—mostly because of the newly hired PARC people. The Apple Computer company extended the original GUI ideas at PARC to include a menu bar, drop-down menus, overlapping windows, icons, and more. In a broad sense, one might say that the methods for human–computer interaction that were eventually incorporated into this original Apple Macintosh provided the basis for the GUIs we have today. [11]

I consider GUI to be an outdated term since most UIs are graphical these days. Voice and gestures are not used in KidNet, so we are going to talk about only UIs from this point on.

2.2.2 Characteristics of a Good UI

A good user interface is not an accident. A good UI is more than lines of code that some coder wrote in a basement, and more than the images made by the graphic designer. A good UI is a combination of graphic design, psychology behind user's behavior and limitations and technical implementation.

There are different design principles that can be used to produce good UIs that will not frustrate the users [12]. Jakob Nielsen, one of the industries pioneers, created ten design principles in 1994 which have been used widely in UI design. The principles, known as "10 Usability Heuristics for User Interface Design" were updated in 2020. The principles are "rules of thumb" which can be used in the design process and afterwards to test the usability of the design. The goodness of a UI can be measured by measuring the usability of the UI. [12], [13]

> Usability is a quality attribute that assesses how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the design process. – Jakob Nielsen [14]

According to Jakob Nielsen, usability can be defined by five quality components: learnability, efficiency, memorability, errors and satisfaction. Learnability means "How easy is it for users to accomplish basic tasks the first time they encounter the design?". Efficiency is about how quickly users can perform tasks when they have learned to use the design. Memorability is about how easily users can re-establish proficiency when they return to using the design after a period of time not using it. Errors are about "How many errors do users make, how severe are these errors, and how easily can they recover from the errors?". Satisfaction is about "How pleasant is it to use the design?". [14]

A good UI is therefore easy to learn, efficient to use, easy to remember, helps users make fewer errors and is pleasant to use. Nielsen's 10 Usability Heuristics can help in the design of a good UI.

Jakob Nielsen's 10 Usability Heuristics for User Interface Design:

1. Visibility of system status – Users should always know what is going on in the system. "The visibility of system status refers to how well the state of the system is conveyed to its users. Ideally, systems should always keep users informed about what is going on, through appropriate feedback within reasonable time." [15]

2. Match between system and the real world – The system should speak user’s language. “The system should speak the users' language, with words, phrases, and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.” [16]

3. User control and freedom – Users make mistakes, support undo and redo and have an emergency exit ready for the user. “Users often choose system functions by mistake and will need a clearly marked “emergency exit” to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.” [17]

4. Consistency and standards – Jakob’s law: users use other people’s products more than yours, use standards. Inconsistent systems may increase users’ cognitive load. “Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform and industry conventions.” [18]

5. Error prevention – Try to eliminate error-prone conditions. Present a confirmation to users before they do anything stupid. “Users are often distracted from the task at hand, so prevent unconscious errors by offering suggestions, utilizing constraints, and being flexible.” [19]

6. Recognition rather than recall – Minimize users’ memory load by making needed information and actions visible. “Showing users things they can recognize improves usability over needing to recall items from scratch because the extra context helps users retrieve information from memory.” [20]

7. Flexibility and efficiency of use – Shortcuts, accelerators, personalization and customization. “Shortcuts— unseen by the novice user — speed up the interaction for the expert users such that the system can cater to both inexperienced and experienced users.” [21]

8. Aesthetic and minimalist design – The interface should have only relevant information. “Interfaces should only include necessary elements, with high informational value. Clarity will always win over visual flourish.” [22]

9. Help users recognize, diagnose, and recover from errors – Error messages should be in plain language so that the user can understand what happened and recover from them. “Design effective error messages by ensuring they are highly visible, provide constructive communication, and respect user effort.” [23]

10. Provide online documentation and help – Provide documentation that users can use if they do not know how to complete a task. “Interface help comes in two forms: proactive and reactive. Proactive help is intended to get users

familiar with an interface while reactive help is meant for troubleshooting and gaining system proficiency." [24]

These principles can be used to create design guidelines which reveal how to approach the principles, the guidelines can be turned into rules which are direct instructions for the design of the UI. E.g., the design principle: "Provide plain-language error messages to pinpoint problems and likely solutions." could be used to create a design guideline: "Write large-lettered, jargon-free text in web-safe font. Use short sentences and draw users' attention to causes and remedies." which could be used to create a design rule: "Use 20-pt, black Georgia on lavender background (#e6e6fa Hex). Put instructions in bold." [13]

Usability alone does not make a "good" design. The design can follow all the principles, but usability will not help if the design is targeted to the wrong user group, or the designer has failed to understand the goals of the users. *"Designing interfaces: Patterns for effective interaction design"* introduced a four-part structure for understanding the design for people: context, goals, research and the patterns. Context means understanding who will use the design, a crucial part since the designer is not the user. Goals are the goals that the user has, the "Interface Is Just a Means to Their Ends", they can vary from being entertained to learning something or working. "Research is the starting point in design for understanding people", the designer should learn at least what the user's goals are, what kind of tasks the user has to do in order to reach those goals and their attitudes towards the design. The patterns mean the cognition and behavior related to the UI design; Chapter 4 will present how these kinds of features influence the user interfaces. Understanding users is the most important part of the UI design. [25]

An important part in the design of a good UI is to understand the user's mental model. "Mental model" is an important concept that comes from HCI. "Mental models are representations of the world that help us understand complex concepts and make better decisions [26]." Mental models are based on past experiences, beliefs and assumptions instead of facts [26],[27]. Because mental models are based on experiences, beliefs and assumptions, all individuals have their own mental models. The designer's mental model is very different from the user's mental model because designer's experience is different, and the designer knows too much compared with the user. This creates a gap between the designer's mental model and the user's mental model. Designers should research user's mental models to create designs that match users' expectations because when the UI matches the expectations, the user does not have to learn new concepts and behaviors [26]. The smaller the gap between the designer's and user's mental models is, the better the outcome will be. [27]

3 User Interfaces and Children

Defining "children" can be difficult. Do "children" mean two-year-old toddlers who are still learning to jump and speak, seven-year-old children who are learning to read and write or twelve-year-old children who know how to read, write and calculate? To make things even more difficult for UI designers, every child develops at their own pace. Some children know how to read when they are four years old, some eight-year-olds still have issues with reading. When the youngest children need visual UIs, the oldest children can easily use the same UIs as the adults do. This chapter goes through those parts of children's development that influence the way UIs should be designed for children. It answers the research question about considering children's age in the UI design by showing how children's age impacts the UIs. Design theories used with children and the role that children have in the design of new technology are also introduced. The chapter ends with a section about how children and adults differ from each other as users.

3.1 Children's Development

Children's physical and cognitive development should be taken into consideration when designing for them. Physical development limits the way children can use computers while doing different tasks while cognitive development limits the way children can solve the tasks. It is important to understand what can be expected of children at what age, in order to design UIs that they can use physically and cognitively without getting frustrated. The sections are short because further exploration of these topics is outside the scope of this thesis.

3.1.1 Cognitive Development

There are many theories about cognitive development. The most relevant theories to this subject are reviewed in this section. Jean Piaget's development theory was chosen because it was discussed during my studies multiple times and again in literature.

Piaget's Four Stages of Development

Piaget's four stages of development are the sensory-motor stage, the preoperational stage, the concrete operations stage and the formal operations stage [28].

0-2-year-old children are in the sensory-motor stage. They gather information by observing and interacting with their surroundings. They repeat different operations in their play and adjust their behavior if they do not get results that they want. E.g., if swaying a toy does not make sound, they might try to push it. [28]

Children in this development stage do not use technology that much. However, they can use it if it is designed for younger children. My own daughter was allowed to use mobile game app for babies from time to time. She was able to tap moving objects when she was 1-year-old and by 1,5-year-old she was swiping the touch screen. She even managed to change games by herself although changing the game was made somewhat difficult.

2-7-year-old children are in the preoperational stage. Their language skills improve very fast during the first years of this stage and they begin to use their imagination while playing [28]. At this stage children learn to think although their thinking is still unsystematic and illogical differing from the way adults think [29].

7-11-year-old children are in the concrete operations stage. At this stage, they learn to think more systematically, but only when referring to concrete objects and activities [29]. Their problem-solving skills develop and the thought process becomes more flexible [28].

11-16-year-old children are in the formal operations stage. At this stage, they learn to think systematically on abstract and hypothetical level. They can think about different possibilities beforehand and test them systematically. [29]

It is important to consider the level of cognitive development when designing for children so that the content and the functions are appropriate for the children's level of development. Children who took part in the design sessions were mostly in the formal operations stage.

3.1.2 Physical Development

Children's physical development is a broad subject. This section is limited to things that are essential from the perspective of UI design, which in my opinion are motor skills and vision. Further exploration of this topic would be outside the scope of this thesis.

Vision

Children's vision is still developing. The eyeball is complete at the age of two, but the ability to distinguish objects from the backgrounds and tracking moving objects is still developing. Visual abilities can be measured by assessing visual acuity. Hourcade defined visual acuity as the ability to distinguish details in objects and can be measured in static or dynamic settings. The static setting is when the object and the person looking at the object are not moving, and dynamic visual acuity involves moving objects. Both have similar development curves where rapid improvements between the ages of 5 and 7 and 9 and 10. Final improvement to dynamic visual acuity happens between the ages of 11 and 12. [4]

Motor skills

This part is based on “UX Design for Children (Ages 3-12)” book by Nielsen Norman Group [30]. Nielsen Norman Group is specialized in researching usability and user experience. They had usability test sessions with children aged 3 to 12 where children used different websites and applications on different devices. They noticed that only two years of age difference had an enormous difference on how children worked on the same task because of their physical development.

Children’s ability to interact with different devices is influenced by the physical development of motor skills and motor coordination. E.g., fine motor skills and hand-eye coordination are needed to move a pointer on the screen with a mouse. Motor skills can be divided into three main categories:

- Gross motor skills – large muscle groups are involved (jumping)
- Fine motor skills – small muscles are used in making small precise movements (handwriting)
- Motor coordination – combining gross and fine motor skills and coordinating different parts of the body

Table 1 – Physical development [30]

		3-5-years	6-8-years	9-12-years
Physical ability	Gross motor skills	Limited	Partially developed	Well developed
	Fine motor skills	Very limited	Limited	Well developed
	Motor coordination	Very limited	Limited	Partially developed
Device preference		Touchscreens	Touchscreens and touchpads on laptops	Laptops and touchscreens. Mouse and touchpad
Gestures mastered		Tapping, swiping and dragging	Clicking with mouse and touchpad, simple keyboard use	Dragging and scrolling with mouse and touchpad. Complex coordination between keyboard and mouse

Children’s motor skills and coordination affect the ability to interact with different devices, websites and applications making device preferences different for different age groups.

3-5-year-olds’ fine motor skills and coordination are very limited, so they prefer touchscreens which allow them to use gestures like tapping, swiping and dragging. Using a mouse might be difficult for this age group also if the mouse is designed for adults because it can be too large to fit a child’s small hands. The UI for this age group should support very simple physical interactions on touchscreens because of their limited motor abilities.

6-8-year-olds’ fine motor skills and coordination are still limited, but they start to learn simple keyboard use and how to click with a mouse and touchpad on laptops. They prefer touchscreens and the touchpad of laptops. The UI for this age group should have simple interaction gestures with mouse and keyboard.

9–12-year-olds fine motor skills are well-developed, and their motor coordination is partially developed. They learn to drag and scroll with mouse and touchpad and manage more complex coordination between mouse and keyboard. They prefer laptops and touchscreens and can use the mouse and the touchpad. The UI for this age group can be more advanced. Children can use the same physical interactions as adults when they are about 11 years old. Although their cognitive development and education level still requires simpler UIs.

The limits and preferences of each age group should be considered in the design. Children will get frustrated if the UI is too difficult to use with their limited skills. It is important to notice that because children get exposed to technology earlier every year, the recommendations concerning gestures for certain age groups can change and children in the same age group can have very different skills depending on the experience they have had with the technology.

3.2 The Impact of Child’s Age on User Interfaces

Children’s developing motor and cognitive skills place certain requirements for user interfaces made for them. Because children are developing constantly their needs are constantly changing.

Age-appropriate design can be difficult because the age groups should be narrow, and age is not the only thing to consider. NN Group specified that there should be minimum of three groups: young (3-5), mid-range (6-8) and older (9-12) children. The groups have different behaviors, different development stages and different needs for designs. The development of reading skills should also be considered since there are pre-readers, beginning readers and moderately skilled readers. [30]

Children are very aware of their age and will react negatively to content that they feel is designed for younger audiences. At the same time, they can get frustrated if the UI is too difficult for them to use or understand. Websites should not be “designed down” for children but their age and developmental stage should be considered in the design. [30]

These sections will go through some of the recommendations for different age groups and show examples of how they have been implemented in an app for babies and a website called Yle Areena. These recommendations are based on Nielsen Norman group’s “UX Design for Children (Ages 3-12)” [30] and Soni et al.’s A Framework of Touchscreen Interaction Design Recommendations for Children [31], which is for children aged 2-11.

3.2.1 Young Children (3-5-years)

Young children do not know how to read or write, and their motor and cognitive skills are at the beginning of the development process. Despite their limitations, they can still use websites and apps if they are designed with them in mind.

Section 3.1. introduced children’s development which has an enormous impact on how children can use different UIs. Weak fine motor skills and hand-eye-coordination are the most critical limitations that young children have. Children in this age group prefer touch screens and simple interactions like tapping and swiping which do not require as many of previously discussed skills as using a mouse would.

Children’s physical development impacts the way children can interact with computers. This age group has limited motor abilities and therefore gestures for this age group should be simple, preferably tapping and swiping on touchscreens [30]. Complicated gestures like drag and drop, pinch, flick, spread and double tap should be avoided [31]. Scrolling should be avoided when a child is likely to be a new user “Avoid scrolling for kids that are likely to have little prior Web and app exposure.” [30]. Limited motor abilities should be considered also in the size of the targets. According to NN Group, the targets should be at least 2x2 cm, and they should have enough space between them because children might have issues in accuracy tapping the target [30].

Children’s cognitive development impacts how children think when they are using the computer. Both sources brought up the importance of consistency in graphics, gestures and readability [30], [31]. Because “inconsistent systems place a high cognitive load on users” [2], and children’s cognitive capabilities are still developing, consistency plays even a bigger role in the designs made for children than in the designs made for adults. Children who have no previous experience with websites and apps benefit from the use of existing mental models [30]. When the UI uses familiar real-life objects children can connect the knowledge from their daily lives to the UI for better understanding [30].

Baby Games-app is a mobile app designed for young children. Screenshots are used to demonstrate some of the recommendations in UI design for young children. The app is used on touchscreens, which are preferred in this age group as said in Subsection 3.1.2.

The starting view of the app can be seen in Figure 1. Buttons are big, they stand out from the background and look clickable. The buttons have icons describing their meaning so that a child who does not know how to read can connect the buttons to real-life objects and make choices based on that connection.

Figure 1 – Baby Games-app – Main menu has big buttons with icons.

Figure 2 – Baby Games-app – Preventing the child from accessing settings.

The limits that young children have can be used in the design to prevent unwanted operations. Children who cannot read can be denied access to certain pages by using pop-ups that require reading skills. Figure 2 shows a pop-up that prevents the child from changing the settings. A parent is needed to read the text and type in the code. This method is very useful in preventing a young child from accidentally purchasing something or getting in contact with content that is meant for adult users.

Figure 3 is a screenshot from closing a game. The close-button is big enough for a child to hit but the child has to slide it from one side of the screen to another in order to get back to the starting screen. This technique might have two purposes, one is to prevent a young child from accidentally clicking the X-button and the other is making it difficult for the child to change the game by themselves. The technique clearly takes advantage of the poor hand-eye-coordination skills that young children have and uses steering law in the opposite purpose, instead of making an action easy, it makes it difficult.

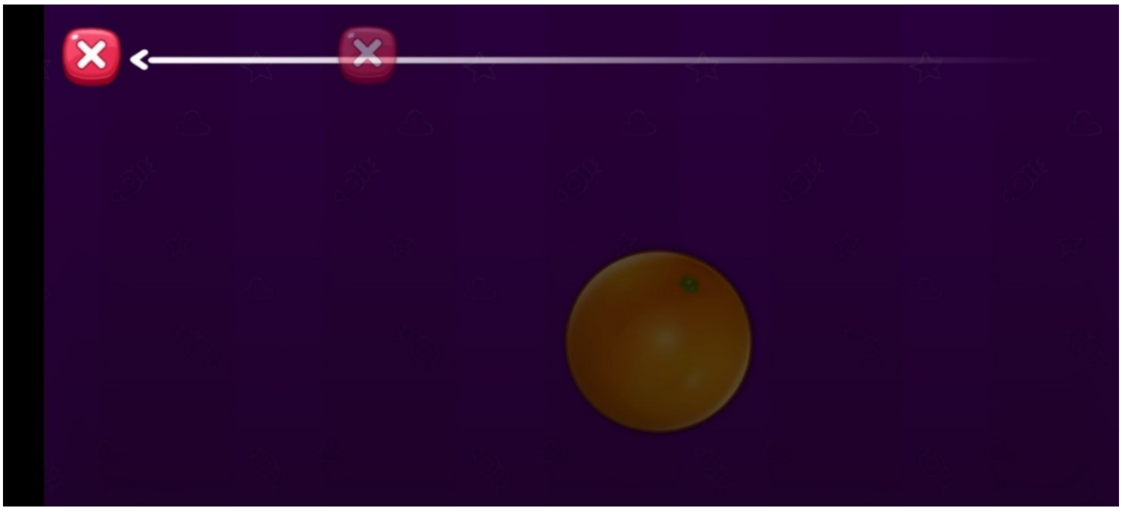

Figure 3 – Baby Games-app – Closing a game.

3.2.2 Mid-Range Children (6-8-years) and Older Children (9–12-years)

I decided to group mid-range children and older children together in the same subsection because as the children get older, the UIs designed for them should start to look like UIs designed for adults making the need for special UIs obsolete.

Mid-range children are cognitively on the verge of moving from the preoperational stage to concrete operations stage and their motor skills have developed enough for them to start using laptops with simple keyboard interactions and mouse clicks. Dragging, scrolling and clicking small objects are still difficult for them, so the actions used in the design should be kept simple. [30]

Older children are cognitively still in the concrete operations stage, but they are moving slowly towards the formal operations stage. Their motor skills are well-developed, and they can start using more advanced interaction techniques, children should be able to use “the same range of physical interactions as adult users” around the age of 11 years. [30]

There were not as many design recommendations for mid-range children as there were for young children. Motor skills are still limited, which should be considered in the design by making targets big enough to hit without getting frustrated. Cognitive skills are still developing, which should also be considered in the design by keeping things simple.

The most important thing for children in the mid-range group is that they are learning how to read. Soni et al. had very precise recommendations concerning children aged 7-11: “Use a minimum of 14-point font size to help children read faster” and “Avoid using Times font style as children report it to be significantly less easy to read.”[31]. NN Group recommended to “Use simple, relatively large fonts, comparable in size to at least 12-point print type. Provide good contrast between the text and the background.”. This is because beginning readers have difficulties reading small fonts and fancy typefaces. The amount of text should be minimized and the text should be chunked into short paragraphs so that it is easier to read and scan. [30]

There were no specific design recommendations targeted for older children. Most of the recommendations made for all age groups can be connected to the guidelines introduced in Subsection 2.2.2., like consistency, support back and undo, display the status of the system and so on. [30]

Because young children are making bigger improvements in their abilities than mid-range and older children, “designers should pay greater attention to the needs for age-specialized interfaces when their target audience is younger”. The differences between three- and four-year-old children are bigger than the differences between eleven- and twelve-year-old children. It is more likely that there is a need for different UIs for a three-year old and a four-year old than eleven and twelve-year old. [32]

One important thing to notice is that dividing children into groups based on age has issues. While motor skills are developing more steadily, the development of cognitive skills has more variance between individuals. Experience with different devices is fully dependent on the choices that parents have made. These differences in children’s skills can make designing for children difficult.

3.2.3 Case Yle Areena

Yle, or the Finnish Broadcasting Company is the national public service media company of Finland. Yle has four television channels, six radio channels and versatile online offering. Yle Areena is Yle’s streaming service offering movies, TV shows, podcasts and radio programs. [33]

Yle Areena is a good example of how different age groups have been considered in the design. Since Yle Areena has programs for children and adults, the UI has been designed so that everyone can use it.

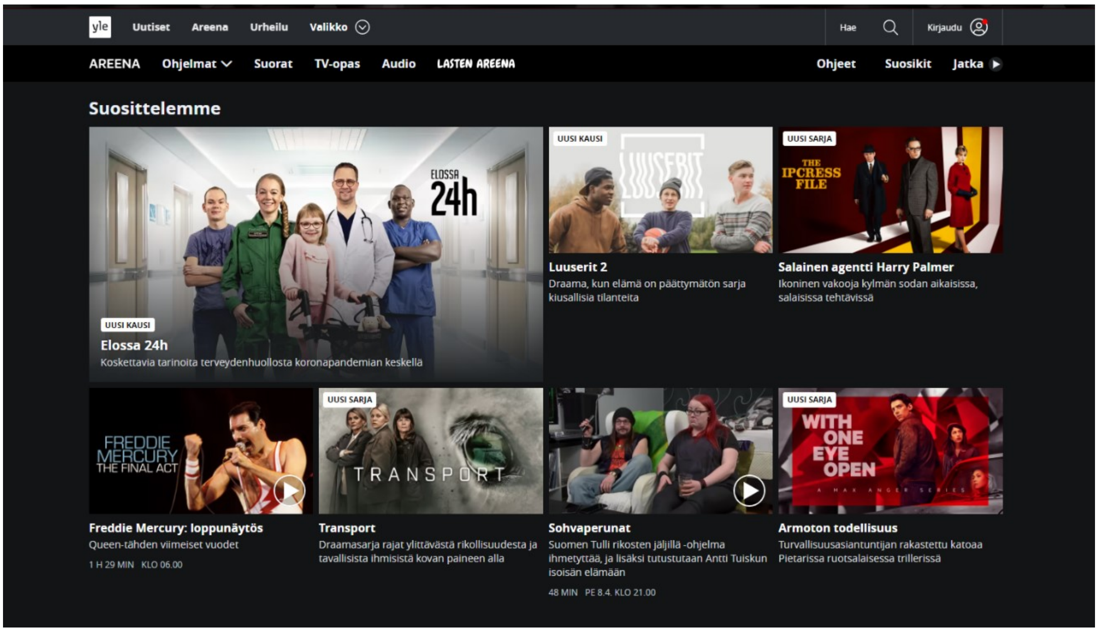

Figure 4 – Yle Areena landing page.

The landing page of Areena can be seen in Figure 4. It has recommendations for users and scrolling down the page would show popular categories of the programs. The programs are displayed as cards with images, titles and brief introductions about the programs. The whole card is clickable making the clickable area so big that a child or a disabled person with limited fine motor skills would be able to use this UI.

When a program icon/card is clicked, the user is taken into the program page (see Figure 5). The program page has a longer introduction about the program, a list of seasons and episodes and the operations for sharing and adding the program to favorites. The user has to click an episode, or Watch-button in order to start watching the program.

Although the UI has a dark color theme, link to Lasten Areena has been made in a way that it pops from the navigation (see Figure 6). Using a different font for Lasten Areena helps children spot the link to their side faster and pre-readers would learn after few times to click the link that looks different. The hover effect has a different color as well. The upper navigation has the color used for adults' side while the lower navigation has the color used for children side.

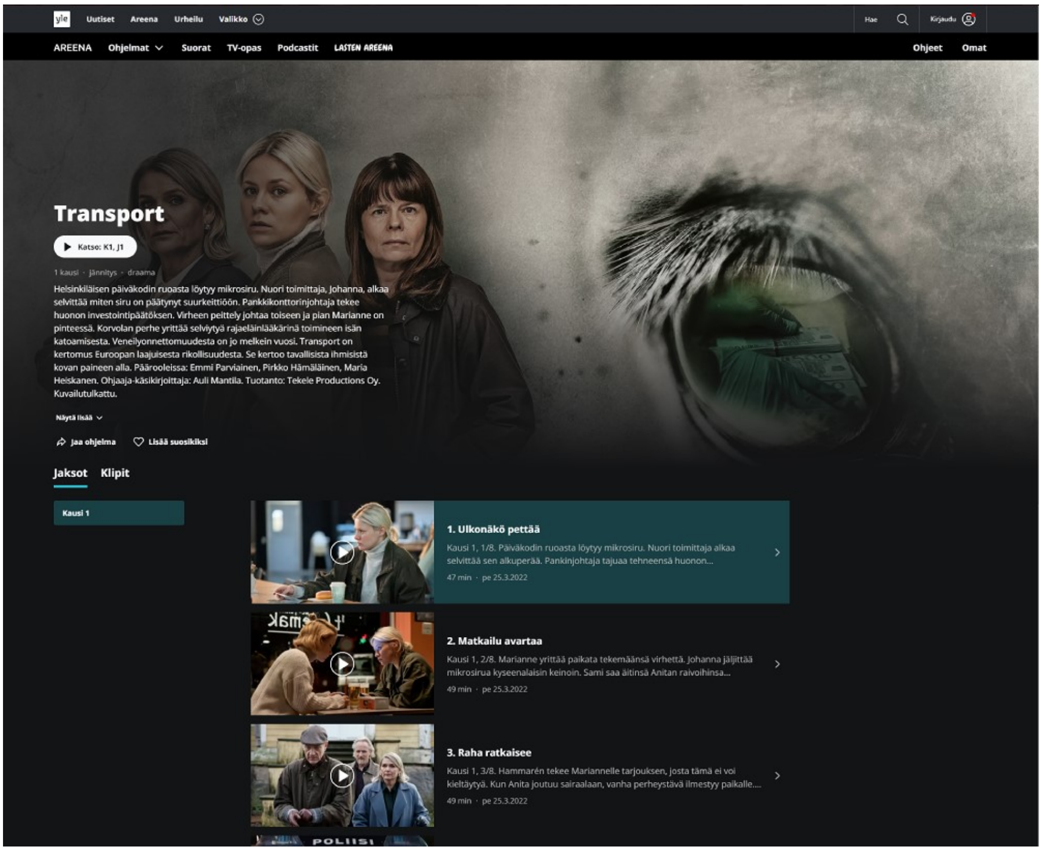

Figure 5 – Program page on adult's side of Areena.

Figure 6 – Yle Areena navigation bar.

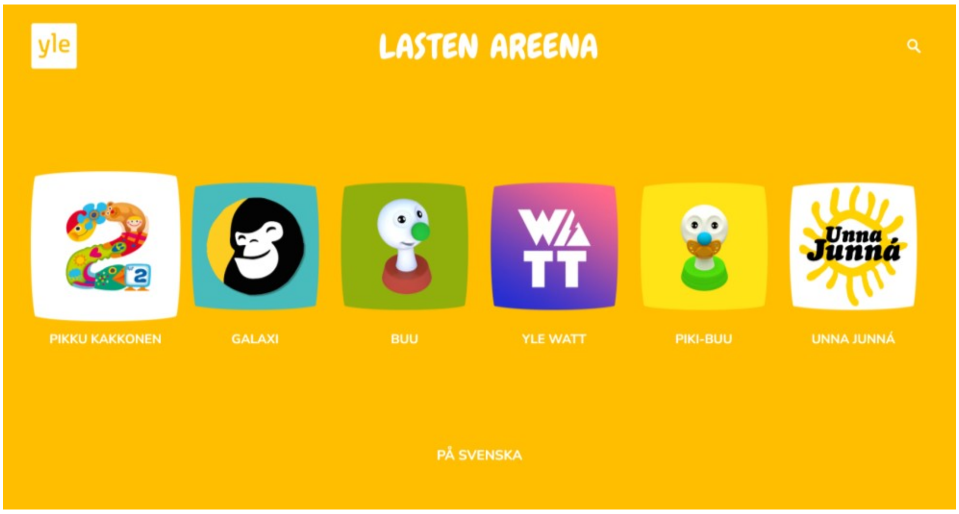

Figure 7 – Lasten Areena landing page.

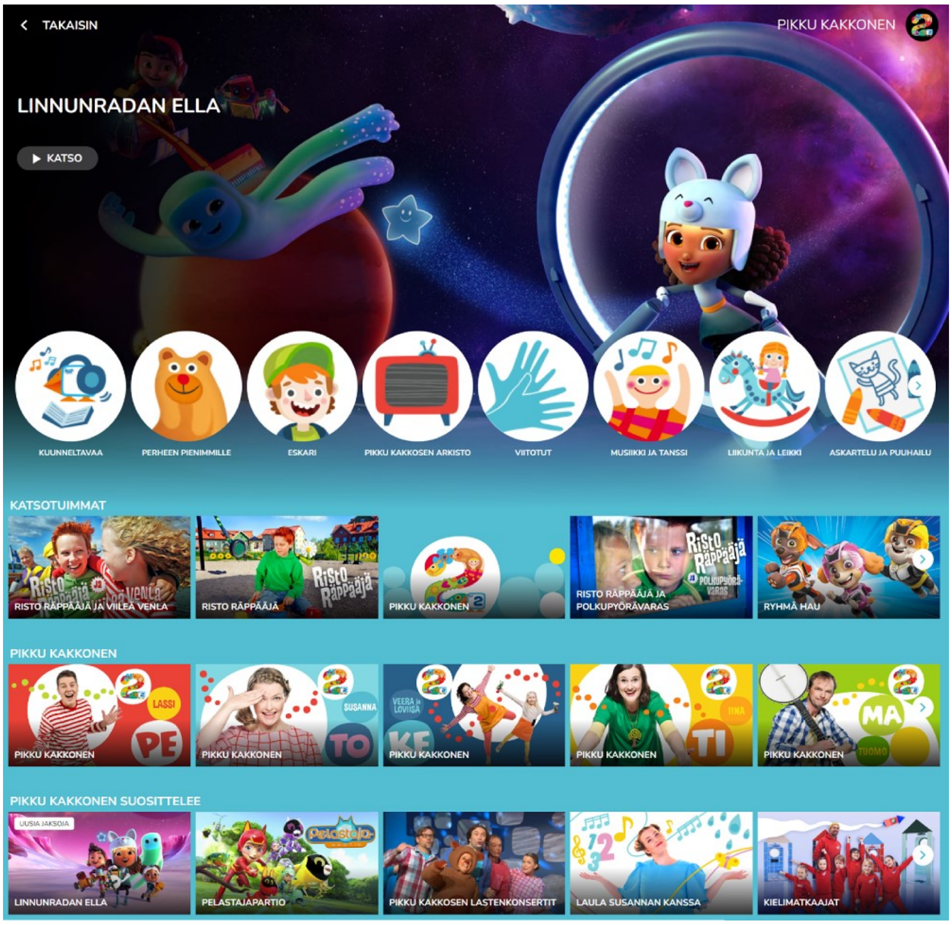

Figure 8 – Lasten Areena Pikku Kakkonen.

Clicking the Lasten Areena takes the user to Lasten Areena, which has a very different UI (see Figure 7). The UI has a bright color scheme with big clickable icons from the most popular children's program categories to help pre-readers find their favorite programs.

Figure 8 shows Lasten Areena's Pikku Kakkonen page. Pikku Kakkonen is a program for children. It has different hosts presenting different programs for mostly younger children.

The page has big clickable icons for different categories. The amount of text has been minimized compared to the adult side of the Areena and the names of the programs are written in uppercase with a different font.

The icons clearly indicate their meaning, audio programs have an icon with musical notes in it, programs interpreted with sign language have hands in the icon, the programs for the youngest children have a teddy bear and programs for preschoolers have an icon with a boy in it. Even pre-readers will learn fast what icon they need to click in order to find their own favorite shows.

The page also shows the most watched programs and recommendations which reduces the number of clicks the child has to make to one if the program is among the ones displayed.

Children's side differs from the adults' side also by functions. The search function is displayed only on the landing page and clicking the search icon takes the user to another view (see Figure 9) which has only the search field.

Figure 10 shows the Areena for the younger children. The UI is similar to the previous page.

Figure 11 shows the other differences between adults' side and children's side. The program page does not have tons of text and the program starts to play immediately as the child clicks the program icon.

Figure 9 – Search on the Lasten Areena

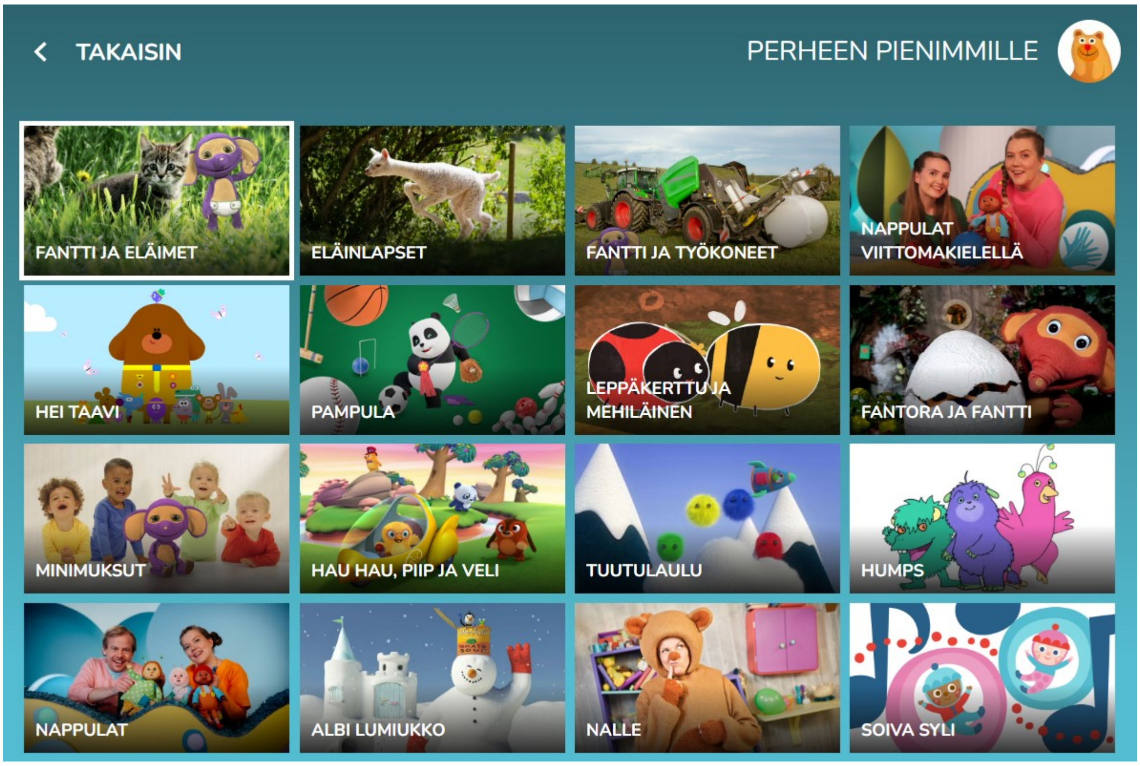

Figure 10 – Lasten Areena for the youngest children.

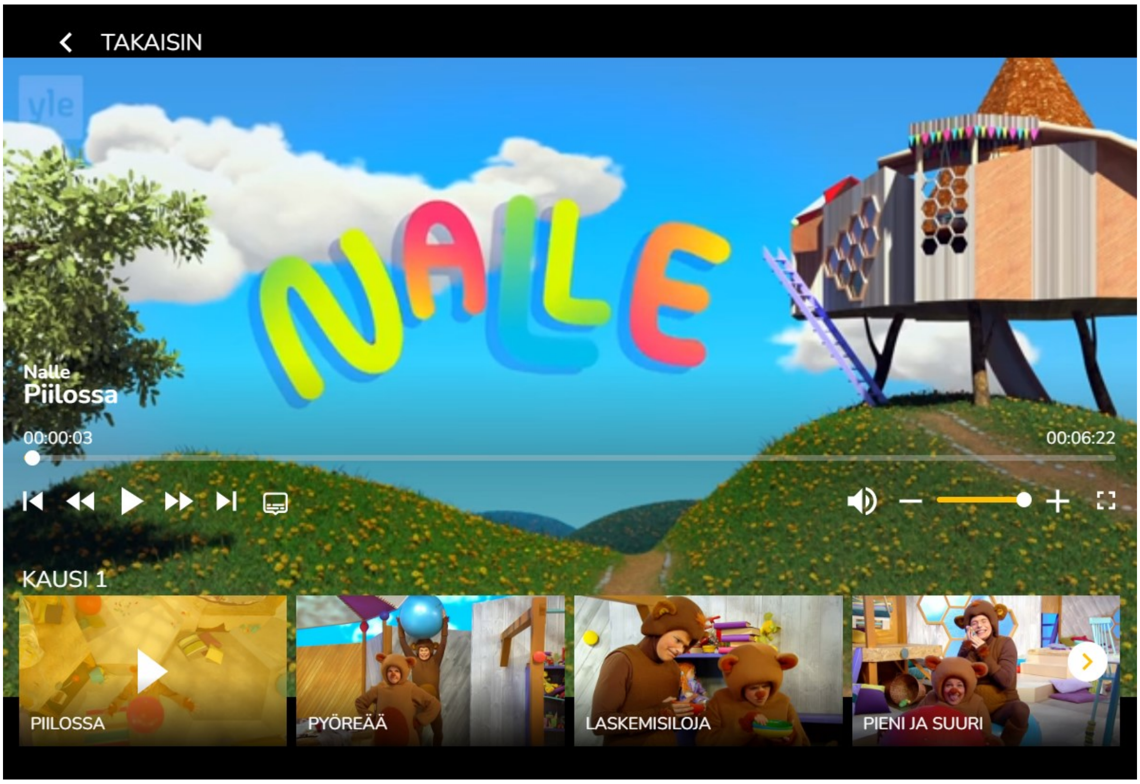

Figure 11 – Program page on Lasten Areena.

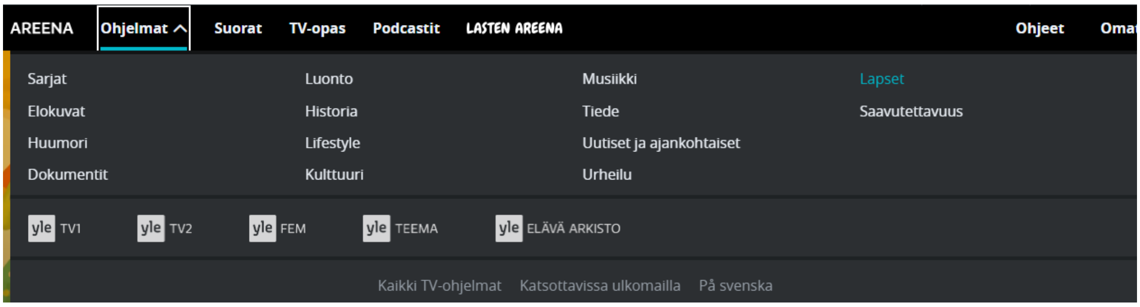

Figure 12 – Dropdown from Areena with different categories.

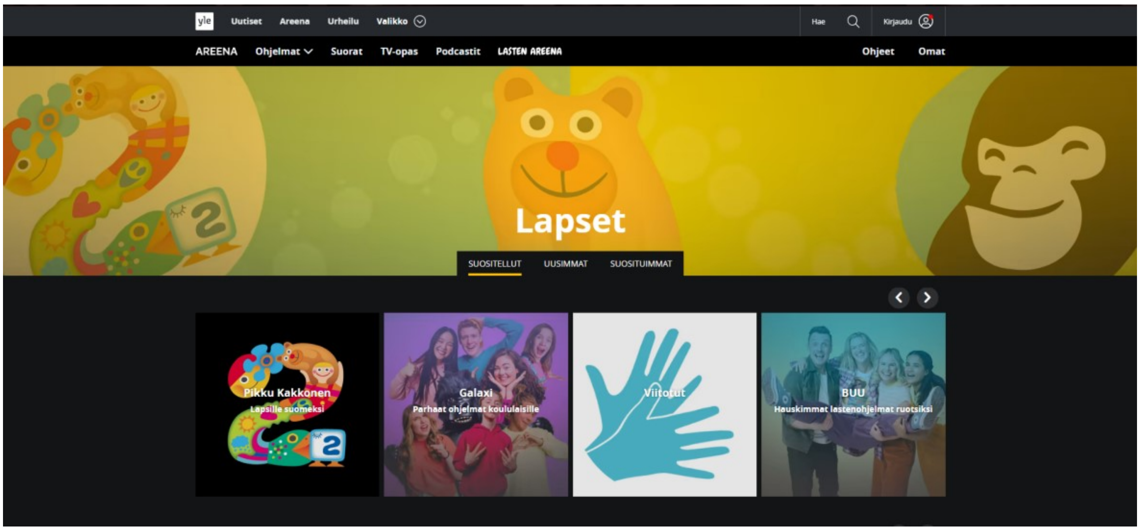

Figure 13 – Category: children in Yle Areena

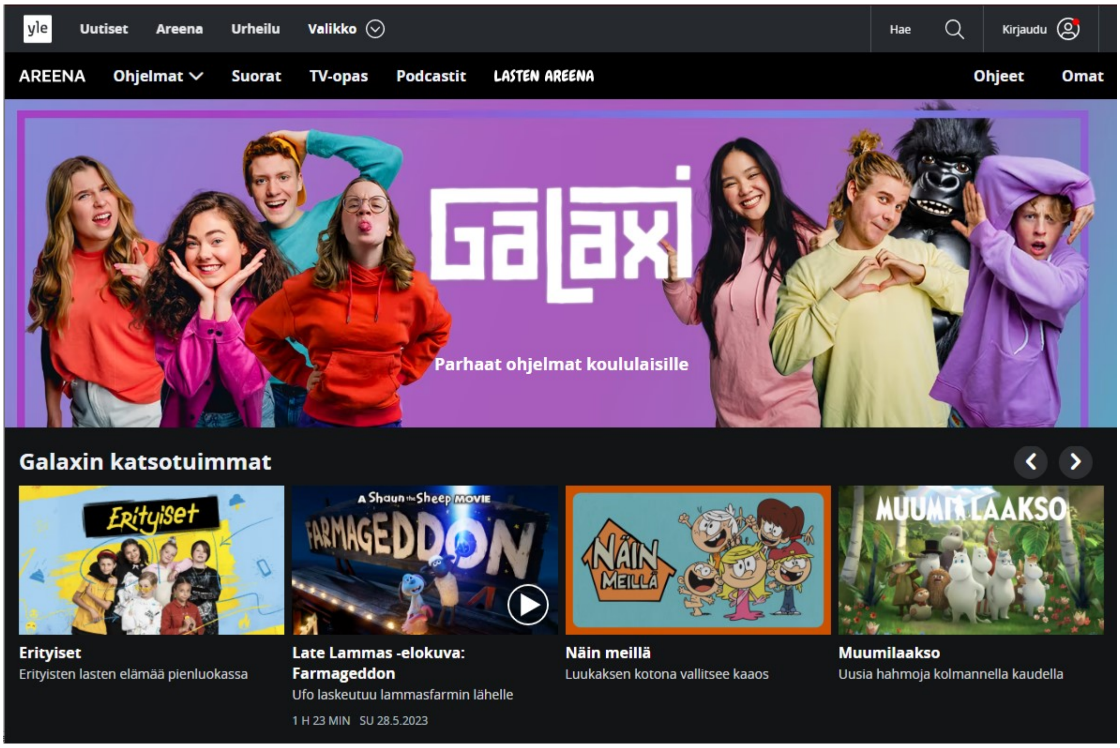

Figure 14 – Areena Galaxi for school children

Figure 12 shows the drop-down with program categories in Areena. Older children who know how to read and have better computer skills, can find programs directed to them in the Children's category displayed in Figure 13. The program pages for these programs are similar to the program pages presented in the beginning of this subsection. Figure 14 proves that Areena has thought about the different user groups and concluded that children who are a bit older can use the same UI as adults can like mentioned in the previous subsection.

3.3 Design Theories Used with Children

How to find out what children want? In an article from 1997 "Designing for or Designing With? Informant Design For Interactive Learning Environments" Scaife et al. approached the relationship between a child and a designer by seeing the child as an informant [34]. Allison Druin introduced cooperative inquiry in 1999 where children were seen as research partners [35]. There are many ways to find out what children want and many ways for children to take part in the design process. Nesset et al. went through some of the theories in their article "Children in the information technology design process: A review of theories and their applications" [36]. The article looked at some usability issues as well. This section will briefly introduce the different design methods used with children based on the article.

User-Centered Design is the oldest approach which includes users in the design process. Methods used in UCD are observation, system logs, qualitative surveys and interviews, quantitative surveys to collect data from pretests and posttests (to determine how using the technology impact the user) and analysis of the work user has done with the technology. Users' involvement is limited as users are involved after the technology has been designed. The user can, however, impact the future versions of the technology. A drawback of using this approach with children is that questionnaires and other methods may be boring for children. The advantage is that children can take part easily and in large numbers.

Contextual Design is an approach which tries to "reveal who the customers really are and how they work". CD has three phases. First, the researchers collect data by observing how the user performs typical activities in the users' own environment, then the designers develop a user environment design based on the data and finally a low-tech prototype of the system is tested with the users. The use of low-tech prototypes and the team approach make it an applicable method to be used with children.

Participatory Design is an approach which allows users to have roles such as: "peer co-designer, design owner, expertise contributor, and self-advocate". PD has two implementation themes: *mutual reciprocal learning* where "users and designers teach each other about work practices and technical possibilities through joint experiences." and *design by doing*, which is a creative process for modeling, designing and learning by doing that uses low-tech tools like blackboards and paper. The principles of PD make it the most suitable method to be used with children: "their creativity and enthusiasm thrive within a flexible structure, and educational techniques have long stressed the benefits of mutual learning". The fact that some participants are trained, and some participants are not, can be seen as a benefit and a drawback. Ordinary users lack the knowledge that professionals have, but they might come up with ideas the professionals would not have thought about.

Cooperative Inquiry was developed by Alison Druin and her colleagues. It combines techniques from participatory design and contextual design and treats a child as an equal member of the design team. "Cooperative Inquiry is grounded in HCI research and theories of cooperative design involving a multidisciplinary partnership with children, field research, and iterative low-tech and high-tech prototyping." Participants have to forget the authority and power structures in order to work as a team where a child is an equal design partner. CI uses observing, prototyping and technology immersion as main techniques. Technology immersion is a technique where children get "exposed to unlimited access to extraordinary amounts of technology" and their actions are observed.

Informant Design "was introduced to address some of the perceived problems with user-centered and participatory design techniques when working with children". User-centered design does not allow children in the design process while the equality of participatory design is perceived as a problem because children might not: "have the time, knowledge or expertise to fully participate in the collaborative Participatory Design model". Children should be included in the design process because their ideas can make educational software more motivational and fun. In ID children are seen as native informants because they "are aware of aspects of learning/teaching practices that we are not and which we need to be told of". ID has three phases, identifying the problems, turning problems into functionality specifications and creating a low-tech prototype which can be tested with children before developing hi-tech prototypes to be tested with children again.

Learner-Centered Design is an approach where "everyone is a learner, whether a professional or a student". The creators of LCD see professionals as "students who happen to learn outside of a classroom". The main focus of LCD is to "ensure that the interface design is adapted to the interests, knowledge and styles of the learners who use the software". The main issues of LCD concerning learning are "understanding (how will the learner learn the practice?) motivation, (how can software motivate a learner?) diversity, (every learner is different—what kind of software can be developed that supports this?) and growth (the learner changes but the software does not)". LCD addresses these issues by using scaffolding[4]. The method has been successfully used with children by Kafai in 1999. She used LCD with children and made them actual software designers. "Her research showed that young student designers are similar to professional designers in their concern for their users." Based on the results, she was convinced that children can be more than just informants in the design process.

There have been many articles written about children taking part in the design process during past few years. In 2019 children took part in participatory design experiment in Japan where a game about bullying was designed by using methods like brainstorming, comic boarding[5], digital storyboarding[6] and exposure to the preliminary prototype [37]. In 2022 141 UK-based 7-13-year-old children were using pen and paper to design privacy warnings [38]. Finally, this year, children were interviewed and designing their own credit cards in a research which examined financial literacy and technology for children [39]. There were many other articles about involving children in the design process, but these were the most interesting ones.

[4] Scaffolding supports learners when they are learning a new task. When the learner's skills or knowledge develops the scaffolding fades away. [36]

[5] "Short comic stories were distributed for reading and children then created comic strips as a continuation of an existing story. Japanese children were familiar with this technique as part of their curriculum." [37]

[6] "Participants were introduced to digital storyboarding to elicit causal inferences between characters' actions and consequences" [37]

3.4 Children's Role in Design Process

This section is based on Allison Druin's article "The Role of Children in the Design of New Technology" [1].

Children's role in the design has usually been minimized for multiple reasons, children go to school during the day, adults might think that children have nothing to say, children might not be able to communicate their thoughts and so on. This article was the main inspiration for giving children the possibility to take part in the design of KidNet, after all, they are the main user group. Children can have various roles in the design of the new technology. The impact that children can have in the design process depends on the role. Druin recognized the following roles.

The User

Child as a user is the oldest of the roles. In this role, the child is using the product and adults observe how the child uses the technology, researchers can e.g., try to understand how the technology influences the learning of a child. The impact on the design is very low or non-existent, the results might be used in the future designs since the product is complete when it gets introduced to a child.

The Tester

Child as a tester is a more recent role, where the child can help change the products before they are published. In this role, the child is testing the product and the product can be changed based on the tests. The impact is bigger although the role is very small in comparison with the role of the adults who have designed and developed the product.

The Informant

Child as an informant is also a more recent role. In this role, the child is included in the design process before anything has been developed. The child can be observed with existing tech, they can be interviewed, or they can take part in a workshop to draw UIs for example. The impact of this role is huge. Children are part of the design process in the beginning, so they have a chance to get their voices heard.

The Design Partner

This role is similar to the previous role, but the child is included in the design process from the beginning to the end. The child is treated as an equal stakeholder in the design process. A child does not have the same skills as adults do, but they should still have equal opportunity to contribute to the design by using participatory design and cooperative inquiry. The impact of the role is enormous because the children are equal and can really make a difference.

3.5 Differences Between Children and Adults as Users

There are many differences between children and adults concerning websites and games. Children have special needs concerning UIs that depend on their age as discussed in Section 3.2. Children and adults have different goals when visiting websites [30]. Children have issues distinguishing advertisements from real content while adults have developed banner blindness [30]. Adults are fully developed while children are still developing, too much time spent online can impact a child's development negatively [4].

Children and adults behave differently online and have different preferences. Children like animations and sound effects which are usually disliked among adults. Children are likely to try many options and "mine-sweep" the screen with a mouse to find elements to interact with while adults usually stick to the main path. Children, especially young children, rarely scroll pages and interact with the visible part of the site while adults scroll. Children are very aware of age differences and will not like the design if they feel like it has been targeted at a younger audience while age-targeted design is usually unimportant for adults. [30]

Users' goals should be considered when designing UIs as mentioned in Subsection 2.2.2. The goals can vary from finding information, learning something, performing a transaction, creating something, communicating with other people or simply being entertained [25]. Children and adults have different goals. Young children are likely to have one goal, to be entertained. As children get older their goals start to include learning for school projects and communicating with friends. Adults have the widest range of goals since their goals include pretty much everything from being entertained to paying bills. UIs should be designed to help the users achieve their goals [25]. The different goals create different requirements for UIs because the tasks needed to complete the goal of being entertained or paying a bill are very different. [30]

Advertisements are everywhere, on bus stops, on television, websites and games. The issue with advertisements on websites is that since children do not understand the commercial nature of the web, they have issues distinguishing advertisements from real content. The advertisements included in games have been proved to be more effective than ads seen on television, 10-14-year old children were more likely to remember the products and brand names because of the interactive advertisement [4]. Adults are used to seeing ads everywhere and have developed "banner blindness", a phenomenon where they might not even notice banner advertisements. Adults can tell the difference between advertisements and real content and view promotions skeptically. It is important to teach children to differentiate advertisements from reliable sources of information so that they learn to treat advertisements differently than real content. [30]

Adults are responsible for their own decisions. If an adult wants to spend his free time on the computer without going out and moving, it is his own decision. Adults understand the consequences of their actions and are capable of making their own decisions. Children on the other hand do not understand the consequences and cannot be held responsible. Adults are responsible for children as well. Although it is good that children learn computer skills, there are risks concerning computers and children. When exercise is replaced by sitting at the computer, the risk for obesity can grow. Obesity increases "the risk for type 2 diabetes and cardiovascular disease". When computers replace humans in children's lives, children become isolated. If playing on computers replaces playing with children, the lack of face-to-face interactions can cause difficulties in developing relationships with people and limitations to social skills in face-to-face interactions. Young children's ability to develop secure attachments can be affected if caregivers are too absorbed with technology and do not pay enough attention to the needs of their children. Taking part in social interactions benefits general cognitive functioning. Adults should be making the right decisions about how much time children spend on computers to make sure that their children are not negatively affected by computers. [4]

4 Users' Influence on User Interfaces

The way we are wired affects the way user interfaces should be designed. As the previous chapter focused on children's development and how it impacts the UIs designed for children, this chapter will focus on how human features impact the UIs designed for all people. The same principles apply to users of all ages, but because children are still developing, some of these principles work differently with children. Possible differences between children and adults are mentioned in the following sections.

4.1 Human Development

We humans have existed for hundreds of thousands of years. Our history was first recorded as stories, songs and passed on by mouth for thousands of years before there was written text. We were programmed to recognize the shapes of potential predators, threats and food very fast, because we would not have survived otherwise. Our brains were wired to find food and to stay away from potentially dangerous predators. [2]

Our lives have changed, we are no longer living in caves where we have to listen carefully for approaching threats. We live in cities, we read and write, we buy our food, and we do not have to be afraid that we would end up being a bear's lunch. Our lives have changed too fast for our brains to keep up with the change. Our brains are still programmed the way they were when we were hunting and gathering.

Our brains can be divided into two parts: old brains and new brains. Old brains are millions of years old, and they work automatically on the background. They keep us breathing and tell us when we are hungry or cold. Our new brains are more recent, they help us solve problems, process inputs and store our memories. Most of our brains are "made of" this new part. [2]

Our development has an impact on how we see and hear things, does not matter if they happen in real life or on the screen of the computer. Reading makes us use our new brains, we react fast to sounds and our brains want you to look at that red button because (overly simplified) it might be a strawberry on the ground.

Our new brains are slower and consume a lot more energy than our old brain. The designer can help the user by keeping the design consistent and simple and guiding the user towards his goals. The less the user needs to use the new brains, the better. Familiar concepts, terms and graphics require less thinking than new unfamiliar ones. [2]

4.2 Perception

Users' past, presence and future have an impact on the user's perception making users perception biased. Users' previous experiences can make the user more trustful or suspicious towards something. "Something" being a person, a brand, a technology or a website. In this context, we are talking about a website. [2]

When every contact with a website has been positive, the user assumes that everything will work fine this time as well. If a website has had issues before, the user might assume there might be issues this time as well. It might be difficult to gain back user's trust on a product if the trust has been broken before.

Users' goals have a massive impact on users' perception. Goals guide the user towards them, and the user might filter out things that are not related to the goal. The designer should understand the user's goals and design with those in mind. Our attention is limited, and we might not notice that we can book hotels and cars on the same site if our main goal is to buy a flight. [2]

We begin to develop perceptual patterns when we do something repeatedly. If we surf the internet and visit multiple pages, we start to assume that there will be a logo of the company, navigation and content. We habituate and develop so-called banner blindness and stop noticing blinking or distracting banners. Our past experiences prime us to detect certain objects and skip other objects. If we are primed to search for information, we can use our past experiences where magnifying glass has been equal to search and scan the page for that icon. These kinds of mental shortcuts help us eliminate the need to inspect every single object on the page, which would be time-consuming and laborious for our brain. [2]

Children are an exception to this. The younger the children the less they have previous experience. They might not have developed a concept of a website and they do not have the habituation to protect them from the blinking and distracting ads. A child is more likely to click on an ad than an adult who might not even notice the ad because of habituation. As children get older, they start to form a mental concept of a website and become habituated. [30]

It is important that the designer knows who he is designing for. Designing for a young child differs from designing for an adult who has mental shortcuts, banner blindness and is primed by past experiences. It is also important to understand that with mental shortcuts and priming becoming an assumption of certain things, do not let the user down. Understand the users' goals and help the user to achieve them as fast as possible by being consistent and unambiguous. [2]

4.3 Attention and Memory

Our attention is limited, and our memory is imperfect. [2]

Our memory can be divided to a long-term and a short-term memory. Long-term memory stores memories and our short-term memory keeps track of what we are doing right now. Short-term memory combines all our incoming information with long-term memory and can be called working memory. [2]

We have different types of long-term memory: semantic, episodic and procedural. Semantic memory stores knowledge: "A whale is a mammal." Episodic memory remembers past events: "That Rammstein gig was awesome." Procedural memory remembers the action sequences. "How do I play the piano." Our old memories start to lose details as time goes by unless they are strengthened by practise or repetition. [2]

Working memory is equal to the focus of our attention. [2]

Our brain does not have the capacity to process everything around us, so our attention is focused on what we need to do to fulfill our goals. We are also programmed to pay attention to movement, threats, people's faces, sex and food. This is directly linked to our development which was introduced earlier. [2]

There have been lots of studies about the capacity of working memory and it is still being researched, but according to the book, the average capacity of working memory is three to five items. Johnson uses the search light metaphor describing our working memory: when the light moves to a new subject, it turns away from the old subject. E.g., when something interrupts you while you are counting something, you might have to start again from the beginning. [2]

Children's attention-related skills and working memory are still developing. Some of the attention-related skills are not fully developed until children are old enough to go to elementary school. "For example, children are not capable of actively searching for objects until early elementary school." Children's working memory is also developing, and children can hold fewer chunks of information in memory than adults can. The capacity of working is correlated with the speed a person can process information. "This limited working memory capacity affects the complexity of tasks that children can handle." Older children and adults have learned to use external aids and chunking, skills that younger children have not acquired yet. [4]

The UI should be designed to help users achieve their goals despite their limited attention and memory. This can be done by attracting the user's attention where it is needed, helping users remember what they have done already and reminding them of clean-up steps like logging out or saving because they tend to forget the clean-up steps after their goal is achieved. The UI should fade into the background and let the user focus on the goals by supporting users' constant thought cycle: "goal, execute, evaluate". Designs with different modes should be avoided because they force the user to remember which mode is active. [2]

4.4 Vision

This section is about our vision. Our vision has an enormous impact on the UIs. The way we see colors, seek structure and the fact that only 1% of our visual field is in high–definition resolution influences the way that UIs should be designed.

Peripheral vision

Our peripheral vision developed to notice movement and bright colors when we were living in caves and hunting and gathering. A movement on the edge of the visual field could have been a predator coming towards us and a little red dot on the ground might have been something edible. [2]

> Stated in developer jargon: in the center 1% of your visual field (i.e., the fovea), you have a high-resolution TIFF, and everywhere else, you have only a low-resolution JPEG. [2]

Because of this narrow HD part, everything on the computer screen that is not within 1-2 cm from the click location is in peripheral vision, in a low-resolution area that the user might not notice at all [2]. If the user is looking at the submit-button after filling in a form and a small text appears 10 cm from the button saying that critical information is missing, the user is likely to miss that information.

The designer can help the user notice things happening on the peripheral area. Because of our evolution, we will react to pop-ups, sound, movement and visual features that "pop". These four features will grab the attention of the user, but they should be used cautiously, because users will get habituated if they are used too much. [2]

1. Pop-ups – they can be impossible to miss but they can break the user's concentration and should be used only when they really are necessary.
2. Sound – the fastest way to get the user to react, but it has many buts. Users' speakers might be muted, there might be multiple users in one space and constant beeping would start to annoy other users who would also react to the sound.
3. Movement – noticing movement has been very important for us and it still is. When there is a sudden movement in our peripheral vision our eyes focus on the movement (because it might be a predator). A little wiggle or a blink will guide users' eyes towards the target.
4. "Pop" – bright colors, distinctive shapes and font weights "pop" in our peripheral vision drawing our eyes towards them. [2]

Figure 15 – The stop-sign demonstrating the "pop". [40]

The stop-sign in Figure 15 is a good example from the real world. The shape and color of the stop-sign differs from other traffic signs, making it "pop" from the other traffic signs and the surrounding environment so that drivers are more likely notice it while driving.

That's why all the annoying ads use bright, distinctive colors and blinking or other kinds of movement. The advertisers try hard to make us click on their ads and know that it is more likely to get our attention using those effects. The designer can help the user notice important stuff in the same manner. The easiest way is to keep the action close to the part of the screen that the user is currently working on, but sometimes that is not possible and in that case the user might miss something important. Adding movement or bright color to the important stuff away from the users' focus point can help the user notice it.

Colors

Many things affect the way we see colors. Our vision is better in detecting contrasts than brightness and some of us are color-blind. The devices that we use have different screens and can be used in different places where there might be reflections for example. [2]

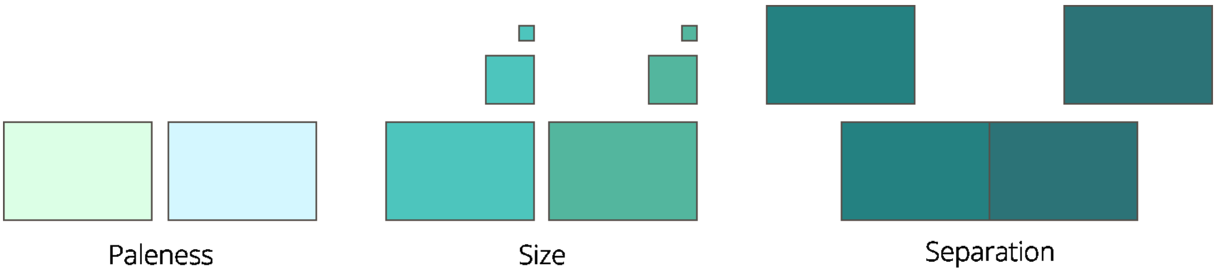

Figure 16 – Paleness, size and separation affect our ability to distinguish colors. Based on image from Designing with the Mind in Mind. [2]

Figure 16 illustrates three factors that affect our ability to distinguish colors: paleness, size and separation. Pale colors, small or thin objects or objects that have a lot of space between them can be difficult to tell apart from one another if the colors are similar. [2]

There are many types of color blindness, from red-green color blindness to total color blindness. 8% of men and 0.5% of women have some sort of color perception deficit. The most common type is red-green color blindness where red and green look alike. [2]

Color choices impact the usability of a website. Low contrast between the background and content can make reading the content impossible, wrong color combination can make the site inaccessible for color-blind people and strong opponent colors used together can strain users eyes. [2]

The UIs should not rely on color alone. A good example from the real world are traffic signs. Yellow triangles are warnings, blue circles indicate driving directions, yellow circles with a thick red stroke indicate prohibitions and restrictions and suddenly a red octagon with the word "STOP". The traffic signs have a similar look for similar purposes. A driver, who is the user of the road, can easily spot different shapes and meanings and the most important sign is very different from the other signs. These same principles should be used in the UIs. Color should not be the only thing distinguishing items from each other, the colors used should be different from each other and there should be enough contrast between the colors.

Gestalt principles

In the 1920s German psychologists were studying how our visual perception works, they found out that our visual system automatically completes disconnected edges and lines into shapes and objects. Shape is Gestalt in German, so the theories became Gestalt principles. [2]

All Gestalt principles except common fate are visualized in Figure 17. Gestalt principles are:

> Proximity – "Objects near each other (relative to other objects) appear grouped, while those farther apart do not."
> Similarity – "Objects that look similar appear grouped."
> Continuity – "Our visual perception is biased to perceive continuous forms rather than disconnected segments."
> Closure – "Our visual system automatically tries to close figures that are open so they are perceived as whole objects rather than separate pieces."
> Symmetry – "Our visual system parses complex scenes in a way that reduces their complexity by recognizing symmetries in the scene."
> Figure/Ground – "Our mind separates the visual field into the figure (the foreground) and ground (the background)."

Common Fate – "Objects that move together are perceived as grouped or related." [2]

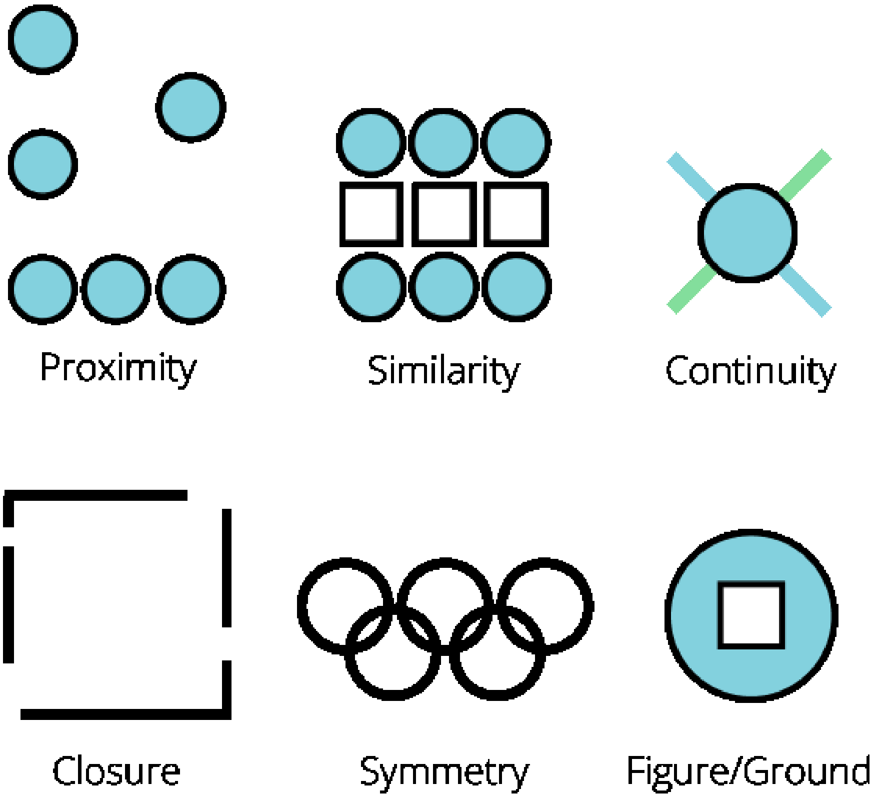

Figure 17 – Gestalt principles

The Gestalt principles can and should be used in UI design. E.g., proximity can be used to create groups without adding visible borders and avoid visual clutter, similarity has been used, e.g., in Google's Gmail to indicate unread and read emails by using bold and nonbold text and continuity makes a slider appear as single range instead of two ranges that are separated by the handle. [2]

Gestalt principles are not the only way to create structure. The visual hierarchy is just as an important method bringing structure into the design. Visual hierarchy means "breaking content up into clearly labelled sections and subsections". Structured content is easier and faster to scan, easier to understand and easier to remember. [2]

Unstructured:

You are booked on United flight 237, which departs from Auckland at 14:30 on Tuesday 15 Oct and arrives at San Francisco at 11:40 on Tuesday 15 Oct.

Structured:

Flight: United 237, Auckland → San Francisco
Depart: 14:30 Tue 15 Oct
Arrive: 11:40 Tue 15 Oct

Figure 18 – Unstructured vs structured information. Based on image from Designing with the Mind in Mind. [2]

Figure 18 shows the benefits of structuring the information. The number of words has been minimized to include only the essential ones so the information can be read faster. There are clear labels and a hierarchy in sections, so the user does not have to read all the information in order to find when the plane is to depart. [2]

Long numbers like phone numbers, credit card numbers and serial numbers can be structured as well. Numbers can be broken into parts or chunks so that they are easier to scan and remember. [2]

4.5 Hand-eye Coordination

When we want to move a mouse cursor into a button on a website, we need to use our hand-eye coordination. Our hand-eye coordination follows two laws: *Fitt's law* and *steering law*. [2]

Fitt's law

Fitt's law was discovered by Paul M. Fitt in 1954. He made different tests with different devices and took time to see how fast the test subject would be able to pass the test. Tests included tapping the center of a plate, transferring discs and transferring pins. He analyzed the results and discovered that the equation

$$T = a + b\log_2(1 + \tfrac{D}{W}) \qquad (1)$$

describes that could be used to predict how long it would take to hit a target. [41]

Figure 19 visualizes Fitt's law. The pointer can be a finger or the pointer of a mouse for example. Formulas T is the time it takes for the user to move the pointer to the target, D is the distance to the target and W is the width of the target measured from the direction of the starting point. [2]

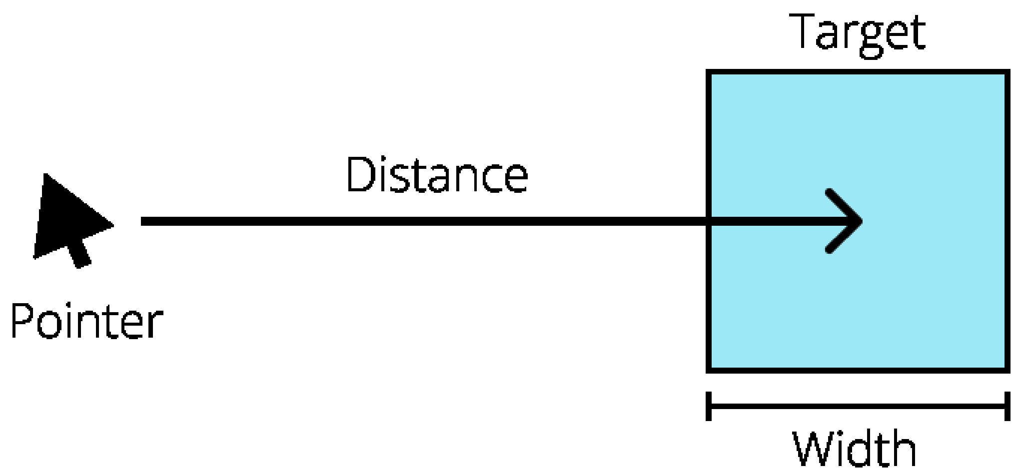

Figure 19 – Fitt's law visualized. Based on image from Designing with the Mind in Mind. [2]

However, the targets placed on the edge of the screen do not follow this formula. The edge of the screen stops the motion of the pointer making the target appear a lot larger than it actually is, making it easier and faster for the user to hit the target. This does not concern smartphones and tablets because there are no raised edges that would stop the movement of the fingers. [2]

The law also predicts that making the target bigger or moving the target closer does not decrease the pointing time after a certain point. When a small target gets doubled in size the pointing time decreases, if the target is doubled in size again the pointing time does not decrease as much. Thus, the relationship between pointing time and target size is logarithmic. The same applies for the distance. Bringing the target closer helps until a certain point. When the target is a certain size or the distance is certain, there are no benefits to making the target bigger or bringing it closer. [2]

Fitt's law can be used to make the UI faster and easier for the user to use by placing the important targets on the edge of the screen, making targets big so that they can be hit easily and adding space between targets so that the user does not accidentally hit the wrong target [2].

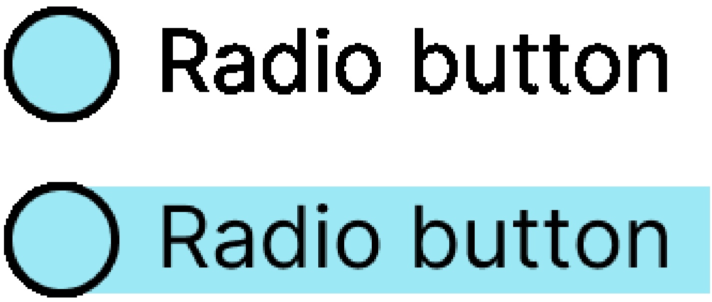

Figure 20 – Two radio buttons with different clickable area demonstrating Fitt's law.

For example, the radio buttons in Figure 20. The upper radio button's clickable area is only the size of the radio button icon, while the lower radio button's label is also clickable, making the area larger and therefore faster for the user to hit. The user is unable to see that the label is clickable as well, so a hover effect is needed to inform the user that the label is clickable.

Steering law

Steering law is the law of paths. It was developed from the Fitt's law by Accot and Zhai in 1997. Accot and Zhai used "steering through tunnels" as an experimental paradigm and found that there actually is a steering law. They did different experiments where test subjects had to draw a line through different tunnels. Their hypothesis was that the time needed to draw the line would be dependent on the tunnel's length and width. They tested straight tunnels, tunnels with multiple targets, narrow tunnels and spiral tunnels and found out that their hypothesis was correct. [42]

The formula of steering law

$$T = a + b(\frac{D}{W}) \quad (2)$$

is simple compared to Fitt's law, Figure 21 visualizes this law. Formulas T is the time it takes for the user to steer the pointer in a constrained path, D is the distance that the pointer has to move in the path in order to hit the target and W is the width of the path. [2]

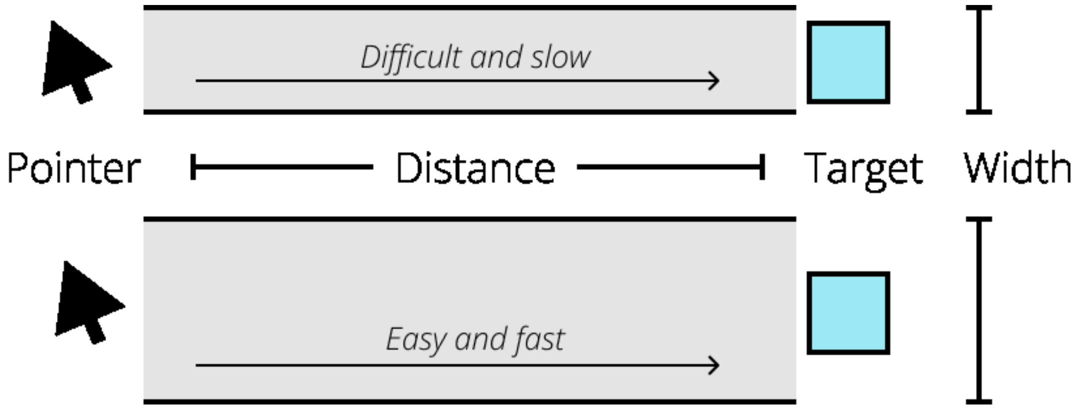

Figure 21 – Steering law visualized. Based on image from Designing with the Mind in Mind. [2]

Pull-right menu is a good example of the application of the steering law. The user needs to move the mouse over the right menu item in order to see the submenu items, follow the path to the submenu and then select the right item from the submenu. In Figure 22, the path is narrower on the left side and wider on the right side. The left menu would need more precise hand-eye coordination from the user, making it a lot more difficult to use than the menu on the right.

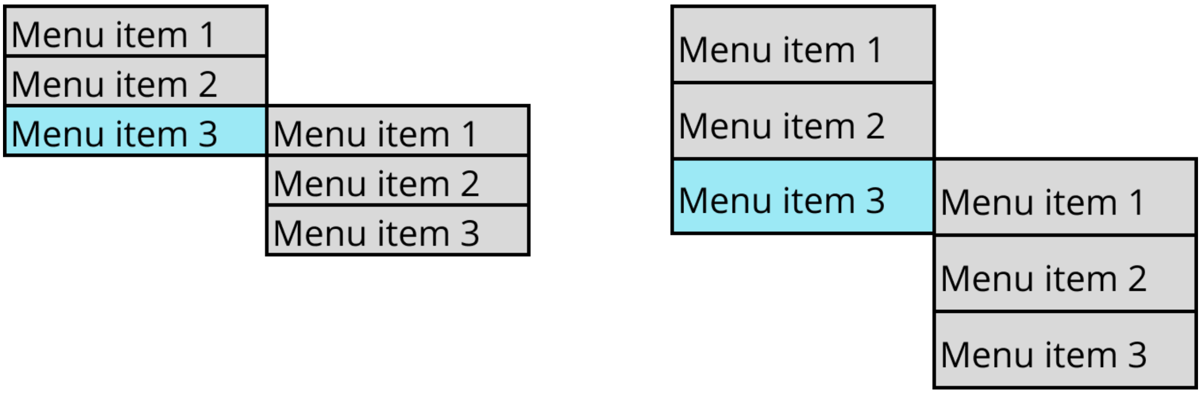

Figure 22 – Two pull-right menus with different path widths.

These laws confirm what might be common sense: a large target is faster and easier to hit than a small target and a wide path is faster and easier to follow than a narrow path. Smaller targets and narrow paths make the website slower to use and can burden the user because the user needs to focus more to hit a small target or stay on a narrow path. [2]

As discussed in Subsection 3.2.1, children are still developing their fine motor and coordination skills. Depending on their age, they might have very poor coordination skills since their fine motor skills and coordination are still developing, or they might have the same skills as adults have.

The applicability of Fitt's law to children as users has been studied on multiple devices. The results on touchscreens have been conflicting. Some of the studies concerning the interaction of children with smartphones have found that the interaction follows Fitt’s law while other studies have found that children’s interaction with smartphones does not follow Fitt’s law [43].

The results on a mouse have proven that Fitt’s law is applicable to children as well. The homing part of the task appears to be the most difficult for children. Children had difficulties when they got close to the targets, especially when the target was smaller than 64 pixels. Children spent more time hovering over the target than adults and had lower accuracy and higher target reentry rates. They also found out that the help needed from the UI got smaller as the children got older. [32]

4.6 Time

We have time requirements for interactive systems. Our perceptual and cognitive processes set certain deadlines where the system has to respond to our actions, or we start to think that the system is unresponsive which can lead to unhappy users. [2]

Robert Miller studied our time limits in his paper “Response time in man-computer conversational transactions” that was published already in 1968. Miller was a behavioral scientist who specialized in task behavior. He calculated different estimates for delay times for different scenarios. The times were more indicative than conclusive and they were based on Millers’ knowledge of our short-term memory and cognitive psychology. [44]

Miller had different scenarios ranging from simple reactions to users’ input to simple inquiries and more complicated and time-consuming operations. The time requirements ranged from an immediate response to 10-15 seconds response time. E.g., a response to control activation should take 0.1 seconds, a response to a request for the next page should take 1 second, a response to simple inquiry should take 2 seconds, and more complex inquiries should be completed within ten seconds. Ten seconds is the time that the user can maintain the continuity of thinking because of our short-term memory. At fifteen seconds, the user might get frustrated and discontinue the waiting. [44]

Although Miller wrote his paper over 50 years ago, our time requirements have not changed that much, because we have not changed that much. Based on Miller's work (partly Card et al. 1991), Jakob Nielsen has simplified the time requirements into three time limits: 0.1 second, 1 second and 10 seconds [45].

0.1 seconds limit feels like immediate response-time and gives the user the feeling that the outcome was caused by the user, not the computer [46]. If the response takes longer than 0.1 seconds, "the perception of cause and effect gets broken" and users might think that they have missed a button or a link and click again [2].

1 second is the time limit to keep users flow of thoughts uninterrupted even though the user will notice the delay [46]. We expect a maximum gap of 1 second in conversation and assume that even from computers, therefore the system should do what the user asked it to do or show how long the operation will take within one second, otherwise the user might become impatient [2].

10 seconds is the limit for users' attention towards the task [45]. Because the ten-second limit is based on our attention (short-term memory), the users' minds start to wander and it might be difficult for them to return to what they were doing when the computer finally responses [2].

Because of our time limits and need for responsiveness, the system should respond to us within these time limits. The user needs to know what is going on and how long an operation will take. A rotating loading icon is good if an operation takes few seconds, otherwise there should be a progress bar indicating the time or percent. [2]

4.7 Errors

Humans make mistakes. The system should be designed in a way that helps users make fewer mistakes and recover from mistakes easily. Errors can be categorized into two groups: slips and mistakes. A slip happens when a user does something they did not mean to do. A mistake happens when user does something intentionally but it turns out to be a wrong thing to do. [2]

Johnson introduced different types of slips that were based on Don Normans research "Design Rules Based on Analyses of Human Error". The slips were collected into Table 2 together with the design guidelines that can be used to prevent them. [47]

Slips are relatively simple to prevent because they are more like accidents as can be seen on Table 2, mistakes on the other hand are more complicated. Mistakes happen when the user's mental model of the UI and the actual UI of the system mismatch. In order to prevent mistakes, the designer should understand the user's mental model and expectations of the system. The user is less likely to make mistakes when the user's and the designer's mental models match. [48]

Table 2 – Slip types, causes and how to prevent them [47]

Slip	Cause	Prevention
Capture slip	User switches to a similar action in the middle of doing another action.	Avoiding overlapping paths or steps in different operations.
Description slip	User does the right action to the wrong object.	Consistency, all objects have the same operations. If an object has different actions, it can somehow communicate it.
Data-driven slip	User gets distracted by external data.	Guiding the user towards the goal. A narrow process funnel can help the user achieve the goal without distractions.
Loss-of activation slip	User loses the goal from short-term memory.	Displaying the system progress and status. Providing memory aids.
Closure slip	User forgets the final step of the task when the goal is achieved.	Warning users if task is not completed (save pop-ups). Completing tasks automatically (logging out automatically).
Mode slip	User does the right action, but the status of the system is wrong.	Indicating the modes clearly if avoiding modes is not possible. "Spring-loading" user has to physically hold the system in different mode (CTRL+S).
Attention slip	User misses an important feature of presented information.	Using visual hierarchy, perceptual pop and movement to direct the user's attention to important details.
Motor slip	Physical slips, user types “N” instead of “M” or pushes wrong button.	Making targets big (Fitt's law) and adding space between them. Avoiding multilevel menus.

Nielsen refers to Don Normans book The Design of everyday things while talking about mistakes. Norman introduced two gulfs: The gulf of execution (“How do I work with this tool to accomplish my goal?”) and the Gulf of Evaluation (“Did this work how I wanted it to?”). Users usually have a goal when they go to a website. They open the site and form an action plan to achieve that goal which is based on the mental model of the site. The user follows the action plan and checks if the result matches the goal they had. Mistakes happen when the user does not get enough help in bridging these two gulfs. Users either form and execute a wrong action plan, or they do not understand how their actions change the state of the system which leads to a mistake. Therefore, it is important that the designer understands users' goals and mental model and designs the website to meet the users' mental model and expectations. [48]

The system should be designed to prevent slips and mistakes. Preventing a slip depends on the type of the slip (introduced in Table2.). Mistakes can be prevented by "providing clear, complete, accurate information". The system should be designed to prevent errors, but it should also help the user get back to where they were before the error occurred, because no matter how much a designer tries to design so that the user would not make mistakes, the user will still make mistakes. [2]

Because children's motor skills and cognitive skills are still developing (see Section 3.1.), children are probably more likely to cause errors. They are still learning hand-eye coordination, so they are more likely to push the wrong button. Their mental model of a website and its different functions are also still developing. Children might need even more help in bridging the two gulfs than adults. Otherwise, the same design choices that prevent adults from making mistakes work for children as well.

4.8 Learning

Do you remember our new brains and old brains from Section 4.1., and our limited attention span from Section 4.3.?

> The first time or even the first several times we perform an activity, we do it in a highly controlled and conscious manner, but with practice it becomes more automatic. [2]

Jeff Johnson used "learning to drive a car" as an example of learning. The first time when we drive a car there are many things, we need to pay attention to, pushing pedals, changing gears, checking the mirrors, keeping an eye on the traffic around… Since we are able to pay attention to three to five items at a time, there are way too many things for us to follow. Our new brains are working really hard trying to keep up with all these new actions and the new driver can feel overwhelmed. When these new things are practiced separately, they gradually become easier and more automatic. Driving becomes easier as our old brains begin to control automatic actions. After a while driving in normal conditions becomes so automatic that the driver can think about dinner or other stuff while driving. Our new brains will take control back when there are traffic jams or dangerous driving conditions where we really need to focus on driving. Compare driving in motor way during summer with no traffic at all or slippery roads and lots of traffic in the center during winter. [2]

There really is no difference between learning to drive or learning to use a computer. Typing on a keyboard for the first time is slow and controlled and takes a lot from our new brain. The user is staring at the keyboard to find the letters and pushing them one at a time. Maybe using only one hand or one finger. When we use a new keyboard that has even a slight difference to what we are used to, we need to focus more until the action of typing becomes automatic again. Imagine if the keyboard's letters would be in different order depending on the manufacturer or the model? We would probably carry our own keyboards with us because learning to type on a new keyboard again and again would slow down the path towards our goal way too much.

We have the same learning curve in interactive systems. Users learn faster when they practice and use a system regularly. The designer can also help the users learn faster by considering that users can learn faster when:

> "The operation of a system is task focused and simple."
>
> The system is consistent and predictable. "Inconsistent systems place a high cognitive load on users."
>
> "Vocabulary is task focused, familiar, and consistent."
>
> Nothing bad happens if the user makes a mistake. "Help users avoid errors and help them recover from errors."
>
> The system uses metaphors. (E.g., a trash can for deleting.)
>
> Advanced features are hidden or deactivated until the user has learned the basics and needs them.
>
> There are demos, online guides and videos of the system. [2]

In my opinion, the learnability of a system depends on the background work that the designer has done. If the designer understands who the user is, how often the user is going to use the system and what kind of tasks the user will be performing, they can design the system accordingly. There is a big difference in designing something for adults to be used eight hours a day and designing something for children to be used occasionally for short periods of time.

If the new system resembles something that the user has already used, the user can take advantage of the automatic actions learned with the previous systems and does not have to use the new brains that much. Learning and generalizing from experience are relatively easy for users. [2]

It should be kept in mind that there is a huge difference between children and adults. Children have little or no previous experience, so especially the younger children have to learn everything from the beginning. Designing an intuitive system for someone who is not familiar with anything relevant can be difficult.

5 Case Description

This chapter introduces KidNet, and the research methods used in this thesis. Section 5.1. is about KidNet, the research made with it and the goals of the UI design. Section 5.2. is about the research methods concerning the execution of the empiric part of this thesis. Section 5.3 is about ethics.

5.1 Introduction

> Kids still don't understand the Web's commercial nature and lack the skills needed to identify advertising and treat it differently than real content. We need much stronger efforts to teach children about these facts of new media. [30]

Learning internet reading kills is very important because children have difficulties distinguishing ads from the real content online and evaluating the reliability of the sources. KidNet is a closed online inquiry learning environment developed where children can practice online inquiry skills and evaluate the relevance and reliability of a source. KidNet was developed for teaching internet reading skills. The data from KidNet has been used in research of children's online reading skills.

The research started with Neurone which was also a closed website for simulating web search. Neurone had linear task flow that consisted of different stages that could be modified for different scenarios. The usual flow was introducing the task, search phase, snippet phase, evaluation phase and summary phase. Neurone became outdated and developing it further turned out to be impossible. A new, more flexible environment was needed and so the current environment began.

In KidNet the task flow is flexible. The users can move back and forth between different phases. Users get an assignment and have to figure out which search terms they should use in order to find relevant sources for the assignment. KidNet's own search engine is used for the search phase. Users go through the search engine results, trying to find relevant sources that will help them to answer the task. Users can save the pages, evaluate the usefulness and reliability of the page and save the main points from the page so that they can be easily used while writing the answer to the assignment. The saved pages and the main points saved from the pages have their own pages so the users can easily take a look at what they have saved. The final phase is writing the answer to the assignment.

The UI for KidNet had to be suitable for children in elementary school. Because KidNet is used for learning new things, it had to be simple and easily learned so that children could focus on learning skills needed to complete the tasks given to them, instead of learning how to use KidNet. This highlighted the importance of usability.

The impact that usability has on learning outcomes has been researched and linked together multiple times. However, it can also be derived from theories presented previously. Section 4.8. about learning highlighted the importance of consistency in learning, and since consistency is one of the 10 usability heuristics introduced in Subsection 2.2.2 it is no wonder that the results confirm the importance of usability.

An article written in 2008, "Investigating the Connection between Usability and Learning Outcomes in Online Learning Environments" came to conclusion that "Results confirmed the relevance of the correlation between system usability and student learning outcomes [49].". The same conclusions were made in 2015 in "The Usability and its Influence of an e-Learning System on Student Participation" that acme to conclusion that "It appeared that the most usable of the two systems had a positive impact on the performance of the group of students that used it. The reported difference in performance was statistically significant [50].". These findings confirm the importance of usability in online learning environments.

The design process of KidNet is based on user-centered design theory presented in Section 3.3. Considering the roles presented in Section 3.4, children have had three roles in the design process. Children could be seen as informants since their use of Neurone was observed and the issues, they had using Neurone were considered in the design of KidNet. Children were also asked questions after each intervention where some questions were about the use of Neurone, the knowledge that was gained was used in the design of KidNet. During this thesis, the children had the opportunity to show what kind of user interfaces they would like to have. Children from Rauma normal school were used as testers early in the development process. Children took part in pretests, interventions, posttests and filled in questionnaires that had questions concerning learning and the usage of KidNet, these methods connect the design process to the user-centered design theory. Children can also be seen as users because the impact of the use of KidNet on their skills has been measured in the larger series of interventions held during the spring of 2023. At that point, KidNet could be considered a finished product since there are no plans to make any major changes. The main purpose of these interventions was to teach children internet reading skills, gather data for research purposes and confirm that KidNet is working well.

5.2 Research Methods

As mentioned in the introduction, the research methods were not considered when I tried to find a way for children to participate in the design. The research methods were considered when the UI "puzzle" was ready and used in the design sessions. I consider this to be a good thing because thinking about research methods in that phase could have limited my creativity.

The research method used for the theory part was a literature review. Information about child-computer interaction, children as users, user interfaces and users in general was gathered from multiple sources such as books, scientific articles and websites.

The empirical part of this thesis had multiple research methods. One of the methods was case study since this study was limited to KidNet instead of UIs in general. Another method was user study, which aimed to find out which UI elements the users prefer. The design sessions, which are the main point here, can be seen as a combination of an interview, observation and participatory design.

The implementation of the empirical part consisted of coming up with the idea, deciding which part of KidNet the participants are going to design, designing the elements, deciding what should be asked from the participants, writing a script for the session, completing the design sessions with participants and analyzing the data gained from the design sessions.

Section 3.3 introduced a research theory called cooperative inquiry which combined contextual inquiry and participatory design. I was inspired by the thought of letting children participate in the design process and started to think about different ways that children could design UIs.

As learned in Subsection 2.2.2, designing a good UI is not a simple task even for trained professionals. Drawing a complete UI with a pen and paper might have been too complicated for 6^{th} graders because they might not understand the meaning of different components. This method would have allowed children to use their imagination and creativity, but since some children are pretty careless and some children are very meticulous, it would have been impossible to predict how much time different children need to draw this kind of UI sketch. The sketches might have been very different from each other and analyzing the results might have been very difficult, which would have reduced the usefulness of the results.

With the usefulness of the results in mind, I started to think about ways for children to participate that would be relatively short, fun and useful for KidNet. I came up with the idea of the UI "puzzle" where children could choose their favorite components from different alternatives and use those components to create their own layout of a website which can be seen as a low-tech prototype. I designed different components, some based on design recommendations and some on imagination, so that there would be uncommon options for children as well, these components are introduced in Section 6.1.

The UI "puzzle" was used in the design sessions which can be seen as a combination of interview, observation and participatory design. The sessions followed a certain protocol which will be introduced later in Section 6.2. Participants were asked certain questions and used the pre-made components to design the UI.

One definition of the participatory design method is: "participants are given design elements or creative materials in order to construct their ideal experience in a concrete way that expresses what matters to them most and why [51]." Section 3.3. introduced different design theories used with children. There is a big difference between participant design as a theory and participant design as a method, and it is important to notice that although participatory design was used as a method, it was not used as a theory.

An interview can be either structured or semi-structured. Structured interviews have a fixed list of questions which are asked exactly as they are written, the data collected can be analyzed using statistical analysis. Semi-structured interviews are more interactive and have more conversational flow where new questions can be asked if something unexpected happens, the data collected can be analyzed using qualitative analysis methods. The interview part was a semi-structured interview, because although it followed a certain structure and the results were partly in a form that could be analyzed statically, there was always space for open discussion and additional questions. [52]

The design sessions were held with three groups, children from Rauma who had already used KidNet, the control group that consisted of children who have not used KidNet and the group of adults who have not used KidNet. Children from Rauma were taking part in the larger research considering the online inquiry skills, children in the control group were mostly children of my friends in the Turku area and the adults were mainly teacher students from the Faculty of Education. The main point in having three groups was to find out how much the previous use of KidNet would impact the designs made by children at Rauma and how much would the UIs made by children and adults differ from each other. Although the design sessions were short, they gave the children the opportunity to express their likes and dislikes and influence the design of the future UI.

5.3 Ethics

Ethics were considered in this research because minors were involved. "The ethical principles of research with human participants and ethical review in the human sciences in Finland" presented ethical principles concerning minors[53]. The following principles concern this thesis:

> A. "Minors must be informed about the research in a way that they are able to understand."
>
> C. "The participation of minors under the age of 15 is primarily decided by the parent or carer."

> D. “Even if participation in the research requires the approval of the parent or carer or a legal representative, minors primarily give their own consent to participating in the research.”
>
> E. “Researchers must always respect the autonomy of minor research participants and the principle of voluntary participation, irrespective of whether the consent of the parent or carer has been obtained for the research.”
>
> F. “If participating in the research is not in the minor’s best interests and the minor does not wish to participate in the research, the researcher must discontinue the minor’s participation.”

The children were asked if they knew what a UI was and presented with a simple example of a UI so that they would understand what it actually was. They were then told their help was needed for making a UI that children would like to use. The presentation of the research was done appropriately and fulfils the principle A. The children from Rauma had a permit from parents to take part in research concerning KidNet and they took part voluntarily. I introduced myself at the beginning of their posttest session and after they had done the posttest, they were allowed to come to a separate room for the design session. Control group’s children came to design sessions with their parents, or the sessions were held at their homes. I introduced my research to the parents and asked them if their children would like to take part in something like this. There were a few “no” answers, but most of the children were excited. All participants took part voluntarily and were allowed to stop if they wanted to, all participants said that they had fun, so the principles C-F were fulfilled as well.

The ethical principles for adult participants concerning this thesis were mainly about voluntary, the discontinuation of the participation and information about the processing of personal data. All the adults participated voluntarily and were allowed to stop at any time. No personal data was gathered, the names of the adult students that participated in the Educarium were not asked.

6 Case Study Design

This chapter presents the UI components used in the design sessions and the protocol that was followed in the design sessions. In the design sessions the participants were designing a page for KidNet where the functionalities of the page were pre-determined. The participants chose their favorite components from the alternatives presented to them and created a layout with the chosen components.

6.1 UI Components for the Study

A UI design tool called Figma [54] was used to create different UI components for the study. The components were printed, glued to a thin cardboard, cut to pieces and covered with contact film so that they could be wiped.

I tried to be creative with the designs so that children would have more options than the standard UI components. At the same time, non-standard components might not be usable because of the design heuristics introduced in Subsection 2.2.2 E.g., the fourth rule about consistency and standards stated that standards should be followed because they decrease users' cognitive load. However, the purpose of the study was to find out what kind of UIs children would make with the components they were given. The final decision about using them in the actual UI would be made after evaluating the usability of the components.

6.1.1 Navigation

The different navigation designs can be seen in Figure 23. There were four different designs for navigation: text-only, icons-only, icons with text and balls with text. Because the navigation can be displayed vertically or horizontally, there were eight components in total. KidNet currently has horizontal navigation with text-only, so some of the participants were familiar with this option.

Figure 23 – Navigation designs

Text-only is the basic option for navigation and the navigation option KidNet has currently. The downside of text is that the user has to read the text which takes longer than “scanning” for icons.

Using only icons would make navigating faster because users can “scan” the icons with their eyes instead of reading descriptive text. The downside is that the users have to click the icon to see what page it will lead to if the icon is unfamiliar to them. Users would obviously learn the meaning of the icons fast, but because KidNet is not something that the user would be using on a daily or weekly basis, there might be a risk that the user would have to learn the meaning of the icons again if there has been a long break in using KidNet.

Icons with text support faster “scanning” and the text describes the meaning of the icon so that the users do not have to guess the meaning. New users would benefit from this design because they would not have to click on the icons to figure out what they mean. Experienced users would also benefit from this design because they could just scan the icons faster than reading.

“Balls with text”-design did not really have any other reason except the fun factor. The funniness probably was not conveyed from the paper. This is an example of why designing user interfaces without the actual context can be difficult. The result might have been different if UI sketches or even prototypes were used. Adding bright colors and a hover-effect where the balls grow when they are pointed could have influenced the choices made by children.

The balls had the same downside as the text-only option because there are no icons. This design might also break the fourth design principle: consistency and standards introduced in Subsection 2.2.2. Balls are not the traditional way to implement navigation and it is better to use established conventions so that external consistency remains. This design has other issues as well. Fitt’s law from Section 4.5. states that user can click objects faster if they are placed on the edge of the screen. The ball would not be on the edge of the screen as tightly as the other designs. This would slow down the users more than clicking on targets on the other designs.

6.1.2 Buttons

Five different button components were made as seen in Figure 24. The most commonly used shape for buttons was chosen with three different border-radiuses[7] 0px, 15px and 50px. A circle and a square were added for a possible fun factor.

[7] Border-radius determinates the sharpness of the corner. 0 is the sharpest, as the number gets bigger the corner starts to resemble circle more than a corner.

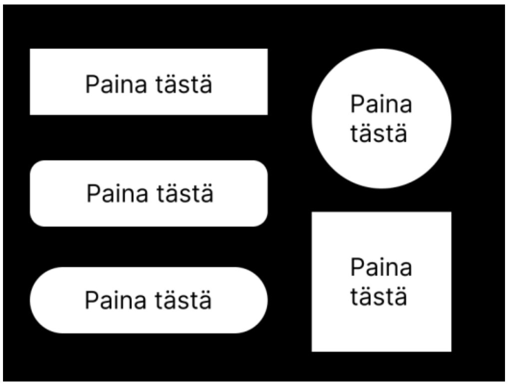

Figure 24 – Button designs

6.1.3 Image

One of KidNet's assignments was about hedgehogs. The image in Figure 25 was used in it, making it a good choice for the image component.

Figure 25 – Image component [55]

6.1.4 Text

A short text of a hedgehog was used as an example text so that the image and the text would go together nicely. Normally "Lorem ipsum" is used while designing, but in this case a real text was a better choice to avoid confusing the children with a weird nonsense text. The text was taken from Wikipedia's Hedgehog-page in Finnish. There were three different font options: Arial, Times and Comic Sans, see Figure 26.

Times is a serif type font. Serif type fonts are commonly used for big amounts of text, as their small lines and curves at the end of the letter guide the reader's eyes from letter to letter [25]. Serif fonts are older fonts that are widely used in books and newspapers. Times should be avoided when designing for 7-11-year-old children [31].

Arial is a sans serif font. Sans serif fonts are commonly used in user interfaces, they do not have lines at the end of the letters and keep their readability even in smaller sizes [25]. Sans serif fonts are a more modern than serif fonts and are often used on websites and UIs.

Comic Sans is also a sans serif font. Comic Sans is the most controversial of three fonts, but it was included because it is known to be used widely in kindergartens and schools. Comic Sans has been used many times in situations where a more formal font would have been more appropriate, and it has a bad reputation among designers.

Figure 26 – Font designs. Text taken from Wikipedia's hedgehog page in Finnish.

6.1.5 Evaluation

Figure 27 – Rating designs

Four different components were designed for rating the reliability and usefulness of the page, see Figure 27.

Emojis were mentioned in multiple sources by Read & MacFarlane [26], Hietala & Ovaska [56] and Read et al. [57]. It is a Visual Analogue Scale (VAS) that uses pictures that children can use to identify their opinions [26]. The design is based on the smileyometer presented by Read & MacFarlane. Although it has emojis in it, it is basically a Likert scale in a disguise since the emojis present the emotions concerning the argument of the reliability and usefulness of the page.

The stars were used in Neurone that was used in the research before KidNet. They have become a standard for rating and are used on various websites where the users can rate products or services.

The school grading was something that I assumed would be familiar to the children from the school world. If we think about usability heuristics, the grading breaks the fourth rule since it is not standard in user interfaces. At the same time, it follows the second rule being a familiar concept to a child who is in elementary school.

The Likert scale is widely used in questionnaires making it familiar to many users. It was interesting to see if children would choose this somewhat boring option instead of funnier emojis and stars.

6.1.6 Support Characters

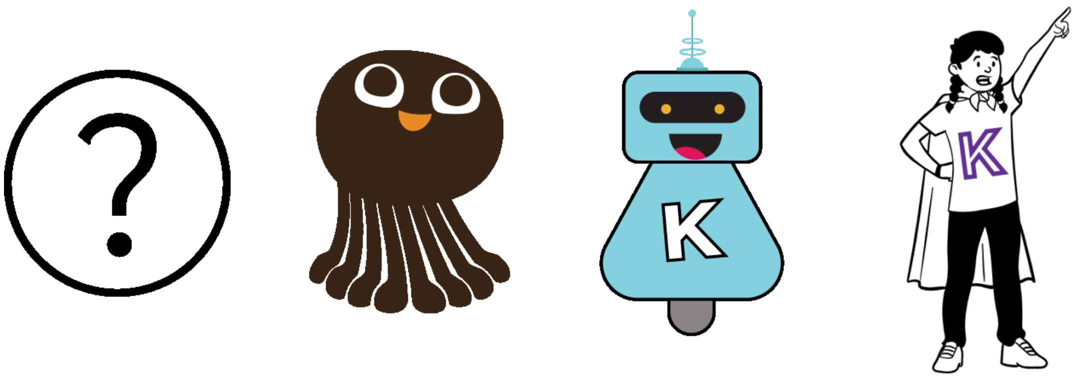

Figure 28 – Support characters

Figure 28 shows the different support characters. "What would you like to click if you don't know what to do on the page?" The help icon was chosen because it is very recognizable, the other designs included one animal, one human and one inanimate object so that there would be funnier options as well.

The question mark is a standard icon for help. Help is usually hidden under the word "help" or a question mark on websites and applications.

The octopus was chosen because it is the logo of Finsci, and it is used in the material and KidNet already. The students received a workbook at the beginning of the study that has two octopuses, teacher and student one. They were taught that Finsci-octopus will help them if they do not know what should be done on the page. Children at Rauma school were used to clicking Finsci if they did not know what to do. It was interesting to see if other children would choose Finsci as well or if they would choose something else.

The benefits of child-like on-screen characters came up in Soni et al.'s A Framework of Touchscreen Interaction Design Recommendations for Children [31]. Kaakinen talked about the benefits of animated pedagogical agents also [56]. A cute little robot and a KidNet kid were created based on these sources. The robot was based on the thought that children might think that robots are cool.

The KidNet "superhero" was born out of all the superhero movies I watched as a kid. The thought was that children might like a child superhero helping them if they encounter problems.

6.1.7 Colors

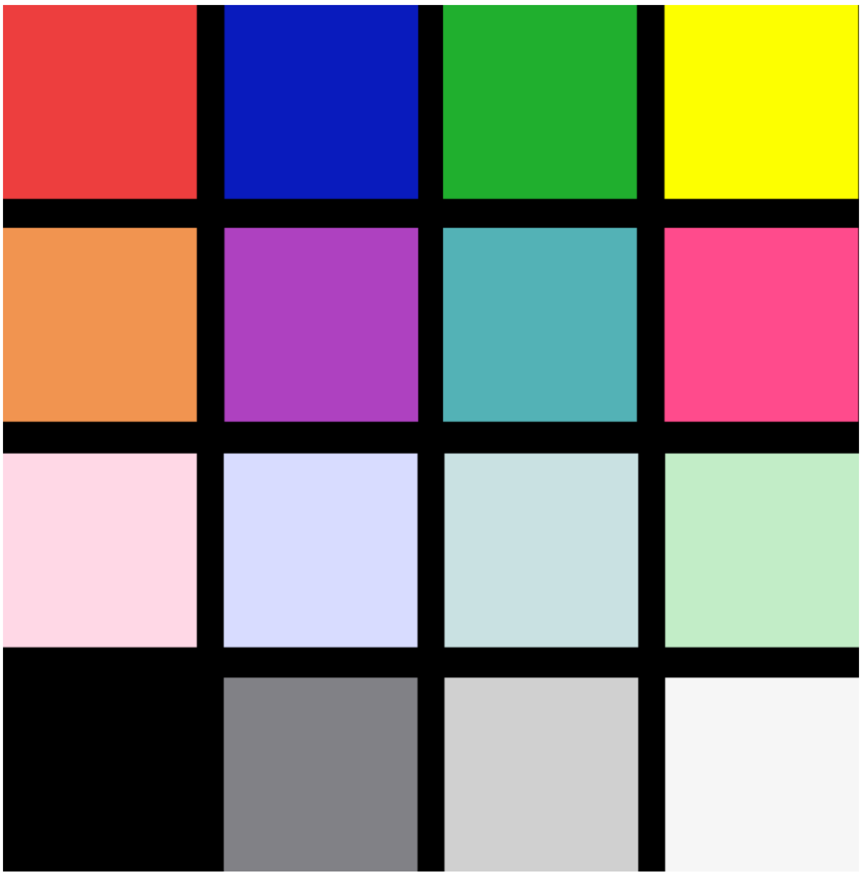

Figure 29 – Colors used in the design sessions.

A mix of bright colors, pastel colors, and grayscale colors was chosen as seen in Figure 29.

This part was the most difficult to implement. The first idea was to let children color the components with crayons after making the layout. Luckily, my boss happens to be a teacher, and she told me that some children are very precise in coloring, and it might take a very long time for them to color the components. Printing colored components would have made the number of components either too large to handle, or the options to choose from would have been minimal. The colored cards that can be placed next to the component were the best option since there were no better alternatives.

The issue with this implementation was that it is difficult to picture what a relatively small patch of color will look like when it is used on a big component, like the background. It is impossible to know if the participants had chosen the colors if they had seen what they really look like in a UI sketch made with Figma.

6.2 Study Protocol

Design sessions were held with two age groups: 10-12-year-old children and adults. Children's group could be divided into Rauma group, which had eight children who had previously used KidNet, and control group from Turku area consisting of seven children who previously had not used KidNet. Adults were from Turku area. Eight of the adults were students from Educarium and two of the adults were parents of children in the control group. None of the adults had previously used KidNet. The total number of participants was 25. The distribution of the participants can be seen in Table 3.

Table 3 – Participants

Grade	Amount
4th	3
6th	12
University	8
Other	2
Total	25

Rauma group consisted of eight 6th grade students from Rauma normal school who had used KidNet during the testing period from November to December in 2022. The first six students were working alone but the last two girls were exceptionally allowed to work together so seven UI puzzles were made by the Rauma group.

Recruiting children for the control group turned out to be more difficult than assumed. Therefore, the control group had a bigger age distribution (4th and 6th graders), and the sessions were arranged differently because most of them were held in friends' homes. Only two of the control group participants came to the Educarium. The other three sessions were held in my friends' homes. The first friend had two children, 4th and 6th graders, the other had a 6th grader and the last had 4th and 6th graders.

The adults' group consisted of ten adults. Eight of the adults were students studying to become a teacher at the University of Turku. Since I work at Educarium where they study, it was easy for me to walk out of my office and ask them to help me with my thesis. I included two of my friends as well since I was doing the sessions with their children anyway.

The sessions started with a short introduction. I introduced myself, the purpose of the session and thanked the participants for helping me. I showed them that I have a recorder and told them that I would record the session so that I would not forget anything crucial. I also told them that I would be taking pictures of their work.

After the short introduction, the participants were asked for background information that might have affected the end results. Children's background questions were related to their computer use and if they considered themselves to be good at using computers. Adults' background questions were related to their minor subjects and hobbies. Experience in coding or graphic design might have shown in the result because knowledge affects the mental model. It was important that the computer skills of the participants would be at a normal level.

After the introduction and background information, the participants were asked if they knew what a user interface is. Most of the participants answered no, and were told that user interfaces are everywhere, and that they are pretty much anything that can be used for using anything. The idea of a UI was demonstrated by telling the participants that light switches are the UI for the lights. The participants were then told that on a website the images, buttons, elements etc. seen on the screen form the UI.

The goal of the session was then introduced to the participants. "We are going to make a page that has an image, text, "Save the page"- and "Save a snippet"-buttons, evaluation tools, support and navigation so you can move between pages."

The selection of components started with navigation. The components were shown to the participants, and they were asked if they would like to have the navigation bar horizontally or vertically. The different navigation components were then handed over to the participants and they were asked to choose the component they like the most. The next component was introduced after the participants had made the decision. This was done with text, buttons and evaluation components. The participants were asked "what would you like to click if you didn't know what to do on the page?" before selecting the support component so the selection of support character was done differently. The participants were also asked if there should be additional characters as decorations.

When the participants had chosen the components, they were asked to create a layout with the chosen elements. When the layout was done, they were asked to add colors. They were told that there should be a color for at least the background, navigation and buttons and that the same color could be used for different components. They were supposed to be asked if they would like the active page to be highlighted and the color for the highlight, but this was forgotten on several occasions. When the participants had placed all the colors and were happy with the results, a picture of their UI design was taken before moving on to the final interview.

The final interview was short. The participants were asked what they would like to happen when they push the support button and if they would like to say something about the UI they made. Finally, the participants were thanked for their help and asked if they thought that the session was fun. All the participants, including the adults and the shy ones thought that the session was fun. Adult students told their friends that they should take part in the session because it was fun and possibly because they were rewarded with chocolate bars.

Sessions lasted from 5 to 15 minutes. Some participants were making decisions quickly while others were really considering different options. After the sessions, the choices made by the participants were typed into an Excel sheet and Figma was used to create a UI sketch based on the picture taken. The pictures taken during the sessions and the UI sketches created based on them, can be found in appendices.

7 Case Study Results

This chapter presents the results from the design sessions. Sections 7.1 and 7.2 are about how the design sessions were executed and how they succeeded. Sections 7.3 and 7.4 begin with the presentation of statistics about the choices made during the design sessions and present a few of the UI sketches made by the participants. The choices made by the participants were gathered into an Excel sheet and Section 7.5. presents this statistical summary.

7.1 Designing with Children

The children can be divided into two groups: eight 6th grade students from Rauma normal school who had previously used KidNet during projects testing and a control group of seven children from Turku area who had not previously used KidNet. In total there were eight girls and seven boys, twelve 6th graders and three 4th graders.

The first session was held at the University of Turku’s Educarium in December 2022. The purpose of the session was to test if the components and protocol work or if something needs to be changed.

The Rauma group sessions were held at Rauma normal school shortly after the first session. Participants came to a small room behind the actual classroom after they had finished the post-test of the KidNet project. Participants came to the room alone, except the last two girls who really wanted to work together. Therefore, there are seven UI designs from Rauma.

The girls that were allowed to work together agreed about everything right away, so letting them work together might have been a mistake. However, the choices they made were similar to choices other children made working alone.

The other control group sessions were held during spring 2023 at the Educarium and friends’ homes. The first and only child who came to Educarium got exposed to octopus-poster on the wall of the room the session was held in. This might have had an effect on the choices he made. Three control group sessions were held in my friends’ homes. Two sessions with two children and one session with one child. It was made sure that there was no chance to peak or eavesdrop during the sessions that had two children.

All sessions went well. Some of the children were shy but not too shy to talk to me or make choices for the puzzle. None of the children got confused or anxious during the sessions and all of them answered “yes” when they were asked if the task was fun.

Doing this kind of research for the first time was exciting and a lot of time was spent thinking about how the children would feel the most comfortable during the short design session. Asking additional questions about their choices was therefore minimal since that might have made children feel uncomfortable. Children's answers to questions like "do you know what a navigation bar is?" were accepted without asking them to explain it, which would have shown that the child really knew what a navigation bar is.

7.2 Designing with Adults

The same sessions were held with ten adults. Eight of the adults were students studying education at the University of Turku and two were parents of the children in the control group.

The first sessions were held at the University of Turku's Educarium in the spring of 2023. Random students were asked to take part in the study in the hallway of the Educarium. The goal was to get the same number of females and males to participate so that possible differences caused by gender would not affect the results. Some of the students were at the beginning of their studies and some were already bachelors.

The first four that came to my office saw a poster on the wall that had the Finsci octopus on a turquoise background. Three of this group chose very similar colors without seeing what the others had done and two of them even chose the Finsci character for the support, so seeing the poster might have affected some of their choices. No one chose the octopus for support after the poster was taken down. Also, the color choices had more variance afterwards so maybe the poster influenced these three participants. All students liked the task and asked their friends to take part in it too.

My friends were asked to do the same task before their children did it so that the situation would be easier for the children when their parents said that the task was fun.

7.3 Interfaces Made by Children

7.3.1 Statistics

For a more detailed presentation of this data, see Section 7.5.

Navigation

8 out of 14 children chose vertical navigation and 10 out of 14 chose icons and text as the navigation style. 4 out of 14 chose only icons for the navigation. It was surprising that nobody chose the balls or text-only option. 5 out of 7 children in Rauma chose the icons and text design and placed it vertically although they were used to horizontal navigation with text-only design. It might be safe to say that the

children were not afraid of making changes into the UI that they were already accustomed to.

Text

6 out of 14 chose Comic Sans for the font and 6 out of 14 chose Times for the font. There was a huge difference between the Rauma group and the control group. Children at Rauma chose Comic Sans 5 times while children in control group chose Times five times. I have no idea what could explain this difference. Maybe schools in Turku do not use Comic Sans?

Buttons

8 out of 14 children chose the button style that had a border-radius of 50 pixels. Button with border-radius of 15 pixels was chosen four times. The choices made by children at Rauma and children in the control group were similar. The ball button was chosen twice at Rauma. None of the children chose the button with border-radius of 0 pixels or the square. It looks like children like more rounded shapes based on this data.

Rating

8 out of 14 chose stars and 4 out of 14 chose emojis for rating the reliability and usefulness of the page. Likert and school grade were both chosen once. The school grade was chosen by a child in the control group. He reasoned that if KidNet is used in schools, then the grading should be the school rating.

Support character

7 out of 14 chose the octopus for support character. There was a huge difference between the Rauma group and the control group. The children at Rauma chose the octopus five times while the children in the control group chose the question mark five times. Only two children from the control group chose the octopus for support, and one of them was the child who had been exposed to the octopus-poster.

Most of the children in the control group did not even think about other options, they grabbed the question mark as soon as they saw it. Some of them even seemed a bit confused that there were other options for support and gave me a weird look. I am not sure if they thought I was mocking their computer skills or if they thought that it was some sort of trick question. Looking back, maybe they should have been asked about the look they gave me, but since some of the children were a little shy, they might have found the additional question somehow unpleasant.

Layout

The layouts that children made had lots of variations. Analyzing different layouts is difficult. The placement of the navigation bar was the only easily analyzed component. The location of support could also be analyzed. Analyzing the position of every component would also be laborious and maybe not that useful since the layout should be designed with usability in mind. There were also additional components in the actual web page, but adding those components could have caused confusion in children since the number of components would have been larger.

Children placed navigation usually at the top or the left of the screen. Three of the children in the control group placed navigation at the bottom of the page. I was wondering why children in Turku area place the horizontal navigation bar at the bottom of the screen at my friend's place after a session. Her daughter had placed the navigation bar at the bottom of the screen like most of the other children in the control group. My friend asked me "Did you know that children in primary school in Turku use tablets? They get laptops at the 7th grade when they go to secondary school?" Children at Rauma had laptops in the classroom, and this explains why the results were so different between the two groups.

The decision for analyzing the placement of the support was made after there was a clear pattern in the UIs made by adults. This is discussed more in Subsection 7.5.5.

Although analyzing the layouts was difficult, there was a difference between the UIs made by children at Rauma and UIs made by children in the control group. One of the children at Rauma recreated the UI layout from KidNet. Other children in the Rauma group grouped certain elements together and placed them in a position that they were in the KidNet UI. E.g., buttons and evaluation were grouped together and placed like they are in the actual UI. The layouts made by children in the control group did not have these similarities.

Some of the layouts that the children made had lots of empty space and gaps in them. This will be discussed in the next section where some of the UIs that the children made are shown.

Colors

The assumption that children like bright colors was confirmed. Children in the Rauma group were not afraid to make changes to the gray color scheme that KidNet had. Gray was not chosen at all in the Rauma group and in the control group it was chosen two times. Children in the Rauma group preferred bright colors while the children in the control group preferred pastel colors.

The color choices for the background color were different in two groups. Children at Rauma chose mostly pure white for the background while children in the control group chose more pastel colors. Four participants chose a bright color for the background.

The color choices for navigation were more similar between the two groups. Pale blue and bright turquoise were used the most. The color choices for buttons were also similar. Children chose bright and pastel colors pretty evenly for the buttons.

Some of the color schemes were pretty wild. A bright blue background with bright orange navigation bar and turquoise background with light pink navigation bar. At the other end there were very light color schemes, some of which could be used on a website without any modifications. It has to be kept in mind that choosing colors from relatively small color cards is not a reliable way to choose colors. The color schemes might have been very different if the method for choosing colors had been different.

There was an interesting difference between 4th graders and 6th graders in the control group. Two out of three 4th graders chose colors for every single component, none of the 6th graders or adults did that. Either they did not understand that same color can be used multiple times, they really wanted to use as many colors as possible, or they were too young for this kind of task. One of these UIs will be presented in the next section.

7.3.2 UI Sketches

All the photographs taken during the session and the sketches that were made with Figma based on them, can be found in Appendices 1 and 2. It was difficult to choose the sketches to be presented in this subsection. The sketches brought up in the previous subsection were chosen with a couple more. The sketches that were made by children at Rauma had more similarities than the sketches made by the control group, so only one sketch from Rauma is introduced.

The sketch seen in Figure 30 is the only sketch from Rauma presented in this subsection. The participant had a computer at home but did not use it that much, he thought he had pretty good computer skills. He chose the balls for buttons and was first going to choose the stars for evaluation but switched to emojis "I will continue with this round theme". He chose the robot for support and when he was asked about the additional characters, he took the question mark and said that he would place it as a sign of important information.

The layout was pretty similar to other layouts made in Rauma. There were no big gaps, and the use of KidNet probably had some impact on some of the layouts made in Rauma. He chose bright yellow for navigation and said that the background should be white so that the text can be read easily. He chose green for buttons saying, "they could be green so there will be a little more color".

Figure 31 is a sketch made by a 4th grader. Three fourth graders took part in this study and two of them had similar color choices as discussed in the previous section.

The choices he made were similar to the choices made by the other children, but the layout and the use of colors differed from the 6th graders.

The participant had a computer at home and answered yes when he was asked if he was good with computers. He made choices very quickly and the choices were similar to the choices made by other participants. However, the use of colors differed from the choices made by the majority of participants because he chose a different color for every component. He was told the same thing that was told to the other participants, that we need color at least for the background, navigation and buttons and that the same color can be used in multiple components. Either he really wanted to use many colors or there was something he did not understand.

The use of colors was similar to another 4th grader who also used a different color for every component. Only one of the 4th graders used colors like 6th graders, the only girl in that age group. It is impossible to draw any conclusions because there were so few participants. The results might indicate that a 4th grader is too young to take part in this kind of experiment or that something should have been done differently with 4th graders in order to get more usable results.

Figure 30 – A sketch made by a participant in Rauma.

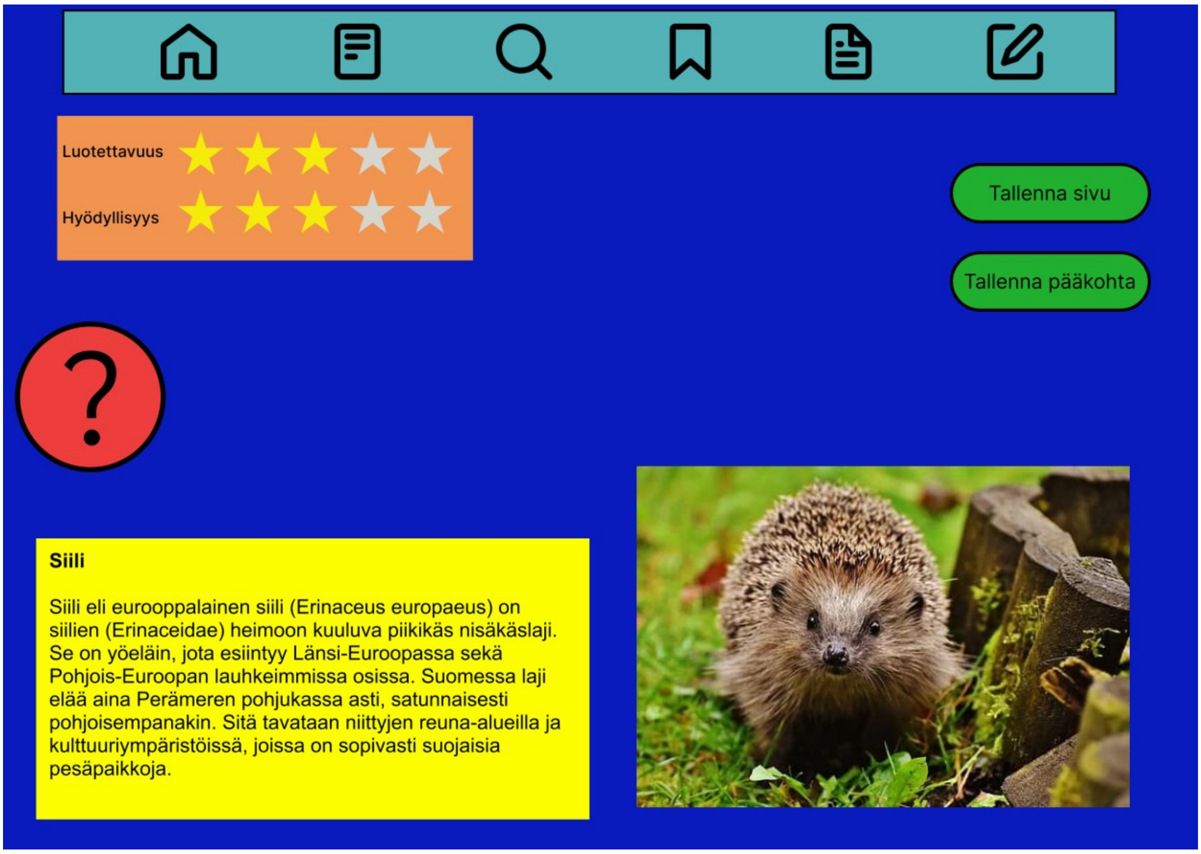

Figure 31 – A sketch made by a 4th grader.

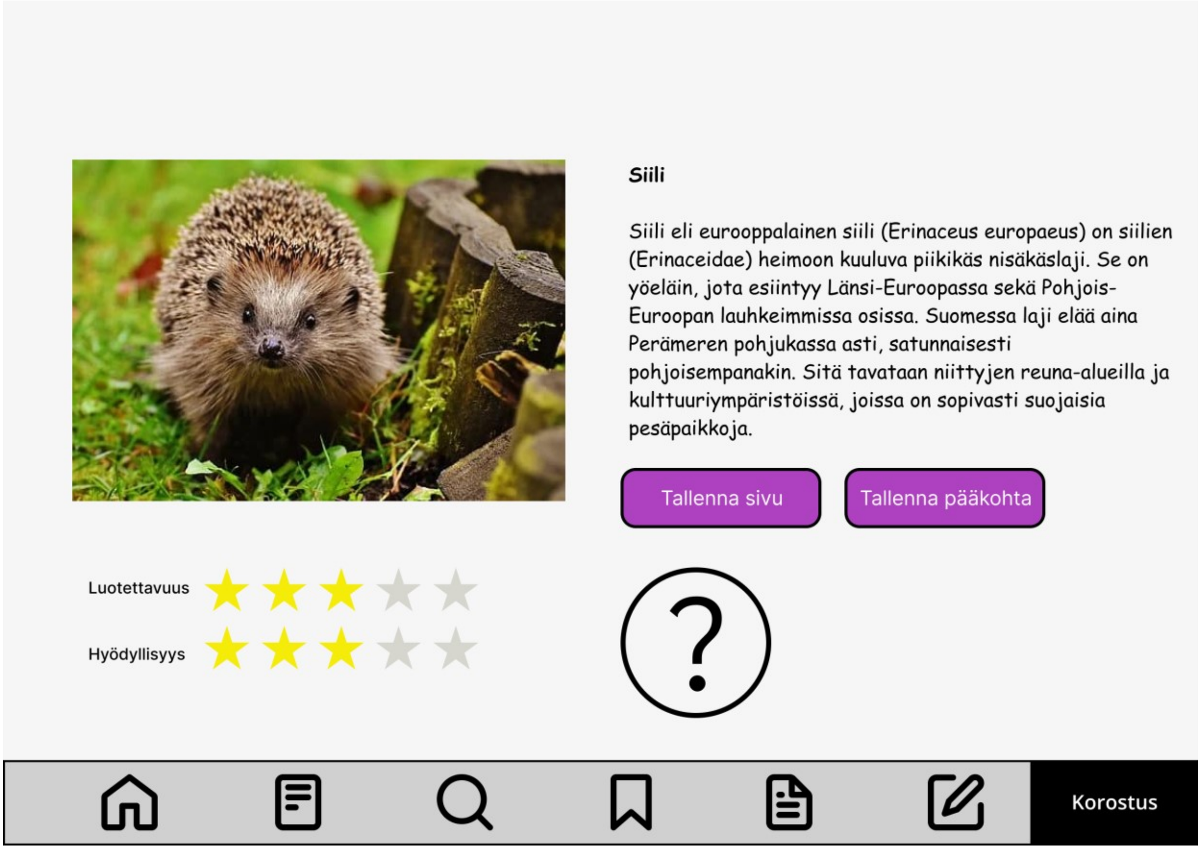

Figure 32 – A sketch made by participant #5 in control group.

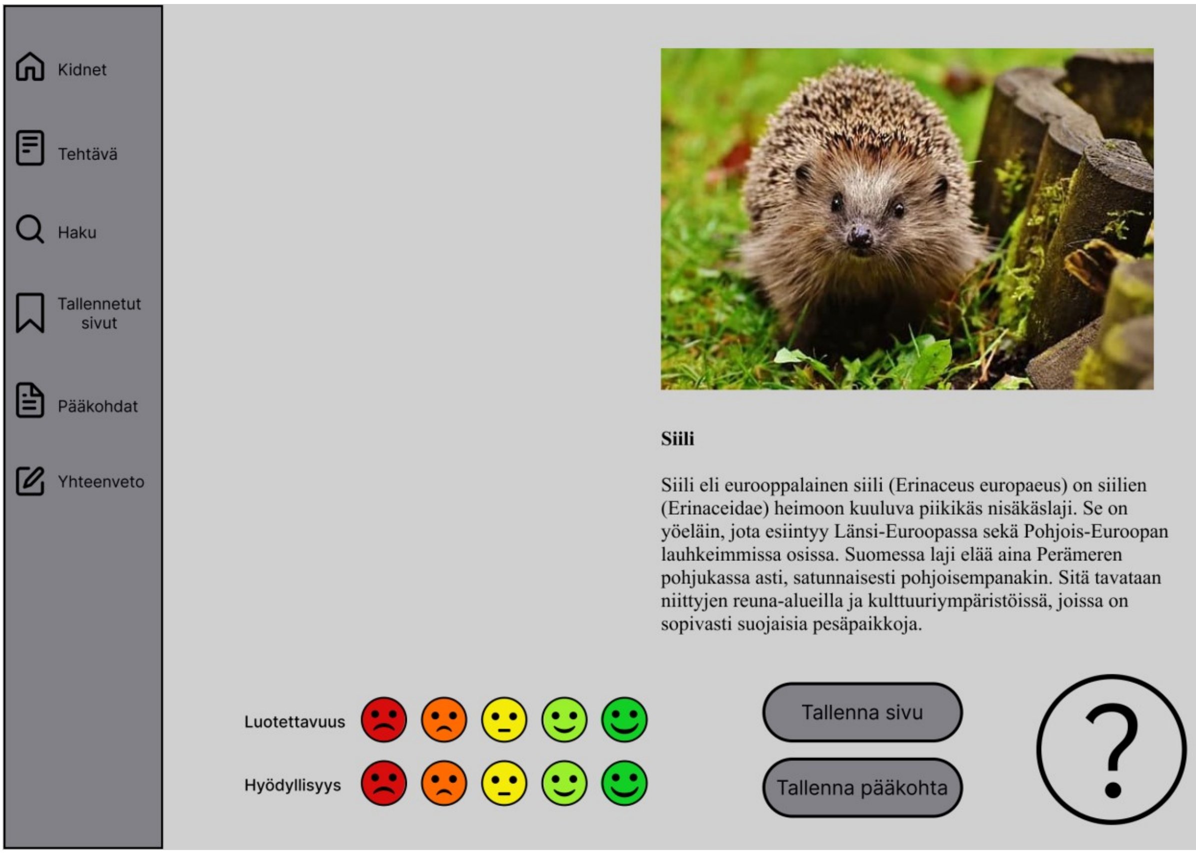

Figure 33 – A sketch made by participant #7 in control group.

The sketch in Figure 32 was one of the many sketches that had the navigation bar at the bottom of the screen. The participant had a computer at home but did not use it much and answered “no” when she was asked if she thought that she was good with computers. She was using a tablet in school.

This participant was the only participant in the control group that chose Comic Sans for the font. The placement of the image and text differed from the others as well although this participant was not the only one who placed the text and image side by side.

Probably the weirdest session was with the participant who made the sketch seen in Figure 33. I had to ask the age of the participant again because I could not believe that I was talking with a 12-year-old. She had her own computer and considered her computer skills to be good. She also told me that they had done some sort of task at school where they had to create their own website.

Her choice for navigation was not a surprise since most of the participants had chosen the same style, she was the first to explain that the navigation with images and text might be more helpful for her. She chose Times for the font because according to her, the navigation and the text looked like they needed a finer font than Comic Sans or Arial. At that point, she mentioned that she is meticulous and easily notices small details like that. The question mark was an obvious choice for the support. She did not want additional characters because she knew that she would be distracted by them, and she would be staring at them instead of reading the text.

I forgot that she was twelve again when she started to create the layout. She took the question mark, placed it in the bottom right corner and told me that it would not get in the way there as much as it would in the top corner. She placed everything at the bottom of the paper and said: “It is easiest to put these down here, so they are not in the way”. I was wondering if she really is only twelve, and she replied: “Yes, I am sure. I am either very meticulous or smart for a 12-year-old.”

She put a lot of thought into the color choices. She made it very clear that pure white hurts her eyes and the background color should be either black or gray so that it would not be distracting. She chose a light gray for the background and darker gray for the navigation bar saying that the navigation bar should be darker gray but not too dark so that black font would still be readable.

Some of the layouts that children made had these weird gaps in layout as mentioned in the previous subsection. Figures 31 and 33 show these pretty well. Layouts made by children at Rauma had less weird gaps and that might indicate that using KidNet influenced the layouts they made. Then again, because the numbers of participants in this study were low, making real conclusions would require more research.

7.4 Interfaces Made by Adults

7.4.1 Statistics

For a more detailed presentation of this data, see Section 7.5.

Navigation

Vertical and horizontal navigation were chosen equally and 9 out of 10 adults chose icons and text as the navigation style. This was surprising since I had an assumption that at least a few of the adults would have chosen the text-only option.

Text

Arial and Times were both chosen equally. One of the participants started to read the text and when I asked her why, she told me that she wanted to know what the text is about before choosing the font. She chose Times because the text was informal. If the text had been different, she would have chosen a different font for it.

Buttons

6 out of 10 chose the button with border-radius of 15 pixels. Two of the adults chose the button with a border-radius of 0 pixels, the option that children did not choose at all.

Rating

5 out of 10 chose emojis for rating the reliability and usefulness of the page. Stars were chosen three times and Likert was chosen twice. This was surprising since I had an assumption that the Likert scale would get chosen more among the adults.

Support character

8 out of 10 chose the question mark for help. The two adults who chose the octopus were among the participants that got exposed to the octopus-poster.

Layout

The layouts made by the adults had more similarities than the layouts made by children. Adults had less white space and weird gaps in their layouts than children's layouts had. This is not a big surprise. As we surf more on the web, we start to build a mental model of what a website looks like and where certain elements are positioned. The placement of the support was a good example of this since the position was almost spot on in many of the designs. This will be discussed more in Subsection 7.5.5.

Colors

The color choices that adults made ranged from "colors annoy me" to a rainbow-colored navigation bar. Only one of the adults chose a bright color for the background. Four of the adults chose pastel green and three of the adults chose pastel turquoise for the background. Five adults chose the turquoise for the navigation bar. Turquoise was chosen most also for the buttons.

It was interesting to see that adults chose pretty similar colors although three of the adults that chose turquoise saw the octopus-poster with turquoise in it. All in all, the color choices made by adults were more similar to each other than the color choices that the children made.

7.4.2 UI Sketches

All the photographs taken during the session and the sketches that were made with Figma based on them, can be found in Appendix 3. Designs made by adults had a lot more similarities than designs made by children had. Therefore, choosing the UI sketches for this subsection was easier than choosing the UI sketches for Subsection 7.3.2. The first sketch introduced presents the average choices made by adults very well. The two other sketches were totally opposite to each other and had very different color choices from the average.

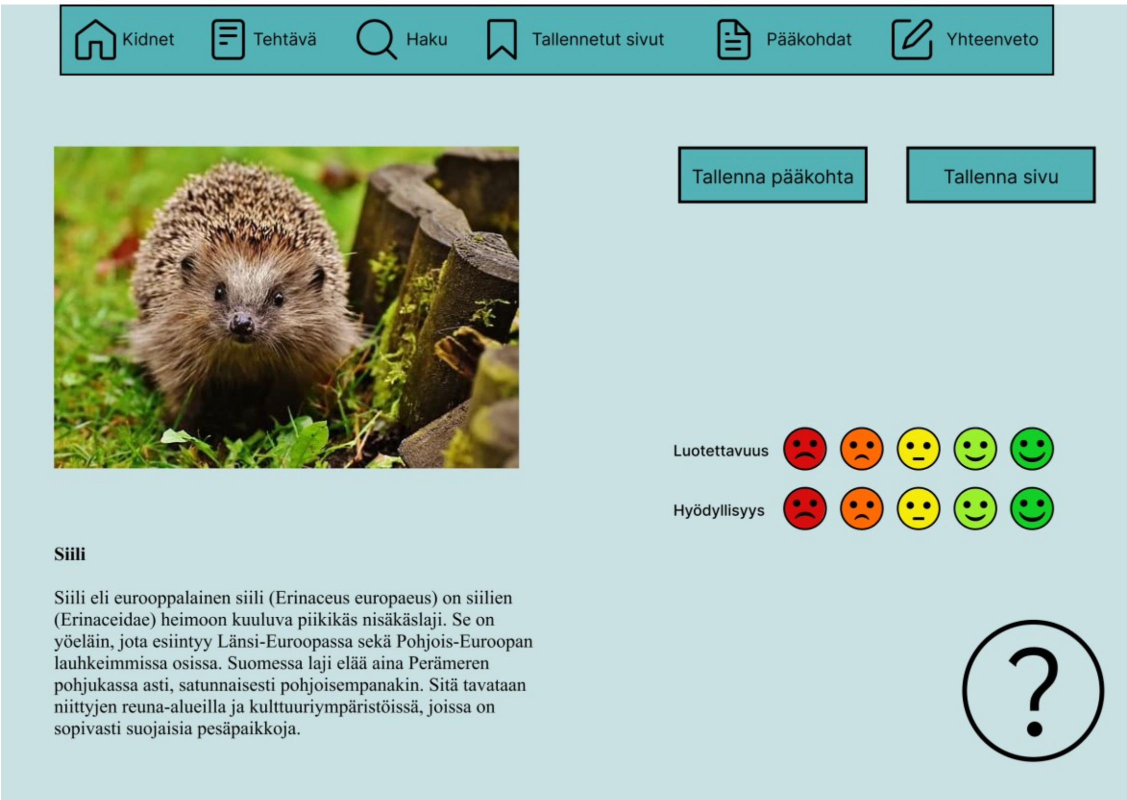

Figure 34 – The color theme of the day

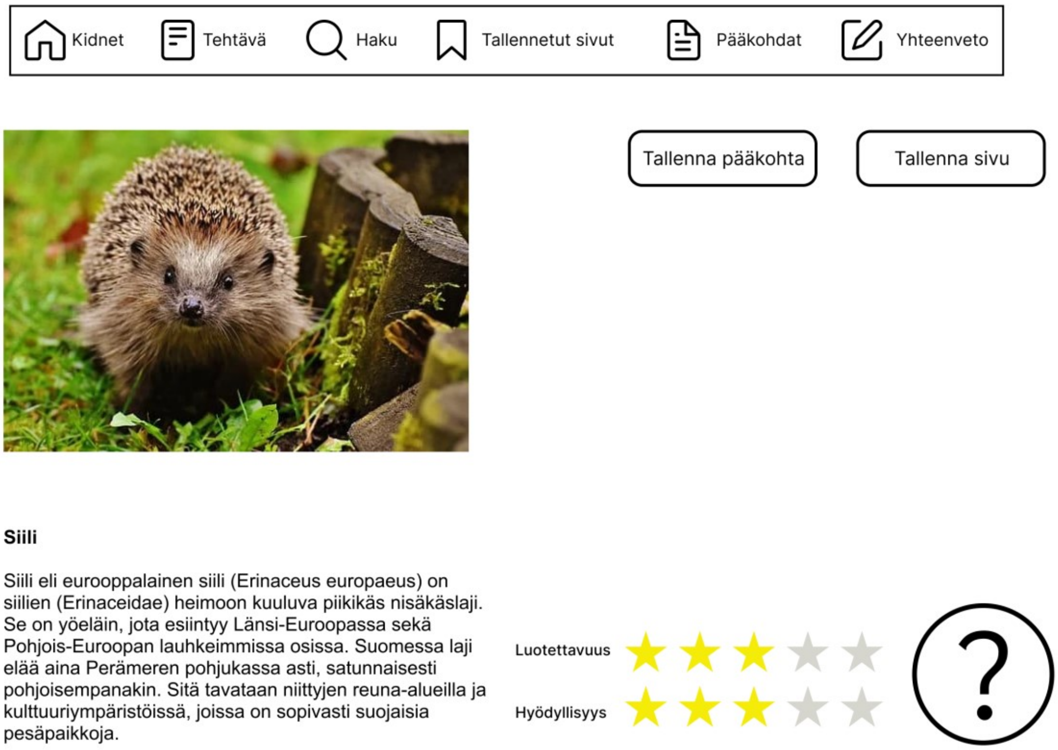

Figure 35 – "Colors annoy me"

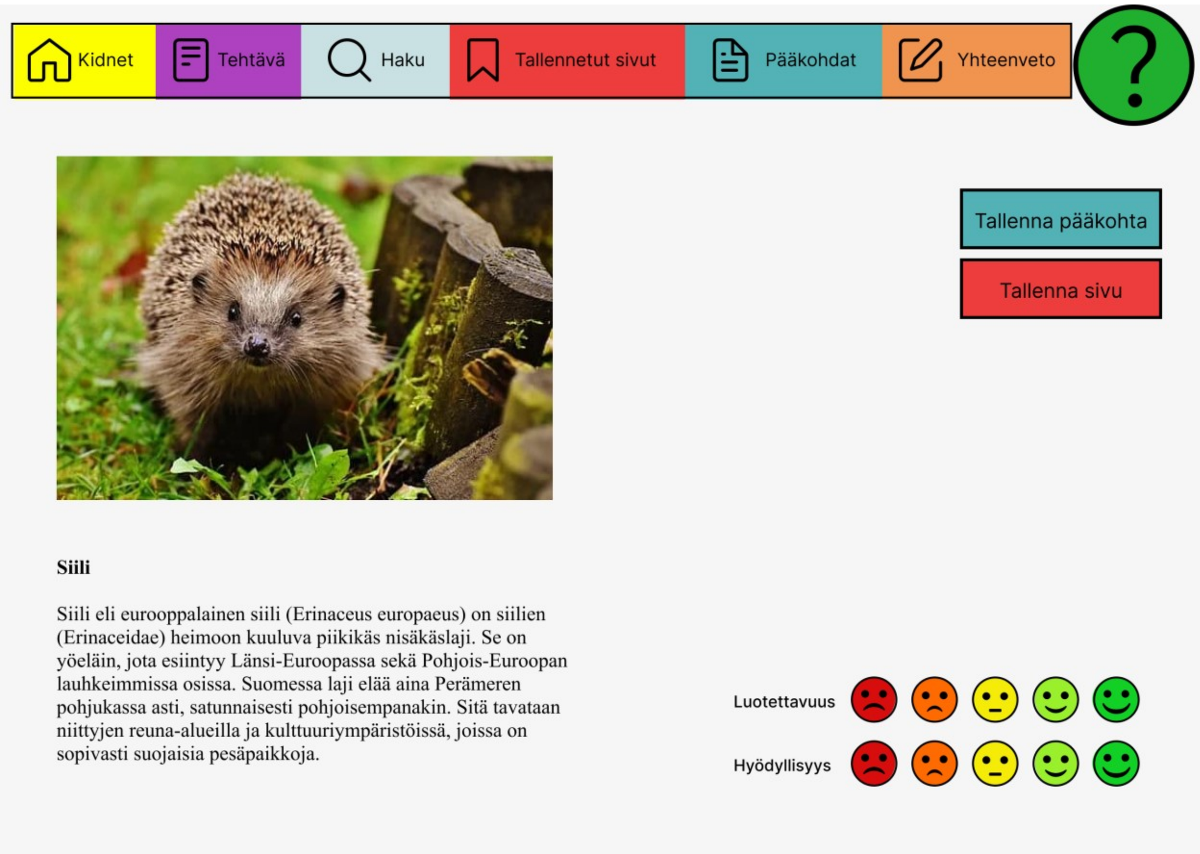

Figure 36 – Color-coded navigation

The sketch in Figure 34 presents the average choices that adults made pretty well. It has icons with text for navigation, Times for the font, emojis for evaluation and the question mark for support placed in the bottom right corner. The color choices are similar to the color choices made by the majority of adults, but it is impossible to know how much the octopus-poster influenced the color choices this participant made.

The sketch in Figure 35 was made by the first adult participant that came to Educarium. His choices for the components were similar to the choices made by other adults and the layout he made could be used without major changes. He was also exposed to the infamous octopus-poster but made it very clear that he does not like colors on websites. He said that colors are annoying and did not want to add any color. Other than that, his choices were in line with choices made by the other adults.

On the other end was the sketch in Figure 36. The choices and the layout made by this participant were similar to other adults, but she was the only one using so many colors. She had an idea that the navigation could be color-coded and that the colors of the buttons would be the same as the pages that the user will find the content related to the button, saved bookmarks or main points in this case. For the background color she chose a light gray because “pure white can make eyes hurt”.

The UIs made by the adults had a lot more similarities than the UIs made by children had. It is safe to assume that this is due to adults having more developed mental models than children have. There were many designs that could be used on KidNet with slight or no modifications. Some of the layouts were similar to the layout KidNet has right now although none of the adult participants have seen KidNet and most of the color combinations were usable.

It is important to remember that all the adults who participated had decent computer skills. If this same experiment were done with adults who have poor computer skills, the designs would probably have a lot more diversity. The generation that grew up without computers has very different skill levels than the generation that grew up using computers. E.g., my mother is constantly asking me to help her with her computer. She knows how to pay her bills and how to use YouTube and Facebook but that’s about it. Even though her computer skills might seem limited to me, she actually has better computer skills than many of her friends, and she often helps them with electronic services. If the participants had been in that age group, there might not be that much of a difference between children and adults because the mental models of a website would probably be more similar.

7.5 Statistical Summary

The question about decorations was not analyzed thoroughly. Adults were not asked about the decorations so there would’ve been only children’s answers. A short mention about this subject: some of the children said that additional characters or decorations would be distracting, few of the children would have liked them and some of the children said no to additional characters.

7.5.1 Navigation

Participants were quite unanimous about the style of the navigation as can be seen in Table 4. The style with icons and text was the most popular style. The results were surprising since there was no difference between the control group and Rauma group and no difference between children and adults.

This alternative for navigation is good for usability. The icons on the navigation let the user scan the navigation bar faster than text only and the text helps new users or returning users to understand what the icon means. KidNet is not something that the user would use on a daily basis so this would make it easier and faster for users to return to KidNet.

Table 4 – Style of the navigation bar

Style	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Icons	4 (29%)	2 (29%)	2 (29%)	1 (10%)	5 (21%)
Icons and text	10 (71%)	5 (71%)	5 (71%)	9 (90%)	19 (79%)
Text	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Balls	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	14 (100%)	7 (100%)	7 (100%)	10 (100%)	24 (100%)

The direction of the navigation was distributed evenly among adult participants and close enough in the control group as seen on Table 5.

I had an assumption that children who had used KidNet before would be more likely to make choices that resemble KidNet's UI, it turned out to be wrong. The number of participants was small but still the choices made by the Rauma group and the control group were drastically different. Children in Rauma were favoring the vertical direction.

KidNet uses media queries to detect the size of the user's screen. The horizontal navigation bar is displayed if the user's screen is above 800 pixels wide. The vertical navigation bar might be better for KidNet since it is implemented in the code already and is used when the screen is narrower.

Table 5 – Direction of the navigation bar

Direction	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Horizontal	6 (43%)	2 (29%)	4 (57%)	5 (50%)	11 (46%)
Vertical	8 (57%)	5 (71%)	3 (43%)	5 (50%)	13 (54%)
Total	14	7	7	10	24

Table 6 – Placement of the navigation bar

Navigation's position	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Left	7 (50%)	5 (71%)	2 (29%)	5 (50%)	12 (50%)
Right	1 (7%)	0 (0%)	1 (14%)	0 (0%)	1 (4%)
Top	3 (21%)	2 (29%)	1 (14%)	5 (50%)	8 (33%)
Bottom	3 (21%)	0 (0%)	3 (49%)	0 (0%)	3 (13%)
Total	14 (100%)	7 (100%)	7 (100%)	10 (100%)	24 (100%)

The participants placed the vertical navigation on the left side of the screen. There was only one exception to this so almost all participants agreed that if the navigation bar is vertical, it should be placed on the left side of the screen as seen in Table 6.

The placement of the horizontal navigation bar had pretty interesting results as can be seen in Table 6. While all the adults and Rauma children placed the navigation bar at the top of the screen, the majority of the control group that chose the horizontal navigation bar, placed the navigation bar at the bottom of the screen.

I was wondering why children in Turku area place the horizontal navigation bar at the bottom of the screen at my friend's place after a session. Her daughter had placed the navigation bar at the bottom of the screen like most of the other children in the control group. My friend asked me "Did you know that children in primary school in Turku use tablets? They get laptops at the 7th grade when they go to secondary school?" Children at Rauma had laptops in the classroom, and this explains why the results were so different between the two groups.

It looks like children who are mostly using tablets might have a different mental model about navigation's location than children who are mostly using laptops. The only child in the control group that placed horizontal navigation in the top of the page has a father who works with computers.

There were differences between groups with the direction and placement of the navigation bar. Children at Rauma preferred vertical navigation placed on the left side of the screen, control group preferred horizontal navigation at the bottom of the screen and adults were equally divided between horizontal navigation at the top of the screen and vertical navigation on the left side of the screen.

Based on the results the navigation should have icons and text and it should be placed vertically on the left side of the screen. This would be a very good and usable choice. The icons let users scan fast as discussed above and the placement follows Fitt's law, where the edge of the page is the fastest for the user to hit the target.

7.5.2 Font

Table 7 – Fonts

Font	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Arial	2 (14%)	1 (14%)	1 (14%)	5 (50%)	7 (29%)
Comic	6 (43%)	5 (71%)	1 (14%)	0 (0%)	6 (25%)
Times	6 (43%)	1 (14%)	5 (71%)	5 (50%)	11 (46%)
Total	14 (100%)	7 (100%)	7 (100%)	10 (100%)	24 (100%)

Table 7 shows the font choices that the participants made. Children at Rauma preferred Comic Sans but the children in the control group preferred Times.

I have no theory about what could explain this difference. Maybe schools in Rauma use Comic Sans in classrooms more than schools in Turku? Adults chose Arial and Times evenly. One of the adults wanted to read the text before making the decision, she said that that content defines the font. Because the content was informational, she chose Times.

Based on the result, the font should be changed into Times but since Sans fonts have better readability and are better for websites, the font will stay the same.

7.5.3 Buttons

Table 8 shows the button choices that the participants made. Children at Rauma and the control group made pretty similar choices. Children seemed to like the rounder options more. Adults preferred the button with soft corners. The square was not chosen at all, and the “sharp” button was chosen only by adults.

Table 8 – Buttons

Buttons	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Border radius 0	0 (0%)	0 (0%)	0 (0%)	2 (20%)	2 (8%)
Border radius 15	4 (29%)	2 (29%)	2 (29%)	6 (60%)	10 (42%)
Border radius 50	8 (57%)	3 (43%)	5 (71%)	2 (20%)	10 (42%)
Square	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ball	2 (14%)	2 (29%)	0 (0%)	0 (0%)	2 (8%)
Total	14 (100%)	7 (100%)	7 (100%)	10 (100%)	24 (100%)

Based on the results, a UI for children should have the button with border-radius of 50px and the UI for adults should have the button with border-radius of 15px. UI for both could use either of two styles or maybe something in between those two values.

7.5.4 Evaluation

Table 9 shows the evaluation choices that the participants made. Children at Rauma liked stars and emojis evenly, maybe because the emojis were used in KidNet. If they were using Neurone before, the stars would be familiar to them as well. The control group preferred stars. The child in the control group that chose the school grading said that if children are using this website in schools, then the grade should be used for evaluation. He was one of the children that stated that he did not like the Likert option.

Table 9 – Evaluation

Evaluation	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Emojis	4 (29%)	3 (43%)	1 (14%)	5 (50%)	9 (38%)
Stars	8 (57%)	3 (43%)	5 (71%)	3 (30%)	11 (46%)
Likert	1 (7%)	1 (14%)	0 (0%)	2 (20%)	3 (13%)
Grade	1 (7%)	0 (0%)	1 (14%)	0 (0%)	1 (4%)
Total	14 (100%)	7 (100%)	7 (100%)	10 (100%)	24 (100%)

Adults preferred emojis. This was surprising since I had an assumption that adults would choose Likert more since it is more familiar to them.

Based on the results the evaluation should use stars. However, because there was no significant difference between emojis and stars and because emojis are Likert's scale in a disguise that might be more useful in analyzing the data, the emojis are staying.

7.5.5 Support

Table 10 shows the support character choices that the participants made. Children at Rauma either really liked the Finsci octopus or they were so used to it that they did not want to change it. The control group's favorite was the question mark as assumed. One of the control groups' children saw a poster with an octopus and that might have had an impact on the choice he made.

Table 10 – Support character

Support	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Question mark	5 (36%)	0 (0%)	5 (71%)	8 (80%)	13 (54%)
Octopus	7 (50%)	5 (71%)	2 (29%)	2 (20%)	9 (38%)
Girl	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Robot	2 (14%)	2 (29%)	0 (0%)	0 (0%)	2 (8%)
Total	14 (100%)	7 (100%)	7 (100%)	10 (100%)	24 (100%)

Adults chose the question mark as assumed. The two adults who chose the octopus saw a poster with an octopus on the wall of the room they had the session in. Those adults were among the first testers at Educarium, and the poster was taken down after realizing that it might affect the choices participants male.

The research made with KidNet had a workbook with the octopus as a character and the children were taught that if they do not know what to do during the assignment, they should click the octopus for help.

Based on the data, children's UI could remain the same. However, the use of the octopus should be talked about because it violates the usability heuristics rule number four: consistency and standards introduced in Subsection 2.2.2. It might also be better to teach children to search for a question mark so that when they do not know what to do on a real web page, they would know that they should be searching for a question mark. If the research continues as it is, and the same material is used, the children's UI could still use the octopus as a support figure because the children at Rauma seemed to like it and it might bring something fun to the learning environment.

A UI for adults or children and adults should definitely use the question mark for support.

Table 11 – The placement of the support

Help position	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Top right	4 (29%)	3 (43%)	1 (14%)	5 (50%)	9 (38%)
Bottom right	1 (7%)	0 (0%)	1 (14%)	4 (40%)	5 (21%)
Other	7 (50%)	3 (43%)	4 (57%)	0 (0%)	7 (29%)
Top left	1 (7%)	0 (0%)	1 (14%)	0 (0%)	1 (4%)
Bottom left	1 (7%)	1 (14%)	0 (0%)	1 (10%)	2 (8%)
Total	14 (100%)	7 (100%)	7 (100%)	10 (100%)	24 (100%)

I could have said that support can be placed on the navigation bar during the sessions. But since this was my first-time doing research, I was worried that it might be leading the participants too much and ruin the reliability of the results. The participants placed the support without additional guidance. The participants that asked if the support can be placed on the navigation bar were answered 'yes'.

The placement of the support was added to the analysis after noticing that many of the adults had placed the support in the same place. The data was gathered to Table 11 which shows the placement of the support. The difference between adults and children was massive.

Children at Rauma were used to having the support in the top right corner in the navigation bar. Only two of the children placed the support inside the navigation bar, one to the top right in a horizontal navigation and the other to the bottom left on the vertical navigation. The top right position was the most popular among the group but that might have been because they had been using KidNet.

The adults placed the support mostly in the top right corner, or the bottom right corner and the placements were almost spot on even on the paper. The adult, who placed the support on the bottom left, had a vertical navigation on the left side and placed the support inside the navigation bar.

The children in the control group had the most variations in the placement of the support. This might again have something to do with children's developing mental models. Children have not been surfing the net so much that they would have a clear mental model of where the help should be. While the adults have more experience and based on the numbers, websites usually place the support in certain places. Changing the position of support is unnecessary based on the results.

7.5.6 Colors

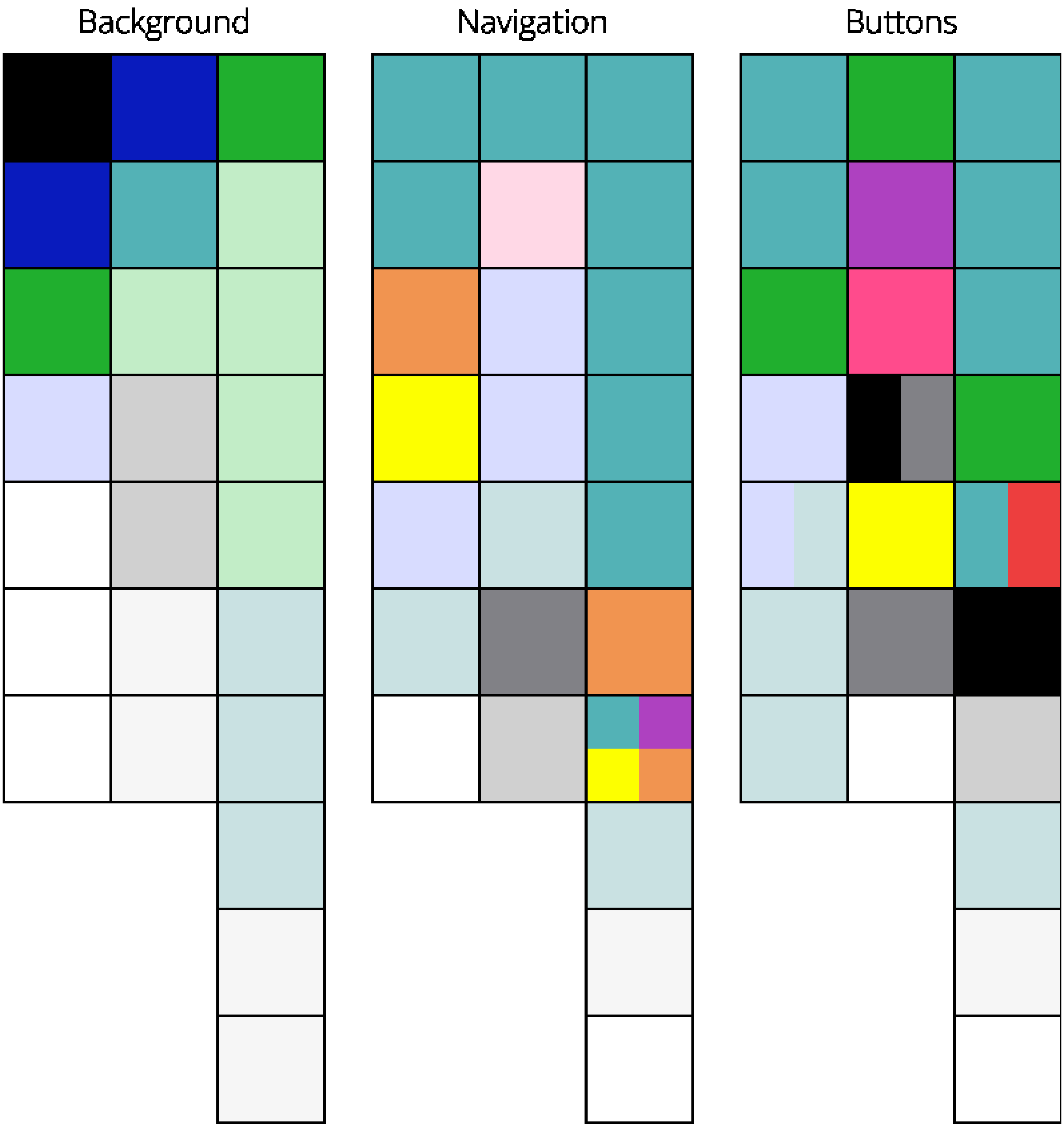

Figure 37 – Colors used in the sketches.

The color implementation had a couple of issues and therefore this section is not as reliable as the other sections. Probably the biggest issue was that it is difficult to picture what a small color card would look like when used on a big surface, e.g., as a background color. Another issue was that the colors looked different when printed out. All the original pictures and UI sketches can be found in appendices.

Figure 37 presents the colors used in the sketches. The presentation has three columns for each component. The first column presents color choices made by children at Rauma, the second column children in the control group and the last column adults. This visualizes that choices made by children have more variance which made analyzing the color choices more difficult.

The color choices were grouped so that analyzing them would be easier. Pastel colors formed one group, bright colors formed another group and black, white and gray each had their own groups.

Table 12 – Background colors

Colors Background	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Black	1 (7%)	1 (14%)	0 (0%)	0 (0%)	1 (4%)
White	5 (36%)	3 (43%)	2 (29%)	2 (20%)	7 (29%)
Gray	2 (14%)	0 (0%)	2 (29%)	0 (0%)	2 (8%)
Bright	4 (29%)	2 (29%)	2 (29%)	1 (10%)	5 (21%)
Pastels	2 (14%)	1 (14%)	1 (14%)	7 (70%)	9 (38%)
Total	14 (100%)	7 (100%)	7 (100%)	10 (100%)	24 (100%)

Colors chosen for the background can be seen in Table 12. Light colors were chosen the most for the background. White was chosen 7 times and pastels were chosen 9 times. Bright colors for the background were more popular among children than adults. At least two participants brought up the fact that pure white can hurt eyes. They wanted the background to be light but not pure white.

Table 13 – Navigation colors

Colors Navigation	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Black	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
White	1 (7%)	1 (14%)	0 (0%)	2 (20%)	3 (13%)
Gray	2 (14%)	0 (0%)	2 (29%)	0 (0%)	2 (8%)
Bright	5 (36%)	4 (57%)	1 (14%)	7 (70%)	12 (50%)
Pastels	6 (43%)	2 (29%)	4 (57%)	1 (10%)	7 (29%)
Total	14 (100%)	7 (100%)	7 (100%)	10 (100%)	24 (100%)

Colors chosen for navigation can be seen in Table 13. For some reason the children in Rauma used bright colors more often on the navigation and the children in control group used pastel colors more. It was surprising that adults used bright colors as much as children did. One of the adults did not want to use colors at all because “colors annoy me”.

Turquoise was the most popular of the bright colors for navigation, it was chosen seven times. Other bright colors chosen for navigation were orange and yellow. One of the adults made a very colorful navigation bar that had lots of bright colors. The idea she had was that each page could have a color of its own and the buttons would be connected to the menu by the color.

Pastel blue (looked more like pastel lilac when printed) was the most popular of the pastel colors for navigation, it was chosen five times. Other pastel colors chosen were pastel turquoise and pink.

Table 14 – Button colors

Colors Buttons	Children (all)	Children (Rauma)	Children (Control)	Adults	Combined
Black	1 (7%)	0 (0%)	1 (14%)	1 (10%)	2 (8%)
White	1 (7%)	0 (0%)	1 (14%)	2 (20%)	3 (13%)
Gray	1 (7%)	0 (0%)	1 (14%)	1 (10%)	2 (8%)
Bright	7 (50%)	3 (43%)	4 (57%)	5 (50%)	12 (50%)
Pastels	4 (29%)	4 (57%)	0 (0%)	1 (10%)	5 (21%)
Total	14 (100%)	7 (100%)	7 (100%)	10 (100%)	24 (100%)

Colors chosen for buttons can be seen in Table 14. For some reason children at Rauma preferred pastels and bright colors but the control group and adults preferred clearly bright colors and used pastels rarely or not at all. Pastel turquoise was the favorite choice of children at Rauma, it was chosen three times. Children in the control group did not have a clear favorite for buttons. Adults chose turquoise for buttons three times although all the adults who chose turquoise had been exposed to the octopus-poster. All the other colors chosen by adults were chosen only once.

Based on the results a bright color should be used for the navigation bar and buttons and off-white or pastel should be used for the background. Although there were three participants that were exposed to turquoise, it was still chosen the most. However, using turquoise should be considered since there is a risk that it will be too bright and distract the users.

8 Implications to KidNet User Interface

This chapter introduces the UI that KidNet has at the moment and what kind of updates should be made based on the choices that participants made during the sessions. The original UI section introduces some of the UI elements KidNet has and reasons behind the choices that were made. The Update suggestions section presents different UI sketches that visualize each participant groups' choices based on statistics. The last sketch is my own interpretation created with the statistics and usability in mind.

8.1 Original UI

Figure 38 shows the UI of the page view-page KidNet has currently. The children at Rauma were using KidNet before the sessions and this is the page view page that they were used to although small changes were made after their test sessions. During their test sessions the user's name and the assignments name were displayed on the navigation bar, that information was later hidden under the user menu.

Figure 38 – KidNet's page view-page

8.1.1 Navigation

KidNet has a horizontal navigation bar placed on the top of the page. KidNet uses media queries and if the user has a smaller screen or the width of the window is less than 1150px, the navigation bar will switch from horizontal to vertical, if the width of the window is less than 860px, the navigation bar will get hidden under a burger menu to add more space for the content.

The navigation bar has a logo, tabs for different pages, octopus-icon for support and the user menu. Tabs are shown only when the user has an active task because the user does not have to see them right after log-in when there are no tasks chosen. Octopus-icon triggers a pop-up that has tutorial images related to the operations of the current page. Users name, the current task and button for logout are hidden in the user menu which is a drop-down menu that opens when hovered.

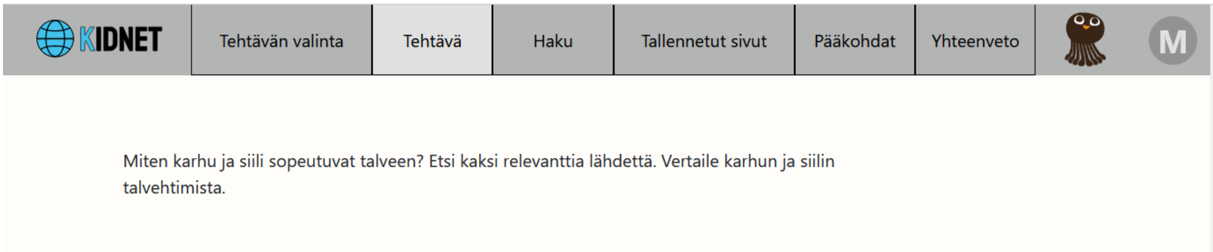

Figure 39 – Navigation bar

The navigation bar in Figure 39 follows Fitt's law which was introduced in Section 4.5. The tabs are big, and the navigation bar is on the edge of the screen so that the users can hit the tabs faster. Tabs change color when hovered, so the user can easily see that the mouse is on the target. The active page has a different color so that the user can easily see which page is active. NN Groups UX reports' guideline "Design tab-navigation to look like tabs: underlining is not enough." was followed in the design of navigation [30].

8.1.2 Colors

I decided to use a more neutral color palette because we are programmed to look at the bright colors (discussed in Chapter 4) and was afraid that using lots of bright colors would be distracting for the users. The buttons have a blue color so that they "pop" from the other content and guide users' eyes towards the actions on the page.

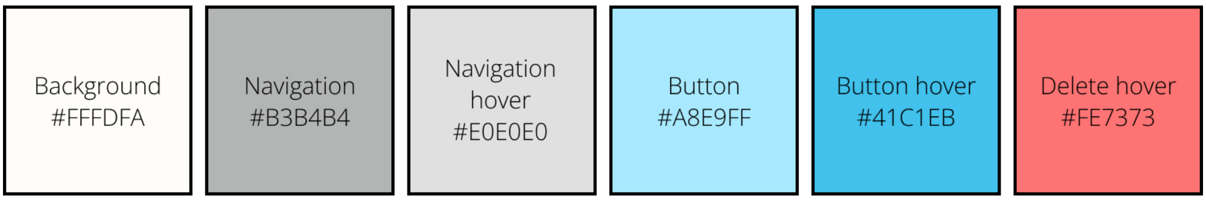

Figure 40 – Colors used in KidNet.

Figure 40 shows KidNet's current color palette. Somewhere along the way doing graphic design and courses at the University of Turku, I learned that pure white is not a good color for websites background because pure white can make users eyes hurt. This was proven during the sessions as well. One participant told me that white background hurts her eyes and another one chose a very light gray for the background saying that she knows that pure white hurt eyes. The background color chosen for KidNet was this off-white color that would look like white but is little easier for the users' eyes. Gray was chosen for navigation because it is neutral and would not distract the user. Red is commonly used for deleting, so it was used for that purpose as hover effect for delete-buttons. Red was not used for the delete-button because that would probably have made the user look at the delete-button instead of focusing on the goal that the user had in mind when coming to the page.

I wanted to add a little color to the design and decided to make the buttons colorful. Brighter color would also guide the user's eyes towards the buttons or the functions that the page has. I googled "the best colors for learning" and found a post about colors that are supposed to boost active learning in classrooms [58].

> The color blue has proved to have a calming effect on the heart rate and respiratory system of students. It encourages a sense of well-being, making it ideal for learning situations that are intensely challenging and cognitively taxing. [58]

Blue was chosen because thought of the situation where researchers come to the classroom and introduce a new learning environment might be exciting enough and the students might benefit from the calming blue in the UI. The post had an image of a classroom with blue chairs, so a color picker was used to get that same blue that was used in the classroom.

8.1.3 Fonts

KidNet has two fonts (see Figure 41): Segoe UI for the interface and content and Roboto Mono for the assignment code. Segoe is a sans-serif font which has good readability, and it works well on websites. The downside of Segoe is that it did not have enough difference between zeros and O's and when the user had to type a code in order to begin an assignment, it was nearly impossible to tell if the character was a zero or "O". This could cause frustration in children if they accidentally typed O instead of zero, this issue was easily fixed by using a font that has a different zero and "O" to display the assignment codes. Roboto Mono was chosen for this purpose. Roboto Mono is mainly a sans-serif font but uses serifs in letters like "i", "l" and "I" so that they would be easier to tell apart from each other. The zero has a line across it so that it will look different from "O".

Segoe UI:
Lorem ipsum 0123

Roboto Mono:
Lorem ipsum 0123

Figure 41 – Fonts

8.1.4 Icons

Icons (see Figure 42) were chosen so that they would “match between system and real world”, they are also based on common standards [13]. Search-button has a magnifying glass and delete-button has a trashcan because they are common standards for searching and deleting.

The emoji rating (see Figure 43) that was used for evaluating the usefulness and reliability of the page was based on standards. Read and MacFarlane’s article “Using the Fun Toolkit and Other Survey Methods to Gather Opinions in Child Computer Interaction” introduced “Smileyometer” which confirmed that this would be a good way to gather children’s opinions [59]. Traffic light kind of colors were used as an effect for hovering the emojis.

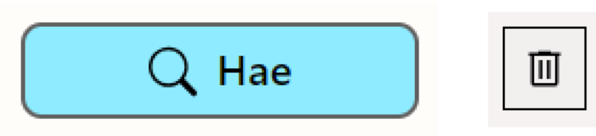

Figure 42 – Icons used in KidNet.

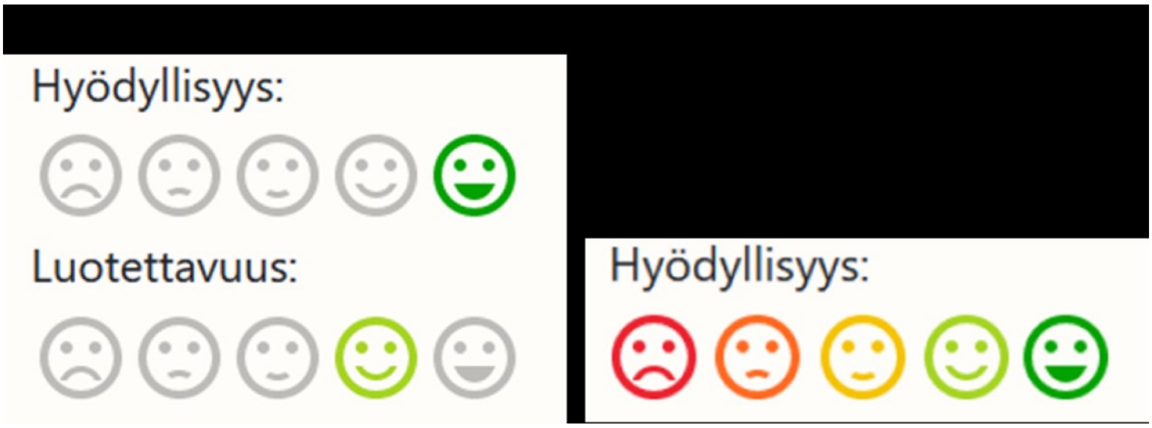

Figure 43 – Emoji rating

8.1.5 Actions

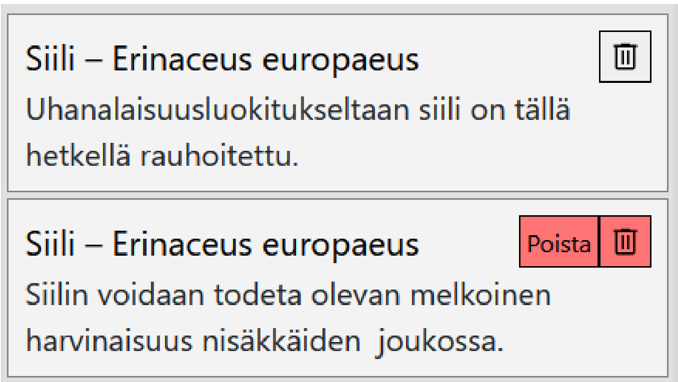

Figure 44 – Deleting snippets.

Error prevention is one of the 10 usability heuristics discussed in Subsection 2.2.2. Deleting snippets was designed in a way that should reduce errors but does not frustrate the user with confirmation pop-ups that users would have to click. Figure 44 shows how the deletion of snippets has been implemented. The user has to hover the trash can icon with a mouse, a button with "Delete" appears. The user then moves the mouse to the left and clicks the delete button in order to delete the snippet.

This design should reduce the number of accidental deletions of snippets without adding distracting pop-ups and additional clicks. The steering law (introduced in Section 4.5.) and children's weaker hand-eye coordination (discussed in Subsection 3.1.2.) and have been considered when deciding the size of the button.

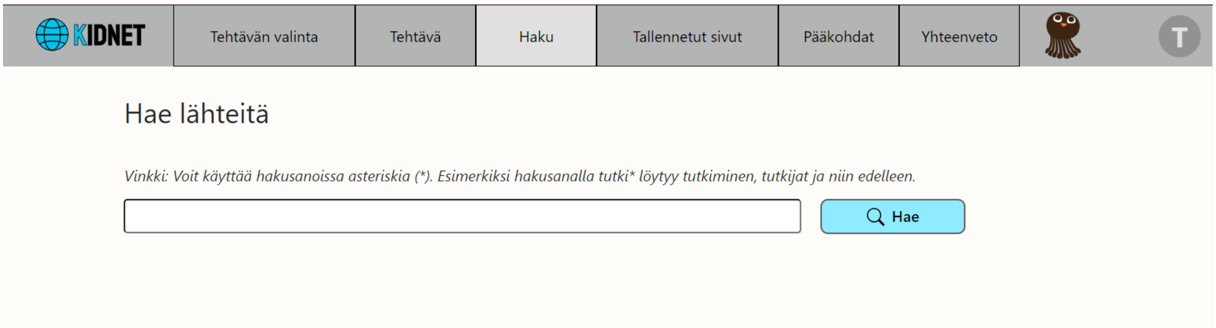

Figure 45 – Search

Figure 45 is a screenshot from KidNet's search-page. Two design guidelines for the design of search function were followed: "Kids tend to formulate full-sentence queries and do not get the concept of keywords for search." and "Make sure your search box is big enough, both in terms of (1) number of characters displayed, and (2) number of characters allowed for the search query." [30]. The reasons behind these guidelines have been true in KidNet's case as well. Preliminary results from the research done during the past year has confirmed that children are using full-sentence queries.

One important action is autosave. Because of our limited attention and memory (discussed in Section 4.3.), we tend to forget the final steps. All inputs coming from the user are automatically saved. This is very important especially in the synthesis page where the user writes the answer to the assignment.

8.2 Update Suggestions for KidNet's UI

The components and colors are based on the statistics introduced in Section 7.5, but the layouts are based on the patterns found in the sketches made by different participant groups. There were cases where the statistics clearly indicated the favorite components for certain groups. In some cases, the choices were distributed evenly, and I had to decide which component to use. It should be noted that the UI sketches presented in this section are not based on any scientific methods. Also, the layouts can be seen in the appendices.

8.2.1 Children's UIs

Rauma group

Figure 46 presents the UI sketch that is based on the statistics of the choices made by the Rauma group. Creating one sketch from all the Rauma sketches was quite easy because the component choices and the layouts were pretty similar. The statistics pointed clearly towards the component and color choices seen in the image, the only exception was evaluation where choices were evenly divided between emojis and stars. Layouts often had the image and text placed close to navigation and buttons and evaluation placed on the other side of the screen. Many layouts had similarities to the layout used in KidNet.

Figure 46 – Children at Rauma

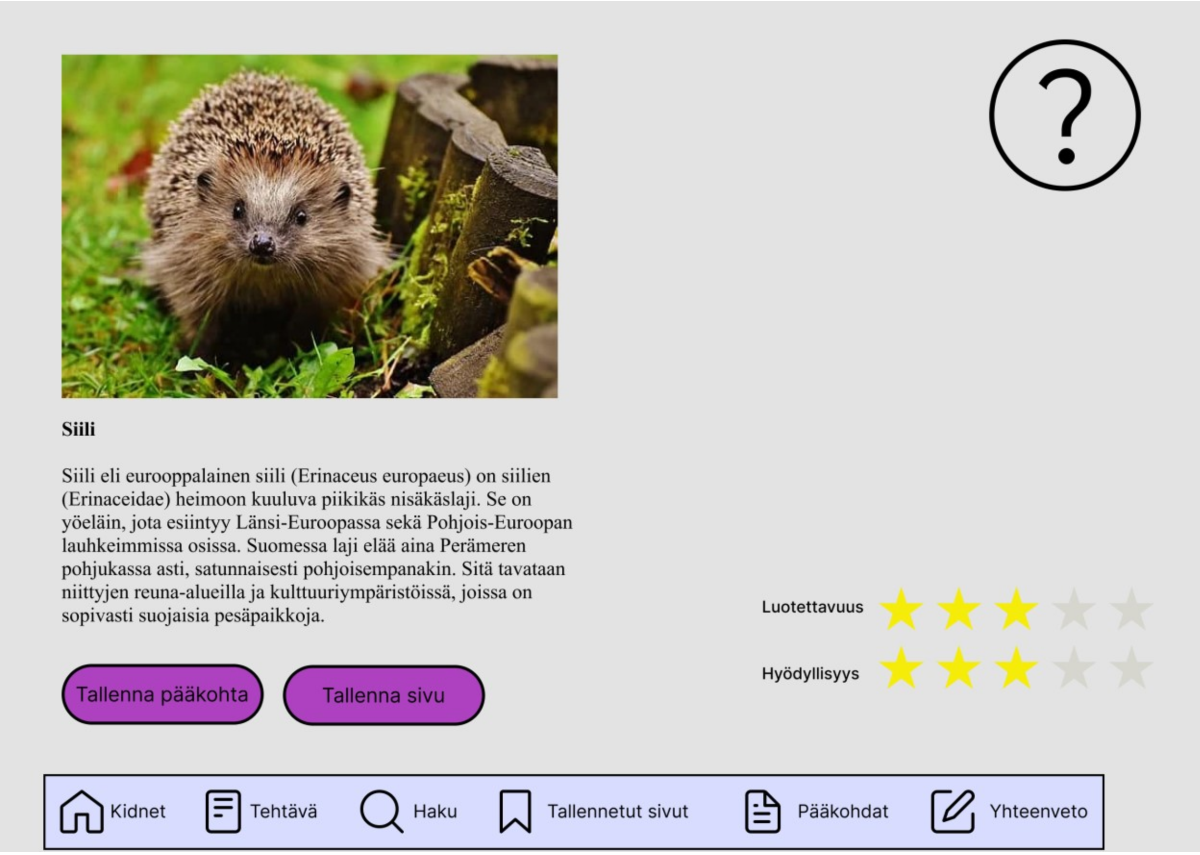

Figure 47 – Control group

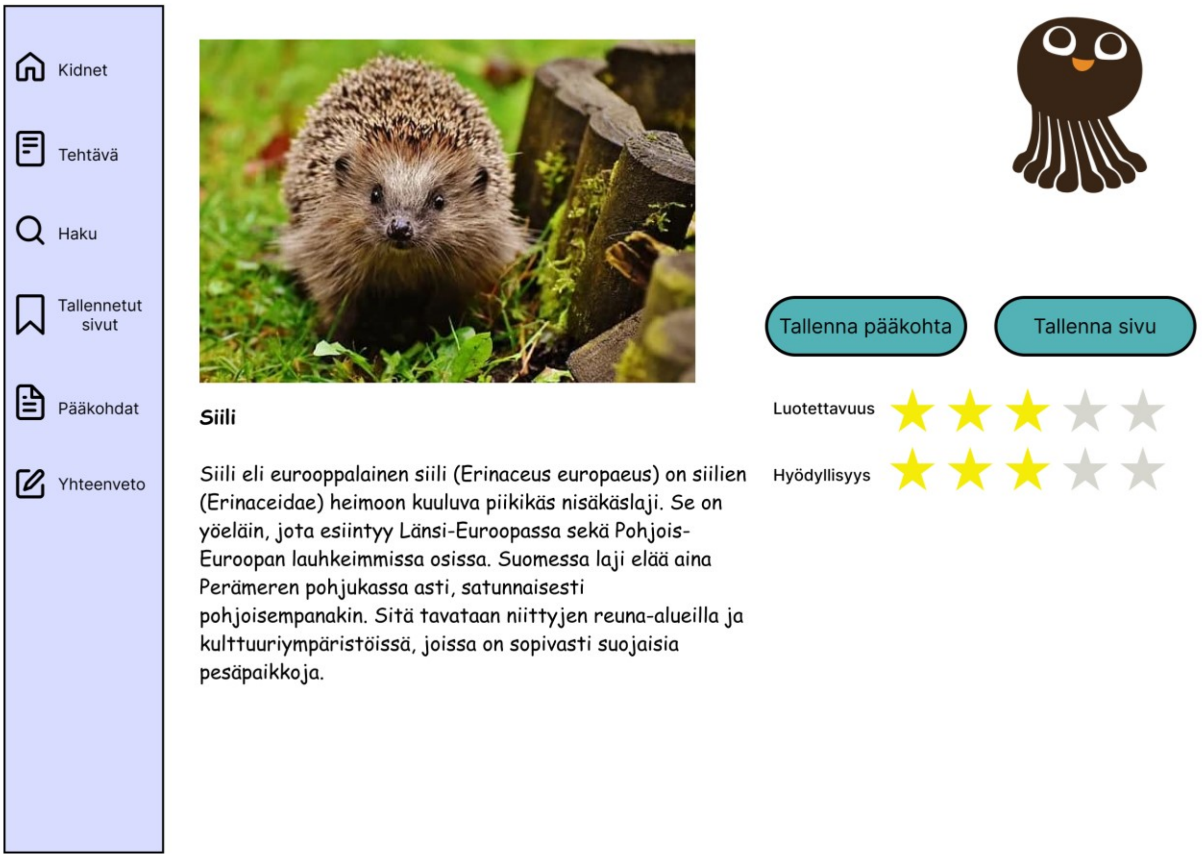

Figure 48 – Children combined.

Control group

The sketch in Figure 47 is based on the statistics of the choices made by the control group. Children in the control group made very different choices compared with children at Rauma. The statistics pointed clearly towards the favorite components used by this group, but color and layout choices had much more variations. Colors and layout are therefore based more on my interpretation of the sketches than actual statistics. The difference between the sketches made based on data from Rauma group and control group is enormous. The component choices were different and the influence KidNet had in Rauma group was obvious.

All children

The sketch in Figure 48 is based on the combined statistics from the choices all children made. The navigation and buttons were the only components that were clearly favorites in both groups. The font choices were evenly divided between Times and Comic Sans. Comic Sans was chosen because the design recommendations introduced in Subsection 3.2.2 stated that Times should be avoided because it is more difficult to read. Based on the color analysis children preferred pastel colors for navigation and bright colors for buttons. The layout is similar to the layout in Figure 46, because children at Rauma made more consistent layout choices.

8.2.2 Adult's UI

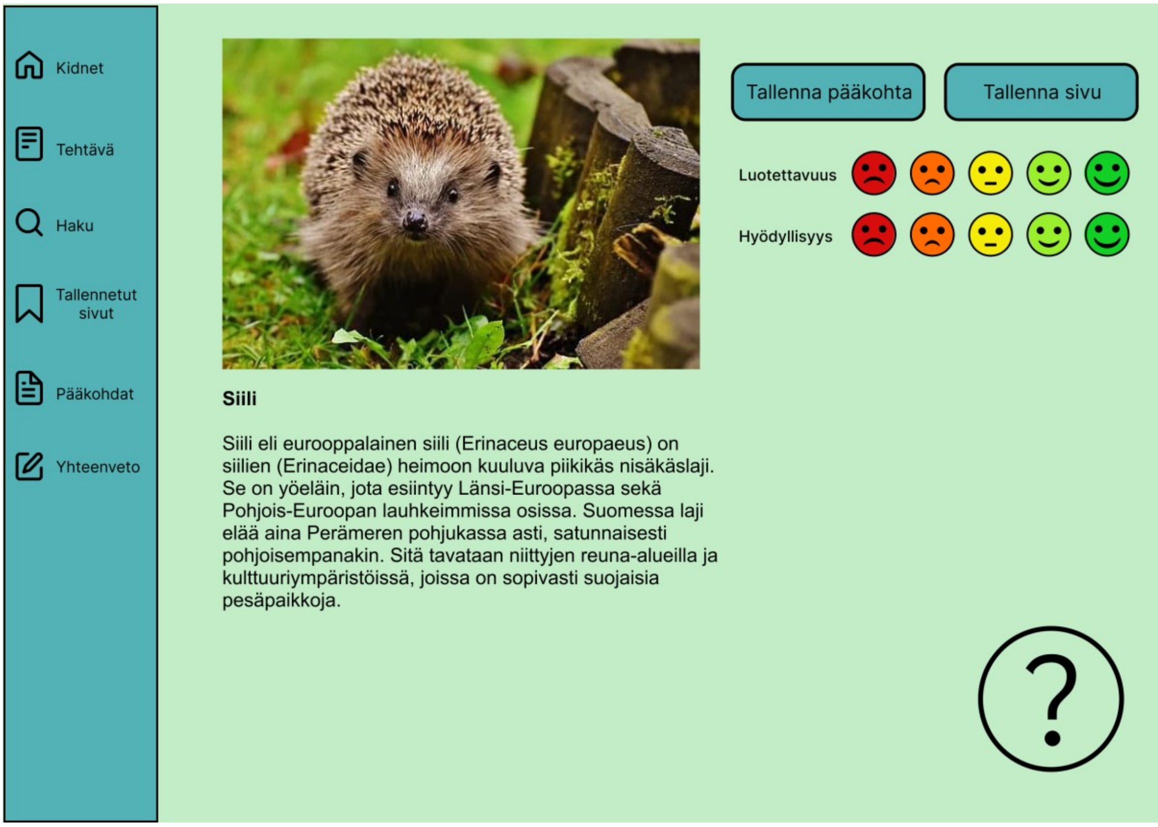

Figure 49 – Adult's UI

The sketch in Figure 49 is based on the statistics of the choices made by the adults. The direction of navigation was evenly divided between horizontal and vertical, and the font choices were evenly divided between Arial and Times. Other components had clear favorites. Even though some of the color choices might have been influenced by the octopus-poster, the turquoise and light green were chosen also by participants who had not seen the octopus-poster. The color theme can therefore be considered the most popular. Adults had less variance in colors and layout. Some of the layouts were pretty close to the layout KidNet has, which is interesting because none of the adults had ever seen KidNet. This might indicate that the adults' mental model is similar to my mental model, and we assume that certain elements are placed in certain places.

8.2.3 All Combined

The sketch in Figure 50 was made based on all the choices combined. Buttons were the only component where statistics were evenly divided between buttons with border-radius of 15 pixels and border-radius of 50 pixels. The consistency of the choices made by the adults can be seen clearly in colors and layout. It was interesting to find that there were no major differences between the component choices between children and adults. I assumed that the differences between the two groups would be more significant. This can be considered as an indication that there is no need for separate UIs for sixth graders and adults.

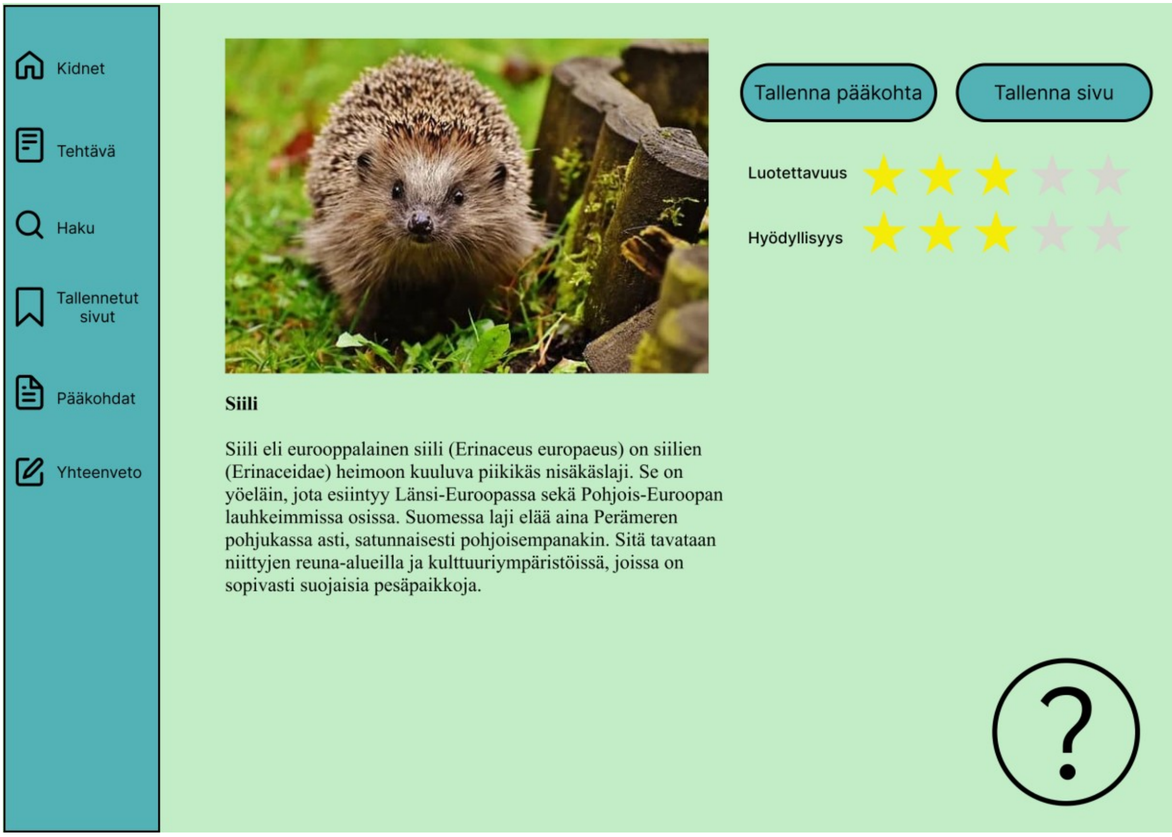

Figure 50 – All data combined.

8.2.4 My Solution

The sketch in Figure 51 is my own solution that was made based on the results and the knowledge that I have. I had an assumption that the choices made by children and adults would be so different from each other that there would be a need for two different UIs. This assumption turned out to be wrong. The same UI can be used with children and adults, because there were no major differences in the choices made. It really does not matter if the button is a bit rounder or if the favorite evaluation is emojis instead of stars.

The icons with text were chosen the most for the navigation bar in both groups. Based on the popularity and the fact that icons would help users scan the navigation faster, KidNet's navigation should be changed to this style. Placing the navigation vertically would reduce the need for media queries. The current horizontal navigation bar turns into a vertical bar at a certain width because the navigation bar cannot shrink enough to fit smaller screens while remaining the readability of the page links. Concerning the layout of other components, I would see that the results proved that the layout is okay as it is, and no changes should be made.

I decided to use Arial as a font although the most popular font choice was Times. As mentioned earlier in Subsection 3.2.2., Times can be more difficult for children to read. Besides that, sans-serif fonts have become standard fonts for UIs because they lack the small details serif-fonts have and keep their readability even in smaller sizes.

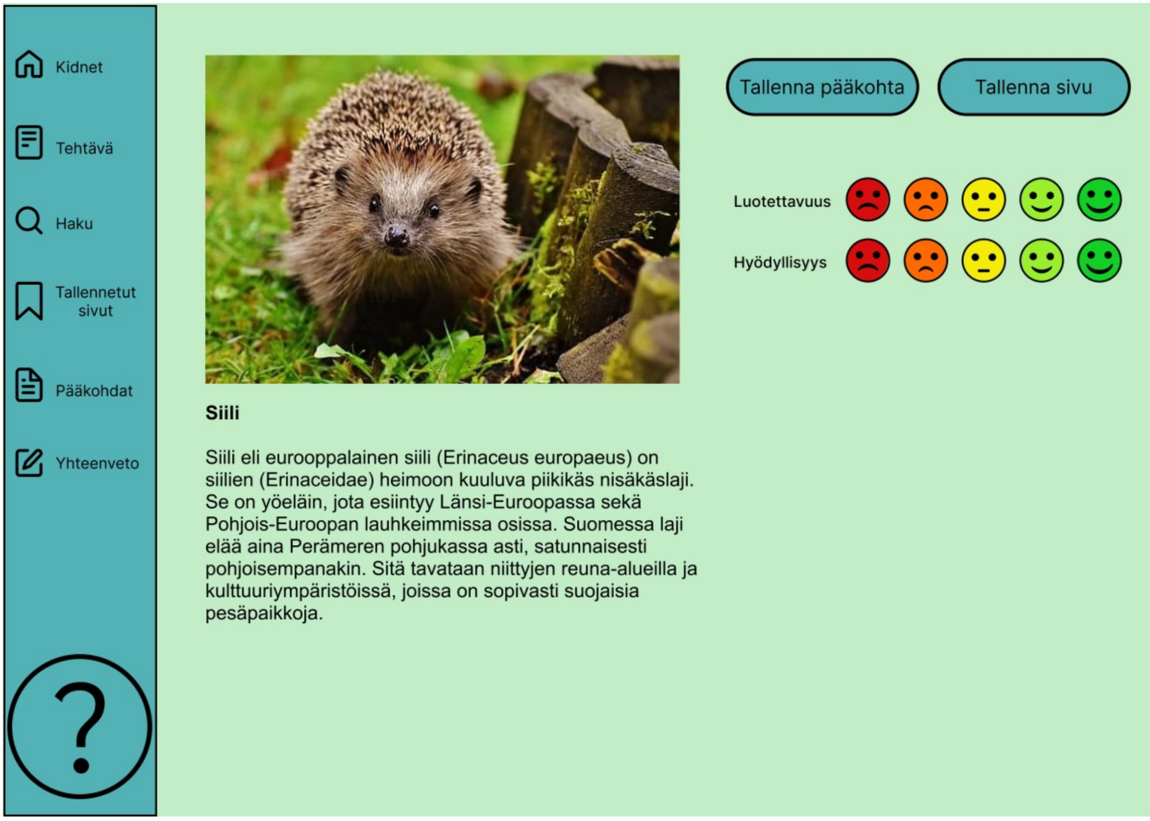

Figure 51 – My own solution

The most popular choice for evaluation was the stars. I ended up using the emojis anyway, because I feel like the emojis communicate with the user better than the stars. Reliability and usefulness can be seen as statements and the emojis can be seen as a scale between “strongly disagree” and “strongly agree”, which is basically a Likert’s scale in a disguise as discussed in Subsection 6.1.5.

Because children in the control group chose the question mark for support more than children in Rauma, it would be important to change the support to the question mark. The question mark is based on the fourth design heuristic: consistency and standards, introduced in Subsection 2.2.2. Children will spend time on other webpages more and the use of the question mark for support would preserve external consistency. The children who are already used to the question mark would know where to look for help and the children who do not know would learn the right icon for help.

The colors are the most difficult part of the UI and should be considered thoroughly before making any changes. It is clear that the great majority of participants would use more color than the UI now has. Because colors can be distracting, and they can be used to guide our attention (discussed in Chapter 4), the choices have to be made carefully. It all comes down to the balance between boring and distracting.

9 Conclusion

The main goals of this thesis were involving children in the design process, investigating how user interfaces should be designed for children, finding out what kind of UI elements children like the most and understanding the reasons behind design recommendations. These goals were accomplished by the literature review which formed the beginning of this thesis, the design sessions and the analysis of the data from the design sessions, which formed the rest of this thesis.

The results support the theory that children can use same UIs as adults when they get older. The choices made by children and adults were relatively similar and there is no need for different UIs in this case. The biggest differences between children and adults were in the layouts of the UI sketches. This might be due to the fact that children and adults have different mental models of websites because children do not have as much experience about websites as adults do and the mental models are based on past experiences as mentioned in Subsection 2.2.2.

RQ1. What kind of user interfaces are good for children? How should the age of children be considered when designing the user interfaces for them?

As discussed in Chapter 3**,** a child can be a toddler, a preschooler or a 6th grader in elementary school. Therefore, there are no good UIs for "children". The goodness of a UI for a child depends on the age of the child using it. A good UI for a toddler is very different from a UI that is good for a 2nd grader or a 6th grader because the children are in different stages of development and their needs regarding UIs are very different. A young child needs a simple UI that relies on visuals and older child can use effortlessly the same UIs that adults use.

The age should be considered to evaluate the level of physical and cognitive development of children in the target group, and the physical or cognitive limitations of the target group should be considered in the design. The research conducted by the NN Group lead to different design recommendations concerning UI design for children [30]. Many of these recommendations were universal and can be traced back to the 10 usability heuristics introduced in Subsection 2.2.2. Children of all ages benefit from the same recommendations as adults do because the recommendations are based on psychology [2]. Yet there are more things to consider when designing for children, especially when designing for young children. Young children have more limitations because their cognitive and motor skills are still developing which creates a need for different recommendations. As children get older and develop these skills, the need for different recommendations starts to disappear.

RQ2. What are the differences between children's and adult's user interfaces? Is it possible to create a user interface that all age groups like?

The answer to RQ1 stated that children cannot be seen as one group and as children get older, they can start using the same UIs as adults use. Therefore, the second research question should be more like "What are the differences between young children's and adult's user interfaces?". I would consider the most important differences between adults and younger children to be the development of fine motor skills and reading skills. The differences in these skills can cause the need for different UIs. Younger children need a UI that can be used with limited motor skills and without reading or writing skills, while older children are getting close to the skills that adults have and can use the same UIs.

Based on the KidNet case study statistics and the choices made by children and adults, it is possible to create a UI that all age groups like. At least in this context, where children are 12 years old and the need for different UIs has begun to fade away like stated earlier in Section 3.2. The results confirmed this to be true since there were no major differences between the choices made by children and adults. In the bigger picture, the answer depends on multiple things. Different goals and needs might not be met in a way that all age groups could use or would like to use the same UI. Also the fact that children are very aware of age differences should be noted [30]. Section 3.5 highlighted the differences between children and adults as users. NN Group found in their research [30] that children and adults have different goals when visiting websites and that design made for children has to follow different guidelines because of the differences between children and adults. The difference in goals creates different design expectations for websites aimed for both audiences although the goals are different and the websites can be very different, children and adults are users and users want to accomplish their goals effortlessly.

RQ3. How can a user interface be designed with children? What kind of role children can have in UI design?

Section 3.3. introduced different design theories that can be used with children. Some theories were considered more suitable for being used with children, these included participatory design and cooperative inquiry. The suitability of these theories originated from the methods used to make children participate in the design. Paper and pen play an important part when children are involved as participants. Children can draw different UI elements or make low-tech prototypes with materials given to them. The fact that children liked the design sessions, and the results were useful confirms that the "puzzle" approach is a good way to include children in the design process.

Section 3.4. presented the different roles that children have in the design of new technology. The roles were the user, the tester, the informant and the design partner. The role children had in this thesis was closest to the role of an informant. In the context of KidNet, I would see that children have multiple roles as users, testers and informants. When children are the role of a user, they use the system and their answers to different questionnaires can be used to make changes in the UI. Children can also be observed performing different tasks and changes can be made if children have issues performing tasks. When children are in the role of a tester, they can test the system before it is finished, the feedback from testing can be used to make changes to the UI. When children are in the role of informant, like they have been in this case, they can actually take part like they did in the design sessions. When children are in the role of design partner they are equal participants in the design process from the beginning to the end.

RQ4. What kind of user interface would children design for KidNet? What kind of UI elements address the target group?

Section 7.3 and Subsection 8.2.1 answered both of these questions. Based on the statistics, children would design a UI with icons and text in the navigation bar, buttons with bigger border-radius and more color than KidNet currently has. The layouts and color combinations made by children were sometimes wild and the difference between the layouts made by children and adults was enormous. The assumption that I had was that children would like the more unusual shapes in buttons and navigation turned out to be wrong since the choices were similar to the choices made by adults.

The research done by NN Group [30] has led to different guidelines concerning UI design for children. Some of the guidelines are based on the 10 usability heuristics introduced in Subsection 2.2.2, e.g., “Make sure actions are reversible: support back and undo.”, “In error messages, use terms that non-technical users understand.”. But there are also guidelines which are targeted at children e.g., “Use motion and sound to attract kids’ attention and engage them.”, “Give positive feedback whenever children have completed a game or an activity. For young children (3–5) the feedback can be given during the activity as well.” and “Use simple icons. Avoid using old-styled or elaborate, custom icons for young kids.”. Some of these guidelines were followed in the design of KidNet, and design of the elements used in the design sessions. While the guidelines are vague on purpose, some of them can still be used to determine likes or dislikes of certain age groups. E.g., “Design characters that kids can identify with.” is justified with the sentence: “Kids are attracted to characters in general, especially when they are popular and funny.”.

The results of this study have sparked multiple ideas for future research. One of the most notable differences between Rauma group and control group was the placement of the navigation bar. The fact that children in different groups were using different devices in schools does not offer a full explanation to these differences, after all, three of the children in the control group placed the navigation at the top of the screen. This raised multiple questions for future research. If interventions with KidNet were held in Turku area, and children would take part after the post test, would there still be a difference between Turku group and Rauma group? Would there be a difference between children who are allowed to use computers at home and children who are using only tablets? Does the time spent online have an impact on the placement of navigation? The influence that the use of KidNet has on children's designs could be measured by conducting an intervention where children would take part in the design sessions before taking part on the intervention concerning online inquiry skills using KidNet and then doing the design sessions again.

Another interesting topic would be the 4th graders. Why did the 4th grader girl design a UI that differs tremendously from the UIs designed by 4th grade boys? Was this only a coincidence? Did the girl have better computer skills? Did the boys listen to the instructions? Did they understand the instructions? Is a 4th grader too young for this kind of design session? No conclusions can be made because there were only three 4th graders. With an improved background survey and bigger number of participants, these questions might get some answers as well.

The layouts had major differences and it would be interesting to understand the reasons behind it. Maybe it had something to do with computer skills or time spent on computers? How do these things impact the UIs that children make? The background questions should be improved, and the number of participants should be bigger in order to answer these questions.

In this study, the participants were asked to pick their favorite component so there is not much knowledge of the dislikes that participants had. If the part where the participant chooses the components would be implemented in a way that participants would be asked to put the different components in order from the best to the worst, there would be more information about the dislikes as well.

Because the low-tech prototype approach causes limitations for color choices, the design sessions could maybe be held in two parts. The participants could first choose the components in the low-tech form and create a layout and then add the colors in Figma. It is possible to create a similar layout with selected components rapidly with Figma because the component can have different variants. Perhaps the low-tech part could be skipped completely, and children could use Figma with my assistance.

Although this thesis might have raised more questions than it answered, the results confirmed that children can take part in the UI design by creating a low-tech prototype of the UI and there is no need for different UIs in the case of KidNet.

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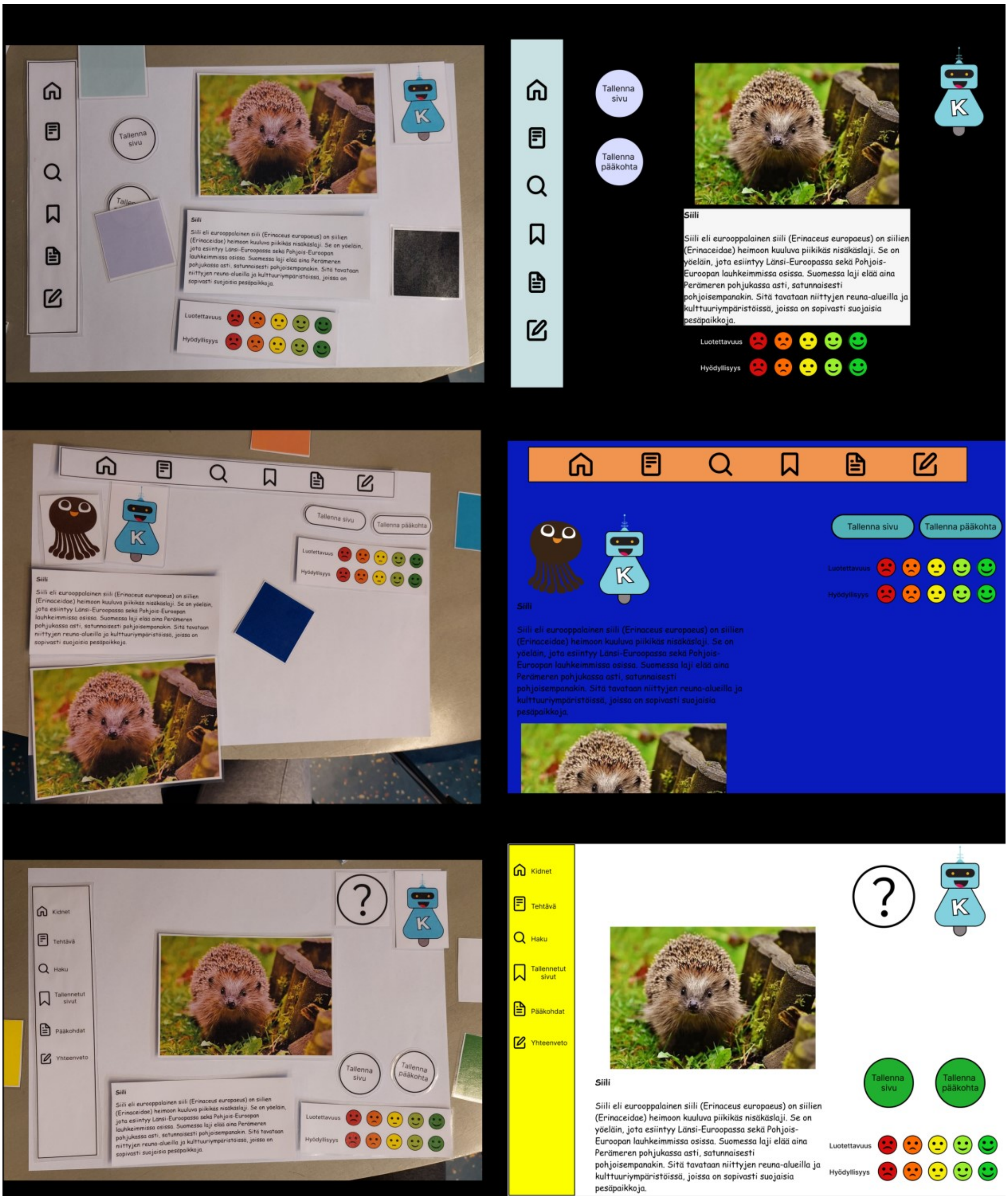
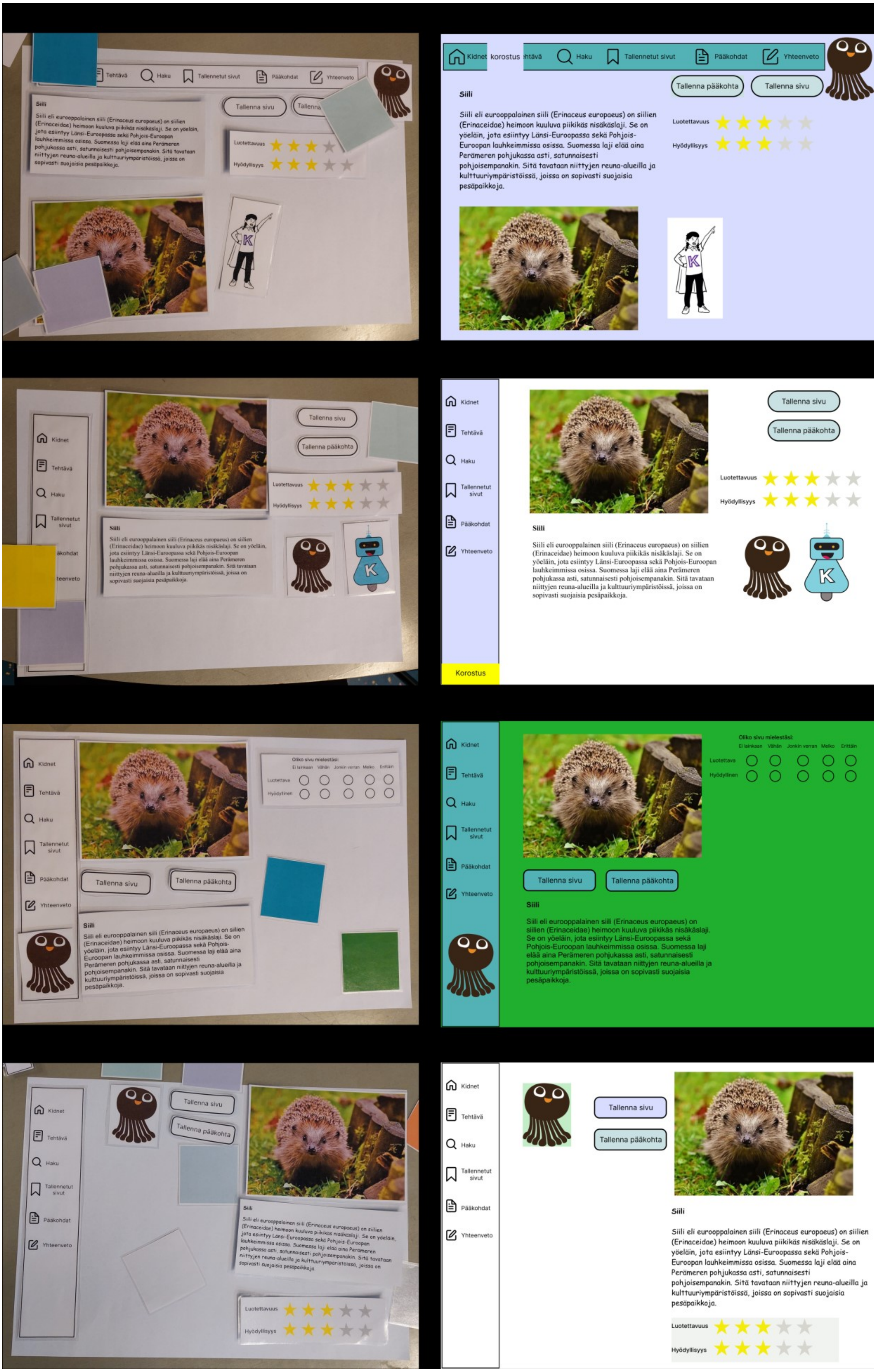
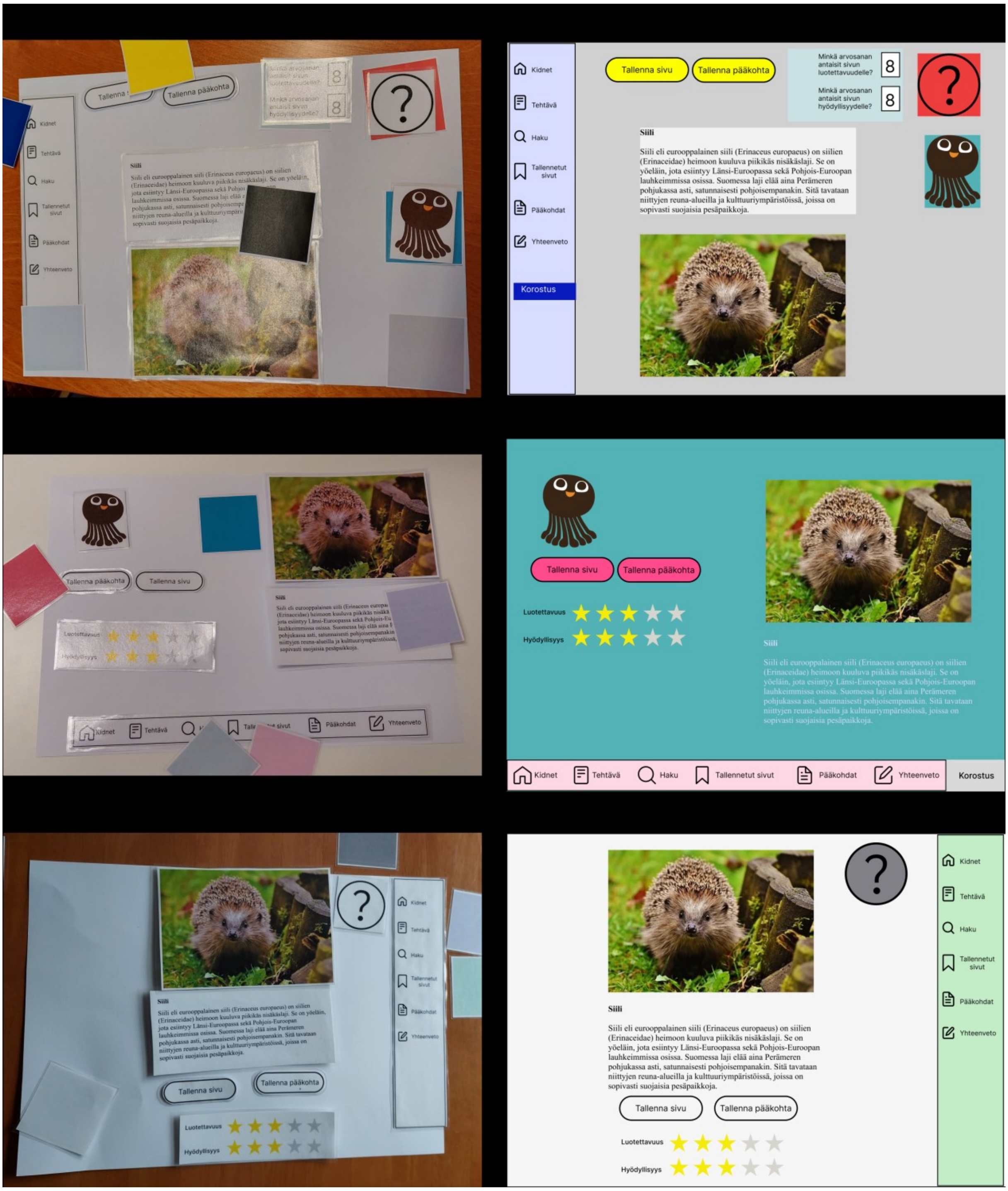
Appendices

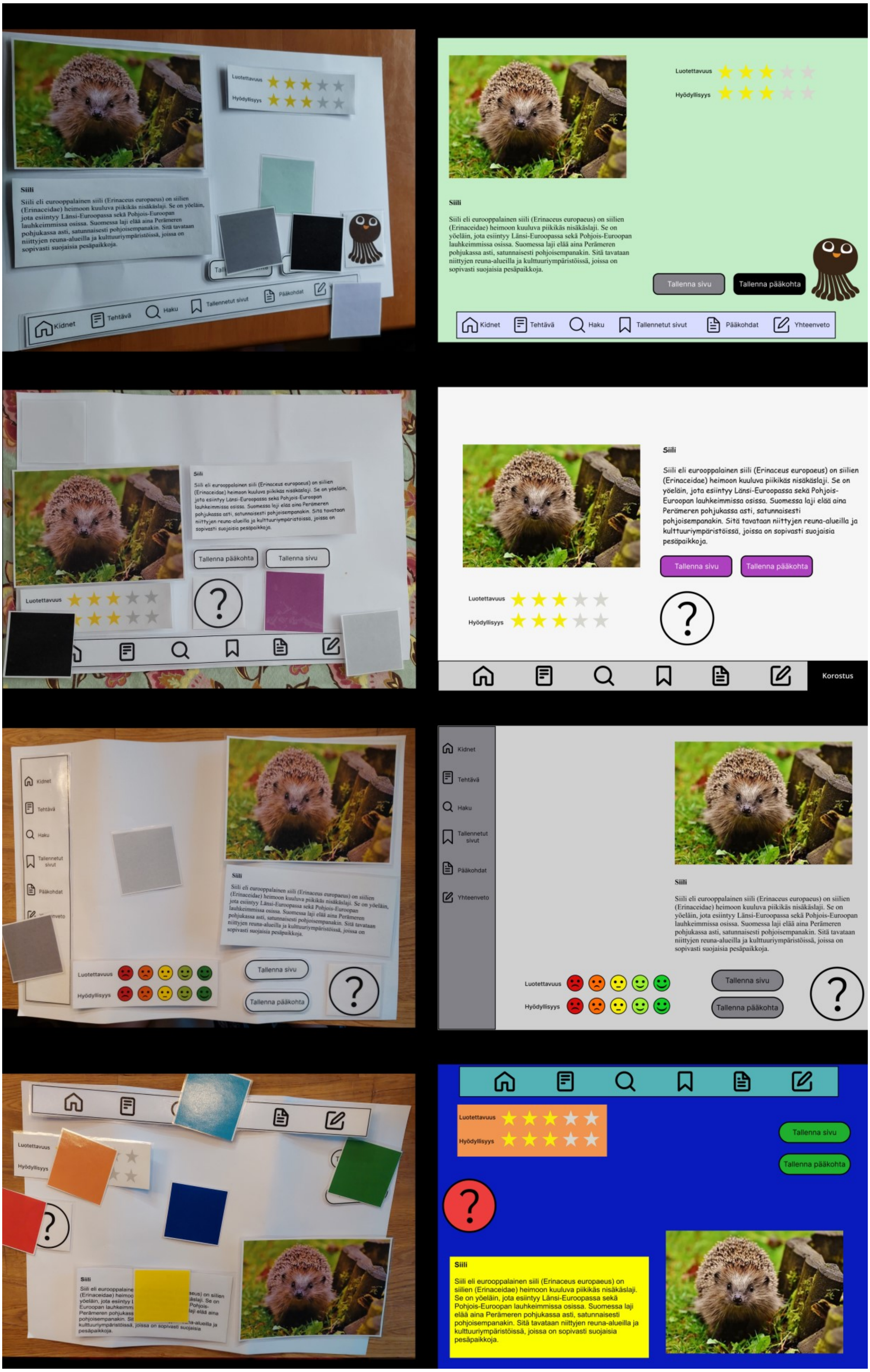
Appendix 1 Photos and Sketches Made by Children at Rauma




Kidnet
Tehtävä
Haku
Tallennetut sivut
Pääkohdat
Yhteenveto
korostus
Tallenna pääkohta
Tallenna sivu
Siili
Siili eli euroopplainen siili (Erinaceus europaeus) on siilien (Erinaceidae) heimoon kuuluva piikikäs nisäkäslaji. Se on yöeläin, jota esiintyy Länsi-Euroopassa sekä Pohjois-Euroopan lauhkeimmissa osissa. Suomessa laji elää aina Perämeren pohjukassa asti, satunnaisesti pohjoisempanakin. Sitä tavataan niittyjen reuna-alueilla ja kulttuuriympäristöissä, joissa on sopivasti suojaisia pesäpaikkoja.
Luotettavuus
Hyödyllisyys
Korostus
Oliko sivu mielestäsi:
Ei lainkaan
Vähän
Jonkin verran
Melko
Erittäin
Luotettava
Hyödyllinen

Appendix 2 Photos and Sketches Made by Children in the Control Group

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Hyödyllisyys
Siili
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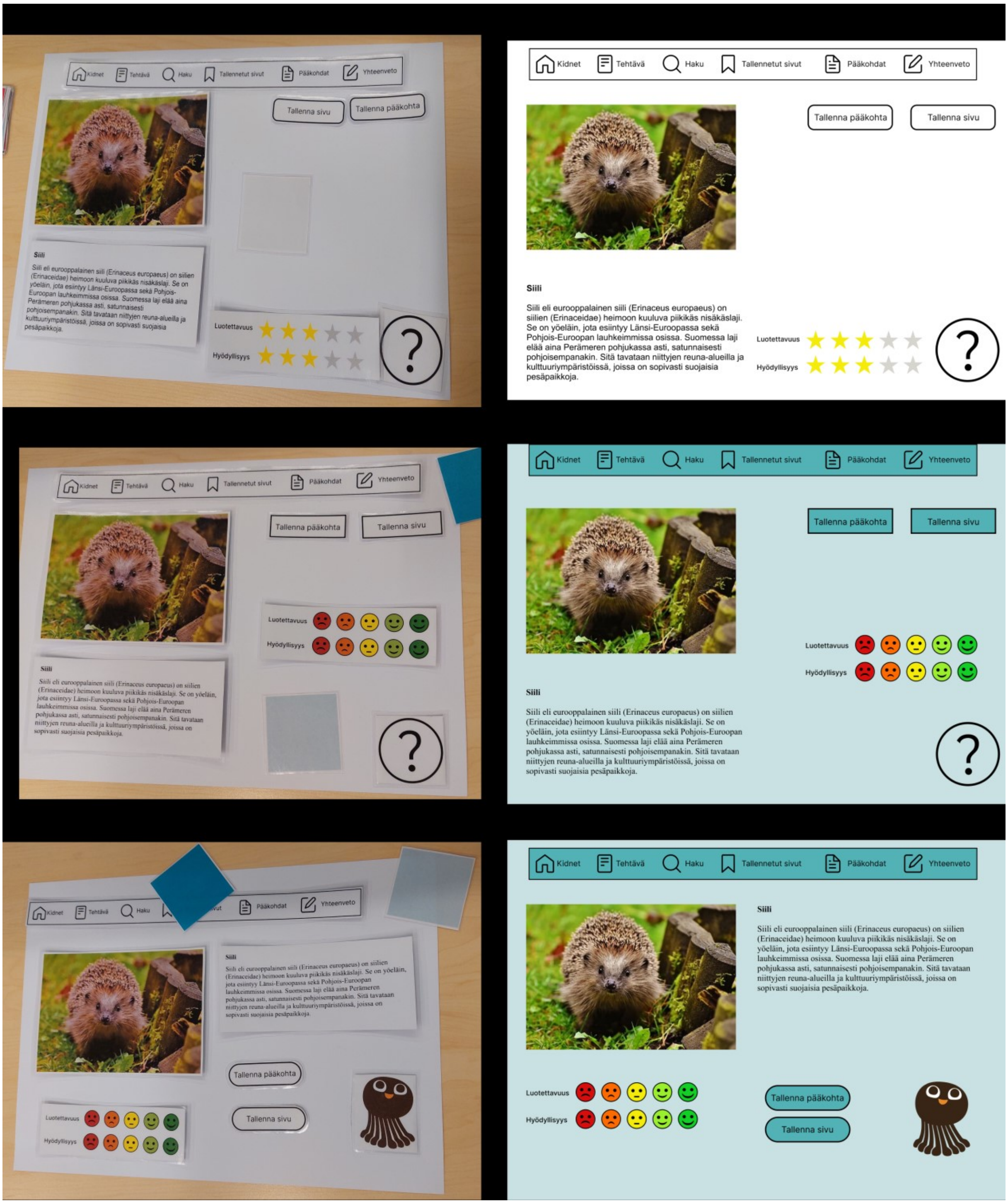
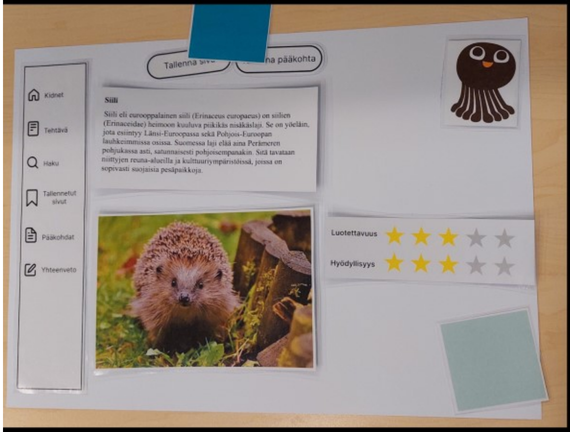
Tallenna sivu
Tallenna pääkohta
Kidnet
Tehtävä
Haku
Tallennetut sivut
Pääkohdat
Yhteenveto
Korostus

Appendix 3 Photos and Sketches Made by the Adults



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Pääkohdat
Yhteenveto
Tallenna sivu
Tallenna pääkohta
Siili
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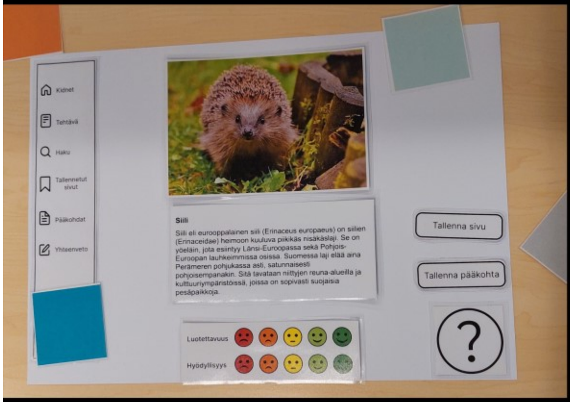
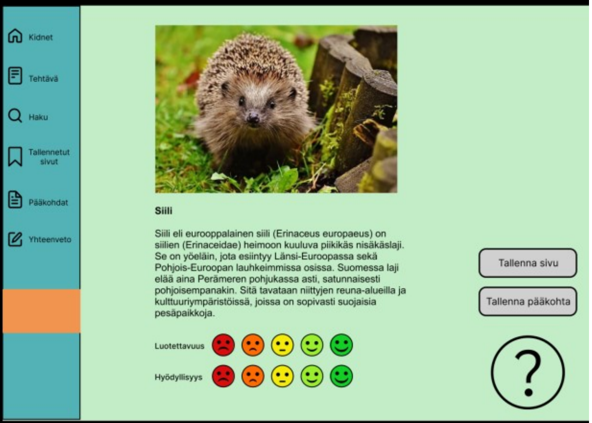
Luotettavuus
Hyödyllisyys

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Tallenna sivu
Tallenna pääkohta
Luotettavuus
Hyödyllisyys
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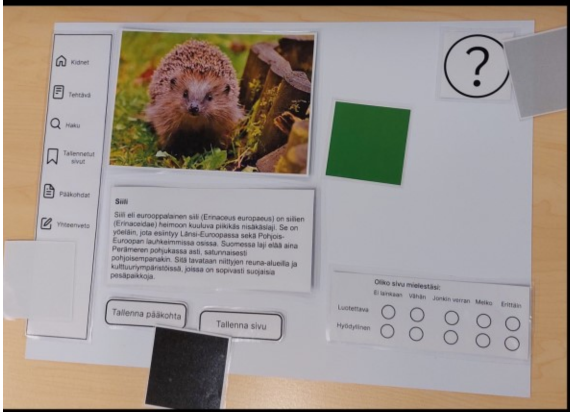

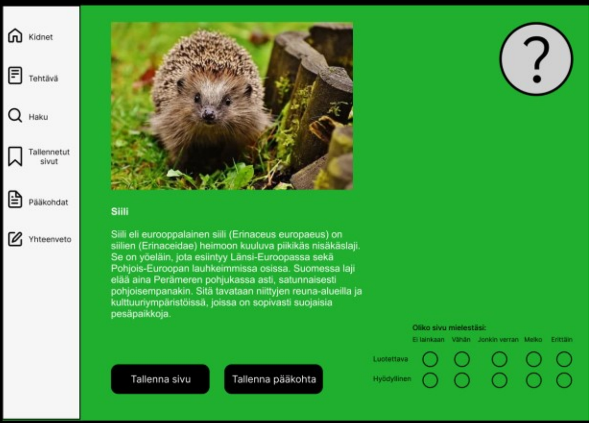
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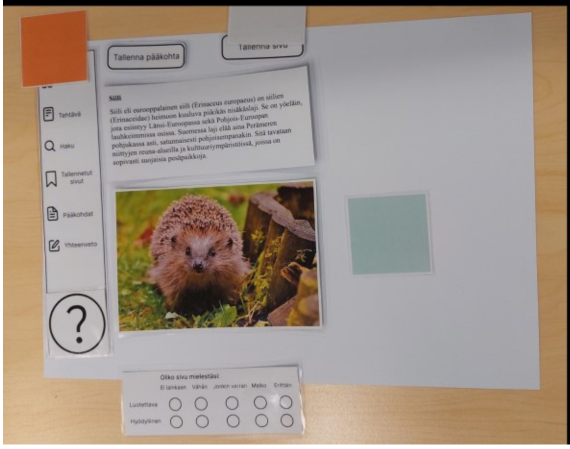
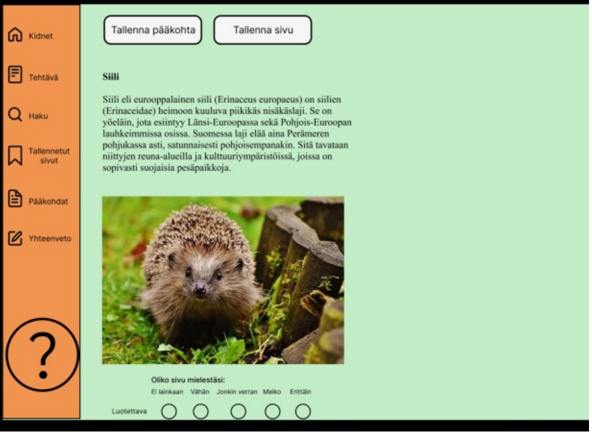
Hyödyllinen
Tallenna sivu
Tallenna pääkohta

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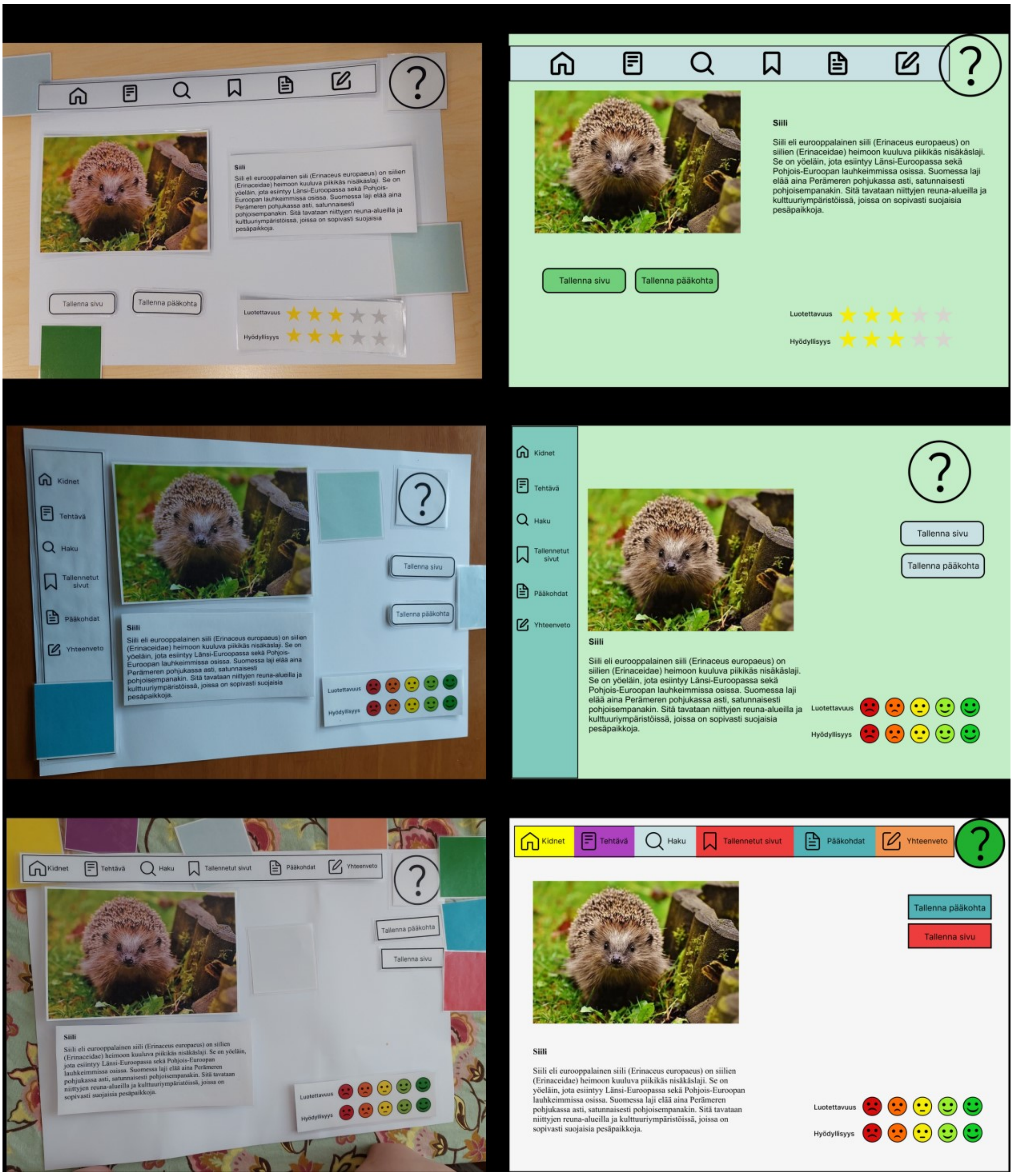
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