

# **An Open Learner Model Dashboard for Adaptive Learning**

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## **Abstract**

An Open Learner Model (OLM) is a learner model that makes information about the learner available to different stakeholders. The OLM is able to support assessment, promote metacognitive activities such as reflection, planning, and monitoring as well as allow the learner to take greater control and responsibility for his learning (Bull and Kay, 2010). The research was carried out as part of the Activity Data for Assessment and Adaption 2 (AVT2) project. The thesis describes the design process of the independent OLM dashboard, MittFagkart, that visualizes student activity data across digital math tools used in Norwegian classrooms for teachers. The goal of MittFagkart is to help teachers gain a good overview of student learning and progress. The peculiarity of MittFagkart is that the data on which it is built is tagged towards the national mathematics curriculum, enabling the data across tools to be aggregated for an individual student or an entire class.

The research involved a systematic literature review that investigated what data should be presented in OLMs, as well as what types of presentation formats are better to use for displaying student progress. The results of the literature review showed that there are some particular visualizations that are most common to use in an OLM, such as skill meters, concept maps, treemaps, word clouds. The choice of the visualizations depends on a variety of factors, from the user's preferences to the OLM's aims. As for the data types that are used for building OLMs, the literature showed that any educational data that is included in a learner model might be suitable for OLMs.

The development of MittFagkart was carried out through user-centered design. This type of design methodology involves the users throughout the entire development process, from the moment of establishing the requirements to evaluating prototypes. As a result, the prototype satisfies the needs and preferences of the users. The pre-phase and three iteration cycles of the development process are described, and the final prototype is presented.

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## List of Abbreviations

**AVT** - Activity Data for Assessment and Adaptivity

**AVT2** - Activity Data for Assessment and Adaptivity, part 2

**COVID-19** - Coronavirus disease 2019

**EdTech** - Educational Technology

**JSON** - JavaScript Object Notation

**KS** - Communal sector (Kommunesektorens organisasjon)

**LRS** - Learning Record Store

**NSD** - Norwegian Centre for Research Data

**OLM** - Open Learner Model

**SLATE** - The Centre for the Science of Learning & Technology

**SMILI** - “Student Models that Invite Learner In” framework

**TEL** - Technology Enhanced Learning

**UCD** - User-Centered Design

**UDIR** - The Norwegian Directorate for Education and Training

**UI** - User Interface

**UX** - User Experience

**xAPI** - Experience Application Programming Interface

# **1 INTRODUCTION**

A learner model is a core element for an adaptive learning environment. It is drawn upon to provide information for making decisions, recommendations, and feedback to learners (Sergis and Sampson, 2019). Learner models are generally not suitable or in a readable format for the learner (Bull et al., 2010); this is where the concept of the Open Learner Model (OLM) becomes useful.

Open learner models refer to the “learner models that can be viewed or accessed in some way by the learner, or by other users” (Bull and Kay, 2010, p. 301). Other users can, for example, be teachers, peers, or parents. Research on OLMs (Guerra et al., 2018) found that opening a learner model to students through a special interface can not only improve the system’s transparency, but also enable the student to know more about their state of the knowledge, the reason for their knowledge, and most importantly to use this understanding to better plan their learning. Such an “opening” raises some questions: what information about the learner’s knowledge should be shown to the user, and how can this information be presented in the most efficient way?

The research reported in this thesis describes the design process of an independent OLM dashboard named MittFagkart. The work explores various presentation formats that can be used in MittFagkart, as well as identifying the benefits and challenges in using the OLM.

User-centered design is chosen as the methodology for the development of the MittFagkart prototype. An early focus on the users helps to create a product that satisfies all the users’ needs and preferences. Corresponding methods for establishing requirements, designing, testing, and evaluating the prototype were selected and applied.

## **1.1 Motivation**

This research is a contribution to the Activity Data for Assessment and Adaptation 2 (AVT2) project that is focused on using learning analytics to improve students' learning in Norwegian schools. The first project, AVT, investigated the possibilities and challenges for sharing activity data between vendors who supply digital tools to Norwegian schools so that they can provide learning tasks and items that are better adapted to a learner’s needs. AVT2 has a focus on using a centralized OLM dashboard that presents learning analytics of student data with various views

for different stakeholders such as students, teachers, EdTech vendors, and researchers for different purposes (e.g., self-reflection, a recommendation of learning resources, decision making about teaching, etc.)(Morlandstø et al., 2019).

Data visualization has always been one of the major interests of mine along with usability and design. The AVT2 project gave me the opportunity to combine these interests and contribute to the development process of the tool that can help to improve students' learning.

## **1.2 Research problem**

The OLM dashboard MittFagkart is designed with the intention of improving teaching and learning processes at school. Based on learning activities performed in digital learning tools, the MittFagkart would be able to display information about the students' progress in accordance with the national curriculum.

The main goal for the current research is to provide an OLM Dashboard, MittFagkart, that can help teachers (and different stakeholders in future versions) gain insight into their students' learning activities and progress across a number of digital learning tools by informative visualizations. In order to lead the research, the following research questions were established:

*RQ1: What do teachers want to know about student activity?*

*RQ2: What data should be shown in a dashboard for teachers and how should it be presented?*

*RQ3: What visualizations are best for the teachers?*

Due to the COVID-19 pandemic, the research could not involve all potential stakeholders in interview and testing processes, only teachers. Thus, MittFagkart is developed for teachers with the possibility of tailoring the content to other stakeholders (learners, vendors, researchers) in future versions of MittFagkart.

## **1.3 Organization of the thesis**

Chapter 2 presents the background for the research: a systematic literature review that identifies the nature of the OLMs as well as what presentation formats are usually used for opening learner

models. The chapter also provides information regarding the related project AVT and the presentation of the new national curriculum, Kunnskapsløftet 2020, for Norwegian schools.

Then, Chapter 3 identifies the methodology used for the development of the MittFagkart prototype along with the methods applied for the establishment of the requirements, design solutions, and evaluation. In Chapter 4, the project AVT2 is described as well as the contribution made to the project.

Chapter 5 presents the target group, the recruitment process of the participants for the testing of the prototype, and the establishment of the requirements for the OLM. In Chapter 6, the pre-phase and three iterations of development of the prototype are described. Finally, Chapter 7 discusses the findings of the research as well as answers the research questions stated earlier. Chapter 8 presents the conclusions.

## **2 BACKGROUND**

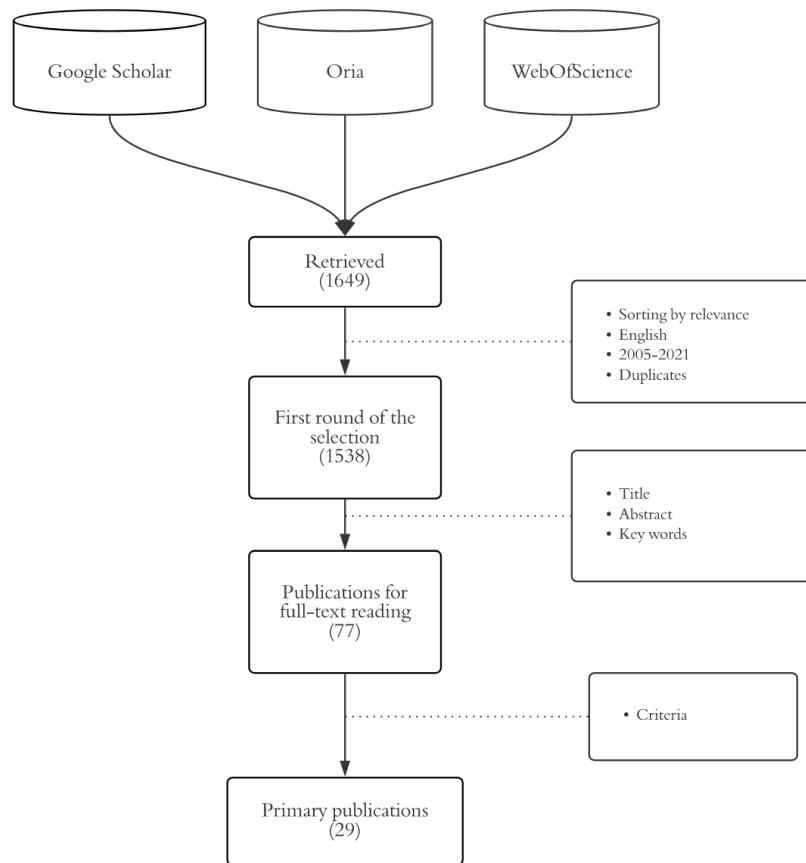
This chapter introduces relevant literature and background information for the current research. First, a systematic literature review is presented, which introduces the open learner model concept, provides an overview of the different visualizations being used in Open Learner Models (OLMs), and presents several examples of already existing learner models. Second, information about the AVT, and the Norwegian national curriculum and related concepts are described.

### **2.1 Open Learner Models: A Systematic literature review**

The current research was grounded in a systematic literature review of OLMs, their design, and data visualization for these models. The established search string was "*Open Learner Model*" AND ("*design*" OR "*data*" OR "*visualization*" OR "*dashboard*"). The academic digital databases used for the review were Google Scholar, WebOfScience, and Oria. Relevant publications were identified by running a search string that combined keywords driven by research questions presented earlier. Figure 1 shows the process used to select publications for the review.

The search query gave 1649 publications in total. In order to narrow down the amount of the publications for the review, the results were filtered by 1) year ranging from 2005- 2021, 2) only publications that are written in English, and 3) duplicates were also removed.

For the second round of selection, the title, abstract, and keywords of each publication were reviewed manually according to the main topic of the study. After inclusion based on topic relevance, a total of 77 articles remained.



**Figure 1:** Selection of publications

The next step was to evaluate the full text of the selected publications. The inclusion criteria by which they were eligible for further analysis:

1. presents the concept of OLM and its purpose
2. describes data/types of data that can be used in OLMs
3. describes types of visualizations for presenting data in OLMs

The third round of the selection identified 29 articles (Table 1) that were included in the systematic review.



**Table 1:** List of publications used in review

<b>ID</b>	<b>Reference</b>	<b>Year</b>	<b>Title</b>
1	(Bull and Kay, 2010)	2010	Open Learner Models
2	(Law et al., 2015)	2015	A Preliminary Study of Open Learner Model Representation Formats to Support Formative Assessment
3	(Sergis and Sampson, 2019)	2019	An Analysis of Open Learner Models for Supporting Learning Analytics
4	(Lloyd et al., 2005)	2005	Some Unusual Open Learner Models
5	(Bull et al., 2013a)	2013	Visualising Multiple Data Sources in an Independent Open Learner Model
6	(Bull and Wasson, 2016)	2016	Competence visualisation: Making sense of data from 21st-century technologies in language learning
7	(Bull et al., 2016)	2016	Introduction of Learning Visualisations and Metacognitive Support in a Persuadable Open Learner Model
8	(Bull, 2016)	2016	Negotiated learner modelling to maintain today's learner models
9	(Bull and Kay, 2007)	2007	Student Models that Invite the Learner In: The SMILI :) Open Learner Modelling Framework
10	(Bull and Kay, 2016)	2016	SMILI :) : a Framework for Interfaces to Learning Data in Open Learner Models, Learning Analytics and Related Fields
11	(Bull, 2021)	2021	Jim Greer's 25-year Influence on a Research Programme on Open Learner Models
12	(Ahmad and Bull, 2008)	2008	Do Students Trust Their Open Learner Models?
13	(Bull et al., 2010)	2010	Preferences in Multiple-View Open Learner Models
14	(Guerra et al., 2018)	2018	Navigation support in complex open learner models: assessing visual design alternatives
15	(Hooshyar et al., 2020b)	2020	Open learner models in supporting self-regulated learning in higher education: A systematic literature review
16	(Bull, 2020)	2020	There are Open Learner Models About!
17	(Mabbott and Bull, 2006)	2006	Student Preferences for Editing, Persuading, and Negotiating the Open Learner Model
18	(Bull and Mabbott, 2006)	2006	20000 Inspections of Domain -Independent Open Learner Model with Individual and Comparison Views
19	(Epp et al., 2014)	2014	Visualising Uncertainty for Open Learner Model Users
20	(Kump et al., 2012)	2012	Seeing What the System Thinks You Know - Visualizing Evidence in an Open Learner Model
21	(Badea and Popescu, 2020)	2020	Supporting Students by Integrating an Open Learner Model in Peer Assessment Platform
22	(Conejo et al., 2012)	2012	INGRID: A Web Service Tool for Hierarchical Open Learner Model Visualization

23	(Bull et al., 2013b)	2013	Learning, Learning Analytics, Activity Visualisation and Open Learner Model: Confusing?
24	(Bull et al., 2007)	2007	Visual Attention in Open Learner Model Presentations: An Eye-Tracking Investigation
25	(Law et al., 2016)	2016	An empirical study of user perceived usefulness and preference of open learner model visualisations
26	(Bull et al., 2008)	2008	Supporting Interaction Preferences and Recognition of Misconceptions with Independent Open Learner Models
27	(Al-Shanfari et al., 2017)	2017	Evaluating the effect of Uncertainty Visualisation in Open Learner Models on Student's Metacognitive Skills
28	(Hooshyar et al., 2020a)	2020	Transparent Player Model: Adaptive Visualization of Learner Model in Educational Games
29	(Bodily et al., 2018)	2018	Open Learner models and learning analytics dashboards: A systematic literature review

### 2.1.1 Open Learner Models

In order to introduce the nature of the OLM, it is useful to mention first a related concept, namely the *learner model*. The learner model refers to “a representation of specific characteristics of learners, relevant to the educational practice” (Sergis and Sampson, 2019, p. 157). Such specific characteristics can be the current level of knowledge, skills, competencies, understanding of concepts, conceptual relationships, misconceptions as well as information about motivation, engagement, effort, learning style, and similar (Bull, 2020). These contents can be inferred during an individual's interaction with a learning application, and are useful for generating appropriate feedback, tutoring, exercises, materials, etc. Therefore, the learner model can be updated as the user learns (Bull and Wasson, 2016).

In turn, *open learner models* (OLMs) are learner models that are “open” to the users. (Bull and Wasson, 2016). Bull and Kay (2016) define open learner models as “learner models that allow user (learner/teacher/peers and/or other stakeholders in education process) to view the content of the learner model of an intelligent tutoring system or other advanced learning environment, in a human understandable form” (p.294). The OLM communicates with the learner and other actors in the learning environment by allowing visualization and/or editing of the relevant profiles (Sergis and Sampson, 2019).

The literature review showed that there are two types of OLMs: embedded and independent. An independent OLM is constructed as any other system, but there is no additional tutoring or system guidance based on the learner model. The control and responsibility for making decisions are entirely upon the learner (Bull and Kay, 2010). The independent OLM helps users to identify their learning requirements in order to encourage learner awareness and independence as well as transfer more accountability to learners (Bull, 2021). In contrast, embedded OLMs generally depend on a tutoring system in order to address a learner's choice (Hooshyar et al., 2020b).

Other types of OLMs also were described in the literature: inspectable, negotiated, editable, cooperative, and persuasive. These types represent a degree of self-control over the learner model in the OLM (Hooshyar et al., 2020b).

Inspectable OLMs cannot be edited and just visualize the profile as defined and populated by the systems that operate the OLM. Negotiated OLMs allow users to change the values of the profile but require the evidence that supports the updated value in order to accept it (e.g., the system will suggest taking a test to demonstrate the learner's new skill level). Editable models are models that can be modified freely by the various actors (e.g., teacher, parent, peer, etc.) (Bull, 2021, 2020; Bull and Kay, 2016; Hooshyar et al., 2020b; Lloyd et al., 2005; Sergis and Sampson, 2019).

According to Hooshyar et al. (2020b), cooperative OLMs enable the learner to co-construct the learner model along with the system. The system initiates the modeling process but requires input from the learner for complementary information. Thus, both take part in modeling tasks that are shared on the basis of which tasks each can perform best. As for persuasive OLMs, they enable the users to alert their learner model. The learner must establish his competency prior to the system agreeing to the proposed changes. The system identifies the learner's competency through questions and claiming validation (Hooshyar et al., 2020b).

### **2.1.2 Benefits of using OLMs**

The literature review also identified several aspects of why OLM can be helpful in teaching and learning processes. First of all, OLMs provide formative assessment opportunities for learners as well as data about individuals and/or a class in order to support teacher's planning and decision-making. The data that OLMs contain can be used as immediate feedback on the learner's competencies and understanding at a given time (Bull and Wasson, 2016).

In addition to that, Bull and Kay (2007) introduce a framework SMILI 😊 (Student Models that Invite Learner In) where they describe different purposes for opening a learner model. The authors claim that OLMs are able to promote metacognitive activities such as reflection, planning, and self-monitoring. OLMs can also help to improve the accuracy of the learner model by allowing the users to contribute information to their models. In general, using OLMs in learning and teaching processes facilitates collaboration between learners and peers, teachers, and parents. In addition, OLMs are useful for facilitating navigation to materials, problems, and tasks, if the learner model provides the resources for it. It is also highlighted that OLMs increase learner trust in an adaptive educational environment by showing visualizations of their knowledge (Bull and Kay, 2010).

### **2.1.3 Challenges**

Opening the learner model to the learners poses several difficulties. One of them is assessment transparency. Even though the OLM seeks to enhance transparency, its own transparency remains deficient (Hooshyar et al., 2020b). Hooshyar et. al (2020a) claim that there are some other instances (besides learning assessment) that potentially can be open in the learner model. This includes information about how the model collects data, and how the assessment mechanism is deployed to infer visualized information. Exposing learners to the process of the learner model can lead to interactive maintenance processes as well providing students with better information to consider while reflecting on their own learning (Hooshyar et al., 2020a).

Another challenge is related to visual representation (Bull and Kay, 2016), (Hooshyar et al., 2020b). While visualizing activity data, level of knowledge, and competencies, there are a lot of things that have to be considered. It is equally important both to keep in mind the degree of detail and the amount of concurrently presentable information made visible to the learner through the model (Hooshyar et al., 2020b). Other factors that may affect the visual representation of an OLM are described further (see section 2.1.6).

OLMs also face a granularity challenge. OLM content is presented from the analysis of large amounts of data sometimes from different sources in different formats. Granularity describes the size of the content: it can be very small and precise content elements as well as elements with a greater degree of abstraction, hence less detail or precision. This raises the question: How much information should learners receive to both comprehend the meaning of the representation and most important act on it? The representation depends on the scope and complexity of the learner

model. While developing an OLM it is challenging to decide whether or not to hide complex information, hence reduce transparency or show it and may negatively affect learner's experience within the system (Hooshyar et al., 2020b).

There is also a question of how much power a learner should be given within the OLM (i.e., can they or can they not edit their knowledge level). If a learner is given the possibility to update their knowledge level in a learner model without any proof, from time to time they could overstate their abilities, hence the OLM visualizations do not correspond to their true capabilities. It is important to note that just stopping the learner from modifying the information in his learner model is insufficient since it will not work for some instances when a learner has prior knowledge about the topic that has not been tracked by the system. Without the ability to update the information, using such a model will be too easy, repetitive, and not interesting (Hooshyar et al., 2020b).

Hooshyar et. al (2020b) also emphasizes that there is a need to theorize OLMs as an educational tool. Indeed, representations of learning activities may stimulate or support learner reflection, while visualizations can motivate students for certain cognitive activities. However, there is a need for conceptual development using broader theoretical frameworks in order to get more insightful results (Hooshyar et al., 2020b).

Furthermore, Ahmad and Bull (2008) discuss user trust in OLMs and user-computer interaction. The key question here is the extent to which users have enough confidence in the system's representation, decisions, and recommendations in order to act on these. Here come the challenges regarding how to visualize in an OLM and how much control the learner can have over the learner model in order to make the system more trustable (Ahmad and Bull, 2008).

#### **2.1.4 Data for Open Learner Model**

Another important aspect that should be discussed is data and data collection for OLMs. In general, the learner model uses educational data, such as personal details, scores in assessment activities, educational resource access/usage patterns, and learning activity access/completion patterns during the delivery of the learning process. Data can be automatically captured by the system or can be provided in a manual manner (Sergis and Sampson, 2019).

Bodily et al. (2018) present research on what types of data are collected in OLM systems. It can be a single type of data (e.g., multiple-choice question scores or activity data from a learning

application), or behavioral metrics such as the information about the number of questions completed. Their research also showed that OLMs rarely use data from multiple applications, but it depends on the type of the OLM because for instance embedded OLMs are part of the tutoring system and do not have access to other systems. In addition, OLMs can collect inputs directly from users, for example requesting the learner to agree with or challenge the OLM when they disagree with the model’s representation (Bodily et al., 2018).

### 2.1.5 Examples of OLMs

The literature review showed that there are a lot of different OLMs, both embedded to the tutoring systems and independent ones. Some of these are described in order to gain a better understanding of the function of the OLMs and how they can visualize information to the users.

#### OLMlets

OLMlets (Al-Shanfari et al., 2017, p. 17) is “a tutoring system that provides an open learner model to help students to become independent learners”. It shows information about the learner’s strengths, weaknesses and misconceptions. The OLM collects the student’s responses to multiple-choice questions and uses an algorithm that weights responses based on when questions are answered, which keeps the model current. OLMlets uses simple visualization such as a skill meter for showing the knowledge level with help of colors: green for strengths, grey for weaknesses and red for misconceptions (Al-Shanfari et al., 2017). Figure 2 presents the standard skill meter used in OLMlets.

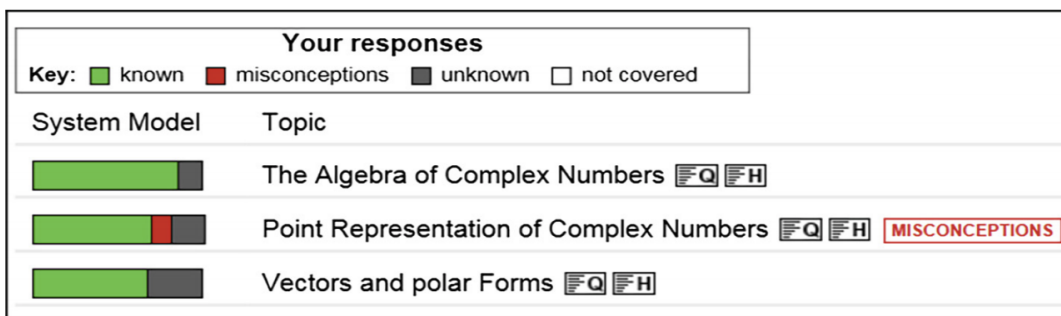


Figure 2: OLM visualization within OLMlets (Al-Shanfari et al., 2017)

#### Flexi-OLM

Flexi-OLM (Bull et al., 2010) was deployed for working on a university C-programming course. It includes complex visualizations that show the level of understanding by color of the nodes and

misconceptions giving the textual feedback. OLM also presents detailed views in the form of maps for showing the concept relationships and tree structure for visualizing the hierarchy of the concepts and lecture structure (Bull et al., 2010). Figure 8 represents some of the views of Flexi-OLM.

### **Next-TELL**

Next-TELL is an independent open learner model that is built from multiple data sources (Bull et al., 2013a). It uses various visualizations, both complex and simple, for learners and teachers in order to display the learner's current competencies (Figure 3). These visualizations can be selected according to the user's preferences as well as the purpose of viewing the activity data (Bull and Wasson, 2016).

According to Bull et al. (2013a), Next-TELL aims to flexibly support the way instructors wish, and need, to work. Large groups of users and different data sources can be united in one open learner model without or relatively little intervention from the instructor side. The OLM also allows for feedback from the instructor that can be useful for the learner.

### **Mastery Grids**

Mastery Grids (MG) interface (Guerra et al., 2018) combines OLM visualization, social comparison and a personalized interface for accessing learning content. It uses a coarse-grained OLM that combines and visualizes the learner's knowledge of course topics. For visualizing the knowledge level, the MG uses two colors and different intensity: green represents the learner's level and blue represents a group's level, while the intensity shows the level of the progress (Guerra et al., 2018). Figure 4 shows how the visualization can represent knowledge level among topics and among the students. It is possible to interact with the visualization by clicking the topic cell and to see the content of the activities. The new view shows the progress for the list of activities to the related topic and links to these activities. Such a design of the OLM turns MG into an interactive navigation tool that guides users to the most appropriate learning content (Guerra et al., 2018).



Figure 3: Visualizations for Next-TELL (Bull et al., 2013a)

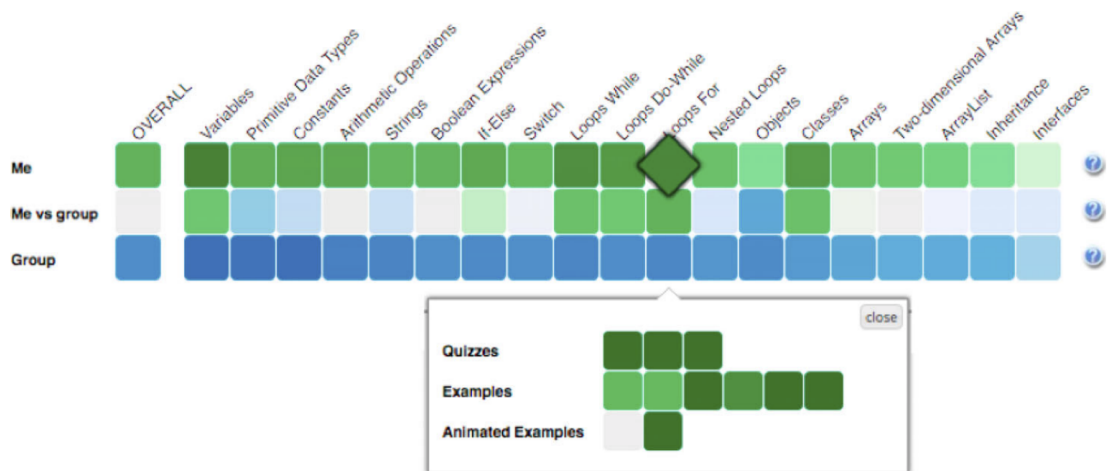


Figure 4: Mystery Grids interface with the social comparison feature activated (Guerra et al., 2018)



## 2.1.6 Open Learner Models and Visualization

A key challenge in opening a learner model is to create an effective interface for presenting the model and enabling interaction with it (Bull and Kay, 2010). While designing the OLM, it is important that the chosen representation formats can provide easy-to-read visual data for users to view, analyze, and compare their learning progress as well as achievement data (Law et al., 2015). The selection of the visualization method is also challenging due to the different preferences and needs of the various actors who will have access to the visualized data (Sergis and Sampson, 2019).

The systematic literature review showed that there are various types of visualization being used for presenting learner models to the different actors in the teaching and learning process. Such variety shows that there is no agreed standard or best approach to opening models to users. The choices of the methods depend on the system's aim (Lloyd et al., 2005). Bull and Kay (2016) also claim that there are some other factors that can influence the choice of the presenting learner models and define them as follows: a) the purpose of the opening of the learner model; b) the target users; c) the learning context (Bull et al., 2013a); d) the learning tasks that are expected to be performed (Bull and Kay, 2016). Individual preferences can also affect the choice of the visualizations for the model (Bull, 2021, 2016; Bull et al., 2010).

It was also mentioned that the size of a domain, its structure, learner modeling technique for OLM, age and information visualization literacy of learners, and purpose of use may as well determine what kind of visualization to use (Bull, 2021).

In several publications, the authors also argue for the use of simple views and multiple views for OLMs. Bull (2021) claims that simpler visualizations can be applied in more cases since the externalization format does not have to match the complexity of the model itself. As for multiple visualizations, they have been found useful to accommodate users' different visualization preferences (Bull, 2016) and information needs as well as to provide flexibility for users to select a method for inspecting the data in their learner models (Law et al., 2015). Different methods of presenting the OLM helps users benefit from effects such as improved self-assessment skills, as they may pay attention to different information depending on whether the OLM uses visualizations, they prefer (Bull et al., 2010).

While analyzing different presentation formats, it was discovered that OLMs use both simple visualizations, such as skill meters, and complex visualizations (for example concept map or treemap) (Law et al., 2015). Each type of visualization has a specific purpose and can work differently for the user. For example, it was shown that more detailed presentations allow specific concepts, misconceptions, connections between them to be presented to the learner (Lloyd et al., 2005). As for the simple visualizations, Ahmad and Bull (2008) discovered that users trust simple overview model information slightly more than detailed model information (Ahmad and Bull, 2008).

More complex, structured visualizations often allow more topics or concepts to be displayed in the same space. This can be especially helpful in large domains with fine-grinded learner models, and where there are many links between different elements of the domain. At the same time, such complexity of the visualization makes it more difficult to identify specific strengths or weaknesses (Guerra et al., 2018).

In addition, it has been found that users have different preferences for how to access their model both when simple formats are used, and when more complex presentations are available (Bull et al., 2007). Therefore, it is possible to conclude that the choice of visualizations depends on the context of using the model and equally important on who will view these visualizations.

For the current research, the systematic literature review identified 41 different visualizations being used in OLMs. Table 2 presents an overview of all types that were either mentioned or described in selected publications. The result shows that among the various visualization forms, there are some types of visualizations that have been mentioned in publications the most, namely skill meter, concept map, hierarchical tree, treemap, word cloud, table, and text. The description of these visualizations and their purpose are presented below.

**Table 2:** Overview of the visualizations from systematic literature review

No.	Type of visualization	Publication (Paper ID from Table 1)	Total number of mentions
1	Skill meter	[1];[2];[3];[4];[5];[6];[7];[8];[9]; [10];[11];[12];[13];[14];[15];[16];[18]; [19];[21];[23];[24];[25];[26];[27];	25
2	Concept map Conceptual graph	[1];[2];[3];[4];[5];[6];[7];[8];[9];[11]; [12];[13];[14];[15];[16];[17];[21];[24];	18
3	Hierarchical tree Hierarchical structure	[4];[5];[7];[8];[9];[11];[12];[13];[14];[16] [17];[22];[24];	13
4	Tree Tree structure	[2];[13];[15];[16];[17]; [22];	6
5	Treemap	[3];[5];[6];[7];[8];[10];[11];[14];[15];[16] [19];[20];[21];[23];[25];	15
6	World cloud Tag cloud	[3];[5];[6];[7];[8];[10];[15];[16];[19]; [21];[23];[25];	12
7	Table Tabular	[2];[3];[5];[7];[10];[13];[16];[18]; [21];[22];[25];[26];	12
8	Smiles Smiley faces Smileys	[2];[5];[7];[9];[15];[16];[19];[25];	8
9	Text feedback Textual description Textual summary Text	[2];[3];[4];[5];[9];[13];[15];[16];[18]; [24];[25];[26];	12
10	Bayesian network	[4];[9];[13];[24];	4
11	Histogram	[3];[7];[16];	3
12	Achievement badges	[2];	1
13	Bar graph Bar chart	[2];[14];[15];[16];[21];[25];	6
14	Pie chart	[2];[16];[21];[25];	4
15	Matrix Grid Grid plot	[2];[16];[25];	3
16	Network Competency network	[6];[7];[8];[10];[11];[14];[15];[19];	8
17	Radar plot	[6];[7];[13];[15];[16];	5
18	Star	[7];[18];[25];	3
19	Gauges	[7];[14];[16];[21];	4
20	Sunburst	[8];[22];	2
21	Magic wands	[9];	1

22	Map-based visualization	[10];[13]	2
23	Proficiency map	[14];	1
24	Bullets visualization	[14];	1
25	Graph	[15];[16];[18];[26];	4
26	Sparklines	[15];	1
27	Prerequisites	[15];[16];[17][21];	4
28	Rose chart	[16];	1
29	Index	[17];	1
30	Box	[18];[26];	2
31	Ranked	[17];[21];	2
32	Boxplot	[21];[25];	2
33	Fan scales	[21];[25];	2
34	Line scale	[21];[25];	2
35	Word count	[23];	1
36	Thread plot	[23];	1
37	Task list	[25];	1
38	Burn down chart	[25];	1
39	Target plot	[25];	1
40	Spider plot	[25];	1
41	Ladder scale	[25];	1

### **Skill meter**

Skill meter (Figure 5) is the most commonly used simple representation of the learner model contents, with a meter assigned to each topic or concept. It is possible that each such skill meter may include a separate skill meter for sub-topics (Bull and Kay, 2010). This presentation format is able to show skills, competency, mastery, or understanding of topics or concepts by the amount of fill in the meter (Bull, 2020; Bull et al., 2013a; Guerra et al., 2018; Lloyd et al., 2005) as well as misconceptions (Bull et al., 2010).

Different studies showed that skill meters are the most frequently used by all groups (Bull and Mabbott, 2006) and some users prefer such presentation format to more complex visualizations (Bull et al., 2013a; Guerra et al., 2018; Law et al., 2015; Lloyd et al., 2005). For teachers, using

skill meters is an efficient way to follow a group’s progress on the spot in the classroom (Bull and Kay, 2016).

Skill meters are simple, easy to integrate into the interface, relatively easy to implement (Bull and Kay, 2007), and can be used in combination with other views (Bull et al., 2010). For example, Wayang Outpost’s skill meters (Bull, 2020) show mastery, and the growth of plants (Figure 6) represents the effort. Typically, skill meters provide no information about uncertainty of data. In order to solve this, Epp et al. (2014) proposed to indicate uncertainty using grain and opacity for skill meter fill.

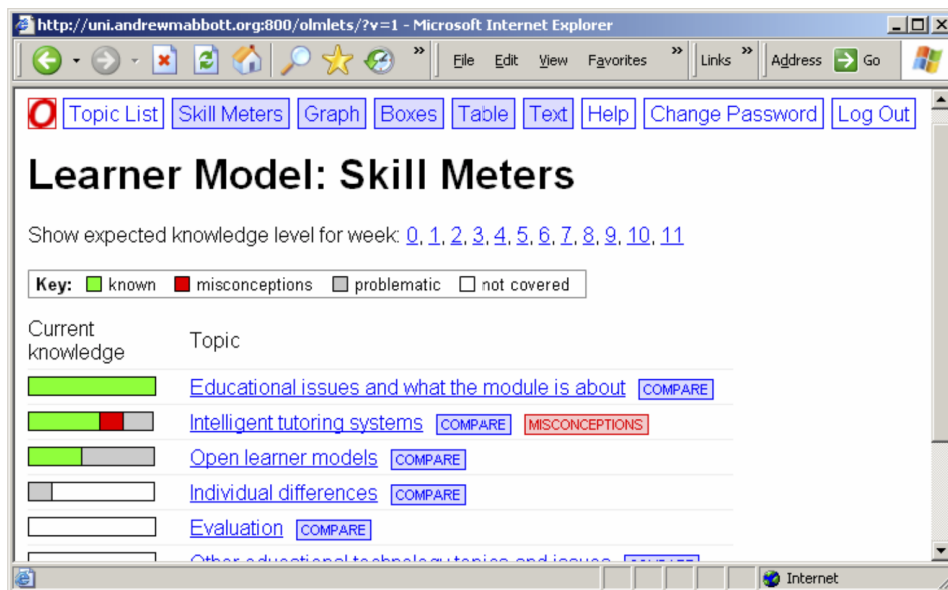


Figure 5: Example of Skill meter (Bull and Mabbott, 2006)



Topic	Remark	Performance	Effort	Action
Numerical Expressions and Operations	Skill mastered! You have demonstrated exceptional help usage in this topic and have this rainbow pepper. Now, do you want to try more challenging problems, or try a new topic? <a href="#">Comments</a>	Mastery Level 97 Problems Done : 115/33 <a href="#">Learn More</a>		<a href="#">Continue</a> <a href="#">Review</a> <a href="#">Challenge</a>
Expressions with Variables	<a href="#">Comments</a>	Mastery Level 88 Problems Done : 108/35 <a href="#">Learn More</a>		<a href="#">Continue</a> <a href="#">Review</a> <a href="#">Challenge</a>

Figure 6: Skill meter as a plant that represents user’s effort (Bull, 2020)



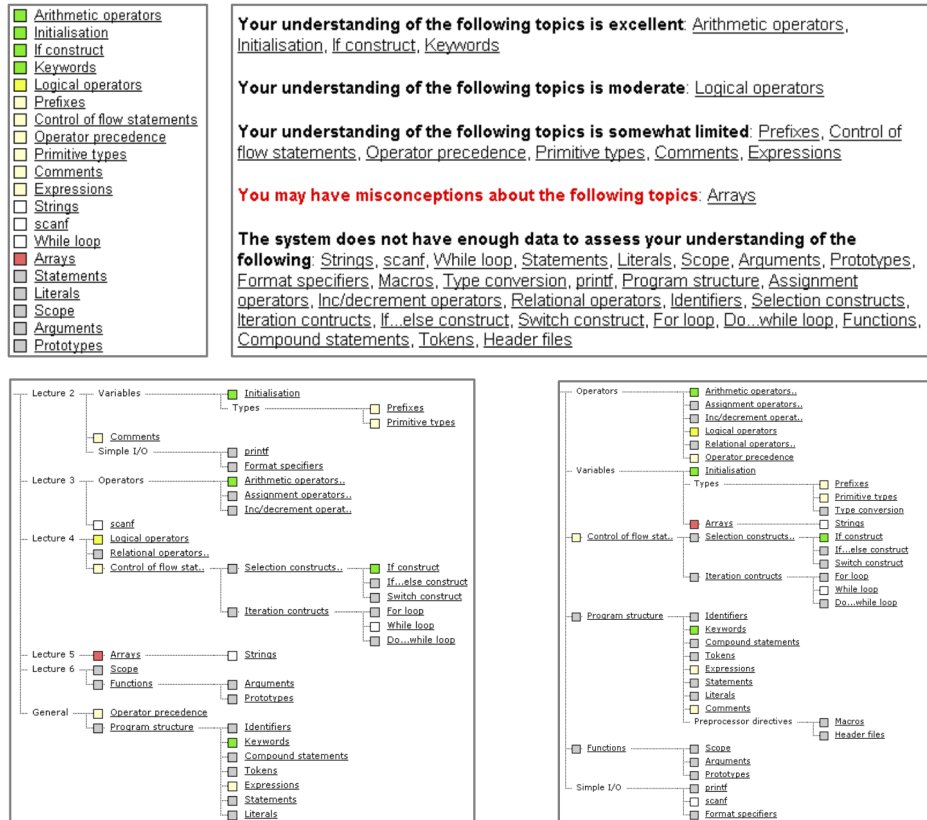


Figure 8: Lecture structure and topics/concepts structure in Flexi-OLM (Bull et al., 2007)

## Treemap

Treemap is a presentation format that helps learners inspect individual learning outcomes (Badea and Popescu, 2020), for example showing the level of understanding for the topics (Bull et al., 2013a). It can be also used for presenting an overview of all concepts for the specific knowledge level (Kump et al., 2012).

Using the treemap visualization can be particularly beneficial for displaying large, hierarchically structured learner models due to the possibility to click on the cells and interact with the visualization. Color and size area reflects corresponding skill level and by clicking on the cell, it leads to the display of the next level of data, but it makes it harder to compare competencies from different parts of the tree (Bull, 2021; Bull et al., 2016; Bull and Kay, 2016). Figure 9 presents one of the options for how the treemap can be used in OLM.

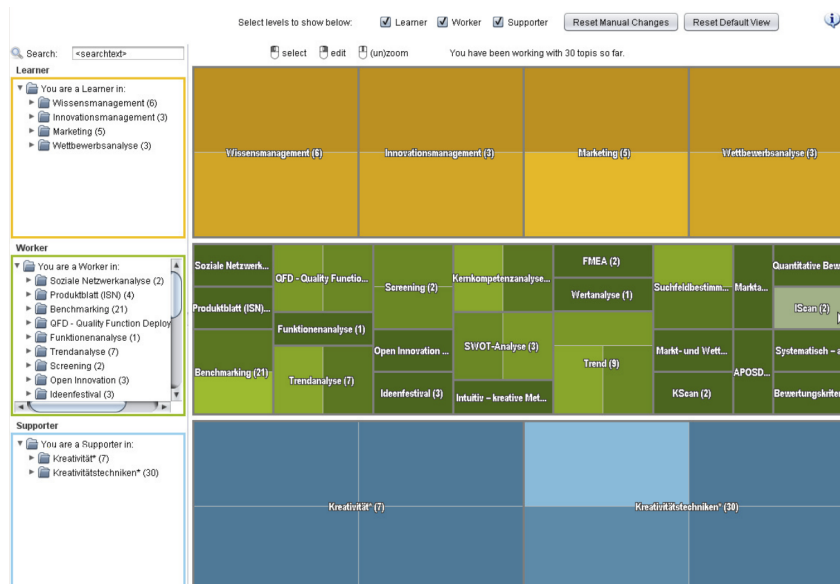


Figure 9: My Experiences: The tree map-based OLM of APOSDLE (Kump et al., 2012)

## Word cloud

Word cloud is a visualization that provides a clear and quick overview of the extremes (strengths and weaknesses) on a specific matter. It can be useful for teacher's on-the-spot classroom decision-making, but less useful for a detailed examination since competencies at borderlines of strong/weak are harder to see (Bull, 2020; Bull and Kay, 2016; Bull and Wasson, 2016). Figure 10 shows that larger blue text indicates stronger areas, with less strong topics in smaller text, while black text represents weaker areas, with less weak (still low) areas in small text (Bull et al., 2016).

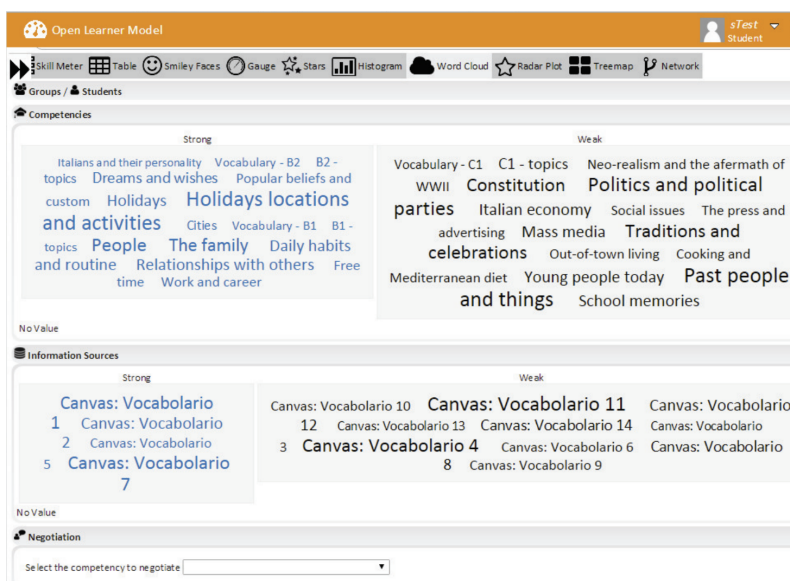


Figure 10: Word cloud (Bull et al., 2016)



## **Table**

Tables are used for presenting details of the knowledge level distribution on individual students for all the concepts (Bull and Mabbott, 2006; Conejo et al., 2012) as well as the activity and topic/competency data (Bull et al., 2013a). For using such presentations in OLM, it is important to provide a good logical organization for them, otherwise, it will be difficult to support instructors to track student data (Law et al., 2015).

## **Text**

This type of visualization can be usually presented as a text statement of knowledge level or a description that provides information about misconceptions (Bull et al., 2010, 2008, 2007; Bull and Kay, 2007). While analyzing the literature, it was also discovered that researchers recommend providing text feedback in addition to visualizations of OLM views as they may help students to have a better understanding of the learner model representations (Law et al., 2015).

## **Non-traditional learner presentations**

Although the main focus of the current work is visualizations, the systematic literature review also identified several non-traditional presentation formats that could be used in OLMs. There are mentioned audio and domain-specific representations that provide information to the learner using text descriptions of learner belief. Animations of a learner's misconceptions for comparison to the correct domain concepts and simulation of the tasks can be also used in OLMs (Bull and Kay, 2010).

Another non-traditional learner presentation is haptic feedback. The strength of knowledge is portrayed by "hardness" or "softness" of a sphere representing an area of the domain (Bull and Kay, 2010; Lloyd et al., 2005).

## **Color**

The current review also showed that colors are a very important aspect that should be considered while designing for OLMs. It is common to use colors for indicating knowledge levels, problematic areas, and misconceptions (Ahmad and Bull, 2008). Multiple colors are useful both in simple and complex visualizations (Bull and Kay, 2007), and changes in shade, opacity, grain could be used to identify the uncertainty (Epp et al., 2014).

## 2.2 Activity data for assessment and adaptivity (AVT)

Activity data for assessment and adaptivity (AVT)<sup>1</sup> is a project that was carried out by Utdanningsetaten, Oslo Municipality, KS, and SLATE in the period August 2017-May 2019. The aim of the project was to explore the possibilities for the integration of activity data between the vendors of different digital tools used for learning in schools. Sharing the data between vendors has the potential for each tool to provide learning tasks that would be better adapted to a learner's needs. The project group had a goal to develop a framework for learning analytics that would structure the data that was generated by learners while working with digital tools, provide secure data exchange between vendors, and recommend relevant tasks for the learners. In addition, the project aimed to gain experience and test solutions for the uniform exchange, structuring, and secure sharing of data (Wasson et al., 2019). Furthermore, a number of stakeholders were interviewed about their understanding of learning analytics; this included teachers and what they wanted to know about their students.

AVT developed a framework for Learning Analytics that included three models: Subject Map named "Fagkart", Integration of activity data, and a Learner model.

### Model 1: Fagkart

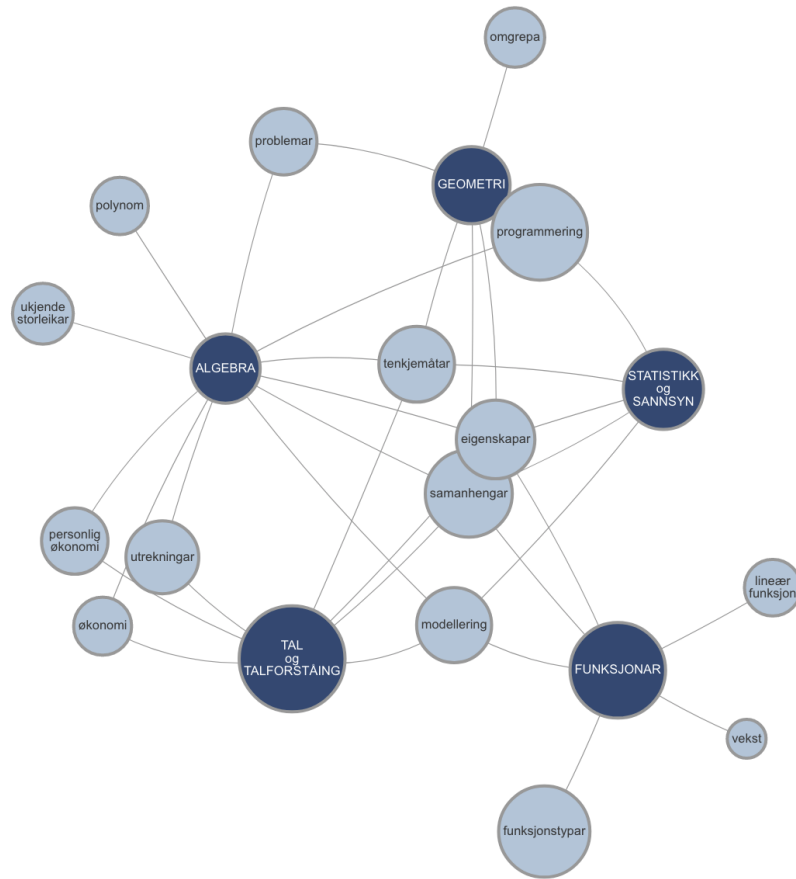
Fagkart presents an organization of the topics within a subject area and enables tagging of the topics to the competence goals in the national curriculum (Wasson et al., 2019). Figure 11 shows an excerpt of Fagkart for mathematics, grade 7.

### Model 2: Integration of Activity Data

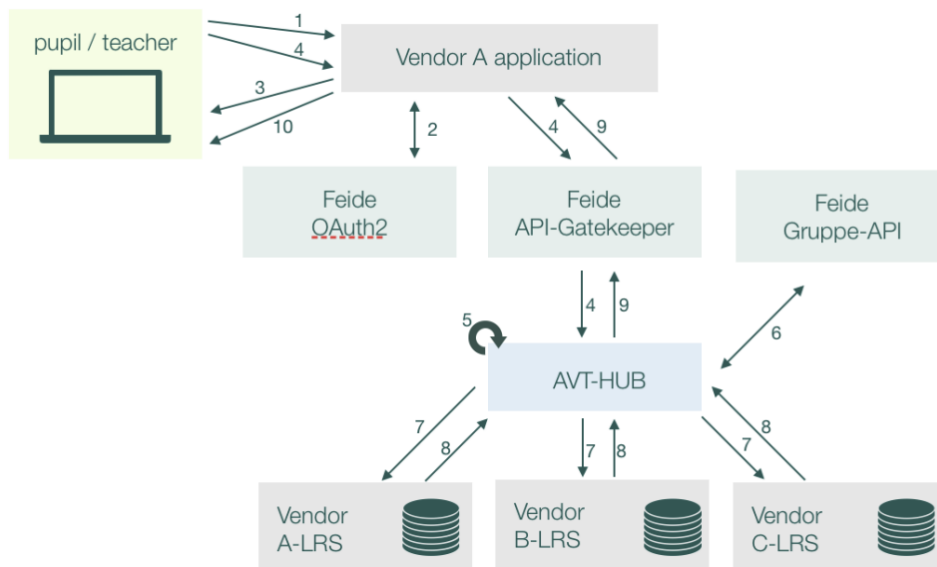
Figure 12 presents integration of the activity data that supports secure sharing of the data between vendors. It was decided that the activity data from vendors has to be shared in xAPI format (Standard Norge recommends this standard) and the activity data has to be tagged against Fagkart. This helps to create a consistent dataset that can be used for learning analytics (Wasson et al., 2019).

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<sup>1</sup> <https://slate.uib.no/projects/aktivitetsdata-for-vurdering-og-tilpasning-avt>



**Figure 11:** Fagkart for mathematics, 7th grade



**Figure 12:** Integration of activity data (Wasson et al., 2019)

### **Model 3: Learner model**

The learner model is a conceptual model that describes the components that are necessary for performing following tasks: a) identifying and representing areas in Fagkart where students have lack of competence; b) recommendation for where in Fagkart student should do some extra work; c) recommendation for an item with which student should work (Wasson et al., 2019). In order to visualize the results of these tasks, it was recommended that an interface that would include an Open Learner Model be designed and implemented. It was recommended that the OLM should contain tailored dashboards with visualizations of aggregated activity data showing the learning progress of the students and recommended items for future work.

### **Interviews with teachers**

In the AVT project a set of interviews with teachers on the subject of what they would like to see in an OLM interface, and what within such an interface could actually help them to improve their teaching routines were carried out. An AVT researcher conducted interviews with 12 teachers who teach mathematics in 8th-10th grades from four schools in the Oslo Municipality. The results of the interviews were a starting point for developing the first ideas for the MittFagkart interface. The analysis of the interviews is presented in Chapter 5.

### **Project continuation**

In 2019 the AVT project received more funding, and the project was extended for 3 years; this extension of the project is referred to as AVT2. AVT2 is focused on the design and development of the OLM dashboard, MittFagkart, a new eco-system of components to support learning analytics in Norwegian schools, a new model for Municipalities and schools to pay for access to learning tools. The research described in this thesis is related to the design and development of MittFagkart and used the teacher interviews as input to the work.

## **2.3 Kunnskapsløftet: The Norwegian National Curriculum**

In 2020 a new national curriculum was introduced in Norway. The AVT2 project decided to adopt this new curriculum as the basis for Fagkart. This means that the OLM dashboard, MittFagkart, being designed in this research will be based on this new curriculum. In particular this means an understanding of the structure of the new curriculum is important for designing the MittFagkart dashboard. This requires a thorough research on what national teaching plans include, how

teachers work with that, and how to visualize activity data in a way it would correspond to teaching plans. In addition, it is also important to explore how teachers can use these visualizations and how these visualizations can help to improve both teaching and learning processes. The following subsections describe the new curriculum, as well as its key elements.

### **Teaching plan 2020 (Læreplan 2020)**

UDIR (The Norwegian Directorate for Education and Training) has responsibility for the national curriculum that describes the competences that students must acquire in different subjects, by different grade levels. A competence consists of a combination of knowledge and skills. Students should be able to use their skills not only in an academic context, but also in their daily life. Thus, the schools and teachers should plan, implement, and evaluate learning in such a way that students will be able to achieve the competence they can use in different contexts such as social context and working life (“UDIR,” 2020).

The curriculum does not present a detailed overview of the knowledge content or a list of the activities that the teacher has to carry out. It, rather, is mostly about exploring a way to involve students in finding working methods, learning resources, arenas, activities, and different forms of assessment that can be relevant for learning, and be able to contribute to learning processes (“UDIR,” 2020).

There is a curriculum plan for each subject area. Each plan includes several concepts: Overall part (Overordnet del), The subject's relevance and central values (Fagets relevans og sentrale verdier), Core elements (Kjerneelementer), Competence goals (Kompetansemål), Interdisciplinary theme (Tverrfaglig tema), Basic skills (Grunnleggende ferdigheter), Assessment scheme (Vurderingsordning) (“UDIR,” 2020).

Some of these concepts that are specifically important and relevant for the research and further development of MittFagkart; these are presented below.

### **Core elements (Kjerneelementer)**

Core elements describe the most important content in the subject. They can represent areas of knowledge and concepts, methods, ways of thinking as well as forms of expression. The core elements are simply about what students must learn in order to master and use the subject. They

are designed to make it easier to see the connections and progression in the subject (“UDIR,” 2020).

All core elements can be used to understand the competence goals and to see the connection between them, as well as to select the content for the competence goals. An example of the core elements for social studies: “Citizenship and sustainable development” (Medborgerskap og bærekraftig utvikling); “Identity and life skills (“Identitet og livsmestring”) (“UDIR,” 2020).

### **Competence goals (Kompetansemål)**

Competence goals describe what pupils should be able to do after different grades. Competence goals emerge from the subject’s core elements and the other introductory texts for the curricula. They are designed in a way that allows the adapting mid-term assessment, learning resources, and other activities to the students. An example of a competence goal after 4th grade in English: “The student must be able to follow simple rules for spelling and sentence structure” (In Norwegian: “Eleven skal kunne følge enkle regler for rettskriving og setningsstruktur”) (“UDIR,” 2020).

### **Knowledge areas (Kunnskapsområde)**

UDIR presents the concept of knowledge areas in mathematics as the areas: Numbers & Number Understanding, Algebra, Functions, Geometry, and Statistics & Probability. Such knowledge areas form the basis that students need for understanding and solving mathematical problems as well as exploring the connections between these mathematical knowledge areas (“Kjerneelementer,” 2020).

### **Verbs (Verb)**

Each competence goal is described with help of specific verbs (e.g., “develop” (utvikle), “explore” (utforske), “use” (bruke), “read” (lese), “understand” (forstå) and similar) (Figure 13). Although the verbs remain the same from grade to grade, there is an increasing complexity of their meaning. In the 4th grade a pupil should be able to read or listen to/read stories, fairy tales, lyrics and other types of texts, while in 7th grade a pupil should still be able read, but poetry, short stories and other fiction/non-fiction texts (“Kompetansemål,” 2020). Thus, the verb is stable over the years and development of the skill depends on the material that a pupil should work with. These verbs are specifically highlighted in the curriculum and can be used for planning and evaluating the learning processes for the students.

### Kompetansemål etter 4. trinn

Mål for opplæringa er at eleven skal kunne

- utforske og bruke målings- og delingsdivisjon i praktiske situasjonar
  - representere divisjon på ulike måtar og omsetje mellom dei ulike representasjonane
  - utforske, bruke og beskrive ulike divisjonsstrategiar
- Å utforske handlar om å oppleve og eksperimentere og kan ivareta nyfikkne og undring. Å utforske kan bety å sanse, søke, oppdage, observere og granske. I nokre tilfelle betyr det å undersøke ulike sider av ei sak gjennom open og kritisk drøfting. Å utforske kan òg bety å teste eller prøve ut og evaluere arbeidsmetodar, produkt eller utstyr.
- bruke ikkje-standardiserte måleiningar for areal og volum i praktiske situasjonar og grunnngi valet av måleining
  - utforske og beskrive strukturar og mønster i leik og spel
  - lage algoritmar og uttrykkje dei ved bruk av variablar, vilkår og lykkjer

**Figure 13:** Representation of the verbs for competence goals in curriculum (“UDIR,” 2020)

## 2.4 Chapter Summary

This chapter presented the background work for the current research. The literature review introduced the concept of OLM and different benefits and challenges while working with such a learner model. A number of different visualizations used for presenting OLMs were identified. Additionally, the AVT and AVT2 projects in which the research is situated were described and the National curriculum on which the AVT2 OLM will be built was presented.

The findings of the systematic review gave valuable insight into the nature of OLMs, OLM visualizations, and will be helpful for the further design and development of the AVT2 project’s OLM, MittFagkart, see Chapters 4-6.

## **3 METHODOLOGY**

This chapter presents the methodology and methods that are used for the research. The User-Centered Design methodology and various methods for prototyping, evaluation, data collection, and organization of the work are described.

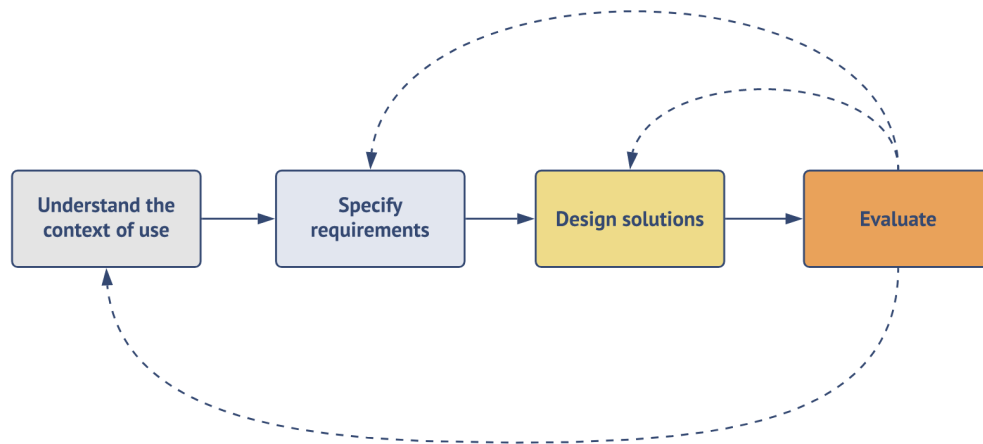
### **3.1 User-Centered Design**

User-Centered Design (UCD) is a design approach where real users and their goals and preferences are placed in the center of product development. As a result, the developed product is relevant and will support users' activity rather than constrain it (Preece et al., 2015, p. 327).

While designing for usability, Gould and Lewis (1985) recommend the following three main principles: an early focus on users and tasks, empirical measurement, and iterative design. The first principle is about understanding who the users are going to be. It is important to study users' cognitive and behavioral characteristics as well as the nature of the work expected to be accomplished. The second principle, empirical measurement, should be used during the early stages of the development process, and has the users actually use the simulations and prototypes to carry out real activities. It is essential to observe and analyze their reactions as well as their performance. The third principle, iterative design, intends that an iterative cycle of design-prototyping-testing will ensure that all mistakes and issues that appeared during user testing are addressed (Gould and Lewis, 1985).

UCD includes four distinct phases (Figure 14). The first phase is focused on gaining an understanding of the context in which users may use a system: who will use it, for what purpose, and what are the circumstances of using it. The second phase includes identification and establishment of the user requirements. The third phase is a design phase where the solution is built based on the requirements. The fourth phase is an evaluation phase where the design is being evaluated against the user's context as well as user's requirements (Le, 2018). An iterative process comprising these four phases continues until the evaluation results are satisfactory ("User Centered Design," n.d.).





**Figure 14:** Four phases of the UCD process

### 3.2 Context of Use

Prior to any usability design it is necessary to understand the context of use of the developing system. It includes the understanding of the goals of the user community, the main user, tasks and environmental characteristics of the situation in which it will be operated (Maguire, 2001).

The current research is a contribution to the AVT2 project. Earlier AVT reports and attendance at the project meetings have given a good understanding of the main concept of the learner model as well as the context of the use of the MittFagkart. Understanding the AVT2 project, which sets the context – is described in Chapter 4. The target group is presented in Chapter 5.

### 3.3 Requirements

Traditionally there are two different types of requirements identified: functional requirements and non-functional requirements. Functional requirements are focused on what the system should do while non-functional requirements describe what constraints there are on the system and its development (Preece et al., 2015, p. 353).

Establishing requirements is an essential part of the user-centered design process. This section presents the methods that have been chosen for establishing functional and non-functional requirements for the system.

### **3.3.1 Persona**

Persona is a rich description of the potential user (Preece et al., 2015, p. 357). Creating a persona in the early stage of the development process helps to present a particular group of people with the same behavior, needs, goals, skills, and attitudes. The persona also helps to prioritize design work, understanding what users' needs are and what functions should be implemented (Le, 2018).

### **3.3.2 Use case**

Use case describes a set of actions that is believed to be most commonly performed within the system (Preece et al., 2015, p. 376). The main focus within a use case is on the user's goal with the emphasis on the user-system interaction.

### **3.3.3 Storyboard**

A storyboard in UX design is a tool that visually predicts and explores a user's experience with a product (Babich, 2017). The concept of the storyboard is to create a linear sequence of illustrations in order to visualize the story. This approach helps to understand the flow of user interactions as well as what is important for them while using the product.

There are several benefits of using storyboards. First, this technique is a user-centered approach that places users at the heart of the design process. It helps to focus on user experience as well as to keep in mind users' needs. Second, storyboards provide a good understanding of user flow and user interactions within the product. Building possible scenarios helps to identify problems that might occur while using the product, hence making developers think about possible solutions in the early stages of the development process. Third, the storyboard method prioritizes what is important for the particular product. It helps to minimize unnecessary work as well as an extra cost (Babich, 2017).

### **3.3.4 Studying documentation**

Studying documentation can be useful for understanding legislation and getting some background information regarding the work (Preece et al., 2015, p. 363). In the current research some documents were provided by the project team. First, the reports of the interviews with teachers about what they potentially would like to have in the OLM were provided. The results of

the analysis of these reports can significantly contribute to the establishing the requirements for the MittFagkart. Second, research work done regarding the national teaching plan 2020 for mathematics will be used to better understand the structure of the curriculum.

### **3.3.5 Experience prototyping workshop**

According to Buchenau and Suri (2000), experience prototyping is any kind of representation, in any medium, that is designed to understand, explore or communicate what it might be like to engage with the product, space, or system being designed. Experience design can include any design prototyping technique, for example, storyboards, scenarios, sketches, etc. (Buchenau and Suri, 2000).

The main purpose of experience prototyping in this activity is in facilitating the exploration of possible solutions as well as directing towards a more informed development of the user experience and the real components which create it. Hence, the experience is already focused on specific artifacts, elements, or functions (Buchenau and Suri, 2000).

This method will be used for getting some design ideas for the MittFagkart. The experience prototyping will be part of the workshop that focuses on finding out what users' needs are and how they see the system that presents the information about students' learning.

### **3.3.6 Systematic literature review**

A systematic literature review is defined as “a means of evaluating and interpreting all available research relevant to a particular research question, topic area, or phenomenon of interest. Systematic reviews aim to present a fair evaluation of a research topic by using a trustworthy, rigorous, and auditable methodology” (Kitchenham and Charters, 2007). For the current research, it was chosen to use a light version of the systematic literature review (Stapic et al., 2021) that include the following phases:

- Developing a protocol.
- Defining the research question(s).
- Specifying what will be done to address the problem of a single researcher applying inclusion/exclusion criteria and undertaking all the data extraction.
- Defining the search strategy.

- Defining the data to be extracted from each primary study including quality data.
- Maintaining lists of included and excluded studies.
- Using the data synthesis guidelines.
- Using the reporting guidelines.

The method was used for gathering information regarding the design of the OLM dashboards, OLM visualizations, and researching similar OLMs. The results were presented in Chapter 2.

### **3.3.7 Researching similar products**

Researching similar products helps to prompt necessary requirements for the development (Preece et al., 2015, p. 363). The systematic literature review identified several research papers that describe some of the already existing OLMs. A review of these OLMs will be carried out in order to generate alternative designs for the OLM visualisations (see section 2.1.5).

## **3.4 Design Solutions**

This section describes the prototyping methods that will be used for the design of MittFagkart.

### **3.4.1 Prototyping**

Creating a prototype is one of the essential parts of the design process. The main purpose of doing it is to allow stakeholders to interact with it in order to explore its suitability (Preece et al., 2015, p. 386). Prototypes can be presented in different forms: it can be a paper-based storyboard or an actual clickable wireframe that shows the layout of the product. They are useful when discussing and evaluating ideas with stakeholders as well as they are able to answer research questions and support designers in choosing between different alternatives (Preece et al., 2015, pp. 387–388).

There are two types of prototypes: low-fidelity prototypes and high-fidelity prototypes. Low-fidelity prototyping is a quick and cheap way to present the ideas and design solutions for a product while high-fidelity prototypes are able to provide more functionality and present a version of the product that is close to the final one (Preece et al., 2015, pp. 389–392).

For this research several methods have been chosen for prototyping: sketching, wireframing, and creating a digital clickable prototype. The choice of the methods is based on their relevance to the methodology as well as personal experience.

### **3.4.1.1 Sketching**

Sketching is one of the most common methods for prototyping. It is efficient for illustrating the ideas and design solutions on the early stages of work as well as on the late iterations of the design process. Sketching the layouts or mind maps can be also useful for illustrating complex systems or processes (Dam and Siang, 2020).

### **3.4.1.2 Wireframing**

A wireframe is a blueprint that helps designers and programmers to build the structure of the software, application, or website that is being built. Wireframing forces designers to focus on the structure over the visual details. The wireframes have an intentional low-fidelity look which encourages discussion. In addition, they are not costly and do not require a lot of time for implementation (Guilizzoni, n.d.).

### **3.4.1.3 Digital clickable prototype**

Digital clickable prototype is a high-fidelity prototype that is able to bring the design to life. It can look like a final version of the product but with limited functionality. Users are able to interact with it in order to understand a concept of the product. Such prototypes help to test the designers' assumptions and move progressively towards a final design solution (Quincy Smith, 2019).

Digital clickable prototypes are usually made with help of special tools or software that work as constructors. There are various different platforms that can be used for this purpose. For current work, it was decided to build a clickable web prototype in Proto.io ("Proto.io," 2021).

## **3.4.2 Design principles**

Design principles are used for promoting the designer's thinking while designing for the user experience. These principles can suggest what can be provided in the design and what should be

avoided. There are a number of design principles, but for this work, the most common are considered, namely: visibility, feedback, constraints, consistency, and affordance (Preece et al., 2015, pp. 26–30).

### **Visibility**

The principle is that the more visible functions are, the more likely the user will be able to use them as well as know what to do next. In contrast, when the features are out of sight, it makes them difficult to find hence difficult to know how to use them.

### **Feedback**

Feedback allows sending back the information about what action has been taken and what was the result of this action, allowing the user to continue with the activity. The feedback can be presented as audio, text, visualizations or the combinations of these.

### **Constraints**

This principle is about restricting a particular form of user interaction with an interface. It is important in the design because the user could become overwhelmed with a lot of different possibilities available in one interface. An example of that can be deactivating certain menu options and coloring them grey in order to restrict the user to take actions that are not relevant at the given time.

### **Consistency**

The consistency principle refers to creating interfaces that have similar operations and use similar elements for achieving similar tasks. If similar-looking things do not produce a similar output, the user becomes frustrated. The more an interface is consistent, the easier to learn it hence easy to use.

### **Affordance**

This principle is focused on the connection between how things look and how they can be used. When the affordance of the object is obvious, it is easy to know how to use it. The same principle for the design: it should be intuitive enough that the users know how to access the desired information by just looking at the interface.

### **3.4.3 System development method**

For structuring the work, it was chosen to use agile software development method due its flexibility. Collier defines agile software development as various approaches to software development under which requirements and solutions evolve through the collaboration of self-organizing and cross-functional teams and their customers/end users (Collier, 2012). Since the research work, particularly designing a prototype of the OLM, is part of a bigger project that involves other contributors, agile development can be an efficient way of structuring the workflow.

It was chosen to work with Kanban framework because it is considered as a better fit for the project team. Kanban framework is based on a continuous workflow structure that keeps teams nimble and ready to adapt to changing priorities. The tasks are organized on a kanban board where they flow from one stage of the workflow (column) to the next. Common workflow stages are *To Do*, *In Progress*, *In Review*, and *Done*. There is also a possibility to have customized stages if it is necessary (Atlassian, n.d.).

## **3.5 Evaluation**

Evaluation process focuses on both the usability of the system and on the users' experience when interacting with it (Preece et al., 2015, p. 452). It is a valuable and iterative process of design that helps to improve the developing product. For the current work, it was chosen to use such methods as usability testing, UI expert evaluation, and Heuristic evaluation. The feedback from the project team is also a part of the evaluation.

### **3.5.1 Data collection**

Data gathering is an essential part in the evaluation process. According to Preece et al. (2015) data collection needs to be planned and carried out carefully. There are five key issues that should be considered in order to make data gathering successful: setting goals, identifying participants, relationship with participants, triangulation, and pilot studies (Preece et al., 2015, pp. 227–231).

## **Setting goals**

Setting goals is important for data gathering since it will influence the techniques for data collection as well as further analysis. The goals may be expressed informally but should be clear and concise.

## **Identifying participants**

The established goals for data gathering lead to identifying the participants for the study. The people who fit the profile called the population. Since the population can include an enormous number of people, there is a need for sampling - choosing the proportion of participants for the study. There are two types of sampling: probability sampling and non-probability sampling. The first type includes such techniques as random sampling or stratified sampling, while for the second type it is more common to use convenience sampling or volunteer panels.

Random sampling can be done by choosing every nth participant when in stratified sampling the participants are divided into groups and then the random sampling is applied. Convenience sampling and volunteer panels are approaches that rely on participants' will to contribute rather than on being selected for the study.

## **Relationship with participants**

Before running data gathering, the relationship between the one who conducts the study and the participants should be clarified. One way of doing it is by creating a consent form that explains what participants are expected to do as well as what will happen with the data they will produce. It is also common to include a statement that participants can withdraw from the study anytime, which means that their data will not be used in the study.

## **Triangulation**

The concept of triangulation is about the investigation of the phenomenon from two different perspectives. To achieve that, different techniques, several data sources, theoretical frameworks or and approaches are used. This can enhance the value of the study.

## **Pilot studies**

A pilot study is a small trial of the main study. Conducting a pilot study helps to be sure that the proposed methods are viable. It is not necessary to involve participants from the target group, it



could be colleagues or peers. The main goal is to understand if the planned methods will help to make the data gathering sessions successful for the project.

### **3.5.2 Usability testing**

Usability testing is an approach that is used for evaluating user interface by collecting data using different methods, e.g., observations, experiments, interviews, and questionnaires. The main goal is “to determine whether an interface is usable by the intended user population to carry out the tasks for which it was designed” (Preece et al., 2015, p.457).

While users perform the set of tasks, they can be recorded as well as their interactions with the system. It helps to compare different kinds of errors that the users make, thus highlighting the problem that needs to be solved in future iterations (Preece et al., 2015). Examples of the tasks that can be given to users include for instance searching for particular information and navigating in the system.

Usability testing is an efficient way to identify uncovered problems in the design as well as discover new opportunities for improving it. In addition, usability testing helps to learn more about the user's behavior and preferences that can be helpful for improving the design solution as well (Moran, 2019).

#### **3.5.2.1 Design of Usability Test**

Due to the COVID-19 pandemic the usability testing will be held remotely over Zoom and Microsoft Teams in a form of semi-structured interviews. Each session will last approximately 1 hour and include three participants: a facilitator, an observer and a user from the focus group. The testing session carries a small presentation about the product, questions regarding the users' occupation and working style, and presenting two tasks for testing the concept of the system. All testing sessions will be recorded in order to enable a detailed analysis of the results.

To run a well-structured and understandable usability testing, a script has to be designed (see Chapter 6, section 6.4.2). There is also a need of making a consent form that describes the goal of the usability testing and asks for permissions for recording the video and audio. A consent form can be found in Appendix A.

### **3.5.2.2 Semi-structured interviews**

Semi-structured interview is a method that has been chosen for holding usability testing of the prototype of the MittFagkart. This type of interview collects detailed information in a style that is somewhat conversational. According to Louise Barriball and While (1994), there are two advantages over other types of interviews. First of all, such interviews are well suitable for exploration of the opinions of respondents as well as they enable probing for more information and clarification of answers. The second reason is that the varied professional, educational, and personal histories of the target group precluded the use of a standardized interview schedule (Louise Barriball and While, 1994).

During the usability testing, semi-structured interviews can provide instant feedback regarding the MittFagkart as well as help to see what teachers expect to get from the product. Some of the comments and questions can be useful for further research.

### **3.5.3 Expert evaluation**

For the current research, there were three types of experts involved in the evaluation of the prototype. First, the project team, who provided their feedback on the design and functionality of the prototype of the MittFagkart. Even though the members come from different disciplines, they have rich experience with system development for learning. Such evaluation was not primary, but still very valuable to the work.

Second, the UI expert was questioned in regard to the functionality and design of the MittFagkart. He provided some comments and suggestions on how the layout of the OLM could be improved as well as clarified some technical aspects that should be considered while designing such systems like MittFagkart.

Third, three usability experts were asked to participate in heuristic evaluation.

#### **3.5.3.1 Heuristic evaluation**

Heuristic evaluation is a usability inspection method that was developed by Jakob Nielsen and his colleagues. This approach includes an evaluation that is performed by experts guided by a set of

usability principles known as heuristics. For better results, it is recommended to use from three to five experts (Preece et al., 2015, pp. 501–503). The Nielsen’s heuristics are presented in Table 3.

**Table 3:** Nielsen's' heuristics (Preece et al., 2015, pp. 501–502)

<b>Heuristic</b>	<b>Explanation</b>
Visibility of the system status	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Match between system and the real world	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.
User control and freedom	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.
Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing.
Error prevention	Even better than good error messages are a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
Recognition rather than recall	Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Flexibility and efficiency of use	Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Aesthetic and minimalist design	Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
Help users recognize, diagnose, and recover from errors	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

It was also chosen to create a heuristic evaluation sheet that would be handed to each expert during the evaluation (Appendix B). It includes a list of heuristics, fields for comments and recommendations for each heuristic, and rating scale from 0 to 4. This rating scale is used for counting the severity of usability problems. The description for each score is presented below (Table 4).

**Table 4:** Rating scale (Nielsen, 1994)

<b>Score</b>	<b>Description</b>
<b>0</b>	I don't agree that this is a usability problem at all
<b>1</b>	Cosmetic problem only: need not be fixed unless extra time is available on project
<b>2</b>	Minor usability problem: fixing this should be given low priority
<b>3</b>	Major usability problem: important to fix, so should be given high priority
<b>4</b>	Usability catastrophe: imperative to fix this before product can be released

### **3.6 Chapter Summary**

This chapter introduced the central methodology of the research, namely user-centered design. The methods of the data gathering for the establishment of the requirements and evaluation processes were also presented. Methods for the prototyping were described along with the system development method.

## **4 AVT2 PROJECT**

This chapter presents the concept of the OLM MittFagkart, and research carried out during the AVT2 project. The contribution of this research to the project is described as well, namely the development process of the logo design, color scheme, and home page for MittFagkart.

### **4.1 Open Learner Model - MittFagkart**

One of the goals of the AVT2 project is to create an OLM dashboard named MittFagkart that will support adaptive learning in Norwegian schools. MittFagkart is an independent and inspectable OLM that visualizes student activity in a subject domain and their progress towards the learning goals defined by the national curriculum plan. Activity data generated when students used digital learning tools is used in learning analytics that evaluate student progress in a subject domain, as well as recommending further learning activities. The results of the learning analytics are visualized in MittFagkart.

Figure 15 shows the work process of MittFagkart. A student is assigned to perform several tasks in a variety of learning tools in Mathematics (e.g., Kikora). Produced activity data from across the applications is processed and visualized by MittFagkart. The visualizations present the information about the progress of the student in accordance with competence goals defined in the national curriculum for mathematics, the core elements of the subject, and the knowledge area where s/he works. Thus, teachers are able to evaluate their own student's level of knowledge and plan further learning with the focus on improvement.

MittFagkart can potentially be accessed by different stakeholders (e.g., students, teachers, parents, vendors, researchers), but at the current state of work, this research addressed MittFagkart for teachers. Due to the COVID-19 pandemic, there was no possibility to interview students, researchers, and parents in order to find out what would be important for them to have in MittFagkart, thus it would not be possible to test the prototypes with other stakeholders either. There was also a need for deeper research into what is legally allowed to show to the different stakeholders about students' progression (the project is currently carrying out this work).

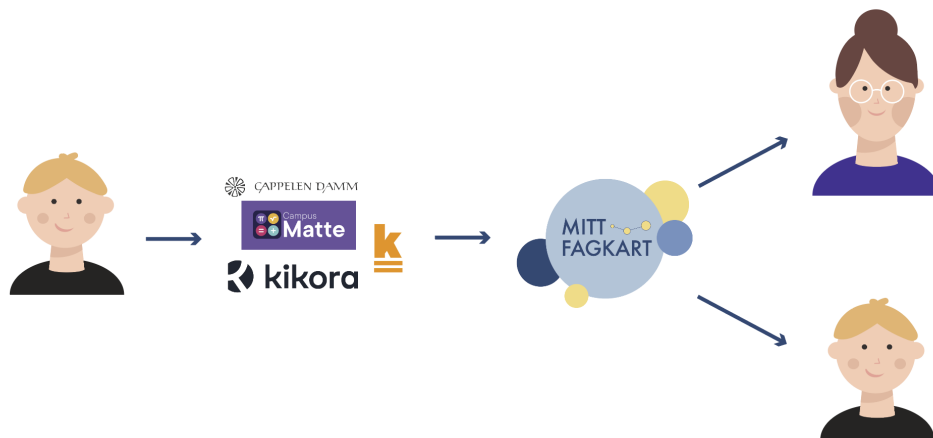


Figure 15: The work process of the MittFagkart

### 4.1.1 Data for MittFagkart

In order to visualize the students' progress in the MittFagkart, activity data is collected. Figure 16 shows the process of collecting and processing data for the MittFagkart.

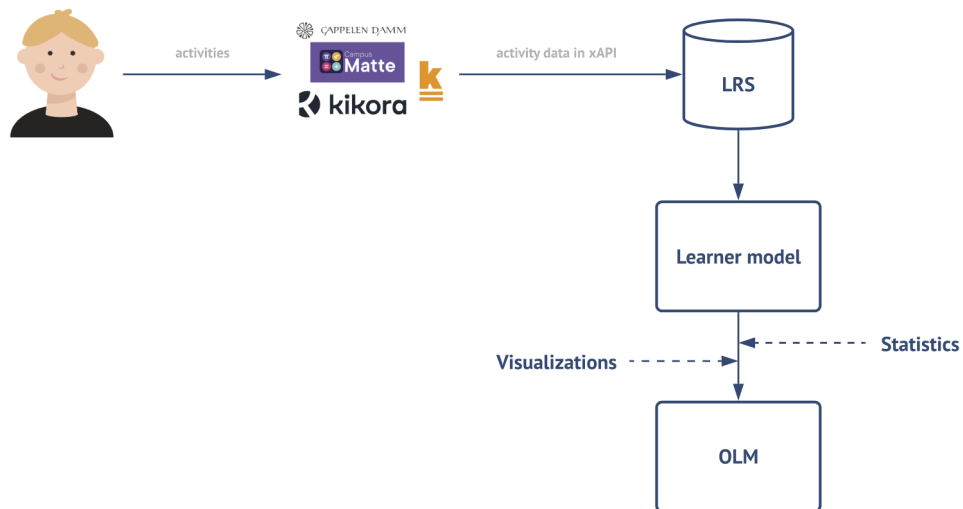
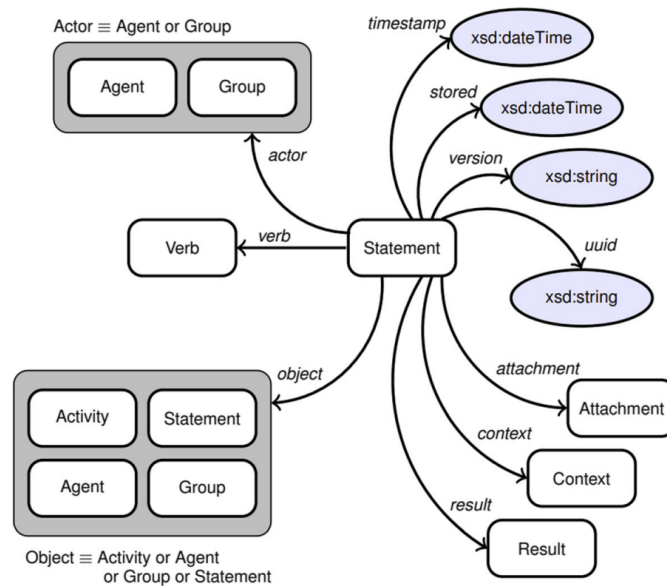


Figure 16: The process of getting data for the OLM

A student performs activities in a digital learning tool. The vendor collects activity data and combines this with tags (Figure 17) that link the items to the national curriculum (as represented in Fagkart (recall section 2.2)) and transfers the data to the Learner Record Store (LRS) as xAPI statements. xAPI statements consist of the block “actor verb statement”, where the actor is who carries out an activity, the verb describes the action that happened between actor and object, and the object represents the object activity/another actor or other statements (Samuelsen et al., 2021). Figure 18 presents the structure of the xAPI statement with available properties.

```
{
  "code": "kunnskapsomraade:algebra",
  "uri": "https://fagkart.no/avt2/ontology/types/knowledge_area/objects/f39d563b-950d-5238-ba95-873b232f41bd",
  "url-data": "https://fagkart.no/avt2/api/ontology/types/knowledge_area/objects/f39d563b-950d-5238-ba95-873b232f41bd",
  "title": "ALGEBRA",
  "fagkart-type": "https://fagkart.no/avt2/ontology/types/knowledge_area/"
}
```

**Figure 17:** An example of the tagging



**Figure 18:** xAPI statement (Samuelsen et al., 2021)

The xAPI statements provided by vendors generally include such values as timestamp, actor, verb, object, result, and context. An example of such an xAPI statement in JSON format is presented in Appendix C.

Then, from the LRS, the learner model collects a set of xAPI statements for an individual student. By applying learning analytics on the data and algorithms that use the results for visualizations, the visualizations are presented in the OLM.

### 4.1.2 Authentication in MittFagkart

Authentication in MittFagkart goes through the Feide portal. Feide is “a centralized identity management solution for the educational sector of Norway and is short for «*common electronic identity management*» (in Norwegian: «*felles elektronisk identitetshåndtering*»)(“Feide,” 2019). It is widely used by universities, university colleges, and schools for authorization of users (students and employees such as teachers) and it generates a digital identity that allows them to access the web services used in educational institutes. This digital identity is used by a vendor to identify the subject in the activity data that is generated by their tool.

### 4.1.3 Vendors

The activity data for MittFagkart is provided by different digital learning tools used in schools. Table 5 shows the list of vendors who participate in the AVT2 project, and the products offered to the schools. Using these tools produces the activity datasets for learning analytics and MittFagkart.

**Table 5:** List of vendors and their products

Vendor	Product
Campus Increment	Campus Matte
Cappelen Damm	Skolen
Conexus	Relemo
Conexus	Lesepakka
Cyberbook	Kunnskap.no
KF	eMatte
KF	Skolerom
KF	Skrible
Kikora	Kikora



## 4.1.4 Visualizations for MittFagkart

The visualizations of the OLM dashboard, MittFagkart, were chosen for the following curriculum components: competence goals, knowledge areas, and verbs. Based on the systematic literature review, the most common visualizations were considered for use in MittFagkart (Figure 19).

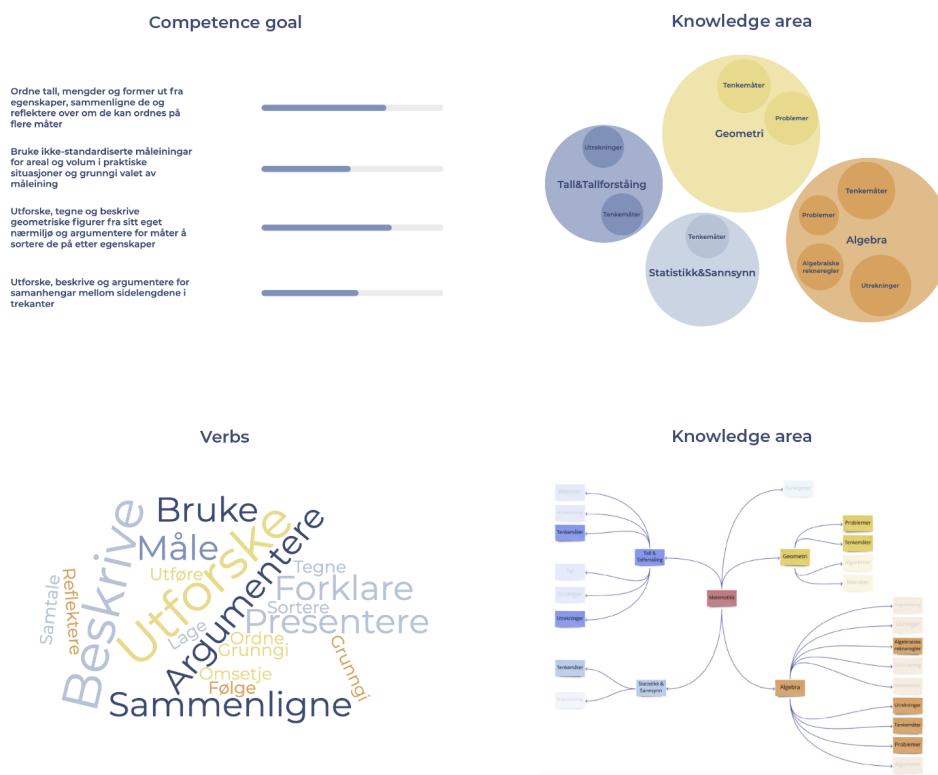


Figure 19: OLM Visualizations for MittFagkart

For displaying the competence goals, it was chosen to use skill meters. They represent the proportion of the activity items that are related to a specific competence goal and to the total amount of items for the same goal. Skill meters are easy to perceive and, most importantly, they directly correspond to the essence of the competence goals - the skill bar shows the progress towards the goal.

A concept map visualization is considered an efficient way of showing the relationships between elements. Hence, this representation format could be useful for identifying the connections between knowledge areas. In order to highlight the knowledge areas that students did not work with, it was decided to lower the opacity of the color for these areas.

The systematic literature review also revealed that the users prefer to have multiple representations of the same data. Thus, it was also decided to present the knowledge areas with help of a circular treemap - the equivalent of a treemap. Each node of such a treemap is represented as a circle and its sub-nodes are represented as circles inside of it. The size of each circle can be proportional to a specific value (Healy, n.d.), which in MittFakart could show the level of the knowledge area. This interactive visualization can also clearly show a hierarchy between the knowledge areas.

Word cloud was chosen for showing a clear overview of the strengths and weaknesses regarding the verbs within the curriculum. It was considered as an efficient way for highlighting what the students' capabilities are as well as for planning how to improve them.

In addition to the components of the curriculum, it was important to present information about the use of digital learning tools. Such an overview could help both teachers and vendors to see how much practice was done by students as well as what products were used the most. It was chosen to use a bar chart for representing this information.

## **4.2 Logo development**

One of the contributions made to the AVT2 project was developing a logo for the MittFagkart tool. The work on the design of the logo started from collecting requirements from the project team. It was established that the logo will be used as a representation of the open learner model "MittFagkart", hence the team wanted to use the title of the OLM for the logo. It was the only request from the team regarding the design.

The next step was to brainstorm the ideas. It was decided to use the mind mapping technique ("Mind Map," n.d.) in order to "open" the meaning "MittFagkart". Figure 20 shows the mind map that was created during the brainstorm.

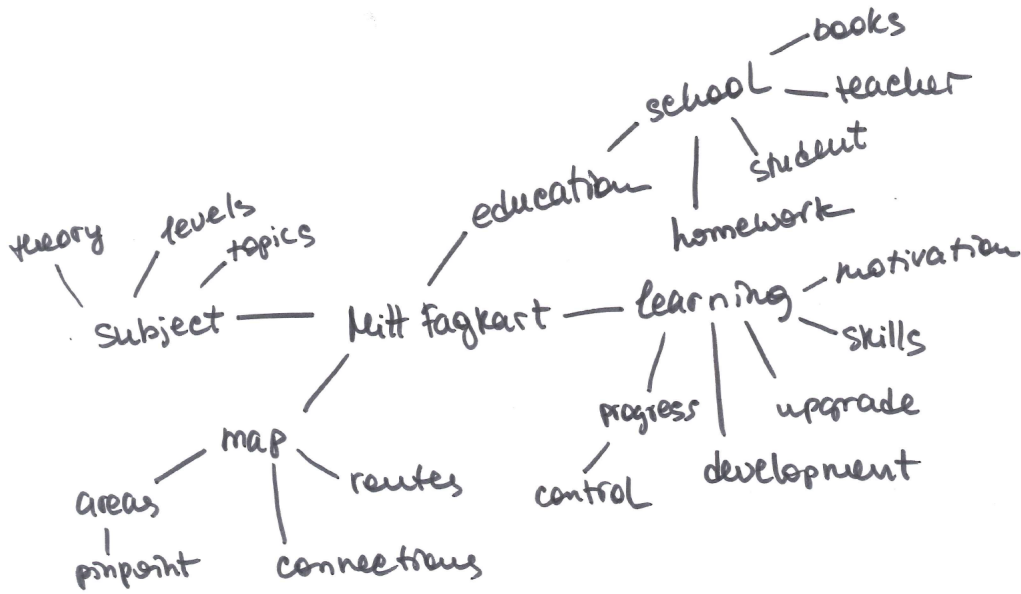


Figure 20: Mind map for brainstorming the ideas for logo

The mind map helped to highlight some elements related to MittFagkart that could be used in the design of the logo. It was decided to focus on “kart”- metaphor and progress in order to show the purpose of MittFagkart.

The main goal was to create a professional, modern, and light design by using clear fonts in combination with not complex elements that would represent the idea of MittFagkart. Figure 21 shows the options designed in Adobe Illustrator.



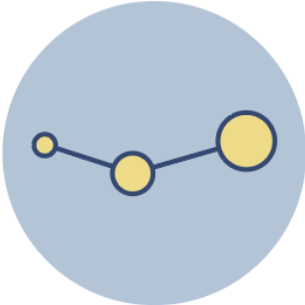
Figure 21: Options for the logo

It was chosen to work with *Futura PT* font as it is a clean, simple, and easy-readable one. There were several ideas of how to show the progress: with the use of bars, nodes, by highlighting the growth of the elements. After the discussion with the team, it was decided to use the logo with nodes-element in yellow color (Figure 22).



**Figure 22:** Final design of the logo for MittFagkart

In addition to the main logo, there was a need for creating an icon that would represent MittFagkart among other applications on the dashboard (Figure 23) and a banner that would be placed on the home page for the project (Figure 24).



**Figure 23:** Icon for MittFagkart for the dashboard



**Figure 24:** The banner for the home page MittFagkart

### **4.3 Color Scheme**

Choosing colors is an essential component of the user experience. Colors are able to obtain various emotions and psychological reactions from the users that can be very important for designers to understand. In the context of learning, colors also play a significant and cognitive role in learner's experiences. It has been proved by various studies that color-use affects learner attitudes, comprehension, and retention (Kimmons, 2020).

While working with color-use in the design, it may be useful to follow some guiding considerations like contrast, attention, meaning, and harmony. High contrast (especially when working with the text), using the right shades for bringing attention to the elements that matter as well as selecting colors in a manner that emphasizes the intended meaning are beneficial for the user and learning experiences. It is equally useful to understand how to use selected colors harmoniously together in order to meet the intended purpose of the project (Kimmons, 2020).

In order to promote color harmony and use the guiding considerations mentioned earlier, it is useful to start working first on a color scheme for the design project. Kimmons (2020) highlights five common types of color scheme: monochromatic, analogous, complementary, complex, and achromatic. For this project, it was chosen to work with a complementary color scheme (Figure

25), where the cooler colors are used as dominant colors, and warmer colors are used as the accent (Kimmons, 2020). It was decided to use blue as a dominant color in a palette and yellow as a contrast. Some hues of blue were also developed as well as orange that would complement them.

The blue color was chosen as a dominant color for the palette because the blue can activate a promotion focus in order to encourage people to achieve positive outcomes, thus enhancing creative tasks. The use of blue color also increases the possibility that presented information will be remembered (Chang et al., 2018). Furthermore, blue is commonly associated with openness and peace (Xia et al., 2016) which is partly symbolic for the idea behind the *open* learner model.



**Figure 25:** Color scheme for the MittFagkart

For the interface, besides primary colors, it was also necessary to provide some information regarding gray shades and some additional colors like red shade for representing warnings, the hue of light blue for the background in OLM, and darker blue for the “hover” effect for the buttons. The final color palette is presented in Appendix D.

## **4.4 Home page for MittFagkart**

While working on the AVT2 project and MittFagkart, it was discovered that there is a need for a home page that would include all necessary information regarding the research, vendors, MittFagkart, and project team. Thus, it was decided to create a simple layout of a home page that will be able to provide such information.

### **4.4.1 Requirements for the Home page**

In order to get some ideas for the layout and functionality of the home page for MittFagkart, it was chosen to research similar home pages for learning applications, including the web pages of

the vendors for the AVT2 project. Based on the results of the research and the purpose of the home page, the following functional and non-functional requirements are established:

### Functional requirements

- Provide access to the MittFagkart with the help of the “login” - button.
- Provide views that show information about the AVT2 project, project team, and vendors.
- Provide views with information regarding privacy policy and terms and conditions for use of the MittFagkart.

### Nonfunctional requirements:

- The home page needs to be user-friendly and quickly responsive to any user’s input.
- The design needs to be aesthetically pleasing to look at.
- The colors used in the design need to be harmonious and complementary to each other.
- There should be easy navigation between different views.

## 4.4.2 Design Process

The design process of the layout for the home page has started from defining the structure for the page. Four different views were established: front page - view, a view that describes the details of the project, a view that presents the project team, and a view that provides some information regarding privacy policy and terms of use for MittFagkart. The structure of the home page is presented in Figure 26.

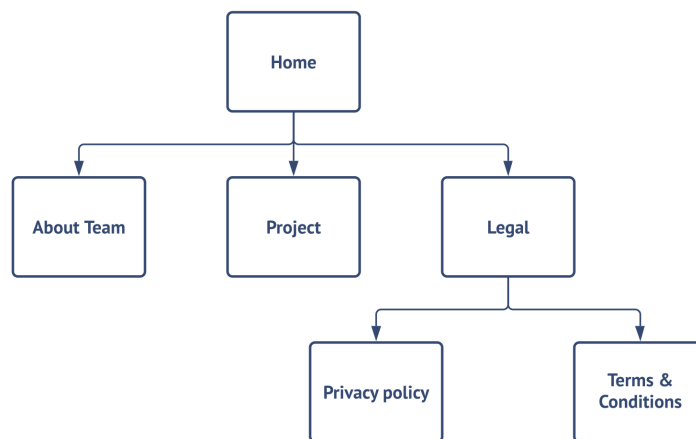
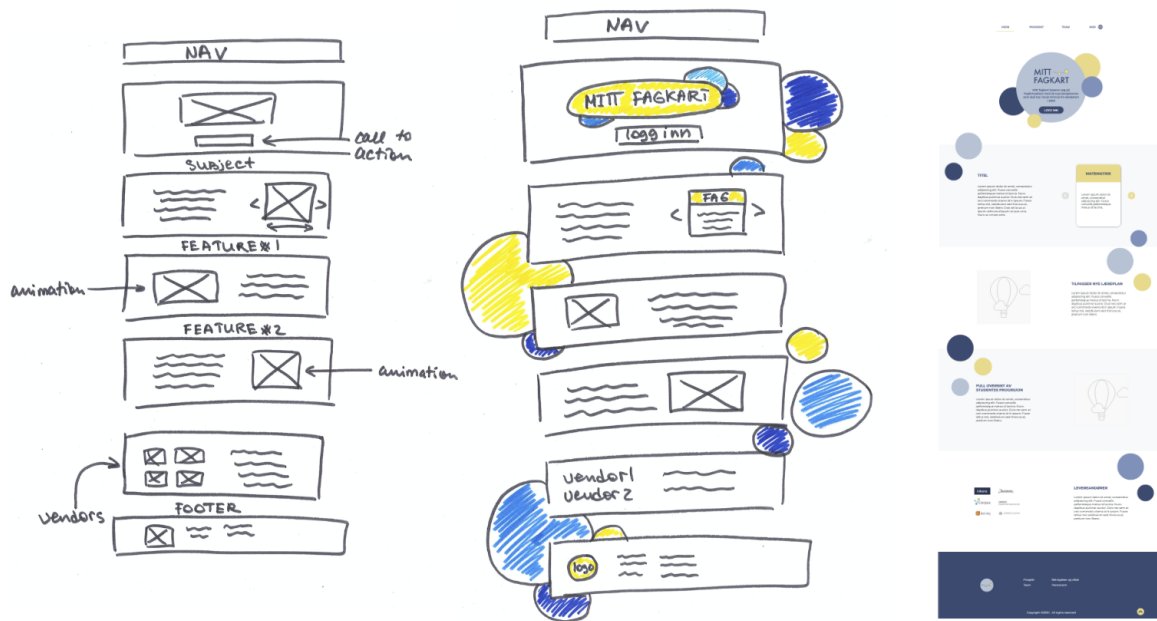


Figure 26: Structure for the home page MittFagkart

Next, the first sketches were created in order to outline the details of the views (Appendix E). The front view would provide the information about MittFagkart, its purpose, vendors as well as login function to the MittFagkart. Through the navigation bar, there would be a possibility to go to the view with information about the AVT2 project and the view that describes the team members. The footer would include transitions to the privacy policy page and terms and conditions for use of MittFagkart. The process of the development is shown in Figure 27.



**Figure 27:** The design process of the home page for MittFagkart

Finally, a clickable prototype for the webpage was created with help of Proto.io for further evaluation. The screens of the prototype are presented in Appendix E.

### 4.4.3 Expert Evaluation of the webpage prototype

In order to evaluate a clickable prototype for the home page of MittFagkart, it was decided to conduct a semi-structured interview with a usability expert. The goal was to test the navigation between views as well as the design solutions regarding colors, placeholders, and background decorations. The evaluation session was run through a Zoom video call and lasted approximately 40 minutes.



The feedback from the expert was mostly positive: she liked the dynamic of the page and color palette. She mentioned that there was a good consistency of the elements that were complimented nicely with the chosen colors. According to her, it was easy to navigate between views since it is possible to access different views both from the navigation bar and footer.

The first thing the expert commented on was a lack of content. For getting a better user experience, it would be good to have some text and pictures (as it was meant) related to the project and MittFagkart. The expert also liked the “nodes” decoration in the background web page but suggested reducing the opacity of the elements or not placing them behind the text. In addition, she thought that it would be a good idea to link each logo for vendors’ own websites.

### **Future work**

Considering feedback from the usability expert, it was decided to perform the following changes in the future version of prototype:

1. Background decoration: place the node elements in lower opacity or try to place them not behind the text.
2. Fill in the content for the home page: texts that would describe the purpose of MittFagkart, its features. Place the animations for showing how the MittFagkart works.
3. Set the links for vendors-block that would transfer a user to their websites.

## **4.5 Chapter Summary**

This chapter described the work made within the AVT2 project. The OLM MittFagkart was presented as well as design decisions for the logo MittFagkart, color scheme, and home page.

## 5 REQUIREMENTS

This chapter describes the establishment of the requirements for the OLM dashboard, MittFagkart. First, it presents a target group for the current work. Second, the recruitment process of the participants for the usability testing and expert evaluation is presented. The terms and conditions for participants are mentioned. Third, the analysis of the prior interviews with teachers and a workshop on the design of a dashboard are described. Then, a persona, a storyboard, and a use case are introduced. Finally, the requirements for the OLM dashboard MittFagkart are listed.

### 5.1 Target group

As it was mentioned earlier, OLM is a learner model that is “open” to everyone. One of the aims of the AVT2 project is to find out how to present the activity data to different stakeholders and which visualizations to use. Initially, the focus of the current research was the presentation of the OLM for teachers and students, but unfortunately due to COVID-19 pandemic, there was no possibility to conduct any interviews or evaluate the prototypes of MittFagkart with students. Thus, it was decided to focus on designing an interface for the teachers first. Table 6 presents a description of the chosen target group for MittFagkart.

**Table 6:** Description of target group

<b>Criteria</b>	<b>Target group</b>
Gender	Male/Female/Others
Age	20-50
Type of user	Teacher
Technology literacy	PC/smartphone user
Use of learning applications in teaching	Preferable, but not necessary

## 5.1.1 Participants

### Usability testing

Participants in usability testing are real users of the product or service that is being tested. It might mean that the user is already using a product or has a similar background to the target user group (Moran, 2019). In order to recruit participants for the usability testing of MittFagkart, an AVT researcher and I arranged several rounds of presentations for principals and schools (Table 7). These presentations included information about the AVT2 project, the concept of an OLM Dashboard, and what we would require from participants during the usability testing. Appendix F shows the invitation letter for the presentations and information that was presented in the recruitment meetings.

**Table 7:** List of the participants in recruitment meetings

<b>Date</b>	<b>School</b>	<b>Number of Participants</b>	<b>Topic</b>	<b>Duration</b>
23.09.2020	Årvall skole	1	Presentation of the project & Invitation to participate	30min
23.09.2020	Branfjell skole	12	Presentation of the project & Invitation to participate	30min
14.10.2020	Hasle skole	1	Presentation of the project & Invitation to participate	30min
24.09.2020 15.10.2020	Midstuen skole	5	Presentation of the project & Invitation to participate	30min
8.03.2021	Snarøya skole	10	Presentation of the project & Invitation to participate	30min
17.03.2021	Stabekk skole	4	Presentation of the project & Invitation to participate	30min

## **Project team**

Members of the project team were chosen for conducting an expert evaluation of the low-fidelity prototype. They all have been working in EdTech and have relevant experience in order to express a professional opinion in regard to usability, OLM content and design.

## **UI expert evaluation**

In order to conduct an expert evaluation, one of the members of the project team was questioned in regard to the UI design of the MittFagkart. He has solid experience in system development, so he could be able to give some comments and suggestions for improving the prototype.

## **Experts for heuristic evaluation**

There were three usability experts for the heuristic evaluation of the prototype. All of them have a Master's Degree in Information science and relevant experience in product development.

### **5.1.2 Terms and conditions for participants**

The research within the AVT2 project has been approved by the Norwegian Center for Data (Norsk senter for forskningsdata - NSD). All the participants involved in the interview process and usability testing were informed that their contribution to the project is voluntary. The participants that decided to take part in interviews and the usability testing have signed a form of consent that explains how the data they provide will be stored and processed. This form can be found in Appendix A.

## **5.2 Establishing requirements for MittFagkart**

Before starting the requirements identification for the MittFagkart, it was decided to analyze prior interviews from the AVT project with teachers where they shared information about their teaching style and what they are interested in while working with the curriculum. In addition, a workshop was conducted in order to ideate the features and layout for the MittFagkart.

## 5.2.1 Analysis of interviews with teachers

As a part of work on the AVT project, one of the researchers conducted a set of interviews with 12 teachers of mathematics for 8th-10th grades in schools in the Oslo Municipality. The main goal of conducting these interviews was to find out what information can help teachers to plan and evaluate student's progress and what teacher's needs are when they use digital applications in their teaching.

All the comments from teachers were listed in a table (Figure 28) and discussed with the project group on the subject of what could be possibly implemented in MittFagkart and what types of data were necessary for that.

1	Question	Recipe	Description	Possible using xAPI and/or avt-hub api	Need metadata	Comments
2	<b>Quantifications and aggregations</b>					
3	N: <i>Oversikt over enkeltelever, klasser og trinn</i> E: Overview of individual students, class, grade x Dashboard: at the individual student, at a class, or an entire grade (over a set of classes at that grade level)			<input checked="" type="checkbox"/>	<input type="checkbox"/>	
4	N: Har eleven gjort det de har fått beskjed om E: Have the students done the items that they were assigned? Dashboard : Has an individual student / the class done the items that were assigned	<a href="#">Recipe:</a> <a href="#">How many tasks (and videos, etc.) were assigned</a>	How do we get the information of what they were assigned – that needs to come from the teacher/arbeidsplan	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
5	N: Antall oppgaver/aktivitet gjennomført E: Number of items (answered) / activities (e.g., see a video) performed <i>For a student, for the class, per vendor</i>		xAPI: verbs (answer; see video; quiz, etc...)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	

**Figure 28:** A snippet of the table created for listing teachers' needs

There were several aspects that had to be taken under consideration while choosing what could be implemented in an OLM for teachers. First, it was important to understand if there was enough data for implementing any of the teachers' needs (e.g., the number of attempts made by an individual student or showing the information if a student did what was assigned by a teacher). Second, if there was not enough data, could the vendors be able to provide such data in the right format. Third, it was also necessary to define how to present necessary data in the most efficient way.

After such analysis of all teachers' needs and comments, it was discovered that not all were possible to implement immediately. Some of the features required more data or more research. Thus, it was decided to focus on presenting the following features:

1. Overview of individual students, class, an entire grade
2. Number of items answered/activities performed (e.g., watching a video)
3. Number of items/activities attempted
4. Number of students in the class struggling with a topic (e.g., fractions)
5. Number of students in a class struggling with an item
6. Number of times a student used a resource (e.g., book, video, web page)
7. Area of subject/topics students are working on (e.g., Mathematics/Algebra)
8. Information about what topics students understand (e.g., functions, percentage)
9. Information about what topics students struggle with
10. Information about what kind of tasks students work with

Figure 29 presents an overview of all these features and key elements that should be implemented for showing the information about students' activity. Through a teacher profile, the dashboard will access the overview of individual students, class, or entire grade. This overview can provide information about the number of activities performed by students and the number of their attempts. Through a student profile, the dashboard will access the same information, but only about the student whose profile is used. Furthermore, there is a MittFagkart element that will provide information about what topics or tasks students work/understand/or and struggle with. Such a structure can be used in the possible layout of the MittFagkart OLM.

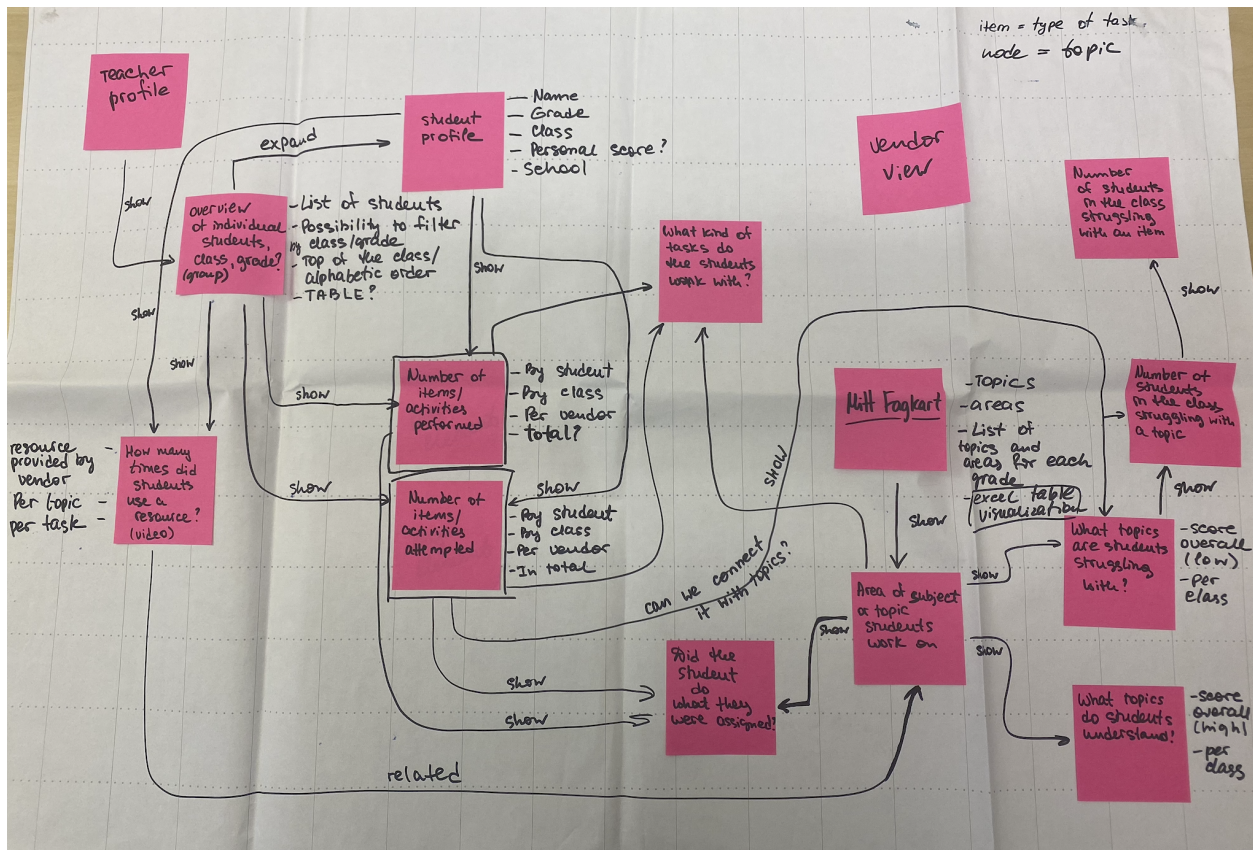


Figure 29: An overview of possible features for the MittFagkart

### 5.2.2 Workshop

At the early stages of the AVT2 project, there was no clear understanding of the best way to present OLM dashboard and what features it should have. A small workshop was carried out where project members and other researchers could share/develop the ideas regarding visualizations, functionality, and possible layout. The main focus of the workshop was not to come up with the design for the whole system, rather, just to get some initial ideas.

There were 10 people who participated in the workshop: several researchers, a developer, students and PhD candidates. All of them somehow worked with the learning analytics field, TEL (Technology Enhanced Learning), and design for learning. The participants were divided into three groups for working on exercises. The duration for the workshop was 2,5 hours including breaks.

The introduction to the workshop was a short presentation of the AVT2 project, MittFagkart, and the goals of the current workshop. Then there were three exercises presented. The first exercise was an “ice breaker” exercise (Heathfield, 2020) for the participants, where the goal was to create a persona - potential user of the OLM dashboard. The second task was focused on ideating a possible set of functions for the OLM dashboard by answering the question: “What does a persona see when he/she opens dashboard? What type of information should be displayed there?”. The third exercise was based on experience prototyping where participants were asked to prototype the ideas from the second task using beforehand prepared elements (e.g., calendar, avatars, charts, bars, gauges, tables, skill meters, etc.). Each group got a package with different elements and paper desktop screens where they could visualize their ideas (Figure 30).



**Figure 30:** Tools for prototyping exercise

## Results

There were six personas (three teachers and three students) created for the first exercise. Each group made an extensive description for each persona and did some drawings (Figure 31).



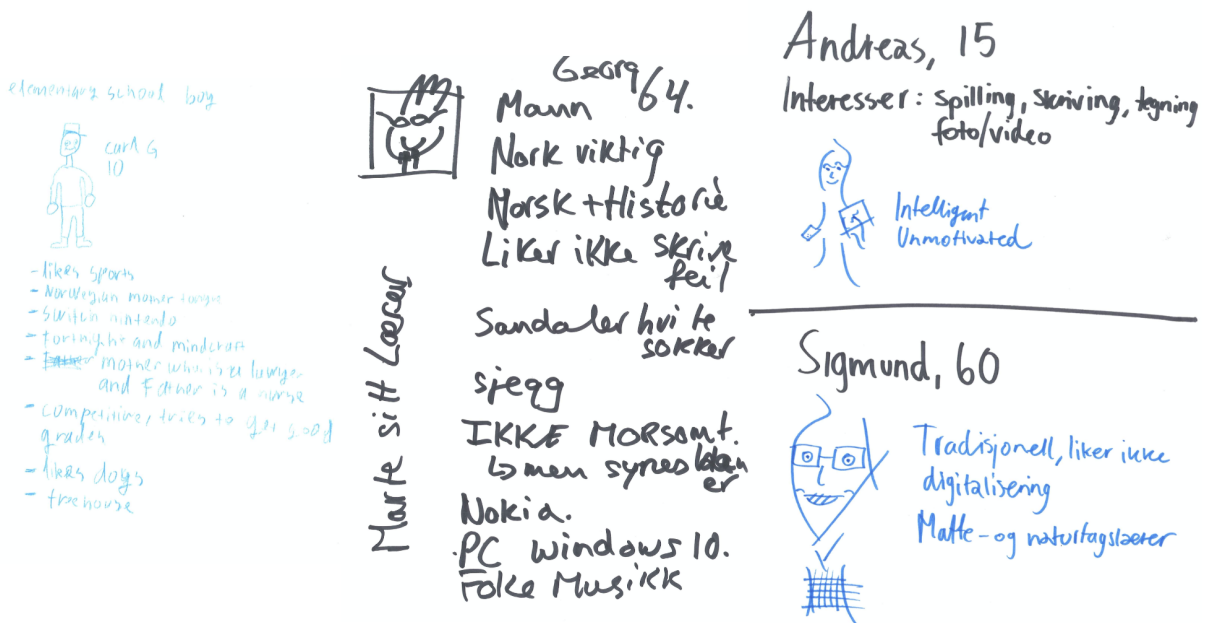


Figure 31: Personas

For the second exercise the participants made a list of features, elements they could see on the dashboard. Some of them chose to use Post-it notes, some of them just wrote down the ideas. Figure 32 shows an example of what has been suggested for the dashboard.

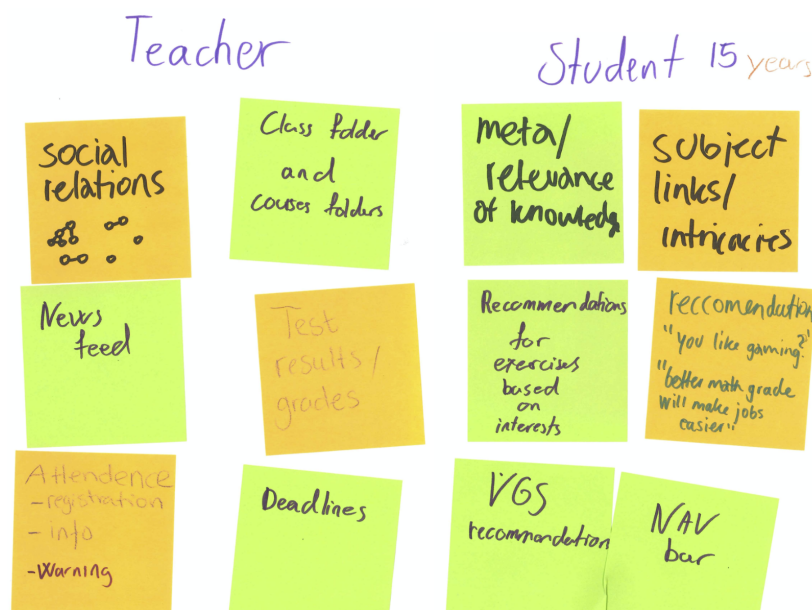


Figure 32: Ideas for dashboard


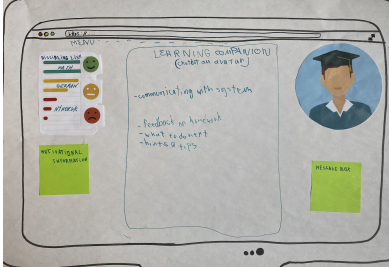

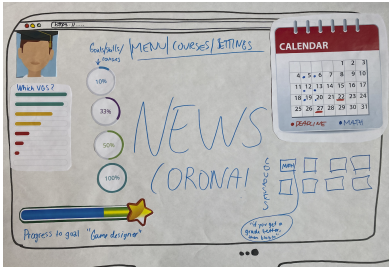
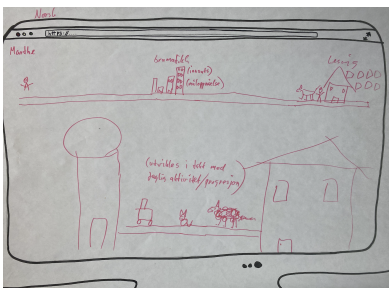
The results for the prototyping task showed a variety of ideas for the dashboard's layout and functionality. Most of the participants would like to have a personalized dashboard with the avatar and/or name of the user. Each created dashboard included different presentations of activity level and achievement level with help of skill meters, bars, pie charts with percentage, and graphs. Two dashboards used smiles for reflecting the progress of the students. Some teacher's dashboards included an overview of students, their progress in learning as well as social relations between them.

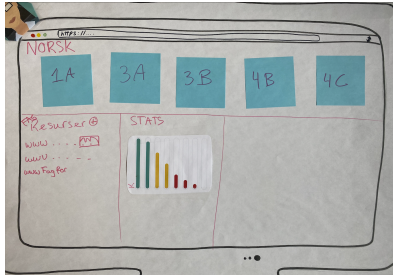
The participants of the workshop were interested in having a chatbot or message box that would provide feedback on the user's learning. One group showed interest in recommendations for the learning resources. Another group wanted to get a recommendation on what high school the user should apply to based on the rating of schools and the user's interests.

One of the dashboards differed from the others by the unusual presentation of the learning process for the student. The learning goals were visualized as animals and houses that a user would collect "on the way" to the main competence goal (e.g., reading). This dashboard is mostly focused on young users (7-10 years), but possible that such an interface could be somehow transferred for the older users as well.

Some dashboards presented a list of subjects that the user works with and a calendar with deadlines and schedules. Table 8 highlights the features and functionality for each designed dashboard.

**Table 8:** Results of prototyping exercise

No.	Desktop	Features	User
1		<ul style="list-style-type: none"> <li>• Overview of students' progress</li> <li>• Graphs</li> <li>• Activity level</li> <li>• Pie charts</li> <li>• Message</li> <li>• Calendar</li> <li>• List of classes</li> <li>• Alerts</li> <li>• Avatar</li> <li>• Export the report</li> <li>• Menu items</li> </ul>	Teacher
2		<ul style="list-style-type: none"> <li>• Smiles</li> <li>• List of subjects</li> <li>• Progress bar</li> <li>• Motivation</li> <li>• Chatbot</li> <li>• Feedback on homework</li> <li>• Avatar</li> <li>• Recommendation</li> <li>• Hints</li> <li>• Messages</li> </ul>	Student
3		<ul style="list-style-type: none"> <li>• Overview of students' progress</li> <li>• Social relations between students</li> <li>• Subjects</li> <li>• Warnings</li> <li>• Calendar</li> <li>• Avatar</li> <li>• Smiles</li> <li>• Check individual students</li> <li>• News information</li> </ul>	Teacher
4		<ul style="list-style-type: none"> <li>• Menu bar</li> <li>• Pie charts</li> <li>• Calendar (deadlines + schedule)</li> <li>• Rating for high schools</li> <li>• Skill meter</li> <li>• News</li> <li>• Recommendation</li> <li>• Avatar</li> </ul>	Student
5		<ul style="list-style-type: none"> <li>• Representation of the learning goals as animals and houses that could be collected</li> <li>• The progress is shown as a road with milestones (e.g., grammar)</li> </ul>	Student

6		<ul style="list-style-type: none"> <li>• Progress bars</li> <li>• Resources for learning</li> <li>• List of student groups</li> <li>• Statistics</li> <li>• Avatar</li> </ul>	Teacher
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## Analysis of the results

The results of the workshop identified several features and elements that could be used in the design of MittFagkart. There were some clear suggestions for personalization (e.g., using avatars/pictures), evaluation of the user's learning (e.g., smiles), recommendation (e.g., schools, learning resources like books, web pages, etc.) within the system.

The workshop also highlighted some problems that had to be considered. The concept of such a learner model is that it is open for everyone, but it is important to understand that different users are interested in getting particular information about their progress and even in different ways. The age, role of the user, and personal preferences should be taken under consideration while designing the interface.

Another issue that emerged from the workshop is that it is important to set the scope of an OLM as well as the goals of the OLM. Will it give recommendations? Will these recommendations be based on the user's activity or personal goals? Will recommendations be given by a teacher or the model? Will just show the information about the students' progress or is it possible to modify the model? Should it be in the form of a game or a more formal presentation? Shall it be an application for smartphones or desktops? All these questions should be considered when designing a useful and usable OLM.

There was also some valuable feedback regarding the workshop itself. The duration of the workshop could have been a bit longer, hence more time to work on prototypes and presenting them, as well as more breaks. There was a lack of information about what "persona" is and the purpose of creating them. This could have been solved with a small introduction before the exercise that would include information about personas, and perhaps giving an example.

Since the workshop was mostly focused on the ideating process, some of the participants were confused at first about what they should create and for what purpose. A solution to this would be to create a specific scenario or problem they could solve with help of a dashboard, and in this way there would be no need for the clarification.

### 5.2.3 Persona

For guiding the design process of MittFagkart, the OLM dashboard, a primary persona “Katrin Hermansen” was created. Figure 33 shows the description of the persona.



Figure 33: Persona “Katrin Hermansen”

### 5.2.4 Storyboard

Creating a storyboard helps to think through a problem, sketch ideas, and empathize with the potential users as they confront everyday challenges (Lupton, 2017, p. 38). It is a good technique to focus on the problem and situation rather than features while working at the early stages of the development process. Figure 34 tells a story, where a created persona, Katrin, is trying to plan

next week's classes. The text under each picture describes the emotions that persona expresses during the different moments of the story. This helps to keep the user experience at the center of the design process.



Figure 34: Storyboard “Planning next week’s classes”

## Story

*Katrin taught Zoom classes all day. After dinner, she spends some extra time planning next week's classes. This week students practiced a lot in Kikora, Campus Matte, and Kunnskap.no. She has to check the results in each tool and analyze across the tools in order to determine what the students should do next week. The plan has to correspond to the curriculum. Since there are a lot of results produced by the students, it is time-consuming for Katrin to check every application, do analysis and search for the relevant resources. She would like to do her job efficiently, but at the same time to not work until night and be able to read a book to her daughter, Olivia, before she goes to bed.*

*Suddenly, she remembers that UDIR introduced a new tool MittFagkart a couple of weeks ago, so she decides to try it out. In MittFagkart she can see all the results from her students in accordance with the national curriculum, aggregated across the tools. Based on the results, she realizes that students are struggling with the Functions topic, so she decides to search for relevant exercises on functions. Thus, she spends less time on preparation and analysis hence, she is done with her work earlier. Now she and Olivia can read a book together before bedtime.*

### **5.2.5 Use case**

A use case was created in order to outline user navigation within MittFagkart. In this use case, the goal of the user is to find an overview of the progress of the students in accordance with the curriculum:

1. The user opens a webpage fagkart.no.
2. The user logs in through Feide-authentication.
3. The user sees his profile.
4. The user clicks on the “MittFagkart” tab.
5. The user selects subject, grade, group, and learning tool in order to get the information about the students’ progress.
6. The user reviews the visualizations.

### **5.2.6 Functional and nonfunctional requirements**

Based on the results of interviews with the teachers, the workshop, the literature review, and an analysis of the national curriculum, the functional and non-functional requirements for MittFagkart were established. The introduction of the persona, storyboard, and use case also contributed to the establishment process.

#### **Functional requirements:**

- Provide an overview of students’ progress in accordance with the national curriculum (For an individual student/for the whole class) and in an understandable form.

- Provide information about topics a student/a class struggle with.
- Provide information about the area of the subject, topics students working on.
- Provide information about what topics students understand.
- Provide information about what learning tools are being used by students.

**Non-functional requirements:**

- The interface needs to be user-friendly and quickly responsive to any user's input.
- The design needs to be aesthetically pleasing to look at, without any complex details.
- The colors used in the design need to be harmonious and complementary to each other.
- The interface should be responsive to different sizes of the screen (Tablet and different sizes of desktop).
- Texts used in the interface need to be easy to read and in good contrast with a background color.
- The visualizations used for reflecting students' activity data are easy to understand for the user.

### **5.3 Chapter Summary**

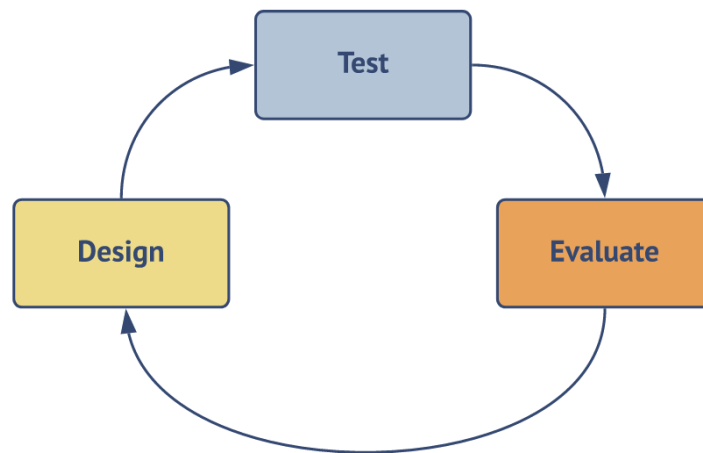
This chapter provided information regarding requirements for the current research. It presented the target group, the participants for usability testing, experts of the evaluation, analysis of the interviews with teachers, and the results of the workshop. The persona, storyboard, and a use case were also introduced. The initial functional and non-functional requirements for the OLM system were established.



## 6 PROTOTYPING MITTFAGKART

This chapter presents the development process of the MittFagkart prototype. Pre-phase and three iteration cycles are described. Each iteration includes the design phase, testing phase, and evaluation phase (Figure 35). Considering the established requirements (see Chapter 5), one low-fidelity prototype and three high-fidelity prototypes were created.

First, the overview of the data collection processes during the development is described. Second, the list of the used tools for development is introduced. Finally, the work that has been done for each iteration cycle is presented.



**Figure 35:** Phases for each iteration cycle

### 6.1 Data Collection

Table 9 describes what data was collected during the development process as well as the methods of how it was collected and what the data was used for. It also includes the data collection methods for the establishment of the requirements that were described in Chapter 5.

**Table 9:** Overview of the data collection processes

	<b>Data</b>	<b>Method</b>	<b>Use</b>
<b>Systematic literature review</b> <i>Establishing requirements</i>	What is OLM? What types of visualizations are used in OLMs? Examples of OLMs What data can be presented in OLMs?	Systematic literature review	Requirements for OLM visualizations Understand the nature of the OLM Data in OLMs
<b>Analysis of the interviews with the teachers</b> <i>Establishing requirements</i>	What should I display in an OLM?	Video meeting with project team	Requirements for MittFagkart Design of the MittFagkart
<b>Workshop: Designing a dashboard</b> <i>Establishing requirements</i>	Ideas for the design of OLM	Workshop Experience prototyping	Design of the MittFagkart
<b>Expert evaluation</b> <i>Pre-phase</i>	Expert opinions on the layout and visualizations for the MittFagkart	Meeting with project team	Improving the prototype
<b>Usability testing</b> <i>1st iteration</i>	How do the users perceive MittFagkart? Is OLM useful for users? Do the users understand visualizations? Do the users understand the concepts used in OLM? How do the users interact with the interface?	Usability testing via Zoom/ Microsoft Teams 2 usability tasks Interview with participants: How do the participants plan classes? Do the participants use curriculum? Do the participants use digital learning tools in teaching?	Redesign OLM visualizations Improving design of the interface Improving the usability of the prototype
<b>Expert evaluation</b> <i>2nd iteration</i>	Expert opinion on the UI design	Video meeting	Better adaptation of the prototype for different screens (desktop and tablet) Make prototype more consistent and precise (spacings and paddings) Improving UI elements (avatars, scrollbar, filter)
<b>Heuristic evaluation</b> <i>3rd iteration</i>	Expert opinions on usability of the MittFagkart	Nielsen's heuristics: Rate from 0 to 4 for each aspect Video meeting	Evaluating the usability Future work

## **6.2 Tools**

### **Proto.io**

Proto.io (“Proto.io,” 2021) is a tool for creating interactive high-fidelity prototypes that look and partly work as actual applications would. It allows sharing the prototype with the users which can be helpful during testing and evaluating stages of the development process.

### **Adobe Illustrator**

Adobe Illustrator is a vector graphics editor and design program (“Adobe Illustrator,” 2021). It was used for creating the logo, icons, avatars, persona, and some visualizations for the MittFagkart. In addition to that, a heuristic evaluation sheet was designed with help of this editor as well.

### **Adobe Acrobat Pro DC**

Adobe Acrobat Pro DC is software that helps to view, modify, print, and manage files in Portable Document Format (PDF) (“Adobe Acrobat Pro DC,” 2021). The application was used for adding forms to the heuristic evaluation sheet.

### **Lucidchart**

Lucidchart is a visual workspace for creating diagrams and graphs, data visualization, and collaboration (“Lucidchart,” 2021). This tool was used for creating the diagrams, wireframing, and some visualizations for the MittFagkart (e.g., concept map).

### **Zoom**

Zoom is video chatting software that allows users to record the call and share the user’s home screen (“Zoom,” 2021). This application was used during expert evaluation as well as usability testing.

### **Microsoft Teams**

Microsoft Teams is a business communication platform for video conferencing (“Microsoft Teams,” 2021). It was used for conducting usability testing as well as for internal meetings with the project team.

## Confluence

Confluence is a web-based collaborative workspace for sharing the documentation within the project team (Atlassian, 2021). This software was used for creating reports of the usability testing, sharing the assets, and documenting some parts of the development process.

## 6.3 Pre-phase

This section describes the pre-phase of the development of the MittFagkart. The first sketches were created in accordance with the established requirements. Wireframing was also used to outline the structure and navigation within the MittFagkart. For evaluating the ideas for the design, the team members of the AVT2 project provided feedback. Figure 36 summarizes the pre-phase cycle.

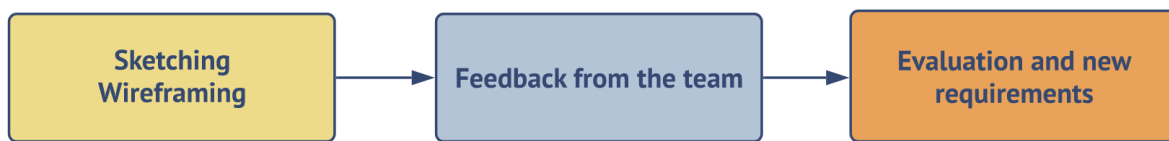


Figure 36: Pre-phase of the development process

### 6.3.1 Low-fidelity prototype

At the pre-phase stage, the first sketches were created based on the findings from the systematic literature review regarding data visualizations, created use case and storyboard as well as established requirements for the MittFagkart. The main focus was on presenting four different views: 1) a teacher's profile; 2) MittFagkart 3) a view with a list of students and information about their progress; 4) a student's profile. Figure 37 presents the first sketches of the views and the connections between them.

The first view shows a teacher profile with information about the classes and subjects he/she teaches. The second view includes the MittFagkart that with the help of filters shows the students' activity and their results according to the national curriculum. The third view displays the list of students with their names, grades, classes, what types of learning tools they have been using, and the progress of their learning. The fourth view represents a student's profile that displays the name, grade, and group of the student.

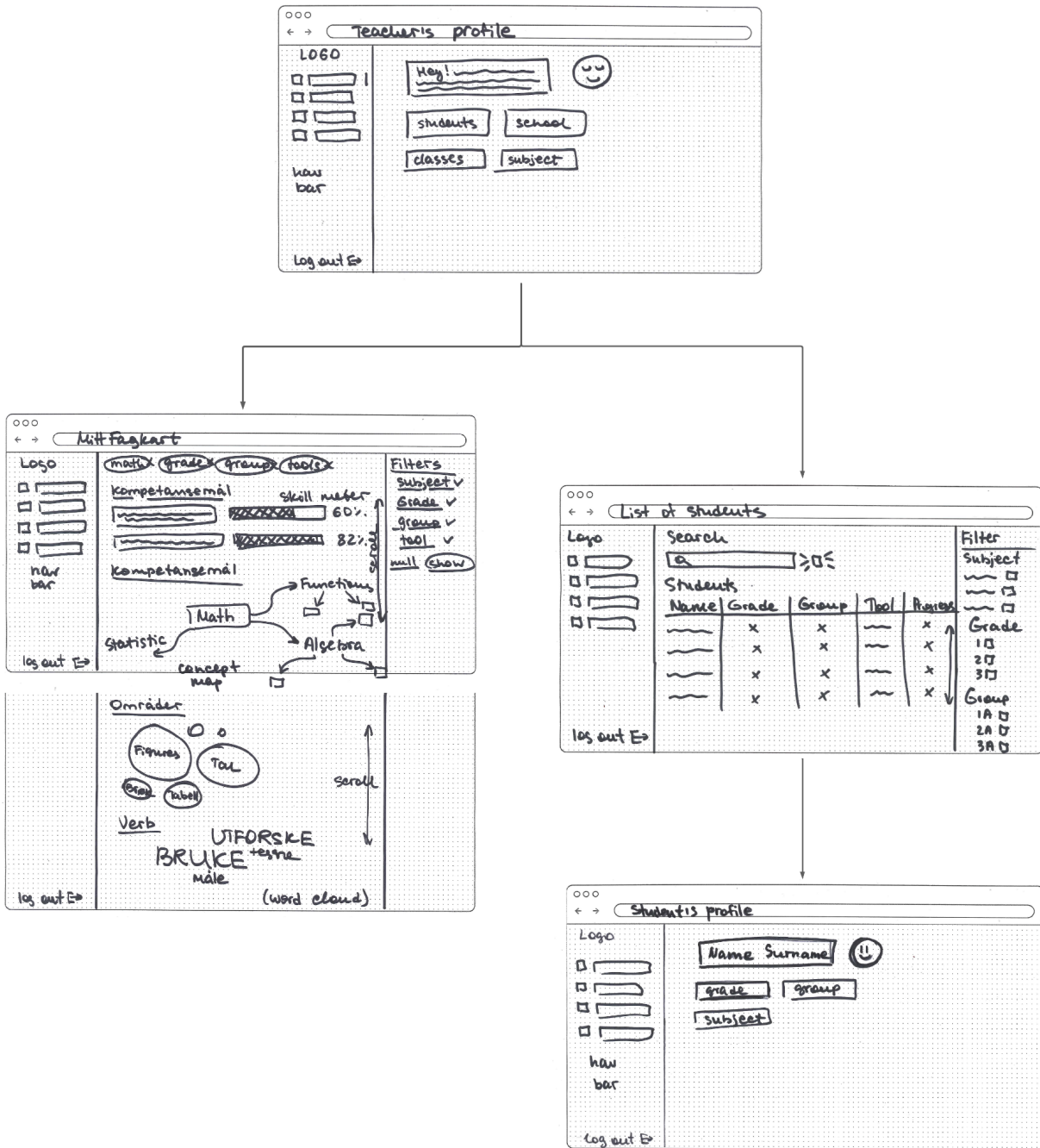


Figure 37: First sketches of MittFagkart

### 6.3.2 Evaluation and new requirements

The sketches were presented to the project team in order to evaluate the first ideas for the prototype of the MittFagkart. First of all, it was discovered that it would be challenging to present the progress of the students for this view. All learning tools have different structures and different types of tasks, so it would be difficult to summarize the progress in a percentage value. It was decided to remove this column from the table and focus on the presentation of the students' progress in the MittFagkart.

Second, the experts suggested redesigning the filter function and making it more compact. Finally, the experts gave positive feedback regarding the choice of the visualizations for the OLM, but they were interested to see how it could look like in the high-fidelity prototype.

Based on the feedback from the project team, the following changes are considered for the next iteration:

1. Redesign the filter function, make it more compact. Possibly, relocate the function.
2. Remove progress information from the table.

### 6.4 Iteration 1

During the first iteration of the design process, a high-fidelity prototype of the MittFagkart was created in Proto.io. In order to evaluate the functionality and design of the prototype, four usability tests were conducted. Based on the results of the usability testing, new requirements were established. Figure 38 summarizes the first iteration cycle.

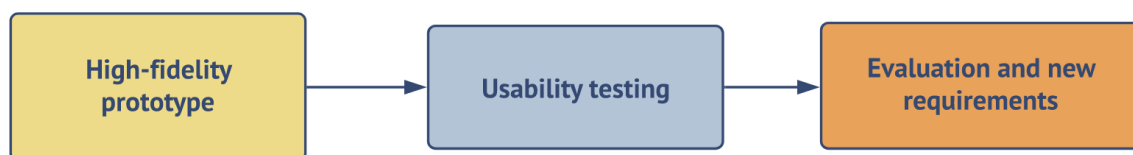


Figure 38: The 1<sup>st</sup> iteration of the design process

### 6.4.1 High-fidelity prototype

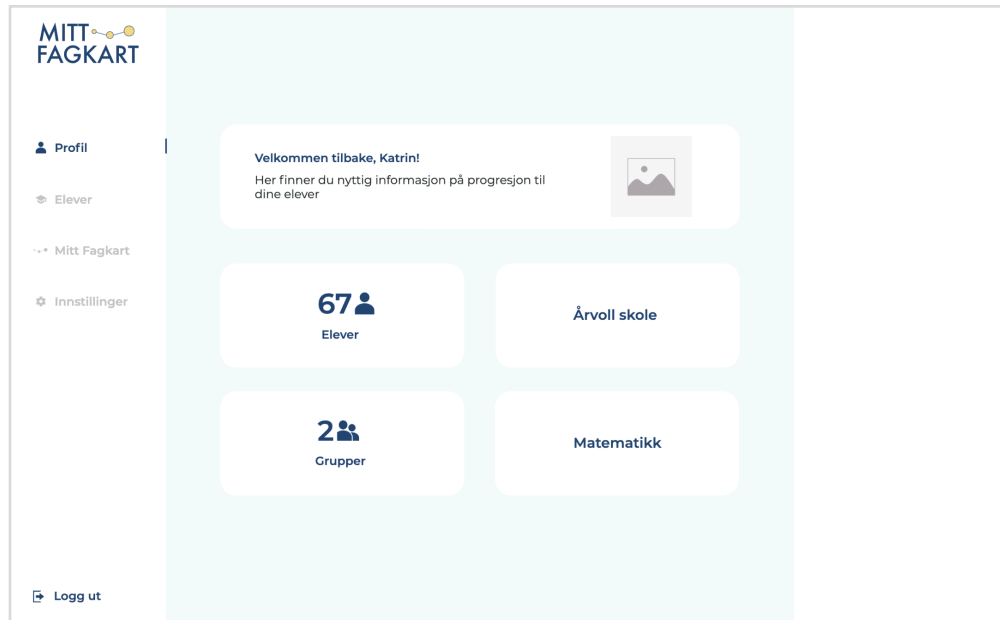
A high-fidelity prototype included four different views: 1) a teacher's profile; 2) a student's profile; 3) MittFagkart; 4) a list of students (Appendix G). Each view should have a sidebar that is used for navigation between pages. The sidebar should be sticky and move along with the scrolling container. It included tabs for the teacher's profile, list of students, MittFagkart, settings, and "logout"- button. Each tab's title was accompanied by a corresponding icon. In addition, a special icon was needed for the MittFagkart-tab (Figure 39).



**Figure 39:** Icons for navigation bar, active (blue) and inactive (grey)

When a user (teacher) logged in to the system, the first view would be a teacher's profile. This view (Figure 40) would include a greeting for the teacher, subject, name of the school, number of the students he/she is responsible for, and number of groups/classes.

By analogy, a student's profile was created that the teacher could view. During the first iteration, it would display only basic information such as name, subject, grade, group, and school. It was decided to test the chosen visualizations for MittFagkart first, and then, in the next iteration, place these visualizations into a student's profile, where they would reflect their individual progress.



**Figure 40:** A teacher profile

For the first iteration, MittFagkart would include the following elements: four visualizations for reflecting the students' progress and the filter feature that would help to sort the data out in accordance with the grade, group, subject, and digital learning tool. It was decided to make the filter function more compact, hence long lists with checkboxes were replaced with the dropdown menus.

The four visualizations represented information about student progress in accordance with competence goals, knowledge areas, and verbs. Unfortunately, it was not possible to implement the full interaction with visualizations in the prototype. Possible solutions would be provided in the next iterations.

In order to view MittFagkart for an individual student, a view with a list of students was created. The search field was added for letting the user search for a specific student by name/surname. The filter function was also implemented so that the teacher would be able to sort the list of students by grade, group, subject, or digital learning tool the students had been using. The view also included a table that presented such information as name, surname, grade, group, tool, and a link that would transfer the user to the student's OLM.



### **6.4.2 Usability testing with teachers**

There were four teachers who participated in usability testing for the MittFagkart. Each testing session took place online and, by agreement of the participants, was recorded. Zoom and Microsoft Teams were used for that purpose. There were always three people who participated in every meeting: a moderator, a person who observed the testing session (a researcher from the project team), and a user (teacher). Each session would last a maximum of 1 hour.

A script (Appendix H) was created to lead the usability testing. It helped to build the structure for the session as well as to analyze the results of the testing afterward. First, there was an introduction of the participants of the meeting, its purpose, and some organizational moments for the usability testing. Second, several warm-up questions were asked. Then, two tasks to test the prototype were introduced. One task was focused on navigation in MittFagkart, while the second task aimed to get feedback on the chosen visualizations. Finally, there was discussion regarding the prototype as well as some questions from the researcher.

After each usability testing session, the recorded video was analyzed, and based on the analysis, a rapport was created. All four reports are presented in Appendix I.

### **6.4.3 Evaluation of the feedback and new requirements**

The participants gave valuable feedback regarding the concept of the MittFagkart, and visualizations used in the OLM dashboard. Every teacher had a different teaching background and own teaching style, which provided an extensive evaluation of the model. Some of the teachers were very familiar with digital learning tools, some of them used them not so often. Their experience in using the new national curriculum for planning their classes varied between the teachers.

While analyzing the results of the usability testing sessions, the feedback from teachers fell into two groups: general feedback regarding navigation and layout, and feedback about the visualizations.

## General feedback

The participants noted that it was easy to navigate within MittFagkart. The filter function was also understandable to the users. One of the participants suggested relocating the search button, while another asked for the possibility of choosing “all options” in filter-dropdowns. All of the participants also mentioned that the expand-button for the competence goals visualization was almost invisible.

The teachers also pointed out that they liked the colors used in the OLM dashboard and the quick response of the web page to their inputs. At the same time, one of the participants mentioned that the design of the page could be more interesting and colorful. There were also some features that the users missed: some of them would like to see the description of the tasks that students worked with, and everyone claimed that it would be useful to see the visualizations displaying progress for each individual student. One of the participants wondered if she could see the student’s results from previous school years. Several other teachers were interested in getting the descriptions of the tasks students worked with. The general concept of the MittFagkart was partly understandable to the teachers.

## Visualizations

Most of the participants pointed out that MittFagkart had an understandable overview of the student’s progress, but at the same time, there was a need for a better explanation for the concepts (e.g., competence goal, verb, etc.). A teacher with 2 years of experience as an ergonomics therapist (miljøterapeut) barely used these concepts in their teaching, so those were not so familiar to them.

The representation of the competence goals gave a good overview, but the percentage after the bar for each goal was confusing to the users (Figure 41). It was hard to understand what it meant.

ordne tall, mengder og former ut fra  
egenskaper,  
sammenligne de og reflektere over om  
de kan ordnes på flere måter



Figure 41: Skill meter for competence goal with percentage

One of the participants liked the concept map visualization of knowledge areas, but almost every user required a bigger version of this visualization. Some teachers mentioned that it would be useful if the visualizations were interactive (like they could navigate in them, clicking, moving, etc.).

The circular treemap visualization was a bit confusing for the participants: some of the users understood that the size of circles represented the level of knowledge, but for some of them it was not clear what knowledge.

As for the word cloud of verbs, the participants understood that it presented the typical words used in the competence goals, and if the words were big, it meant that the students worked with these verbs the most. One of the teachers would like to see the connection between verbs and tasks. She also suggested presenting the core elements for competence goals, because it could be helpful for talks with parents and other teachers while evaluating the progress of the students.

The participants also mentioned that it would be useful to get an overview of what tools were used by students and to what degree. One teacher asked for a similar MittFagkart for his subject (English).

### **New requirements**

Considering the results of the usability testing and the project's resources, the following changes were considered:

1. Add "all options" for filter-dropdowns.
2. Find another solution for expanding the box that includes competence goals.
3. Work with visual design (colors, avatars).
4. Include OLM visualizations in the student's profile.
5. Add explanation for each concept (competence goals, verbs, knowledge areas).
6. Make visualizations interactive.
7. Make visualizations a bit bigger.
8. Redesign the competence goal - visualization.
9. Add the visualization that would present the overview of used learning tool.

## 6.5 Iteration 2

For the second iteration, all new requirements were considered, and based on them, the new prototype was designed. In order to evaluate the designed prototype, an expert evaluation with a focus on the UI design was carried out. A developer from the project team gave his feedback regarding the visualizations and the layout of MittFagkart. Based on his comments and suggestions, new requirements were established. Figure 42 illustrates the second iteration cycle.



Figure 42: The 2<sup>nd</sup> iteration of the design process

### 6.5.1 New version of the high-fidelity prototype

Considering the results of the usability testing, a new version of the high-fidelity prototype was developed (Appendix J). The filter dropdowns were redesigned: include the option “choose all” and make the design of the dropdowns more pleasant to look at. In addition, the “show”- buttons were removed in order to make the pages responsive automatically to any input at the filter section and search field in the list of students. In this way, MittFagkart would open with the visualizations about all the students and could be rebuilt according to the input in the filter-dropdowns afterward. Next, the expand-button was made more visible by changing its color, but it was not considered as the final solution.

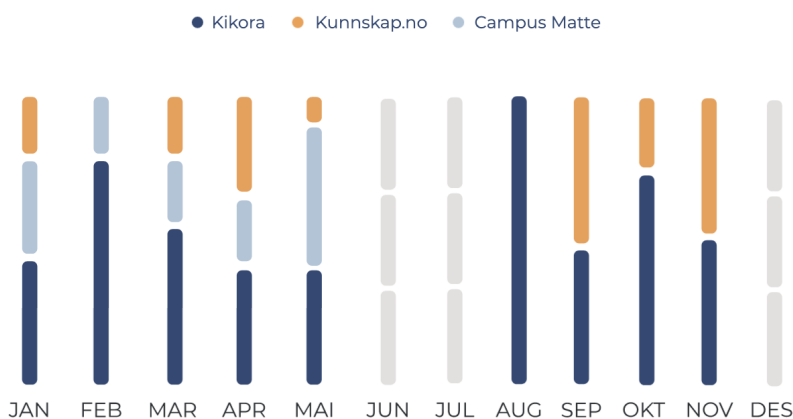
In addition, the background color was changed to a brighter hue of the initial color, so the light elements would be in better contrast. In addition, a set of avatars for teacher and student profiles were developed for use by the users. Figure 43 shows some of the avatars created in Adobe Illustrator.



**Figure 43:** Some of the avatars for the users' profiles

Finally, the layout of the teacher profile was redesigned to present information about classes and subjects differently. A greeting text for the teacher was modified in order to introduce the idea MittFagkart.

The OLM visualizations used to present the progress for an individual student were integrated into the student's profile. In addition, a new visualization was created that shows the use of the different digital learning tools over a year for all the students and for an individual student (Figure 44).



**Figure 44:** Bar chart that shows the use of digital learning tools

In order to provide explanation for each concept used in MittFagkart (competence goals, verbs, knowledge areas), an element was added with a question mark, which by clicking on, would give a short message about what the concept is about (Figure 45).

It was also necessary to reconsider the design of the skill meters for the competence goals. In order to explain which data, the skill meter represented, the proportion of the number of items used for a specific competence goal against the total amount of items for this specific goal were shown. The user could see the proportion by hovering the skill meter (Figure 46). The same hovering effect was implemented for the circular treemap-visualization and the bar chart.

Unfortunately, for this iteration, it was not possible to implement zoom-effect for the visualizations. It was decided to consult the expert first, and then find a possible solution.

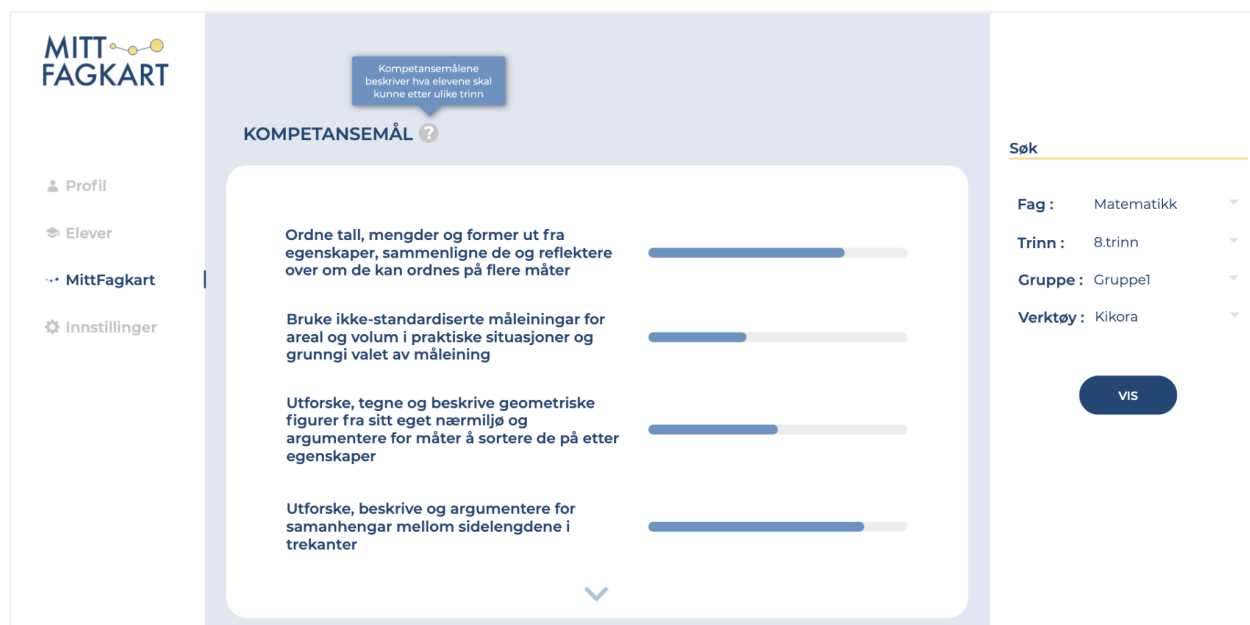


Figure 45: Pop-up message with an explanation of the concepts used in MittFagkart

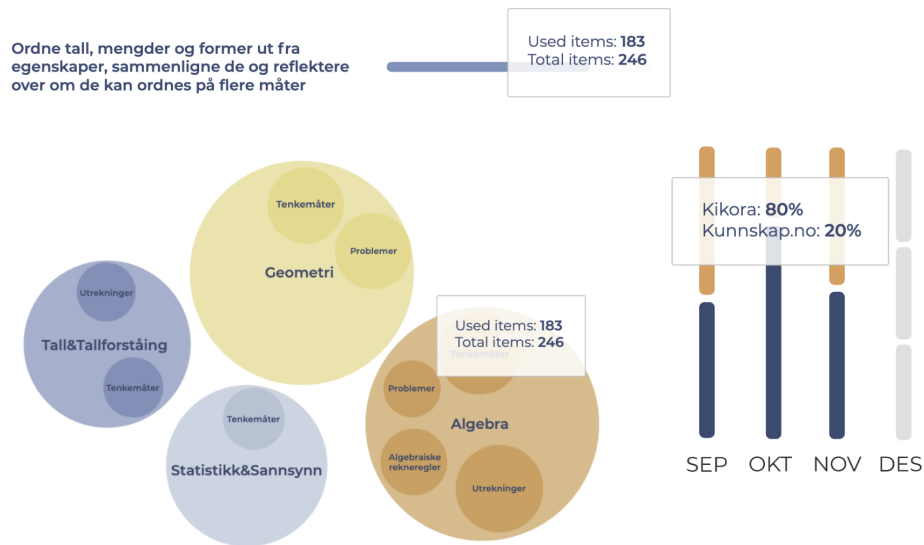


Figure 46: Hovering over the visualizations

## 6.5.2 Expert evaluation

Expert evaluation of the new high-fidelity prototype was conducted as a semi-structured interview where the developer/UI expert from the project team reviewed the prototype and made some suggestions on how it could be improved. A Zoom meeting was arranged and lasted approximately 1 hour.

First, the expert suggested reconsidering a different layout for the prototype. The filter field should be part of the middle area or could pop up by clicking on a button. These design solutions were strictly recommended since they were more universal for different screen sizes.

The second suggestion was regarding the avatars for teacher and student profiles. Unfortunately, there was no information about the gender of the user from the activity data, hence it was not possible to use the avatars created during the second iteration. As a solution, the expert suggested making universal avatars: one for the teacher and one for the student. He also advised to display the name and avatar of the user who was currently logged on at every view. In addition, the expert questioned the need for the teacher's profile at the current stage of the project as there was not so

much information to display; he suggested disabling this view in the prototype and to do more research on that matter.

Third, the feedback regarding the expand button was to consider a scrollbar instead. The content of the box could be endless and expanding the box would require a lot of space.

Finally, the expert commented on the placement of the elements of the prototype and advised being more precise and consistent when working with the distances between elements and headings as well as the padding around the content in the boxes.

### 6.5.3 New requirements

Based on the expert evaluation, the following changes are to be considered for the next iteration:

1. Find another solution for displaying the filter feature.
2. Create neutral avatars: one for the teacher and one for the student.
3. Identify a logged user at different views.
4. Fix the prototype: precise and consistent distance between elements of the prototype.
5. Replace the expand button with a scrollbar.

## 6.6 Iteration 3

The third iteration includes the prototyping of a new version of high-fidelity prototype taking into consideration all suggestions and comments from the expert. In order to evaluate the new prototype, a heuristic evaluation of the MittFagkart was conducted. Based on the results of the evaluation, the new requirements were presented. Figure 47 summarizes the iteration cycle.



**Figure 47:** The 3<sup>rd</sup> iteration of the design process



## 6.6.1 New high-fidelity prototype

Based on the new requirements, a new high-fidelity prototype was developed (Appendix K). To update the prototype for most screen sizes (for desktop and tablet), the filter feature was moved from the sidebar and placed on the top of the pages (Figure 48). The content placed under the filter bar would be responsive to the input automatically.

A new solution for the filter placement in the prototype allowed for more space for visualizations. Hence, the details of the visualizations (e.g., concept map) were more visible. In addition, the expand button was replaced with a scrollbar, which allowed boxes for the content to be more compact.

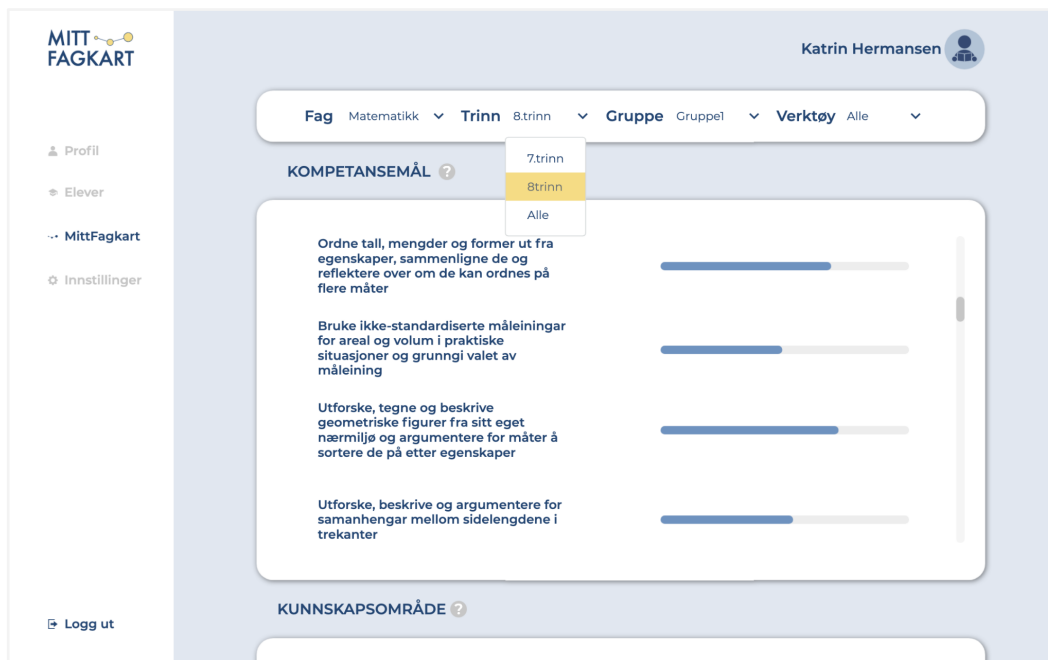


Figure 48: A snippet of the new design

Since at the current stage of the research it was problematic to use the designed avatars, two new neutral avatars were created in theme colors, see Figure 49. The teacher avatar was placed in the header of the web page for identifying a teacher who was currently logged in. The student avatar was used for identifying a student in the list of students and for the student profile. In order to have consistency in the layout, all the spacings and paddings were standardized and the prototype was rebuilt according to them.

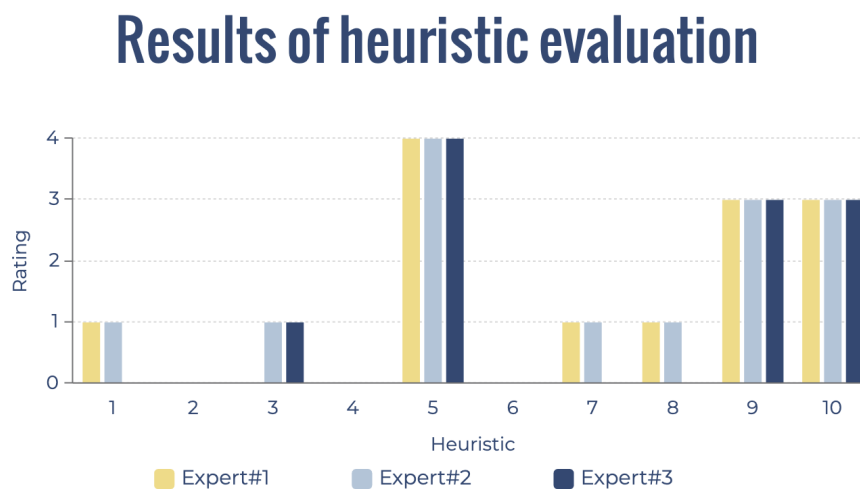


**Figure 49:** Avatars for the student (on the left) and for the teacher (on the right)

### 6.6.2 Heuristic evaluation

There were three experts who performed Nielsen’s heuristic evaluation of the high-fidelity prototype in the third iteration. Each expert was given a link to the prototype and a heuristic evaluation sheet (Appendix B). All of them were asked to rate the prototype in regard to usability problems, from 0 to 4 for each heuristic. Table 4 shows the meaning for each score.

Figure 50 shows the overall result from evaluation; heuristics 1, 3, 7, 8 should be considered for improvement, while heuristics 5, 9, and 10 strictly need to be prioritized. The summary of the feedback from all experts for each heuristic is presented below.



**Figure 50:** Scores for each heuristic

*1. Visibility of system status* - The experts were mostly satisfied with the visibility of the system status of the prototype. One of the experts suggested finding a better solution for identifying the current tab of the user (e.g., changing the background of the tab). Another expert suggested adding some elements that show the loading of the visualizations: if there is a lot of activity data to present, it will require some time for loading and visualizing the data.

*2. Match between system and the real world* - The experts agreed that the prototype uses the user's language. Even if some of the concepts were not familiar (e.g., competence goal), the interface displays a short explanation by clicking on the question mark next to the concept.

*3. User control and freedom* - The only suggestion provided by experts was to link the logo MittFagkart with the start page, in this case, with the teacher's profile view. "Undo" and "redo" options were not relevant for the prototype.

*4. Consistency and standards* - No conflicts were identified by the experts.

*5. Error prevention* - Since it was not possible to test a fully functioning prototype with interactive visualizations and real activity data, the error preventions were not designed for the current state. The experts suggested that this needs to be prioritized for the future version of the prototype.

*6. Recognition rather than recall* - The experts were pleased with the recognition and noted that everything was clear and well-structured.

*7. Flexibility and efficiency of use* - In general, the experts agreed that the prototype is flexible and efficient to use. However, one of the experts suggested allowing customization of the visualizations. He claims that the user should be allowed to choose what visualizations to use based on their own preferences. In that case, unnecessary presentations could be removed from the dashboard in settings or directly in the dashboard. Another expert suggested adding the "go to the top" - button for not scrolling all the way back to the top in the OLM dashboard.

*8. Aesthetic and minimalist design* - The experts were pleased by the color scheme for the prototype and the simplicity of the details. One of the experts suggested making icons for the navigation bar a bit bigger, but it was not extremely necessary. Another expert's advice included

the alternative option for color-blind people. This can be considered for future versions of the prototype.

*9. Help users recognize, diagnose, and recover from errors* - No expert opinion regarding this heuristic since error prevention was not designed.

*10. Help and documentation* - The experts agreed about the need for the documentation. The user might be interested in how to use the model, how it collects the data and which processing algorithms are being used. In this way MittFagkart will be more transparent and possibly result in higher trust of the results. A manual for how to use the OLM dashboard might be also useful.

### **6.6.3 New requirements**

Based on the heuristic evaluation results, the following changes were suggested for future iterations:

1. Find another design solution for identifying the selected tab in the navigation bar.
2. Design the loading screens for the OLM visualizations.
3. Link the logo MittFagkart with the OLM dashboard view.
4. Design error prevention.
5. Design the “settings” view.
6. Add the option of customizing the OLM dashboard (choice of visualizations).
7. Add the “go to the top”- button.
8. Create documentation for the MittFagkart: information about the OLM, guide how to use it.

## **6.7 Chapter Summary**

This chapter described the development process of the low-fidelity and high-fidelity prototypes of MittFagkart. All the prototyping, testing, and evaluating methods as well as the results of each iteration were presented.

## **7 DISCUSSION**

This chapter presents the findings of the research and answers the research questions.

### **7.1 Findings in the systematic literature review**

The systematic literature review provided a good explanation of the OLM concept and an overview of the different types of OLMs. It helped to understand the nature of such a model and, most importantly, helped with the choice of OLM dashboard to design.

The review also helped highlight the benefits of the use of OLMs in teaching, as well as the challenges that might occur while opening the learner model. Some of the listed challenges were also faced during the development of MittFagkart. The questions regarding the visual representations were constantly raised during the research. The issue of transparency was also relevant since during the usability testing some teachers were interested in how the OLM collects data and processes it in order to build the visualizations.

Other valuable findings were the examples of the existing OLMs. Several papers described the development process as well as some case studies regarding the testing of these models. It helped a lot during the work with visualizations for MittFagkart. These examples also gave some thoughts on what might be done in the future versions of the OLM dashboard.

Another finding discovered during the review is that users prefer multiple views for representing the data, thus they should be able to choose which representations work best for them, without excluding other options that might be useful for others.

The literature review also provided useful information about the data for OLMs. Unfortunately, there were not so many papers that described the data types and data collection in detail. However, one paper mentioned that the learner model uses educational data (e.g., personal details, scores, attempts, etc.). It was also highlighted that OLMs can use single types of data (e.g., multiple-choice scores) as well as behavioral metrics (e.g., number of questions completed).

Possibly, that a separate search string on data collection and data types for OLMs and learner models could give a better result.

Finally, the systematic literature review revealed that the selection of the visualization methods for presenting the activity data is challenging due to the different preferences and needs of stakeholders. Some actors prefer simple and clear visualizations, others would like to use more complex and detailed. Such preferences are based on the nature of stakeholders' work as well as on their experience working with data. In addition to that, the choice of the presentations can depend on the learner model's aims and learning context.

There are various different types of visualizations that are being used in OLMs. The literature review identified 41 visualizations, but it is possible to believe that it is not a final number. Such variety shows that there is no agreed standard or best approach to visualize the data, everything depends on the context of the work.

## **7.2 Findings in the development of the prototype**

This section presents the findings discovered during the work on the development of the prototype. It includes the discussion of the chosen methods for the development process along with their results.

### **7.2.1 Central methodology**

User-centered design was chosen as the main methodology for the development of the prototype. An early focus on the users and their needs helped to develop a product that is relevant and that is able to support the user's activity. Iterative cycles of the development enabled continuous evaluation of the prototype, hence helping to identify and fix all issues and usability problems with the design.

### **7.2.2 Establishment of the requirements**

For establishing functional and non-functional requirements, a set of methods were used. As was mentioned earlier, the systematic literature review provided some valuable information regarding the OLM visualizations and features that can be used in the design of MittFagkart.

The analysis of the interviews with teachers gave insights into what information about student progress is useful to display in the OLM dashboard, and what they are missing in the digital learning tools. The results of the workshop gave some ideas regarding the UI design of MittFagkart.

Creating personas, use cases, and storyboards are typical user-centered approaches that helped to focus on the problem and situations that users could experience, rather than on the features and functionality of the developing product. The persona “Katrin Hermansen” helped to set the goal for the OLM dashboard: to get an overview of the student progress according to the curriculum while teaching online. A storyboard told why she actually needed it, while the use case provided a set of steps that could be taken within MittFagkart in order to achieve the goal. Creating multiple personas, more use cases, and storyboards could help to identify other different problems and lead to other design solutions.

### **7.2.3 Prototyping**

Sketching and wireframing methods can be considered very useful for creating a low-fidelity prototype. They were easy to implement and if necessary to modify, which is important for the early stages of development.

Implementing a clickable digital prototype was the essential task for the current work. It provided the possibility to simulate the navigation and functionality within the OLM dashboard as well as to test out the chosen visualizations. Most importantly, it allowed sharing the prototype with the test participants and experts, which is essential when the testing sessions were held online.

Creating a clickable prototype is time-consuming, but a very efficient way of prototyping, and results in prototypes as close to the real product as possible. It allows making prototypes as close to the real product as possible. For MittFagkart, most of the functionality was displayed in the prototype, but unfortunately, Proto.io software did not allow implementing fully interactive OLM visualizations.

## 7.2.4 Design principles

While designing for the user experience, the design principles were followed. The *visibility* of the prototype was evaluated by both test participants and usability experts. No major problems were identified, the users understood the navigation within the MittFagkart, its structure, and the main features. There were some small suggestions and recommendations on how the visibility could be improved. These comments can be considered for future work.

MittFagkart is also able to provide *feedback* about the action that has been taken. The views of the prototype are responsive mostly to any user's input. The exception was the interactivity with the OLM visualizations: not all visualizations were fully clickable, some of the features such as zooming or expanding were not possible to implement. During the last iteration, some of the interactions with the visualizations were imitated, but they cannot be considered as fully functioning. Error prevention was not developed for the current versions of the prototype.

In order to focus the users on a particular view of the prototype, the *constraints* principle was applied. The navigation sidebar highlighted the view where the user was currently at by disabling the other tabs. In this way, even though the sidebar was always visible and sticky to the main part of the view, the user was still concentrated on the tab that was currently used by him.

The same principle was applied to some of the visualizations. For example, in the concept map, the knowledge areas that students did not work with were presented with colors of lower opacity. In this case, the user had a focus only on the ones that were bright, so he was able to see what the student knew in accordance with the whole map.

The *consistency* principle was applied to the UI design of the prototype. After the UI expert evaluation, it was necessary to be more precise and consistent in the distances between elements and spacing of the titles. Other than that, similar-looking elements were able to achieve similar tasks (e.g., navigation, dropdown filters).

The *affordance* of the prototype was evaluated by both usability testing participants and heuristic evaluation. During the usability testing, some of the visualizations were not clear as well as the concepts that were used in the OLM. In order to fix that, some pop-up windows were added that



would explain the concepts. As for visualization, the implementation of the interactivity (Figure 46) improved the affordance of the prototype. As for expert evaluation, they were pleased by the recognition of the prototype, but still provided some recommendations on how to increase the flexibility and efficiency of use of the OLM dashboard (e.g., allowing the customization of the visualizations, “go to the top”- button).

## **7.2.5 Evaluation**

There were four different types of evaluations: usability testing with four participants (teachers), expert evaluation/review with the project team, UI expert evaluation in the form of a semi-structured interview, and usability expert evaluation in the form of a heuristic test. Each evaluation session provided various feedback on the different aspects of the prototype such as usability, design, and functionality.

### **7.2.5.1 Usability testing**

Usability testing was an essential part of the evaluation of the prototype. The results showed what the users understood about the concept of the OLM dashboard as well as how well they could perceive the interface of MittFagkart along with all design decisions made.

There were four test participants, coming from different schools and with different teaching experiences. The difference in their teaching techniques and ways of planning classes helped to evaluate the OLM from different perspectives. Some of the teachers were familiar with the concepts from the national curriculum, some of them barely used them in their teaching. Thus, in order to provide some sort of guidelines in the MittFagkart dashboard, the pop-up elements with the short messages that explain the concepts were made.

During the usability testing, valuable feedback regarding the OLM visualizations and design was provided. Some of the presentations were unclear to the users, so it was important to find a way to improve them. It was mostly fixed by adding some interactivity to the presentations: when the user hovers over the skill meter or treemap, the additional information (e.g., the proportion of the used items to the total number items) would be displayed. In addition, there were some teachers who suggested adding more elements from the curriculum, such as information about the core elements and their connections with tasks.

The users also noted that they liked the colors and the minimalistic design of the model, but some of them expected something more colorful and complex. Overall, the participants were pleased by the design and the concept of MittFagkart.

### **7.2.5.2 Expert evaluation**

The expert evaluation provided valuable feedback regarding the design, functionality, and usability of the prototype MittFagkart. Experts from the project group tested out the low-fidelity prototype with a focus on usability and choice of the OLM visualizations. The suggestions for improvement were considered and applied in the further iterations.

The UI expert identified some problems in the design of the high-fidelity prototype and gave some recommendations on how it could be improved. The relocation of the filter increased the flexibility of the view, while the compliance with the distance between elements and equal spacings made the prototype more consistent and its design cleaner. Some ideas for a redesign of the UI elements, like scrollbar and universal avatars, also improved the usability of the prototype.

Finally, three usability experts performed a heuristic evaluation of the prototype MittFagkart. The results of the evaluations showed that there is a need for implementation of the error prevention as well as a loading screen that would identify that the visualization is not empty, it is loading the data in order to build the presentation. The experts also suggested including some documentation about how MittFagkart works, how it gets and processes data. This would increase the transparency of MittFagkart dashboard. Some small changes regarding the UI design were also recommended (e.g., a different way of highlighting the chosen tab in the sidebar, “go to the top”-button, link the corner logo MittFagkart with the start page (teacher’s view)).

## **7.3 Answering the research questions**

Based on the findings from the systematic literature review and the process of the prototype development, the research questions stated earlier can be answered.

### ***RQ1: What do teachers want to know about student activity?***

The analysis of the interviews showed that the teachers are interested in getting a good overview of the progress of an individual student, as well as the whole class. By the progress of the students,

the teachers meant the number of the activities performed/answered, the number of the attempts for completing an exercise, and information about which topics the student understands/struggles with.

During the usability testing, the teachers agreed that it could be very useful to connect the activities performed by students with the national curriculum (e.g., the core elements of the curriculum such as the competence goals). Thus, it is possible to conclude that teachers are also interested in seeing how well the students do according to the curriculum while working with the digital learning tools.

***RQ2: What data should be shown in a dashboard for teachers and how should it be presented?***

The systematic literature review did not identify particular specifications or rules on what data should be displayed in the OLM dashboard, however it is important that the data is presented in a structured and easy-to-perceive form.

The results showed that MittFagkart should present educational data, such as personal details, scores in assessment activities, educational resource access/usage patterns, and learning activity access/completion patterns during the learning process. During the usability testing, some teachers suggested that it would be useful to display the text description of the tasks students performed.

***RQ3: What visualizations are best for the teachers?***

As was stated earlier the systematic literature review showed that there are no agreed standards or the best approach of visualizing the OLMs. There are different factors that may affect the choice of the visualizations, such as the aim of MittFagkart, learning context, target group, size of the domain, age and information visualization literacy, etc.

In order to choose the right visualization for MittFagkart, it was important to keep in mind the context of use of the visualizations, the goals that are wanted to be achieved through the

visualizations, and the individual preferences of the target group. The view with multiple visualizations can be provided for satisfying preferences of as many users as possible.

The usability testing sessions showed that teachers preferred easy-to-perceive visualizations, but at the same time they liked creative decisions for the presentation of the student progress. The most common visualizations, such as concept maps and skill meters, were approved by the teachers as long as the methods were clear about what data they represented. The concept map was especially identified as one of the favorites. The circular treemap was the most complex according to the teachers. Possibly, the reason for that was that the users did not have enough experience using/viewing this type. Word cloud was clear and considered as a useful presentation of the data if the user focuses on the verbs while teaching.

It is also important to note that the ability to interact with the visualizations is highly recommended. During the testing, the teachers really wanted to click, move, zoom in on the representations in order to get more information. In that case, both simple OLM visualizations (e.g., skill meter) and more complex, such as treemap, should be interactive.

## **7.4 Limitations**

The current research was conducted under some limitations. This section presents the limitations for different aspects of the work.

### **7.4.1 The systematic literature review**

The findings of the literature review have to be seen in the light of some limitations. First of all, there was limited access to different databases. It was decided to use only three databases for conducting the literature review which means that there is a possibility that some valuable sources of information for the research were missed.

Second, publications were limited by inclusion criteria. Publications were chosen for the analysis that particularly focuses on visualization and describing OLMs as a concept, written in English in a period of time 2005-2021. There is a chance that some case studies were missed, hence specific

examples of how OLM can be used and benefit the learning process in various learning environments.

Third, not all selected publications presented extensive information about various visualizations. Some of the work just mentioned the type of visualization, without any additional information. Possibly, a manual search could give better results in describing different presentation formats.

Finally, the literature review showed not so much information about different types of data that can be used in OLMs. The selected publications did not describe data collection or data types in detail, therefore there is a need for thorough research on that topic.

### **7.4.2 Usability testing**

Conducting online usability testing was not as challenging as the recruitment of the participants. Even though there were multiple meetings with teachers where the AVT2 project was presented, there were only four teachers who agreed to participate. We attribute this to the COVID-19 pandemic, as most of the teachers in Oslo municipality were teaching online, so it was very hard for them to find extra time between online classes and preparations.

Holding only online usability testing could be also considered as a limitation of the research (it was originally planned that the usability testing would take place in Oslo). Possibly, testing the prototype in person would give different results as well as reaching out to more participants.

### **7.4.3 Target group**

Initially, the target group for the OLM dashboard included such stakeholders as students, teachers, EdTech vendors, parents, and researchers. Due to the COVID-19 pandemic, there was no possibility to involve all stakeholders in the prototype development, thus the target group was narrowed down to the teachers.

## **7.5 Chapter Summary**

This chapter presented the findings discovered during the research work. It also provided the answers on the research questions and described the limitations of the work.

## **8 CONCLUSION**

This master thesis has described the design process of the high-fidelity prototype for the OLM dashboard, MittFagkart, that supports adaptive learning in Norwegian schools. MittFagkart presents information about a student's progress towards knowledge in accordance with the national curriculum for Mathematics. It visualizes the students' activity data collected from different learning tools, hence teachers are able to get a good overview of the student's progress across the tools, as well as being supported in decision-making and planning their teaching. The prototype will be taken for further development by the AVT2 project team, considering all the results and suggested improvements from the latest evaluation.

### **8.1 Summary**

During the research, the systematic literature review provided a solid understanding of the OLM concept. Different types of OLMs, their benefits, and challenges that might occur while opening a learner model were described. The review identified a list of the visualizations that might be used for representing the data in OLMs. The most common presentation formats (e.g., concept maps, treemaps, skill meters, word clouds, etc.) were described in detail with their specifics and purposes. Several examples of the OLM were also provided. Unfortunately, there was not so much information regarding the data types that could be represented in OLMs that were identified. More research is needed.

A user-centered design methodology was chosen for carrying out the development of MittFagkart prototype. The development process included a pre-phase and three iterations of the designing-testing-evaluating cycle. Different versions of the prototype were evaluated by the usability experts, UI experts, and the users during the usability testing sessions. The variety of the evaluation methods allowed to test the usability, functionality, and visual design of the developed prototype.

The current work also described contributions made to the AVT2 project. The processes of the development of the logo, home page, and color scheme were presented. The limitations were described and can be taken into consideration with future work.

Finally, based on the findings from the literature review and prototype development process, the research questions were answered.

## **8.2 Future work**

The current research offers possibilities for future work. Considering the results of the heuristic evaluation, there is a need for designing error prevention. It is essential to alert the users when they are making an error as well as showing the way how they can recover from it. In order to provide more feedback to the user, there is also a need for showing the process of the loading of the data in the OLM visualizations. Designing the loading animation could solve this issue.

In addition, the UI design of the MittFagkart could be improved by adding a short-cut button “go to the top”, choosing different design solution for the selection of the tab in the navigation bar as well as linking the logo MittFagkart with the start page (user’s profile). In order to increase the flexibility and efficiency of the MittFagkart, the mobile version of the OLM dashboard should be developed. In order to increase transparency, the dashboard could provide some documentation on how it collects and processes activity data.

For future versions of the OLM dashboard, multiple visualizations are highly recommended. The ability to customize the dashboard visualizations according to the user’s preferences should be implemented. Possibly more concepts from the national curriculum could be presented (e.g., core elements), but more research is needed.

The essential part of the future work is creating the OLM dashboard MittFagkart for different stakeholders: students, parents, EdTech vendors, and researchers. Significant research is needed in regard to what data is allowed to be presented to the different users (the project team is currently participating in the national Data Protection Agency’s AI Sandbox where many of these limitations and possibilities are being discussed). Creating MittFagkart for various subjects like English, Norwegian, and Natural Science should also be considered.

Finally, more usability testing sessions and field research on how different stakeholders interact with the MittFagkart is highly recommended.

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## 10 APPENDICES

### Appendix A - Consent form

#### Vil du delta i forskningsprosjektet Aktivitetsdata for vurdering og tilpasning (AVT)?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke og utvikle teknologi som støtter innsamling og presentasjon av data fra digitale læremidler, samt utvikling av et rammeverk for leverandører av digitale læremidler. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

##### Formål

Elever i dagens skole har tilgang til flere ulike digitale læringsressurser fra ulike leverandører. Når elever bruker disse ressursene i undervisningen, legger de igjen en stor mengde data om sine aktiviteter, som for eksempel hvilke oppgaver de har løst. Dette kalles *aktivitetsdata* og kan f.eks. brukes til å finne oppgaver og ressurser som er tilpasset den enkelte elev.

AVT omfatter 5-10. trinn i fagene engelsk, matematikk, norsk, naturfag og samfunnsfag. Prosjektet skal undersøke hvordan aktivitetsdata kan tas i bruk av elever, lærere og leverandører. Som del av prosjektet vil det også være masterprosjekter og prosjektet vil gi kunnskap til fremtidige prosjekter.

##### Hvem er ansvarlig for forskningsprosjektet?

Centre for the Science of Learning and Technology (SLATE) ved Universitetet i Bergen har ansvar for prosjektgjennomføringen. Prosjektet er initiert av Utdanningsetaten i Oslo kommune og eies av Kommunenes Sentralforbund (KS)

##### Hvorfor får du spørsmål om å delta?

På bakgrunn av en åpen invitasjon fra skoleeier, har din skole meldt sin interesse.

##### Hva innebærer det for deg å delta?

For å få kunnskap om hvordan lærere og elever bruker digitale læringsressurser, og aktivitetsdata som genereres fra slike læringsressurser, ønsker vi å innhente forskningsdata gjennom: intervju, surveys og observasjon i relevante kontekster. Intervjuene vil bli foretatt med hjelp av nettmøte eller fysisk møte om mulig. Intervjuene varer mellom 1- 1,5 timer. Vi vil foreta 1-2 intervjuer i løpet av prosjektet. Det blir gjort opptak av intervjuene. Vi ønsker også å ta notater og bilder ved observasjon av bruk av de digitale ressursene som brukes til undervisning og læring og teknologien som utvikles i prosjektet.

##### Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

##### Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvermregelverket. Transkriberte data, notater og bilder blir lagret. Det er kun forskningsgruppen SLATE, ved UiB som behandlingsansvarlig institusjon, som har tilgang til dataene. Dataene lagres sikkert på maskin låst med passord. Hverken navn eller kontaktopplysninger vil bli lagret. Personer vil ikke kunne gjenkjennes i publikasjoner.

##### Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?

Opplysningene anonymiseres når prosjektet avsluttes, noe som etter planen er i desember 2021. Data fra AVT er ikke bare verdifull informasjon for selve prosjektet, men et tidsbilde til fremtidig forskning om digitale læringsressurser i skolene. Etter AVT prosjektet vil anonymiserte data bli lagret hos Norsk senter for forskningsdata AS (NSD) på ubestemt tid, regulert av UiB. Vi vil derfor ta vare på disse for mulig fremtidige relevante prosjekt. Notater, bilder og transkriberte opplysninger blir lagret.

#### **Dine rettigheter**

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg, og å få utlevert en kopi av opplysningene,
- å få rettet personopplysninger om deg,
- å få slettet personopplysninger om deg, og
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger.

#### **Hva gir oss rett til å behandle personopplysninger om deg?**

Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Universitetet i Bergen har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

#### **Hvor kan jeg finne ut mer?**

Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- SLATE, UiB ved [redacted] eller [redacted]
- Vårt personvernombud: [redacted]

Hvis du har spørsmål knyttet til NSD sin vurdering av prosjektet, kan du ta kontakt med:

- NSD – Norsk senter for forskningsdata AS på epost [redacted] eller på telefon: [redacted]

Med vennlig hilsen

[redacted]

---

## Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet *Aktivitetsdata for vurdering og tilpasning (AVT2)*, og har fått anledning til å stille spørsmål. Jeg samtykker til:

- gi tilbakemelding på teknologien som blir utviklet i prosjektet
- å bruke avtalte digitale læremiddel i min undervisning
- å delta i intervju
- tillate observasjon av bruken av digitale læringsressurser

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

---

(Signert av prosjektdeltaker, dato)

# Appendix B - Heuristic evaluation sheet

## Heuristic Evaluation Sheet

Expert:

Device:

Date:

Webpage: MittFagkart

- 0 I don't agree that this is a usability problem at all
- 1 Cosmetic problem only: need not be fixed unless extra time is available on project
- 2 Minor usability problem: fixing this should be given low priority
- 3 Major usability problem: important to fix, so should be given high priority
- 4 Usability catastrophe: imperative to fix this before product can be released

### 1. Visibility of the system status

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

0 1 2 3 4

Comments/suggestions

### 2. Match between system and the real world

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.

0 1 2 3 4

Comments/suggestions

### 3. User control and freedom

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.

0 1 2 3 4

Comments/suggestions

### 4. Consistency and standards

Users should not have to wonder whether different words, situations, or actions mean the same thing.

0 1 2 3 4

Comments/suggestions

<p><b>5. Error prevention</b></p> <p>Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.</p> <p>0 1 2 3 4  <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/></p>	<p><b>Comments/suggestions</b></p> <div style="background-color: #e6f2ff; height: 60px;"></div>
<p><b>6. Recognition rather than recall</b></p> <p>Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.</p> <p>0 1 2 3 4  <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/></p>	<p><b>Comments/suggestions</b></p> <div style="background-color: #e6f2ff; height: 60px;"></div>
<p><b>7. Flexibility and efficiency of use</b></p> <p>Accelerators — unseen by the novice user — may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.</p> <p>0 1 2 3 4  <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/></p>	<p><b>Comments/suggestions</b></p> <div style="background-color: #e6f2ff; height: 60px;"></div>
<p><b>8. Aesthetic and minimalist design</b></p> <p>Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.</p> <p>0 1 2 3 4  <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/></p>	<p><b>Comments/suggestions</b></p> <div style="background-color: #e6f2ff; height: 60px;"></div>
<p><b>9. Help users recognize, diagnose, and recover from errors</b></p> <p>Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.</p> <p>0 1 2 3 4  <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/></p>	<p><b>Comments/suggestions</b></p> <div style="background-color: #e6f2ff; height: 60px;"></div>



## 10. Help and documentation

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.



## Comments/suggestions

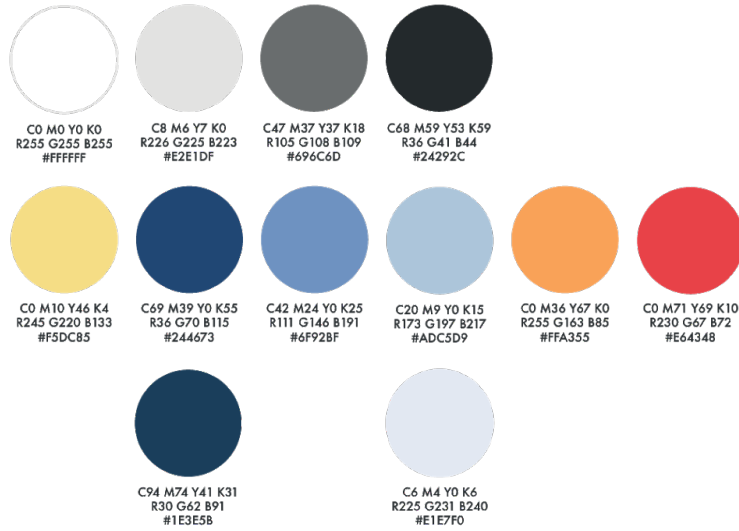
A large, empty light blue rectangular area intended for user comments or suggestions.

## Appendix C - A snippet of the xAPI statement

```
{
  "id": "ab2b8bed-98c0-46d5-a432-c9646f638a58",
  "timestamp": "2018-05-10T11:50:00Z",
  "actor": {
    "objectType": "Agent",
    "account": {
      "homePage": "https://docs.dataporten.no",
      "name": "76a7a061-3c55-430d-8ee0-6f82ec42501f"
    }
  },
  "verb": {
    "id": "http://adlnet.gov/expapi/verbs/completed",
    "display": {
      "en-US": "completed",
      "nb-NO": "fullførte"
    }
  },
  "object": {
    "objectType": "Activity",
    "id": "https://osloprovene.inspera.no/ov-mat-4/test/123",
    "definition": {
      "name": {
        "nb-NO": "Overgangsprøve i regning 4. trinn 2017"
      },
      "type": "http://adlnet.gov/expapi/activities/assessment"
    }
  },
  "result": {
    "duration": "PT38M44S",
    "completion": true,
    "success": true,
    "score": {
      "min": 0.0,
      "max": 45.0,
      "raw": 38.0,
      "scaled": 0.844
    }
  },
  "context": {
    "registration": "e28fa121-91e1-43c7-9192-d9d6546bd76e",
    "platform": "Inspira prøvemotor for Oslo",
    "language": "nb-NO",
    "contextActivities": {
      "grouping": [
        {
          "objectType": "Activity",
          "id": "https://data-nsr.udir.no/enhet/976820037",
          "definition": {
            "name": {
              "nb-NO": "Oslo kommune Utdanningsetaten"
            },
            "type": "https://w3id.org/xapi/avt/activity-types/school-owner"
          }
        },
        {
          "objectType": "Activity",
          "id": "https://data-nsr.udir.no/enhet/974589648",
          "definition": {
            "name": {
              "nb-NO": "Abildsø skole"
            },
            "type": "https://w3id.org/xapi/avt/activity-types/school"
          }
        },
        {
          "objectType": "Activity",
          "id": "https://clientadmin.dataporten-api.no/clients/cc2b2720-4dae-4220-8258-1f6ac8c6dd4f",
          "definition": {
            "name": {
              "nb-NO": "Inspira"
            },
            "type": "https://w3id.org/xapi/avt/activity-types/feide-clientinfo"
          }
        }
      ]
    }
  }
}
```

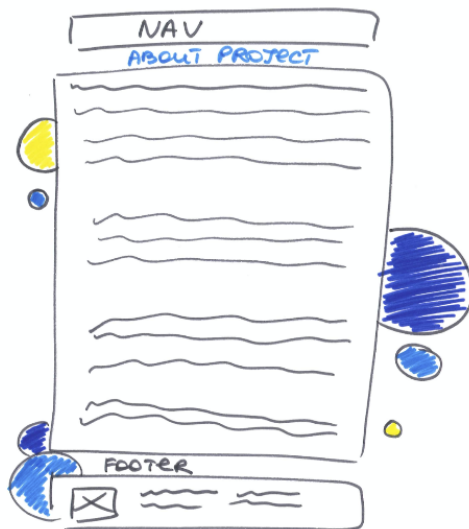
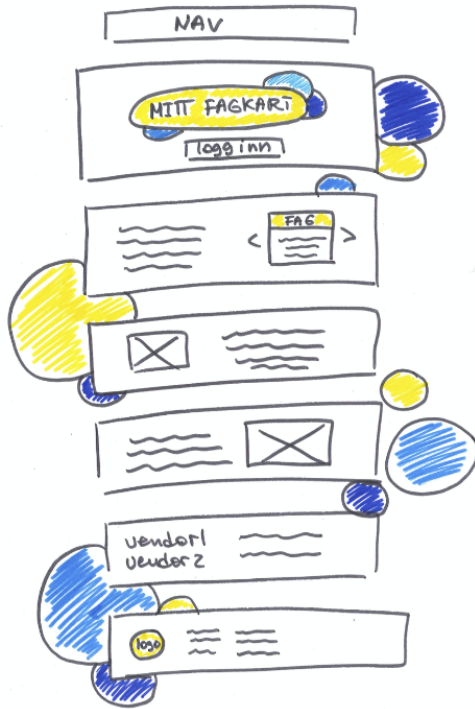
# Appendix D - Color palette

## COLORS



# Appendix E – Home page for MittFagkart

## Sketches



# Layout





[HJEM](#)[PROSJEKT](#)[TEAM](#)[NOR](#) [LOGG INN](#)

## MØT TEAMET VÅRT



Lorem ipsum dolor sit amet, consectetur adipiscing elit. Fusce convallis pellentesque metus id lacinia. Nunc dapibus pulvinar auctor. Duis nec sem at orci commodo viverra id in ipsum. Fusce tellus nisi, vestibulum sed rhoncus at, pretium non libero. Cras vel lacus ut ipsum vehicula aliquam at quis urna. Nunc ac ornare ante.

## KONTAKT OSS



**Name Surname**

JOB TITLE

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy



**Name Surname**

JOB TITLE

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy



**Name Surname**

JOB TITLE

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**Name Surname**

JOB TITLE

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy



[Prosjekt](#)  
[Team](#)

[Betingelser og vilkår](#)  
[Personvern](#)

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## Appendix F - Invitation letter

Hei “navn”,

Jeg kontakter deg da jeg har fått navnet ditt fra “navn” og din skole er med i KS-prosjektet [Aktivitetsdata for Vurdering og Tilpasning, vol.2 \(AVT2\)](#). The Centre for the Science of Learning & Technology (SLATE) ved Universitetet i Bergen har ansvar for forskning og utvikling i prosjektet.

Jeg er veldig glad for at du har sagt ja til å bidra inn i prosjektet.

Mitt navn er Maria Ovchinnikova jeg er masterstudent ved UiB, med min masteroppgave er tilknyttet dette prosjektet hvor jeg er designer og testmoderator.

I prosjektet jobber vi med å lage et system som heter MittFagkart. MittFagkart skal samle data fra ulike digitale læringsverktøy (f.eks Kikora, Conexus, Cerpus osv.) og presenterer dette til lærere og elever på en god måte. For å utvikle MittFagkart må vi teste den med ekte brukere. Derfor vil vi gjerne invitere deg til brukertesting med oss.

Som deltaker blir du spurt om å gjennomføre enkle oppgaver innen systemet, som f.eks. å søke og finne fram navn på elever, sjekke om elevene har jobbet med oppgaver som har blitt tildelt og andre lignende funksjoner. Vi vil også gjerne vite din mening om MittFagkart og ber derfor om dine kommentarer på funksjonalitet. Hva kan forbedres eller er det noen funksjoner som mangler?

Jeg vil påpeke at dette ikke er en test av deg og dine kunnskaper, men en test av produktet og dets brukervennlighet.

Vi håper det er mulig å finne en passende dato. Vi er fleksibel med dato og tidspunkt, men håper det er mulig å finne en dato i uke 16/17. Hele møtet vil ta maks 1 time, inkludert testing og uformell samtale. Det skal gjennomføres på Zoom/Teams. Om du foretrekker å bruke et annet plattform, kan vi også gjøre det. Vi sender lenken til møte når vi er enig om dato og tidspunkt. Hvis du har noen spørsmål, ikke nøl med å kontakte meg eller “forskers navn”.

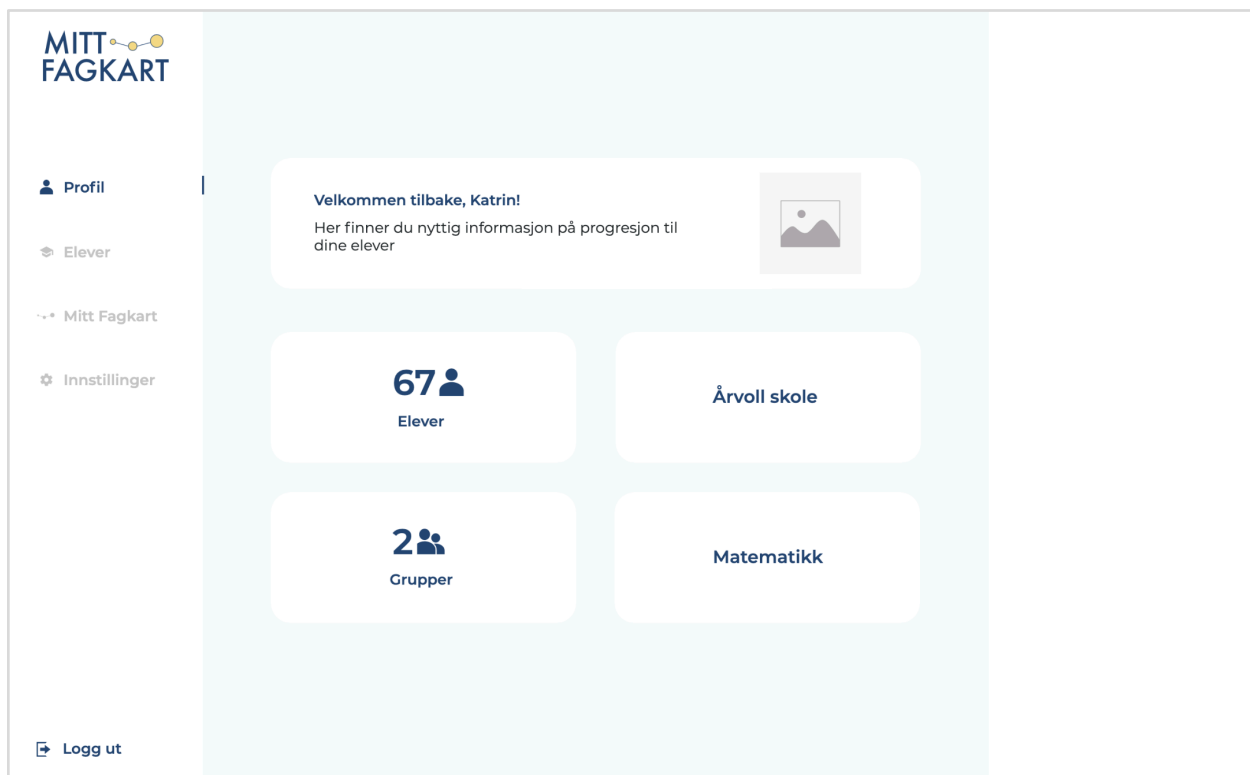
I mailen legger vi ved et informasjonsbrev med samtykke til deltakelse. Det er viktig for at du vet at deltakelse er helt frivillig.

Vi gleder oss til å høre fra deg!  
Med vennlig hilsen,  
Maria Ovchinnikova



## Appendix G - MittFagkart prototype, 1<sup>st</sup> iteration

### Teacher profile



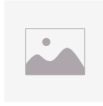
## Student profile

**MITT FAGKART**

- Profil
- Elever
- Mitt Fagkart
- Innstillinger

Logg ut

**Hanne Pettersen**  
BIO til eleven




**5**  
Trinn

**Årvoll skole**

**1**  
Gruppe

**Matematikk**

# List of students



MITT  
FAGKART











- Profil
- Elever
- Mitt Fagkart
- Innstillinger
- Logg ut

### Søk

Q Søk etter elev

Matematikk x 8.trinn x Gruppe1 x Gruppe2 x Kikora x

### Elever

Navn	Etternavn	Trinn	Gruppe	Plattform	
	Magnus Carlsen	8.trinn	Gruppe1	Kikora	<a href="#">Se mer</a>
	Navn Etternavn	8.trinn	Gruppe1	Kikora	<a href="#">Se mer</a>
	Navn Etternavn	8.trinn	Gruppe1	Kikora	<a href="#">Se mer</a>
	Navn Etternavn	8.trinn	Gruppe1	Kikora	<a href="#">Se mer</a>
	Navn Etternavn	8.trinn	Gruppe1	Kikora	<a href="#">Se mer</a>
	Navn Etternavn	8.trinn	Gruppe2	Kikora	<a href="#">Se mer</a>
	Navn Etternavn	8.trinn	Gruppe2	Kikora	<a href="#">Se mer</a>
	Navn Etternavn	8.trinn	Gruppe2	Kikora	<a href="#">Se mer</a>
	Navn Etternavn	8.trinn	Gruppe2	Kikora	<a href="#">Se mer</a>
	Navn Etternavn	8.trinn	Gruppe2	Kikora	<a href="#">Se mer</a>

### Filter

- Fag v
- Trinn v
- Gruppe v
- Verktøy v

# OLM dashboard

**MITT FAGKART**

Profil

Elever

Mitt Fagkart

Innstillinger

Logg ut

Matematikk x 8.trinn x Gruppel x Verktøy x

**Kompetensemål**

ordne tall, mengder og former ut fra egenskaper, sammenligne de og reflektere over om de kan ordnes på flere måter	80%
utforske, tegne og beskrive geometriske figurer fra sitt eget nærmiljø og argumentere for måter å sortere de på etter egenskaper	55%
bruke ikke-standardiserte måleiningar for areal og volum i praktiske situasjoner og grunnngi valet av måleining	15%
utforske, beskrive og argumentere for samanhengar mellom sidelengdene i trekantar	50%

**Kunnskapområde**

**Område i MittFagkart**

**Verb**

**Filter**

Fag v

Trinn v

Gruppe v

Verktøy v

## Appendix H - A script for usability testing

Hei, jeg heter Maria, og jeg skal lede deg gjennom dagens økt. Som jeg har nevnt via e-post, samarbeider teamet mitt for tiden med Utdanningsetaten og KS på et prosjekt som heter "Aktivitetsdata for vurdering og tilpasning, del 2". Hovedformålet med dette prosjektet er å utvikle et system vi kaller MittFagkart som samler inn data fra forskjellige digitale læringsverktøy og presenterer en oversikt over aktivitetsdata som produseres av elever når de jobber med skolearbeid, på mest effektiv måte. Med oss på samtalen er \*navn\*, min kollega og forsker i dette prosjektet.

Jeg vil begynne med å takke deg for at du har tatt deg tid til å snakke med oss. Tilbakemeldingene dine er verdifulle og vil hjelpe oss med å avgjøre om systemet vårt fungerer som forutsatt. Bare for å bekrefte, vil vi holde denne økten på ca 45 minutter - 1 time. Passer dette fortsatt for deg?

Flott. Om du trenger pauser kan vi stoppe når som helst, bare si ifra.

Jeg vil begynne denne økten med å stille deg noen spørsmål rundt arbeidet ditt. Senere vil jeg be deg om å dele skjerm med meg for å utføre noen oppgaver ved hjelp av en prototype vi har laget.

Jeg ønsker også å gjøre deg oppmerksom på at det ikke finnes noen feil eller dårlige svar. Når du begynner å bruke systemet, vil jeg be deg tenke høylytt så mye som mulig: å beskrive hva du ser på skjermen og hva du prøver å gjøre. Dette vil være til stor hjelp for oss.

Vær heller ikke bekymret for å være for kritisk. Vi gjør dette for å forbedre systemet vårt, derfor ønsker vi å høre dine ærlige reaksjoner.

Hvis du har spørsmål underveis, er det bare å spørre. Jeg kommer ikke til å være i stand til å svare på alle spørsmålene med en gang, siden vi er interessert i hvordan folk bruker applikasjonen når de ikke har noen som sitter ved siden av dem og hjelper. Men hvis du fortsatt har spørsmål når vi er ferdige, vil jeg prøve å svare på dem så godt som mulig da.

Med din tillatelse vil jeg ta opp denne samtalen. Opptaket vil bare brukes til å hjelpe oss med å finne ut hvordan vi kan forbedre Mitt Fagkart, og det vil ikke bli sett av andre enn de med behov. Vi kan også slå av kamera og kun ta opp lyd. Har jeg tillatelse til å ta opp denne samtalen?

Til slutt vil jeg bekrefte at du har mottatt og har hatt tid til å gjennomgå deltaker avtalen? Har du noen spørsmål relatert til dette? Hvis du har signert avtalen, kan du sende meg en kopi. Godtar du ellers vilkårene i deltakeravtalen?

Flott. Har du noen andre spørsmål så langt?

### Warm up

Før vi tar en titt på MittFagkart, vil jeg gjerne høre litt om deg - hva er ditt yrke? Kan du beskrive noen av dine vanlige daglige rutine som lærer i \* fag \*? Bruker du digitale læringsverktøy for å undervise? (Conexus, Kikora, itslearning osv.)

### Setup screen sharing

Ok flott. Vi er nå ferdige med spørsmålene, og vi kan begynne å se på prototypen. Det første jeg vil at du skal gjøre er å dele skjerm med meg. Du kan gjøre dette ved å klikke på "Del skjermbildet" nederst til høyre i videochatten vår. Før du deler, må du sørge for å lukke alt du ikke vil at skal spilles inn.

Flott. Nå vil jeg at du besøker linken jeg sendte deg i chatten. For å starte, kan du se på denne siden og fortelle meg hva du synes om den: Hva er ditt førsteinntrykk? Hva er denne siden til? Du kan bla hvis du vil, men ikke klikk på noe ennå.

### **Task completion (2-3 tasks)**

Takk. Nå vil jeg at du skal svare på de følgende to scenariene. Jeg leser opp scenarioet høyt, men sender det også til deg via chat.

#### **Task#1**

Se for deg at underviser i matematikk med elever fra \*trinn\*. Etter dagens time vil du sjekke hva elevene klarte å gjøre mens de jobbet i \*verktøy\*. Klarer du å finne noe informasjon om dette ved hjelp av nettsiden?

#### **Task#2**

Jeg vil spørre deg å åpne MittFagkart (om applikasjonen ikke var tatt i bruk) og ta en titt på siden. Hva synes du om dette? Hva forklarer det du ser på siden?

#### **Follow up**

Flott, vi er ferdig med mesteparten av testen. Du nevnte [noe de sa høyt tidligere], og jeg ville ikke hoppe inn på det da. Kan du fortelle mer om dette?

Hva er tankene dine om disse konseptene, generelt? + spørsmålene fra forskeren

#### **Wrap up**

Tusen takk for tiden din. Det har vært veldig nyttig og lærerik for oss!

## Appendix I - Usability testing reports

### Usability testing#1

<b>Date of interview</b>	13 Oct 2020
<b>Interviewers</b>	Maria Ovchinnikova; *Researcher's name*
<b>Contact info</b>	*Participant*
<b>School</b>	Brannfjell skole, Oslo
<b>Iteration</b>	1
<b>Duration</b>	1 hour

#### Warm-up questions

Q1. What is your occupation?

- Teacher in Mathematics, Natural science, PE for 8th and 10th grades

Q2. Can you describe your usual routines as a teacher of \*subject\*?

- Uses "Campus Inkrement" plan for the school year (it is a bit complicated to use this one now because of the new teaching plan 2020)

Q3. Do you use digital learning tools for teaching? (Conexus, Kikora, itslearning etc.)

- Campus Inkrement
- Books "Faktor"
- Kikora

Q4. How do you plan your work?

- Makes her own plan for teaching (week by week)
- Works together with other teachers
- No system for creating a teaching plan
- Competency goal are a basis for planning

#### Use cases

##### First impression

- Basic start page
- Simple and easy

##### Task1

Imagine that you teach mathematics to students at \*grade\*. At the end of the school day, you would like to check what students were able to do while working with digital learning applications. Can you find any information about this using the prototype?

## Task2

I would like to ask to open MittFagkrt. What do you think about it? Are the presented visualizations understandable for you?

*Remark:* the user was testing a prototype where not all visualizations were presented.

### **Observations**

- User understands navigation for the web page
- Understable filter system
- “Search” - button could be placed on the top
- A clear understanding of visualization for progress
- The user does not see the way how to expand the progress-visualization
- Quick feedback on what she is looking for
- The system gives a bit of useful information
- The user would like to see the task's descriptions
- Will it be possible to see the results for the student's previous grades?

### **Follow-up questions**

*Q1. What do you think about the concept?*

- What does this system give me that other platforms do not? ---> MittFagkart
- Is it just for Kikora?
- 

*Q2. What would you like to change? Any suggestions?*

- The user is looking forward to seeing how MittFagkart could be used in her work



## Usability testing#2

<b>Date of interview</b>	02 Nov 2020
<b>Interviewers</b>	Maria Ovchinnikova; *Researcher's name*
<b>Contact info</b>	*Participant*
<b>School</b>	Midstuen skole
<b>Iteration</b>	1
<b>Duration</b>	1 hour

### Warm-up questions

*Q1. What is your occupation?*

- Contact teacher for 9th grade
- Social Science, Norwegian and English
- Subject of choice: Entrepreneurship for 8.trinn

*Q2. Can you describe your usual routines as a teacher of \*subject\*?*

- Different routines every day
- Teaches her own class the most of the time
- Talks with students, parents, and other teachers
- Subject meetings

*Q3. Do you use digital learning tools for teaching? (Conexus, Kikora, itslearning etc.)*

- Interested in using digital tools
- OneNote for collecting activity data, giving feedback to students (Teacher knows what activity data is from a IT-course for teachers)
- Apropos skiving for Norwegian
- Escape room
- Presentations
- Podcasts
- 3d modules and some online games
- "Digital agenda" is more preferable over the regular books
- Search
- Its Learning

*Q4. How do you plan your work?*

- Searching the tasks online and create subject book for students
- 3-years teaching plan
- 6 periods with main themes (f.eks. Identity, role in the society, war&love, religion)
- Competence goals- not so prioritized
- Does not use GREP
- Interdisciplinary theme is used but not so much for her subjects
- How much do you work with verbs? - using for 6 weeks planning
- Planning tool is not used

## Use cases

### First impression

- Good overview
- The user understands navigation
- “Seems like it is a tool for the teacher, maybe there is one for students as well”

### Task1

Imagine that you teach mathematics to students at \*grade\*. At the end of the school day, you would like to check what students were able to do while working with digital learning applications. Can you find any information about this using the prototype?

### Task2

I would like to ask to open MittFagkrt. What do you think about it? Are the presented visualizations understandable for you?

## Observations

- Glad that there is a possibility to filter information
- Specify what tool was used (Kikora, Campus, or ?)
- Competence goal - percentage, what does it say?
- Knowledge area - the user likes concept maps, a good overview of what was done by students (maybe visualization should be a bit bigger?)
- Område i MittFagkart - what was mastered by students
- Verb - typical verbs that are used in competence goals
- Would like to see the connection between verbs and tasks
- The user likes the web page
- She would like to see core elements for competence goals → it is gonna be useful for talks with other teachers, parents and etc
- Make an option to choose all groups
- Understandable overview for progression
- The concept is semi-understandable
- The expand-button is not visible

## Follow-up questions

*Q1. What do you think about the concept?*

- Very useful tool
- The teacher misses some info that MittFagkart can produce
- Would be nice to have for Norwegian and English
- A good tool for working together with other teachers

## Usability testing#3

<b>Date of interview</b>	04 Nov 2020
<b>Interviewers</b>	Maria Ovchinnikova; *Researcher's name*
<b>Contact info</b>	*Participant*
<b>School</b>	Brannfjell skole,Oslo
<b>Iteration</b>	1
<b>Duration</b>	1 hour

### Warm-up questions

Q1.What is your occupation?

- Teacher in Mathematics, Natural science, PE
- Have been working as teacher for 2 years

Q2.Can you describe your usual routines as a teacher of \*subject\*?

- Different routines every day

Q3.Do you use digital learning tools for teaching? (Conexus, Kikora, itslearning etc.)

- Campus Matte
- Kunnskap.no

Q4.How do you plan your work?

- Curriculum with a focus on competence goals
- Learning's aim
- Year plan
- Working together with other teachers
- Sometimes she needs to act according to the situation and plan "on the go"
- Does not use UDIR-tool to planning

### Use cases

#### First impression

- Could be more "interesting"
- More colors
- Looks simple and fine

#### Task1

Imagine that you teach mathematics to students at \*grade\*. At the end of the school day, you would like to check what students were able to do while working with digital learning applications. Can you find any information about this using the prototype?

## Task2

I would like to ask to open MittFagkrt. What do you think about it? Are the presented visualizations understandable for you?

### **Observations**

- The user a bit confused about knowledge area
- A bigger picture for the concept map-visualization is necessary
- The user does not understand what “område i MittFagkart” is
- She does not focus on verbs
- She needs more explanation for concepts and visualizations
- Clear navigation
- Filter options: for all would be nice to have
- The progress for a student is clearly shown
- The expand-button is not visible

### **Follow-up questions**

*Q1. What do you think about the concept?*

- The user would like to use the tool in order to see the progress of her students
- The user thinks that it can be useful

*Q2. What would you like to change? Any suggestions?*

- Would be nice to have more explanation for visualizations and concepts that are used in MittFagkart

## Usability testing#4

<b>Date of interview</b>	06 Nov 2020
<b>Interviewers</b>	Maria Ovchinnikova; *Researcher's name*
<b>Contact info</b>	*Participant*
<b>School</b>	Midstuen skole,Oslo
<b>Iteration</b>	1
<b>Duration</b>	1 hour

### Warm-up questions

Q1.What is your occupation?

- 8th - 10th grades
- Visits students at home
- Works with different tasks
- English, Social Science, help at the kitchen

Q2.Can you describe your usual routines as a teacher of \*subject\*?

- Days depend on the students (special needs)

Q3.Do you use digital learning tools for teaching? (Conexus, Kikora, itslearning etc.)

- Min skole
- Cappelen Damm
- OneNote to post tasks for students
- OneNote to create an escape room

Q4.How do you plan your work?

- Using interdisciplinary themes
- Does not use books, mostly digital tools and resources
- The user does not use udir-tool for planning

### Use cases

#### First impression

- The user is interested to see what this page has

#### Task1

Imagine that you teach mathematics to students at \*grade\*. At the end of the school day, you would like to check what students were able to do while working with digital learning applications. Can you find any information about this using the prototype?

## Task2

I would like to ask to open MittFagkrt. What do you think about it? Are the presented visualizations understandable for you?

### **Observations**

- Understandable navigation
- Filter-system is understandable
- The user would like to see MittFagkart for English
- The user would like to have more info about visualizations and concepts
- Nice colors
- The user would like to look at the concept map in more details
- Circular treemap is not so clear → explanation
- The user would like to click on areas in MittFagkart
- The user understands that size means smth but does not know what
- What do I see if I click on “tenkemåter”?
- The user is interested in how we get data
- Can he see what they used for getting these results?
- Expand-button is not visible
- Nice to have an overview for each single student
- Would like to see the text of the tasks

### **Follow-up questions**

*Q1. What do you think about the concept?*

- Very useful tool
- Easy to get a good overview
- Intuitive
- The user likes that there is a simple and easy menu
- Would like to participate in the future iterations

## Appendix J – MittFagkart prototype, 2<sup>nd</sup> iteration

### Teacher profile

The screenshot shows a user interface for a teacher's profile. On the left is a navigation sidebar with the logo 'MITT FAGKART' at the top. The sidebar contains the following items: 'Profil' (with a person icon), 'Elever' (with a magnifying glass icon), 'MittFagkart' (with a double arrow icon), 'Innstillinger' (with a gear icon), and 'Logg ut' (with a door icon) at the bottom.

The main content area features a header with a greeting: 'Hei Katrin!' followed by a welcome message: 'Velkommen til MittFagkart! Her finner du informasjon om progresjonen til elevene dine, hvilke oppgaver de jobber med og hvor bra de forstår ulike temaer i forskjellige fag.' To the right of the text is a stylized illustration of a woman with brown hair in a bun, wearing a blue top.

Below the header, there are two columns of information:


- FAG**: A list of subjects with icons: 'Matematikk' (with a yellow circle containing a white 'x²') and 'Naturfag' (with a yellow circle containing a white leaf icon).
- ELEVER**: A list of grade levels: '7.trinn' and '8.trinn', each preceded by a blue dot.

# Student profile

**MITT FAGKART**

- ▲ Profil
- Elever
- MittFagkart
- Innstillinger

Logg ut



**Magnus Carlsen**  
 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Fusce consetetur pellentesque metus. Id iaculis. Nunc dapibus pulvinar auctor.

**KOMPETANSEMÅL**

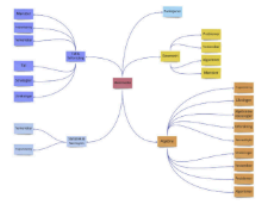
Ordne tall, mengder og former ut fra egenskaper, sammenligne de og reflektere over om de kan ordnes på flere måter

Bruke ikke-standardiserte målelønninger for areal og volum i praktiske situasjoner og grunnleggende valøst av målelønning


Utforske, tegne og beskrive geometriske figurer fra sitt eget nærmiljø og argumentere for måter å sortere de på etter egenskaper

Utforske, beskrive og argumentere for sammenhenger mellom sidelengdene i trekkanter


**KUNNSKAPSOMRÅDE**



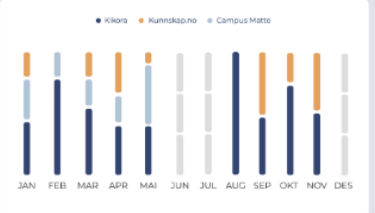
**OMRÅDER I MITTFACKART**



**VERB**




**AKTIVITET**





## List of students













MITT FAGKART

- Profil
- Elever**
- MittFagkart
- Innstillinger

Logg ut

Søk etter elev

**ELEVER**

Navn Etternavn	Trinn	Gruppe	Plattform	
 Magnus Carlsen	8.trinn	Gruppe1	Kikora	<a href="#">Se mer</a>
 Navn Etternavn	8.trinn	Gruppe1	Kikora	<a href="#">Se mer</a>
 Navn Etternavn	8.trinn	Gruppe1	Kikora	<a href="#">Se mer</a>
 Navn Etternavn	8.trinn	Gruppe1	Kikora	<a href="#">Se mer</a>
 Navn Etternavn	8.trinn	Gruppe1	Kikora	<a href="#">Se mer</a>
 Navn Etternavn	8.trinn	Gruppe2	Kikora	<a href="#">Se mer</a>
 Navn Etternavn	8.trinn	Gruppe2	Kikora	<a href="#">Se mer</a>
 Navn Etternavn	8.trinn	Gruppe2	Kikora	<a href="#">Se mer</a>
 Navn Etternavn	8.trinn	Gruppe2	Kikora	<a href="#">Se mer</a>
 Navn Etternavn	8.trinn	Gruppe2	Kikora	<a href="#">Se mer</a>

**Filter**

**Fag:** Matematikk ▾

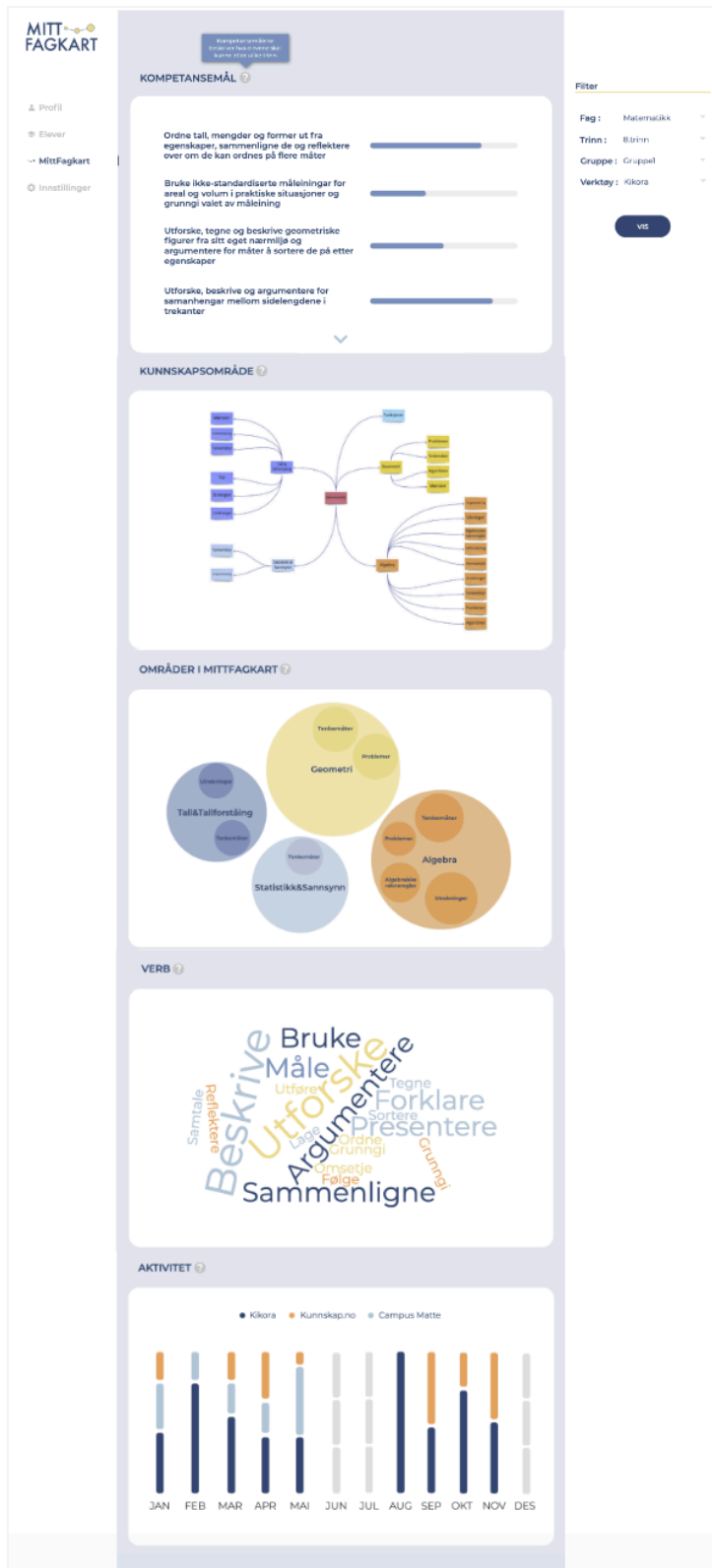
**Trinn:** 8.trinn ▾

**Gruppe:** Vis alle ▾

**Verktøy:** Kikora ▾

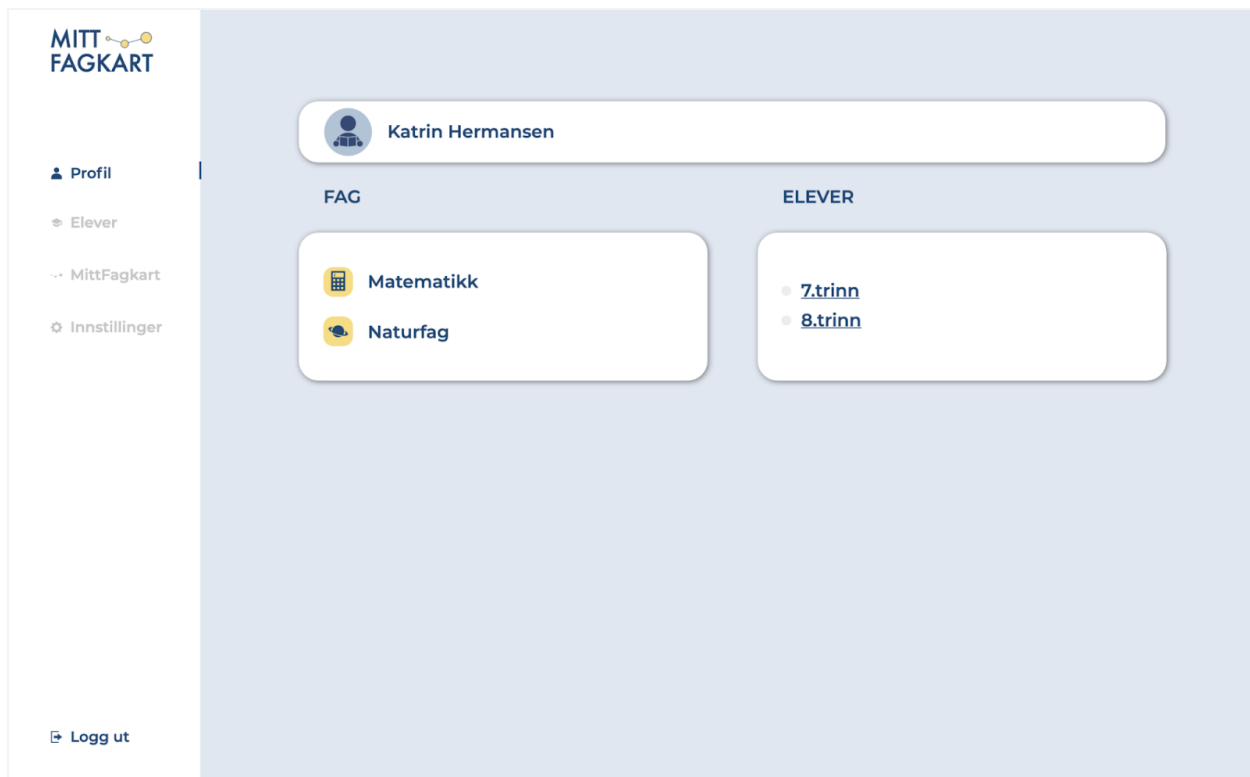
**VIS**

# OLM dashboard



# Appendix K - MittFagkart prototype, 3<sup>rd</sup> iteration


## Teacher profile












# List of students

**MITT FAGKART**

Katrin Hermansen 

Fag Matematikk ▾ Trinn 8.trinn ▾ Gruppe Gruppe1 ▾

**ELEVER**

	<b>Magnus Carlsen</b>	Matematikk	8.trinn	Gruppe1	<a href="#">Vis mer</a>
	<b>Marcus Johansen</b>	Matematikk	8.trinn	Gruppe1	<a href="#">Vis mer</a>
	<b>Ida Nilsen</b>	Matematikk	8.trinn	Gruppe1	<a href="#">Vis mer</a>
	<b>Maria Eriksen</b>	Matematikk	8.trinn	Gruppe1	<a href="#">Vis mer</a>
	<b>Kristin Magnus</b>	Matematikk	8.trinn	Gruppe1	<a href="#">Vis mer</a>
	<b>Stian Os</b>	Matematikk	8.trinn	Gruppe1	<a href="#">Vis mer</a>
	<b>Kristian Olsen</b>	Matematikk	8.trinn	Gruppe1	<a href="#">Vis mer</a>

[Logg ut](#)

# OLM dashboard

