Mobile Collaborative Learning

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Abstract

Mobile technology is a well-known part of the life of most children and adults in Norway today. Over the last several years, a lot of research has been done to improve this technology and it seems a mobile collaborative learning system can be an important tool for learning in the future.

By using ubiquitous computing and context-aware computing, the technologies are integrated into the environment and enable the user to move around and learn in a natural environment. This leads to many challenges in areas such as Computer Supported Cooperative Learning and also involves pedagogical challenges.

This report aims to develop an understanding of important issues when dealing with a mobile collaborative learner, and looks at important aspects and advantages with such technologies. The vision for the system is to provide functionality enabling the users to increase their learning in a ubiquitous collaborative environment. This report presents two scenarios for a mobile collaborative learner, followed by an analysis. Pedagogical theories are used to model users and task models.

By building user models based on heterogeneous users, the system is able to compare users. Stereotypes and facet’s are gathered from Gardner’s multiple intelligence, Dreyfus’ stages and Hofstede’s cultural dimensions. The findings show that the pedagogical theories give a promising approach, appropriate for strengthening the users learning process.

Keywords: collaboration, ubiquitous, context, user model, stereotypes, task model, Gardner’s multiple intelligences, Dreyfus’s stages, Hofstede’s cultural dimension
Preface

This report was written in the fall semester 2007 as part of the graduate level course "TDT4520 Software Engineering, Depth Study". The course is a part of the Master program at Department of Computer and Information Science (IDI) at the Norwegian University of Science and Technology (NTNU).

The people involved in this project are mainly members of IDI's software engineering group. The subject of this report was chosen in cooperation with my co-advisor Anders Kofod-Petersen. He has contributed his knowledge about mobile collaborative learning and shared his experience with the author. The supervisor for this project has been John Krogstie at IDI.

Parts of this work has been submitted to the journal Revue d’intelligence Artificielle, special issue on Modelling and Reasoning on Context: The Role of Context in Human Tasks [Kofod-Petersen et al., 2008].

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Gunhild Griff Bye
Contents

I Introduction 1

1 Introduction 3
  1.1 Motivation ................................................... 3
  1.2 Problem definition ........................................ 4
    1.2.1 Original problem definition ......................... 4
    1.2.2 Problem elaboration ................................ 4
  1.3 Report outline ............................................. 5

II Prestudy 7

2 Prestudy 9
  2.1 Central Concepts ........................................... 9
    2.1.1 Educational aspects in the learning process ........ 9
    2.1.2 Collaborative learning ................................ 10
    2.1.3 Ubiquitous learning .................................. 10
    2.1.4 Context ............................................... 11
    2.1.5 Intelligence tutoring system ....................... 13
  2.2 Existing services ......................................... 14
    2.2.1 Wireless Trondheim and Geographical Positioning Service 14
    2.2.2 CAERUS .................................................. 14
  2.3 Challenges .................................................. 14
    2.3.1 Security ............................................... 14
    2.3.2 Privacy and trust ..................................... 15

III Research 17

3 Research 19
  3.1 Scenarios ............................................... 19
    3.1.1 Scenario 1: History exercise in the city ........... 19
    3.1.2 Scenario 2: Natural science fieldwork ............ 20
  3.2 Analysis ................................................... 20
  3.3 User modelling ............................................. 22
  3.4 Pedagogical theories .................................... 22
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.1</td>
<td>Gardner’s multiple intelligences</td>
<td>22</td>
</tr>
<tr>
<td>3.4.2</td>
<td>Dreyfus’ stages</td>
<td>25</td>
</tr>
<tr>
<td>3.4.3</td>
<td>Hofstede’s cultural dimensions</td>
<td>26</td>
</tr>
<tr>
<td>3.5</td>
<td>From stereotypes to user models</td>
<td>29</td>
</tr>
<tr>
<td>3.5.1</td>
<td>Stereotypes from Gardner</td>
<td>30</td>
</tr>
<tr>
<td>3.5.2</td>
<td>Stereotypes from Dreyfus</td>
<td>32</td>
</tr>
<tr>
<td>3.5.3</td>
<td>Stereotypes from Hofstede</td>
<td>34</td>
</tr>
<tr>
<td>3.5.4</td>
<td>Example</td>
<td>35</td>
</tr>
<tr>
<td>3.6</td>
<td>Task modelling</td>
<td>36</td>
</tr>
<tr>
<td>3.6.1</td>
<td>Example</td>
<td>38</td>
</tr>
</tbody>
</table>

IV Results and Conclusions | 41

4 Conclusions and further work | 43
4.1 Summary | 43
4.2 Further work | 44

V Appendices | 49
A Stereotypes and facet’s from pedagogical theories | 51
## List of Tables

3.1 Stereotypes from Gardner’s multiple intelligences ........................................... 30  
3.2 Stereotypes from Dreyfus’ stages ................................................................. 33  
3.3 Stereotypes from Hofstede’s cultural dimensions ........................................... 34  
3.4 Simplified characteristics for Kari ................................................................. 35  
3.5 Simplified characteristics for Pia ................................................................. 36  
A.1 Summary stereotypes and facets, Gardner’s multiple intelligences ... 51  
A.2 Summary stereotypes and facets, Dreyfus’s stages ................................. 52  
A.3 Summary stereotypes and facets, Hofstede’s cultural dimensions ... 52
# List of Figures

2.1 Meronomy of context ................................. 12
2.2 Cultural-Historical Activity Theory ................................. 12
2.3 CHAT and context ........................................ 13
2.4 CAERUS handheld application .................................... 15

3.1 Use case for Scenario 1 ........................................ 21
3.2 Use case for Scenario 2 ........................................ 21
3.3 Hofstede’s onion-diagram ....................................... 26
3.4 Decomposition of a task ...................................... 37
3.5 Context versus rules .......................................... 38
Part I

Introduction
Chapter 1

Introduction

Learning is a process that everyone experience through their whole life. In Norway, children start compulsory school when they are 6 years old.

Ever since I started working in a project called "Jenter og data" at the Norwegian University of Science and Technology (NTNU), I have been experiencing that different people need different educational methods. After some years I changed employer and started working with e-learning for Amendor. Amendor produces digital teaching aids for helping people with their learning process. This led to the interest in mobile collaborative learning and how this could help people with their learning.

In this report I have gathered the result of my work and the most important aspects I found in learning technology.

1.1 Motivation

In everyday life we are surrounded by technology. Children in middelschool are familiar with mobile devices, so why not integrate these devices into their education?

It is interesting to look at mobile collaborative learning and see how this can be used to motivate and challenge these children. Today school youths have the most of their teaching in classrooms in the schoolhouse, but with mobile collaborative learning the learning can be ubiquitous and context-aware.

Completing such a technology involves alot of challenges, one challenge is to make all the different technologies and technical sciences to collaborate towards such a mutual goal [Petersen and Kofod-Petersen, 2006].

By using the user’s context it is possible to adjust the children’s learning process, and by integrating this in an ubiquitous environment makes it possible for the learner to learn everywhere and at any time.

Today a technology like this is under development, but still has a long way to go. Problems developers are facing is how to get good enough position of the user, how to display useful content in a small-screen device and how to support learning across many contexts.

By activating the children and making it possible for them to learn in ubiquitous environment, I hope to increase their interest of learning. In this report I hope to be
able to make a plan for such a system, and in an additional paper I hope to implement this system and test it in practice.

1.2 Problem definition

In this section the original problem definition from NTNU is represented followed by my own goals for the project.

1.2.1 Original problem definition

**Mobile Collaborative Learning**

Advances in ubiquitous and mobile technologies have facilitated learners to continue their learning outside their classrooms, when and where they desire. Learners are now able to access their learning resources and interact with their peers and teachers through technology. The design and creation of such learning spaces pose many challenges. The learner’s context defines the needs of the learner at any time. To meet the needs of the learner, a set of services must be available anytime and anywhere. To establish the learner’s context, a model of the learner is essential. This project focuses on the development of a prototype for mobile collaborative learning. In particular on a PDA platform running in the Traadloese Trondheims environment. The project requires knowledge of Java programming, in particular J2ME, and interest in developing distributed small-footprint applications on PDAs and mobile phones.

1.2.2 Problem elaboration

This project is separated into to main goals, under is a description of these two goals. There will also be a description on how this project will help me with the upcoming Master’s Thesis.

**Goal I.** How can an application find relevant help for a pupil in a ubiquitous environment?

*(Goal a:)* How can an application know what ubiquitous objects are relevant and not relevant in order for the pupil to solve the task?

**Goal II.** How can an application find a proper task for a pupil in an ubiquitous environment?

Every pupil find themselves in different divisions in different subjects, and every pupil prefers to learn in different ways. Some pupils like to work in groups, and others like to work individually. These differences between users lead to other important issues that should be covered in the report.

*(Goal a:)* How can the application help the pupil by finding the pupil’s preferred working method?

This report will attend to describe give me a good plan on how to make such an application. In the upcoming Mater’s Thesis I will continue with this work by a implement on an iPod and then test the application on potential users.
1.3 Report outline

In this section a brief introduction to the report is given.

Chapter 2 - Prestudy
The aim for this chapter is to get a deeper understanding of central concepts in a mobile collaborative learning environment, understanding these concepts are important to get a full exploit of the report. There will also be a brief introduction on existing services and challenges related to mobile collaborative learning.

Chapter 3 - Research
This chapter starts with two scenarios followed by an analysis. Further in the chapter there will be descriptions on user models and the advantages of user models. There will also be represented pedagogical theories that will be related to stereotypes and user models. In the end of the section task modeling is introduced.

Chapter 4 - Conclusions and further work
This chapter gives a summary on the achievements of the work presented in this report. There will also be some directions on how this project may be extended in further work.
Part II

Prestudy
Chapter 2

Prestudy

It is amazing to see that Norway with a population of 4,721,600 citizen 1.10.2007 [ssb], had according to Dagens Næringsliv [dn] 5.2 million existing mobile subscribers after the first six months of 2007. This implies that there is a demand to be supported in the way people live and do things.

This section describes central concepts of the project. There will also be a brief presentation of existing services and challenges that are central to mobile collaborative learning. The purpose of this part is to give an overview and an understanding of concepts in a mobile collaborative learning environment.

2.1 Central Concepts

2.1.1 Educational aspects in the learning process

Today technology enables to make many different systems for education, but unfortunately not all of them are to the advantage of the user in an educational aspect [Nie, 2007]. There are many pedagogical theories about teaching, but most of them are based on classical classroom environments, therefore most of these theories are not appropriate for mobile learning. It is important to remember that in a mobile environment the learners are usually outside the classroom, and therefore have a dynamic environment.

One person that has great success with his pedagogical theory is Howard Gardner. Gardner introduced his multiple intelligence theory in "Frames of Mind" [Gardner, 1984]. His theory is about how humans perceive things, and how we are aware of those things. Another person who has researched learning is Hubert Dreyfus, who is a well-known professor in Philosophy. Dreyfus claims that every human are in different stages when they are learning, with this concept he introduced Dreyfus’ stages. Dreyfus stages are based on Merleau-Ponty’s1 Phenomenology of Perception.

Another area that is important to look at is how culture is affecting the learning. Geert Hofstede is known for his comparisons within cultural research. Hofstede

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1Merleau-Ponty was a French phenomenological philosopher.
has researched cultural differences in IBM. IBM have employees in over 50 countries. Based on this research Hofstede introduced Hofstede’s cultural dimensions.

2.1.2 Collaborative learning

Collaboration is a powerful tool in the process of learning. Collaborative learning is about learning by interacting with others. When collaborating we increase each other's learning by solving a common problem. This can create a greater understanding of the problem. The usual way to collaborate is human to human, but it is important to remember that collaboration also can be done by using information and communication technology. Collaborating by using information and communication technology are known as Computer Supported Cooperative Learning (CSCL). According to Bannon [1989], CSCL can make a significant impact on learning outside the classroom.

When collaboration is used in a school project, the classical way is to solve the common problem face to face in groups, or outside the classroom or by using information technology. There are many advantages of using collaborative learning, the user will need to think for himself and to think with others. The user needs to interpret what the others mean and discuss the solutions, before the user tries to negotiate the best solution. This way the users also learn proper behaviour for working in projects. In this way the user will increase both learning skills, life skills and work skills [Noble et al., 2000].

2.1.3 Ubiquitous learning

In this section different aspects of ubiquitous learning will be introduced. Ubiquitous learning is using ubiquitous computing, therefore in the end it will be an introduction on ubiquitous computing.

People usually refer to various learning environments when talking about ubiquitous learning. The most common environments are briefly presented under.

U-learning:
U-learning is a shortening for ubiquitous learning. Characteristics of ubiquitous learning are that anyone can learn anytime and anywhere, and for any purpose [Yoshida, 2006].

E-learning:
E-learning is what most people today are thinking about when talking about ubiquitous learning. E-learning stands for electronical learning and is used for computer-based learning. E-learning is technology that is accessible at all hours. The system allows users to access relevant work and materials from any location as long as they have a computer with network access. This technology is not a complete ubiquitous learning environment because it is not possible to learn in an ubiquitous situation.

M-learning:
M-learning stands for mobile learning and has a focus on learning across contexts.
2.1. Central Concepts

This technology is portable, location aware and has ubiquitous access to information. M-learning makes it possible for the user to access information anywhere and any-time [Dochev and Hristov, 2006]. It is important that ubiquitous learning will not be reduced to m-learning. According to Fischer [2001] the challenge is: right things at right time in the right way, and not that information is available at any time, at any place, in any form.

Mark Weiser [1995] stated that: "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

In ubiquitous computing distributed systems is a fundamental technology, but to fulfill Mark Weiser’s statement about profound technology it need something more, otherwise the user are aware of the absence when he moves [Satyanarayanan, 2001]. To accomplish this ubiquitous technology one must take advantage of mobile computing and the technology needs to be context-aware.

2.1.4 Context

In this section explanation of what context is and a representation of a context in cognitive science is presented.

Context-aware computing was introduced by Schilit and Theimer [Haseloff, 2005]. They explained context-aware computing as location, nearby people and objects that changes over time. Recently context has many definitions and explanations, but still there is no general accepted definition. Dey [2001] has a wider approach on context: Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.

By taking basis in Dey’s definition and by using Kofod-Petersen and Cassens [2005] pragmatic definition on context, an introduction on how this can be used in a basic model with relation to the activity theory will be presented.

2.1.4.1 A basic context model

According to Kofod-Petersen and Cassens [2005] context can be represented as a meronomy, where the user context are on the top of the hierarchy and all the context relevant to the user are represented lower in the meronomy, as illustrated in Figure 3.4 (adopted from Kofod-Petersen and Cassens [ibid]). Under is a brief explanation of context in the meronomy.

Task context consist of the user’s activities and goals.

Social context contain the relationship and roles for the user.

Personal context include both the physical and mental characteristics of the user.

Spatio-temporal context has information about the location and time.

Environmental context includes both entities present and the surroundings.
2.1.4.2 Cultural-Historical Activity Theory

The Cultural-Historical Activity Theory (CHAT) was initiated in the 1920s and 1930s with Lev Vygotsky (1896-1934) and his colleagues Alexander Romanovich Luria and Alexei Nikolaevich Leont’ev. Their work was based on Karl Marx’s concept of reality that is represented in Theses on Feuerbach (1968) [Foot, 2001]. Vygotsky was the first to introduce the notion of artifact-mediated action. The actions consist of a subject, this can be an actor that wants to achieve a certain goal, this goal is the object. To be able to achieve this goal the actor can use language or material that is the mediational tool, and this leads to the fact that an actor can never react directly to environment.

Leont’ev continued Vygotsky’s work and developed what today is known as activity theory. In The activity unit Leont’ev distinguished between action, operation and activity. The major difference Leont’ev pointed out was that action are deliberate, tool-mediated and goal-orientated. An activity consists of a collection of actions, and an action consists of operations that are methods to accomplish the action. Engeström [ibid] proceeded with Leont’ev’s work on activity as a unit.

Engeström claims that three additional components was necessary to explain the

Mobile Collaborative Learning
social structure of activity. First the subject would be regulated by rules towards the object, and relations with other participants in the activity. A community would consist of people who shared an interest in and involvement with the same object. The last addition was division of labor, what is being done by whom toward the object. Engeström extended Vygotsky’s triangular model with these three social relations, this model is known as the Cultural-Historical Activity Theory and can be found in Figure 2.2 (adopted from Cassens and Kofod-Petersen [2006]).

By this extension the model takes both social and cultural context. According to Kofod-Petersen [2007] “the community is used to represent that a subject is embedded in a social context.” With this model there is established a connection between the subject and the community and the object and the community respectively.

On the subject side of the figure we have the actor with his characteristics, constituting his personal context. On the other side of the figure we have the object, defining the task context. In addition the community will have a spatial-temporal context, which consists of knowledge about the other users. An illustration of this can be found in the Figure 2.3 (adopted from Kofod-Petersen [2007]).

![Figure 2.3: CHAT and context, adopted from Kofod-Petersen[2007].](image)

### 2.1.5 Intelligence tutoring system

Intelligence tutoring systems have earlier been known as computer-aided instruction [Freedman et al., 2000]. An intelligence tutoring system is any computer that has some intelligence that can help students without needing intervention from humans. The different systems are extremely different in the level of intelligence, and in where the intelligence is in the architecture. Therefore they vary in their usefulness. The classic intelligence tutoring architecture [Corbet et al., 1997] is divided into four different components:

**Domain knowledge**: In the domain knowledge model there is a description of the behaviour that represents expertise. An example from Corbet et al. [1997] is that when a student is engaged in problem solving activities, the actions will be evaluated with respect to the domain knowledge component, which is often solved by an expert

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Mobile Collaborative Learning
system.

**Pedagogical Module:** The pedagogical module is delivering an instructional action based on the evaluation of the student actions from the student module.

**Student model:** The student model contains descriptions of the student behaviour.

**Problem solving environment:** The problem solving environment use methods in the intelligent tutor to supply the user with information.

### 2.2 Existing services

#### 2.2.1 Wireless Trondheim and Geographical Positioning Service

Wireless Trondheim is a project that has a goal of giving wide range of wireless network to users in Trondheim. The project started by initiative from researchers at NTNU and Norwegian companies in the year 2005 [Andresen et al., 2007]. In the year 2006 it became a limited company established with the name Trådløse Trondheim AS. Owners in the company where Sør-Trøndelag County Council, Sparbank 1 Midt-Norge, Adresseavisen, the city of Trondheim, NTNU and Trondheim Energiverk.

Geographical Positioning Service (GeoPos) is a technology that started as a project at NTNU in the year 2004. Later on the project has become a part of the Wireless Trondheim project. GeoPos is used to acquire a position from a user terminal by sending a request to a Cisco Location Appliance [GeoPos homepage].

#### 2.2.2 CAERUS

CAERUS is a context aware educational resource system developed at the University of Birmingham. The system is developed for outdoor use [CAERUS, University of Birmingham]. The system is intended for tourist sites and educational centers, and consists of a handheld delivery system and a desktop administration system. In the system it is possible to add maps, multimedia tours and mark regions of interest. The users are being located trough a GPS receiver [Naismith et al.]. If the user is at a place with audio content, the device starts the presentation, the user has the possibility to continue with multimedia content or just ignore the options. An illustration of the handheld application can be found in Figure 2.4 (adopted from caerus’s homepage [CAERUS, University of Birmingham]).

### 2.3 Challenges

In this section there will be a brief introduction of challenges related to security, privacy and trust in mobile collaborative learning.

#### 2.3.1 Security

There are many security issues associated with mobile learning systems. In this report there is no focus on security, but it is an important subject for such an application. An
example of a security problem that may appear in a ubiquitous environment is the use of wireless networks leading to vulnerabilities. Questions that are related to security are: What authorisation techniques are best suited for ubiquitous computing? How does the security enable the user to trust other users in the system? How are the information secured, that preventing outsiders from accessing it.

Security is related to privacy and trust, these subject are briefly explained under.

2.3.2 Privacy and trust

The focus on privacy and trust in an ubiquitous environment will not be represented in this report, but it is important to point out that privacy and trust are issues, not only within computer science but everywhere in our surroundings.

Important questions for the development; should the user decide when it is available or invisible? How much private information are permitted for the system to keep, and how is the security on this information?

In Section 2.1.3, Mark Weiser stated that the most profound technology should disappear. If a technology is so integrated into our life, it may increase the risk of us forgetting about our personal privacy.

Trust is as mentioned, another important issue with ubiquitous environment. In *System Software for Ubiquitous Computing* [Kindberg and Fox, 2002] there is stated that a human can make judgment about their environments trustworthiness, and the physical world offers mechanisms for bootstrapping security based on that trust. Trust has been successfully applied in some areas, like eCommerce and virtual communities.
Part III

Research
Chapter 3

Research

In this chapter there will be focus on developing an appropriate plan for a mobile collaborative learning system. The chapter starts with two scenarios followed by an analysis. Further there will be a presentation of user modelling, pedagogical theories, and how these theories can be used in the user model by providing stereotypes. There will also be an introduction to task modelling.

3.1 Scenarios

In this section there will be presented two scenarios where a user is using a mobile device for an ubiquitous collaborative learning.

3.1.1 Scenario 1: History exercise in the city

Ola is a pupil at Kalvskinnet school in Trondheim. Kalvskinnet school is a member of some services that are ubiquitous to their pupils. One Saturday Ola is in town where he is waiting for his friend to meet him within two hours. Ola is thinking that two hours is a long time to wait, so he needs to find something to do while waiting. Ola takes up his mobile telephone and opens an application that localizes him on a map over the area. On the map he can see several nearby possibilities he can join, the application now lets Ola decide what he wishes to do. He can chat to nearby friends, see what is happening in the town like theatre, concerts, different shopping centres and so on. Ola also has the possibility to look at some relevant school exercises about the local history. These exercises are added by teachers at Kalvskinnet with some given meta-data\(^1\). This makes it possible for the application to use this meta-data to find a relevant match on the map. Ola looks closer at the exercises and notices that one is about the Nidaros Cathedral. Ola decides to take a look at the Cathedral and see if he manages to do some of the tasks in the exercise. When Ola is in front of the Cathedral he takes a new look at the exercise, at the same time the system searches after a proper task for Ola to solve. The system finds the proper task based on Ola’s interests and his history skills. The task Ola is going to solve is: "What does the Crown

\(^1\)meta-data is data about data. An item of metadata may describe the object so it can be retrieved.
Regalia consist of?” Under the task Ola gets options to look at hints on the map or answer the task, Ola wants to look at the hints on the map. On the map Ola can see symbols representing the tourist information center, the Archbishop’s Palace in the artillery building, the option to ask a friend that are in the area or to search in a wiki. Ola thinks that is would be interesting to see the Crown Regalia, so he goes to the artillery building and looks at the crowns. Beside the crowns Ola finds information that answers the task in the exercise. Ola looks at the clock and realises that it is time to go back and meet his friend.

3.1.2 Scenario 2: Natural science fieldwork

A natural science class at Byåsen school in Trondheim is having a fieldwork day. The subject of the fieldwork day is the bog and the forest in an ecosystem. All the pupils that are attending this fieldwork have an application on their mobile telephones that has integrated GPS and some tasks they are going to perform during the fieldwork. The different tasks are related to two different types of natural landscapes, so the pupils need to be active to get through all the tasks. Since these tasks are placed in different environments the pupils are also going to take pictures of the environment to the report they are going to make later. As the pupils perform these exercises they have the possibility to ask for hints. The pupils also have the possibility to collaborate on the different tasks, but they can not copy the different answers because each pupil has a random question to answer.

We will follow Kari as she is headed towards the bog to perform the task: “Find a Drosera, take a photo of it, and describe the environment around it?”. Kari is worried about this task because she can not remember what these plants looks like, but she thinks that she can recognise it when she finds one. On the way to the bog Kari takes out her mobile telephone to see if she is in the right direction for the bog, and at the same time she takes another look at the task. As Kari looks at the task, the application asks Kari if she wants to chat to Pia, a nearby classmate of Kari. Kari knows that the application just wants to help her to perform the task and that it searches for relevant help that Kari may use. Kari asks Pia if she can tell her what this plant looks like, and if she knows something more about it. Pia takes a look at the map, there she can see that Kari is just over the hill so Pia decides to go to Kari and show here some Drosera.

3.2 Analysis

In this section the two scenarios from Section 3.1 will be analysed by using use case. Further there will be an analysis on similarities between these two scenarios.

Scenarios are useful in seeing things from a users perspective. For developers, a scenarios helps to understand central issues that are important for the user in a system, and it is therefore useful for requirements specification. A scenario describes how system components, the environment, and users work concurrently and interact in order to provide system level functionality.
In making this model I will find the activities and resources that are required for this process.

![Diagram for Scenario 1](image1.png)

**Figure 3.1: Use case for Scenario 1.**

![Diagram for Scenario 2](image2.png)

**Figure 3.2: Use case for Scenario 2.**

From these two scenarios the user needs to have some sort of connection to get the user’s location on a map. Both users will perform an assignment where they will solve a given proper task. They both have the possibility to use hints to answer the task, but one interesting question is how they can get meaningful hints. What this report will be focusing on further, is how the users can get meaningful hints to help them solve these tasks, and how to find proper tasks for each user.
3.3 User modelling

Up to now we have looked at scenarios and characterised what we need, but how can we actually find all the relevant information about the user that makes it possible to find suitable help and tasks for the user?

One way to gather the information about a user is by building user models. A general user model may be comprised of different personal information about the user. For a learning system a user model will be helpful because it makes it possible to personalise the learning for the user.

Rich [1999] states that, for building a good system where a user and a machine cooperate to perform a task, it is important that the system takes advantage of some significant characteristics of the user.

The usual way to build a user model is by building a canonical user. For a system with purpose of having only one kind of users that is not depended on personal characteristics, it would be adequate to use a homogenous user. For this learning system a canonical user will not be sufficient. The user model will be filled with personal characteristics. It is therefore essential to have heterogeneous users. To build a heterogeneous user model it is important to collect characteristics about each user and use these characteristics in probabilistic reasoning. This would make the system able to personalise the learning for the given user.

Further, pedagogical theories will be presented and an explanation on how these can be used to collect characteristics will be described.

3.4 Pedagogical theories

From Section 2.1.1, we know that it is important to have solid pedagogical theories to build systems up-on. In this section there will be a description of three pedagogical theories, which will be important for this system.

Kolås and Staupe [2007] states that in the next generation of online learning environments heterogeneous users need to be covered with e.g. different intelligences, different intellectual levels and different cultural background. To accomplish this they introduce three pedagogical theories that will be covered in the next three sections, these theories was briefly introduced in Section 2.1.1.

3.4.1 Gardner’s multiple intelligences

The system is at this stage a tool to help pupils in their ubiquitous learning, and it should therefore have information about each pupil’s educational achievements. Today many uses standardised tests to measure a pupil’s intelligence and represents this result as a intelligence quotient (IQ). Gardner states that IQ-tests and tests at school only get to measure one part of our intelligence. One of the weaknesses Gardner is pointing out is that even if you get a low score on such a test, it does not mean that you do not have the properties suitable for that given purpose [Sjoberg, 2007]. In Frames of Mind [Gardner, 1984], Gardner introduced his multiple intelligences theory. Gard-
3.4. Pedagogical theories

Gardner states that every individual has several different intelligences, and that the level of these intelligences is different from individual to individual [Sjøberg, 2007].

Following is an explanation on the different intelligences Gardner represents in his theory.

**Linguistic intelligence**
This intelligence is about understanding communication and meaning by learning and using language to achieve certain goals. This includes the ability to be strong in both writing and speaking presentation. According to Gardner [ibid, ch.5], a language has a rhetorical aspect, which is the ability to use a language to convince other people. Another characteristic a language has is a mnemonic potential, the ability to help someone to remember information. Gardner also emphasises that language plays an important role in explanations. Linguistic intelligence syntax and phonology are central, while semantics and pragmatics also has input from other intelligences.

**Logical-mathematical intelligence**
Logical-mathematical intelligence is the ability to analyze problems logically. The user explores patterns and relationships, and uses these to experiment in a structured way. A person that is strong in this intelligence has the possibility to rapidly mentally calculate very large numbers. Gardner [ibid, ch.7] claims that there is a strong connection between science and mathematics. An example Gardner uses is related to chemistry and physics where a human is going to explain the evolution of physical systems, he point out that this can be very difficult without calculating every tiny step of the process. Scientists needs mathematics and use it like a tool to explain some reality, while a mathematician is interested in exploring abstract systems.

**Musical intelligence**
Musical intelligence is the ability to understand the relationships between rhythm, sound and music. The human need to have skills to perform, composition and understand the musical patterns. According to Gardner [ibid, ch.6], musical intelligence is independent from physical objects in the world, because it can be explored through oral and aural channels.

**Bodily-kinesthetic intelligence**
This intelligence is about controlling your body movement. An example is to coordinate your arms and legs when in a physical activity to solve a problem. Gardner [ibid, ch.9] states that there are two core elements in bodily-kinesthetic intelligence, which is to control your body motions and to handle objects skillfully.

**Spatial intelligence**
This intelligence is the ability to mentally represent the world in your mind. According to Gardner [ibid, ch.8], spatial intelligence have some loosely related capacities:

- The ability to recognize instances of the same element
- The ability to recognize transformation of one element into another

Mobile Collaborative Learning
• The capacity to conjure up mental imagery and then to transform that imagery

• The capacity to produce a graphic likeness of spatial information

Spatial intelligence is a mental process where the brain tries to interpret certain types of visual information. This intelligence is important for orientation in various locations. A human with a high spatial intelligence can without problems orientate in a two- or three-dimensional version of real-world scenes.

Interpersonal intelligence
This intelligence is about the ability to interact with others. It is about understanding the relationship between people and their situations, including other people. The core capacity in this intelligence is according to Gardner [ibid, ch.10]: the ability to notice and make distinctions among other individuals.

Intrapersonal intelligence
This intelligence differs from interpersonal intelligence, where interpersonal intelligence is about the interaction with others this intelligence is about the capability to understand oneself and one’s relationship to others and the world. Gardner [ibid, ch.10] states that the core capacity is the access to one’s mental life, as a series of affects or emotions.

Up to now all these intelligences were represented in Frames of Mind. Later Gardner has suggested additional intelligences [Howard Gardner, multiple intelligences and education].

Naturalistic intelligence
Naturalistic intelligence is about the ability to understand the nature and relationships in it. A person with high naturalistic intelligence is someone who easily recognise and classify of for example plants and animals for instance.

Existential intelligence
This intelligence is about one’s relationship to the universe. This intelligence depends on one’s personal philosophy. At this moment this intelligence is not added to the multiple intelligences [Howard Gardner, multiple intelligences and education].

Moral intelligence
Moral intelligence is about understanding own behaviour and relationships with other living things. Gardner has accepted this intelligence, but it is not included in the multiple intelligence theory.

From Gardner’s multiple intelligences we get eight different intelligences, that all exist in a human. Gardner suggests that most humans are strong in three intelligences, and that these intelligences indicates the persons capabilities and how they are preferring to learn [Howard Gardner’s multiple intelligences].
3.4.2 Dreyfus’ stages

Heterogeneous users will be at different levels when they are learning, some users learn fast, others need more time and help. Hubert Dreyfus [Berkeley] is a professor of Philosophy in the Graduate School, where he has a strong interest of phenomenology. Phenomenology is about how we can get knowledge about things and situations that exists in the world. In different phenomenologist’s studies of the human learning process it is found interpreted that humans go through many different stages when they are learning. According to Dreyfus [Cognitive science], intelligent behaviour can be described from two important components, learning and skillful action. He states that these components of intelligent behaviour can be described and explained without recourse to mental representation. To strengthen these claims Dreyfus uses Merleau-Ponty’s Phenomenology of Perceptionm. Merleau-Ponty expresses that: “...the intentional arc and the tendency toward achieving a maximal grip.” Merleau-Ponty states that intentional arc is how our skills are increasing when we are dealing with things and situations, and that these things and situations show up for us as requiring to our responses. Dreyfus has an approach on how to view such a user and have developed a model that contains different stages a learner can find himself in. This model is built up on five stages that each describes different stages in the humans learning process [Dall’Alba and Sandberg, 2006].

Following is an explanation on the different stages Dreyfus represents in his theory.

**Novice**
When a person is a novice, he is a beginner facing context-free characteristics that he can recognise without previous experience. The novice usually gets some rules to follow making it possible for him to do some actions. But since the novice misses an understanding of the big scheme of things, his actions will be according to how good he is as following the rules. Dreyfus [Dreyfus] gives an example of a user in a automobile, who knows that he should change gear when driving at a given speed.

**Advanced beginner**
This person is beginning to get experience in handling real situations. He needs to interpret the situations, he begins to note, and the rules are not enough. Gradually he will increase his experience and he will be able to recognise aspects of situations easier. This leads the advanced beginner to be able to deal with situations based on rules and the aspects.

**Competence**
The person’s experience with relevant elements increases and the person needs to think out a plan or select a perspective that reduces the aspects. According to Dreyfus [Dreyfus], the performer avoids mistake by using reasoning procedures to decide which of these plans and perspectives to adopt. This way the person can faster manage the choices he have to make, his experience and the person’s understanding in-
creases. Since there exists more situations in the world than the rules are capable to describe, the person will experience that the result depends on his perspective, and in this way he will feel responsible for his choice.

**Proficiency**
Through experience in different situations the person makes more effective decisions and more fluent decisions than earlier. The person has the possibility to distinguish features without needing to consciously choose a plan. The proficiency is able to see goals, but have not enough experience with the outcomes to know how to achieve these goals. The performer needs to look at the rules and the aspects of the situation, and then needs to decide what to do.

**Expert**
The person has the knowledge to know what to achieve and how to achieve it. Dreyfus [Dreyfus] states that the difference between a proficiency and an expert is that an expert has the ability to make more subtle and refined discriminations. The expert has learned to distinguish those situations requiring one action from those demanding another.

According to Dreyfus humans are finding themselves in one of these stages when they are in a process of learning.

### 3.4.3 Hofstede’s cultural dimensions
To be able to develop an application that is taking advantaged of collaboration it is important to look at cultural differences to better understand different values, needs and motives. People act differently based on their culture and since the world becomes more and more international it is important to take a look at these qualities. Geert Hofstede is known from his comparisons within cultural research. Geert Hofstede [1991] states that all humans act from an inherent pattern. These patterns consist of mindsets, feelings and potential act-patterns that every human develope through their life experience. Hofstede use an analog to programmed computers that is known as *software of the mind.* Hofstede represents an onion-diagram of the mental assumptions that humans act from.

![Figure 3.3: Hofstede’s onion-diagram (adopted from Hofstede [1991])](image)

In the centre of the diagram is the fundamental property of the user based on
the human’s views and identity. Hofstede states that these properties are difficult to change when the users are older than 10 years old. The next layer is rituals, this contains necessary social activities. This can be the way one greets each other or ceremonies. The two outermost layers of the diagram are easier to affect, and these two layers are also more cultural dependent. The outermost layer, symbols, refers to words, gestures, pictures or objects that have a special meaning for the users and others with the same culture. An example of a symbol can be a hairstyle or a dress, new symbols easily arise and old ones disappear. When it comes to heroes, these are humans, cartoon characters or other characters that one look up to in the culture. The three outermost layers are placed into a group called mores, and may be comprehended by an outsider. The cultural importance’s are hidden in the centre, and it is the society that interprets these in their own way. This indicates that cultural affects all sides of a person’s identity.

From Hofstede’s research at IBM he found five cultural differences conspicuously large, these five differences are known as Hofstede’s cultural dimensions.

I will now look at these dimensions from a social constructivism point of view, the way the individuals and groups participate in the creation of their perceived social reality. Here the user can affect the group, or the group can affect the user. In this application the user is in focus, so I will look at how the user can affect groups.

**Power distance index**

This dimension is about how accepted a power distance is in a society. As Hofstede [Cultural Dimensions] states:

"Power Distance Index (PDI) that is the extent to which the less powerful members of organizations and institutions (like the family) accept and expect that power is distributed unequally."

In communities with high power distance index, children are expected to be obedient to their parents. Hofstede [ibid, ch.2] states that pupils evolve their software of the mind additional in the school. In addition to the parent/child relation, there will be a teacher/pupil relation, where the fundamental values and behaviour pattern will be shared. If the power distance index is high the teacher will be authoritarian and the pupils show a high level of respect for the teacher. It is the teacher is who is the guru, and the children are learning from him and are disciplined so they only do things they are told to do. In a low power distance index level the teacher is expected to treat the pupils as equals and the teacher expects to be treated the same way. The teaching is expected to be pupil-based, the children are active and ask questions if they does not understand. In a community with low power distance index the pupils will be less dependent on their teachers.

**Individualism**

Hofstede’s individualism is about the degree of which individuals are integrated into groups. According to Hofstede [ibid, ch.3], most of the people in the world are living in a community where the interest of a group come before an individual’s desire, this is what he calls a collectivism society. The children are brought up to know themselves as a part of a group, *we*, and the others who are not in the groups *them*. The
**we**-group becomes the person’s identity, and the worst thing a person can do is breaking the loyalty to the group.

In an individualistic society, the individual desire comes before the group. In contrast to the we, the children early learn to use I. The child’s identity is its own and they learn that their I are separated from other Is, the child learn to stand on its own feet.

Now I will look at individualism vs. collectivism situations in the school. Hofstede states that the pupil’s behaviour is evident in teaching. If a teacher in an individualism environment has a development project, he often moves to a collectivism environment. Often the background for this decision is that the pupil does not say anything in class even if the teacher asks a question. Hofstede explains that if the pupils are in a collectivism environment, then they are not supposed to answer without the group’s approval. The teacher then needs to ask the pupil directly to get an answer. In an individualism society group tasks are easier for new groups than in a collectivism society. In collectivism society the pupils from the same ethnical or family background expect special treatment, but in individualism societies this is immoral.

**Masculinity**
This dimension refers to the distribution of roles between genders. In a masculine society it is competition, attainment and success that are the dominating values. The opposite is a fact in feminine societies where it is of value to care about others and quality of life. In a society with high social difference, it would in a masculine society be important to show his status.

Hofstede [ibid, ch.4] states that in a masculine civilization the pupils try to be visible in the classrooms and compete with each other (if there are no restrictions from a collectivism society). An antagonism is in a feminine civilization where the pupil does not want to be too eager and the pupils follows the fellowship.

**Uncertainty avoidance index**
Uncertainty avoidance index is about the degree a human feels threatened from uncertainty and ambiguity, and is trying to avoid these situations. Hofstede [ibid, ch.5] points out that angst is an indicator on high uncertainty avoidance index, and that there is a difference between angst and fear, and uncertainty and risks. Both fear and risk points to something particular, in contrast angst and uncertainty does not point to any object. Uncertainty is based on what you have learned as a child that are dangerous, what you are allowed to do and not. An example is that in some communities the children are allowed to run around and play without being controlled, if the child falls he just stands up again. But in other communities the adults look at this situation as dangerous and would not let the child out of their sight.

At school, classes with high uncertainty avoidance index prefer to have a structured teaching situation with precise goals and a right answer to the questions. In a class with low uncertainty avoidance index the pupil prefer to have a open teaching situation where the main goal is open, and the task is wide and there exist no exact answer.
3.5. From stereotypes to user models

Long-term orientation
This dimension looks at the difference between long-term and short-term orientation. Hofstede [ibid, ch.7] states that in a short-term orientation the people have respect for traditions, and respect the social and status contractual obligations without concerning what it costs. The people are feeling a social pressure that they need to have the same as everyone else, even if this means over consumption. This leads to small savings and little money to invest with. People are expecting rapid results. In difference from short-term orientation, people adjusted traditions to a more modern setting. They save resources and money so they have the possibility to invest. In contrast to expecting rapid results, they have a persevering behaviour.

Both Gardner’s multiple intelligences, Dreyfus’ stages and Hofstede’s cultural dimensions are properties that exist in every human, and therefore it will also exist in each user who will use the application. In the next section there will be an explanation on how the system can take advantage of these theories for the users benefit.

3.5 From stereotypes to user models

In this section there will be an introduction on the benefits of using stereotypes, and how stereotypes can be used with the pedagogical theories in the system. In the end of this section there is an example that uses stereotypes and gives an insight into the benefits of using stereotypes. The example is related to the scenario in Section 3.1.2, where a pupil is receiving help from a friend.

According to Elaine Rich [1998], a user model is the so-called "stereotype approach". A stereotype contains characteristics of the user, and may contain conditions that represent important characteristics, which for instance can indicate that the users are belonging to a given group. One advantage of stereotypes is that they are easy to build. This property is important in an ubiquitous environment since the users change over time. If the system is to slow to generate the user model there is a risk that the user will not use the system. The stereotypes may change over time, depending on current events that influence the user. Another advantage of stereotypes is that they are able to trace. This means that if something is harsh it is possible to go to the stereotype and see why this is happening.

To summarise, by using stereotypes we get a possibility to make some interactions between the user and the system, like Rich proposed. From the stereotypes the system will get structured information about the users, which is useful when building user models. Rich [1998] declare that if a system wants to take the complete advantage of a stereotype it must consist of two types of information. The first one is the stereotype itself, and the second is the characteristics for each stereotype, Rich calls these characteristics for facets. Each facet is represented with a numeric value between -5 and 5, the value represents the users talents and skills in the facet. Rich [1999] states that to avoid conflicts in the user model, it is advantageous to have an estimate of the system’s confidence in that value. This estimate is called a rating, and will be a number between 0-1000. High ratings represent a high certainty that this is the correct
characteristic for the user.

When all the stereotypes are built, it is time to build a user model of each individual user, it is known as a User Synopsis (USS). A user model will calculate the values and the ratings when all facets are received by Equation 3.1 and Equation 3.2.

\begin{equation}
USS_{value} = \frac{\sum_{i=1}^{\infty} value_i}{x}
\end{equation}

\begin{equation}
USS_{rating} = \frac{\sum_{i=1}^{\infty} rating_i}{x}
\end{equation}

In Section 3.4 there were introduced three pedagogical theories that all contains some characteristic that could be of great value for a user in a learning system. Next section I will use the literature to find important characteristics of users in a learning system.

3.5.1 Stereotypes from Gardner

In this section the pedagogical theory from Gardner represented in Section 3.4.1 will be related to stereotypes. A summary of Gardner’s multiple intelligence can be found in Table 3.1.

<table>
<thead>
<tr>
<th>All stereotypes</th>
<th>Possible stereotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial intelligence</td>
<td>3</td>
</tr>
<tr>
<td>Linguistic intelligence</td>
<td></td>
</tr>
<tr>
<td>Logical-mathematical intelligence</td>
<td></td>
</tr>
<tr>
<td>Bodily-kinethetic intelligence</td>
<td></td>
</tr>
<tr>
<td>Musical intelligence</td>
<td></td>
</tr>
<tr>
<td>Interpersonal intelligence</td>
<td></td>
</tr>
<tr>
<td>Intrapersonal intelligence</td>
<td></td>
</tr>
<tr>
<td>Naturalistic intelligence</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1: Stereotypes from Gardner’s multiple intelligences

The intelligences contain information about the user, and it would therefore be appropriate to use these as stereotypes. Since there are in total eight intelligences, and a user (as Gardner stated) are strong in three of those intelligences. For the system each of the intelligences will be represented as stereotypes with a value from 0-100. To find out which of these intelligences that are the dominant for the user, the three stereotypes with the highest value will be chosen. To fill these stereotypes with the values from -5 to 5 the values will be represented like in Equation 3.3. To get the complete advantage of these stereotypes I will represent the facets for each of them.

Mobile Collaborative Learning
3.5. From stereotypes to user models

\[
(3.3) \quad \text{Value} = \begin{pmatrix}
0 - 10 \\
10 - 20 \\
20 - 30 \\
30 - 40 \\
40 - 50 \\
50 - 60 \\
60 - 70 \\
70 - 80 \\
80 - 90 \\
90 - 100 \\
\end{pmatrix} = \begin{pmatrix}
0 - 9.09 \\
9.10 - 18.18 \\
18.18 - 27.27 \\
27.27 - 36.36 \\
36.36 - 45.45 \\
45.45 - 54.54 \\
54.54 - 63.63 \\
63.63 - 72.72 \\
72.72 - 81.81 \\
81.81 - 90.90 \\
90.90 - 100 \\
\end{pmatrix} = \begin{pmatrix}
-5 \\
-4 \\
-3 \\
-2 \\
-1 \\
0 \\
1 \\
2 \\
3 \\
4 \\
5 \\
\end{pmatrix}
\]

Following is a representation of all stereotypes and facets collected from Gardner’s intelligence in Section 3.4.1. All facets are represented in italic and a summary of these can be found in the appendix A in Table A.1.

**Linguistic intelligence**
From linguistic intelligence a user use the language to communicate, because of this the language will be an important characteristic in linguistic intelligence. This characteristic is consisting of to important aspects that are represented in the section about linguistic intelligence, writing and speaking. Mnemonic potential is another important characteristic for the user that Gardner has introduced.

**Facet’s:** write, speak, mnemonic

**Logical-Mathematic intelligence**
In the paragraph about logical-mathematic intelligence it is important that the user is able to analyze problems logically. This is an important characteristic of the user and is therefore represented as a facet. Another characteristic of the user in this intelligence is the user’s ability to deal with large numbers in a rapid and controlled way.

**Facet’s:** logical, numbers

**Musical intelligence**
From musical intelligence the user should have the ability to understand rhythm and have the ability to recognise rhythmic patterns. In Section 3.4.1 it is also stated that the user should understand musical patterns, a facet that will be known as music. The last ability stated in the paragraph is the ability to appreciate and make use of sound.

**Facet’s:** rhythm, musical, sound

**Bodily-Kinesthetic intelligence**
From bodily-kinesthetic intelligence a user has the ability to control the body movement. An important characteristic in body movement is to have a good physic and a good physic control. Physic control is how good control the user has over its own body and consist of two important aspects that; touch and feeling.
Facet's: physic, touch, feeling

Spatial intelligence
From the paragraph in Section 3.4.1 there is pointed out some capabilities for the user. One of these is the capacity to conjure up mental imagery and then to transform that imagery. This characteristic will be a facet known as images. Another point was about the ability to recognise and transform elements, this facet will be known as shapes. In the end of the paragraph a last facet is being introduced, this is the ability to oriented oneself in a multi-dimensional version of the real world. This facet will be represented as 3D-spaces.

Facet's: images, shapes, 3D-spaces

Interpersonal intelligence
From the section about Gardner and his intelligences, this intelligence is about the ability to interact with others. Human contact is an important facet, because this intelligence indicates that the user likes to be with other people. Another important facet from this intelligence is communication, which will increase the ability to understand other humans. Cooperation is a characteristic depending on how well a user understand the group and use this understanding when cooperating with others.

Facet's: human contact, communication, cooperation

Intrapersonal intelligence
Intrapersonal intelligence is about the user’s ability to understand himself and his relationship to others and to the world. A user who has a strong intrapersonal intelligence will be self-aware and reflect about oneself, this facet will be known as self-reflection. The user likes to discover, this facet will be represented as self-discovery.

Facet's: self-reflection, self-discovery

Naturalistic intelligence
As introduced in an earlier section this ability is about understanding the nature and relationships in it. Important facets in naturalistic intelligence will be natural contact and natural communication.

Facet's: natural contact, natural communication

3.5.2 Stereotypes from Dreyfus
In this section Dreyfus’s stages from Section 3.4.2 will be related to stereotypes. A summary of Dreyfus’s stages can be found in Table 3.2.

Dreyfus states that every user can find himself in only one of the stages, and that this stage contain characteristics about the user. From Rich [1998] I know that to get a complete advantage of these stereotypes I need to represent the facet for the stereotypes. Following is a representation of all the stereotypes I got from Dreyfus’ stages with their belonging facets. Under each facet is a little explanation of what the facet. All facets are represented as italic and a summary of these can be found in the appendix A in Table A.2.
3.5. From stereotypes to user models

<table>
<thead>
<tr>
<th>All stereotypes</th>
<th>Possible stereotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td></td>
</tr>
<tr>
<td>Advanced beginner</td>
<td>1</td>
</tr>
<tr>
<td>Competence</td>
<td></td>
</tr>
<tr>
<td>Proficiency</td>
<td></td>
</tr>
<tr>
<td>Expert</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2: Stereotypes from Dreyfus’ stages

**Novice**
From Section 3.4.2 a novice is defined as a beginner who is facing context-free characteristics that he can recognise without previous experience. From this an important facet will be the ability to **recognise**. Since the user is faced with some rules that make him able to do some action, another important facet will be the ability to **remember** these rules.

**Facet’s:** recognise, remember

**Advanced beginner**
From Section 3.4.2 the user is now getting some experience in handling real situations, this makes him able to interpret and note. **Interpret** and **note** are now two important characteristics for the user. But these two characteristics is not the only characteristics for an advanced beginner, his ability to **recognise** is still important.

**Facet’s:** interpret, note, recognise

**Competence**
The user is beginning to be able to think out plans or select perspective that reduces the possible aspects. This leads the user to be able to **reasoning** and **understanding** situations. Since the user now sees that his choices lead to results he get **emotional involvement**. The user is starting to feel responsible for his choices.

**Facet’s:** reasoning, understand, emotional involvement

**Profience**
The user’s experience increases and their user is able to think out a plan or select perspective that reduces the aspects. This leads the user to be able to do **situational discrimination**. The user has the ability to **see goals** which is an important facet for the user.

**Facet’s:** situation discrimination, see goals

**Expert**
As stated in Section 3.4.2, the user know how and what to do. Important facet will therefore be that the user **see goals** and **achieve goals**.

**Facet’s:** see goals, achieve goals

Mobile Collaborative Learning
3.5.3 Stereotypes from Hofstede

In this the pedagogical theory from Section 3.4.3 will be related to stereotypes. A summary of Hofstede’s cultural dimension can be found in Table 3.3.

<table>
<thead>
<tr>
<th>All stereotypes</th>
<th>Possible stereotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power distance index</td>
<td>5</td>
</tr>
<tr>
<td>Individualism</td>
<td></td>
</tr>
<tr>
<td>Masculinity</td>
<td></td>
</tr>
<tr>
<td>Uncertainty avoidance index</td>
<td></td>
</tr>
<tr>
<td>Long-term orientation</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.3: Stereotypes from Hofstede’s cultural dimensions

From Hofstede the system has five different stereotypes, each of these will be represented with a value from 0-100. This value represents how strong these stereotypes are for the user, and will be represented like the stereotypes from Gardner in equation 3.3. I will now represent each stereotype from Hofstede’s cultural dimension with belonging facets. All facets are represented as italic and a summary of these can be found in the appendix A in Table A.3.

**Power distance index**

As stated in 3.4.3, this dimension is about how accepted a power distance are in a society. One characteristic a child is showing is respect for adults. This is indicating that this is a society with high power distance. Another characteristic a child can have is discipline, if it is in a class and the pupil is doing like he is told, and only what he is told. Hofstede states that children in society with high power distance is teacher depended, he explains that the teacher is the guru and the children are depended on him.

Facets: respect, discipline, teacher depended

**Individualism**

In an individualism society, as stated in Section 3.4.3, a characteristic for a user is that the child is independent and can stand on it’s own feet. The child has an individual desire and has no problem with being talk active.

Facets: independent, individual desire, talk active

**Masculinity**

A child in an environment with high masculinity will need attention and likes to attract attention and competition. The user needs to achieve attainment and show this to the others, that will amplify the need to attract attention. The child has a desire for success.

Facets: attract attention, competition, attainment, success

**Uncertainty avoidance index**
A child in an environment with high uncertainty avoidance index have the characteristic of being *uncertain*. An indicator on this property is that the child is uncertain and asks for help all the time. If the child have a combination of fear, uneasiness and worrying about unspecified objects the child can be characterised as having *angst*.

**Facets:** uncertain, angst

**Long-term orientation**

From Section 3.4.3, it is stated that characteristics for a child in an environment with high long-term orientation is *persevering behaviour*. Persevering behaviour is evident when the child is patient and has the ability to wait for results rather than expecting rapid results. Another characteristic is that the users like to *save money* and have a strong economy.

**Facets:** persevering behaviour, save money

### 3.5.4 Example

All these stereotypes and facets enable me to build user models. Let’s have a look at two simplified tables, one representing Kari (Table 3.4) and one representing Pia (Table 3.5).

<table>
<thead>
<tr>
<th>Stereotype</th>
<th>Facet</th>
<th>Value</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistic intelligence</td>
<td>Words</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Language</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bodily intelligence</td>
<td>Physical experience and movement</td>
<td>4</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td>Touch and feel</td>
<td>3</td>
<td>600</td>
</tr>
<tr>
<td>Interpersonal intelligence</td>
<td>Human contact</td>
<td>5</td>
<td>900</td>
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</tr>
<tr>
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<td>400</td>
</tr>
<tr>
<td></td>
<td>Save money</td>
<td>-4</td>
<td>600</td>
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</table>

Table 3.4: Simplified characteristics for Kari

I now compare these two tables and see how the system can take advantage of them. From Kari’s user model I can see that she likes to collaborate with others. The system can interpret that Kari prefers to work with others, and that the system should search for other users in the system with similar characteristic. The system finds out that Pia is nearby and also has the characteristic that she likes to collaborate. Further, the system checks if there is something more that makes Pia a proper help for Kari. The system knows that Kari is a novice and that Pia possibly can help Kari since she is a competence and have high ratings on the uncertainty avoidance index. But the system also notice one risk by allowing Pia to help Kari, since Kari is short-term orientated and Pia is the opposite there may be a conflict. The system decides that...
<table>
<thead>
<tr>
<th>Stereotype</th>
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<th>Value</th>
<th>Rating</th>
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<td></td>
<td>Sounds</td>
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<td>600</td>
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<td></td>
<td>Rhythm</td>
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<td>Human contact</td>
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<td>Anst</td>
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<td>Long-term orientation</td>
<td>Persevering behaviour</td>
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<tr>
<td></td>
<td>Save money</td>
<td>4</td>
<td>600</td>
</tr>
</tbody>
</table>

Table 3.5: Simplified characteristics for Pia

this risk is not that critical and therefore allows Kari to have the possibility to chat with Pia.

From these stereotypes and facets I will, as mentioned, get information about the user that can guide the rest of the system. These user models makes it possible for the application to compare a pupils user model with others user models. This leads to the possibility to match user models in an ubiquitous environment, and see if the other nearby users that have some similarities which the user can take advantage of.

The system now has the ability to take advantage of characteristics from the users and compare user models. In the next section there will be a presentation of task modelling and how the system can take advantage of task modelling.

### 3.6 Task modelling

It is important to build task models for heterogeneous users so that the system has a possibility to help the user. In contrast to earlier sections, the focus will move from a objective perspective to a subjective perspective. The system needs to know how to solve the task and which users who will perform the tasks. Gundersen and Kofod-Petersen [2005] has described a way to do task modelling, this approach will be described in the following section. In the end of the section there will be an explanation on how to use these task models and how they can be related to user models.

For the system to be able to help the user to deal with a certain task, it is required that the system know what the task is about. Gundersen and Kofod-Petersen describe
3.6. Task modelling

a way to decompose tasks to make the information accessible for the system. When the user will perform a certain task, the system will decompose the goal into a tree consisting of the main task and subtasks. The main task is the root in the tree, this is what the user wants to achieve. The task will then be decomposed into subtasks, and each subtask will, if possible be decomposed into more subtasks, until all tasks are accomplished. Gundersen and Kofod-Petersen state that there are some rules that are required to be able to decompose a task into subtasks. The first is that the decomposed subtask must take in the same input as the upper task. There is only one subtask that will have this property. Second, the subtask must have the same output as the upper task, also here there is only one subtask that is allowed to have this property. The rest of the decomposed subtasks must fulfill the third requirement, the task must connect to the other subtasks that are part of the upper task set of subtasks. This means that for a subtask to be able to connect to two other subtasks it must take one’s output as input and must be taken as input for another subtask. If one subtask has the same input or output as some other subtask, it is the same task. When the task is decomposed enough the leaf-nodes of the tree are agents. When an agent performing a leaf-node it leads to the solution of subtasks, and when all agents are done the main task is solved. Each tree represents how to solve a given task and is represented as a Direct Acyclic Graph (DAG). An illustration of an example of such a tree can be found in Figure 3.4 (adopted from Gundersen and Kofod-Petersen [2005]).

![Figure 3.4: Decomposition of a task (adopted from Gundersen and Kofod-Petersen [2005])](image)

To be able to take advantage of such a task tree, Gundersen and Kofod-Petersen used agents to achieve the tasks specified in the tree. If there were available and capable agents the task in the structure were mapped. The capabilities map to the Unified Problem-Solving Method description Language (UMPL) concept Reasoning Resource

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As tasks have been decomposed into subtasks and every subtask that are being solved leads to solution of the main task, this main task will from now on be referred to as the goal the user wants to achieve. If we look at the system as a rule-based system, the goal will be dependent on very large sets of rules. But as the goal is decomposed in the task-tree, there will be more context and less rules as the distance from the root increases, see Figure 3.5 (adopted from Kofod-Petersen et al. [2008]).

For our system, the goals are what the pupil should learn in the topics. The sub-tasks are tasks the pupil should solve to achieve these goals. The leaf-nodes are actions the user can perform to solve the tasks and achieve the goals. Figure 3.5 (adopted from Gundersen and Kofod-Petersen [2005]) is suitable for this approach, because a goal has little context but an action has a lot. This makes it possible for the system to compare the objective perspective with this subjective perspective, it has the possibility to compare the stereotypes with the task’s context.

Following is an example related to the Scenario 3.1.1 in Section 3.1 based on task modelling.

3.6.1 Example

In the scenario 3.1.1 Ola is at the Nidaros Cathedral and would like to perform a task. The task Ola likes to solve is: What does the Crown Regalia consist of? At this stage Ola has no idea on how to perform that task and has little information about the surroundings and the possibilities. In this example the root node will be the learning goal for this subject, this goal has little context and are therefore difficult to achieve. The decomposed tasks are the different tasks the pupil can solve, the tasks have some context but are still difficult to solve. The leaf-nodes will be actions that the pupil can perform to solve the given task, these leaf-nodes will have much context and

UPML, it solves a subtask that are specified by a Problem Decomposer. The Problem Decomposer is another problem-solving method in UPML, it decompose a task into several subtasks and then specified the operational control structure over the subtask.

Mobile Collaborative Learning
therefore the user are able to perform these actions and solve the tasks. When all tasks are solved the learning goal of this given subject are being achieved. Ola who stands outside Nidaros Cathedral and have little information about the context are getting help from the system. Ola now have some options on how he can solve the task. From the scenario Ola has the possibility to go to the tourist information center, the Archbishop’s Palace in the artillery building, ask a nearby friend or search in the wiki. Ola has now some actions he can choose to perform, and decides to go to the artillery building and look at the crowns. Ola is now in an environment with a lot of context, so finding information about the crowns is easy. Ola finds his answer and are returning to meet his friend.
Part IV

Results and Conclusions
Chapter 4

Conclusions and further work

This chapter gives a summary on the achievements of the work presented in this report. In the end of the section there are directions on how this project may be extended to a deeper study.

4.1 Summary

A mobile collaborative learner is influenced by different technologies in their everyday life. Important technologies which are used is ubiquitous computing and context-aware computing, these technologies makes it important to remember that the place of teaching are dynamic, so it does not necessarily take place in the classroom.

In every learning system it is required to have a good pedagogical model. In this report the pedagogical theories presented are based on how a user prefers to learn, what division the learning should be in and the cultural background of the user. By using these theories the system has an approach to get data on what kind of users it is dealing with and by taking advantage of stereotypes, this has given us a promising approach for personlising the learning for the user. The user models that are generated make it possible for the system to compare the user with other users in the environment, which enable the system to help the user with finding proper help.

By building user models based on stereotypes the system is able to compare user models. From the literature I have used Gardner’s multiple intelligences, Dreyfus’ stages and Hofstede’s cultural dimensions to find appropriate stereotypes for the system. Total stereotypes found were 18, where a user model exists of 8 of these. The stereotypes consist of facet’s that are the users characteristics. From the pedagogical theories I gathered facets of users in learning systems. This seems to be a promising approach. The totals of facet’s found in the literature were 47.

To achieve the second goal of this report the system takes advantage of task modeling. The task model consist of a task structure where the root of the tree are the goal the user wants to achieve, and the nodes are tasks, and the leaf-nodes are actions the user can perform to achieve the goal. When a user wants to achieve a goal the system compare the user model with the goal and finds task that are suitable for the user to perform. This led the system to be able to help the user to achieve a certain goal.
4.2 Further work

Mobile collaborative learning offer a new solution to already existing and well known problems. It enables the learner to get a personalised learning in a ubiquitous environment. Such a learning system is very new and need more experiments to be performed to document the advantage of this technology in the future.

This report presents three pedagogical theories, I will suggest how to find a pupil’s place in these theories. Gardner’s multiple intelligences can easily be found by taking a test on the net, there are plenty of those. Dreyfus’ stages consists of five stages, a teacher can place the pupil in a stage based on his experiences with the pupil. Hofstede’s cultural dimensions are based on personal characteristics that are difficult for others to assume, this is therefore a remaining challenge to be solved.

My master thesis will concern development of a mobile collaborative learning system, and this report will serve as the foundation for my further work. The system will be tested on users to see if this is a technology that are suitable for a mobile collaborative learner.
Bibliography


Part V

Appendices
Appendix A

Stereotypes and facet’s from pedagogical theories

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<thead>
<tr>
<th>Stereotypes</th>
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</tr>
<tr>
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Table A.1: Summary stereotypes and facets, Gardner’s multiple intelligences
## A. Stereotypes and facet’s from pedagogical theories

### Table A.2: Summary stereotypes and facets, Dreyfus’s stages

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### Table A.3: Summary stereotypes and facets, Hofstede’s cultural dimensions

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