MOBILE LEARNING – LEARNING CONTENT, LEARNER STYLES, AND MOBILITY – A DIFFERENTIATED EXAMINATION ON THE ADVANTAGES AND DISADVANTAGES OF MOBILE LEARNING

A Thesis
Presented to
The Graduate Faculty
University of Wisconsin-Platteville

In Partial Fulfillment
Of the Requirement for the Degree
Master of Science
Student’s Program

By
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2010
Statement of Authorship

I hereby certify that this master thesis has been composed by myself, and describes my own work, unless otherwise acknowledged in the text. All references and verbatim extracts have been quoted, and all sources of information have been specifically acknowledged. If no source is referenced all figures and code fragments in this thesis are created by me. This thesis has not been accepted in any previous application for a degree.

____________________________
Bobenheim-Roxheim, June 30\textsuperscript{th}, 2010
Abstract

Mobile Learning (M-Learning) is the buzzword in computer technology today. Thanks to the wide availability of mobile internet access and the potential of cell phones, PDAs, and laptops, everybody can be online anywhere and anytime. M-Learning creates completely new possibilities in learning. The learning can take place at any particular point of interest. In addition to the opportunity to learn anytime and anywhere, M-Learning creates entirely new learning scenarios.

This master’s thesis critically investigates the potentials of M-Learning while examining the positive and negative effects of M-Learning for learners. Furthermore, it will investigate what kind of learners and which types of learning content may and may not benefit from M-learning.

There are two different ways to use M-Learning: as a support to classical learning and to create new ways of learning. In the support of classical learning, the learning can take place at anytime and anywhere. The basic example is the reading of learning material, such as lecture presentations or scripts, while on the go. This could be called learning to go, such as the coffee to go.

The second use of M-Learning is the creation of new ways of learning. M-Learning enables the student not only to learn anywhere and at anytime; it enables the student to learn at the point of interest, for location-based learning. It is now possible to combine the learning of a topic with the topic itself.
Acknowledgement / Danksagung

I would like to express my gratitude to my advisors Bettina Harriehausen-Mühlbauer, Rob Hasker and Udo Bleimann for their support while writing this thesis. I want to thank Mrs. Harriehausen-Mühlbauer for the revisions in her office and the telephone calls. Also, I want to thank Mr. Hasker for his support during my time in Platteville. Furthermore I want to express thanks to the University of Applied Sciences – Darmstadt and the University of Wisconsin – Platteville for the very good education and a great time in my life.

A very special thanks goes to Jennifer Krahn for helping me with the spell checking, grammar and formulation of this thesis and of course for the great moments in Platteville!

Darüber hinaus möchte ich mich bei meinen Eltern bedanken, dass sie alle die Jahre die nötig waren um zu diesem Punkt zu kommen für mich da waren und mich in allem unterstützt haben.
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1. Introduction

1.1. Central Problem Statement

Mobile Learning or short M-Learning creates completely new possibilities in learning. By having the learning material on a mobile device, the learner can use train rides and other waiting time to learn. In addition to the opportunity to learn anytime and anywhere, M-Learning creates completely new learning scenarios. Thanks to the possibility of being mobile, the learning can take place at any particular point of interest. For example, a lecture about the unique architectural design of a building could take place at the building itself. This creates an entirely new learning experience.

Based on these advantages, M-Learning has the possibility to enhance learning for everyone, who owns a cell phone and wants to learn mobile, according to the people who support M-Learning. But the question is, are these claims correct or are the possibilities of M-Learning just hype?

This master thesis critically investigates the potentials of M-Learning while examining the positive and negative effects of M-Learning for learners. Furthermore, it investigates what kind of learners and which types of learning content will and will not benefit from M-Learning.

1.2. Objective Target

This thesis will research the scientific relevance of the M-Learning hype. Therefore, M-Learning, or more precisely the special features of M-Learning for the learner, will be discussed based on the following factors:

- Socio-demographic (such as age and level of education)
- Learner styles
- Mobile devices and applications
- Learning content
Due to the limited scope of a master thesis, the Socio-demographic factor will be confined to students at the high school and university level.

Every learner has an individual preference in learning style. In consequence, existing learner style theories will be introduced and investigated for their suitability to judge the effect of M-Learning on the learner.

Another factor is the type of mobile device and the applications running on it. It is important to know if learning content is intended to be read on a small cell phone display or on a larger laptop screen. In addition, the variety of available devices supports different applications. Therefore, the devices and applications will be classified and their applicability for M-Learning discussed.

The learning content also has a great influence on the benefit or disadvantage of M-Learning. This thesis will attempt to briefly categorize the different kinds of learning content. They will be evaluated in detail in order to see the impacts of the learning content on M-Learning and which types benefit and which types are not well suited for M-Learning.

These three factors will be reviewed in greater detail in this thesis. The goal is to critically analyze when M-Learning brings greater benefits to learners and when M-Learning does not benefit or even hinders learners.

In addition to this analysis, some learning scenarios will be presented to further point out the advantages and disadvantages of M-Learning. These scenarios will address the different advantages, such as learning at the point of interest, and disadvantages, such as reading long texts, and discuss them.

1.3. Thesis Overview

Following the introduction, M-Learning will be defined and its advantages and disadvantages will be examined. Next, the three factors, learner styles, mobile devices and applications, and learning content will be explained and discussed.

After this analysis, several scenarios for M-Learning will be suggested, and the advantages and disadvantages for these examples reviewed in detail. We then give a checklist indicating
the requirements for a valuable M-Learning scenario. This checklist will be evaluated with professionals in education.

A simulation of M-Learning will demonstrate the importance of adjusted learning content. It will show the impact of non-adjusted learning content on the learning success. And point out that adjusted learning content leads to positive results in the learning process.

1.4. Related Work

This thesis can be seen in the context of the Atlantis University project of the University of Applied Science in Darmstadt (Schneider, et al., 2009). Atlantis University is an ambitious international project in the area of learning being developed by a group of universities and companies. It combines support for three different types of learning and teaching to form a single package offered to students and people in the workplace alike: face-to-face learning, E-Learning, and project-based learning (Bleimann, 2004). This thesis addresses the second part of learning, the E-Learning. With M-Learning, this part of Atlantis University can be extended and new learning possibilities can be added.

MLE – Mobile Learning Engine - is an open source solution for M-Learning. Developed in 2004 by Meisenberger, this project attempts to realize the main goal of M-learning: learn anywhere, anytime, and whatever you want. MLE is written in J2ME and therefore runs on many cell phones available today (eLibera OG, 2010). This project demonstrates a software framework solution for M-Learning. Instead of implementing an own application, this framework could be used for M-Learning scenarios, such as presented in this thesis. The skeletal structure given by MLE allows the authors of M-Learning scenarios to concentrate on the content.

An example of a concrete application for M-Learning is “Explore!”. Explore! is a M-Learning system that supports middle school students during their visit to an archaeological park. This application uses a learning technique called “excursion-game”. It helps students acquire historical notions while playing, making archaeological visits more effective and exciting (Costabile, 2008). This scenario presents one concrete application of M-Learning and shows the benefit of it.
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(Frohberg, et al., 2010) presents a list of M-Learning projects and analyzes them critically. The review uses a mobile learning framework to evaluate and categorize 102 Mobile Learning projects and briefly introduce exemplary projects for each category. All projects were analyzed with specific criteria, including: context, tools, control, communication, subject and objective (Frohberg, et al., 2010). Their work gives an overview of the currently existing M-Learning projects in the scientific world.

The website e-teaching.org deals with all aspects of E-Learning and also M-Learning (e-teaching.org, 2007). It presents learning scenarios, discusses media technical concerns and also gives feedback from practical experience.

Thus previous work has focused on specific domains and implementation methods. This thesis addresses when M-Learning is generally useful, across domains and technologies. It will investigate the potentials of M-Learning and its suitability to be used in learning.
2. Mobile Learning

2.1. Definition

The term “Mobile Learning” can be defined in many different ways. From a technological point of view, M-Learning is related to E-Learning. “E-learning means learning in which digital media is used for the presentation and distribution of educational content and / or supports the interpersonal communication” (Kerres, 2010). Taking this description into account leads to the first possible definition of M-Learning:

M-Learning means learning where mobile media and mobile communication is used.

Another possible definition could be created from a more geographic point of view. The term mobile indicates movement or an unfixed location. Therefore the term “Mobile Learning” could be defined as:

Learning from an unfixed location.

Both definitions combined can be seen as a starting point for another definition:

“Learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies” (O’Malley, et al., 2003).

These definitions highlight the mobile aspect of M-Learning. The possibility of the mobile devices and mobile internet creates completely new learning possibilities, such as learning at any point of interest. Another definition comes from Karren:

Mobile Learning encompasses all systems that allow learners to access distributed data and communicate with each other without relying on wired power and communications. (e-teaching.org, 2007)

This definition focuses on mobile devices and applications. M-Learning needs customized learning applications. Of course it is possible to just read text on a mobile device, but the real enhancement of the learning effect could be created with special learning applications or content with adjustments for the use with mobile devices.
Combining the definitions of Karren and O’Malley gives the following working definition of M-Learning:

Learning that uses mobile technologies to provide opportunities outside of fixed, predetermined locations, where mobile technologies include all systems that provide access to distributed data and communications without relying on wired power or tethered network access.

While M-Learning is essentially a type of E-Learning, the distinctions are important; M-Learning distinguishes itself from E-Learning in special technical conditions. Mobile technologies with small screens, limited bandwidth and limited storage space are especially developed for the mobile usage. On the other hand, mobile technologies enable the learner to learn anywhere and anytime in contrary to classical E-Learning application. Consequently, E-Learning applications can be extended or customized with mobile technologies, such as adding access for cell phones or PDAs. By this, existing E-Learning applications can be used for M-Learning.

2.2. Three factors for M-Learning

There are three factors which need to be taken into account when discussing the benefits and disadvantages which M-Learning brings to the learner:

- The learner or the learning style
- The mobile device and/or mobile application
- The learning content
The following image shows the dependencies of these three factors on each other:

![Figure 2.1 – Three factors for M-Learning](image)

As depicted above, each factor depends on or influences the others.

The learner chooses the learning content according to the own learning style. Ideally, there are different versions of the same learning content, as different learning content is variably suited for different learner types. By this, the learner can choose the most preferred version of the learning content.

The learning content itself needs to be prepared for the mobile device it is meant to be used on. This could mean a different layout of a text to suit a cell phone display or the development of a learning application for a PDA. The mobile device or application used influences the learning content and vice versa. If there is only a PDA with no internet connection available, the learning content needs to be customized in order to work offline.

There is also dependence between the learner and the mobile device or application. For example, depending on the learner’s preference, a laptop could be better suited than a PDA. And of course, the learner needs the mobile device in order to “do” M-Learning.
Figure 2.1 shows that all three factors need to be taken into account when talking about M-Learning. All three factors influence the success of M-Learning or can result in the failure of it.

2.3. Advantages of M-Learning

M-Learning has many advantages for learners, (e-teaching.org, 2007) presents a categorization into four key advantages:

- Efficiency
- Personal Sphere
- Connection
- Context sensitivity

Efficiency

“M-Learning enables (learners) to learn at places, which do not have a reference to the learning content, but could be used to learn due to time rational occasions (such as in the metro or train).” (e-teaching.org, 2007)

Of course anyone could print out a script and take it with on a train ride, but this script needs to be printed out upfront and therefore spontaneous learning is not possible with this method. In this new way, a script or other learning material that is readily available on a cell phone is much more convenient. Nearly every student, 97.8% of all German adults between in the age range 20 to 29 have a cell phone (Informationszentrum Mobilfunk, 2010). For that reason, the online available learning material can be accessed anytime and anywhere with M-Learning.

Personal Sphere

“Learning takes place in the personal sphere of the user. Due to the immediate access of information, problem-oriented learning is supported.” (e-teaching.org, 2007)

This advantage is not restricted to M-Learning; E-Learning is also possible in the user’s personal sphere such as classical learning, too. The advantage of a personal sphere for learning is important, but it is not constrained to E-Learning. Furthermore nearly all learning
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methods can be used within a personal sphere, such as learning at home, in a corner of a library and so forth. Therefore this advantage by (e-teaching.org, 2007) is not as strong as the other ones, when talking about the benefit of M-Learning.

Connection

“Because of the permanent internet connection, interaction and communication with the lecturer and other students is more intensive and group-work more flexible.” (e-teaching.org, 2007)

This is a huge advantage of M-Learning. Many learners profit from group work, or more specifically, from the exchange of information about learning content. There are learners, the so called Active Learner, who prefer discussing or talking about a topic with other learners. This learner type and other types are discussed in more detail in section 3. Learner Styles.

With the possibilities of M-Learning, the learners can communicate with each other outside of the classroom or group meetings. Aside from the classic email, there are a variety of instant messaging programs which run on mobile phones, such as Skype or ICQ. This ability to communicate in real time leads also to greater efficiency, instead of weekly group meetings, the group member can communicate synchronous (with instant messenger or phone calls) or asynchronous (with email) with each other, which leads to increased time efficiency.

Context sensitivity

“M-Learning allows the collection and evaluation of environmental information, like researches in a laboratory or museum.” (e-teaching.org, 2007)

This advantage highlights the “mobile” in M-Learning. Due to the handy size of cell phones and laptops, they can easily be taken with someone to such learning places. With the possibility to connect to the internet, and furthermore to web-accessed learning programs, the learning or research is much more efficient. Also, it is possible to store the collected data directly on the device, such as in a database. This is an additional time-efficiency advantage
because it eliminates unnecessary repetition, such as first writing the information on paper and transferring it later into the system.

Aside from these four advantages, there is another huge advantage of M-learning: learning at the point of interest. The point \textit{context sensitivity} cuts this advantage a little, but (e-teaching.org, 2007) does not highlight the real advantage of it. The next section will explore this in greater detail.

\textbf{Learning at the point of interest}

With M-Learning it is not only possible to learn anywhere, moreover it is possible to learn on site. As an example, it would be possible to learn about train signals at the switching yard instead of in a classroom presentation. This is a huge advantage for some learner types.

However, this is just one example of the many possible scenarios which benefit from \textit{learning at the point of interest}. M-Learning creates the possibility to combine the teaching material, such as scripts, presentations, and so forth, with the content itself, such as a building, architectural site, etc. This combination can positively influence the learning effect.

The benefits for the learners created by M-Learning can be roughly divided into two categories. The first category includes the benefits stated in the point’s \textit{efficiency} and \textit{personal sphere} above: Learning anywhere and anytime and the possibility to learn in a personal sphere. This category will be defined as \textit{convenience benefit} in this thesis.

The second category includes the point’s \textit{connection}, \textit{context sensitivity}, and \textit{learning at the point of interest}. The benefit in this category is created by the use of mobile technologies, such as being able to enter information about a tree into an online information system while sitting near the tree in a park. This category will be defined as \textit{technology benefit} in this thesis.

\subsection*{2.4. Disadvantages of M-Learning}

Despite all of its advantages, M-Learning also has some disadvantages. First of all, M-Learning does not replace classical learning situations such as lectures and can only support
them under certain circumstances. As shown above, there are three factors which need to be taken into account when talking about the advantage or disadvantage of M-Learning.

First of all, the learning content itself needs to be applicable to be taught with M-Learning. There are different types of learning content. For example, learning facts, such as historic dates or vocabulary, or doing something practically, such as an experiment in a physics class. Learning content needs to be prepared in all types of classes or learning forms. Depending on the topic, the time needed to customize the content for M-Learning could be too high to justify the learning benefit which would be achieved. See a detailed discussion about learning content in section 5. Learning Content.

The learners themselves or more specific their learning styles need to be suited to M-Learning. There are different learner styles, such as the already spoken of Active Learner, who prefers group work. This type of learner benefits from M-Learning, on the contrary a so called Reflective Learner, who likes to first think about a topic quietly does not benefit from M-Learning. Section 3. Learner Styles will discuss the different learner styles and their influence on M-Learning.

The last factor is the mobile devices and applications. There are many mobile devices available currently, having their own advantages and disadvantages. For example, a cell phone has limited input possibilities and a small screen for the output, but can be carried easily with the learner. A laptop has a big screen and a full keyboard but could be too heavy and bulky in some situations. It needs to be analyzed when a specific device brings benefit to the learner or not. Section 4. Mobile Devices and Applications will give an overview of available mobile devices and talk about when a specific device and application brings benefit or disadvantage.

2.5. Summary

This section showed that the mentioned three factors need to be analyzed critically and differentiated in order to investigate the background of M-Learning and the hype around it. They will be analyzed in greater detail in the next chapters. Detailed scenarios will also lay
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out the advantages and disadvantages of M-Learning in specific learning situations. The thesis, determining whether M-learning is over-hyped or not, will be revisited on this basis.
3. Learner Styles

3.1. Learner Styles for M-Learning

The learner’s style of learning is one important factor which needs to be taken into account when judging the benefits or disadvantages of M-Learning. This factor will be discussed now.

“Every adult has his own learning style, to introduce necessary attitude changes and has an individual cognition style, to handle information.” (Eichelsbacher, 2010).

Every learner has an own style of learning, in order to investigate these styles, the term learning first needs to be clarified:

Learning in a structured educational setting may be thought of as a two-step process involving the reception and processing of information. In the reception step, external information (observable through the senses) and internal information (arising introspectively) become available to students, who select the material they will process and ignore the rest. (Felder, et al., 1988).

According to these definitions, learning is the handling, reception and processing of information. Therefore the term learner style means the student’s preferred style of handling, receiving and processing, information. The diverse learning styles of different learners can be combined into learning style models:

A learning-style model classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information. (Felder, et al., 1988).

These scales need to be discussed in order to determine which preferences are supported by M-Learning and which do not benefit from M-Learning. There are many different models available in the scientific world. An overview of the different models of learning styles can be found in (Jonasson, et al., 1993). In the following section, two of these models by Röll and Felder are presented. The model by Röll is selected because it is used in the Atlantis University project (Bleimann, 2004), the context of this thesis. Felder’s Model is one of the most used and cited in the scientific world; therefore his model is presented too. Both
models will be discussed and analyzed in detail. After this one model will be selected and used in the further thesis to judge the advantages and disadvantages of M-Learning.

3.2. Model according to Röll

The model by Röll (Röll, 2005) is used in the Atlantis University Project (Bleimann, 2004) where Röll describes six different characteristics. He calls his model a mixed-type model because a person inherits all of these six characteristics, in varying degrees. The six characteristics are:

- Rational-cognitive type (analyst)
- Pragmatic-experimental type (constructor)
- Organizational-structural type (administrator)
- Sensory-kinesthetic type (perceiver)
- Emotional-communicative type (communicator)
- Intuitive-creative type (creator)

Figure 3.1 shows a possible learner style preference for a fictional person:

![Figure 3.1 – Learner style preference by Röll](image)
The fictional person was tested with the questioner provided by Röll (Röll, 2004). This figure shows the varying values of the six characteristics. The fictional student is strong in the *construction* and *communication* dimension, but weak in the *perceiver* and *administration* dimension. The *analyst* and *creator* dimension are about equal.

The six characteristics are described in detail below, followed by a discussion of the applicability of this model for M-Learning.

**Rational-cognitive type (analyst)**

The analyst learns best from lectures, reading, working with text and data-oriented contents. Facts, figures, logical conclusions, theories and case studies are among the preferred sources of information for this type of learner. The analyst enjoys challenges and is good with *casual thinking*. In addition, this learner type likes discussions and needs rational schemes for everything.

**Pragmatic-experimental type (constructor)**

This preference type prefers abstract conception in combination with concrete thinking and active experimentation. According to Röll, the constructor uses scientific models as a starting point for the understanding with active application of the learning content. Due to the high media literacy of this learner type, the learning process can be positively influenced by media.

**Organizational-structural type (administrator)**

This preference type is characterized by pragmatism. The administrator likes data, facts and numbers; furthermore, this learner type is good in systemizing, administrating and organizing. Röll states this preference type is skeptical of new ideas and favors simple and clearly structured learning content. The administrators learning approach can be characterized by step-by-step and consequential procedure.

**Sensory-kinesthetic type (perceiver)**

The sensor is predominantly led by its senses. This learner type is both detail-oriented and fact-oriented, and its biggest strength is the imaginary power. If the learning process
includes visual, auditory and kinesthetic stimuli, this type learns better and faster than without such input. The perceiver prefers active experimentation and group work.

**Emotional-communicative type (communicator)**

This learner type prefers working in a group or with interactive dialog. The communicator is interested in values, not facts. The advantages of this learner type lies in active listening and exchange of ideas. According to Röll the communicator needs interaction and requires human recognition. This preference type is a good team player and has highly developed social skills.

**Intuitive-creative type (creator)**

Ideas and overall-coherency are important for this type. The creator is oriented towards practical issues and prefers experimentation and intuitive problem solving rather than cognitive-relational thinking. Röll says that this learner type questions conventional methods. Furthermore this type of learner discovers hidden learning potentials and uses them if the currently used learning method does not lead to results.

**Impacts on M-Learning**

M-Learning profits, among other things, from the possibility to learn at the point of interest. Consequently, a learner, who prefers visual presentation or learning, benefits from learning at the point of interest. Röll has the perceiver preference type in his model to test this characteristic, among other characteristics, which are also represented by this preference type.

In order to test if a learner profits from M-Learning, Röll’s model, or more specifically the perceiver preference type, can be used. As already stated, the perceiver preference does represent more than just the preference of visual input.

The following model by Felder and Silverman has, among other dimensions, the visual – verbal dimension. This dimension tests explicit the visual preference of a person and therefore this model is more useful to test if a learner benefits from M-Learning or not.
3.3. Model according to Felder & Silverman

Felder and Silverman published their model in 1988 (Felder, et al., 1988). It was originally created for engineering classes, but the resulting model is not limited to these types of classes it can be used in teaching in general.

A refined version of Felder and Silverman’s model defines four dimensions: perception, input, processing and understanding. Each dimension has two characteristics which indicate the student’s own learning style. Figure 3.2 shows the characteristics for the four dimensions:

<table>
<thead>
<tr>
<th>Preferred Learning Style</th>
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</thead>
<tbody>
<tr>
<td>sensory</td>
</tr>
<tr>
<td>intuitive</td>
</tr>
<tr>
<td>visual</td>
</tr>
<tr>
<td>auditory</td>
</tr>
<tr>
<td>active</td>
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<td>global</td>
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<tr>
<td>perception</td>
</tr>
<tr>
<td>input</td>
</tr>
<tr>
<td>processing</td>
</tr>
<tr>
<td>understanding</td>
</tr>
</tbody>
</table>

Figure 3.2 - Learning Styles according to Felder & Silverman

Felder and Silverman provide an online questionnaire to test someone’s learner preference (Felder, 2010). A fictional student could have the following preferred learning style:
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The fictional student has the following learning style preference, indicated by the X in the accordant rows:

- Processing Dimension: Active
- Perception Dimension: Intuitive
- Input Dimension: Visual
- Understanding Dimension: Global

In the following section, the four dimensions and their characteristics will be discussed. An explanation of the different learner types can be found in (Felder, 2010). Additionally, the influence of the different scales on M-Learning will be explained.

**Processing Dimension**

The processing dimension has the following characteristics: active and reflective. Active learners tend to retain and understand information through learning by doing. They like discussing and explaining the topic to others. In contrast, reflective learners generally prefer to first think about a topic quietly. Active learners prefer group work more than reflective learners, who prefer working alone.

In regards to M-learning, both, active and reflective learner can profit from it, depending on the specific use of M-Learning. For example, the active learner can profit from the possibility

![Figure 3.3 – Learner style result for a fictional student](image-url)
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to communicate with other learners with the mobile devices. On the other hand, a reflective learner can use M-Learning to receive information about the topic while learning alone at the point of interest.

Perception Dimension

The perception dimension has the following characteristics: fictional and sensing. Fictional students like to discover possibilities and relationships, they also like innovation and dislike repetitions. On the other hand, the sensing learners like to learn facts, solve problems with well-established methods and dislike surprises. Sensing learners tend to be patient with details and good at memorizing facts. Intuitive learners may be better at grasping new concepts and are often more comfortable with abstractions and mathematical formulations than sensing learners.

Again, both preference types can profit from M-Learning. The innovative factor of M-Learning itself can be an advantage for an intuitive learner. Additionally, scenarios where M-Learning is used as a mobile guide to investigate a certain topic, such as a building or a historic site, can benefit this kind of learner. Similarly, the possibility to review teaching material again anywhere and anytime can be beneficial for the sensing learner. As for the processing dimension, it depends on the realization of the M-Learning scenario if there is a benefit for the learner or not.

Input Dimension

The input dimension has the following characteristics: visual and verbal. Visual learners learn best from what they see in pictures, presentations, diagrams and so forth. In Contrast, the verbal learners learn best from spoken or written words.

M-Learning support the visual learners by enabling them to be at any point of interest. The student can see the topic, such as a building, a flower, etc., while learning the topic. This is one of the prime benefits created by M-Learning. Verbal learners do also profit from M-Learning, if the used scenario supports them with a careful description of the object or content of interest. Audio outputs on mobile devices are possible and beneficial for verbal learners, but the costs to create an application which reads to the learner would likely be too expensive. Therefore, this dimension designates how much a learner benefits from M-
Learning. Learners with a strong visual learning preference can profit from M-Learning; whereas verbal learners only profit if they can read a text on the mobile device or if the application supports audio output.

**Understanding Dimension**

The understanding dimension has the following characteristics: global and sequential. Global learners tend to learn in large jumps, meaning they learn material randomly without seeing connections and then suddenly “get it”. Sequential learners tend to gain understanding in linear steps. They follow logical step-by-step processes in finding solutions. Global learners, on the other hand, are able to solve complex problems quickly or in novel ways, but they have difficulties in describing how they did it.

M-Learning has no influence on this dimension. The difference between both characteristics lies in the way the material is understood by the learner. Global learners want context, sequential learners want to step through the material. The material presented with M-Learning can satisfy both needs in an adequate way.

**3.4. Summary**

The learner’s preference is an important factor when judging the influence of M-Learning on their learning success. There are individual preferences, such as being a visual learner or preferring to communicate with others, which profit from the technology benefits offered by M-Learning.

Not all learner preferences take advantages of the technology benefits. But all learners benefit from the convenience benefits offered by M-Learning. For example, learners who are strong in the verbal dimension do not really benefit from the possibility to see the learning content. But it is still possible for Mobile Learning to support them, e.g. by reading a text on the mobile device on a train ride. The following table gives an overview of which learner type profits from the technology benefits and convenience benefits:
The symbols indicate how high the benefit for the learners is, “+++” indicates very high benefit, “++” a good benefit, “+” some benefit, and “0” indicates no benefit. The table shows that all learner type can profit from the convenience benefit. The technology benefit affects only some learner preference, especially the active and the visual learner.

The presented models help lecturers to create customized learning material in order to support different learner preferences. In summary, learner preference is a factor which certainly needs to be taken into account. The other two factors, learning content and mobile device / application, are also important to investigate the full extent of M-Learning’s influence and will be discussed in the following sections.
4. Mobile Devices and Applications

4.1. Introduction

The second major factor influencing M-Learning is the mobile device and the applications running on it. Mobile devices are all types of computer or communication devices which can be used without a permanent cable connection, such as notebooks, netbooks, cell phones or smartphone’s. Notebooks and netbooks are inexpensive and widely available, starting at less than 300€ for basic devices. Additionally, these mobile PCs are getting lighter and the battery capacity has improved, making them even more portable. Furthermore, cell phones are more powerful than they were just two or three years ago. Even average devices provide a fully functional web browser, Java support, Wi-Fi and mobile internet connection. This section discusses mobile devices and their available applications in more detail along with their influence on M-Learning.

4.2. Mobile devices

The term mobile device encompasses cell phones, smartphone’s, PDAs, laptops, notebooks and netbooks. A generalization of these devices is difficult due to the diversity of the different models and the different specifications and features of them; therefore, this thesis will divide them into two categories: phone and laptops.

The category phone encompasses cell phones, smartphone’s and PDAs. Today the classical cell is more than just a device to call someone or send a text message. Smartphone’s, such as the Nokia N97 (see Figure 4.1) provide a variety of multimedia and communication features, such as video players, email clients, Java support or web browser and represent the current state-of-the-art phone.
Cell phones have a large storage space with some models holding more than 32 GB. Devices of this category have sufficient resources to run learning applications.

The category laptop encompasses laptops, notebooks and netbooks. Consumers today can choose from a variety of different devices, anything from small, light netbooks up to bigger, heavier workstation laptops.

The following table gives an overview of these two categories according to the average characteristics in: display size, input and output possibilities, dimensions, and connectivity. Due to the fast development in the market of the cell phones, the stated characteristics are taken from (chip.de, 2010). This list gives a snapshot of the available top ten phones in March 2010, according to the editors. Chip.de is the website from the computer and communications magazine Chip published in fifteen countries of Europe and Asia (Hubert Burda Media, 2010).
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<table>
<thead>
<tr>
<th>Display size</th>
<th>Resolution varies from 320x240 pixels up to 800x480 pixels</th>
<th>Resolution varies from 1024x600 pixels to 1650x1050 pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>Vary from 95g to 152g in weight and 97x49x15mm to 123x59x14mm</td>
<td>Vary from less than 1kg to 3kg and the size from less than a sheet of paper (DIN A4) to two sheets of paper (DIN A4)</td>
</tr>
<tr>
<td>Input/output</td>
<td>Limited keyboard size, no navigation device such as a touchpad or a mouse, some devices have a touchpad</td>
<td>Full-size “QWERTY” keyboard and a touchpad</td>
</tr>
<tr>
<td>Connectivity</td>
<td>GSM connection for mobile internet and Wi-Fi support</td>
<td>Wi-Fi support and the possibility to use USB-GSM dongles for mobile internet</td>
</tr>
</tbody>
</table>

**Figure 4.2 - Mobile devices characteristics**

All mobile devices can be used to learn in a mobile environment. The advantage of phones is small size and portability. But the small dimensions obviously result in a small display with often low resolution. Laptops have a bigger display with higher resolutions and also a full size keyboard, but are not as portable as cell phones. The tradeoff between size and resolution means not all applications will work on all devices.

### 4.3. Applications for M-Learning

The supported software is one of the main validation points. M-Learning needs some kind of application in order to present the learning material or guide the learner in some way. This application could be a web page, an office document such as a PowerPoint presentation, or a tutoring application. The possible applications are manifold; the Figure 4.3 gives one possible categorization:
The applications for M-Learning are divided into three categories: standalone applications, websites and all kind of document formats.

Stand alone applications are created in a programming language such as Java, C++ or Object C. There are many different programming languages available in the market; these three are taken as an example.

Websites are divided into static sites, containing only HTML and basic CSS formatting, and interactive sites. Interactive websites could contain JavaScript functionality or Flash elements for example.

The document formats category contain PDFs, Office documents such as DOC, PPT or other document formats such as txt and so forth.

The following table (Figure 4.4) gives an overview of the support of these categories by different mobile devices:

<table>
<thead>
<tr>
<th></th>
<th>Java</th>
<th>C++</th>
<th>Object C</th>
<th>static website</th>
<th>interactive website</th>
<th>PDF</th>
<th>PPT</th>
<th>DOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laptop</td>
<td>ME/SE/EE</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Nokia N97</td>
<td>ME/-/--</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>iPhone</td>
<td>--/--/--</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no Flash</td>
<td>yes</td>
<td>yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cell phone</td>
<td>ME/-/--</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>viewer</td>
<td>viewer</td>
</tr>
<tr>
<td>Compatibility</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
</tbody>
</table>

Figure 4.4 - Supported features
As shown in the section before, the different mobile devices have different characteristics; these characteristics influence the choice of the application. Figure 4.4 shows the supported features for four exemplary devices.

The first device represents a standard laptop which supports all features listed in the table. The second device is the Nokia N97 which stands for the current high-end smartphone. The technical specification of the Nokia N97 can be found under (Nokia, 2010). Next is Apple’s iPhone, like the Nokia N97 it is a smartphone and widely available today. The technical specification can be found under (Apple, 2010). The last device represents a standard cell phone with the currently average features taken from (chip.de, 2010).

The row compatibility shows how many devices the specific feature support. The more “+” the more devices support the feature. Static websites and PDF documents are supported by all four exemplary devices. In order to create a learning application which is supported for all kind of mobile devices these two are the first choice. All current phones from (chip.de, 2010) have an installed web browser. They are all able to render HTML, which should be enough for the most learning web sites. Furthermore some of them support JavaScript and Flash in their web browsers, such as the Nokia N97. There is also a PDF reader available for all of the mobile phones from (chip.de, 2010).

Office documents such as Word or PowerPoint files can also be viewed on all four exemplars. Depending on the specific device, the supported features of the applications to show the office documents vary. Apple’s iPhone (Apple, 2010) has the possibility to edit those files, whereas a standard office document viewer is only able to show the files.

Applications developed for a specific learning scenario can be written in programming languages such as Java, C++, or Object C. The advantage of Java is its platform independence. There are Runtime Environments available for most of the common phones and their operating systems, such as Antroid or Symbian OS. Only the iPhone does not support Java. Apple has its own programming language; Object C. Object C is supported by iPhones only at the moment in the phone market.
4.4. Summary

The mobile device and the respective application used are important factors in the success of M-Learning on the learning effect. Depending on the specific scenario, one mobile device and/or application may be more suitable than another.

Devices on the phone class are more flexible as a many students regularly carry one already. Therefore, spontaneous learning can take place everywhere and at anytime with these types of devices. On the other hand, these devices have strong limitations including smaller displays and reduced keyboards. Devices in the laptop class have bigger screens and a full-sized keyboard. The possible applications are countless with these devices. In some scenarios, such as a field trip, the learners already know that they will learn, and therefore carry the device with them. Likewise, a student normally does not take along the laptop every time, and therefore spontaneous learning is not supported.

The choice of the best-suited application depends on the specific learning situation and the available mobile devices. Static websites and PDF documents are supported by the most phones, and in case of different phone models used in the scenario the best choice. Java applications can provide more functionality than PDFs and static websites and is supported by the most current phones in the market, except for Apple’s iPhone.

In conclusion, both device classes all types of applications have their own merit in M-Learning; it just depends on the specific scenario which combination of mobile device and used application is the best.
5. Learning Content

The third factor influencing M-Learning is the learning content. The term learning content will be described and defined, and a given model by an educationalist will be presented and analyzed. Based on this the meaning for M-Learning will be discussed.

5.1. Definition of learning content

“Learning content is some sort of information which is consumed by the learner in order to gain knowledge.”

This definition addresses two points:

- “consuming the information” means the learner receives the information in some way
- “gain knowledge” means the learner receives something new

This information could be received by reading something, seen, heard, smelled, or experienced. Information can be consumed with all five senses. A combination of senses is also possible such as in a film, which stimulates the seeing and hearing senses.

In order to gain knowledge, the consumed information needs to be something the learner does not already know, with the exception of learning through repetition. Most lectures cover topics which the student does not know already, for that is the reason the student is taking the courses.

Most lectures at the university level are done with some sort of presentation (such as a PowerPoint presentation). Additionally, there could be some sort of script or book written or suggested by the lecturer. Aside from these types of lectures, there are also laboratory classes for the practical training of the content.

So it can be defined that learning material is all the information that a learner receives to learn new things. Following this aim, the learning material will be categorized in order to analyze if it supports M-Learning or not.
5.2. Classification according to Bloom

The learning material, or more accurately the learning target which should be achieved by learning the specific content, can be classified. A classification is given by Benjamin Bloom (Bloom, 1976). He describes, among other things, six taxonomies in the cognitive domain of learning targets:

1) Knowledge

This first level includes the basic knowledge, such as facts, basic terminology, classifications or principals. It is the first topic a student learns, and the following levels build on this. A possible question in this level is, “What are the health benefits of eating apples?”

2) Comprehension

The second level in this model includes the understanding of knowledge and the possibility of understanding and interpreting it. In addition, the student is able to understand coherencies. A possible question in this level is, “Compare the health benefits of eating apples and oranges.”

3) Application

The application level requires solving of problems in a new way by using learned facts, terminology and principles (knowledge). A possible question is, “Which kinds of apples are best for baking a pie, and why?”

4) Analysis

In analysis level, the student is able to examine and break information into groups by identifying motives and causes. The student is able to discover antilogies and see coherencies. A possible question is, “List four ways of serving foods made with apples and explain which ones have the highest health benefits. Provide references to support your statements.”
5) Synthesis

The student is able to compile information in a different way by combining elements in a new pattern or proposing alternative solutions. The student is able to create new ways of solving a problem or suggest a new hypothesis. A possible question is, “Convert an "unhealthy" recipe for apple pie to a "healthy" recipe by replacing your choice of ingredients. Explain the health benefits of using the ingredients you chose vs. the original ones.”

6) Evaluation

In this final level the student is able to see and judge the value within ideas and material. Using this criterion, the student is able to present options by making judgments about this information. A possible question is, “Do you feel that serving apple pie for an after school snack for children is healthy? Why or why not?”

5.3. Learning content and M-Learning

This model by Bloom describes the different levels of learning and what kind of learning material a student learns at which time. The model helps to plan a study plan for education, starting with the knowledge level in the basic lecture, going to the higher levels in more advanced lectures. M-Learning can be useful and useless in every phase of this model. There are no characteristics in the different phases which indicate if M-Learning is useful or not. Therefore, such a model cannot be used to judge if a certain learning content is suited for M-Learning or not.

At the moment there is no study available which investigates this topic in detail. There are some publications about M-Learning which touch on the topic, when talking about M-Learning in general or about M-Learning projects. These fragments are used to create a categorization of learning content for M-Learning.

The scenarios for M-Learning can be divided into two parts: M-Learning as support for classical learning methods and M-Learning in new learning scenarios.
M-Learning as support for classical learning methods

In support for classical learning methods, M-Learning can be used to repeat the already learned content. For example, it could be possible to learn the vocabulary of a language with a cell phone. The application on the cell phone questions in some sort of multiple choice quiz the correct translation of a word (more on that scenario in 6. Scenarios). This is just one example for this type of scenario, but in all cases the learning material needs to be prepared in order to be learnable with M-Learning. In these learning scenarios the learning happens unexpectedly and could be interrupted, such as learning while waiting for a bus or while a train ride. Therefore the learning content should be prepared in small portions, in order to learn two minutes or two hours, without any disadvantages of interrupting and resuming it.

The requirements for these repetition scenarios are:

- The learning content can be displayed on a mobile device
- The learning content needs to be divided in small portions
- The small portions should be learnable individually without interconnections
- The learning content should be paused and resumed without disadvantages

Aside from these requirements, there is no other requirement for the learning content itself. There is a need for an adequate learning application to present the learning content.

M-Learning in new learning scenarios

M-Learning enables the learners to not only learn at anytime and anywhere, it enables the learner to learn at any point of interest. This can be used for location-based learning. Additionally, M-Learning supports the interaction between learners in groups. This leads to the first two characteristics of learning content for these scenarios:

- Location-based learning content
- Learning content for group work where interaction is possible

Location-based learning means the learning takes place at the spot of the learning content, this could be a building (for an architectural class), a historic site (for a history class) or in a botanic garden (for a biology class) for example. The common factor of these examples is
that the learning content can be seen, touched, experiences, smelled, or heard in person. Therefore the requirements can be extended with:

- Learning content which could be seen, heard, experiences, smelled, or touched

The social interaction can also benefit the learning experience. Such as group work within classical lectures, many students profit from the exchange of ideas and concepts. Working in projects has an additional benefit on the learning effect.

Many learners benefit from this (see 3. Learner Styles). M-Learning creates new ways of learning because the interaction with the learning content itself is possible, unlike in a classroom lecture in most cases. (Costabile, 2008) is one example of this type of scenario, where the students explore a historic site guided by mobile devices. The learning content is the historic site itself and the life of old Romans. By wandering through the site and replaying the life of the Romans, the students learn far more than in a classical history lecture.

In summary, there are the following requirements for learning content which is suited to be taught with M-Learning:

- Location-based learning content
- Learning content for group work where interaction is possible
- Learning content which could be seen, heard, experiences, smelled, or touched
5.4. Summary

Summed up, the learning content itself is quite important, but more important is the scenario in which the learning content is used. There are some requirements for the learning content to be taught with M-Learning, but these requirements are vague and can be interpreted or realized in many ways. The pivotal point is the learning scenario in which the content is presented.

Therefore, the original picture (Figure 2.1 – Three factors for M-Learning) of the three factors needs to be corrected so that not only the learning content is represented, but also the learning scenario is taken into account. Figure 5.1 shows this modification:

![Modified three factors for M-Learning](image)

It makes sense to combine learning content and learning scenario into one factor. Of course the mobile device and application are also a part of the scenario, but the learning content is the important part of the scenario. Therefore, these two factors are combined into one factor. In the following, the learning scenarios are discussed in more detail.
6. Scenarios

6.1. Introduction to Scenarios

After the presentation and description of the three factors (learner style, mobile devices and applications and learning content and scenarios) which may benefit or hinder M-Learning, the following scenarios will provide practical examples for the application of M-Learning. They will show the benefit and the disadvantage M-Learning has for learners.

The presentation of the scenarios is divided into three parts. The first part contains examples in which M-Learning supports classical learning, such as the repetition scenario explained above. The second part shows scenarios in which M-Learning is used to create new ways of learning. The final part presents the so-called bad example scenarios in which the usage of M-Learning disadvantages the learner.

6.2. M-Learning as support for classical learning

The following scenarios present examples of the use of M-Learning to support classical learning. They show how M-Learning can be used to enhance the learning effect and extend the possibilities of learning.

6.2.1. Reading learning material on the mobile device

Most lectures are available in electronic form such as a PDF, a PowerPoint presentation, or website. Therefore, the capability to read this learning material on a mobile device while on the move is obvious. This scenario is a basic example of M-Learning; the document can be read anytime and anywhere. The learner can read the material for lecture while driving to or from the university in the train, tram and so on. Furthermore, a student can suddenly have free time, and if the information is on the mobile device, the learning material is readily available to review at the spur of the moment.

There are also disadvantages to this scenario. Due to the small size of a cell phone screen, the document display is small. Depending on the type of document, it could be difficult to read. A website, for example, can be easily read on a device from the phone category as
most web browsers on these devices have the functionality to enlarge texts in order to make them more readable on a small display. If the website contains many images, the loading of the website is increased, depending on the used bandwidth of the internet connection. Images can be hard to view depending on the display size as well.

Other types of documents, such as a PDF or a PowerPoint presentation, are a little bit more complicated to read. Most of these files are intended to read on a standard resolution, such as 1024x768 pixels or even higher. Cell phones have lower resolutions. Depending on the layout of the document, the fonts can be too small to be read easily and images or diagrams can be too small. It would make sense to customize such lecture documents in order to make them more readable due to the smaller resolutions of the devices. Concerning the websites, a so called mobile view or a customized website with fewer images and customized layout would also make sense in order to be more user-friendly.

In summary, this scenario presents one convenience benefit of M-Learning: the opportunity to read learning material on the move. Depending on the type and layout of the learning material, some customizations of the material could enhance the learning effect.

### 6.2.2. Learning vocabulary on the mobile device

While learning a new language, aside from the grammar, the learning of the vocabulary is a time-consuming and difficult job. Words need to be repeated as often as possible in order to memorize them.

One established learning method is known as the “card box” method. A card box contains five slots. On the front side of the card, the word is written in the mother tongue, the backside contains the translation into the foreign language. All of the cards start in the first slot. While learning the learner takes out one card of a slot and tries to memorize it. If the word is recognized, the card is moved to the next slot. If a word is not recalled correctly, it remains in the current slot. This principle is continued until the word is identified in the fifth and final slot.

This learning principle can be used in a mobile application, too. A database contains all the words and the user interface could be implemented in the following way: a multiple choice test on how the word is translated correctly or the word needs to be typed in. Also it could
be possible to create an audio response of the words to enhance the learning effect by hearing the word. This application is not restricted to vocabulary training. It is also suited for any learning material which need to be memorized and can be learned in small portions. History facts, technical definitions, medical terminology, etc., can also be learned with this method.

This scenario is well suited for the potentials of M-Learning. Vocabulary training is the sort of learning which can be paused and resumed anytime, no matter how long the learning parts are. The learners have some advantages in this solution. First of all, the learning material is available at anytime and anywhere because the users have the cell phone with them in most cases. Also, the learning of vocabulary or similar material needs to be learned or repeated as often as possible until it is memorized. Therefore, this scenario enables them to use short breaks to learn a few words or facts. Additionally, there is no need for any further preparation, such as preparing the learning content in an adequate way to be learnable as it is already done in the application. Thus, the learners just need to install the application and can start the learning process.

A disadvantage of this way of learning is the lack of a pronunciation check. In classical lectures the teacher verifies the correct pronunciation of the vocabulary. This is not possible with a cell phone application or other learning environments without a supervisor as students can only hear the correct pronunciation and see the phonetic spelling. Therefore this scenario can be seen as an extension to classical supervised learning.

6.2.3. Medical state examination preparation

In Germany, and other European countries, the study of medicine is completed with the medical state examination. This final examination tests the knowledge gained from the lectures taken. In Germany this examination, such as most of the tests of the medicine lectures, is a multiple choice test and the questions well-known; there is a catalog of possible questions from the previous examinations. These questions ask about the name or position of muscle, bones or nerves for example. Also disease patterns or treatment methods are topics of this examination.
There are already existing applications for PCs which can be used for the preparation for the examination. These applications are based on the real "medical state examination" multiple choice questions on medical knowledge.

It would be possible to create an application for cell phones to prepare for the examination. This scenario is very similar to the previous scenario. The questions and possible images are displayed and the learner selects the correct answer out of the options listed. In this special scenario, the learning content is excessive, and therefore, the medicine students learn as often as possible. In addition to the preparation at home with books, scripts and the PC application, they can use train rides, waiting time and so forth to keep learning while going about their day. As an extension it would make sense to link and synchronize the application on the PC with the application on the cell phone to get a statistical feedback of the learning process from both applications. Also, learned and mastered questions / topics are marked and doubled work is avoided.

### 6.2.4. Drivers license preparation

This scenario is unique from the other academic learning scenarios, but it will show that M-Learning can be used in more ways than just in the academic field. In order to get a driver’s license in Germany, people need to pass a theoretical examination and a practical examination.

The theoretical examination consists of a number of multiple choice questions about the car itself and the traffic laws in Germany. These questions are commonly known, and in the examination, a random selection of them is asked. In order to prepare for the examination, the learner uses study guides with the possible question to test himself and prepare. There are also applications available which include these questions and simulate the examination.

Therefore, and like in the previous scenarios already described, it would make sense to port this application on the cell phone. The questions are typically multiple choice questions with some text and a picture which shows the traffic sign in question or a traffic situation. Sometimes there are questions which need to be answered by the input of a number, such as the allowed speed limit or the distance between cars and so forth. These inputs can easily
be done with the cell phone. This example shows that M-Learning can not only be used in the academic field but can be used in many learning situations.

6.2.5. Interactive quiz on learning material

This scenario can be seen as an extension to the previous scenarios. In addition to the learning itself, a quiz about the learning accessible by a number of students could be added. A group of students logs into the learning application, such as a Java application, a web site or something similar, and compete in a quiz against each other.

This quiz could be created with some sort of multiple choice questions with a time limit for example. Otherwise one student could act as a quiz master and select the question from a collection and the other competitors need to answer this question. Also some sort of chat, with text or speech, could be implemented to make the application more user-friendly and add more functionality to it. The chat could be used to clarify questions about the topic.

Like all other scenarios in this section, the main advantage lies in the availability of the learning content anywhere and at anytime. An additional benefit of this scenario is the competitive situation. For some students this could be a stimulus, to compete against fellow students, while also making the learning itself convenient and challenging. Furthermore, it is a good possibility to see how well the learning content is already understood.

6.3. New ways of learning

Following the scenarios that support classical learning, the following examples will show new ways of learning with M-Learning. In these scenarios M-Learning is used to create new learning scenarios and experiences.

6.3.1. Architectural lecture in the building

The study of architecture includes lectures about special buildings and their astonishing structure, the Saint Bartholomeus's Cathedral of Frankfurt being an example. This cathedral is a Gothic building located in Frankfurt, Germany, it was constructed in the 14th and 15th century (Kalusche, et al., 1992).
A lecture in history classes about this cathedral could be done with a PowerPoint presentation with text and some images of the building itself. With M-Learning this lecture can be enhanced to be more interesting and more informative.

Instead of a lecture in the classroom, the M-Learning lecture takes place in the building itself. The students have the lecture on their cell phone, and the lecture itself is a guide through the cathedral. Beginning with the outside of the building, the students are prompted to see the special construction of the building. The guide on the cell phone shows or talks about the unique features in a text or audio output and the students can see the points of interest directly in front of them. This pattern is used in the entire guide, first a point of interested is presented by text or speech, and then the students can look at it directly. In addition images of the point of interest could be shown, to help the learners to identify it in the cathedral.

This scenario shows one of the biggest benefits of M-Learning: learning at the point of interest, or location-based learning. The current location of the student is part of the learning content. By being at or in the cathedral, the student learns by the guide and by visually seeing the cathedral and its architectural attractions. Mainly the Visual Learner, according to the learner style model by Felder and Silverman, profit by this. Also the Active Learner can profit in this scenario because learner can be “active” in the cathedral and discuss the learning content with other students in the group. Other learner types can also profit from this scenario. It is an additional learning benefit to be at the cathedral over the classical PowerPoint presentation.

Summed up, this scenario is a basic example for new ways of learning with M-Learning. The mobile aspect enables the students to learn at the point of interest.

6.3.2. Anatomy lecture at the corpse

The study of medicine includes anatomy lectures and practical training with a corpse. The students learn the structure of the human body by the dissection of a body. Of course, they need some guide in order to be directed to the current parts of interest.

This guide can be accomplished with M-Learning. A laptop can be placed near the dissection table and the guide run on it. The guide can be some sort of application with text, speech
and also images or movies on how to do the dissection to get to the part of interest. In addition voice recognition would be beneficial since the student's hands are not free. The parts of interest, such as a specific vein or muscle, can be introduced by a description paired with some images and/or a video to explain its function in the human body.

Furthermore, this guide can be used as a preparation to the active part: the actual dissection. This improves the success rate of the dissection because the students already know which parts of the human body they will cut. Additionally the possibility of cutting incorrectly or too deep and miss or destroy the point of interest is reduced.

This scenario shows how M-Learning can be used to modify existing lectures in order to make them more interesting and more informative. Normally, the dissection lectures are instructed and lead by a supervisor, tutor or lecturer. In contrast to classical dissection lessons, in the M-Learning scenario the students are independent from an instructor because this part is adopted by the laptop and the guide running on it.

This can be seen as both a benefit and a disadvantage. The benefit is the already discussed independence from the tutor and the additional information presented by the guide. Also the possibility to prepare for the dissection is a benefit from such a guide.

The disadvantage could be the missing of the tutor. The human body is such a complex system; a guide cannot consider all circumstances which can occur. Therefore, the presence of a tutor for the active dissection lecture is needed. However, the tutor is only needed under special circumstances, and the main part of description can be done by the guide.

All medical students can benefit from this scenario as well. Visual Learners have a little advantage, due to the preference in visual learning in the guide, whereas Verbal Learners are possibly hindered by such a guide. The existence of the tutor can even out the disadvantage for Verbal Learners.

In addition, the guide can be used to prepare and learn without a corpse, which is a benefit for all learners. Due to the high amount of data and processing power, like the videos, it makes sense to create an application which runs on a laptop because the devices of the phone class do not have the resources to run such an application.
6.3.3. Biology lecture at the botanic garden

The study of biology includes, in addition to other lectures, some lectures about botany, and the scientific study of plants. This scenario shows how M-Learning can be used to study plants in a new way, not in a classroom but at a botanic garden.

The students are given a cell phone with a build-in camera and the possibility to connect to the internet. They also get a sheet with the name and a short description of the plant they need to find. This can be done with a whole group of students with everyone assigned a different plant.

First, they need to find the specific plant in the garden. When they have found the plant, they need to document it with a description and an image. This material is directly uploaded to a wiki, where they create an article about the plant, complete with a description and some images.

This scenario could also be used for other topics, like a zoological garden. Instead of plants, the students would need to find and document animals. Such a field study is of course also possible in other fields aside from biology.

This scenario shows a new way of teaching the scientific study of plants with M-Learning. Instead of classroom presentation or wandering around in a garden just looking at the plants, the student can use the new technology to create their own learning material to better interact with the learning topic.

The student’s task is to create a wiki page with a selection of plants and to document them well according to their dimensions, colors, and other botanic characteristics. The mobile devices can also be used to look up information about the plants of interest. Aside from the scientific value, such a scenario is also more interesting and more fun than the classical lecture and creates a positive additional benefit.

Visual Learners benefit in this scenario because they see the learning content. In addition, the Active Learner benefits because of the group work and the special features of this type of lecture can be an additional motivation benefit for learners in general.
6.3.4. History lecture at an historical site

The study of history includes field trips to visit historic sites. These field trips can be enhanced with M-Learning in order to make them more interesting and informative. An example of such a scenario is (Costabile, 2008). This scenario is based on this idea and then modified slightly.

In Explore! (Costabile, 2008), the students are guided through a historic site and relive the life of an ancient Roman. This modified scenario takes place in the ancient Pompeii where the students are guided by a virtual city map of the city. This virtual city map could be a 3D reconstruction of the ancient Pompeii, and by this, the students see the original city in the guide and also the current ruins in reality.

The students can be divided into several groups of ancient Romans for a kind of role play. For example, one student could be a city guard who travels around the city; another student could play the role of an ancient baker and so forth. Those basic scripts (baker, butcher, city guard, etc.) are independent of the location; they can be reused for other ancient cities as well. The guide of Pompeii is also a kind of script which leads the students through the ancient everyday life. This script can be enhanced with some videos or 3D animations to make the ancient life more realistic.

Additionally, this guide application could include some sort of chat. This chat can be used by the students to communicate with each other, in order to set up meeting points or other administrative tasks, while playing the ancient life in this role play.

This scenario combines many positive aspects of M-Learning. The first aspect is the location-based learning. Of course students can wander around in Pompeii without such an electronic guide and read information out of books or printed sheets, but the electronic information is much handier.

Also the 3D animation of the ancient Pompeii is an additional information bonus as the students do not only see the ruins but also the reconstructed ancient city. This is especially a benefit when studying Roman life.
The role play also helps to understand the ancient Roman life better than by just reading texts or listening to stories or explanations about it. And of course it is definitely more fun acting out the ancient life rather than just hearing about the life of the ancient Romans.

6.4. Bad examples

After the “good” examples on how M-Learning can help students to improve the learning experience, two “bad” examples show when the usage of M-Learning does not make sense or even hinders the learning effect.

6.4.1. Reading a book on a cell phone

Due to the potential of mobile devices and the availability of eBooks, it is possible to read entire books on these devices. In addition to reading books for fun in the free time, it is also possible to read recommended literature and scripts for classes on mobile devices. Most scientific papers are available in PDF form and notes for many classes are also available in some sort of digital format.

The reading of long texts on a mobile device can be exhausting for many persons. This disadvantage and the missing of the possibility to mark passages of interest or add own notes, depending on the used software, are the problems in this scenario. Especially while reading literature or scripts for classes, the student needs to work with the text. This means a student highlights special parts or adds own remarks and conclusions to the text. This is barely possibly with PDF viewer or other reading software on a mobile device. Therefore reading on a mobile device cannot substitute working with physical texts, like books or print outs.

6.4.2. Java lecture on a cell phone

The learning of a programming language includes theoretical training, like learning the instruction set and the grammar of the language. It also includes practical training like actively programming small programs to test the knowledge.
In this scenario, this training is done by a lecture on a cell phone. The theoretical part could be done by some sort of PDF file or a website instructing the learner what commands a programming language has, the grammar rules and so forth.

The practical part cannot be done on a cell phone. Except for some special modified smartphone’s, such as Google’s Android with a hacked Linux command shell on it, there are no compilers available for cell phones. And without a compiler, there is no programming possible. Also, the programming with a standard cell phone keyboard is nearly impossible, due to the missing full-size keyboard and some special chars such as “[””, which are needed in most programming languages.

Cell phones could be used as some sort of reference to look up commands, or grammar, but while programming, the student is already in front of a computer. Therefore, the reference can be used on this computer, too.

6.5. Summary

These examples gave an overview when the use of M-Learning is adequate, and furthermore, pointed out the benefits M-Learning brings to learners. There are two different ways to use M-Learning: to support classical learning and to create new ways of learning.

In support of classical learning, the mobility factor of M-Learning is used. Learning can take place at anytime and anywhere, and this is used to extend the classical learning with M-learning. This could be called learning to go, such as the coffee to go, the learning material can be put on the mobile device and consumed while on the way.

Aside from reading the lecture material, M-Learning is also well suited for repetitive learning such as learning the vocabulary of a language or historic dates. This type of learning can be divided into small portions and therefore paused and resumed without any disadvantages. Furthermore, as in the case of learning a new language, the learning can be done as often as possible, increasing learning success. In addition, the possibility to interact with other learners, such as in the quiz scenario, could be an enjoyable benefit for the students and a motivation factor.
The second use of M-Learning is the creation of new ways of learning. M-Learning enables the student not only to learn anywhere and at anytime; it enables the student to learn at any point of interest, for location-based learning. It is now possible to combine the learning of a topic with the topic itself, such as learning about the unique architectural elements of a cathedral in the cathedral itself. These guiding applications can also be used for preparation and post-processing of the learning content.

Mobile devices can also be used for more than just presenting the learning content. They can be actively used to create further learning content, such as in the example with the botanical garden. The cell phones are used to take pictures of the plants of interest, and with the mobile internet connection, the images and a description of the plant can be uploaded to a web page directly.

In addition to “good scenarios,” there are also “bad examples”, which shows that the use of M-Learning is not always beneficial. In some situations it can hinder the learning effect or, more over, it can obstruct the learning effect.

In summary, these examples gave an introduction to what is possible and what is reasonable with M-Learning. There are many scenarios possible in which M-Learning enhances the learning effect.
7. M-Learning outline

The use of M-Learning in lectures brings many benefits and some disadvantages. Depending on the specific scenario, the learner type of the student and the mobile devices used, M-Learning can either enhance or hinder the learning effect.

In the following section, the advantages and disadvantages of M-Learning will be summarized briefly into a short outline.

7.1. Advantages

M-Learning enables the learner to learn anywhere and at anytime, thus being the basic characterization of it. The features of the mobile devices and the mobile internet connections today allow the learning to go.

The possible scenarios are numerous. They vary from simply reading scripts on the move to supportive learning scenarios and from learning a new language to 3D guiding applications through ancient sites.

Specifically, Visual and Active Learners benefit by M-Learning because these learners can see the learning content and interact with it and other learners. Depending on the scenario, all learner types can benefit from the possibilities of M-Learning in some way or another.

Repetitive learning, such as learning the vocabulary of a language or studying for special examinations, is supported by M-Learning.

Moreover, M-Learning creates new ways of learning, such as the aforementioned 3D guide through an ancient site. The students are guided by a mobile device and application through historic points of interest, such as Pompeii. In addition, these applications can be enriched with further information, such as text, images or animations about the point of interest. This is a huge benefit of M-Learning and in addition to the informative advantages, such guides can be more enjoyable than the classic guides.

Another benefit is the location-based learning and the possibility to use M-Learning to create new learning content. For example, students can upload images in real time and edit
learning content while at the place of learning, which brings additional benefits. Also, the possibility to communicate with other learners enhances the learning effect. Not to forget the entertainment such scenarios provide to the learner, compared to classical classroom lectures.

7.2. Disadvantages

Aside from the advantages mentioned above, M-Learning has some disadvantages. First of all, M-Learning can be cost intensive, depending on the scenario, and can vary from very little cost to very cost intensive. Cost intensive means there are monetary and time costs involved buying the mobile device, costs for the mobile internet connection if needed, and of course, cost for creating the required application.

In addition to the costs, there are other disadvantages. M-Learning cannot substitute classical learning, but it can be used as support or to create new ways of learning. However, it can never stand alone or supersede classical learning.

Also, M-Learning is not suited for every learner type, especially learners who prefer learning on their own or learning from books benefit less or not from it. Again, it depends on the specific scenario.

7.3. Checklist

The following is a short checklist which indicates when the use of M-Learning benefits learners. Not all attributes must be covered, except for the need for a mobile device. Moreover, some of them exclude others, but the more attributes that are covered the better.

Attributes of the learner:

- The learner is a Visual Learner.
- The learner is an Active Learner.
- The learner owns some sort of mobile device, such as a cell phone or a laptop
Mobile Learning – learning content, learner styles, and mobility
A differentiated examination on the advantages and disadvantages of Mobile Learning

- The learner has access to an internet connection, such as a WLAN hotspot or mobile internet access.

Attributes of the learning content:

- The learning content is some sort of location of interest, such as a building, a historic site and so forth.
- The learning content allows interaction with other learners, such as group work or discussions.
- The learning content can be seen, heard, smelled or touched, such as the example with the botanic garden or the anatomy dissection.
- The learning content can be divided into small potions, where pausing and resuming does not hinder the learning effect, such as learning of vocabulary.
- The learning content allows for the use of multimedia devices, such as taking pictures or writing (online) articles while at the location.
- The learning content is available on a website or a supported file type, such as a PDF or PowerPoint file.
8. Evaluation

8.1. Interviews

An informal interview with learning professions was used to review the results of this thesis. The interviewees were given the outline from the previous chapter (7. M-Learning outline) and asked the following questions:

- What lectures do you teach?
- Do you think M-Learning is advantageous in lectures in general? Why?
- Would you use M-Learning in your lectures and in which subject? Why would you use M-Learning / why not?

In addition the age, sex and type of school of the learning professional were noted. The results of the interviews are presented and discussed in the following section. The interview notes can be found on the included CD-ROM in the back of the thesis in the directory [2] Interview Notes.

8.2. Results

The following table (Figure 8.1) gives an overview over the interviewees of the evaluation:

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Sex</th>
<th>Age</th>
<th>School type</th>
<th>Lectures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>male</td>
<td>43</td>
<td>high school</td>
<td>Math, Physics</td>
</tr>
<tr>
<td>2</td>
<td>male</td>
<td>39</td>
<td>high school</td>
<td>Religious Education (school pastor)</td>
</tr>
<tr>
<td>3</td>
<td>female</td>
<td>36</td>
<td>high school</td>
<td>German, Religious Education, Italian</td>
</tr>
<tr>
<td>4</td>
<td>female</td>
<td>37</td>
<td>high school</td>
<td>Music, German, Ethics</td>
</tr>
<tr>
<td>5</td>
<td>male</td>
<td>47</td>
<td>high school</td>
<td>Latin, Philosophy, Ethics, Math</td>
</tr>
<tr>
<td>6</td>
<td>female</td>
<td>28</td>
<td>high school</td>
<td>German, History</td>
</tr>
<tr>
<td>7</td>
<td>female</td>
<td>29</td>
<td>high school</td>
<td>German, History</td>
</tr>
<tr>
<td>8</td>
<td>male</td>
<td>30</td>
<td>high school</td>
<td>German, Sports</td>
</tr>
<tr>
<td>9</td>
<td>male</td>
<td>39</td>
<td>high school</td>
<td>English, Biology</td>
</tr>
<tr>
<td>10</td>
<td>female</td>
<td>51</td>
<td>Realschule</td>
<td>French, Geography, English</td>
</tr>
<tr>
<td>11</td>
<td>male</td>
<td>47</td>
<td>high school</td>
<td>Art, French</td>
</tr>
<tr>
<td>12</td>
<td>male</td>
<td>61</td>
<td>high school</td>
<td>History, Religious Education</td>
</tr>
</tbody>
</table>

Figure 8.1 - Interviewee overview
Twelve learning professionals were interviewed: eleven high school teachers and one from secondary school (German Realschule). Five female and seven male teachers, three teachers were younger than 35, seven in the age group of 35 – 50 and two teachers were older than 50.

The next table (Figure 8.2) shows the author’s analysis from the questionnaire in coded form:

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Familiar with the topics new media and M-Learning?</th>
<th>M-Learning is advantageous in lectures in general?</th>
<th>Use M-Learning in your lectures and in which subject?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>4</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>3</td>
<td>German: as support Italian: as support Reli. Ed.: no</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>3</td>
<td>Latin: as support Other: no</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>4</td>
<td>History: yes German: as support</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>3</td>
<td>Sports: no German: in special projects</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>2</td>
<td>Biology: yes English: as support</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>3</td>
<td>French: as support Geography: no English: as support</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>4</td>
<td>as support</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
<td>No</td>
</tr>
</tbody>
</table>

**Figure 8.2 - Evaluation analysis**

The second column codes the interviewee’s familiarity with the terms new media in general, and specifically M-Learning. Code 1 stands for no knowledge about those terms. Code 2 stands for basic knowledge about the topics, but the interviewee’s mix up those terms, such as “creating a homepage is an example for M-Learning” (Interviewee 8). Code 3 indicates the interviewee has a profound knowledge in these terms.

The third column codes the answers to the question if the interviewees think M-Learning is advantageous in lectures in general on a scale from 1 (worse) to 5 (best). The rating was done by the author of this thesis.
The forth column gives the feedback to the question if the interviewee would use M-Learning in their lectures and in which subject. If not stated differently, the answer addresses all subjects taught by the interviewee.

As a first impression from the interviews, it can be seen that ten out of twelve teachers are not sure of the definitions of new media and M-Learning. Many of the interviewed teachers were confused by the terms; such as “creating a homepage is a benefit of M-Learning” (Interviewee 8) or “interactive travels with Google Earth” (Interviewee 10) as an example for M-Learning. There is a need for further information and training about those terms. Therefore, teachers should be trained in the possibilities of new media when used within their lectures as a supplement to the current instructional methods. This training could take place in the education of new teachers and/or in extension trainings for teachers.

Natural science teachers, such as Biology (Interviewee 9), and language teachers, such as English (Interviewee 9, 10), Latin (Interviewee 5) or French (Interviewee 10), are interested in M-Learning. The vocabulary training on cell phones was one of the favorite scenarios of the language teachers. Most students are expert in the handling of cell phones, therefore the teachers assume such an application will be accepted by the students easily and be motivated by it (Interviewee 9).

In addition, many teachers see the importance of the new media in society and favor the use of it in education, but the usage of new media in education is difficult. One teacher stated that there are strict regulations in Germany about the structure and content of lectures by the so called “Aufsichts- und Dienstleistungsdirektion” (Supervising- and Service board) (Interviewee 1). These regulations state that new media can only be used in addition too, not as a replacement of, classical learning. One teacher reported that there is not enough money available for the use of new media (Interviewee 10).

There were also negative responses to M-Learning. Some of them are justified opinions against the use of M-Learning. Some teacher stated M-Learning is not useful in group discussion, as in ethics or religious education lectures for example (Interviewee 2, 3, 4 and 5). In such lectures, the personal interaction is important and M-Learning is not able to transmit values and personal feedback according to the teacher (Interview 5). Another example given by an interviewee is the so-called “integrative” learning (Interviewee 6).
Integrative learning means that many different learning targets are combined in one lecture, such as reading an essay combined with training students’ writing skills for reports (in a German lesson). This opinion by the teachers is not entirely true, M-Learning does support integrative learning, but it depends on the implementation.

There were some teachers who dislike the ideas of M-Learning and new media in general (Interviewee 2, 4, 7 and 12). One teacher stated that the classic frontal lecture (meaning instruction by the teacher in front of the class, without group work or other interactive activities) has proved valuable, and therefore, no change is needed (Interviewee 12). Surprisingly, these teachers were not only of old age as a younger teacher (Interviewee 7) is against the idea of M-Learning in lectures. The counter-arguments of these teachers are that M-Learning does not substitute a human teacher or classical lectures in general (Interviewee 2 and 4). Moreover, they stress the importance of human interaction within lectures and state that computers cannot transmit such human interaction (Interviewee 5).

In summary, one result from this evaluation is that M-Learning could be useful in a number of learning scenarios according to some interviewee’s. The vocabulary training can especially be valuable for students according to teachers. But more importantly, most teachers do not know what M-Learning is, and what possibilities the new media brings in general to students. Therefore, there is a big need for further information and training for teachers in this new learning technology.
9. M-Learning Simulation

This section presents an initial evaluation of M-learning using test subjects. This simulation shows the impact of modified and unmodified learning content in M-Learning scenarios. Two lessons, representing one positive and one negative example, are presented to test subjects. A questionnaire investigates the reaction and perception of M-Learning.

9.1. Implementation

The simulation was performed according to the activity diagram in Figure 9.1.

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Figure 9.1 - Simulation activity diagram
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In the beginning of the simulation, each subject was randomly split into two with an equal number in each group. Group one started with a phone-sized version of lesson one and then saw a full-size version of lesson two. The second group started with a full-sized version of lesson one and saw a phone-sized version of lesson two.
Following both lessons, a short multiple-choice quiz verified how much the subject retained. A questionnaire subsequent to the quiz asked the subjects about their opinion, reaction, and perception of the lesson and quiz.

The simulation is written in HTML and PHP and uses a MySQL database. Figure 9.2 shows the data model of the simulation.

![Data Model Diagram]

**Figure 9.2 - Simulation database model**

The first lesson, the positive example, is a text about the cathedral of Frankfurt taken from (Kalusche, et al., 1992) and shortened. The full-sized and phone-sized versions display pure HTML text. The only difference is the size of the presentation frame, created with an iFrame (an iFrame is a HTML object that places another document or picture in a website), and the amount of text displayed at any moment. This means that the subject who sees the phone-sized version needs to scroll more than the subject who sees the full-sized version. The presentation frame of the full-sized version has a size of 800 x 600 pixels. The phone-sized version frame has a size of 240 x 320 pixels, the lowest standard resolution from current devices of the phone class (see 4.2 Mobile devices).

The second lesson is about Quality Management taken from a Bachelor’s class of the author. The original PDF files are exported as images and presented within an iFrame. The full-sized version displays the images in full resolution (800 x 600 pixels); the phone-sized version displays the images in small resolution (320 x 240 pixels). This smaller resolution is hard to read, particularly for the diagrams. This phone-sized version of the lesson will demonstrate
that learning content for M-Learning needs to be customized in order to be useable on mobile devices.

9.2. Questionnaire

After both lesson and quizzes the subjects are asked to fill out a questionnaire about the lesson and the quiz. There are five questions which are as follows:

**Question 1: How do you feel about the reading / learning of the lesson in general?**

This question will show the subject’s general feelings about the learning content.

**Question 2: What do you think about the presentation of the lesson? Please justify your opinion!**

This question is intended to show whether the subject found the presentation easy to read.

**Question 3: Do you think you understood the content of the lesson? Please justify your opinion!**

This question will determine whether the presentation was sufficient to teach the learning content to the subject.

**Question 4: Do you think something is missing within the lesson? If so, what?**

This question asks what the subjects might have been missing within the lesson. This could be some images or a better layout, depending on the subject’s personal preferences.

**Question 5: How do you feel about the multiple choice quiz? Please justify your answer!**

This question will show whether the test person felt confident enough about the content to answer the questions or not. This determines if the lesson was sufficient to properly teach the learning content.
9.3. Evaluation

The simulation was evaluated by 36 subjects, eighteen female and eighteen male. Nineteen subjects were randomly assigned to group one and seventeen subjects assigned to group two. The group was randomly assigned to the subject in the beginning of the test. The distribution is not even due to some subjects failing to complete the lessons. The ages of the subjects were distributed as follows: three people did not state their age, four people were younger than 20, nineteen were between 20 and 30 years old, eight people were between 30 and 40 years old, one subject was between 40 and 50 years old, and the final subject was older than 60. The complete results from the simulation can be found on the CD-ROM in the back of the thesis in folder [4] Simulation Results.

The results from the multiple-choice quiz are shown in Figure 9.3. It shows the mean value of the correct answers and standard derivation for each quiz. The maximum result on a quiz is five correct answers.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Quiz 1</th>
<th>Quiz 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean value</td>
<td>3.31 (phone-sized)</td>
<td>3.63 (full-sized)</td>
</tr>
<tr>
<td>standard derivation</td>
<td>1.15</td>
<td>1.30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 2</th>
<th>Quiz 1</th>
<th>Quiz 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean value</td>
<td>3.14 (full-sized)</td>
<td>2.76 (phone-sized)</td>
</tr>
<tr>
<td>standard derivation</td>
<td>1.02</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Figure 9.3 - Multiple choice quiz results

The results from the multiple choice test show that the subjects who learned with the full-sized version have better results in general than subjects who learned with the phone-sized version. The following diagrams show the mean value (as a bar) and standard derivation (as a dash within the bar) for the quizzes sorted by groups (Figure 9.4) and sorted by quizzes (Figure 9.5).
In the first lesson, the positive example about the cathedral of Frankfurt, the difference between phone-sized and full-sized version is small, only 0.17 correct answers. This marginal difference indicates that both versions are usable in order to learn the content and answer the given questions.

In the second lesson, the bad example about Quality Management, the deviation between both versions is higher than in the first lecture. The difference between phone-sized and full-sized version is 0.87 correct answers. This means that the full-sized group scored nearly one more question correct than the phone-sized group. This difference and the following results from the questionnaire indicate that not adjusting learning content hinders the learning effect.
The feedback from the questionnaire is varied. Following, some of the comments are cited and interpreted. The feedback is organized by the two lectures.

**Lesson one**

Nearly half of the subjects of both groups said the readability of this lesson was good, and there was “no problem in reading, text is well structured, clearly arranged”. The other half of the subjects had some problems in reading the text. One subject stated that the “scrolling hinders the reading in general” and that he is not used to reading long texts on a display and prefers printing out material and making notes. Another subject stated that she likes writing down information by herself in order to familiarize herself with learning content. Especially subjects of the phone-sized version had problems with the scrolling and stated that scrolling hinders fluent reading.

In addition the majority of the subjects missed some images and illustrations in the lesson in order to make the learning content more understandable and “to imagine the structure of the cathedral better”. Two subjects answered that “Architectural history is hard to understand without pictures”.

Most subjects also did not like the topic itself and therefore found it hard to understand and follow. Therefore, future experiments need to be done against subjects who have more of an interest in the subject matter.

**Lesson two**

All subjects in the full-sized version found the presentation clearly arranged and readable. The size of the font and the images were clear enough to read and understood the information presented in the lecture. One subject stated that it was “more pleasing to read” than the first lecture when comparing the sizes of both presentations.

On the other hand, all subjects of the phone-sized version stated that the reading and learning of this lesson was difficult because of the small size of the presentation. Illustrations were especially hard do identify, and one subject stated that the setup was “Catastrophic, because nearly anything was readable and the graphic illustration was not identifiable”. “The presentation itself was not bad” stated one subject “but a little bit unpleasing, because it
was so hard to read”. Generally, all subjects had difficulties understanding the lesson because of the tiny presentation. Answering the quiz was consequently harder than in the full-sized version. One subject stated “I sensed it was hard, because I did not understand most parts of the lecture due to the tiny size and therefore just guessed at most of the questions”.

9.4. Summary

The first lesson with the adjusted content about the cathedral of Frankfurt was found to be easy-to-read in the phone-sized version by the subjects. The results and feedbacks from the quiz and the questionnaire showed that the subjects were able to read the lesson and understand its content. Some of them stated that missing some images and illustrations hindered the learning effect. There are no images in both versions, and therefore, the results can be compared. This statement could be interpreted that these subjects are Visual Learners and subsequently prefer images and illustrations in their learning content.

Despite missing images, this lesson is an example that learning with mobile devices is possible. The difference in the results of the quizzes of both versions is marginal and the feedback from the questionnaire also suggests that subjects accept this form of presentation.

The second lesson without the adjusted content about Quality Management is barely readable in the phone-sized version. The illustrations within this lesson are especially hard to identify due to the small resolution. This is the general feedback from the questionnaire, and all subjects stated this fact in their answers. Due to the tiny resolution, not only the illustrations but also the text is not easily viewed, and therefore, most subjects did not understand the content of the lesson. Comparing the results of both quizzes shows that on average, the group with the full-sized version answered nearly one question more correct than the group with the phone-sized version. This indicates the need for an adjusted and consistency readable learning content in M-Learning scenarios.

Summed up, this simulation showed the impact of modified and unmodified learning content in M-Learning scenarios. Learning content which is not modified and adjusted to the
special characteristics of a cell phone, or mobile devices in general, disadvantages the learner. On the other hand, the group with the lesson with the adjusted learning content showed similar test results as the control group with the full-sized lesson.
10. Conclusion

This thesis tries to answer the question of whether M-Learning is just hype or has practical use in education. After the investigation of the three factors, the presentation of the scenarios, the evaluation with the learning professionals, and the simulation it can be reasoned that M-Learning has its place in education, under certain conditions. Depending on the learner, the learning content, the used mobile device, and the specific scenario, the learning effect can be enhanced or reduced.

These three factors (Figure 10.1) determine if M-Learning enhances the learning effect or not. It is to their advantage if the learner is either an *Active* and / or a *Visual Learner*. Especially in scenarios where the learning content can be seen or interacted with, such as in the example with the historic site or the botanic garden, these types of learners are supported by M-Learning. Another aspect is that M-Learning supports learning content that can be seen, touched, smelled, or heard, such as the example with the anatomy dissection. Also, learning content which can be divided in small portions, such as learning the vocabulary of a language, suits M-Learning well. The effectiveness of the used mobile device
and application varies from scenario to scenario. In the learning vocabulary example a cell phone is better suited and handier than a laptop. On the other hand, a laptop with a high resolution and a full-sized keyboard might be better suited in another scenario.

There are two types of scenarios: the support to classical learning and the new ways of learning. In support of classical learning scenarios, M-Learning enables the user to learn while on the go. Proper learning content for learning to go is some sort of repetitive content, such as vocabulary training. This type of learning content can be paused and resumed without any disadvantages to learner, which is due to the short timed learning units recommended. This sort of learning usually happens on train rides or other timed waiting situations; therefore the actual learning time is varied.

The second type of scenarios is the new ways of learning, such as the presented location-based learning. These scenarios use the potentials of mobile devices to create an innovative learning scenario for the students. Mobile devices are able to connect to the internet while at the point of interest and access further information about it over the internet. In addition, mobile applications can be run on these devices in order to teach the students on location. The location itself can be the learning content as the location-based learning is one big benefit of M-Learning. The students are instructed by the mobile device at a special building or an ancient site. This instructive application can be some sort of guide with text, images or even videos. Furthermore, these applications can be used to communicate and interact with fellow students, which are additional benefits to the learning process and a motivational benefit, too.

Aside from all advantages of M-Learning, there are also some disadvantages. First of all, M-Learning does not replace classical learning methods; it is only an extension of them, according to the comments by educators. The interviews with the teachers showed that there is need for further information and training in the use of the new media technologies in general. Most teachers mixed up the different terms such as M-Learning, E-Learning and other new media technologies. Based on this misinformation, only a few of the interviewed learning professionals saw a benefit in M-Learning. On the contrary, some of them disliked the idea of M-Learning and the new media technologies in general. Aside from the need for further information, the interviews point out that M-Learning can bring benefits to the
learners. The vocabulary training scenario was especially favored by most of the language teachers as an addition to their classical learning methods. All teachers stressed that M-Learning can only be used as an addition, due to its own limitations and governmental regulations in Germany. The interviews with the learning professionals were a first step, but in order to get significant data, a bigger survey with students and lecturers would be recommended.

In order to use M-Learning there are significant investments to be made up front for devices and modifying the learning content and applications. Depending on the scenario, these investments can be from very little cost, such as reading a document on an already owned cell phone, up to very high costs when implementing a 3D guide with videos, such as in the Pompeii example.

The simulation provides support for the need for adjusted and modified learning content in M-Learning scenarios. Based on the feedbacks of the questionnaires and the results from the multiple choice quizzes it can be seen that non-adjusted learning content hinders the learning effect. On the contrary, the adjusted learning content produced similar positive results. Additional simulations would help to create more evidences for the positive influence of M-Learning. It would make sense to try some of the presented scenarios to investigate the influence on the learners based on real world results. The presented scenarios are just a small insight into the possibilities of M-Learning and the benefits for the learners are just a theoretic conclusion.

The benefits to the learners by M-Learning can be divided into two categories. First the convenience benefits, such as learn anywhere and anytime and the possibility to learn in a personal sphere. And second the technology benefits, such as the possibility of location-based learning and the potentials of the mobile technology in general.

In conclusion, M-Learning has a long way to go before becoming a substitute for classical learning. It is an extension or an addition to the classical learning that can enhance the learning process. Depending on the scenario, it provides additional informative benefits or an enjoyable and interactive alternative to the learner. Such an alternative can be a good motivation for learners and is more engaging than classical classroom teaching, as in the
example with the botanic garden. Therefore, the proper use of M-Learning within lectures provides promise of enhancing the learning process.
References


Mobile Learning – learning content, learner styles, and mobility
A differentiated examination on the advantages and disadvantages of Mobile Learning


Appendix A - CD-ROM Content

The content of the CD-ROM added to this thesis is organized as follows:

[1] Master Poster

This folder contains the Master Poster in PowerPoint format hung out in the computer science department of the h_da, University of Applied Sciences, Darmstadt.

[2] Interview Notes

This folder contains the interview notes in DOCX format, one file per interviewee.

[3] Simulation Source

This folder contains the source code of the simulation website, the learning content and the MySQL database code.

[4] Simulation Results

This folder contains the results of the simulation in an Excel file.