

# EVALUATING QR CODE CASE STUDIES USING A MOBILE LEARNING FRAMEWORK

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## ABSTRACT

The aim of this study was to evaluate the feasibility of Quick Response (QR) codes and mobile devices in the context of Finnish basic education. The feasibility was analyzed through a mobile learning framework, which includes the core characteristics of mobile learning. The study is part of a larger research where the aim is to develop a theoretical framework for mobile learning and mobile learning practices. QR codes were chosen in particular because teachers were interested in seeing how this relatively easy and versatile technology could be utilized in their classrooms. QR code implementations blended in and enriched the traditional teaching methods and classroom learning in a motivating and meaningful way. The core characteristics of mobile learning were realized comparatively well. However, the study also indicated that the factors that should be added to the framework are the school curriculum, ICT integration strategies, teacher competencies, and technological, social and cultural change.

## KEYWORDS

Mobile learning, mobile learning framework, pedagogical practices, Quick Response (QR) codes.

## 1. INTRODUCTION

Old Chinese proverb advises: *"Tell me and I'll forget. Show me and I may remember. Involve me and I'll understand"*. One globally increasing trend and an efficient way to involve learners is mobile learning, which can be understood as learning with mobile devices in various contexts (O'Malley et al., 2005). There is a consensus among the researchers that mobile technologies have great potential to improve teaching and learning. However, the concept of mobile learning is still developing rapidly and a cohesive theoretical mobile learning framework is missing.

The present paper focuses especially on the process and impact of implementing Quick Response (QR) codes and mobile devices in the context of Finnish basic education. The aim of the study is to evaluate QR code case studies by using the mobile learning framework. The study is part of a larger research where the aim is to develop a theoretical framework for mobile learning as well as tools and practices for the educational use of mobile technologies.

The study of QR codes in education can be placed in the context of mobile learning. At best, mobile technologies, such as QR codes, facilitate learning outside of classroom and learning materials are no longer limited to textbooks (Shih et al., 2011). There is a variety of ways to use QR codes in educational context (Rikala & Kankaanranta, 2012). In this study, teachers were cooperating in developing new ways to embed QR codes in learning.

The feasibility of the QR code implementations was evaluated through a theoretical framework, which includes the core aspects of mobile learning. The study advanced the two most recent and extensive frameworks introduced by Koole (2009) and Kearney et al. (2012) as a basis of the theoretical framework. The characteristics discovered in the QR code case studies could be used to develop the framework further.

This article is organized as follows: first the theoretical background is discussed, which is followed by experimental investigations and results, and concluded with reflective remarks.

## 2. THE MOBILE LEARNING FRAMEWORK

In recent years, mobile devices have become an important part of everyday life. Improvements in mobile devices have made them appropriate for educational use also, and mobile technologies have promoted a new learning style known as mobile learning. Mobile learning in itself has a surprisingly long history (Naismith & Corlett, 2006): while its roots are in the 1970s, its popularity did not peak until in the 2000s (Lam et al., 2010). Despite the relatively long history, mobile learning is evidently undeveloped compared to other technologies and their pedagogies (Traxler, 2007). Thus, mobile learning has not yet reached a stable form and the concept of mobile learning is still developing rapidly (Lam et al., 2010).

Many researchers have attempted to encapsulate the unique characteristics of mobile learning in the form of a simplified framework (e.g. Parsons et al., 2007; Koole, 2009; Nordin et al., 2010; Ozdamli, 2012; Kearney et al. 2012). However, all these frameworks emphasize different characteristics and a cohesive theoretical framework is still missing. The lack of a cohesive theoretical mobile learning framework and mobile learning standards have led to a situation in which the mobile learning pilots and trials are characterized by short-term and small-scale studies focusing on either user acceptance or attitudes (Rushby, 2012). Consequently, one major challenge is that mobile learning solutions are not deeply-rooted in educational contexts or in practices. Without a cohesive framework, it simply takes too much of the teachers' time and energy to interweave all crucial aspects together. In other words, there should be a framework that would help the move from theory to practice.

As teachers alone will be unlikely to bring about the width of implementation needed, this study argues that there is a need for a theoretical framework that takes into consideration the core characteristics of mobile learning as well as pedagogy and that all these aspects can explain the process that can at best lead to a pedagogically sensible and sustainable way to utilize mobile technologies in educational contexts. In other words, at best the framework can help in planning, implementing, evaluating and developing mobile learning and its solutions.

In this study, the core aspects identified by Koole (2009) and Kearney et al. (2012) in their respective frameworks provide an evaluation framework in which the feasibility of the QR code implementations is analyzed. These frameworks introduced by Koole (2009) and Kearney et al. (2012) suggest that mobile learning has certain elementary characteristics that separate it from other types of learning. Koole (2009), for instance, described mobile learning as a process resulting from the convergence of mobile technologies, human learning capacities, and social interaction. Learners may move within different physical and virtual locations and participate in and interact with other people, information, or systems. In other words, three aspects – the device, learner and social aspects – are intersecting. The framework introduced by Kearney et al. (2012), in turn, includes three core characteristics: 1) personalization, 2) authenticity, and 3) collaboration. The personalization has implications of ownership, agency, and autonomous learning; the authenticity highlights the opportunities for contextualized, participatory, and situated learning; the collaboration captures the conversational and connected aspects of mobile learning. The way learners experience these characteristics is strongly influenced by the organization of the spatial and temporal aspects of the mobile learning environment.

Based on these two frameworks, an evaluation framework was developed. The evaluation framework includes/consists of two levels (see Figure 1) titled core level and medium level. The core level and medium level are explained briefly below. Mobile technologies have a unique ability to support learning anywhere anytime. For example, mobile devices can expand the learning environment to authentic contexts such as parks, museums, and nature. Therefore, the aspects such as context, time and space form the core of mobile learning (see Figure 1). Many researchers (e.g. Silander and Rytönen, 2005) have stressed that the mobile learning process should be as authentic as possible. For this reason, authentic contexts and real-life problems are considered important. At best, mobile technology can extend the learning environment into authentic contexts and provide a variety of stimuli, schemas, and techniques, and extend learning beyond the traditional learning space in a motivating way (Naismith et al. 2004; Rikala and Kankaanranta, 2012).

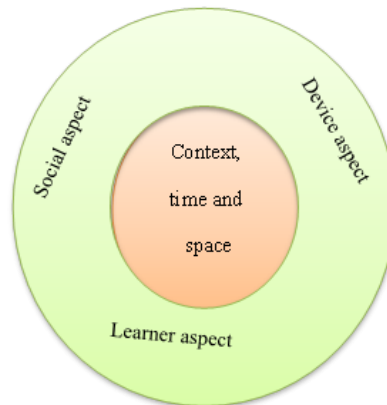


Figure 1. Core characteristics of mobile learning.

The other important aspects of the mobile learning process are the learner aspect, device aspect and social aspect. These aspects form the medium level of the mobile learning framework (see Figure 1). An Individual learner's cognitive abilities, memory, emotions, motivation, attitudes, and experiences are in a significant role in the learning process and thus in the mobile learning process as well. For this reason, it is important to understand the learners' needs and the factors that are influencing their learning (e.g., the current level of knowledge, attitudes, experiences, and motivations). In other words, the learner should be placed at the centre of the learning process (Ozdamli and Nadire, 2011; Zhang et al., 2010).

On the other hand, the device aspect should not be forgotten either. Despite the fact that mobile devices by themselves do not guarantee enhanced teaching or learning, technological decisions are also important when mobile learning activities are being planned. In the device aspect, especially device usability is emphasized. The device usability involves the physical, technical and functional characteristics of a mobile device and applications that influence for instance the learner's experience, perceived ease of use, and perceived usefulness. The learners' motivation can suffer and they become frustrated if they encounter problems with technology (Rikala and Kankaanranta, 2012). For this reason, it is important to choose easy-to-use devices that have sufficient capabilities and, if at all possible, try to identify and limit errors in advance.

Social aspect's importance as a part of the learning process cannot be underestimated (Koole, 2009). Different kinds of interactions can stimulate learning (e.g. learner-learner, learner-instructor, learner-content, and learner-technology). For this reason the relationships and interaction with other learners, experts, systems and contents should be considered; how the use of mobile devices might change the process of interaction between learners, communities, and systems? Therefore, the process of mobile learning is defined and continuously reshaped by interaction between the learner, device, and social aspects (Koole, 2009). At best, mobile devices can enhance and encourage social interaction with the instructor and peers (Rikala and Kankaanranta, 2012). From the learner's point of view, it is also important that they receive sufficient feedback and guidance during the process. This kind of support can increase the learner's confidence and competencies as well as help them overcome any arising difficulties (Nordin et al., 2010).

### 3. RESEARCH DESIGN

This study reports the findings of two QR code case studies conducted in schools in Central Finland in the autumn of 2012. The case studies were part of the Personal Mobile Space project funded by Tekes (the Finnish Funding Agency for Technology and Innovation) and led by Professor Pekka Neittaanmäki and Marja Kankaanranta from the University of Jyväskylä (see Kankaanranta, Neittaanmäki & Nousiainen, 2013).

The use of a case study method is appropriate because it provides in-depth examination and gives an understanding of the perspectives, opinions, and expectations relating to smart phone usage and QR code activity and thereby also brings new perspectives and aspects to the mobile learning framework.

A group of interested volunteer teachers developed new ways to embed mobile technologies and QR codes in learning in cooperation. QR codes were chosen in particular because the teachers were interested in seeing how this relatively easy and versatile technology could be utilized in their classrooms. The research data was collected with multiple data collection methods; observations, student surveys, and teacher interviews. The questionnaire and interview questions were designed to cover the core aspects of mobile learning as well as to measure and understand the perspectives, opinions, and expectations of smart phone usage and QR code activity. Below, two QR cases are briefly described.

Table 1. QR code cases.

Case	School	Sample & Grade level	Equipment
<b>Math trail</b>	Primary school	Twenty-four 5 <sup>th</sup> grade students (aged 10-11 years)	Provided by the researchers
<b>Literature tree</b>	Secondary school	Sixteen 9 <sup>th</sup> grade students (aged 14-15 years)	Provided by the researchers

**Math trail** – In the primary school, a Math Trail was conducted for 5<sup>th</sup> grade students (aged 10-11 years). The overall objective of the activity was to enhance the students' mathematical skills and to bring much-wanted variation to the school day. The learning subject and objective of the experiment was to learn about decimal numbers. The math trail was located in the school surroundings – e.g., corridors, classrooms, and furniture. At the beginning of each math lesson, the teacher taught the theory and the students solved five problems from the textbook. After solving textbook problems, the students could go circulating the math trail. During the math trail experiment, each student had one loaned smart phone and a map of the trail including QR code locations given to him or her. For each QR code location, the students answered one problem by scanning the code and submitting their answer using an online form on the mobile device. If the answer was correct, the student received a hint on the following QR code location. The math trail included a total of 65 decimal number problems (textbook-like).

**Literature tree** - In the secondary school, a Literature tree activity was conducted for 9<sup>th</sup> grade students (aged 14-15 years). The overall objective of the activity was to revise the lessons learned earlier about Finnish literary history. The literature tree activity was located in the school surroundings – e.g., corridors, statues, and paintings. The activity included a “literature tree”, a kind of a map where the students were asked to place certain concepts in the right places. The students circulated around the school in small groups and tried to find QR codes which contained the hints. The QR codes contained for instance weblog texts and pictures, which helped the students to place the concepts in the right places in the literature tree map.

## 4. FINDINGS

The two QR code case studies were evaluated through a mobile learning framework (see Figure 1). The core level aspects, medium level aspects as well as other emerging aspects are described in the following Chapters.

### 4.1 Core Level Aspects

The context where the mobile devices and QR codes were used was interspersed with traditional classroom learning. The students were able to work at their own pace and in the ways that they preferred. However, the time when the mobile devices and QR codes were used was specifically planned and consequently the activities were not spontaneous situations. QR codes were placed around the school surroundings, so in other words learning was extended outside the classroom. However, at best, these kinds of implementations could be arranged in authentic real-life contexts where students could discover and solve problems relating to what they find.

## 4.2 Medium Level Aspects

The other important aspects of the mobile learning process are the learner aspect, device aspect, and social aspect. These aspects form the medium level of the mobile learning framework. The results of these aspects are described in the following sub-Chapters.

### 4.2.1 Learner Aspect

In both cases, students were very curious about the new approach that deviated from their routine exercises. In other words, QR codes had a stimulating effect on learning. In primary school, all students agreed that QR activities were an interesting and exciting way to learn mathematics and that they would like to do QR activities again. All the students also found new teaching and learning methods more attractive than the traditional ones. Based on the survey, the new way to learn mathematics inspired and motivated boys in particular but also girls were engaged and claimed that QR codes made decimal problems somewhat or a lot more interesting. In the secondary school, the experiment divided student opinions. 75% of the students agreed that QR activities were an interesting new way to learn and over half (63%) of the students would like to do them again. 50% of the students found new teaching and learning methods more attractive than the traditional ones. However, some of the boys commented on the experiment in a negative tone. Also the observations during the experiment indicated that some boys' attitude was negative and that they were more interested in what else could be found on the phone. These negative feelings were probably the reason why girls claimed more often than boys that QR codes made literature history tasks more interesting.

In the primary school, the teacher was satisfied with experiment. She commented that the math trail inspired and motivated students. She presumed that the students' motivation derived from the autonomy as the learners could have control over the pace at which they learned and were able to solve the challenging tasks in an interesting way instead of through the traditional textbook learning. However, according to the students' feedback, there should be a wider range of math problems, as two students found the problems too easy. Another student commented: "The QR codes were an interesting new way to learn, but the math problems could have been more difficult." According to the teacher interview, the math trail served most of the students' needs but two students couldn't participate because they received remedial or special needs education in mathematics. The QR code activity was too difficult for these two students. The teacher commented: "It did not occur to me when we were planning this Math Trail that these two pupils would not be able to participate because they progress slower. In retrospect, there should have been even more variation in the math problems. Now there was quite a strong dissimilarity experience for these two pupils and that was not good." In other words, by providing a wider range of tasks, the math trail could be personalized in such a way that it would better serve different types of learners and even students who receive remedial or special needs education. In this experiment, however, the special needs of the two students were not taken into account adequately in the planning process.

In the secondary school, the teacher and two teacher trainees who participated in the experiment argued that QR codes can attract and serve a wide range of learners. The activity offered many opportunities for personal instruction but they were not utilized. Another teacher trainee commented: "One major aspect that was missing was proper feedback. In these kinds of trials there should be much more time for feedback and the way feedback is given should be planned beforehand." The lack of sufficient feedback and guidance led to a situation where the students perceived the trail more as a competition than a learning task.

### 4.2.2 Device Aspect

In both cases, there were some challenges with the devices. However, no major technical problems occurred during the experiments. The problems that were reported and observed were mainly caused by the QR code decoding software. In the future, it would be reasonable to test various QR code readers.

In the primary school, the students strongly agreed that it was easy to use QR codes (100%) but somewhat disagreed that the QR code scanner always functioned as they expected (61%). Only 26% of the students had used QR codes before the experiment. This can be one reason why students experienced problems. Another problem is related to the QR code scanner itself. The software that was used for decoding the QR codes was slightly unsteady and some students grew impatient with it. One student for instance wrote "The math trail activity was fun, but sometimes when I was scanning the code, the code reader became blurry." Another student wrote "It zooms by itself and that was annoying."

In the secondary school, the students strongly agreed that it was easy to use QR codes (94%) but somewhat disagreed that the QR code scanner always functioned as they expected (56%). Only 38% of the students had used QR codes before the experiment. This might be one reason why some students experienced problems with the QR code scanner. Even though mobile devices and their use are familiar to the students the scanning of the QR codes raised a lot of questions. During the experiment, one student for instance asked: “Oh, does it take the picture automatically?” Another student asked: “Should I take a picture?” Another problem was again related to the QR code scanner. Observations made during the experiment indicated that the QR code scanner was unsteady. One student for instance commented during the experiment: “This is not working. This is fuzzy. What on earth...”

Furthermore, the scanning of QR codes could become more difficult depending on the circumstances. In the primary school, it was discovered that a rounded surface made the QR code scanning more difficult. Also lighting conditions can interfere with the scanning as the teacher reported that the students could not scan the codes if they were placed in a dark location.

Another considerable challenge was the loaned smart phones (Nokia 5800 XpressMusic). They are a few years old and utilized in several experiments, which clearly had an effect on their reliability. In the primary school, the students claimed that the smart phones did not always function as they expected: 61% of the students disagreed with the statement “The phone functioned as I expected”. According to the teacher the phones, however, functioned surprisingly well and the battery charge was running out or students reported problems only once or twice during the math trail. In the secondary school, nearly half (44%) of the students claimed that the smart phones did not function as they expected. Also observations made during the experiment indicated that there were some problems with the phones and especially with the data connection.

According to the primary school teacher, the students learned how to use the loaned smart phones and applications instantly. Few students had problems and needed help during the experiment. This is consistent with the survey results as only 13% of the students expressed that they had to learn many things before they could use the phone and QR code application and with the fact that mobile devices are familiar to students, as all students reported that they own a mobile device. Technical problems naturally had an effect on the students’ learning experiences but not inauspiciously, as all students would like to do QR activities again. One student commented when asked for an opinion about the experiment: “It was fun as you were able to use a phone.”

According to the secondary school teacher and teacher trainees as well as observations, the students instantly learned how to use the loaned smart phones and QR codes. This is also consistent with the survey results as none of the students expressed that they had to learn many things before they could use the phone and QR code application. Technical problems naturally had an effect on the students’ learning experiences but not inauspiciously, as 63% of the students reported that they would like to do QR activities again.

#### **4.2.3 Social Aspect**

The Math trail activity was planned to be a self-directed and independent activity, but cooperation was allowed. According to the teacher, the students regularly formed groups and solved problems together. The math trail activity encouraged social interaction. However, in this activity, mobile technology was not used to mediate collaboration and therefore the social aspect is slightly questionable.

In Literature tree activity, the students solved problems in small groups and, according to the observations made by researchers, actively advised each other when they encountered problems. Based on the observations, the Literature tree activity encouraged social interaction.

### **4.3 Other Emerging Aspects**

Teacher interviews revealed several aspects that emerged from outside the framework. These were teacher competencies, ICT integration strategies, and technological, social, and cultural change. It is obvious that technological, social, and cultural changes do and will influence learning. These changes were mentioned in teacher interviews. One of the teachers for instance commented: “When you are considering this time and this life, then yes, you should include some good things into teaching as well.” Teachers mentioned that using technology as part of teaching makes students feel that teaching and learning are more present-day, making it easier for school to come closer to the students’ everyday life.

Teacher competencies were mentioned several times during the teacher interviews. One of the teachers commented: "If I was to take this kind of implementation as a teaching method, I should study more information technology." Teachers' opinions about mobile learning were very positive. They reported that the experiment extended their thoughts and that they had started to consider additional uses of mobile technologies in educational context. However, they all said that they would need more practicing. One of the teachers suggested that QR code activities and similar could be included in and enclosed with the textbook, providing an easy way for the teachers to organize mobile learning activities. It was also a big relief to the teachers that the students already knew how to use smart phones, allowing them to skip one major step, i.e., teaching students to use the devices. One major issue that came up in the interviews was the fear and anxiety that teachers need to overcome before they can start to utilize mobile technologies as a part of their teaching practices. One of the teachers commented: "It is like stepping away from your comfort zone. However, when you do it, you notice that actually you did not have to step away from your comfort zone at all."

One obvious challenge in the implementation of mobile learning is, according to the teachers, the ability of the school to provide the necessary tools and devices. One teacher commented that schools should purchase equipment needed. She commented: "Some students have flashy devices but some only have standard phones, not even smartphones." All the teachers also speculated about the abusive and disruptive use of the devices. One teacher commented that there should be some kind of restrictions to ensure the safe use of the devices. It was also mentioned that technology should not be used only because it exists but rather because there is a clear pedagogical meaning and reason for its use. All these comments are related to ICT integration strategies.

## 5. CONCLUSION

Based on teacher interviews, student surveys, and observations, the experiments indicated that QR codes provide motivating and meaningful experiences for students. Students were enthusiastic and motivated about the new approaches that deviated from their routine exercises. However, it is important to design activities well and take students' needs into account. This was observed especially during the math trail experiment, where the special needs of two students were not taken into account adequately in the planning process. The learners' motivation can suffer or they are not able to participate in the activities if their needs are not taken into account sufficiently. This highlights the learner aspect in the mobile learning process.

Both activities encouraged social interaction. However, especially in the math trail activity, mobile technology was not used to mediate collaboration and therefore the social aspect is slightly questionable. Also the device aspect was challenging as there were some challenges with the smart phones and especially with the QR code reader. The activity therefore clearly highlighted the need to test various QR code readers as well as to ensure that it is possible to scan QR codes without much effort.

The context where the mobile devices and QR codes were used was interspersed with traditional classroom learning and unfortunately the implementation situations were not as authentic and spontaneous as they at best could have been. One reason for this is that in both cases the activities needed to be relevant to school curriculum. Another reason was that the activities were not structured around authentic contexts or real-life problems. The study therefore indicated a need for widening the framework with characteristics related to school such as curriculum. In teacher interviews, there were also other aspects that were emerging from outside the framework. These were ICT integration strategies, teacher competencies, and technological, social, and cultural change. All these aspects should be added in the third level of the framework (the external level).

Based on the present findings, it seems that the appropriate way to utilize mobile applications in an educational setting requires a balance where technology use is matched with the curriculum, student needs, and human interaction; in other words, pedagogy. The pedagogical practices are, for instance, highlighted by Parsons et al. (2007), Nordin et al. (2010) and Ozdamli (2012) in their frameworks. Especially, in QR code activities, the teacher's contribution is significant, as they plan the situations in which the QR codes are used and define the targets and contents of learning as well as the ways used by the learners to utilize mobile technology in order to achieve these targets. As QR codes were new to teachers and as the cases were their very first mobile learning implementations, it is self-evident that all of the aspects in the framework were not fulfilled satisfactorily. More mobile learning case studies are needed to verify the aspects. Nevertheless, the study provides a good basis for continuing research on the educational use of QR codes and constructing and reconstructing a theoretical framework for mobile learning.

## ACKNOWLEDGEMENT

These case studies were part of the Personal Mobile Space project funded by Tekes (the Finnish Funding Agency for Technology and Innovation) and led by Professor Pekka Neittaanmäki and Marja Kankaanranta from the University of Jyväskylä.

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