BLENDING CLASSROOM TEACHING AND LEARNING WITH QR CODES

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ABSTRACT
The aim of this case study was to explore the feasibility of the Quick Response (QR) codes and mobile devices in the context of Finnish basic education. The interest was especially to explore how mobile devices and QR codes can enhance and blend teaching and learning. The data were collected with a teacher interview and pupil surveys. The learning outcomes were measured with the test results after the experiment and with the pupil’s self-evaluation. From a learner’s point of view, the QR activity was motivating and brought much-wanted variation to the traditional school day. The QR problems encouraged the pupils to persevere with the problems, an effect which led to good learning outcomes.

KEYWORDS
Mobile Learning, Pedagogy, Quick Response (QR) Codes.

1. INTRODUCTION
Modern information and communication technologies, such as mobile technologies and Quick Response (QR) codes, have great potential to improve teaching and learning because mobile technologies enable learning across multiple contexts, through social and content interactions (Crompton, 2013). In other words, learners can learn anytime and anywhere and learning can be personalized, situated and authentic (Traxler, 2009).

Research on mobile learning has been conducted all over the world, but only a small portion of the studies have addressed the use of QR codes in education (Law & So, 2010). Findings from the scarce but rich studies have, however, indicated that there is a variety of ways to use QR codes in an educational context. Because QR codes are versatile, they can support learning in different contexts. These contexts can include the woods, the gym, school surroundings and learning materials could consist of videos, texts, pictures and more (Rikala & Kankaanranta, 2012). In other words, QR codes can expand the learning experience and provide authentic tasks that take place in real-world settings. With the QR code embedded in the environment, students can obtain contextual or location-aware information (Osawa et al., 2007). QR codes can also enrich paper-based materials so that the material serves different types of learners (Chen et al., 2010). In addition, QR codes allow the implementation of systems based on paradigms such as just-in-time and collaborative learning (De Pietro & Frontera, 2012).

However, systematic empirical measurements and investigations of learning outcomes are lacking (Ozcelik & Acarturk, 2011). This study explores the impact of QR codes and mobile devices on pupils’ learning outcomes and motivations as well as looks at how mobile devices and QR codes can enhance and blend teaching and learning. This paper focuses on the process and impact of the implementation of the QR codes and mobile devices in Finnish basic education settings. The data were collected with a teacher interview and pupil surveys. The learning outcomes were measured with the test results after the experiment and with pupil’s self-evaluation.

The following sections describe QR codes in an educational context. The paper continues with the sections on the research design and the results and it concludes with reflective remarks and proposals for future research.
2. QR CODES IN EDUCATIONAL SETTINGS

The study of QR codes in education can be placed in the context of mobile learning. However, QR codes are not designed in educational terms. These two-dimensional barcodes were originally intended for tracking automobile parts in factories but nowadays they have a much broader purpose (Shin et al., 2012). QR codes have become widely popular because they provide a large amount of data comparatively quickly. QR codes can contain information such as text, URL links, or other data that can direct users to sources of further information about a particular place or subject. Users with a camera phone equipped with a QR code reader application and Internet connection can scan QR codes to display text, open a web page, get GPS coordinates, or perform some other similar action (Lee et al., 2011).

Because QR codes are not designed in educational terms, it is important to see the technology as an enabler. The aim is to explore how QR codes can be effectively integrated into teaching practices, which means the focus should therefore be more on the learners and pedagogy than on the technology itself. For this reason the use of the codes should promote learner-centered learning, not bind teaching and learning to mobile technology (Zhang et al., 2010).

QR codes can meet the needs of learners in a range of ways. First, it is possible to enrich paper-based materials to serve different types of learners (Chen et al., 2010). For instance, QR codes in paper-based tasks can contain links to multimedia resources such as audio materials or video clips. Law and So (2010) noticed that having the codes in paper-based tasks provide an efficient and flexible way for students to obtain the resources ubiquitously. Second, QR codes can guide learners through the self-assessment process. Law and So (2010), for instance, used the codes to guide learners through the self-assessment process. The QR code printed on the worksheet directly linked to a web page with the right answers and guided the learners through the individual exercises. The same kind of self-assessment process was observed in study by Rikala and Kankaanranta (2012). Teachers can also give directions and information to students on how to complete their assignments. In art workshops, QR codes can be placed, for example, on pieces of equipment such as different kinds of brushes, or in an engineering workshop on different electronic equipment to guide students in their use. Rikala and Kankaanranta observed a situation where QR codes guided students in how to use gym equipment. Third, QR codes provide a flexible way to share materials. Robertson and Green (2012) reported on how learners can find pictures of famous figures and generate a code for that figure. Learners can also produce and share reports or other materials online. In Rikala and Kankaanranta students shared their reports with others as a way of guiding the students’ self-assessment process. When the focus is on learners, the use of the codes supports learner-centered learning and enhances students’ motivation and excitement. Rikala and Kankaanranta also noted that students were curious about the new approach and that they found QR codes motivating.

The impact of interaction on learning cannot be underestimated. The philosophy of social constructivism, for instance, views learning as collaborative and it emphasizes social interaction (Koole, 2009). The social aspect of learning can also be enhanced with QR codes. In the studies by Susono and Shimomura (2006), Chaisatien and Akahori (2007) and Al-Khalifa (2008), students used mobile phones and QR codes to send questions, comments and suggestions to the teacher during the lecture. Al-Khalifa (2008) argued that with a QR-code based system students can ask questions and make comments without embarrassment. At best, this approach supports communication and information transfer. QR codes can also support the implementation of systems based on the collaborative learning paradigms, among others (De Pietro et al., 2012). Trail activities, for example, can be organized in as a collaboration or a competition between students (Law and So, 2010).

QR codes are very versatile. Lee et al. (2011) found that with QR codes, teachers can create customized guidebooks for individual field studies and that students can learn more effectively because the code only contains information that is relevant to the matter at hand. They furthermore noticed that QR code activities help integrate digital materials with field trips in a motivating way. In other words, QR codes support a variety of teaching practices.

However, the use of QR codes in education is still in its infancy. The main feedback from the teachers is that the planning of QR activities is an arduous task if one does not know how to utilize them, because it simply takes too much of the teachers’ time and energy to organize QR activities (Rikala & Kankaanranta, 2012). In this paper, we address this issue as well as others in our discussion of one case utilizing QR codes in an educational context.
3. **RESEARCH DESIGN**

This is an exploratory case study that examines the feasibility of the QR code activity and mobile devices in one basic education context in Finland. The case study was conducted as part of the Personal Mobile Space project at the University of Jyväskylä, Finland (see Kankaanranta, Neittaanmäki & Nousiainen, 2013). The use of the case study method is appropriate because it provides an in-depth examination and reveals perspectives, opinions and expectations of smart phone usage and QR code activity. The case study method was specifically chosen because only a few mobile learning studies have addressed the use of QR codes in education (Law & So, 2010). Another reason was that the test group and control group research frame would have been very challenging. The challenge stems from how the Finnish education system is set up. The system offers everybody equal opportunities for education. There are no gender-specific school services nor are students channeled to different schools or streamed. Students are not divided corresponding to their level of performance, all of which makes groups very heterogeneous. For these reasons, the decision was to focus only on one case. This case study examined one Grade 5 classroom in Central Finland. The participants included one teacher and her pupils. Twenty-four pupils (11 girls and 13 boys) aged 10–11 years participated in the Math Trail QR activity for two weeks.

3.1 **Research Questions**

This study addressed the following research questions:

- How do QR codes and mobile devices impact pupils’ learning outcomes and motivation?
- How can mobile devices and QR codes blend teaching and learning?

By addressing these research questions, we can make recommendations on what the key characteristics are of sustainable integration of these technologies into a formal education context.

3.2 **Instructional Design**

The QR code implementation and its contents were planned together with the Grade 5 teacher. She has worked as a teacher in basic school for over ten years but this was the first time she had taken advantage of mobile devices as part of her teaching practices. She commented: “This fall I thought that I need to get some new ideas and some kind of a boost to my work and something nice and exciting for the children.”

The overall objective of the implementation was to enhance the pupils’ mathematical skills and to bring much-wanted variation to the school day. The subject and objective of the experiment was to learn about decimal numbers. Mathematics was a good choice for a learning domain because according to Hwang and Tsai (2011), the ratio for mathematics in mobile learning research had been relatively low.

The results of short-term pilot experiments have indicated that students are excited when they are able to go outside the classroom during the lesson (Rikala & Kankaanranta, 2012). For this reason, a Math Trail was chosen as the form of the activity. In short, a Math Trail activity is a walk to discover mathematics. The walk can be organized almost anywhere – in a neighborhood, a park, a zoo, and elsewhere. A map guides the learners to places where they can formulate, discuss, and solve mathematical problems. The very earliest Math Trails appeared in England and in Australia in the mid-1980s, but as the idea of the Math Trail has spread, people have adapted it to suit their specific needs. The Math Trail is a flexible idea and can easily be amended to meet the needs and inventiveness of the users in many situations and contexts (Shoaf, Pollak & Schneider, 2004).

In this case, the Math Trail was located in the school environment (e.g., in corridors, in classrooms, and on furniture). During the Math Trail experiment, each pupil used a smart phone and a map of the trail including QR code locations. Contrary to the original idea of the Math Trail, the problems used were the same ones pupils were currently solving at school. The teacher designed textbook-like decimal problems (see Figure 1). The online forms (implemented with HTML and JavaScript) and QR codes were prepared by the researcher. The decimal problems needed to be relevant to the school curriculum, which is why the problems were the same as pupils were solving at school. The Math Trail included 65 decimal number problems.
ranging from easy and to challenging. The purpose was to give the learners control over the pace at which they learn and promote fulfilment from their achievements. The aim was to ensure that the learners would think that they were treated as individuals and that they would be content and learn at their own preferred pace.

At the beginning of each lesson, the teacher taught the theory and the pupils solved five problems from the textbook. After solving these five textbook problems, the pupils followed the Math Trail. Along the trail, the pupils could also use a paper and pencil to solve the problems, making the experiment a blended example of traditional and mobile learning approaches.

At each QR code location, the pupils answered a problem by scanning the code and submitting their answer using the online form on the mobile device. If the answer was correct, the pupil would receive a hint for the next QR code location. The Math Trail was intended as a self-directed and individual activity, but cooperation was allowed.

### 3.3 Data Collection

The research data were collected with surveys and a teacher interview. The questionnaire and interview questions covered the core aspects of mobile learning and measured the perspectives, opinions and expectations of the smart phone usage and QR code activity. The learning outcomes were measured with the test results after the experiment and with the pupils’ self-evaluation.

In the pupil questionnaire, the questions covered three areas: smart phone use (5 questions), QR code activity (10 questions) and self-evaluation of learning (1 open-ended question). Answers were given in three forms: a three-point scale (a lot, a little, not at all), agree/disagree or yes/no. The teacher interview resembled an informal discussion but it followed some key themes.

### 4. THE RESULTS

After two weeks of activity the pupils completed a questionnaire. Each pupil completed the questionnaire alone. The teacher interview was also carried out immediately after the experiment. The interview lasted for 39 minutes. The interview was recorded, transcribed and analyzed using a thematic analysis method. Soon after the experiment the teacher organized a test for pupils. The test contained similar textbook-like decimal problems and it was evaluated using a scale from 4 to 10 (where 4 is failed and 10 is excellent). The teacher reported the test results to the researcher.
4.1 How did the QR Codes and Mobile Devices Impact Pupils’ Learning Outcomes and Motivations?

From a learner’s point of view, the Math Trail was motivating and brought much-wanted variation to the traditional school day. The pupils strongly agreed that the QR activities were an interesting and exciting new way to learn mathematics, and that they would like to do QR activities again (See Table 1).

Table 1. Pupil’s feedback about learning with QR codes (N = 23)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
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<tr>
<td>I would like to do QR activities again</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>QR activities were an interesting new way to learn mathematics</td>
<td>100%</td>
<td>-</td>
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In their open-ended answers, 50% of the pupils highlighted that they had learned mathematics with QR codes (See Table 2). However, 38% of the pupils claimed that they did not learn anything new with QR activities. The boys claimed more often than girls that they did not learn anything new. Some pupils mentioned the problems as being too easy.

Table 2. Pupil’s self-evaluation of learning (n=23)

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<tbody>
<tr>
<td>Examples of pupils’ questionnaire quotes</td>
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<tr>
<td>I learned mathematics with QR codes</td>
<td>50%</td>
</tr>
<tr>
<td>A boy: “I learned to solve decimal problems a little bit better.”</td>
<td></td>
</tr>
<tr>
<td>A girl: “Solving math problems better.”</td>
<td></td>
</tr>
<tr>
<td>A boy: “It was easier to solve math problems with QR activities.”</td>
<td></td>
</tr>
<tr>
<td>A girl: “I learned to solve different kinds of decimal problems.”</td>
<td></td>
</tr>
<tr>
<td>I did not learn anything new</td>
<td>38%</td>
</tr>
<tr>
<td>A boy: “I did not learn anything because I already knew how to solve them.”</td>
<td></td>
</tr>
<tr>
<td>A boy: “It was a new way to learn but tasks could have been more difficult.”</td>
<td></td>
</tr>
<tr>
<td>A boy: “Nothing much”</td>
<td></td>
</tr>
<tr>
<td>A girl: “Nothing new.”</td>
<td></td>
</tr>
<tr>
<td>I learned to use a smart phone</td>
<td>8%</td>
</tr>
<tr>
<td>A girl: “To solve decimal problems and to use a smart phone.”</td>
<td></td>
</tr>
<tr>
<td>A girl: “I learned to use a different kind of smart phone.”</td>
<td></td>
</tr>
<tr>
<td>A girl: “I learned to navigate and to use a smart phone.”</td>
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</table>

The teacher was satisfied with the experiment. She said that the Math Trail inspired and motivated pupils and that for once the pupils’ ability to use smartphones benefited the learning. The teacher presumed that the pupils’ motivation emerged from the autonomy they were given. The learners had control over the pace at which they learned and were able to solve challenging tasks in an engaging way instead of the traditional textbook exercises. The teacher furthermore described that along the Math Trail pupils even solved problems she had not yet taught them. The QR implementation, therefore, encouraged pupils to work through the problems, which led to deeper knowledge and affected their test grades as well.

In Finnish primary school, pupils’ test results are evaluated using a scale from 4 to 10 (where 4 is failed and 10 is excellent). According to the teacher, seven pupils received a grade of 10 (excellent), ten pupils received a grade of 9 (very good), six pupils received a grade of 8 (good) and one pupil received a grade of 7 (satisfactory). The teacher was surprised that the pupils’ test results were so good despite the reduced amount of textbook practice, commenting: “Although we practiced less than normal, something more happened in the pupils’ brains.” The new way to learn mathematics inspired and motivated girls in particular, but boys were also engaged and claimed that QR codes made decimal problems more interesting.

The design and implementation of math problems requires care. This requirement was discovered along the Math Trail when there arose one error. It stopped the whole exercise and pupils were confused. The teacher commented that “I accidentally provided the wrong answer to one math problem. The pupils were not able to solve it and the whole exercise stopped, after which the pupils had to choose the next QR code at random.” Hence, rushing with the planning and implementation of the math problems can lead to many challenges. The pupils’ motivation can suffer if they encounter problems or the problems are not challenging enough. According to pupil feedback, there should be a wide range of problems, because some pupils found them too easy. The Math Trail served most of the pupils’ needs, but there were two pupils who could not participate because they were receiving remedial or special needs education in mathematics. For these two pupils, the QR code implementation was too difficult. Commenting on this difficulty, the teacher stated
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 designing a wide range of tasks, the Math Trail can be personalized in such a way that it can serve different types of learners, even pupils who receive remedial or special needs education.

4.2 How Mobile Devices and QR Codes Blended Teaching and Learning

The Math Trail experiment turned out to be a successful experiment. It blended and enriched traditional teaching methods and classroom learning. The math theory was taught with traditional methods and in a teacher-centered way but along the Math Trail pupils were able to work at their own pace and in their preferred manners. Some pupils were quick to solve problems and the teacher had to design another Math Trail for them, whereas other pupils did not complete the first trail. The Math Trail activity also encouraged social interaction. It was planned as a self-directed and independent activity, but cooperation was allowed. Each pupil solved the problems in their own preferred way and at their own pace but, according to the teacher, the pupils also regularly formed groups and solved the problems together.

The context where the mobile devices and QR codes were used was interspersed with traditional classroom learning. The math problems were planned in such a way that they had relevance to the school curriculum and therefore the implementation was not as authentic as it could have been. QR codes were placed around the school. In a sense, learning was extended outside the classroom. However, at its best, this kind of implementation could be arranged in a park, a zoo or almost any place where pupils could discover and solve problems relating to what they find (Shoaf et al., 2004). Differently implemented QR code activities could support situated and authentic learning.

According to the teacher, the phones functioned surprisingly well and only once or twice did the battery run out during the Math Trail or the pupils report problems. According to the teacher, the pupils instantly learned how to use the smart phones and QR code reader. Only a few pupils had problems and needed help during the experiment. This is consistent with the survey results as only 13% of the pupils expressed that they had to learn many things before they learned how to use the phone and QR code application. Because there were only a few problems, the activity went smoothly and the teacher as well as the pupils were satisfied.

The online form embedded in the QR codes was implemented by the researcher with HTML and JavaScript. This part of creating the task was too difficult for the teacher. The teacher commented: “If I were to take this kind of implementation as a teaching method, I should study more information technology.” She also suggested that Math Trails or QR code activities could be included in and enclosed with the textbook. This would be the easiest way for the teacher to organize the QR code activity.

5. CONCLUSION

The present study aimed to examine the process and impact of implementing QR codes and mobile phones in the context of Finnish basic education. The interest was to explore the impact of QR codes and mobile devices on pupils’ learning outcomes and motivations as well as to explore how mobile devices and QR codes can enhance and blend teaching and learning.

The Math Trail experiment was successful. It blended and enriched the traditional teaching methods and classroom learning and indicated that, with the QR codes, it is possible to arrange motivating and meaningful activities for pupils. However, the implementation was not as authentic and spontaneous as it could have been. The math problems were planned so that they had relevance to the school curriculum, which negatively affected the authenticity of the task. At their best, QR codes can expand the learning experience and provide authentic tasks that take place in real-world settings.

Even though the experiment was not as authentic and spontaneous as it could have been, pupils found it motivating. The pupils even tried to solve problems that they had not yet been taught. The QR implementation, therefore, encouraged the pupils to work through problems, which perhaps also led to deeper knowledge. This process had an effect on pupils’ test grades as well, which were good.
The experiment highlighted the importance of pedagogical design. Even though the Math Trail served most of the pupils’ needs, it also indicated that a wide range of tasks is required so that the activity can serve different types of learners and even pupils who receive remedial or special needs education. These findings are consistent with the fact that the individual learner’s cognitive abilities, memory, emotions, motivation, attitudes and experiences play a significant role in the mobile learning process (Koole, 2009). In other words, the appropriate way to utilize mobile technology in education settings requires balance. Technology use must be matched with the curriculum, the learners’ needs and human interactions.

Traxler (2009) has argued that mobile learning is an inherently noisy phenomenon where context is everything and confounding variables abound. This potential for confusion is why the positive results may be caused by other factors. The novelty effect, for example, is one of the intrinsic shortages in mobile learning research. This effect, according to Cheung and Hew (2009), means that learners and teachers are more likely to use technology because it is new to them compared with participants who have used technology for a longer period of time. Hence, the effect may bias the results. Thus, to clarify the findings, more thorough evaluations should be conducted. Especially, the repetition of the approach would give more evidence of the feasibility of the approach. In particular, learning outcomes and motivation should be measured and investigated more systematically. However, the findings in this study provide some insights and best practices of QR code usage in a basic education context. The study provides a good basis for continuing research into the educational use of QR codes.

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REFERENCES

Book


Journal


Conference paper or contributed volume


