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Using Mobile Technology To Provide Outdoor Modelling Tasks - The MathCityMap-Project

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Abstract

Linking mathematics with reality is not new. It is also not new to use outdoor activities to learn mathematics. It seems to be new, to combine such mathematical outdoor activities with mobile technology, like the geocache community which makes use of GPS technology to guide their members to special places and points of interest. The use of mobile technologies to learn at any time and any location is known as “mobile learning”. This type of learning can be seen as an extension of eLearning. Considering the definition of O’Malley one notices that this definition does not exactly match with the idea of the MathCityMap-Project (MCM), because the learning environment in the MCM-Project is predetermined. Combined with the math trail method the project enables mobile learning within math trails with latest technology. In the MCM-Project students experience mathematics at real places and within real situations in out-of-school activities, with help of GPS-enabled smartphones and special math problems. In contrast to the paper versions of math trails we are able to give direct feedback on the solutions by using "mobile devices" such as smartphones or tablets. If the user has difficulties in solving the modeling task, stepped hints can be provided. The teacher is able to use the MCM-Portal to upload tasks developed by himself or by his students and he is also able to build a personal math trail for his students.

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1. Introduction

At many places around the world there are special locations where mathematics can be experienced in everyday situations, but there are also a lot of places where mathematic problems are hidden in secret. The MathCityMap-project (MCM-project) wants to help students and teachers to use this kind of application of mathematics. Math problems, which can be solved at interesting places, can be localized with GPS- coordinates. With the help of a special internet platform, interested students and teachers can receive these math problems via a smartphone while being present at the respective place. Additionally, they can also use a special service. This is organized step by step depending on different levels of difficulty in order to solve these problems, the so-called stepped aids. Thus, one can experience, discover and learn math on the spot using the latest technology. The creation of realistic everyday mathematical problems is a very important subject in mathematical education research today (Istron-group (Blum, Henn, Klika & Maaß, 1994), Modelling-community (Blum, Galbraith, Henn & Niss, 2007)). Furthermore, pupils, parents, teachers, and the Ministry of Education require such interesting tasks. However, the creation of these tasks is very complex, especially if one aims to develop the above mentioned special help service which is realized in the MCM-project. Moreover, real-life math problems in the context of mobile learning are a relevant topic nowadays. So far, mobile learning is understood as the learning of any content at any location (O'Malley, Vavoula, Glew, Taylor, Sharples & Lefrere, 2003). In the MCM- project this is combined with an outdoor learning process. With the availability of GPS-technology in the latest smartphones, learning is taken to the places where people are motivated to solve interesting math problems (McLean, 2003). As a consequence, cognitive contents are connected to real places where the learner actually has to be!

2. Theoretical Framework

The use of mobile technologies has significantly increased during the last few years. Internet usage via mobile phone, for example, has increased by 78% in Germany in 2010 compared to the last year with the result that 16% of the internet was used by mobile phone in 2010 (Statistisches Bundesamt, 2011). If one considers that 98% of the group of the 16- to 24-year-old Germans uses the internet, it is evident which important role the internet and especially mobile internet play in the everyday life of students. Moreover, it shows that the percentage of students who use mobile technologies as mobile internet has greatly increased. Consequently, the appropriate technique for the MCM-project is available for many students now. The use of mobile technologies to learn at any time and at any location is known as “mobile learning” (m-learning). This type of learning can be seen as an extension of “electronic learning” (eLearning). (Winter, 2007) Considering the definition of O’Malley et al. (O'Malley, Vavoula, Glew, Taylor, Sharples & Lefrere, 2003). “Any sort of 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.” One notices that this definition does not exactly match with the MCM-Project, because the location is predetermined. Therefore, it is a process of "mobile learning at predetermined locations". In the MCM-project mathematics should be discovered and experienced using math problems, which are based on real examples of daily life situations and have to be done on the spot. For many students this is an entirely new perspective on their environment. The discrepancy between the previous and the new perception produces curiosity, which can be defined as a prime example for intrinsic motivation (McLean, 2003). Intrinsic motivation also arises because of the fact that mathematic education takes place in an out-of-school activity. Furthermore new, and for students interesting, technologies are used which is a discrepancy to their previous perception, too. The concept of stepped aids is another important component of this project. According to Friedrich & Mandl (1992) learning aids generally fulfil the following functions: to paraphrase, to focus, to elaborate sub-goals, to activate prior knowledge, to visualize.

However, it is not excluded that single learning aids can have several functions. The main goal of learning aids is to give students the opportunity to treat and solve math problems independently. Even if they fail at their first solution process, they can get a result with the help of the learning aids. Studies (Franke-Braun, Schmidt-Weigand, Stäudel & Wodzinski, 2008) show that stepped hints have a positive impact on learning performance, learning experience and communication.

3. State of The Art

3.1. GPS based applications

There are already many services provided on the web which enable GPS-based applications. An example for this is the Internet platform called Jogmap (www.jogmap.de). With the help of a smartphone it is possible to load running routes from this platform then run and finally send the run result back to the system. It is also possible to load its own running track in the system so that other people can "run after" this track. All over the world GPS technology is also mainly used by so-called geocachers. Geocaching is the modern form of the internationally popular scavenger hunt. Geocachers search special locations with the help of GPS devices or GPS-enabled smartphones. Treasures and logs to sign up are hidden at these places. The discovery of the treasure is reported to the platform, but the exact locality remains secret. The community only works on the mutual exchange of information. Consequently, one can also upload a cache on the platform (www.geocaching.com, (Taylor, Kremer, Pebworth & Werner, 2010)). Further applications of modern GPS technology can be found in GPS-based city guides, for example in Hamburg (www.itour.de).

3.2. Mathematical city guides and city hikes

In many cities, city tours with a mathematical focus are offered. In Germany, the Mathematikum (www.mathematikum.de) in Giessen, for example, offers mathematical city guides, too, in which people interested in mathematics get to know the city from a mathematical point of view. The idea to combine mathematics with a hike trail is relatively new. The preparation is intensive and at times at which internet platforms didn't exist, the information could be barely transmitted. Meanwhile, projects have been set up, for example a mathematical hike from Schaffhausen to Neuhausen am Rheinfall in Friedrichshafen (mathematik-in-friedrichshafen.jimdo.com) or a project of a summer school in Cuxhaven (www.mathe-spezialist.de).

3.3. School based applications

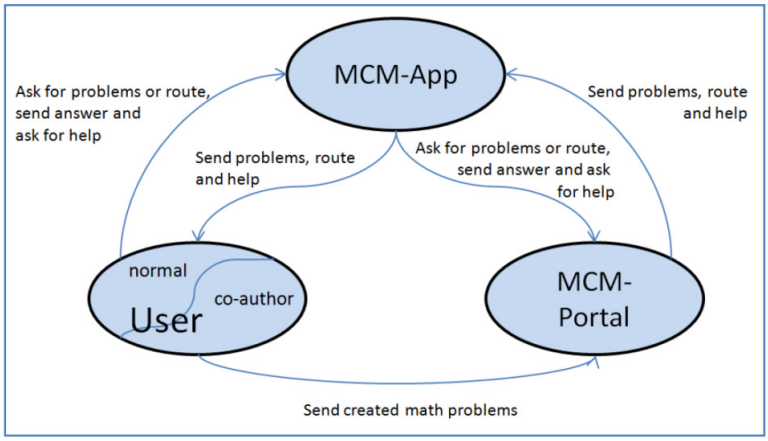
In schools you can also already find some applications which work with GPS-data. Thus, in the field of mathematical games one can find appropriate examples. In the context of the project MobileMath (Wijers, Jonker & Drijvers, 2010) a game was developed which allows students to walk along the shape of geometric objects outside of the school by using GPS devices. Here the number and size of the objects determines victory or defeat.
Further examples of combinations of GPS data with learning content are tasks in interactive maps. In this context tasks are positioned on interactive maps (e.g. Google Earth). Students can do these tasks on a computer by using the program and their mathematical skills (edte.ch/blog/maths-maps).

4. The Project

4.1. Technical implementation

As you can see in Fig.1 the technical implementation of the MCM project is made up of two main components- the MCM-portal and the MCM-app. In the MCM-portal, one can find the entire problems, corresponding GPS data and corresponding aids. In the portal, normal users (Fig.1) can put together the problems in which they are interested in by using the problem database. There are several options to narrow down the selection. Beside the selection of the start and end points of the route, you can choose the length of the route or the district in which the tasks should be given. Additionally, you can select the grade, the season, the level of difficulty, the topics, and the tools available (e.g. measuring tape).

Figure 1: The technical structure of the MCM-Project



In the MCM-portal the user can also participate actively (co-author user, Fig. 1) in the project. On the one hand, one has the possibility to create one's own tasks and deliver them to the math problem database. On the other hand, one can rate math problems from other users to ensure the quality. This portal is accessible to students/teachers from the Internet via computer as well as via smartphone and the MCM-related app.

Figure 2: MCM-app test version

The MCM-app (Fig. 2) is the second most important component of the technical implementation. The user receives the math problem on the spot via mobile internet and the app and the app shows one the particular route to the corresponding math problem. Furthermore, the request for additional help and the appropriate transfer from the portal is provided by the MCM-app.

4.2. MCM-math problems

As mentioned above the math problems are localized at certain places by the help of GPS coordinates. They deal with a local object or situation at a particular place. Depending on the object or situation, the tasks correspond to different topics of mathematics. An example for a problem of the MCM project is the following:

Figure 3: Example problem "Ludwig Erhard park"

4.3. Stepped hints

In addition to the math problems, the system sends hints on demand. This supports the user, who wants to solve a problem but stopped in the solution process. In the case of any further problems one can retrieve more and more concrete hints. At the end of the solution process the correct answer and a sample solution is provided. During the solving process the stepped hints fulfill the functions listed in the theory section. Stepped hints for the above mentioned problem are the following:

- Which shape comes close to water surface?
- Assume that the water Surface has the shape of a rectangle.
- The Surface of a rectangle is calculated as follows A_R= length x width.

If help for the task is required, the first aid will be sent. This should give the student a first idea for the solution of the task. If there are still any problems, the user has the possibility to ask the system for further help and one will get the next clue.

4.4. Answers

Another important component of the project is the entry of answers into the MCM-app by the user. There are various possibilities. Depending on the problem, students, for example, can choose between several possible answers and receive direct feedback concerning their correctness. For questions where they should approximate or estimate values, they get the literary value from the system after they entered their own conclusion. All answers are stored by the system, so that further conclusions can be drawn from this. Thus, the teacher can get direct feedback by the system on the individual solutions. The possibility to send answers to the system also provides the opportunity to collect statistical data on special places (e.g. streets) and to compare these data to previous entries of other users.

4.5. Usage scenarios

The MCM-project presents various opportunities for its realization in the practice.

Teachers who want to perform, for example mathematical hiking days or school trips with their classes can benefit from the MCM-project. They can do the planning stage prior to the start and the MCM-System point out possible devices and tools needed for the project (e.g. measuring tape, calculator, ruler…). Moreover, the math problems can also be used by teachers to spend time sensibly, for example by doing a sightseeing tour. The problem with this use is that the stepped hints cannot be made available individually or must be prepared by the teacher in a written form. Another disadvantage is that the use of youth-affinity technology is just in the hands of the teacher or single students.

However, students can also work with the MCM-tasks on their own. Guided by the teacher or on their own, students can use the MCM-app and the MCM-portal and work individually with the problems and stepped aids. In this case the stepped aids have the most practical function. Consequently, this is regarded as the optimal use because the intended positive aspects of the project become evident. If there is an insufficient number of smartphones, students should work in small groups.

The above mentioned active participation in the MCM-project, where co-author users (e.g. teachers) create tasks or evaluate tasks of other co-author users is another possibility to work with the MCM-project. The creation of math problems can be done by professionals (e.g. teachers, lectures), but also directly by the students. Then the personal tasks could be integrated in a personal math trail. The MCM-System allocates a password to the personal mathtrail. With this password everybody can start the personal mathtrail. When the personal tasks are reviewed by peers the personal task becomes a public task and everybody can see this task by starting the MCM system. This also provides a large field of application for projects at schools or seminars at universities. An example of the title of such a project could be "A math trail through ..."

5. Research Ideas

We have run the test version of MCM once and many research ideas occurs. Interesting questions which come up during the planning stage and the first run are, for example: How does this kind of mobile learning influence the learning and the students' attitudes towards math? How often is the portal used by students in their spare time or do they need a stimulus from the teacher? Do teachers accept those kinds of outdoor math-experiences? Does the intrinsic motivation increase by carrying out a MCM powered math-trail? How are the technical preconditions used? Will the stepped hints be used sensibly, or are they just used in order to come as quickly as possible to a solution? Which changes during or in the solution process of a student occur by the use of stepped hints?

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