What influences in-service and student teachers use of MathCityMap?

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At the Goethe University Frankfurt am Main a new digital tool was developed to easily create mathematics trails as a mathematical outdoor activity aimed at school education, called MathCityMap. Following the articles and studies of many others, the usage of a new tool is quite an issue for teachers. Following some teacher training activities offered by our team, we offer interim results of user behavior based on data from an online survey. Our results can be useful for the implementation other digital tools.

Keywords: Mathematics activity, handheld devices, computer uses in education, teacher education.

Introduction

In their publication "Learning Outside the Classroom" the English and Welsh Department of Education and Skills strongly recommended that more lessons should take place outside of the classroom. They listed many benefits "nurture creativity, develop skills, improve attitude to learning, stimulate and improve motivation" just to name a few. (DfES, 2006)

The advantage is quite obvious, going outdoors means to encounter real life objects. For mathematics education, it is possible to create authentic tasks such as: What is the height of a certain building? how many stones have been used to build that wall over there? how much water is in that pond? and so on. Tasks such as these immediately require many process competences such as problem solving, reasoning and proof, communication, connections and representations. In the early 1980s Blane and Clark proposed the idea to connect those kind of tasks to form a *mathematics trail*. This requires a map on which to find the tasks, a description of the tasks (both together is called the *trail guide*) and then you can start to walk around and solve mathematical problems. (Blane & Clark, 1984)

In short, a mathematics trail is a set of mathematical outdoor tasks in walking distance. To solve the tasks you normally will need tools like a measuring tape and so on, which should be listed in the trail guide.

Although mobile devices and computers are widely used in every aspect of our daily lives (especially among pupils), they play a small role in education (Chen & Kinshuk, 2005). Going on a mathematics trail could be greatly enhanced by the use of mobile devices, since they allow learning to occur in an authentic context and extend to real environments. At the Goethe University of Frankfurt am Main we started the MathCityMap Project (MCM) which combines traditional mathematics trails with the opportunities of new technologies. In 2013 the first ideas were made concrete

(Ludwig, Jesberg, Weiss, 2013), but it took until 2016 to finally launch an accompanying web portal and mobile application. These have been released mainly for teachers to use in class, but are openly available to anyone who wishes to use it.

In spring 2016 we started to promote mathematics trails in combination with MCM by providing in-service teacher training and student courses at the university. Although the feedback on the training and courses was highly positive, the real usage of the MCM tools falls short of our expectations. In this article, we investigate reasons for this phenomenon we have encountered.

Theoretical background

Challenges creating a mathematics trail

Many mathematical tasks today are contextualized and appear to be realistic. But are they authentic? Following the definition Vos (2011) has given, an object is authentic, if it is clearly not created for educational purposes. Consequently, it is not easy to find authentic tasks. The objects in the tasks of MCM can be described as real-life objects, however, the authenticity of the tasks depends on the creators. We provide assistance by offering training alongside best-practice examples.

Usually the creation process of a mathematics trail consists of designing appropriate tasks and the trail guide or trail booklet (Cross, 1997). On the one hand, creating the tasks can be challenging for teachers as studies have shown (Jones & Pepin, 2016). On the other hand, manually putting the tasks together into a trail guide which should also contain a map overview and a title page, may be time consuming.

Difficulties integrating new technologies into mathematics classes

Given the availability of new technology in schools, questions have always arisen such as, do teachers work with the new tools? how do they use them? and so on. Drijvers made a study in 2012 about the factors for successful use of new technology amongst teachers. One of the three important factors is the role of the teacher (Drijvers, 2012). In Germany, a majority of teachers report to have not enough time alongside their daily tasks at school (Schneider, 2015 p. 20). Consequently, the time a new tool needs to be set up is an important issue. The MathCityMap project tries to simplify the creation process of designing tasks and trails to make it less time consuming for teachers.

In addition, Kuntze, Siller and Vogl (2013) have shown that both pre-service and in-service teachers self-perception towards mathematical modelling is mainly negative. Especially the in-service teachers lack of knowledge about new technologies and modelling. They feel unprepared for modelling by their university education. Pre-service teachers on the other hand feel a lack of diagnostic pedagogic skills and feel unable to give good hints to the pupils. There is a difficulty to integrate modelling into classes, especially with new technologies.

GPS-based applications in mathematics education

Two examples of applications in mathematics education, that already successfully use mobile GPS-data, are Wijers, Jonker & Drijvers (2010), who developed a game which allows students to walk along the shape of geometric objects outside the school, and Sollervall and de la Iglesia, who have developed a GPS-based mobile application for embodiment of geometry (Sollervall & de la Iglesia, 2015)

The MathCityMap project

The intention of the MathCityMap (MCM) project is to automate many steps in the creation of the mathematics trail booklet/guide and to provide a collection of tasks and trails that can be freely used or just viewed to get inspiration for own tasks. Furthermore, it gives users (e.g. groups of pupils) the possibility to go on a mathematics trail more independently by using mobile devices' GPS functions to find the tasks location, by giving feedback on the users answer and by providing hints in the case that one got stuck at a particular task. The core of the MCM project can be divided into two parts, the MCM web portal and the MCM app.

MCM web portal - www.mathcitymap.eu

The web portal is a mathematics trail management system. After a short registration, the user can view public trails and tasks or create his own tasks and trails by typing in the necessary data (e.g. position, the task itself, the answer, an image of the object etc.) into a form (see Figure 1). For every mathematics trail, the mathematics trail booklet can be downloaded as PDF or accessed via the MCM App (see Figure 2). It contains all task information, a map overview and a title page.

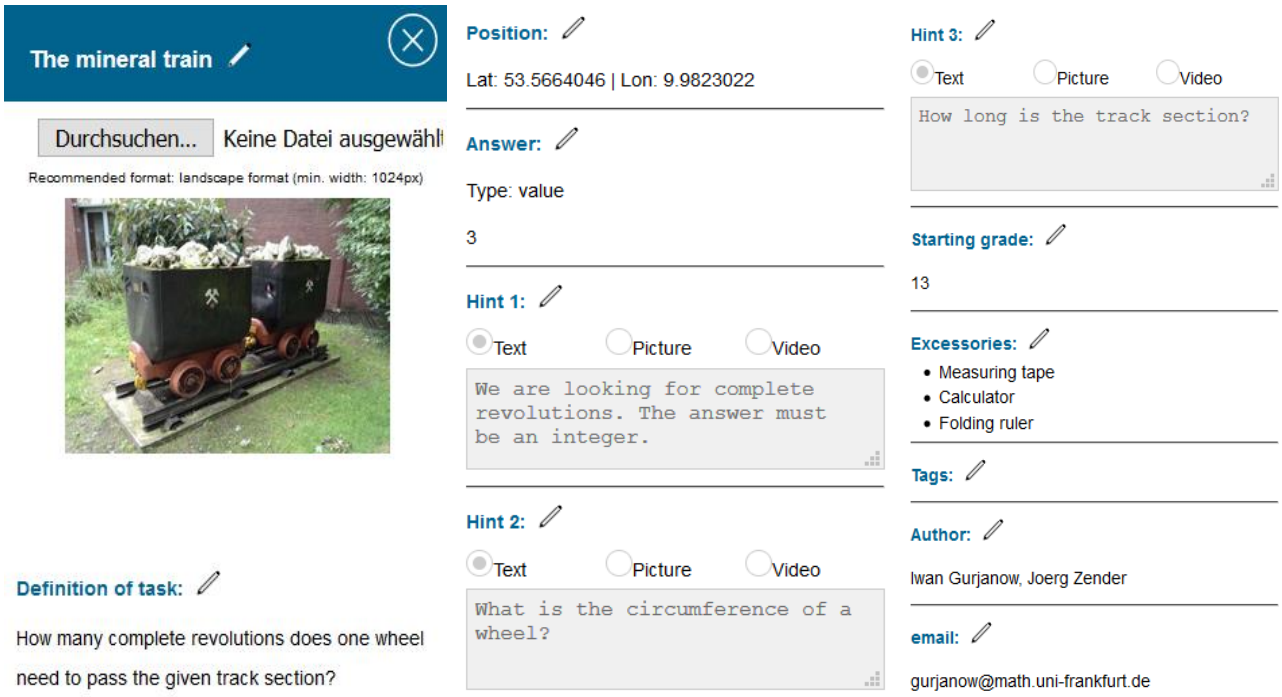


Figure 1: The MCM web portal form for tasks

MCM app for mobile devices

The MCM app allows the user to access mathematics trails created within the web portal. The trail data, such as images and map tiles, can be downloaded to the mobile device. After this procedure, it is possible to use a trail without an internet connection (see Figure 2). This design decision minimizes technical issues when using the app without mobile internet or in an area with low connectivity. Furthermore, the app offers an open street map overview for orientation purposes, feedback on the entered answers and a stepped hint system. The hint system enables pupils to solve the tasks independently and additionally has a positive impact on learning performance, learning experience and communication (Franke-Braun, Schmidt-Weigand, Stäudel, & Wodzinski, 2008).

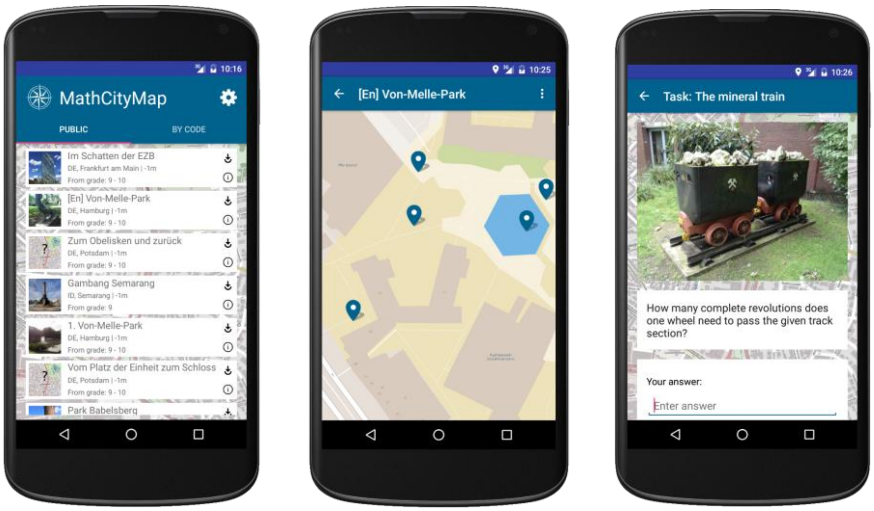


Figure 2: Screenshots of the MCM App

To describe the pedagogic functionality of MCM, we use the model by Drijvers, Boon and Van Reeuwijk (2010). It divides digital technologies into three groups of didactical functionalities: (a) do mathematics, (b) practice skills, (c) develop concepts. MCM offers mathematical tasks at real life objects where the user mainly can practice his skills.

Research question

Following the teacher training events, we had expected more teachers to become active by creating own mathematics trails with MCM. This leads us to the research question:

Why do (and don't) in-service teachers and student teachers use MathCityMap? By this question we follow Drijvers study of the usage of digital tools by teachers (Drijvers, 2012).

Methodology

To promote MathCityMap as a digital tool (and therefore the usage of mathematics trails in school) we have implemented three teacher trainings with 143 participants and two university student courses with 30 students during spring/summer 2016. To evaluate the trainings and gather further information for future improvements of the MCM tool, an online questionnaire was created. Additionally, we have analyzed the usage statistics.

Teacher training

The training is a half-day intensive training for in-service teachers. Since they have already studied mathematics and have a lot of teaching experience, we keep the theoretical parts on outdoor mathematics and task design rather short and prefer to go out on a prepared mathematics trail so they can experience this kind of activity. Later on, we also let them find tasks and focus more on the handling of the web portal and the app. After this course every teacher will have experienced doing mathematics outdoor with MCM, but also how to create new tasks in the web portal.

Student courses

The student courses took place at Goethe-University in Frankfurt (11 students) and the University of Potsdam (19 students) in the summer semester of 2016. The following topics formed part of the seminar: Theoretical introduction to mathematics trails, introduction to the MCM App and going on

a mathematics trail with the app, aspects of outdoor task design, creating new tasks and setting them up in the MCM web portal, arranging a mathematics trail, testing the trail with a school class (grade nine), reworking the trail, testing the trail with another class (grade eight). Compared to the teacher trainings the students had to really engage themselves in mathematics trails with MCM.

Online survey

About 200 people (143 participants of the teacher trainings plus registered users of the web portal), who have agreed to receive e-mails about MCM, were invited to take part in the survey. Twenty (eight students and twelve teachers) of them completed the questionnaire.

The online survey consists of 27 items, from which twenty are closed questions or statements and seven are open text fields. The questionnaire is divided into five sections:

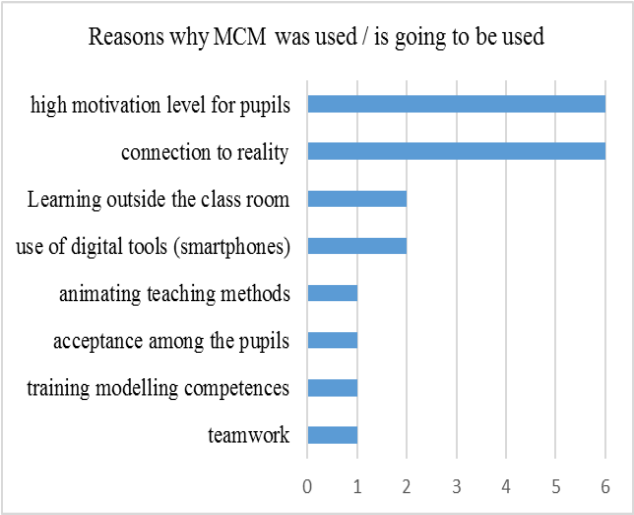
1. General Information (Five closed questions)
   Sample item: How did you hear about MathCityMap?
2. Usage of the MCM web portal (Seven mainly closed questions)
   Sample item: Do you already have created a task in the web portal?
3. Statements about the MCM web portal (Seven 5-point Likert scale items: I do not agree – I agree)
   Sample item: The interaction between web portal and app is easy to understand.
4. Feedback on MCM (Four mainly open questions)
   Sample item: Which are the reasons for you to use MathCityMap?
5. General use of digital tools in mathematics classes (Four closed and open questions)
   Sample item: What are your requirements for using a digital tool in mathematics classes?

Results

Questionnaire

Four of twelve teachers stated that they had created their own tasks. Two of them had already used the mathematics trail with a class. All eight students had created tasks and went on a mathematics trail, because it was part of the seminar.

Due to the low number of participants we report the reasons why MathCityMap was used or is going to be used and the reasons why it was not used yet in a qualitative way by forming categories. The answers were collected by an open text field, so multiple reasons could be given. The following categories are sorted by the number of mentions.



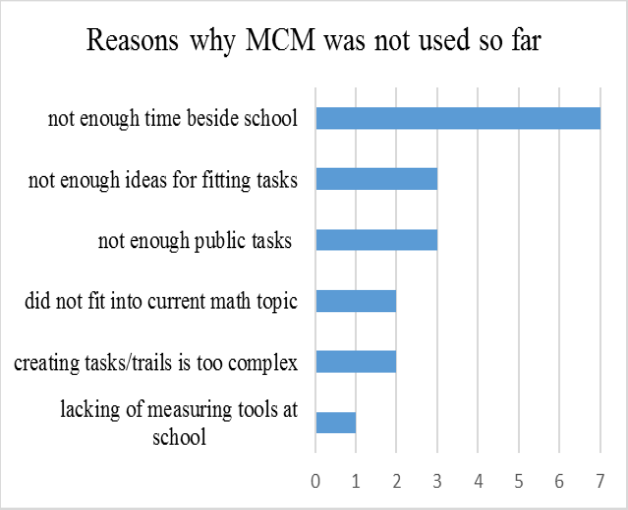


Figure 3: results of the survey about the reasons for using / not using MCM (13 / 8 persons in total, open text answers)

If we take a look at the things teachers do require from a digital tool to be used by them, MCM is doing quite fine. MCM is easy to get and free to use. It is not time consuming to learn it and some of the teachers already have positive experiences (see Figure 4).

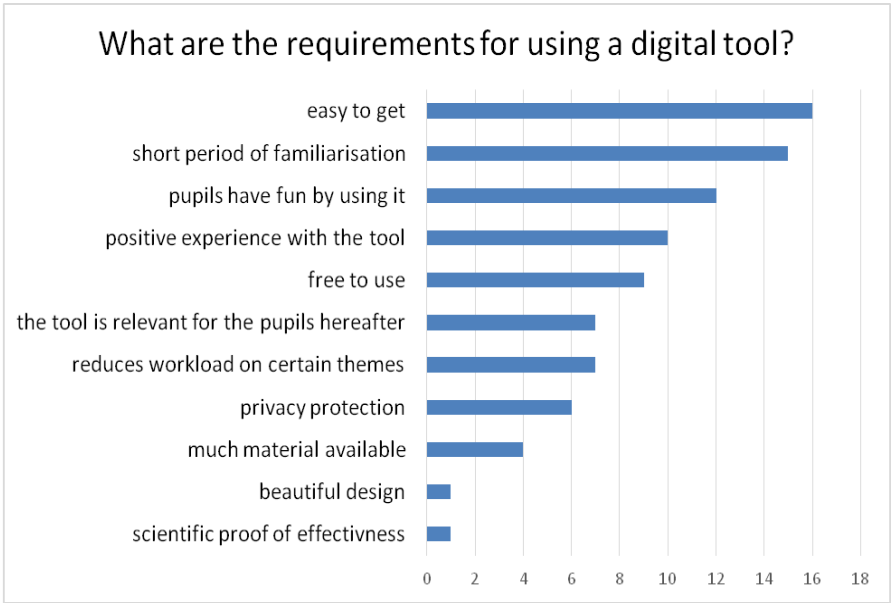


Figure 4: results of the survey about the requirements to use a digital tool in class (17 persons in total, preset answers, several selections possible)

Usage statistics

Independent of the online survey, we also analyzed the statistics relating to the web portal and the app to describe the current state. In September 2016 74 users were registered in the web portal. Thirty of these were in-service teachers who participated in the trainings, about 20 were students who were part of the student courses. The other users were not part of the trainings or courses. In total 33 unique users (45%) created 140 tasks. About 25 mathematics trails were created by 22 unique users (30%). The app has been installed 210 times which means that there must be some people who use only the app, without being registered in the portal (e.g. pupils).

Discussion

MathCityMap as a digital tool seems to be mainly used as the mathematics trail idea is considered positively (high motivation for students and connecting mathematics to the reality). Hereafter the integration of digital tools in mathematics classes is another reason to use MCM (see Figure 3).

The lack of time, difficulties in creating appropriate tasks and the integration into the current lessons are the most mentioned reasons for why MCM had not yet been used. However, the findings also suggest that the task and trail creation processes in the web tool might be too complex at its current state (see Figure 3). All of these reasons could be interdependent. If one has difficulties in finding tasks or difficulties in integrating the mathematics trail into the lessons, it will take more time to solve these problems. Since many teachers report that they are short of time, this might lead to not using MCM (Kuntze, Siller, Vogl 2013, Schneider 2015).

Conclusions

In our case the reasons for not using the tool (web portal and app) were mainly identified not in the tool itself, but in the mathematics trail concept (creating tasks, implementing the trail in classes). The teacher training events and student courses need adjustments so that they pay more attention to the following identified difficulties:

1. Higher focus on task design – guidance, best practice examples, blueprint tasks which can be easily adopted to the participants' school surroundings.
2. Creating a teaching concept – concrete example of how to integrate mathematics trails in combination with MCM into mathematic lessons for a particular topic.

In addition, 'doing mathematics outdoors' could be integrated into the school curriculum to increase its significance. On the technical side, further research is needed on how to improve the usability of the MCM web portal to make the creation process more intuitive.

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