ANALYSIS OF STUDENT-TEACHER CHAT COMMUNICATION DURING OUTDOOR LEARNING WITHIN THE MCM DIGITAL CLASSROOM

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Abstract. *Mathematics trails offer students the possibility to apply their knowledge in authentic outdoor contexts. Organizing and carrying out such an activity is a challenge for teachers. The MathCityMap project digitizes the math trail idea and consists of a smartphone app for students to run math trails and a web portal for teachers to create math trails. Recently, a new feature called the 'digital classroom' was introduced, which allows teachers to track their students' progress in real-time and communicate with them via chat., offering the teachers the possibility to give synchronous feedback. In this article, we examine the use of the chat functionality against the theoretical background of challenges of outdoor learning environments and how technologies help to overcome them. A quantitative analysis of ten Digital Classrooms used in authentic settings shows that more than half (54.3%) of the messages sent in total during those sessions were about organizational aspects, whereas 26.4% contained didactical aspects. We therefore conclude, that the Digital Classrooms provides teachers with a valuable functionality for the conduction of math trails.*

Key words: math trails, mathematics, smartphone, app, mobile learning, learning analytics

INTRODUCTION

Mathematics in out-of-school situations is a proven concept for popularizing mathematics and offers many possibilities for use in the school context. As early as the 1980s, Blane and Clarke (1984) published a so-called math trail, which enabled interested individuals and families to take a tour in the city of Melbourne where mathematics could be discovered. For this purpose, the authors designed mathematical questions on interesting objects, which were intended to encourage visitors to discuss, calculate and develop questions. Ludwig and Jesberg (2015) presented the idea of combining the concept of math trails with the opportunities of modern smartphones in the MathCityMap (MCM) project. This article aims to identify potentials and challenges of math trails in general, and to examine the use of the chat functionality of the newly developed Digital Classroom.

THEORETICAL BACKGROUND

Benefits of outdoor learning

Sauerborn and Brühne (2009, p. 79) list the possibility to make first-hand experiences, illustrative tasks, increased interest and the possibility to make connections between subjects as theoretical benefits of outdoor learning. Numerous studies confirm these theoretical advantages. Falk and Dierking (1997, p. 211) report that about 96% of the participants have long lasting memories of excursions and could re-call details, such as activities or other participants, even years after the event. In a study with 60 twelve to fourteen years old, Wijers, Jonker and Drijvers (2010, p. 789) asked the students to construct parallelograms (also special cases of parallelograms, such as rectangles or squares) outside the classroom and with the help of a native smartphone app that uses GPS.

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The study authors report that the participants were highly motivated and learned about using the GPS-system, reading maps, and constructing parallelograms.

In a case study, Swedish researchers investigated the experience of regular, extracurricular learning of 14 students in lower and middle school (Fägerstam & Grothérus, 2018). Over a period of three years, one lesson per week in mathematics and German (third foreign language) was taught in the schoolyard. The following student quotes demonstrate that learning outdoors has triggered positive emotions in the students.

> I am not so good at maths, I don't know why; I must be born that way. But, sometimes it is fun. To be able to learn you need to think that something is fun, otherwise it doesn't work. With outdoor lessons you don't get bored and you learn easier and don't think it is quite as boring anymore. /…/ They [teachers] should do it [have outdoor lessons] because you can sense how students enjoy it and they pay more attention.
> Nelly, grade 9
> (Fägerstam & Grothérus, 2018, S. 383)

In this quote it is clear that the student finds it easier to learn mathematics when she enjoys it. This seems to be the case with out-of-school learning, which is why she advocates more outdoor teaching. Another student in the ninth-grade stresses that, unlike in the classroom, one can try out procedures practically outside (Fägerstam & Grothérus, 2018, p. 383). This statement speaks for the vividness of tasks in outdoor learning.

Mathematics Trails – Outdoor learning environment for mathematics classroom

Mathematics trails are one way to learn mathematics outside the classroom. According to Shoaf, Pollak and Schneider (2004, p. 6) a mathematics trail is "… a walk to discover mathematics". It can be almost anywhere and a so-called math trail guide "… points to places where walkers formulate, discuss, and solve interesting mathematical problems" (ibid.). In the context of mathematics education in schools, math trails offer opportunities for application of mathematics in real, authentic situations, as well as the modelling activities that precedes the calculations (Gurjanow, Oliveira, Zender, Santos & Ludwig, 2019). The major advantage of math trails over stationary learning facilities like mathematical museums or student labs is the spatial independence. Therefore, teachers may implement their own outdoor learning activities in the near surrounding of their school.

Methodologically, math trails are a form of learning at stations that takes place outside the classroom. Usually, students form groups of three and follow the math trail guide to work independently at the stations. To prevent task stations from getting too crowded, we recommend assigning every group a different starting position. The first empirical study on math trails was probably done by Kaur (1992). Kaur sent 20 students on a trail in the first attempt and developed a questionnaire with ten items in a pre-post design, which is to measure the attitude towards mathematics. It represents a significant difference: the students are aware of the mathematics around them have become more conscious and now see mathematics much more positively than before. Cahyono (2018) and Zender (2019) examined the influence of running math trails on the mathematical performance empirically (using a pre-post-test design). Both conclude that students could improve their scores significantly. In contrast to the Indonesian study (Cahyono, 2018), the significant results of the German study (Zender, 2019) are limited to students that ran a math trail twice and were part of the group of middle-achievers.

Challenges of mathematics trails

There are two main concerns that we will address in this article. The first issue arises from the spatial separation of the math trail tasks, which leads to a loss of overview for the teacher. Consequently, the teacher loses the ability to quickly make organizational adjustments or to support students in case they were stuck. Secondly, we know that learners with low prior knowledge are more likely to be overwhelmed by tasks that require them to take responsibility of their own learning process (Edelmann & Wittmann, 2012). Hence, the outdoor experience may turn into frustration and the students will not continue working on the math tasks.

THE MATHCITYMAP PROJECT (MCM)

The idea of MCM

During the last four years the working group MATIS I in Frankfurt develops a digital tool to support outdoor education with math trails (Ludwig & Jesberg, 2015). By means of the math trail method, students can explore their environment with a focus on mathematics. In the past, it was quite a challenge to create a math trail. The MathCityMap system provides a simplified, digital way of creating and sharing tasks and math trails.

Components of MCM

The MathCityMap system is a two component system that consists of a web portal and an app. The web portal (www.mathcitymap.eu) is a database that can be used to create tasks and trails. A trail is a collection of existing tasks. Those can be either private or public. All tasks are private by default. By request of the task owner, an expert review can be done. A task that fulfills the best practice aspects of MathCityMap will be published and made available for all users. Public tasks can be owned by another member of the worldwide community. The aspect of sharing one's work with others is one of the core features of the portal. The expert review system ensures the general quality of public tasks and trails.

The core feature of the MathCityMap app is giving access to math trails, which were created on the web portal. After downloading a trail to the mobile device, it is possible to run the math trail offline. The MathCityMap app guides students by GPS navigation to the next task, provides hints on demand (for each task the app displays up to three stepped hints) and gives an immediate feedback on the correctness of a students' solution. Depending on its quality, groups receive up to 100 points per task. Finally, the app also provides a sample solution, which can be viewed immediately after solving a task or giving wrong answers for at least six times. Providing a sample solution is mandatory for any author during the creating process of a task. This way, learners can always complete a task with a correct solution, even if they were unable to find the solution themselves.

The Digital Classroom

With the Digital Classroom, MathCityMap provides an educational environment that has three core features (see Figure 1). The GPS monitor shows the teacher where the students are and which tasks they are currently working on. It is also possible for the teacher to monitor the students' path and to instruct them, if they are walking into the wrong direction. It is one of the basic ideas of the Digital Classroom to reduce problems that occur in terms of organization. The chat function, which is meant to act as a channel for direct supervision, enables the teacher to provide instructions or a differentiated help for learners. In addition, students can have some of their interim results (e.g. measurements) validated by the teacher. Therefore, MathCityMap offers multiple feedback sources, as a combination of asynchronous (predefined hints) and synchronous (direct supervision) feedback. The third function is a log for process data which has the use of an e-portfolio. It is designed as an evaluation tool and contains information on the progress along the math trail for each participating small group. This includes, for example, the number of tasks processed so far, taken hints and the answers entered. The information obtained through the e-portfolio can be used for diagnosis and can be incorporated into further lesson planning. If for example

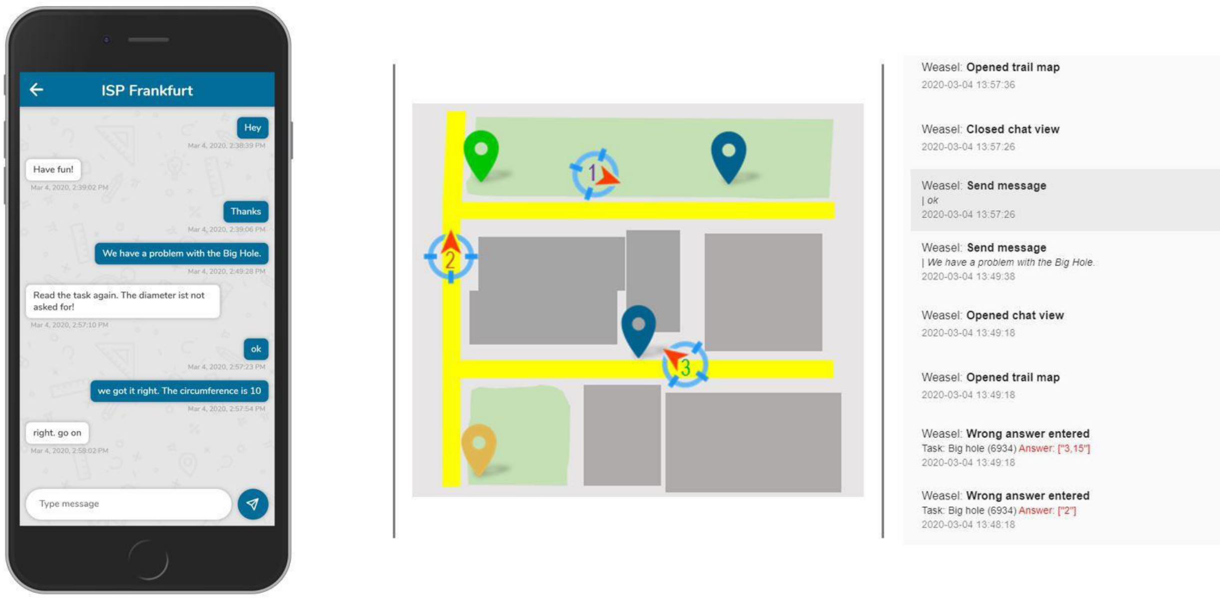

Figure 1: Left) The chat window. Middle) The tracking tool. Right) The event log.

RESEARCH INTEREST

The previous sections identified potentials and challenges of mathematics trails as a way to learn mathematics outside the classroom. To face these challenges, the MathCityMap Digital Classroom was developed. As described, one of the core features is the chat functionality. Since the introduction of the new feature in 2019, many data could be gathered in order to examine the use of the chat tool by teachers and their students and how they make use of it to deal with the above-mentioned challenges.

EVALUATION OF THE MCM DIGITAL CLASSROOM

Choice of Methodology

The number of messages sent during the conduction of a digital classroom by itself can be used as an indicator of the total usage and overall acceptance of the tool, but cannot give us further insights into the way and purpose it is used for. Furthermore, many Digital Classrooms are created for teacher trainings and as a test run by teachers themselves before employing it in their classes. The unfiltered data thus contains many unauthentic test cases. To answer the research interest about the way the Digital Classroom is used, a qualitative analysis of a selected number of Digital Classrooms used in authentic settings seems therefore preferable.

Data selection

All in all, since its introduction as a tool for MCM, the Digital Classroom has been used to create 417 sessions with at least two groups, sending in total 1.262 messages between the creator of the Digital Classroom and the participants. Out of those 417 sessions, 264 were created in English or German, and thus available for our analysis.

Furthermore, we wanted to analyze the communication between teachers and students from an authentic setting, as the Digital Classroom is also used during teacher trainings by MCM educators. Based on the title of the session, we could therefore again discard several sessions. Other criteria were the number of participating groups (at least five) and the duration of the session (at least an hour). Out of the remaining data, we chose the ten sessions with the most messages sent. Those ten sessions were created by ten different teachers, offering also a variety within this data sample.

Qualitative Analysis and categorization

Overall, 87 student groups participated in the selected Digital Classrooms, sending in total N = 368 messages. By assuming that a group consists of three students and a Digital Classroom is led by one teacher, we can estimate the total number of participants at about 261 students and 10 teachers. Since we do not collect personalized data within Digital Classrooms such as names, genders or age to comply with the European GDPR, the age of the students can only be estimated to be between 14 and 18 (grade eight to grade twelve) by the math trails they walked.

Theoretically, we expect the chat tool to be used for organizational or didactical purposes (see the challenges section above). Due to this reason, we conducted a qualitative analysis of the send messages and categorized them as (1) organizational, (2) didactical or (3) other. We categorized an exchange as organizational (1), if the content of the messages was about the course of the math trail, i.e. the time, problems and technical issues, meeting points and information regarding the leaderboard. When the context of the messages was about mathematical aspects regarding the tasks, we attributed them to the second category, as didactical (2). Everything else was sorted into the third category, other (3).

Results

Firstly, we want to give examples of messages sent between a teacher and a group of students about organizational aspects (1):

> Teacher: It is possible that the trail automatically closes at 12.00. If so: we meet at 12.15 at the subway station.

Here, the teacher uses the Digital Classroom to give information about the meeting time and place for when the session is over. Sometimes the tasks weren’t solvable due to missing or shut off objects:

Group:	The well isn't running.
Teacher (to Group):	Then you can't solve the task. Pity.
Teacher (to all):	The well isn't running. Skip that task.

After receiving the information, the teacher used the chat to remotely inform all groups to skip the corresponding task. The following exchange gives us insights on many different levels.

Teacher:	Are you cheating? You are very fast!
Group:	we are just running
Group:	We don't have that much time left

Firstly, the teacher obviously used the event log of the Digital Classroom to have a closer look at the course and required time of the students to solve the tasks. Secondly, the responding group was highly motivated to solve the tasks as fast as possible, making them even run. Other messages we categorized under organizational aspects were messages sent to remind the students about the remaining time, to solve technical issues or to motivate the students by pointing out the current leaders when the gamification option was used during the session. Out of the 368 messages sent in total, the exchange of 200 messages (54.3%) was about organizational aspects of the trail

We want to give an excerpt of one of the longest exchanges in a didactical context.

Group:	Should we round off?????
Teacher:	Sorry for which task?
Group:	Solid of revolution.
Teacher:	yes, that is ok
Teacher:	but that shouldn't matter for this task
Teacher:	What did you measure?
Group:	41cm
Teacher:	You should get a correct result with that. Did you consider the binomial theorem?
Group:	Yes
Teacher:	Then there has to be an arithmetical error. Did you integrate correctly?

In the end it turns out that the teacher made a sign error. In this case however, the students initiated the communication and used the Digital Classroom to get in touch with the teacher when they couldn't solve the task anymore. This exchange in the chat tool resembles a lot a conversation taking place in a real classroom. 97 messages (26.4%) were sent in the context of mathematical aspects, i.e. the teachers giving additional information, correcting a task or the students requesting help during the solving process.

Salutations and other informal communication took up the remaining number of messages, accounting for a 19.3% of the sent messages.

Our findings are summarized in Table 1.

	Category 1 - Organizational	Category 2 - Didactical	Category 3 - Other	Total
Students	72	38	47	157
Teachers	128	59	24	211
Total	200	97	71	368
%	54.3%	26.4%	19.3%	

Table 1: Categorization of messages sent during ten trails.

DISCUSSION

As expected, the teachers used the chat tool foremost to make organizational adjustments or to give organizational information, as well as to support the groups individually on a didactical level during the solving process. Not surprisingly, the spatial separation and different, often unforeseeable situations outside of the rather predictable environment of the classroom lead to a higher need of commutation of organizational aspects. The lower number of messages with didactical content can be explained by the available hints inside the MathCityMap system to each of the tasks, resulting in less required support during the solving process. Furthermore, a math trail is usually run as group consisting of three students. Before consulting the teacher, the students therefore most likely already discussed the problem amongst themselves and helped each other. Especially the need of didactical support is thus already lower in comparison to the setting inside the classroom, when the students work on the tasks individually. The communication between a single student and the teacher could thus be again different.

A finer analysis taking also the party initiating the communication into consideration could give further insights in the way the communication takes place. We also cannot exclude the possibility that the teachers used other channels to get in touch with the students during the conduction of the math trail to give additional advices.

CONCLUSION AND OUTLOOK

As shown in our qualitative analysis, the Digital Classroom provides the teachers with the possibility to address the aforementioned challenges while conducting outdoor learning. Currently the transmission of pictures and audio files over the chat is in development, offering the students and teachers another way to exchange information fast and easily. As a follow up to the analysis conducted in this article, it could be studied how this new functionality yet again changes the way and nature of the communication between teachers and students. Using the event log of the Digital Classroom, further research regarding the solution process of students like the usage of hints, the required time for specific exercises and the use of the sample solution could be conducted. Based on the chronology of the events in combination with the communication, it would be possible to make further conclusions about the need and efficient nature of asynchronous support in the form of hints.

As already mentioned, the math trails are usually run by a group of students with different roles. An analysis of the communication between the students during the solving process would also be interesting.

In conclusion, the digitalization of the math trail idea using the possibilities of modern technology together with the features of the Digital Classroom inside MathCityMap offers teachers a meaningful way to re-gain control in an open and outdoor learning environment.

References

Blane, D.C., & Clarke, D. (1984). *A Mathematics Trail Around the City of Melbourne*. Monash Mathematics Education Centre, Monash University.

Cahyono, A. N. (2018). *Learning Mathematics in a Mobile App-Supported Math Trail Environment.* Springer International Publishing

Edelmann, W., & Wittmann, S. (2012). *Lernpsychologie*. Weinheim: Beltz Verlag.

Fägerstam, E., & Grothérus, A. (2018). Secondary School Students' Experience of Outdoor Learning: A Swedish Case Study. *Education, 138*(4), pp. 378-392.

Falk, J. H., & Dierking, L. D. (1997). School Field Trips: Assessing their long-term impact. *Curator*, *40 (3)*, 211-218. Accessed on March, 2nd 2020 at https://onlinelibrary.wiley.com/doi/abs/10.1111/j.2151-6952.1997.tb01304.x

Gurjanow, I., Oliveira, M., Zender, J., Santos, P. A., & Ludwig, M. (2019). Mathematics trails: Shallow and deep gamification*. International Journal of Serious Games, 6 (3)*, pp. 65–79.

Kaur, B. (1992). *Attitudinal outcomes from environmental activities*. Lecture at the 6th Annual Conference of the Educational Research Association. Singapur.

Ludwig, M., & Jesberg, J. (2015). Using Mobile Technology To Provide Outdoor Modelling Tasks - The MathCityMap-Project. *Procedia - Social and Behavioral Sciences*, 191, pp. 2776-2781.

Sauerborn, P., & Brühne, T. (2009). *Didaktik des außerschulischen Lernens*. Djurcic, Schorndorf: Schneider Verlag Hohengehren GmbH.

Shoaf, M., Pollak, H., & Schneider, J. (2004). *Math Trails*. Lexington: COMAP.

Wijers, M., Jonker, V., & Drijvers, P. (2010). MobileMath: Exploring mathematics outside the classroom. *ZDM: The international journal on mathematics education*, 42(7), 789–799. doi:10.1007/s11858-010-0276-3.

Zender, J. (2019). *Mathtrails in der Sekundarstufe I: Der Einsatz von MathCityMap bei Zylinderproblemen in der neunten Klasse.* Münster: WTM-Verlag