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MathCityMap: Motivating students to engage in mathematics through a mobile app-supported math trail program

1. Introduction

Mathematics has functions in daily life – both individual and social – and occupational life. However, public understanding of mathematics is unsatisfactory and only a few are involved in mathematics during their schooldays with pleasure (Behrends, 2009, p. 1). At school, and globally, mathematics is sometimes perceived as a difficult and abstract subject. Internationally, by the eighth grade, only about one-fourth enjoys learning mathematics (Mullis et al., 2011, p. 325). It leads mathematicians and mathematics educators to think of popularizing mathematics to the public. A variety of projects in numerous countries took place to raise public awareness of mathematics. The MATIS I Team from Goethe University Frankfurt has also given attention to this subject by developing the MathCityMap-Project, a project of mobile app-supported math trail program. Since 2013, this project began to be implemented in Indonesia, tailored to the country's situation. In the first study, the math trails have been designed in several locations and a mobile app was also created (Cahyono, Ludwig, & Marée, 2015). Subsequently, in the second study, students have carried out the mobile app-supported math trail program and we explored its potential to motivate students to engage in mathematics. Further, we report the results of this study through this paper.

2. Theoretical Framework and Research Question

A math trail is a path to discover mathematics (Shoaf, Pollak, & Schneider, 2004). Trail walkers explore mathematics by following a planned route and solve mathematical outdoor tasks related to what they encounter along the path. It is constructed to develop an appreciation and enjoyment of mathematics in daily situations (Blane & Clarke, 1984). Almost all places that allow for safe walking provide opportunities for educators to construct math trails that contain several mathematical outdoor tasks. The trail should be enjoyable, a rich experience of mathematics and encourage all students to use what they know. The tasks should be interesting, challenging, supporting invention, encouraging obtaining new knowledge, promoting discussion, and fun. They are varied (in topics and places) and might be connected to other subjects. In outdoor locations, there are special sites where mathematics can be experienced on a daily basis. These locations (e.g. school area, market, and city park) provide numerous ideas for constructing math trails that contain several mathematical tasks. Sometimes, the task locations are hidden and become covert. In this project, these sites with mathematical challenges are localized by GPS (Jesberg & Ludwig, 2013). Subsequently, the tasks are pinned into a manual or digital city map. Students can access them by utilizing manual guide set or a GPS-enabled mobile phone application. They follow a planned route, discover the task locations, and answer the tasks related to what they encounter along the path; further, they continue with the subsequent tasks. Information, guidance, and direction on how to access or download the app and manual guide set are provided in www.mathcitymap.eu.

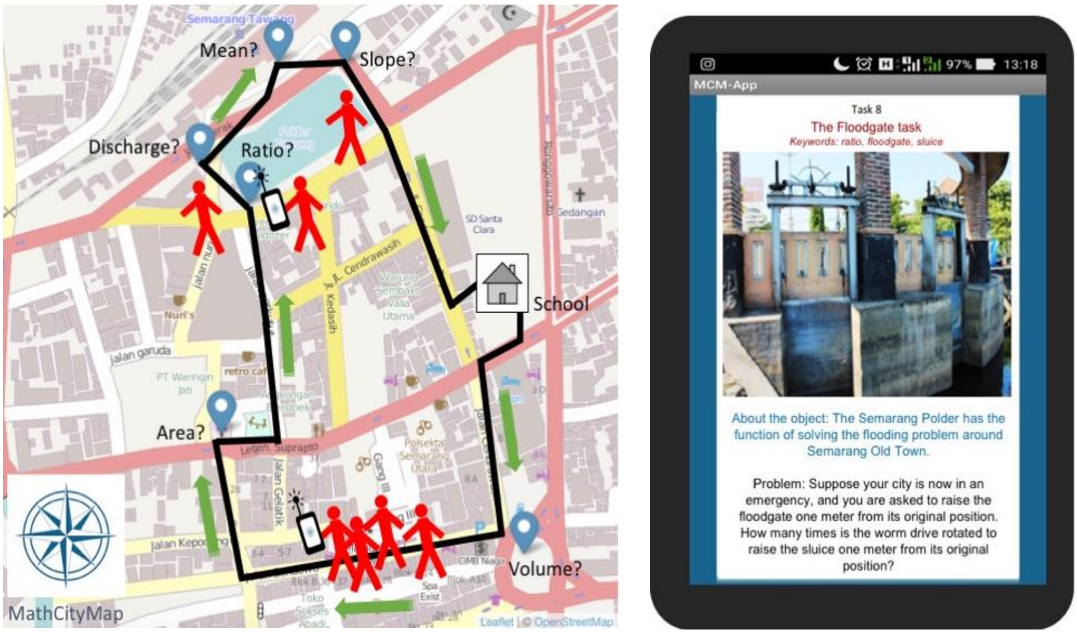

Figure 1. Illustration of technical implementation (Map: ©OpenStreetMap contributors) and an example of the interface of the app

The project aims at sharing mathematics with the public (especially students), encouraging them to be more involved in mathematics, increasing their motivation to engage in mathematics. Students' motivation can be characterised as having both an intrinsic and an extrinsic pole: preference for challenge against preference for easy work assigned (PC), curiosity/interest against pleasing the teacher/getting grades (CI), independent mastery against dependence on the teacher (IM), independent judgment against reliance on the teacher's judgment (IJ), internal against external criteria for success (IC). These five dimensions of learning orientation were defined by Harter (1981). The question was: *how can the mobile app-supported math trail program promote students' motivation to engage in mathematics?* The question 'how can' means that our research not only aims to discover the effect, but also explore the conditions that enhance the affordances the math trails offer.

3. Method

A field experiment was carried out by arranging a sequence of pilots, which involved 272 students from eight secondary schools in the city of Semarang.

These schools represent three school levels (high, medium, and low) and two locations (downtown and uptown). In this study, math trails were supported by the use of a GPS-enabled mobile phone application as a tool and guide for students. The implementation consisted of an introduction session, math trail run with the use of the mobile app, and debriefing session. Researchers observed activities and subsequently, interviewed participants. A questionnaire developed by Harter (1981) was also filled in by students. Further, qualitative and quantitative methods were employed to analyze the data.

4. Results

Thirteen math trail routes containing 87 mathematical outdoor tasks were designed around the city of Semarang and a mobile app was also created to support the program (Cahyono, Ludwig, & Marée, 2015). Field experiments were then conducted with 272 students and nine mathematics teachers. Before and after the activities, the questionnaires were completed by the students. Findings indicated that the mean scores for before and after implementation were: 3.74 vs 4.37 for IC; 3.64 vs 4.45 for PC; 3.39 vs 4.39 for CI; 3.91 vs 4.44 for IM; and 3.39 vs 4.34 for IJ. The result of the Mann-Whitney U test showed that p values for all dimensions were 0.000 (less than 0.001). This shows that the students' motivation in these two conditions was significantly different. Compared with the initial conditions, there was a change in the orientation of students' motivation from extrinsic to more intrinsic. The open-ended questions resulted that 30% of students were delighted to engage in this activity because it was conducted outside the classroom, an unusual setting that offered comfortable conditions and it was a free and fun activity. The use of mobile devices for outdoor mathematics learning activities has become an attraction, encouraging 23% of students to engage in this activity. 18 % reported that they learned how to apply mathematics in the real world. 16% liked collaborating, and 11% reported a different reason or did not give a reason. To clarify these findings, here is given a case for an example. The example is about the students' work on the flood gate task (Figure 2). The problem statement can be seen in Figure 1. This task is situated at one of the tourist attractions, an icon of the city, namely the Old Town area of Semarang City. All students agreed this was a pleasant place for learning math. Not only the location was exciting for them, the task was also considered by students to be a meaningful mathematical task because it was an important issue for them as citizens to know how this floodgate works. This way, they could save their town if there was an impending disaster.

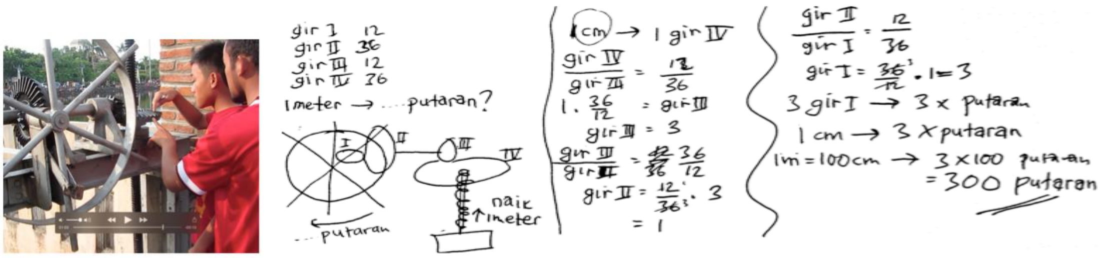

Figure 2: Students work on the flood gate task

Figure 2 also shows that students have been studying and practicing the mathematizing process in solving the problem. Working in the environment to find the hidden task location was interesting and challenging for the students. Here, students recognized the importance and attractiveness of utilizing a GPS-based mobile app as a navigation tool in the math trail activity.

5. Conclusion

We conclude that the MathCityMap-Project was successful in designing and offering an engaging activity for students. Students enjoyed and gained experience in mathematics through these activities. They were highly intrinsically motivated to be engaged in mathematics activity. The design of the learning environment, the use of a mobile app, and the value of the mathematical tasks have contributed to this result. Further research is essential for project development and implementation in other places/cities with different situations.

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