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Mobile technology in a mathematics trail program: how does it works?

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Abstract

The aim of the study is to explore the potential of the use of mobile technology for supporting mathematics trail program. An explorative study was conducted in of Semarang, Indonesia involving 30 students of SMPN 10 Semarang. The study consisted of an introduction session, a mathematics trail activity supported by the use of mobile phone application session, and a debriefing session. The data collection was done through participatory observation, students' work, and interviews. Afterwards, the results of this study indicate that mathematics trail programs supported by the use of mobile phones have promoted the engagement of students in mathematical activities. The use of mobile technology has the potential to support the program. Mobile app has been able to play a role in guiding students in mathematics trail activities with features offered, such as: navigation features, help buttons, and direct feedback.

1. Introduction

In recent years, several countries have seen an increase in interest in the development of outdoor and adventure education (Fägerstam, 2012; Higgins & Nicol, 2002). Various educational programs conducted outside the classroom are specifically designed to improve student achievement. In addition, integrated programs are also being developed to combine outdoor learning advantages with learning in the classroom. This type of educational program is not a new one. In 1984, Dudley Blaine had developed the concept of mathematics trails as one form of outdoor education by creating a mathematical trail in the centre of Melbourne, Australia (Shoaf et al., 2004). Math trails bring students into the outside the classroom to discover mathematics in the environment with its aim to create the atmosphere of challenge and exploration.

Although the math trail project is not new, the idea of this program supported by mobile technology which is new. This idea is facilitated by the fact that in recent years, developments in mobile technology and mobile phone have significantly improved (Cisco, 2016). These improvements are followed by many mobile phone applications (apps), including those which intend to be used for outdoor activities. However, up until now, most mobile technology apps for mathematics learning have only been employed in regular teaching settings (Trouche & Drijvers, 2010). Even though, in learning activities, mobile devices could be employed to promote the learning in the outside of the classroom (Wijers, Jonker, and Drijvers, 2010).

By combining the concept of math trails with advanced technology in a modern learning environment, we develop a mobile math trail as a new approach to an already well known idea. This approach aims to engage students in mathematics on a math trail programs supported by the use of GPS in mobile phones. Therefore, the overarching aim of the study is to explore the potential of the use of mobile technology for supporting math trail program.

This study is supported by the concept of the math trail program and the use of mobile technology for supporting the math trail program.

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1.1. Math trail

A math trail is a planned route that consists of a series of stops which trail walkers can explore mathematics in the environment (English et al., 2010; McDonald & Watson 2010; Shoaf et al., 2004). It is constructed to improve an appreciation and pleasure of mathematics in daily settings (Blane & Clarke, 1984). Further it can be used as the media for experiencing characteristics of mathematics (Shoaf et al., 2004), namely communication, connections, reasoning and problem solving (National Council of Teacherss of Mathematics, 2000).

Moreover, math trails are designed for everyone, cooperative activities, focusing on the process of problem solving, self-directed, voluntarily, adaptable, and not permanent (Shoaf et al., 2004). Along the trail, the walkers can employ mathematics concepts and discover the varied real problems related to mathematics in the environment (Richardson, 2004, p. 8). They also gain experiences which connect mathematics with other subjects, such as engineering, architecture, geography, art, history, science, economics, etc.

Math trail walkers explore mathematics by following a designed path and solving outdoor mathematical tasks related to what they encounter along the path (English et al., 2010). Such participants need a math trail map or guide to lead them to places where they formulate, discuss and solve interesting mathematical problems (Shoaf et al., 2004). A math trail guide, such as a math trail map or a human guide, also informs walkers about the math trail task stops and shows walkers the problems that exist at each location. A guide also describes the tools needed to solve the problems, so that they are prepared before starting to walk on a trail. Then, on the trail, they can simultaneously solve mathematical problems encountered along the path, make connections, and communicate and discuss ideas with their teammates, as well as use reasoning and skills in problem solving (Richardson 2004).

With the rapid development of mobile technology (Cisco, 2016), it is possible to collect the tasks and design a math trail guide based on a digital map and database. Mobile devices can be used to integrate learning environments and real-life environments which learning can occur in an authentic situation and context (Silander, Sutinen, & Tarhio, 2004). Furthermore, the potential of mobile technology to support outdoor mathematics educational programs must be exploited (Wijers, Jonker, & Drijvers, 2010).

1.2. Mobile technology

In recent years, rapid developments have occurred related to the scope, uses and convergence of mobile devices (Lankshear & Knobel, 2006). These devices are used for computing, communications and information. Cisco (2016) estimates that the total number of smartphones will comprise nearly 50 per cent of all devices and connections globally by 2020 (p. 3). Mobile devices are portable and usually easily connect to the internet from anywhere. These properties make mobile devices ideal for storing reference materials and supporting learning experiences, and they can be general-use tools for fieldwork (Tuomi & Multisilta, 2010).

The portability and wireless nature of mobile devices allow them to extend the learning environment beyond the classroom into authentic and appropriate contexts (Naismith, Lonsdale, Vavoula, & Sharples, 2004). Wireless technology provides the opportunity for expansion beyond the classroom and extends the duration of the school day so that teachers can gain flexibility in how they use precious classroom activities (Baker, Dede, & Evans, 2014). However, in mathematics education, the use of mobile devices is still in the early stages and it is not yet a common practice (Rismark, Sølvberg, Strømme, & Hokstad, 2007).

The use of mobile devices in mathematical activities is expected to occur not only in regular teaching and learning settings, as is the current trend as stated by Trouche & Drijvers (2010), but also outside the classroom setting, as recommended by (Wijers, Jonker, and Drijvers, 2010). Thus, it is necessary to explore the potential of this recent trend in technology use in mathematics learning. Hence, students are engaged in meaningful mathematical activities, such as math trail activities.

In many places around the world, there are special locations where mathematics can be experienced in daily situations and used for math trail activities. However, there are also many places where mathematics problems are hidden in secret. By taking advantages of this benefit of mobile technology, math trail tasks can be localized with GPS coordinates and pinned onto a digital map through a web portal (Jesberg & Ludwig, 2012).

The trail walkers can then access the tasks and run the math trail activity with the help of a GPS-enabled mobile application. The app can be designed as a guide for trail walkers to find the task locations and help them in solving the mathematical problems faced. It shows that this tool can act as a representative of the presence of teachers in facilitating the learning process of mathematics (Cahyono & Ludwig, 2017).

1.3. Statement of research question

Regarding to the background and theretical framework, the research question of this study is how can the mobile technology be used as a supporting tool for running math trail program?

2. Methods

An explorative study was conducted in of Semarang, Indonesia involving 30 students of SMPN 10 Semarang. This study is a part of development research on the MathCityMap-Project for Indonesia. There were two main phases in this research, namely the design phase and the field experimentation phase. There are several studies in both phases.

This study is a part of a study in the second phase that focuses on the exploration of the potential of the use of mobile technology for running math trail activity. The study consisted of an introduction session, a math trail activity supported by the use of mobile phone app session, and a debriefing session. Data were gathered by means of participatory observation, students' work, and interviews.

3. Results & Discussions

In the first phase of the MathCityMap-Project study in Indonesia, technical implementation of the project was formulated, and a mobile app was also created to support the program (Cahyono & Ludwig, 2014). Thirteen math trails containing 87 mathematical outdoor tasks were also designed around the city of Semarang (Cahyono, Ludwig, & Marée, 2015). The authors found mathematical problems that involved objects or situations at particular places around the city. Then they created tasks related to the problems and uploaded them to a portal (www.mathcitymap.eu). In this portal, the tasks were also pinned on a digital map and were saved in the database.

Each task contained a question, brief information about the object, the tools needed to solve the problem, hint(s) if it is necessary, and feedback on answers given. Math trail routes can be designed by connecting a few tasks (6-8) in consideration of the topic, level, or location. In designing the trails, it is also necessary to consider several factors such as: safety, comfort, duration, distance, and accessibility for teachers who would observe and supervise all student activity.

Figure 1. App interfaces (Map: ©OpenStreetMap contributors)

Figure 1 shows the examples of the app's interfaces including an example route, task, feedback, and hint. Math trail routes can be accessed by students via the mobile app, a native app that was created by the research team as part of this project. Installation of a file in *.apk format was uploaded to the portal as well as the Google PlayStoreTM. From there, students could download and install the app which works offline and runs on the Android mobile phone platform.

Further, they can carry out math trail activities. There are several roles of the mobile app in this activity. Through this app, they follow a planned route displayed in the app, discover task locations, and answer task questions related to their encounters at site, then move on to subsequent tasks. The app informs them of the tools needed to solve the problems, the approximate length of the trail, and the estimated duration of the journey. On the trail, the app, supported by GPS coordinates, aids the users in finding the locations. Once on site, users can access the task displayed in the app, enter the answer, get the feedback directly form the system, and ask for hints if needed.

As the groups trekked the trail, teachers observed and supervised student activities but were not expected to provide assistance because all the necessary information was to be provided by the app. Once the activity was completed or maximum time allowed for the activity had passed, the students moved to the next task. After completing the trail, each group returned to class, then had a discussion with the teacher about the task solutions and what they learned along the trail. The illustration of the technical implementation of the activity is shown in Figure 2.

In the second phase, field experiments were conducted in several locations involving students from several schools, one of which is in SMP 10 Semarang, a junior high school in Semarang, Indonesia. In this school, the activity was conducted with 30 students. They were divided into groups of six members. The activity was conducted in the school area during normal school hours over two 45-minute periods beginning with the teachers giving a brief explanation of the learning activities and goals. The groups then began their journeys, each from a task location that was different from the others (Group I started at task I, Group II from task II, and so on).

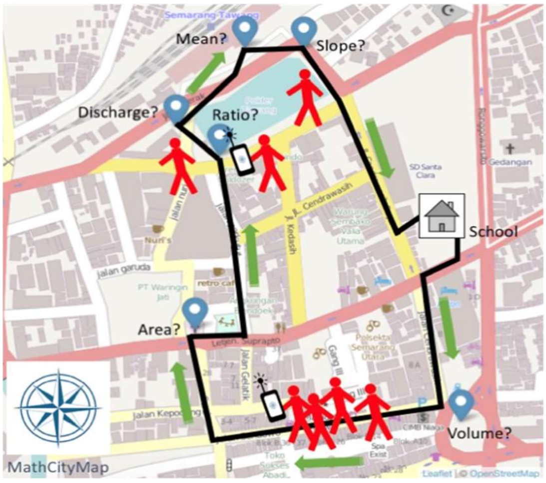

Figure 2. Illustration of technical implementation (Map: ©OpenStreetMap contributors)

Then, students worked together in teams. Generally, in a team, one student operated the mobile device, two or three students were measuring the object, and others were calculating the results. Then, they rotated the job positions for every task. In solving the task, they had understood that they were not competing to get better grades than the other group, because there is no assessment and this is not a competition. They knew that the goal of this activity is to learn mathematics, and not to test their skills though.

Most students actively involved in the activities and expressed positive feelings (93%) and had no problems in carrying out the math trails, including the use of the app. Through follow-up questions, we have investigated about what made them happy and interested in these activities. About 27% of students who were asked, mentioning learning outside the classroom as a reason, 26% said the use of advanced technology or mobile phone, 21% argued for the application of mathematics in the environment or in daily activities, 12% for collaborating with friends in learning or team working, while 11% mentioned other reasons (such as: the novelty of the activities and the break from their daily routines). Some negative feelings were also mentioned: fun but bad weather/tiring/shy/difficulties/technical problem (3%) and no reason (0%). This result indicates that mobile app usage has been one of the biggest factors affecting student engagement in the activity.

In accordance with its purpose, this study focuses on a deeper discussion of the role of mobile phones in this program. Results of observations and interviews show that there are three features that were commonly reported as attractive and useful features for the students. First, the students were interested in the use of a GPS-based mobile application as a navigation tool in the math trail activity. 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.

Second, the availability of the hints-on-demand feature was also an attraction for the students carrying out these activities. The students did not have to leave the task without any results. They could still learn and acquire new knowledge from the task, even with assistance. Third, the students also reported that the direct feedback from the system was very useful for checking whether they had completed the task correctly or not. If their answer is correct, then they can continue the trip to the next station. If the students' answer is not correct, they had the opportunity to look back to determine what error they had made and to repeat the process of problem solving, if time permitted.

Here, there is an example of the activities and roles of the mobile app. In the school area there is a math trail route (Figure 3a) with six tasks. The tasks are placed in a hidden location and even students do not think there are such objects, or they do not think if those objects are related to math, though they often see it or touch it. An example is a task of the area of a small park in the backyard of the school hall, called the Toga Garden (Figure 3b).

Figure 3. (a) SMP 10 math trail route; (b) The Toga Garden Task

With the help of GPS feature and photos displayed in the app, users can find this object, then they get a problem: *"Calculate the area of the grass field. Give the result in m²!"* To solve this problem, students must identify the shape of the grass field, then look for the concept in mathematics accordingly. Some groups have difficulty when it comes to determining what formulas can be used to calculate the area. The role of mobile app in this situation is to offer help if users need it. The first aid is to invite students to think about how students use the mathematical concepts they have learned in class to solve the real problem. First Hint is *"Divide the area into shapes you know"*. The purpose of this hint is to direct students to acquire geometric shapes, for example: a rectangle and two semicircles.

By this hint, they are expected to be able to determine the area of each part, because the formulas have been studied in the previous class. Unless, there are students who have no idea, then the app offers a second hint, namely: "One possibility is to divide the area into a rectangle and two half-circles". The third hint is *"Calculate the area of the rectangle with the formula $L = p \times l$ and calculate the area of the circle with the formula $L = (22/7) \times r^2$"*. The app also inform that students can take advantage of the existence of the paving sections that surround the garden to help in measuring the length, in case their ruler or measuring tape is unable to measure the length. One of the student work results in problem is presented in Figure 4.

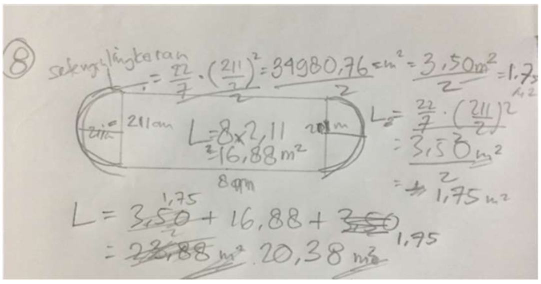

Figure 4. An example of students' work

The work of the students shows that they have completed the work to solve this problem well. Interviews showed that they used some hints. The advantage of using this feature is that they do not leave the task even if they do not have an idea to solve it. The mistakes made (can be seen in the correction of work by crossing out some parts) are not careful, they calculated the area of each semicircle into a full circle. After entering the answer, the system directly gives feedback, so they check their work before leaving the location. The system will also provide the following solution so that students can find out one alternative of the correct way in solving this problem.

Alternative solution:
If you divide the area into a rectangle and two half-circles:
$V_{rectangle} = 8.00\ m \cdot 2.10\ m = 16.80\ m^2$
$V_{HalfCircle} = ((2.10/2)^2 \cdot \pi)/2 \approx 1.73\ m^2$
So, $V_{GrassFiled} = 16.80 + 2 \cdot 1.73\ m^2 \approx 20.26\ m^2$

The accepted answer as the correct answer is in the interval between 20.00 m² and 20.50 m². From the example above, the student's answer is 20,38 m² and included in the interval.

However, it is one case that can be an example. Generally, field findings have supported data obtained that mobile app has been able to play a role in supporting math trail activities with features offered, such as: navigation features, help buttons, and direct feedback.

In this section, researchers interpret data with observed patterns. Any relationships between experimental variables are important and any correlation between variables can be seen clearly. The researcher should include a different explanation of the hypothesis or results that are different or similar to any related experiments performed by other researchers. Remember that every experiment does not necessarily have to show a big difference or a tendency to be important. Yet negative results also need to be explained and probably are important to change the research.

4. Conclusion

In brief, our findings indicate that generally math trail programs supported by the use of mobile phones have promoted the engagement of students in mathematical activities. The results of this study also show that the use of mobile technology has the potential to support math trail program. Some features offered in this application in accordance with the concept of math trail and play a role in guiding students in performing math trail activities. However, the reports from students also show that outdoor activity factors are more dominant than other factors, including the use of mobile devices. It leads to suggestions for future development research that mobile phone use for outdoor activities needs to be more optimized by exploring the latest developments of mobile technology.

References

Baker, A., Dede, C., & Evans, J. (2014). *The 8 essentials for mobile learning success in education*. Retrieved from https://www.qualcomm.com/documents/8-essentials-mobile-learning-success-education.

Cahyono, A. N., & Ludwig, M. (2014). Designing of The MathCityMap- Project for Indonesia. In S. Oesterle, C. Nicol, P. Liljedahl, & D. Allan (Eds.), *Proceedings of the 38th Conference of the International Group for the Psychology of Mathematics Education and the 36th Conference of the North American Chapter of the Psychology of Mathematics Education, 6*, 33. Vancouver: IGPME.

Cahyono, A. N., Ludwig, M., & Marée, S. (2015). Designing mathematical outdoor tasks for the implementation of The MCM-Project in Indonesia. *Proc. ICMI-EARCOME 7,* 151−158. Quezon City: EARCOME.

Cahyono, A. N. & Ludwig, M (2017). *MathCityMap: Motivating students to engage in mathematics through a mobile app-supported math trail programme*. In Institut für Mathematik der Universität Potsdam (Hrsg.). Beiträge zum Mathematikunterricht 2017. Münster: WTM-Verlag.

Cisco. (2016). *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015-2020*. Retrieved from http://www.cisco.com/c/en/us/solutions/collateral/service- provider/visual-networking-index-vni/mobile-white-paper- c11-520862.pdf

English, L. D., Humble, S., & Barnes, V. E. (2010, March). *Trailblazers. Teaching Children Mathematics, 16*(7), 402−409.

Fägerstam, E. (2012). *Space and place, perspectives on outdoor teaching and learning*. Linköping: Linköping University.

Higgins, P., & Nicol, R. (2002). *Outdoor eeducation: Authentic learning in the context of landscapes* (Vol. 2). Kisa: Kinda Education Centre.

Jesberg, J., & Ludwig, M. (2012). MathCityMap-Make Mathematical Experiences in out-of-School activities using mobile technology. *Proc. ICME-12,* 1024-1031. Seoul, South Korea: ICME.

McDonald, S., & Watson, A. (2010). *What's in a task?: Generating rich mathematical activity*. Oxford: QCDA.

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). *Literature review in mobile technologies and learning (Futurelab Series Report 11)*. Bristol: Futurelab.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Richardson, K. M. (2004, Augustus). Designing math trails for the elementary school. *Teaching Children Mathematics, 11*(1), 8−14.

Rismark, M., Sølvberg, A. M., Strømme, A., & Hokstad, L. M. (2007). Using mobile phones to prepare for university lectures: Student's experiences. *The Turkish Online Journal of Educational Technology, 6*(4), 86−91.

Shoaf, M. M., Pollak, H., & Schneider, J. (2004). *Math trails*. Lexington, MA: The Consortium for Mathematics and its Applications (COMAP).

Silander, P., Sutinen, E., & Tarhio, J. (2004). Mobile collaborative concept mapping − Combining classroom activity with simultaneous field exploration. *Proceedings of The 2nd IEEE International Workshop on Wireless and Mobile Technologies In Education,* 114−118. WMTE 2004.

Trouche, L., & Drijvers, P. (2010). Handheld technology for mathematics education: Flashback into the future. *ZDM: The International Journal on Mathematics Education, 42*(7), 667-681.

Tuomi, P., & Multisilta, J. (2010). MoViE: Experiences and attitudes- Learning with a mobile social video application. *Digital Culture & Education, 2*(2), 165−189.

Wijers, M., Jonker, V., & Drijvers, P. (2010). MobileMath: Exploring mathematics outside the classroom. *ZDM Mathematics Education, 42*, 789-799.