# MobileMath: a location-aware game for mathematics

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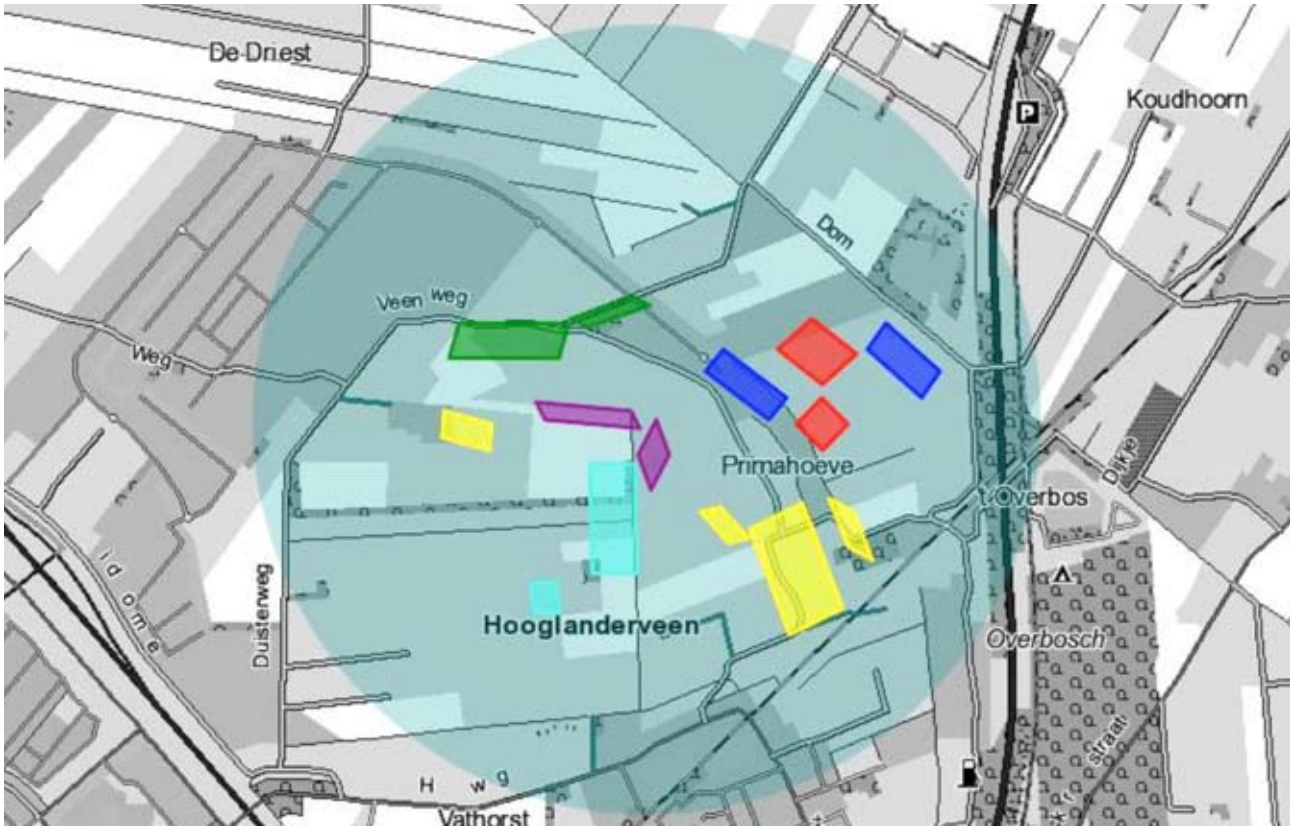


**Figure 1: MobileMath**

## Background to the work

Mathematics is traditionally seen by a lot of secondary school students as a boring, difficult subject with not much personal involvement, creativity or social aspects. A lack of motivation and engagement leads to less effective learning. In order to be effective, the mathematics should become meaningful to the students. The theory of Realistic Mathematics Education (RME), that originated in the Freudenthal Institute, stresses that problem situations presented in learning activities should be 'experientially' real to students *(Gravemeijer, 1994)*. Other important tenets of RME are that students' own productions and constructions should be used and that social interaction is a necessary condition for learning mathematics *(Freudenthal, 1991; Treffers, 1987; Treffers, 1991)*.

Mobile devices rapidly open up new contexts for learning. A key characteristic of mobile learning is that it enables knowledge building and constructing understanding by learners in different contexts *(Winters, 2007)*. It is a small step from mobile learning to mobile gaming. Recent research has shown that the use of mobile location-aware games can contribute to engagement and meaningful learning with several school and academic subjects such as science *(Squire & Klopfer, 2007; Squire, 2008)* and history *(Admiraal et al., 2007)*. Whether this is possible for mathematics is the central question addressed in the design-research on MobileMath and other mobile gaming applications for mathematics.

## Contribution to current work

Researchers/designers of WaagSociety[1] and Freudenthal Institute[2] investigated in a small scale design research how a modern, mobile and social game could contribute to students engagement in learning mathematics. In 2007/2008, a location-based mobile game that integrates concepts from mathematics and geography was designed and piloted on three secondary schools. The prototype was called MobileMath (see Figure 1).

MobileMath[3] is played on a mobile phone[4] with a GPS receiver. Teams compete on the playing field, which can be defined anywhere. The goal of the game is to cover as much area as possible by constructing squares, rectangles or parallelograms. This is done by physically walking to and clicking on each vertex

1 *http://www.waag.org/*
2 *http://www.fi.uu.nl/en/*
3 *http://www.waag.org/project/mobilemath and http://mobilemath.nl*
4 *HTC running Windows Mobile 6.0*

(point). The constructed shapes are virtual elements added to the real world. As the game proceeds the free playing space gets smaller. It is possible to 'hinder' other teams and to deconstruct their shapes. Points are gained relative to the area of the shapes constructed or deconstructed. During the game, in real-time the locations of all teams and all finished quadrilaterals are visible on each mobile phone.

The game play promotes interaction and asks for strategic thinking. The tracks of all teams as well as the constructed shapes can be viewed online during the game. The game data are stored and can be reviewed later, providing the opportunity to discuss the game play as well as the math involved.

In a pilot study the usability of the game was tested in three different secondary schools with students aged 13-14 years. Four one-hour games, each with seven or eight teams of two students (n=60), were played around the schools. Data were gathered by means of (participatory) observation, storing game data, a questionnaire for the students and interviews with students and teachers. The results from data analysis indicate that these were highly motivated students, who enjoyed playing the game. Students indicated that they learned how to use GPS, how to read a map and how to construct quadrilaterals. The experience of using MobileMath was very engaging and interactive, which itself is an important positive result. One student noted: 'It felt as if I where a ruler (measurement instrument) myself.'

## Summary and challenges for the future

The pilot made clear that MobileMath is a mobile location-aware game that can be played in a school setting. Since MobileMath was also successfully played by adolescents at a music festival, we can conclude that it is also a fun game in a totally different, out-of-school context.

A strong feature of the game is that it integrates mathematics and game-play in an intrinsic way. Often games for mathematics lack this intrinsic integration: mathematics and the game-play are often only superficially connected. Design research on the integration of game-play and mathematics within the mobile gaming platform Games Atelier[5], is part of the current and future work of the Freudenthal Institute and Waag society. This includes the design of scenarios for mobile games for mathematics in Games Atelier. Within Games Atelier, pupils can create, play, share and view their own locative mobile games.

One aspect of the future work directly connected to previous work is to fully exploit and research the potential of MobileMath for learning.

Another challenge is transferring the affordances of MobileMath to other, more accurate, location-based technologies such as RFID. MobileMath is played within an area of about 3km$^2$ , and thus outside the 'safe' environment of school. This may be an

**5** *http://www.waag.org/project/gamesatelier*

obstacle for using mobile technology, especially for younger children (aged 6-11). We are thus investigating the possibilities for using RFID or other near-field technologies in the immediate environment around school. The schoolyard (area about 30 x 60 metres) may thus become the context and the playing field for mobile (math) games, when all children have an RFID-tag (passive or active) and three RFID readers are placed around the playground. All geo-positions can then be logged, for example during a 10-20 minute game-play. Ideas for such mini-games are:

- Making geometrical patterns like squares, triangles (based on the game-play of MobileMath);
- Enacting and studying the development of an epidemic virus;
- Measuring and playing with density during a game where all children move from one place to another on the playground.

In both cases (GPS and RFID) an important requirement is access to log-files to replay the mini-games afterwards using a computer/projector (beamer) or on an interactive whiteboard. Debriefing sessions with discussion and reflection on the games played are necessary to enhance learning.

Apart from the technical and design challenges involved, the biggest challenge may be to connect the 'mobile' learning experience to the formal learning context of school in such a way that the best of both worlds is preserved.

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