RESEARCH ON OUTDOOR STEM EDUCATION IN THE DIGITAL AGE – BACKGROUND AND INTRODUCTION

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"*Can we have class outside?*" Teaching and learning outside the classroom – what sounds like a student's dream, becomes more relevant in every days' classes. Leaving the classroom provides new perspectives on subjects and connects the school contents with real world problems (Karpa, Lübbecke, & Adam, 2015). Even though learning is not limited to the school building, teaching outdoors requires additional considerations and organization, which naturally provokes the question of its added value. Different efforts have been made in order to provide guidelines, templates, ideas and research results – summarized under the heading of "outdoor education". In the big number of new science centers which are created for learning outside the school, we see that there is a need for a new learning format.

Especially the combination of outdoor education with digital tools seems contemporary and brings benefits for students and teachers. Technology allows new dimensions of mobility which outdoor education asks for. Under the name "mobile learning", digital tools are used to enable learning in different contexts and independent from a location. Simultaneously, technology can assist students in their outdoor learning activities, either through guidance or feedback.

With both topics being relevant for different subjects, it has been our intention to especially disseminate outdoor education with digital tools primarily for mathematics education through math trails. A math trail is a walk where one can discuss and solve mathematical tasks (Shoaf, Pollack, & Schneider, 2004). Originally, math trails were created for tourists and families. Nevertheless, their idea suits the claim for authentic mathematics education. In contrast to mathematics tasks in school books, mathematics can be discovered in authentic, relevant contexts with real objects. By using math trails in the educational context, new challenges arise. Especially the preparation and organization of math trails can be challenging and time-consuming. By means of digital tools, these challenges can be met. With this intention, the co-funded Erasmus+ project "Mobile Math Trails in Europe (MoMaTrE)" started in 2017 with a project duration of three years. The consortium contains seven partners (see also Figure 1 and 2):

- Goethe University Frankfurt (Germany)
- Autentek GmbH Berlin (Germany)
- University Claude Bernard Lyon 1 (France)
- School of Engineering, Polytechnic of Porto (Portugal)
- Institute of Systems Engineering and Computers, Research and Development, INESC-ID (Portugal)
- University Constantin the Philosopher Nitra (Slovakia)
- Federation of Mathematics Teachers Societies (Spain)

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Figure 1: The Location of all the MoMaTrE Partners in Europe.

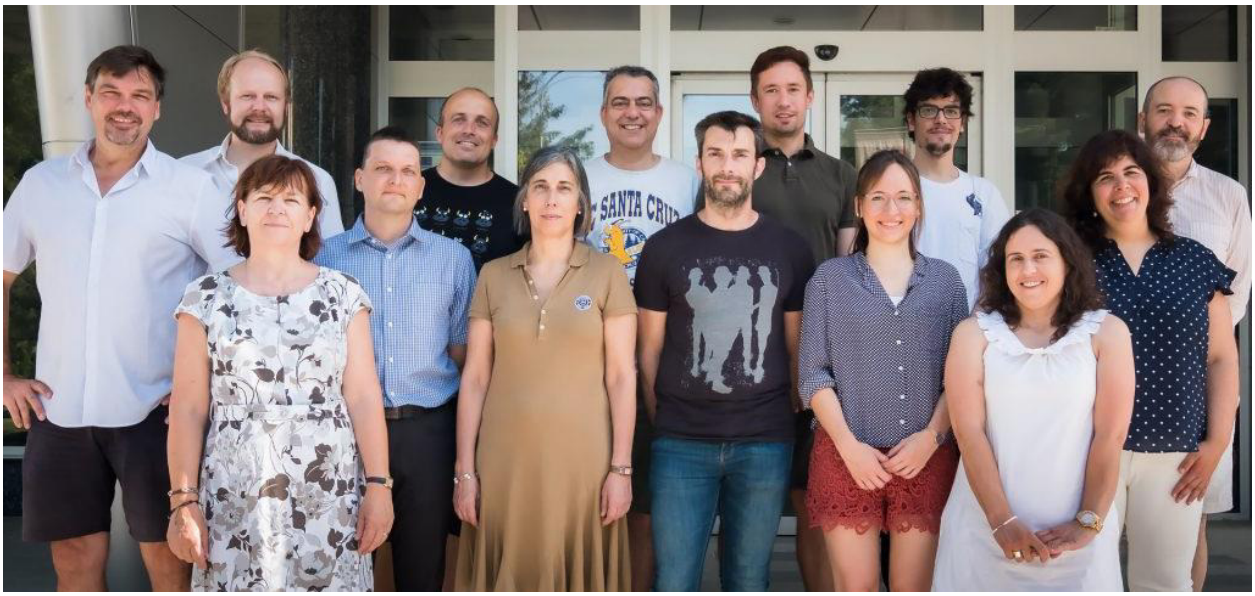

Figure 2: The MoMaTrE Consortium during the third Project Meeting in Nitra, Slovakia (from left to right: Matthias Ludwig, Goethe University Frankfurt, Johannes Scheerer, autentek, Sona Ceretkova, University Constantin the Philosopher Nitra, Radoslav Omelka, University Constantin the Philosopher Nitra, Imrich Jakab, University Constantin the Philosopher Nitra, Claudia Lázaro, Federation of Mathematics Teachers Societies, Pedro Santos, Institute of Systems Engineering and Computers, Research and Development, Bienvenido Espinar, Federation of Mathematics Teachers Societies, Iwan Gurjanow, Goethe University Frankfurt, Simone Jablonski, Goethe University Frankfurt, Miguel Ferreira, autentek, Ana Moura, School of Engineering, Polytechnic of Porto, Amélia Caldeira, School of Engineering, Polytechnic of Porto, Christian Mercat, University Claude Bernard Lyon 1).

The main intention of MoMaTrE is to support and educate teachers in conducting outdoor mathematics activities. Therefore, the project is structured in Intellectual Outputs on different levels:

- Technical Outputs

  Mobile Application: The mobile application "MathCityMap" for navigation and running math trails on the one hand, and for creating math trails on the other hand is developed and improved.

  Web Portal: An interactive web portal which provides authoring tools to create math trails is developed. The web portal should further allow interaction between users in order to create a community in which the users share their work.

- Material

  Generic Tasks: The consortium develops a catalogue of generic tasks, which is a collection of tasks ideas that can be found frequently outside. These tasks can easily be adapted to different locations and support the interactive web portal with numerous ideas for mathematical problems.

- Education

  Long-Term Curriculum: A long-term curriculum for a university course is developed and evaluated. It educates students of mathematics education in their outdoor teaching and is accredited with 3 ECTS for Erasmus students amongst the partner universities.

During the project, the ideas and advantages of outdoor mathematics are disseminated through research, workshops, articles and events. One of these events is the "Research on Outdoor STEM Education in the digiTal Age (ROSETA)" conference. With the ROSETA conference, the previously discussed relevance of outdoor learning and digital learning should not be limited to mathematics and math trails, but extended to further subjects, namely Science, Technology, Engineering and Mathematics (STEM).

STEM education has always been essential to the wealth of the mankind. Nowadays, there are many initiatives on integrating outdoor learning and digital technologies in STEM classes.

With the ROSETA conference, we intend to make these initiatives visible by

- receiving and sharing inputs from the STEM community,
- connecting different approaches from the community,
- sharing outdoor learning experiences,
- disseminating the MoMaTrE intellectual outputs and the MathCityMap system to the scientific and educational community.

Originally being scheduled in Porto from 16th to 19th June 2020, the conference could not take place physically due to the Corona pandemic. So the conference had to become true to its name and use the benefits of the "digital age" that allowed a virtual exchange of experiences and research results.

It is our pleasure to present and combine these results in the proceedings of the ROSETA conference. The proceedings contain 27 articles by 50 authors from eleven different nations. Being structure in three invited papers, 19 papers and five poster presentations, the authors present their research, experiences and ideas on outdoor learning and digital tools.

In "Contextualizing STEM Learning: Frameworks & Strategies", Helen Crompton gives an overview on an effective use of technology in STEM education by presenting different frameworks and strategies.

Through the influence and the context of the MoMaTrE project, a major focus of the conference are digital tools that can be used for outdoor mathematics. Especially the math trail idea is presented by the use of the digital tools

- MathCityMap, e.g. in "MathCityMap – Popularizing Mathematics around the Globe with Math Trails and Smartphone" by Iwan Gurjanow, Joerg Zender and Matthias Ludwig,
- Actionbound, in "The Norwegian Study Math & The City on Mobile Learning with Math Trails" by Nils Buchholtz,
- LabStar™ in "Mathematical Modelling in STEM Education: A Math Trail using LabStar™" by Defne Yabas, Hayriye Sinem Boyacı and M. Sencer Corlu.

Further, the potential and use of Augmented Reality is evaluated, either in connection to math trails and/or with GeoGebra 3D as in "Disocvering Everyday Mathematical Situations Outside the Classroom with MathCityMap and GeoGebra 3D" by Zsolt Lavicza, Ben Haas and Yves Kreis.

Another focus of the proceedings are considerations for the task design and experiences on outdoor learning tasks. On the one hand, this includes theoretical and exemplary perspectives on task design as in "Some Remarks on 'Good' Tasks in Mathematical Outdoor Activities" by Philipp Ullmann. On the other hand, evaluated outdoor tasks and learning environments are presented for

- Chemistry, e.g. "Developing and Assessing E-Learning Settings by Digital Technologies" by Christiane S. Reiners, Laurence Schmitz and Stefan Mueller,
- Technology and Engineering, e.g. in "Teaching Privacy Outdoors – First Approaches in the Field in Connection with STEM Education" by Sandra Schulz,
- Mathematics, e.g. in "Learning Math Outdoors: Graph Theory using Maps" by Aaron Gaio, Laura Branchetti and Roberto Capone.

The proceedings contain ideas for the curriculum design and the education of university students and (pre-service) teachers as in "Math Trails through Digital Technology: An Experience with Pre-Service Teachers" by Ana Barbosa and Isabel Vale.

With this international collaboration, it is our intention to contribute to the current and prospective research in the Outdoor STEM Education in the Digital Age.

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