

# Supporting individual learning of mathematical competences with the app TouchTimes

Marina Lentin<sup>1</sup>

<sup>1</sup>University of Education Schwäbisch Gmünd; [marina.lentin@ph-gmuend.de](mailto:marina.lentin@ph-gmuend.de)

*Keywords: Multiplication, heterogeneous grouping, embodiment, technology.*

## Introduction

The research project "DigiHet: Digital Heterogeneity. Supporting individual learning of mathematical competences with the app TouchTimes" investigates to which extend the targeted use of the app TouchTimes (Jackiw & Sinclair, 2019) supports heterogeneous students at the primary level in the development and expansion of aspects of multiplicative thinking. How can a learning environment for the app TouchTimes be designed in order to develop and establish a) the 'Grundvorstellungen', b) the distinction of factors, c) the creation and usage of composite units and d) the recognition and usage of structural contexts? The project focuses on the development of multiplicative thinking of very low-performing, low-performing, average, high performing and very high-performing students.

## Theoretical framework

The project was influenced by several theories. It was fundamentally influenced by activity theories (Leont'ev, 1977; Engeström, 2015) and—derived from it—the Artifact Centric-Activity Theory (ACAT, Ladel & Kortenkamp, 2016). Furthermore, theories of embodied cognition guided the planning. Activity theories and theories of embodied cognition have some overlap as for example, the relevance of actions. From the perspective of embodied cognition, (virtual) manipulatives, gestures and actions show promise for learning effectiveness in mathematics (Tran et al., 2017). In the ACAT model, there is an increased focus on the (digital) artifact, which is the mediator between subject and object. The manipulatives do not necessarily have to be physically present, they can also be virtual in nature. However, the use and benefits of (virtual) manipulatives in the classroom are complex because there are many influencing factors. This requires tools that help in the structured design and analysis of (virtual) manipulatives as well as in the use of learning environments with (virtual) manipulatives in a way that promotes learning. Based on activity theory, ACAT serves as a methodological tool to understand and structure the complex web of relationships in teaching and learning. This web of relationships consists of five components (subject, object, artifact, group and rules) that influence each other. Thereby the (digital) artifact is in the center.

## Methodical framework

The research project applies „Fachdidaktische Entwicklungsforschung“ (Prediger et al., 2012). It aims to obtain a research-based and practicable design for lessons. Each Design Research-cycle is object-oriented, process-oriented, iterative and networked. The pilot study included four 3<sup>rd</sup> grade classrooms and two 4<sup>th</sup> grade classrooms and pursued the goal of creating conditions for success. Cycle I included two 3<sup>rd</sup> grade classrooms. This was followed by an evaluation and revision of the learning environment. Cycle II included one 3<sup>rd</sup> grade classroom. Each cycle included three diagnostic interviews. The first diagnostic interview (t1) took place prior to the project. The second

diagnostic interview (t2) took place post project. The third diagnostic interview (t3) took place twelve weeks post project (follow-up). The researcher interviewed 20 pupils (3<sup>rd</sup> grade). The evaluation of the diagnostic interviews was realized with a qualitative content analysis according to Mayring (2015). The data interpretation is still in the process.

## First results regarding the distinction of factors

The order of factors used in TouchTimes (multiplicand  $\times$  multiplier) led to disruptions in meanings for Canadian (Sinclair et al., 2020) and German teachers. The research by Sinclair et al. (2020) shows how hard teachers can find thinking about multiplication in a way that is not exclusively repeated addition. These results could be confirmed in this research project. In contrast, students showed no problems with the unfamiliar way of speaking, both in Canada (Sinclair et al, 2020) and in Germany. In some cases, students used the unfamiliar way of speaking implicitly in the first interview. Kandi and Kator, two glove puppets, usually serve as a reminder to the questions "How many?" (multiplicand) and "How often?" (multiplier). Furthermore, very low-performing, low-performing, average, high-performing and very high-performing students name four ways of speaking multiplication (for example 4times 6, 6 4times; 6times 4, 4 6times). According to that the drawings of  $4 \times 6$  were obviously improved.

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