

# Using manipulatives for teaching mathematics: how creative are the teachers?

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## Background

Using manipulatives seems to have a positive impact on students' learning outcomes, when compared to instruction using only abstract symbols (Carbonneau et al., 2013). However, the same study revealed that high levels of instructional guidance are generally associated to significantly higher levels of student learning. Specifically, the mathematical meaning of the manipulatives and their use should be made explicit, and representations should be gradually adapted from concrete to more abstract ones (Laski et al., 2015). The benefits of high guidance also emerge from the literature review on discovery-based instruction (Alfieri et al., 2011). The findings suggest that hands-on activities should provide scaffolding and require learners to go beyond the use of the material, by asking them to explain their own ideas and ensuring their relevance with appropriate feedback.

The importance of focusing students' attention on the targeted mathematical knowledge when using manipulatives invites to consider the teacher's role. Mariotti (2009) describes the need for the teacher to identify the personal and mathematical meanings arising from the use of an artefact (*semiotic potential of the artefact*) and to connect these two types of meanings (*process of semiotic mediation*). Here, the teacher draws on multiple interventions, helping students identify aspects from the empirical experiences relevant to the mathematical meaning at stake, and decontextualize these experiences towards generalizable mathematical knowledge.

## Research

Based on these considerations, the study we propose to carry out is based on the following hypothesis: the use of manipulatives by students does not ensure in itself the acquisition of the mathematical knowledge intended by the teacher. We promote the use of manipulatives in an *experimental approach* of mathematics learning (Dias, 2008), where the manipulatives are conceived not only as a means of observation, but also as a support for the generation of hypotheses, their investigation (trials, experiments) and their confrontation (verification, debate).

Designing and implementing a task including manipulatives therefore requires the teacher to create a learning environment adapted to the constraints of his/her teaching context. This skill relates to Lubart's definition of creativity, as the ability to produce something that is both new and appropriate to the context in which it occurs (Lubart et al., 2015). We therefore seek to understand how to characterise the creativity required for the teacher to (1) anticipate the role played by the manipulatives and their use (identification of the semiotic potential and anticipation of the process of semiotic mediation) and (2) guide the students' empirical experiences towards the desired mathematical knowledge (process of semiotic mediation).

## Context and research method

A two-year in-service teacher training is currently offered at the University of Teacher Education in Lausanne, dedicated to developing innovative practices in mathematics teaching. Within this training, a unit seeks to put into action the teachers' creativity in the collaborative design of a teaching sequence including manipulatives. The sequence design and implementation are conducted through a *Lesson Study* cycle (Lewis & Hurd, 2011). To create the manipulatives that they want to involve in the sequence, the teachers have access to a digital fabrication space, where they are coached in the use of 3D printers, laser and mechanical cutters. The manipulatives' design process could provide insight into teachers' ability to identify the semiotic potential of an artefact. Specifically, how mathematical relationships are embodied into it and how students are expected to use and interpret it. The process would also allow to analyse how teachers anticipate the process of semiotic mediation: how students' interpretations are to be assessed and connected to the mathematical meaning at aim. The lesson observation then gives access to teachers' interventions aimed at guiding the process of semiotic mediation, seeking to connect students' interpretations to a shared mathematical knowledge. The poster presenting the research project is available [online](#).

After rich discussions in the group, an embodied perspective on the teachers' design process seems more fruitful than considering creativity aspects. The results could contribute to a better understanding of the teachers' practices involved in using manipulatives in class.

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