Artefacts to support multiplicative thinking: Semiotic interference using TouchTimes

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Abstract

General description, objectives, theoretical framework

Multiplication and multiplicative flexibility are challenging for students (Siegler et al., 2012). One of the reasons is that multiplication is often framed as repeated addition, or because the focus of multiplication is on the product and not on the relationship between the multiplier and the multiplicand (Askew, 2018). Artefacts play a significant role in teaching multiplication so students can gain access to semiotic potential of multiplicative relationships. In this study, two artefacts are used to support the learning of multiplication. One of the artefacts is the area model of multiplication that students are typically presented with through the manipulation of square tiles, and the other tools is an iPad application called TouchTimes (from now on referred to as TT) (Jackiw & Sinclair, 2019), which represents multiplication through the touching of the iPad screen (TT is elaborated below).

In this study, I focus on the semiotic linking potential between these two artefacts in the learning of multiplication. Understanding how artefacts can be linked, and how students link them, will help teachers of early learners exploit the semiotic potential of the artefacts to support the development of multiplicative thinking. The study is inspired by the tentative definition of semiotic interference by Maffia & Maracci (2019). Based on the semiotic tradition of Vygotsky, semiotic interference addresses how the character of internalized signs, which are originally public, can be linked together for individual psychological cohesion. The signs which are public are changing and ideally converging towards shared conventional mathematical meanings. Interference, proposed by the Maffia and Maracci, is when a student reuses sign from one artefact with another. The significance of this semiotic chaining as theorized through interference is that the process involves a "continuous interpreting process in which teachers and students approximate more and more the culturally established mathematical signs" (p. 7).

The focus of the study is to use TT along with standard tools of area models to see how children link and qualify forms of interference. This is in an effort to better understand the linking of artefacts to support multiplicative thinking. The research question asks: what is the relationship of the multiplicative meaning making, specifically the semiotic linking of the array model and of TT, and the emergent semiotic interference between these two artefacts?

Touchtimes

TT, (Jackiw & Sinclair, 2018) is a free, iPad application that uses the multi-touch modality of the iPad to allow access to the relationship between multiplicand and multiplier as well as their combined relationship to the product. In TT, children make both vertical and horizontal bolts of lightning when they touch the iPad with their fingers. The bolts of lightning create a grid of nodes that represents the product of the horizontal and vertical bolts. When a child lifts a finger or places another finger down, a bolt with disappear or appear respectively. The dynamic interplay of TT affords the opportunity for students to see the functional relationship between the horizontal and vertical numbers created by children's fingers. I suggest that this will strengthen students' understanding of the functional approach of multiplication proposed by Vergnaud (1983) who "addresses the difference between a scalar interpretation of multiplication and a functional one". The *a priori* similarity of the array model and of TT, suggest that there will be semiotic potential of linking. (For more information on the app, see www.touchcounts.ca.)

Methods

In this study, two different grade three classes will explore multiplication through two artefacts: area model using square tiles and TT. The study of the two classes takes place in an inner-city school in a west coast school in Canada. Students will be presented with the array model of multiplication which ties multiplication with area and rows and columns and then students will use TT that highlights rows and columns they make with their fingers. A collective discussion will follow which will "play any essential part in the teaching and learning process where the core of the semiotic process … will take place" (Bartolini Bussi & Mariotti, p. 755, 2008).

During this process students were videotaped, the two episodes will be transcribed and a microgenetic learning analysis (MLA) (Parnafes & di Sessa, 2012) will be applied so as to capture the dialogue and potential gestural signs. MLA is a fine-grained analysis which through multiple viewings of the video captures potential signs such as gestures, gaze, bodily actions, etc.

Outcomes

The outcome of this study will draw attention to the subtle ways children are using signs from one artefact to explain the other and how this continuous process of enchaining signs in the collective discussion, children narrow in on the culturally accepted conceptions of multiplication. This study will also show how meaning making occurs using two artifacts to bolster multiplicative understanding in children.

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