THE USAGE OF TABLET-APPLICATIONS BY STUDENTS WITH SPECIAL LEARNING NEEDS IN MATHEMATICS EDUCATION

Daniel Walter

Technical University of Dortmund, Germany

This paper presents a study that investigated the students' usage of the 'Twenty-frame' tablet-application that has been developed to support the improvement of mathematical conceptual knowledge. Nineteen students with special learning needs were interviewed, especially those who predominantly solve addition problems through counting strategies. The aim of the research project was to investigate if and how students make use of digital media's potential to overcome learning obstacles on the way to internalize non-counting strategies. Descriptive data analyses clarify that quite a few students with special learning needs make use of these potentials after a short introduction into software's features. Although, usage types can be observed, for whom the digital media is even counterproductive for overcoming counting strategies. Hence, mathematics educators and researchers should be aware of the fact that simply providing digital media does not guarantee an appropriate usage by students.

COUNTING AND NON-COUNTING STRATEGIES IN SIMPLE ARITHMETIC

Using predominantly counting strategies to solve simple arithmetic problems can indicate 'mathematics learning disability' (e.g. Baroody 2006; Wartha & Schulz 2013). Withal, at the end of grade one, students *should* either know addition and subtraction facts till twenty directly or compute them via derived fact strategies (c.f. Schipper 2009). However, several research projects show that there are many students who do not reach this central goal of mathematics education in first grade (e.g. Gaidoschik 2010; Gray 1991).

Considering these empirical results, there should be more emphasis placed on fostering students' individual pathways to overcome the main usage of counting strategies. In this context, Häsel-Weide et al. (2014) underline the importance of developing conceptual insights regarding part-whole number relations as well as supporting the development and adaptive choice of mental calculation strategies. Several tablet-applications offer potential to cope with these subjects.

LEARNING WITH DIGITAL MEDIA IN PRIMARY MATHEMATICS EDUCATION

Especially in Germany, research concerning the implementation of digital media has pointed out, that so-called 'educational software' is a crucial component of early media use in primary mathematics education (e.g. Insitut für Demoskopie Allensbach 2014). But the fact that the majority of mathematics educational software is mainly based on 'drill-and-practice'-methods has sufficiently been perceived and criticized as well (c.f. Krauthausen 2012). There are only a few ICT-based learning arrangements, which can support the development of (and not simply practice on) mathematical conceptual knowledge. Hence, it is important to highlight software, which is *potentially* capable to support students' mathematical learning processes. By way of example, the scientifically developed software by Urff (2014) and also Ladel and Kortenkamp (2009), which consider the potential of digital media and empirical findings of mathematics education all at once, should be mentioned.

RESEARCH INTERESTS

The project presented in this paper pursues the goal of collecting empirical findings about special needs students' usage of tablet-applications, which particularly have been developed to support mathematical knowledge. Hence, the focus is set on descriptive analyses on students' actions while using selected software. Within the framework of the empirical investigation the virtual 'Twenty frame' (see Fig. 1) has been selected as well as one other tablet-application ('Math Tablet'). In the following, the potential and the students' usage of the 'Twenty frame' software as an example for digital media to overcome the predominantly appropriation of counting strategies will be described.

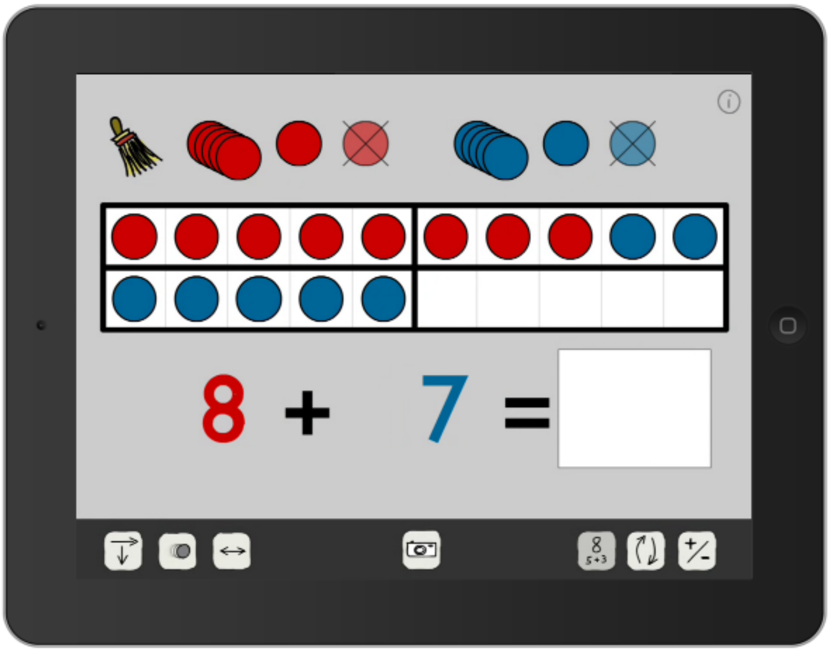

Figure 1: Tablet-application 'Twenty frame' (developed by Urff 2014)

The 'Twenty frame' offers three main features that can be valued as potential to overcome central obstacles on the way to internalize non-counting strategies. Firstly it is possible to *add five counters simultaneously*, what may counteract a primarily ordinal number sense (c.f. Ladel & Kortenkamp 2009). Secondly, *multiple external linked representations (MELRs)* are provided to support students by connecting different representations of one mathematical object (c.f. Ainsworth 1999; Ladel 2009). Thirdly, *counters are automatically ordered*, what might be a beneficial feature to encourage students' 'conceptual subitizing' ability (c.f. Clements 1999).

The empirical investigation aims to point out whether and how students make use of these potentials. Three questions are of peculiar interest: (1) How do students represent addition problems? (2) On which representation(s) do they focus? (3) How do students proof their computated results?

RESEARCH METHODOLOGY

In order to explore the research interests qualitative interviews have been conducted with $n = 19$ students at the beginning of their second year in school. The investigation started by selecting students with special learning needs on the basis of a set of acknowledged diagnostic mathematical tasks (from Peter-Koop et al. 2007; Wartha & Schulz 2013; Häsel-Weide et al. 2014). Afterwards, on three consecutive days, each child has been interviewed once a day. During the first interview day students dealt with addition problems by using the traditional 'Twenty frame', while the second and third session provided its digital counterpart. Consequently, students used traditional teaching materials before the virtual 'Twenty frame' has been introduced. Right at the start of sessions the students became acquainted with the features of the (traditional or digital) 'Twenty frame' under guiding support by the interviewer (here: the author of this paper).

On the basis of the collected data, answers to the abovementioned questions will be given by using the example of analyzing students' usage of the 'Twenty frame' facing the addition problem 8+7. Therefore, students have initially been asked to determine the result without using the software. While doing so they mainly applied a variety of different counting strategies. Subsequently students represented the problem via 'Twenty frame' and verified their mentally calculated answer.

SELECTED RESULTS

How do students represent addition problems by using the 'Twenty frame'?

Analysis of data has shown that more than half of the participants (10) represented at least one addend of 8+7 by making use of the chance to add five counters simultaneously. These students often reasoned their usage by referring to the higher speed of adding five counters compared with itemized approaches. Beyond, eight students indeed added counters itemized and consequently did *not* take the opportunity to add multiple counters. One child acted without regard to the given addition problem whereby its approach cannot be assigned to one of the other types of use.

On which representation(s) do students focus?

During representing addition problems with the 'Twenty frame' three different approaches have been detected. Firstly, some students mainly referred to the iconic representation of laid counters and finished representing the addition problem either by counting all the counters or making use of the ability of conceptual subitizing. Secondly, several students focused on the symbolic representation by adding counters until the addends of the orally given addition problem were shown by the 'Twenty frame' software. The orientation to the given symbolic representation can be detected by analyzing student's body tension and attention regarding the tablet's display. For instance, it has been frequently observed that students did not place their hands on the table until the wanted numbers were displayed. Lastly, there is a third group of students, who did not refer to the iconic or symbolic representations, which are represented by the 'Twenty frame'. This last strategy type is accompanied by counting procedures, which are conducted mentally while adding itemized counters.

How do students proof their computed results?

The most frequently used strategy for verifying computed results was to *uncover the result's symbolic representation* through shifting the white visual cover, which masked the sum's number (see Fig. 1). Furthermore, another students' strategy was to *count all the counters* once more. These students relied on their subjectively successful counting strategies and did not see any reason to verify computations in another way. The third approach is guided by conceiving the amount of counters via *conceptual subitizing*.

CONCLUSIVE REMARKS

To sum up the descriptive data analysis, it can be stated that a few students already made use of digital medias' potential just after getting introduced to the software's features. Hence, the usage of high-quality tablet-applications might contribute to overcome central obstacles of students with special learning needs. Nevertheless it should be taken into account that usages with possibly counterproductive effects occurred, too. Several observed approaches might rather facilitate the predominantly application of counting strategies than fostering the development of non-counting approaches. Thus, software features, which are sometimes labeled as auspicious potential of digital media by mathematics experts and software developers does not necessarily fulfill these expectations in its entirety. The fact that software provides a potential does not guarantee that students make use of it in an appropriate way. Likewise, it should be regarded that *how* students use software determines if the mathematical learning processes can be facilitated.

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