Strategies in Numerosity Estimation
Comparison of Students with High and Low Accuracy

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Estimation is an important part of everyday activities and is present in everybody's life. Many problems can be sufficiently solved by estimating. Especially if a precise value requires too much time or means (Booth & Siegler, 2006). Additionally, estimation is conceived as problem-solving process. Every problem requires different mathematical knowledge and flexible ways. Adaptive problem solving is one crucial goal of mathematics education (Siegel, Goldsmith & Madson, 1982; Siegler & Booth, 2005). Another reason for fostering estimation abilities is the great impact for the development of arithmetic skills (e.g. Luwel, Lemaire & Verschaffel, 2005; Siegler & Booth, 2005). Research results suggest that students who are gifted estimators show better arithmetic skills in terms of counting, number sense, mental computation, strategy flexibility, and conceptual understanding (Booth & Siegler, 2006; Crites, 1992; Luwel & Verschaffel, 2008; Sowder, 1992).

Generally, an estimation suggests methods that lead to reasonable, not necessarily accurate results. Estimation is also defined as mental comparison and measurement (Schipper, 2009). Consequently, it includes a varied set of processes which differ depending on the task and type of estimation. In literature, four types of estimation are distinguished: Measurement estimation, computational estimation, numerosity estimation and numberline estimation (Sayers, Petersson, Rosenqvist & Andrews, 2020). The present project refers to numerosity estimation as one type. 'Numerosity estimation involves assigning a number to a set of discrete objects, such as pennies in a jar or people at a concert' (Siegler & Booth, 2005, p. 204). It requires translating a non-numerical quantitative representation into a number (Siegler & Booth, 2005). Particularly, numerosity estimation influences the development of number knowledge with increasing numbers (Wessolowski, 2014). Furthermore, there is a connection between number sense and determining numbers because using number magnitude to make quantitative judgments is one part of number sense (Crites, 1992). Simultaneously, it is anticipated that number sense is fundamental for an estimation process. Siegler and Booth (2004) concluded that research results show low skills in estimating by young children. They also summarized the attribution to various causes: 'mindless symbol manipulation, reliance on procedure rather than principles, lack of number sense, and lack of relevant central, conceptual structures […] [as well as] reliance on inappropriate representation of numbers' (op. cit., p. 429). Despite the importance

of numerosity estimation, there is a lot more known about other basic numerical processes (Booth & Siegler, 2006). Verschaffel, Greer and De Corte (2007) determine that numerosity estimation has received the least research attention in comparison to the other types of estimation. However, previous research shows various strategies in numerosity estimation. Furthermore, the accuracy in estimating quantities increases with age. For instance, older students show more sophisticated strategies. The performance as well as the adaption to task characteristics seemed to increase with age (e.g. Crites, 1992; Luwel & Verschaffel, 2008). In general, former studies show that strategy choices in numerosity estimation depend on specific problem characteristics (Crites, 1992; Siegler & Booth, 2005).

Though, less is known about the strategies used when quantities are unstructured (Siegler & Booth, 2005). In addition, there are a lot more research gabs in numerosity estimation. For instance the relationship between estimation strategies and accuracy in various types of tasks, task-specific influences on the choice of strategy as well as the accuracy of estimated values. According to previous research, the present study targets to investigate estimation processes from third-grade students. It focuses on comparing strategies in numerosity estimation in two- and three-dimensional tasks of students with high and low accuracy in estimation. Thereby, there is an emphasis on investigating the strategy choice in relation to task characteristics. Further, this research project addresses strategies which lead to high estimation accuracy according to the type of task. Therefore, estimation accuracy as well as estimation strategies will be analysed. Data will be collected by two discretely developed instruments; a numerosity estimation test and a semi-structured interview. The evaluation of the test conduces to select the students for the interviews. Students who made accurate and less accurate estimates will be part of the interviews. The semi-structured interview will be conducted with third graders (10 high accuracy, 10 low accuracy). It explicit allows to look into students' processes of estimation. The use of both instruments enables new perspectives on numerosity estimation. In the "New-Researchers' Day" of ETC9 I would like to present details of my method.

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