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# Dynamic vs. static! Different visualisations to conceptualize parameters of quadratic functions

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## Background

The technology has gotten faster over the last years; students became more proficient in the use of smartphones etc. But is the power of speed with a quick visualisation when dragging a slider bar or grabbing a graph really beneficial while learning and understanding the concept of parameters? The study presented here uses a guided discovery approach (adapted from Mosston, 1972) to investigate different visualisations to conceptualize parameters of quadratic functions as it is the first non-linear function taught and can serve as a prototype for the conceptualization of parameters of higher polynomial functions. To specify the intended learning process in the study, the core elements for a conceptual understanding are presented: For this study in the frame of quadratic functions the two mathematical objects variables and functions and their “Grundvorstellungen” (as defined in vom Hofe & Blum, 2016) are important for the conceptualization. For functions it is important to develop the ideas of a function as mapping, covariation and object (vom Hofe & Blum, 2016). All these three aspects are crucial, when learning how a graph is changing when one of the parameter changes. Parameters can be classified as a specific type of variables. While many authors distinguish the Grundvorstellungen of variables as unknown, generalized number and changing variable (e.g. Malle, 1993), Drijvers (2003) applies these specifications on parameters. The role of parameter is not fixed to one aspect, but can be placeholder, unknown, changing quantity or generalizer. All roles are crucial to understanding the concept and the conceptualization can be supported through technology. Another important aspect to understand the concept of a function is to be aware and to be able to change between different representations of functions (algebraic-symbolical, numeric-tabular, graphic-visual, situative-linguistical, e.g. Duval, 2006). Duval (2006) describes it as the critical threshold for learning. This can be supported by technological tools (Drijvers et al., 2016). It is still an open question whether the conceptualization differs when different visualisations are used when learning. These points lead to our research questions: How can technology-assisted guided discovery support the conceptualization of parameters in the field of quadratic functions?

## Methodology

In a control-group design intervention study with one control- and three experimental groups a total of 14 Year 9 classes worked on a series of tasks designed using a guided discovery approach, which was implemented through hints on the tasksheet how to investigate the influence (for information on the tasks see Göbel, Barzel, & Ball, 2017). The different control- and experimental groups differed only in the kind of visualisation used. The control group had no technological visualisation while the three experimental groups used different types of digital environments (standard function plotter tool, pre-programmed file with the possibility to drag the graph, pre-programmed file with

sliders for the parameters) to investigate the influence of parameters in the vertex form of quadratic functions  $f(x) = a \cdot (x - b)^2 + c$ . Students designed a summary sheet of their findings during the intervention, which was collected. For an overview on the intervention and the differences between the four groups see Göbel et al. (2017). A paper-pencil test was given to all students to collect baseline data for the comparison between classes. As well as the summary sheets collected a focus group in 13 classes was filmed. The summary sheets were analysed using a coding manual developed by qualitative content analysis. The videos transcripts were analysed with regards to the role of parameters, as well as using technology to explore and validate students' own hypotheses.

## Results

Overall it can be said that the dynamic visualisations seem to support the students learning better than the static visualisations. Dynamic groups design significantly more overall appropriate summary sheets. Students in the dynamic visualisations groups, so students using sliders (SL) or drag mode (DM), found out more details about the influence of the parameters than students in the control group or students using a standard function plotter (FP). While in the control group 70,4% of students identified the influence of parameter c adequately (FP 46,3%, DM 76,5%, SL 73,8%), this number drops to 52,1% while identifying the influence of parameter b (FP 40,3%, DM 68,2%, SL 72,3%). Analysis of the summary sheets show that students in the dynamic groups seem to view parameter more as a changing quantity compared to students in the static groups who view parameter as placeholder. The video analysis shows that students use the technology to explore on their own, explain something to each other or to check their hypotheses even though they worked on their own in a guided discovery. Technology-assisted guided discovery can support the learning, but the pre-structuring and dynamic manipulation of the visualisation is crucial for benefiting the learning.

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