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“What are functions and how do they work? You'll find out by watching this explainer video“ - A mixed-methods study on opportunities to understand the function concept

An important part of teaching and learning processes is the use of online explainer videos (e.g. via YouTube) with their learning opportunities (FORSA, 2020). In particular, explainer videos dealing with mathematical content are the most popular among the different school subjects: more than one fifth of students watch explainer videos on mathematics at least once a week (Wolf & Kulgemeyer, 2021). Although complex concepts can be understood by watching explainer videos (Korntreff & Prediger, 2021), there is a preponderance of studies that point to negative effects in terms of understanding with explainer videos: Explainer videos contain partially incorrect or didactically deficient explanations, which can deepen misconceptions and lead to an illusion of understanding (Kulgemeyer et al., 2022). In an *illusion of understanding*, learners assume that they have understood a topic (*belief of understanding*) even though they have not understood factually (*objective understanding*) (Kulgemeyer et al., 2022).

In this research context, we conducted a mixed methods study to investigate which specific descriptive features of explainer videos on the concept of function predict belief of and objective understanding. We address the following research questions (RQs):

RQ1: To what extent can opportunities to understand the concept of functions be reconstructed from online explainer videos?

RQ2: To what extent does the occurrence of opportunities to understand the concept of functions in explainer videos influence the conceptual understanding of functions?

RQ3: To what extent does an illusion of understanding arise when using explainer videos to learn the concept of functions?

Theoretical framework

Explainer videos are audiovisual media that are used in a variety of ways to explain sections of topics informally and instructionally (Korntreff & Prediger, 2021; Kulgemeyer et al., 2022; Mayer & Fiorella, 2022). Within subject matter education, explainer videos are classified on the basis of *instructional explanations* (Klinger & Walter, 2022). According to Korntreff and Prediger

(2021), explainer videos are instructional explanations in the form of produced audiovisual media.

Following a cognitive constructivist approach, explainer videos (or their instructional explanations) can be understood as learning opportunities within teaching and learning processes (Ohrndorf, 2021). Teaching and learning processes are described and analyzed using *opportunity-to-learn models* (Seidel, 2014). By integrating explainer videos into opportunity-to-learn models, we are able to analytically separate explainer videos as learning opportunities, the use of those learning opportunities, and the learning outcomes of their use. Explainer videos offer a rich set of learning opportunities in the form of representation of functions through multimedia (Mayer & Fiorella, 2022).

To examine opportunities to understand the function concept, Zindel’s (2019) three-level *understanding model of the function concept* can be used. The model’s first level is divided into three aspects: the function concept (correspondence, covariance, and mathematical object) (Vollrath, 1989) and mathematical properties of functions, such as right-uniqueness and left-totally. The second level is divided into external representations of functions, such as verbal, symbolical, numeric, and graphic (Swan, 1985). The third level consists of several interconnected comprehension elements, which are facets of the core of the function concept (Zindel, 2018). The *facets* of the core of the function concept are essential for all representations of functions and all types of functions (Zindel, 2018, 2019).

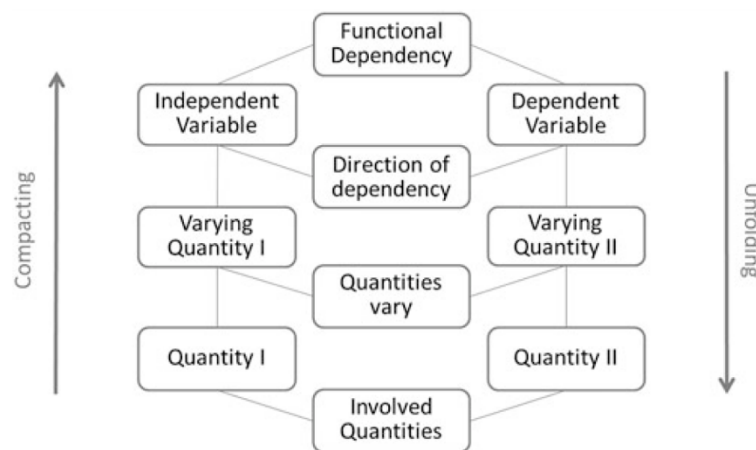


Figure 1: Third level of the understanding model of the function concept (Zindel, 2018, p. 79)

Methods and research design

As a first step, our data corpus for analyzing learning opportunities comprises four online explainer videos on introductions of the function concept from YouTube and sofatutor. We conducted a qualitative content analysis

(Mayer & Alexander, 2017) of these videos in terms of their opportunities to understand the function concept (Zindel, 2019; Ohrndorf et al., in press). In a second step, we conducted a quantitative quasi-experiment with 115 eighth and ninth graders from a secondary school (Gymnasium) in Bremen. We used a pre-post design to investigate whether students' belief of and objective understanding differed in relation to the video they watched.

Results

Regarding the first research question (RQ1), it was possible to reconstruct 21 out of 24 learning opportunities of the understanding model of the function concept from the four selected videos. On all three levels, the selected videos offer opportunities. However, the videos differ in the opportunities they offer. The range of differences varies between the videos. For one video, 21 out of 24 various opportunities were reconstructed, while for another video, only 15 various opportunities were reconstructed.

Regarding the second research question (RQ2), a significant increase in objective understanding was observed, regardless of which of the four videos was watched. However, there was no statistically significant difference between the increases related to the watched videos. Similar to RQ2, regarding the third research question (RQ3), there was a significant increase in the belief of understanding, irrespective of which of the four videos was watched, and no statistically significant difference between the increases related to the watched videos. However, the illusion of understanding (difference between belief of and objective understanding) varied statistically significantly depending on which video was watched.

Discussion

Overall, the increase in objective understanding could not be attributed in a statistically significant way to the occurrence of opportunities to understand the function concept of the respective explainer videos. Despite this, the video with the fewest opportunities to understand the function concept created the strongest illusion of understanding.

In accordance with Kulgemeyer and colleagues' (2022) research on physics videos, we agree that it is not advisable to leave students unsupervised while using media such as explainer videos. One approach to reducing the illusion of understanding and developing a more realistic assessment of one's own understanding might be to complete a task after watching explainer videos (Kulgemeyer et al., 2022). Another approach is to study the use of explanatory videos during use (Ohrndorf, 2021) and to optimize videos for this use.

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