The effect of augmented reality on global coherence formation processes during STEM laboratory work in elementary school children

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Introduction

In science education, hands-on student experiments are used to explore cause and effect relationships. Conventional lab work requires students to interact with physical experimentation objects and observe additional information like measurement values to deduce scientific laws and interrelations. The observable information, however, are usually presented in physical distance to the setting, e.g., on a separate display of a measuring device. The resulting spatial split (Chandler & Sweller, 1991) between representations hampers global coherence formation (Seufert & Brünken, 2004): Mapping processes between the spatially distant sources of information are assumed to lead to an increase in extraneous cognitive load (*ECL*; Ayres & Sweller, 2014). Consequently, learning outcomes can be impaired (Kalyuga et al., 1999).

Augmented Reality (AR) can be used to overcome the split-attention effect by allowing additional information to be virtually integrated into the real-world set-up (Azuma, 1997). A study by Altmeyer et al. (2020) with university students showed that AR-support during experimentation led to a higher conceptual knowledge gain but had no effect on ECL. The current study provides a conceptual replication of Altmeyer et al.'s (2020) research and focuses on three main objectives:

First, we aimed at investigating the generalizability of the advantage of AR on experimental learning in a sample of elementary school children. Second, we examined if low prior-knowledge of children even amplifies the split-attention effect, as proposed by Kalyuga et al. (1998). Finally, we focused on obtaining deeper insights into global coherence formation processes during lab work using specific tests and eye tracking measures.

Method

Based on Altmeyer et al.'s (2020) research, the current study compared a tablet-based AR presentation of measurement values integrated into the experimental environment with a split-source presentation on a separate tablet display. Fifty-nine elementary school children conducted experiments on electrical circuits. Altmeyer et al.'s (2020) experimentation process and setting were adapted to the target-group. In addition to the original study's test on conceptual knowledge, the present research used further posttests to differentiate between four levels of acquired global coherence and recorded eye tracking data during experimentation.

Results

Children improved in the conceptual knowledge test, regardless of the measurement presentation format. Only a posttest requiring a high level of global coherence showed group differences: AR-supported children performed better than children provided a separate display. Analyzes on the influence of AR-support on gaze behavior are in preparation and will be completed in summer 2021.

Discussion

In line with theoretical assumptions, AR is of particular benefit for tasks requiring a high level of global coherence. Results on gaze behavior will provide further insight into how AR can support coherence formation processes during experimentation. To sum up, the advantage of AR depends on the representational interrelations required to solve a specific task.

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