Understanding the Benefits and Drawbacks for Augmented Reality in Collaborative Learning of Electromagnetism

Iulian Radu (Harvard University) iulian_radu@gse.harvard.edu
Bertrand Schneider (Harvard University) bertrand_schneider@gse.harvard.edu

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Theory

As Augmented Reality (AR) technology rapidly continues to broaden its popularity, there is a need to critically explore the nuances that make this technology effective or ineffective in collaborative learning settings. The medium of Augmented Reality presents unique affordances for enhancing education and collaboration (Radu, 2014). In the domain of physics, studies have compared AR to non-AR applications and shown improvement in student abilities to visualize structural phenomena (Ibáñez et. al. 2014; Dünser et. al. 2012), reduced cognitive load (Bellucci el. al. 2018), improvements in motivation (Behesthi et. al. 2017). Some research shows improvements in some topics but not others (Cai et. al. 2017). In this project we use the lens of multiple representations theory (Ainsworth 2008; Kohl et al, 2007) to investigate how the informational content provided in AR experiences can impact learning and collaboration, specifically focusing on the effects of tangibility and various types of AR visualizations.

Design & Implementation

Our AR experience consists of an interactive hardware system that replicates an audio speaker. AR visualizations are displayed on multiple Hololens devices that are networked together and responding to changes in the hardware. Through AR, users can see different invisible physical phenomena - such as flow of electric current, amplification and alternation of electricity, generation of magnetic fields from electricity, production of forces acting to vibrate membranes, audio waves, etc. Physical electronic modules allow groups of learners to collaborate while observing 3D visualizations of invisible phenomena occurring in the physical space.

Participants were randomly assigned to four experimental conditions. "Non Hololens" condition involved the same activity without wearing a Hololens device. "Hololens Simple" condition wore the Hololens device and saw limited AR visualizations (without educational content). "AR Full" group saw AR representations such as of electricity, magnetic fields, forces, and other information. "AR Scaffold" condition wore the Hololens device, but started with no AR representational information; then were sequentially exposed to all the representational layers in the "AR Full" condition.

Assessment

We assessed N=60 dyad pairs interacting in 4 different conditions of varied AR content. We compared participants' learning (relative learning gains on different curriculum topics), attitudes (engagement, curiosity, self-efficacy), and collaboration (quality of communication, information exchange, leadership, etc) in multiple experimental conditions containing varying layers of AR information. We found that educational AR representations were beneficial for learning specific knowledge and increasing participants' self-efficacy (i.e., their ability to learn concepts in physics). They learned topics ranging from spatial knowledge, such as shape of magnetic fields, to abstract conceptual knowledge, such as relationships between electricity and magnetism. However, we also found that participants in conditions that did not contain AR educational content, learned some concepts better than other groups and became more curious about physics. Some of the motivational effects were found to be due to the novelty of the AR technology, not due to the presence of AR educational content. In the larger paper we discuss possible reasons for these results, as well as benefits and detriments of implementing augmented reality for future unstructured learning contexts.

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