Interactions and meaning-making in an AR learning environment

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This study aims to identify the interaction between students as they use augmented reality and understand how the students' interaction may help them disclose mathematical ideas. In this study, we focus on how augmented reality may lead students to disagree and how the disagreement allows them to disclose mathematical objects.

Keywords: Augmented reality, layers of meaning, interactions, disagreement.

Introduction

Augmented reality (AR) is an innovative technology that overlays virtual objects into the real world (Akçayır & Akçayır, 2017). AR allows juxtaposing real-world phenomena and virtual objects and provides real-time data layers that model dynamic situations. In addition, AR promotes interaction among students (Akçayır & Akçayır, 2017; Kamarainen et al., 2013) and facilitates mathematical discussions (Wang et al., 2014). These characteristics create opportunities for exploring and creating meanings for relations between real-world dynamic phenomena and virtual mathematical representations. In this contribution, we shed light on how a specific design of augmented reality technology affects students' interaction and their meaning-making processes.

Theoretical framework

According to the phenomenological perspective (Rota, 1991), mathematical meaning-making happens through a gradual interpretation of the surrounding world and of the various situations in the world in the contexts in which they are exposed. This process resumes the Husserlian concept of disclosure: the same situation may evoke different contexts and produce different sense-making according to the people's background, age, and culture. Such different contexts are not isolated but layered upon each other and generate different layers of disclosure in time flow. Disclosure happens when one can grasp an object's functionality in a given context. The disclosure process is far from natural. Students should be educated to make sense of what they disclose when they meet with mathematical objects.

The relationship between interaction and sense-making of mathematical concepts – as a case of knowledge construction – has been acknowledged among several mathematics educators. For instance, Balacheff (1999) argued that the literature on social constructivism has confirmed the productive and essential character of social interaction and revealed that the social interaction processes are conducive to the construction of mathematical concepts by their very nature. Berland and Reiser (2009) argued that interaction and sense-making are two interlinked, essential scientific practices that schooling should make available to science students. In tune with Berland and Reiser, our basic assumption is that interaction, which includes, among other things, questioning, agreement/disagreement, and the search for explanations and justifications, may foster the students' understanding and prompt their subsequent disclosure of the mathematical relationships depicted in the digital tool. In particular, disagreements are essential expressions of interactions in a learning process. Such expressions cause participants to raise new and additional ideas, change their minds and perceptions and increase creativity (Van Offenbeek, 2001; Sharma, 2012). Hence, this study's research question is: How does the augmented reality environment promote disagreement between students, and how do these disagreements contribute to disclosing layers of mathematical meanings?

Method

The present study reports on the interaction processes of three 15-year-old students from Israel. The task analyzed in this contribution aimed to disclose the relationship between spring elongation and mass through performing a real experiment and with the support of AR technology. The technological tool we used in this study is an AR headset that collects real-time data of a dynamic phenomenon during a physical experiment about a spring elongation obtained by adding some cube-weights at its free extremity (Figure 1). The data are collected by sensors and analyzed, and the mathematical representations are displayed simultaneously to the students using the designated headset.

Figure 1: Spring elongation phenomenon- students experimenting and observing the graph

In this qualitative study, we adopted as an analytic method a descriptive coding of the emergent forms of interactions (Saldana, 2015). Videos of the learning experiments were watched repeatedly to identify all the relevant interactions. These interactions were classified during the first coding cycle, describing their features. During the second coding cycle, they were grouped into categories and provided with an entitling tag. Eventually, we revised the coding and elaborated on three macro-categories: i) interactions promoting the discussion; ii) interactions based on disagreements; iii) asking questions. Among these categories, in this contribution, we will specifically focus on a selected episode in which interactions based on disagreement emerge.

Results

In the following episode, three students, Sagi, Alex, and Noam, were asked to endow the axes of the Cartesian system in their task with meanings. This episode illustrates the disagreement that emerges because of observing different virtual representations.

2	Alex:	So, the x-axis... it seems to me…
3	Sagi:	The y-axis… we saw the length of the ... the height of the spring. It is the... from its initial state plus the elongation.
4	Alex	Spring length… umm... in cm. The x-axis was the weight of the cubes.

5 Sagi: The x-axis was…

6 Noam: On the x-axis was only two points. Points between the lengths and points between the parallel lines of the box. It was like this [draws on the right in Figure 2]. There were two boxes between the spring; I had two points along the y-axis that connected the spring. These two points describe the distance between them.

7 Alex: It is not; it is given on the graph itself, not on the boxes as you draw in the figure

8 Noam: Which graph?

9 Sagi: There was a graph when you saw the ... on the spring itself, there was a graph.

10 Noam: I only had a table next to it; I only noticed a table next to it.

[…]

14 Sagi: Can I check it again for a moment?

15 Noam: The table of values had two columns, length, and weight

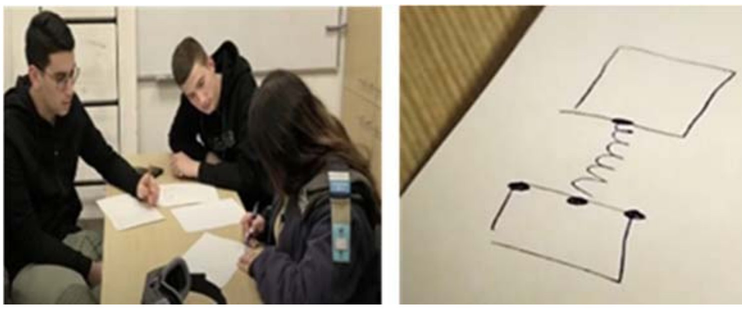

Figure 2: Noam's drawing-graph points seen as edge points of the reference box

In [2-5], Alex exchanges what they disclosed through the headset. Alex and Sagi conjectured that the x-axis is for the cube's weight and the y-axis is for the spring length. The interaction between Sagi and Alex is characterized as one completing each other's ideas. This harmony is interrupted when Noam says that the x-axis has only two points. Her utterance "On the x-axis was only two points… parallel lines of the box" [6] suggests that Noam focuses on specific virtual objects while she ignores the Cartesian system. It seems that Noam's disclosure led her to disagree with her classmates. In [7], Alex revives the discussion by disagreeing with Noam's argument "[i]t is not" and describes what he has disclosed (the graph). In [9] Sagi confirms Alex's argument and describes what he has disclosed "on the spring itself, there was a graph". In [10], Noam also describes what she has disclosed "I only noticed a table [of value] next to it". Sagi's utterance in [14] suggests that he needs to look again through the headsets to be sure of what he noticed. Noam, in [15], adds that the table of values she has disclosed consists of two columns: length and weight.

Final remarks

This short contribution is part of a large research project aiming at investigating how AR technology shapes students' interactions. In this paper, we present and discuss one case in which the use of AR leads to disagreement between the students. Of course, this is not the only type of interaction we found. However, we present this type since we found that the features of AR prompt disagreement between the students. The ways used by students to overcome disagreement led them to look for justification and explanations to convince their classmates. In our case, even though the headsets present the same data, different students focused their attention on different aspects of the virtual representations.

Situations in which students disagree may create opportunities for meaning-making. In our case, the disagreement between the students leads each one of them to contribute with the specific aspects (s)he has disclosed. As the discussion progresses, the students pay attention to the aspects that have been disclosed by the others. In this case, the sum is bigger than its parts.

As we showed in the episode above, even though the same information was presented to all students using the headsets, each student paid attention to something different. This issue requested them to reexperience. Hence, the AR not only helps in the creation of the disagreement but also plays a crucial role in solving disputes by examining different opinions and ideas. The students are free to explore and test and thus AR promotes the potential for self-building knowledge (Ibáñez & Delgado-Kloos, 2018). As a future direction of research, we aim at collecting data from other teamwork activities focused on learning other scientific concepts and refining the coding of the interaction categories identified in this preliminary study.

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