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Keep on Moving - pa(i)r excellence

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Introduction

A plethora of studies adopting frameworks of embodied design have been carried out on the design of learning materials to foster students' conceptual understanding of mathematics and their interaction with these materials (e.g., Abrahamson, 2009). Acknowledging the social dimension as key component in learning and understanding, the presented study builds on prior embodied design approaches and extends them by emphasizing social interaction as part of learning as 'Being-in-the-world' (van Dijk, 2018).
Embedded in a design based research study based on the theoretical framework *Design for Embodied Being-in-the-world (D4EB)* of van Dijk (2018) , several learning environments will be designed, allowing students to experience the more **abstract concepts of continuity and differentiability** in the context of motion diagrams through physical and social engagement and through interactions with artifacts differently.

Theoretical Background

The D4EB theoretical framework by van Dijk (2018) is an approach which is inspired by Merleau-Ponty's concept of a "lived body" that actively moves and acts within a changing lifeworld. As a result, we are in a constant state of adaptation and responsiveness to disturbances or changes in our lifeworld. This process is referred to as "socio-sensorimotor coupling" (van Dijk, 2018). The artifacts within the learning environment therefore also play a significant role in D4EB since artifacts have the potential of assistance/ facilitation of social interactions, which are crucial for the creation of meaning. Since sense-making is the process of creation of one's own identity mediated through the environment - and individuals are in each other's environment with their own sense-making - an entanglement of the individual's sense-making processes is possible. This is called participatory sense-making (de Jaegher & Di Paolo, 2007).

Bringing this core concepts together leads to the theoretical framework of Design for Embodied Being-in-the-world, as shown in Figure 1, by van Dijk (2018).

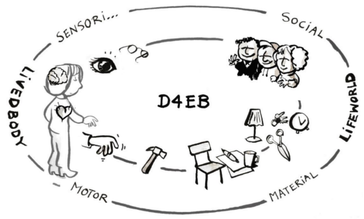

Figure 1. Design for Embodied Being-in-the-world (van Dijk, 2018)

Research aim & question

Research aim

- Designing embodied designs to enhance interaction and
- development of local theories of (a) the interplay between student's interaction, language, bodily movement and the artifacts in different settings and (b) investigation of the learning processes in the context of calculus education.

Research questions

How can an embodied design facilitate interaction between the various elements of the student's lifeworld (physical/ social) to enhance participatory sense-making and make the abstract concepts of continuity and differentiability and meaningful in the context of motion diagrams?

This research question can be divided into two domains with their own research questions. These research questions are concerning (a) the design itself (b) the learning process.

- How can participatory sense-making be promoted within the learning environment? (Design)
- How can the students gain conceptual understanding while working within the learning environment? (Learning process)

Objectives

Design

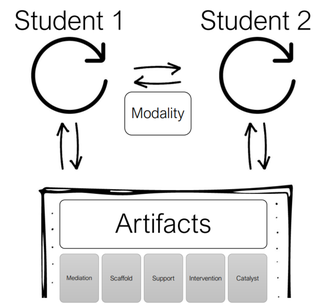

Figure 2. Socio-sensorimotor coupling

In relation to design, the focus is on how participatory sense-making can be fostered. The following questions are of interest:

- How can we make sure that students stay interested and involved with what they're learning? (e.g., game-based learning?)
- Which aspects of a learning environment are functional/ interactional (de Jaegher & Di Paolo, 2007) for coordination of the student's interaction?
- How does the learning environment affect the modality of interaction?
- Is there modality preference in certain learning environments? (e.g., Figure 3 and Figure 4)

Figure 3. Shared screen

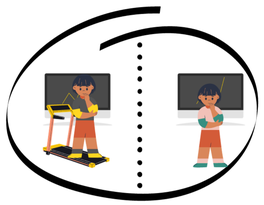

Figure 4. Multiple screens

Learning Process

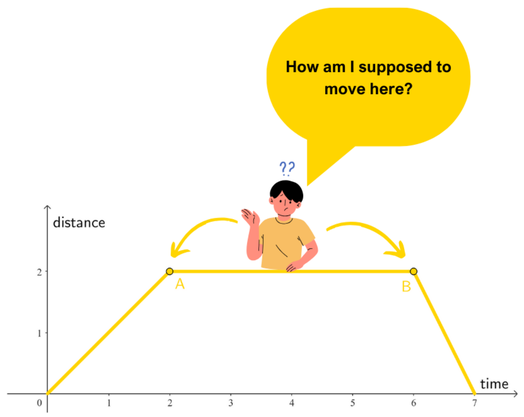

Figure 5. Graph of Motion?

The graph shown in Figure 5 models a steady motion with a constant positive velocity, followed by an interval of zero velocity and finally an interval of negative velocity. This largely neglects the embodied meaning of the specific points highlighted at the boundaries of the defined domains (see Figure 5). These points deserve particular attention due to the multitude of possibilities they offer—particularly in terms of capturing more **abstract concepts such as continuity or differentiability**—as these points represent a discontinuity in the acceleration or velocity profile.

Research Status

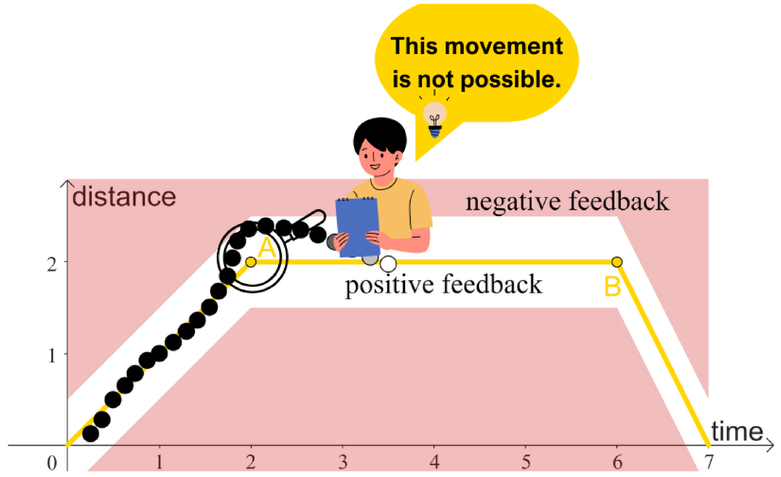

Figure 6. Possible implementation

Questions of interest

- Which components of the learning environment are enacted by students?
- How does the process of sense-making look like?
- Are there certain types of language, bodily movement (e.g., gestures) associated with the mathematical concepts of continuity and differentiability?

Within the initial exploration, the movement is carried out with the assistance of a hand crank (see Figure 7) - focusing on the implementation of the digital artifacts.

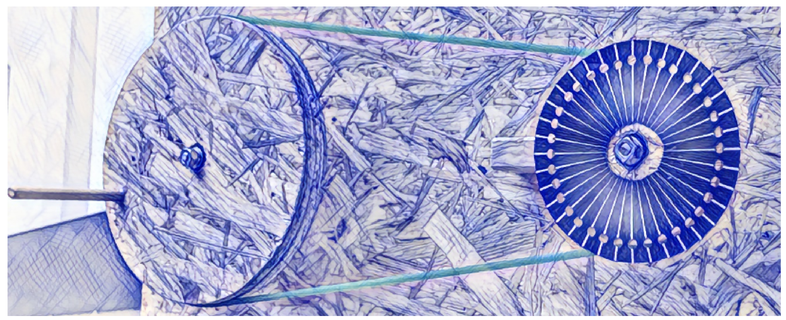

Figure 7. Crank

References

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de Jaegher, H., & Di Paolo, E. (2007). Participatory sense-making. *Phenomenology and the Cognitive Sciences*, *6*(4), 485–507.
van Dijk, J. (2018). Designing for Embodied Being-in-the-World: A Critical Analysis of the Concept of Embodiment in the Design of Hybrids. *Multimodal Technologies and Interaction*, *2*(1), 7.