Access the Molecular World through Haptic Quantum Chemistry

Conference Poster

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Access the Molecular World through Haptic Quantum Chemistry

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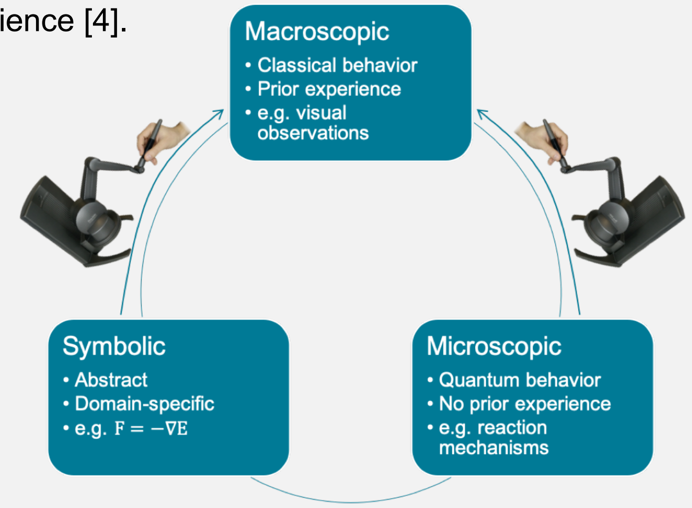
1 Introduction

Haptic learning environments (HLE) have been shown to facilitate learning, if the haptic features add value to the environment and the latter is easy enough to use [1, 2]. The microscopic and abstract nature of chemistry shows many potential applications, of which we focus on the concepts of **potential energy and forces in reactions.** We develop and test a HLE which allows to observe and feel systems who act according to quantum laws.

2 Theoretical Framework

- Chemists understand observations on a **macroscopic, microscopic, and symbolic level**, the connections between which are sometimes hard to make as a novice, especially because the microscopic (molecular) world does not behave classically (but quantum mechanically) [3].
- The theoretical framework of **grounded cognition** suggests that experiencing (scientific) concepts through multiple modalities can help ground new information in prior sensory experience [4].



The haptic device allows to metaphorically translate between conceptual levels which are not accessible to our senses and the macroscopic world that we experience every day. For example, the user can feel a force that corresponds to the change in energy and therefore learn about this relationship, or they can explore different reaction mechanisms and learn about minimal-energy paths and byproducts.

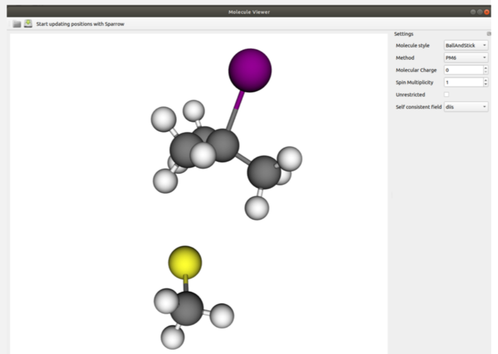
3 Hypotheses

I. The higher the **level of embodiment** (movie < HLE w/o haptic feedback < HLE w feedback) , the better the **preparation for learning** about energy and forces in a chemistry context.

II. Using the HLE increases affect, state curiosity, and knowledge gap awareness more compared to watching a movie about it.

4 Learning Environment

- The molecules act quantum mechanically, their movement is calculated based on semi-empirical methods [5].
- The user can drag and drop atoms across a computer screen, triggering reactions and feeling forces that act on the atom.
- Anytime the user stops manipulating the system, it relaxes in the energetically lowest state.

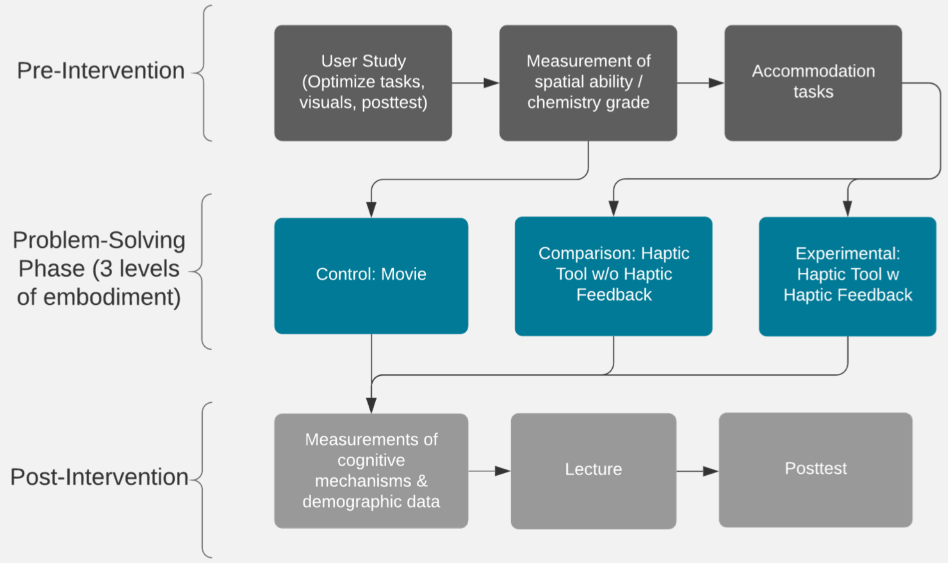


5 Conclusion

- The environment, as well as the posttest were content validated by two chemistry professors.
- The environment & the posttest will be further optimized according to the results of a user study in fall, 2021
- The PFL study is planned for spring, 2022
- Any feedback is appreciated.

6 Methods

- The environment is developed for a **1st year university** chemistry course syllabus. We are aiming for 40 participants/condition.
- We will follow a preparation for future learning (**PFL**) study design with preliminary user study
- We will test the **learning outcome**, and will explore **cognitive mechanisms** (embodiment, affect, knowledge gap awareness, & state curiosity)



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