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Grasping Mathematics with Embodied Interactions

Julia Chatain^{1,2}, Virginia Ramp¹, Venera Gashaj², Violaine Fayolle¹, Manu Kapur², Robert W. Sumner¹, Stéphane Magnenat¹ ¹Game Technology Center, ETH Zurich; ²Professorship for Learning Sciences and Higher Education, ETH Zurich

1 Introduction

Grasping mathematics can be difficult. Often, students struggle to connect mathematical concepts with their own experiences and even believe that math has nothing to do with the real world¹.

To create more concreteness in mathematics education, we focus on the role of learners' bodies, and in particular embodied interactions for learning derivatives.

We compare different degrees and different types of embodiment.

2 Game and Interaction Design

- Embodied game where students explore the relationship between the function curve and the derivative curve.
- Validated with 6 experts: math learning, math education, haptic feedback, art and game development, embodied cognition, cognitive sciences.
- Two degrees of embodiment: low (tablet) and high (Virtual Reality)².
- Two types of embodiment: direct-embodied (body *position* represents the derivative), and enacted (body *action* represents the derivative)³.



Three ways of grasping derivatives: direct-embodied on tablet (TAB), direct-embodied in Virtual Reality (DIR), and enacted in Virtual Reality (ENA)^{2,3}.

3 Research questions

- a. How do different embodied interactions compare in terms of **usability** and resulting **manipulations**?
- b. Which embodied interaction brings the greatest sense of

4 Methods

- 38 high-school students, 2 weeks before the lesson
- 2 interventions, 1-7 days apart



5 Results

- a. Although the usability and simulator sickness were similar, VR took more time (p < 0.001), in particular ENA, that also resulted in more superfluous manipulations (p < 0.001).
- b. DIR resulted in larger movements (p = 0.001), while ENA seemed to result in less curve agency (p= 0.11).
- c. ENA seemed to reduce persistence in PS (p = 0.08) and result in lower score in the learning outcomes post-test (p = 0.09).

6 Conclusion

- Virtual Reality does not always result in higher embodiment
 → Favor direct interation and include a familiarisation phase.
- An interaction that is good from a usability perspective is not necessarily good from a learning perspective → Include desirable difficulties in interaction.
- Enacted interaction represents derivatives as variation rates, while direct-embodied interaction represents derivatives as slopes →
 Align activity design and interaction design.

embodiment and sense of agency?

c. How do different embodied interactions influence **learning outcomes**?



With embodied interaction, users' bodies are at the core of the digital content → Design for the feeling, living body (*Leib*), not the physical body (*Körper*)⁴.

References

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Contact: julia.chatain@inf.ethz.ch

