Navigating Memory Palaces: The Role of Instructional Agents in Teaching the Method of Loci in Virtual Reality

The Eighteenth International Conference on Mobile, Hybrid, and On-line Learning (eLmL) 2026

Benedikt Hensen[1], Lena Juliane Linke[1], Fridolin Wild[2], Stefan Decker[1]

[1]RWTH Aachen University, Aachen, Germany [2]The Open University, Milton Keynes, United Kingdom

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Motivation

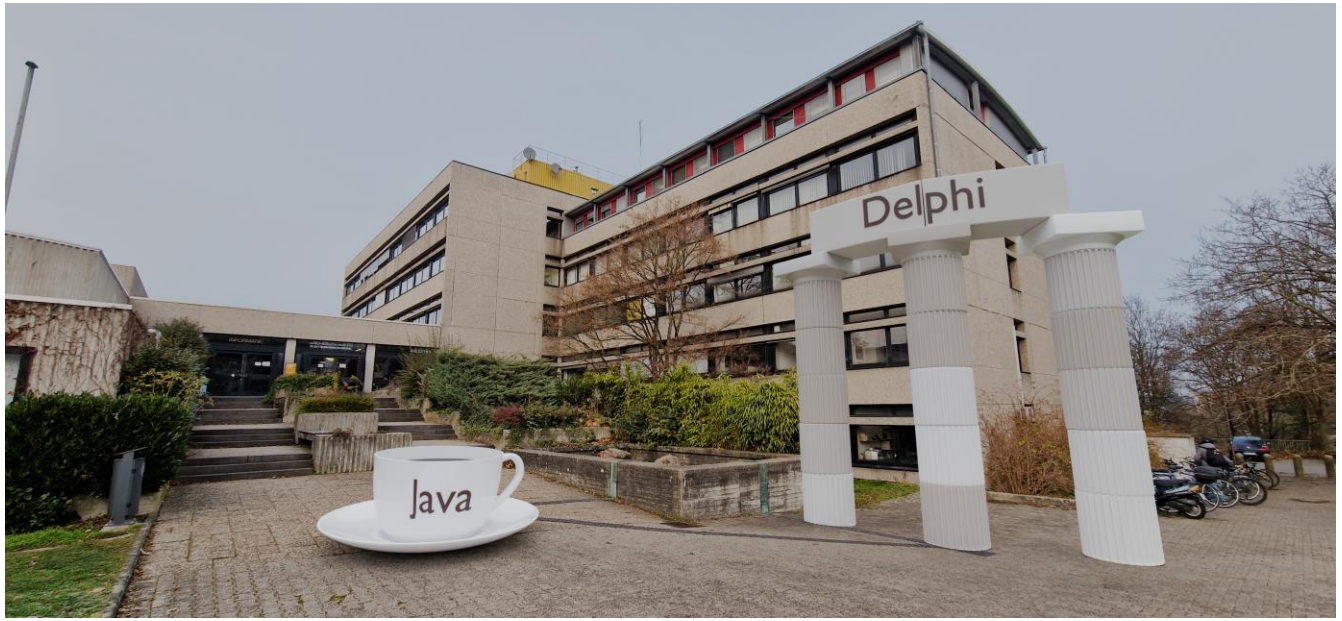
The Challenge of Teaching Mnemonics

- Students frequently rely on ineffective memorisation strategies [USAr23]
- => Convey powerful memorisation techniques like the Method of Loci (MoL) to students
  - Rarely taught by educators
- Challenges of the MoL
  - Abstract
  - Purely mental
  - Difficult for educators to demonstrate, guide or verify
- Solution: use virtual reality (VR) to demonstrate the MoL [MoSy23]
  - Apply a virtual agent to explain, guide and practice

Introduction

What is the Method of Loci?

- Utilises spatial memory of familiar environments [WKS*21,McCa15]
- Learners establish a fixed mental route through the location
- Target information are associated with vivid mental images; placed in each location
- Recall triggered by mentally retracing the route
- Location -> Mental Image -> Information



[Hens25]

Introduction

Research Objective

- Investigate how VR environments guided by instructional agents influence:
  - Understanding & correct application of the MoL
  - Immediate vs. long-term retention
  - Transferability to independent learning tasks

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Related Work

VR & Virtual Agents in Learning

VR for MoL

- Spatial memory also works in virtual environments [REBR20]
- Immersive environments improve spatial recall and motivation [HuRo17, KPVa19, MoSy23]
- Textual descriptions lead to differing understandings and recall successes [MoSy23]

Virtual Agents

- Serve as effective guides in museums [HMSM20]
- Increase task performance [BKS*21]
- Intuitive, high usability [HMSM20, BKS*21, HBB*22, HeBe23]
- Boost motivation, confidence and enjoyment [HeBe23, BKS*21]

Research Gap

Combined use of VR memory palaces and instructional agents remains underexplored

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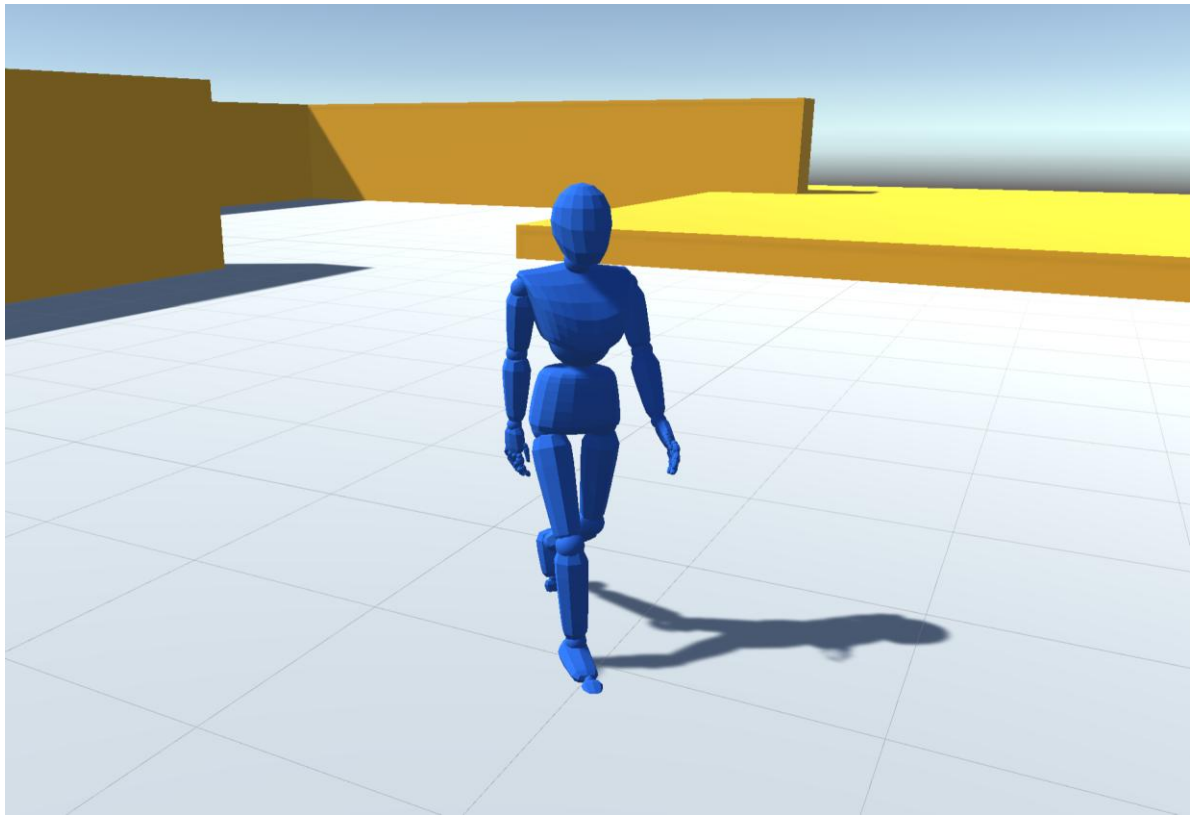
Realisation

System & Technologies

- Unity 3D engine, Meta Quest SDK
- For the Meta Quest 2 and 3
- Custom virtual agents framework for reusable, task-driven guidance [HBB*22, HeBe23]
- Spatial mapping mirrors real-world room dimensions
- JSON export for persistence / sharing
- Open-Source implementation:

  https://github.com/rwth-acis/MR-MiRA-Method-of-Loci-App



Virtual Agents Framework [HBB*22]

Realisation

Learning Workflow Phase 1: Environment Setup

- Learners construct & furnish virtual rooms
- Colour-coded doors enforce a linear traversal route
- Encourages multi-room palaces for scalable memorisation
- Agent teaches interactions, furniture placement and navigation

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Realisation

Learning Workflow Phase 2: Memory Formation

- Users place 3D “information objects”
  - 103 categorised items
  - Multi-modal setup with audio
- Objects visually distinct from furniture
  - Optional grayscale mode highlights them
- Agent provides placement suggestions & warns against cognitive overload per room

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Learning Workflow Phase 3: Guided Repetition

- Agent leads the learner through the established route sequentially
  - Highlights each object with gaze direction & dynamic spotlights
- Supports spaced repetition
- Spatial anchors ensure exact physical positioning across sessions

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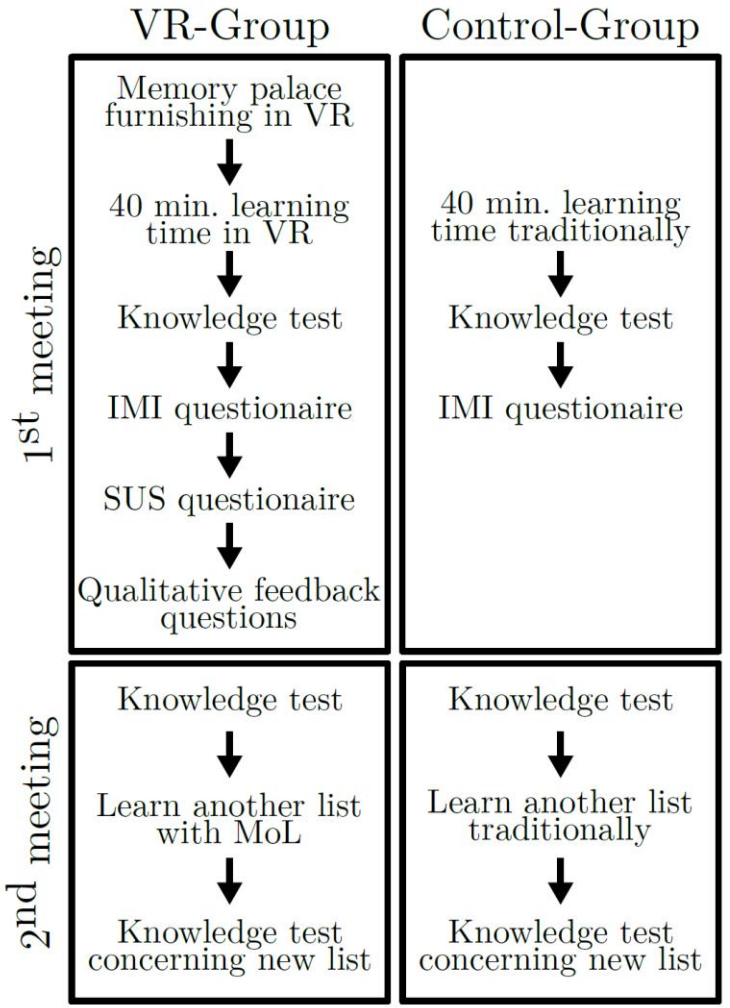
Evaluation

User Study Design

- Design: Between-subjects
  (VR group n = 14 vs. control group n = 13)
- Materials: 15 item list, story, 20 digit number
- Procedure:
  - VR group memorises with the application
  - Immediate knowledge test
  - Intrinsic Motivation Inventory (IMI) questionnaire [Ryan82]
  - System Usability Scale (SUS) questionnaire [Brook96]
- 1-week follow-up: original content + 4 new story questions
  - Transfer task: learn new 20-word list using the MoL



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Evaluation

Quantitative Study Results: Retention & Transfer

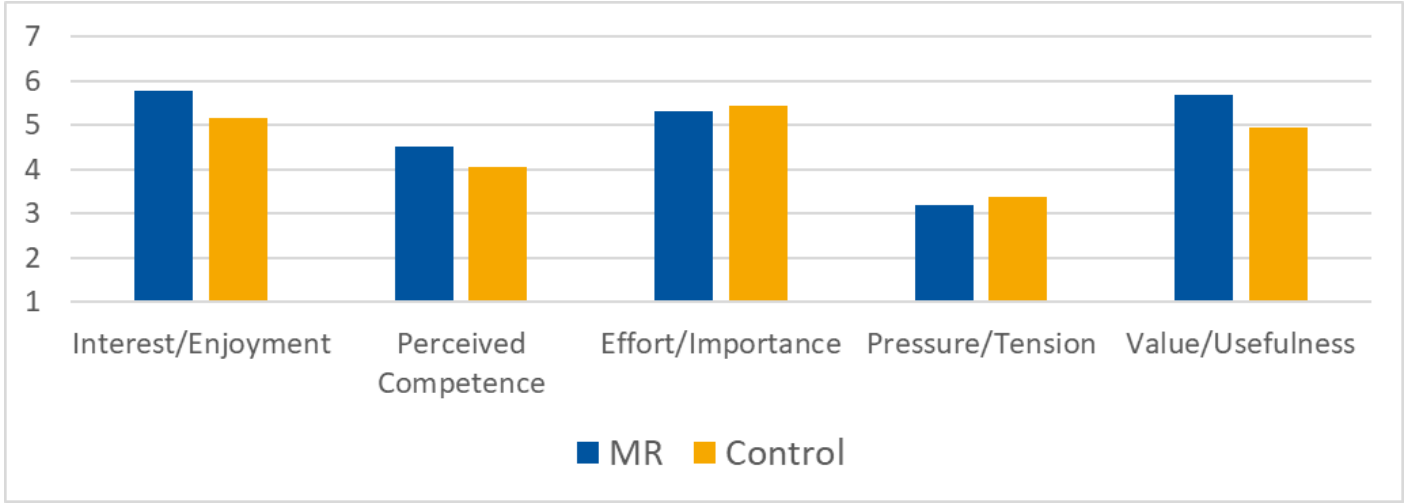
- Initial performance: comparable across groups (~90% list/story recall)
- Follow-up (1 week later)
  - VR group significantly outperforms control group in story retention & new questions
  - Faster answer times overall (1.5 min avg.)

- Transfer task: VR group achieves 99.7% accuracy vs. 85.4% in the control group
  - Statistically significant (p = 0.022)

Evaluation

Usability, Motivation and Qualitative Insights

- SUS score: 73.6 – classified as “good” usability [BKMi09]
- IMI results:
  - Higher interest / enjoyment
  - Higher perceived competence & usefulness
  - Lower pressure in the VR group



- User Feedback
  - Praise for intuitive controls, agent guidance, audio cues & real-world alignment
  - Critiques: HMD weight, menu positioning, occasional loading delays

Conclusion & Future Work

- VR and instructional agents effectively teach MoL => long-term retention & independent transfer
- Higher motivation, confidence and perceived usefulness
- Future directions
  - Phase-specific impact analysis of the agent (setup vs. formation vs. repetition)
  - AI / LLM integration for dynamic object generation & route planning
  - Scalable learning paths blending VR onboarding with self-directed practice

References

- [BKMi09] Bangor, A., Kortum, P., & Miller, J. (2009). Determining what individual SUS scores mean: Adding an adjective rating scale. *Journal of Usability Studies*, *4*(3), 114–123.
- [BKS*21] Bickmore, T., Kimani, E., Shamekhi, A., Murali, P., Parmar, D., & Trinh, H. (2021). Virtual agents as supporting media for scientific presentations. *Journal on Multimodal User Interfaces*, *15*(2), 131–146. https://doi.org/10.1007/s12193-020-00350-y
- [Broo96] Brooke, J. (1996). *SUS -- a quick and dirty usability scale* (S. 189–194).
- [HBB*22] Hensen, B., Bekhter, D., Blehm, D., Meinberger, S., & Klamma, R. (2022). Mixed Reality Agents for Automated Mentoring Processes. In L. T. De Paolis, P. Arpaia, & M. Sacco (Hrsg.), *Extended Reality* (S. 3–16). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-15553-6_1
- [HeBe23] Hensen, B., & Bekhter, D. (2023). Mixed Reality Agents as Language Learning Tutors. In C. Frasson, P. Mylonas, & C. Troussas (Hrsg.), *Augmented Intelligence and Intelligent Tutoring Systems* (S. 565–575). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-32883-1_50
- [HMSM20] Hammady, R., Ma, M., Strathern, C., & Mohamad, M. (2020). Design and development of a spatial mixed reality touring guide to the Egyptian museum. *Multimedia Tools and Applications*, *79*(5), 3465–3494. https://doi.org/10.1007/s11042-019-08026-w
- [HuRo17] Huttner, J.-P., & Robra-Bissantz, S. (2017, August 12). *An Immersive Memory Palace: Supporting the Method of Loci with Virtual Reality*.

References

- [KPVa19] Krokos, E., Plaisant, C., & Varshney, A. (2019). Virtual memory palaces: Immersion aids recall. *Virtual Reality*, *23*(1), 1–15. https://doi.org/10.1007/s10055-018-0346-3
- [McCa15] McCabe, J. (2015). Location, Location, Location! Demonstrating the Mnemonic Benefit of the Method of Loci. *Teaching of Psychology*, *42*, 169–173. https://doi.org/10.1177/0098628315573143
- [MoSy23] Moll, B., & Sykes, E. (2023). Optimized virtual reality-based Method of Loci memorization techniques through increased immersion and effective memory palace designs: A feasibility study. *Virtual Reality*, *27*(2), 941–966. https://doi.org/10.1007/s10055-022-00700-z
- [REBR20] Reggente, N., Essoe, J. K. Y., Baek, H. Y., & Rissman, J. (2020). The Method of Loci in Virtual Reality: Explicit Binding of Objects to Spatial Contexts Enhances Subsequent Memory Recall. *Journal of Cognitive Enhancement*, *4*(1), 12–30. https://doi.org/10.1007/s41465-019-00141-8
- [Ryan82] Ryan, R. M. (1982). Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory. *Journal of Personality and Social Psychology*, *43*(3), 450–461. https://doi.org/10.1037/0022-3514.43.3.450
- [WKS*21] Wagner, I. C., Konrad, B. N., Schuster, P., Weisig, S., Repantis, D., Ohla, K., Kühn, S., Fernández, G., Steiger, A., Lamm, C., Czisch, M., & Dresler, M. (2021). Durable memories and efficient neural coding through mnemonic training using the method of loci. *Science Advances*, *7*(10), eabc7606. https://doi.org/10.1126/sciadv.abc7606
- [USAr23] Urrizola, A., Santiago, R., & Arbea, L. (2023). Learning techniques that medical students use for long-term retention: A cross-sectional analysis. *Medical Teacher*, *45*(4), 412–418. https://doi.org/10.1080/0142159X.2022.2137016

Thank you for your attention

The code is open-source on GitHub

https://github.com/rwth-acis/MR-MiRA-Method-of-Loci-App