Teaching Practical Tasks with **Virtual Reality** and **Augmented Reality**

An Experimental Study Comparing **Learning Outcomes**

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The project on this posters outlines results of the Master's theses of Alexander Arntz and Dustin Keßler. Ideas and results of this project have partly been reused in the CoopLab Initiative and adapted to fit specific requirements.

Motivation

- Augmented Reality and Virtual Reality offer potential benefits for education in terms of flexible, inclusive and motivational learning arrangements.
- Although several studies (1) covered VR as a teaching tool, the interactive capabilities for teaching practical tasks is widely neglected.
- This denied the full potential of the VR-Technology as haptic motion controls allow to faithfully recreate tasks that involve motor skills.
- However, the effectiveness of using VR for learning practical tasks has yet to be proven (2).
- If successful the technology can facilitate teaching by offering cost efficient courses that allow to explore complex or abstract facts in an engaging way.
- Based on the Cognitive Theory of Multimedia Learning (3) an experimental study was created to verify VR against AR and a real setup.

Hypotheses

- **H1)** Participants of a VR-scenario outperform the PC and control group regarding the identification and designation of hardware assembling parts.
- **H2)** VR and the control scenario are on par in their outcome in terms of success rate at assembling all hardware components. AR is expected to fall off compared to both other conditions.

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Method

- Experimental setup with 3 conditions (VR, AR, real situation).
- Each condition contained **N = 20** test persons (41.66% women, 58.33% men), average age 23.35 years (*SD = 3.96*).
- **First session:** Contained the learning scenarios presented by VR, AR and the real computer scenario.
- **Second session:** A week later learning effectiveness (i.e. application of instructions) was tested.
- The experimental experiments were accompanied by online questionnaires
- Questionnaires were available in 6 different versions (scenario specific with pre- and post-condition).
- Learning success was measured by means of knowledge queries on the naming and functionality of the PC components.
- In addition to the questionnaire, further measurements were recording of the required time and assembly checklist.
- Measurement of learning outcomes based on the Methods of Measuring Learning Outcomes and Value-Added Grid (4) developed at MIT.

VR-Scenario

- **Development goal**: As close as possible to reality - scale ratio, assembly procedure and properties of the objects were precisely replicated.
- Participants had to assemble 10 PC components using interactive motion controls.
- Each component was equipped with information labels as well as voice descriptions on function and installation set by Google Text to Speech API
- Errors could be undone at any time, either by step or by reset the scene completely.

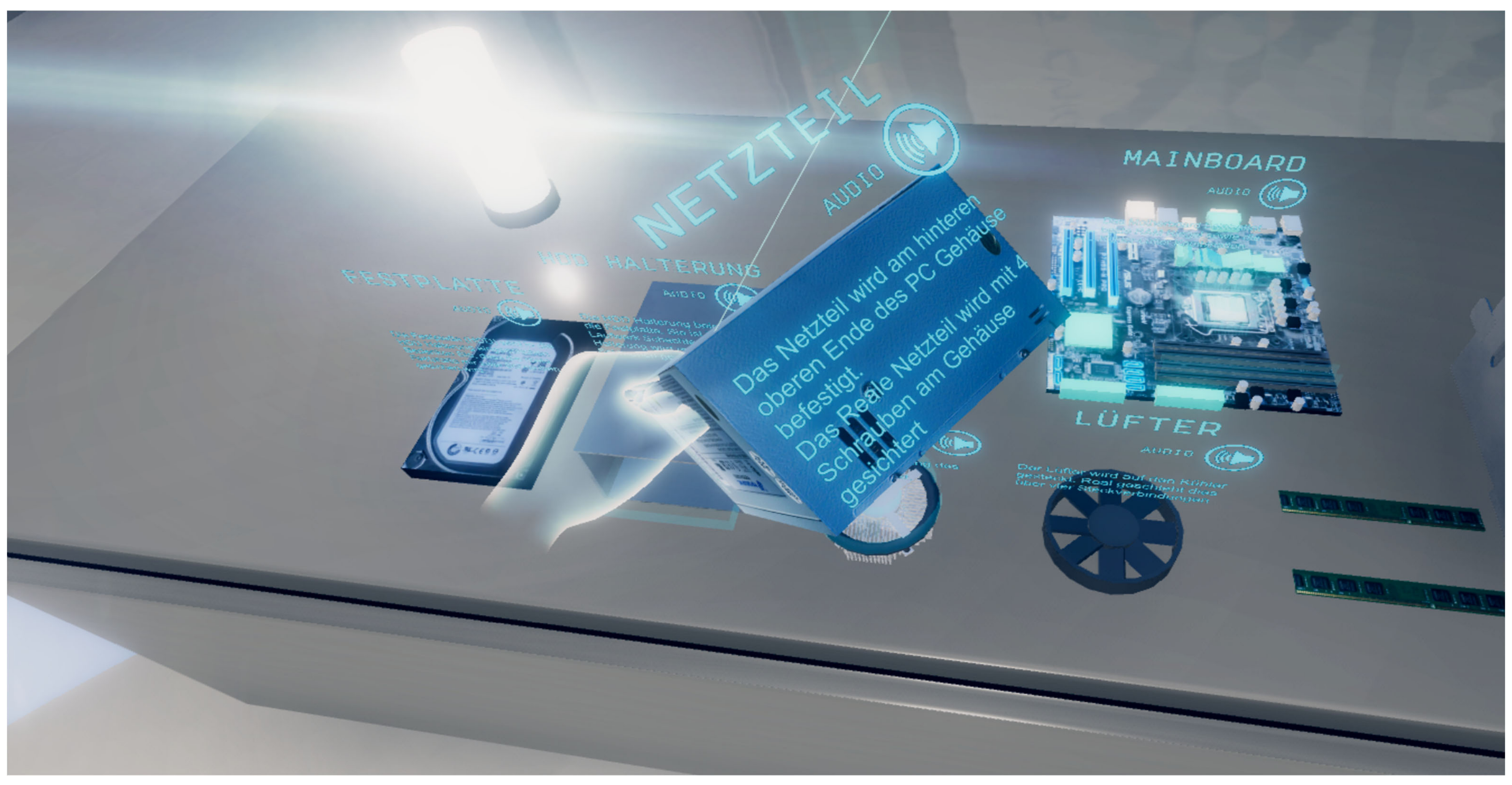

Figure 1: The interaction mechanics used to assemble the computer components.

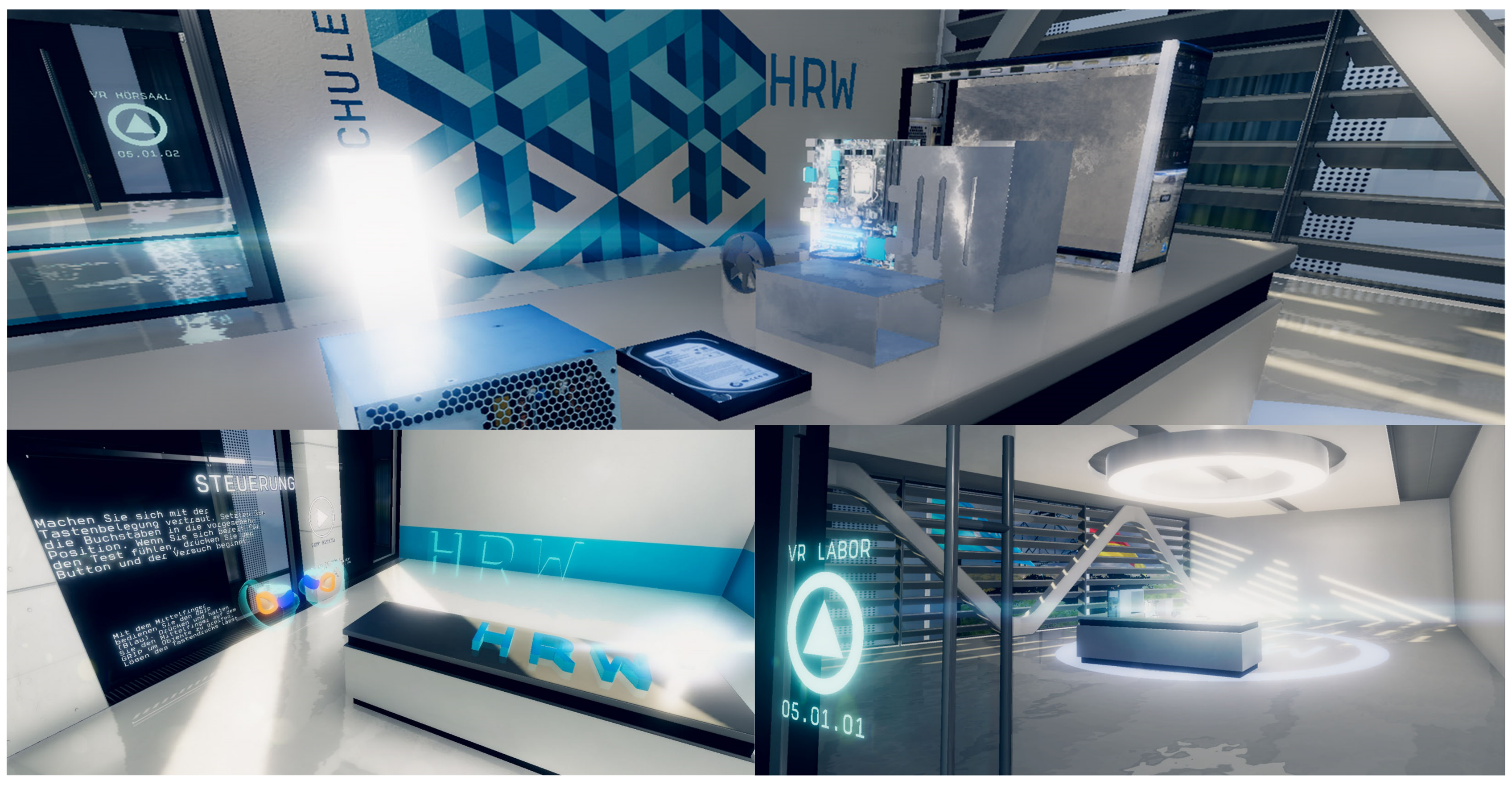

Figure 2: The virtual environment along the accurate replicated computer components as well the recreated environment.

Results

- **H1):** Previous knowledge: univariate ANOVA analysis shows significant differences between the two groups, F (18.19) = 0.19 p = 0.002.
- Interest in computers: univariate ANOVA analysis shows significant differences between the two groups, F (17.19) = 0.49 p = 0.001.

Condition	Previous Knowledge	Interest
VR Scenario	*M*=3.52 (*SD*=0.67)	*M*=4.15 (*SD*=0.85)
PC Szenario	*M*=4.10 (*SD*=0.71)	*M*=4.90 (*SD*=1.16)

- Knowledge queries: Significant increase in answers
- VR scenario: F (18.19) = 0.22, p = 0.003.
- PC control scenario: F (17.19) = 0.27, p = 0.004.
- H1 is supported.

Condition	Pre-Test	Post-Test
VR Scenario	*M*=1.95 (*SD*=0.88)	*M*=2.90 (*SD*=0.44)
PC Scenario	*M*=1.90 (*SD*=0.78)	*M*=2.45 (*SD*=0.60)

- **H2):** Results showed that participants of the VR condition slightly outperformed the other groups.
- H2 is supported.

Condition	Pre-Test	Post-Test
VR Scenario	*M*=9.90 (*SD*=0.30)	*M*=10.0 (*SD*=0.00)
AR Scenario	*M*=9.85 (*SD*=0.48)	*M*=9.80 (*SD*=0.41)
PC Scenario	*M*=8.80 (*SD*=1.36)	*M*=8.95 (*SD*=1.27)

Discussion & Limitations

- Participants do not represent the major population, as most of them were students.
- This study does not cover long term recall evaluation, further studies are needed to validate VR and AR effectiveness for long term learning.
- Although the results show a learning success for practical tasks, current iterations of VR technology lack the capabilities to mimic fine motor skills, which limits its usefulness in some areas.
- Continuous integration of technology in the education sector requires new concepts for effective learning.
- Theoretical basis for effectiveness of AR / VR: Multimedia Principle (5), Cognitive Theory of Multimedia Learning.
- Participants not only showed objective learning effects, subjective assessment and perceived added value were also positive.

Outlook

- VR-Technology is still in its infancy; future development: better hardware and presentation, as well as self-sufficient eyewear.
- VR offers potential for the implementation of many new didactic concepts.

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