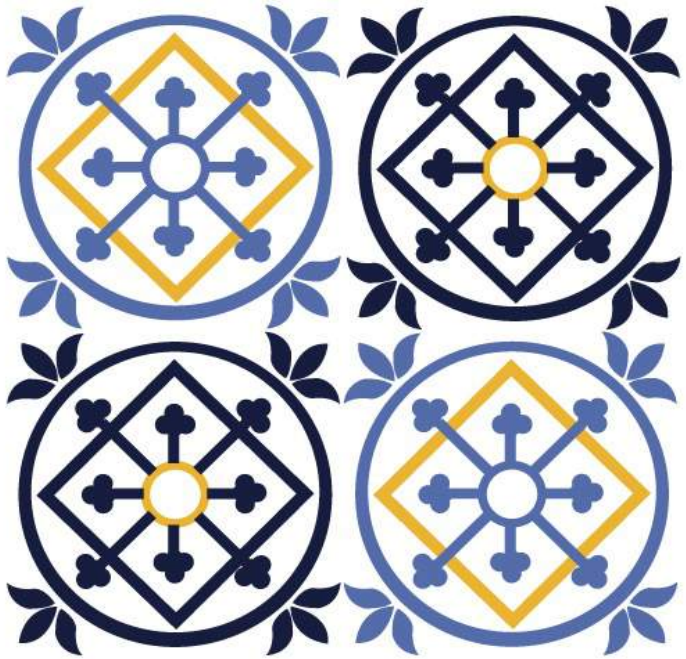

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Encountering Students' Learning Difficulties in Electrics – Didactical Concept and Prototype of Augmented Reality-Toolkit

L. Lauer, M. Peschel, H. Javaheri, P.Lukowicz, A. Grünerbl, K. Altmeyer, S. Malone, R. Brünken

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Welcome

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Workshop Goals

- Introduction to teaching and learning with Augmented Reality (AR)
- Demonstration of a didactically substantiated educational AR-technology for physics education
- Provision of insights into challenges and applicability of educational AR-technology for physics education

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Outline

- Theoretical Background: Augmented Reality (AR) in Education
- Theoretical Background: Electrical Circuit Schematics
- Demonstration: AR-Toolkit for Electrical Circuit Schematics
- Outlook and Discussion: Applicability of the AR-Toolkit

Outline

- **Theoretical Background: Augmented Reality (AR) in Education**
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Augmented Reality (AR)

- Real world (initial channel of perception) is supplemented with virtual objects (Azuma, 2001; Milgram & Kishino, 1994)
- Real world and virtual objects can be perceived simultaneously in real-time (Carmigniani, 2011)
- AR is viewed as a concept for computer-generated environments (Silva et al., 2003)
- AR can enhance the perception of reality by providing supplementary information (Liu et al., 2007)

AR-Devices

Handheld display AR

Head-mounted display AR

real environment

virtual object

AR in Education

- AR can promote the acquisition of knowledge and skills
  (Arici et al., 2019; Garzón & Acevedo, 2019)
- AR can positively influence motivation and engagement
  (Zhang et al., 2020)
- The use of AR can be hampered by technical difficulties
  (Munoz-Cristobal et al., 2015)
- The use of AR in education requires further scientific research
  (Akçayır & Akçayır, 2017)

AR in Physics Education

Developments and didactical research on AR in the field of electrics:

- Real-time display of measured values in electric ciruits (Altmeyer et al., 2020; Kapp et al., 2019; Thees et al., 2020)
- Visualization of electromagnetic field lines (Abdusselam & Karal, 2020; Barma et al., 2015; Buesing & Cook, 2013) and electrostatic charge (Permana et al., 2019)
- Visualization of the eletrical potential alongside the circuit (Weatherby et al. 2020)

Outline

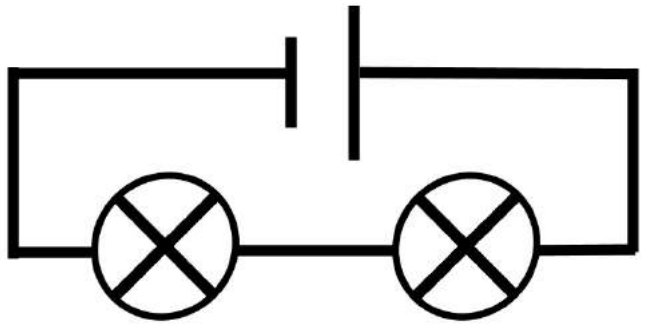
- Theoretical Background: Augmented Reality (AR) in Education
- **Theoretical Background: Electrical Circuit Schematics**
- Demonstration: AR-Toolkit for Electrical Circuit Schematics
- Outlook and Discussion: Applicability of the AR-Toolkit

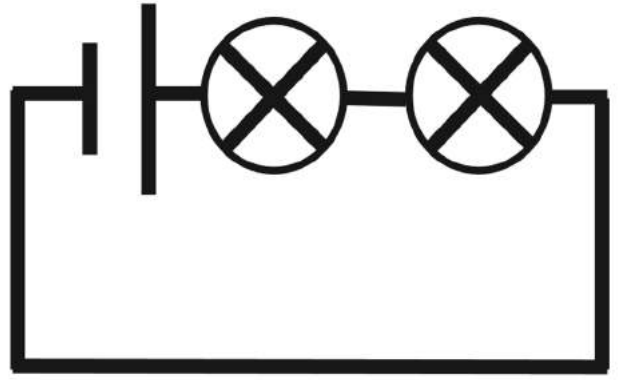
Electrical Circuit Schematics

- Provision of a simple, structured symbolic representation of electrical circuits
- Difficulties of understanding and using electrical circuit schematics are: (Wilhelm & Hopf, 2018)
  - Matching physical components with the corresponding symbol
  - Handling the discrepancy between spatial arrangement of the components and the simplified structure of the circuit schematic

Electrical Circuit Schematics

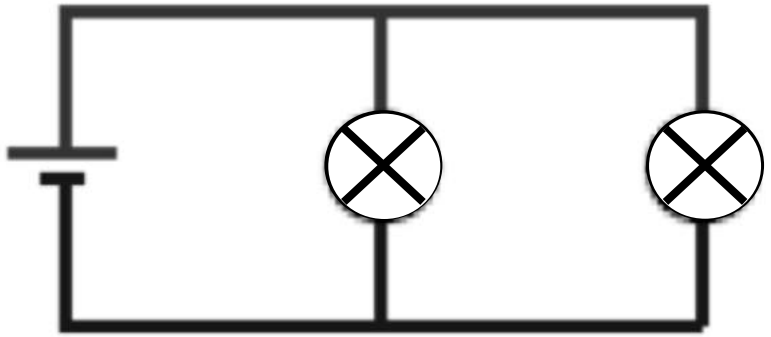
Spatial arrangement of components, example 1:

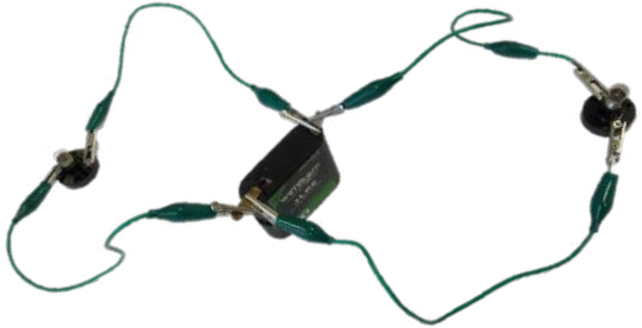




Electrical Circuit Schematics

Spatial arrangement of components, example 2:





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AR-Toolkit: Features

- Real-time visualization of electrical circuit symbols in spatial proximity to the components
- Real-time visualization of electrical circuit scematics in accordance to the components' semantic connection
- Use of the toolkit may faciliate the acquisition of representational competencies (concerning the matching of components and symbols and the matching of circuits and circuit schematics)
- Usable with either handheld AR-devices or head-mounted AR-devices

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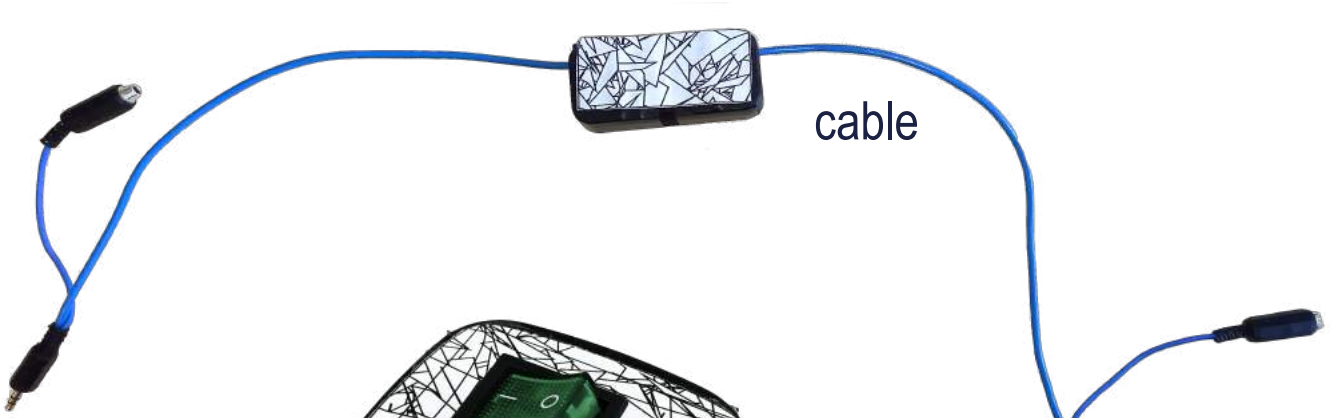
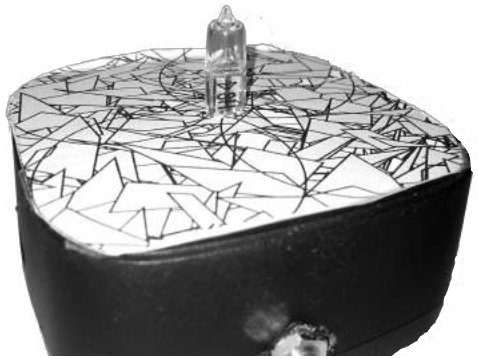
AR-Toolkit: Components



lamp



switch

battery

interior

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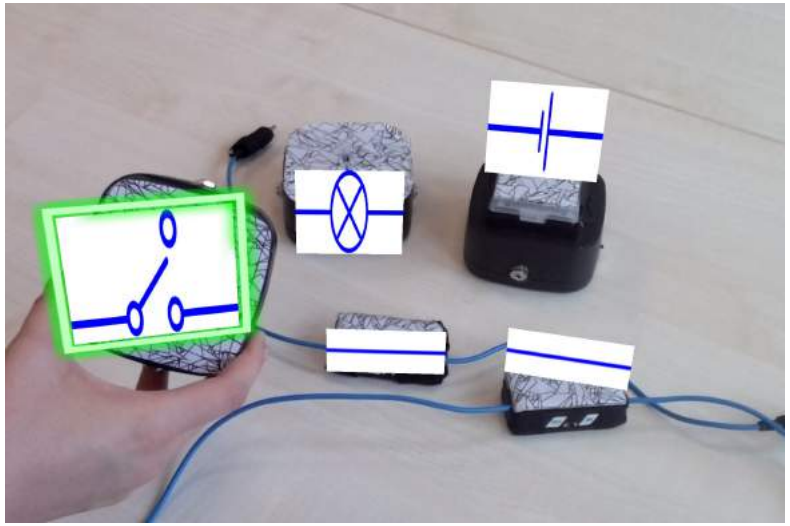
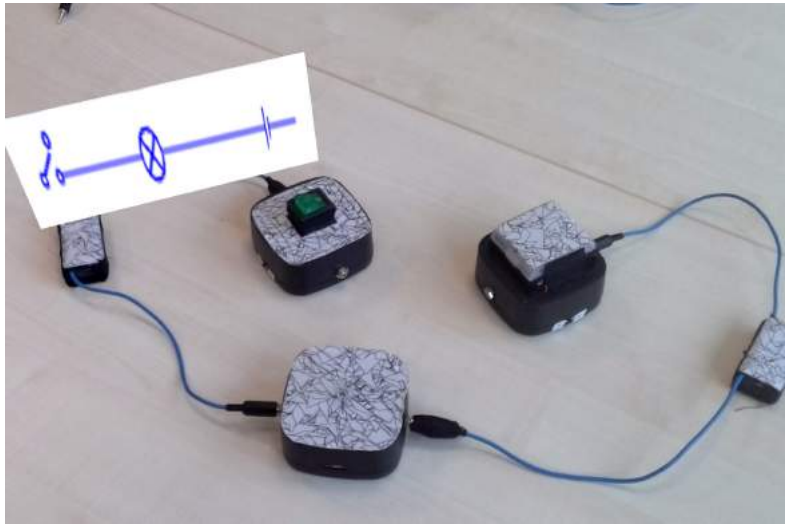
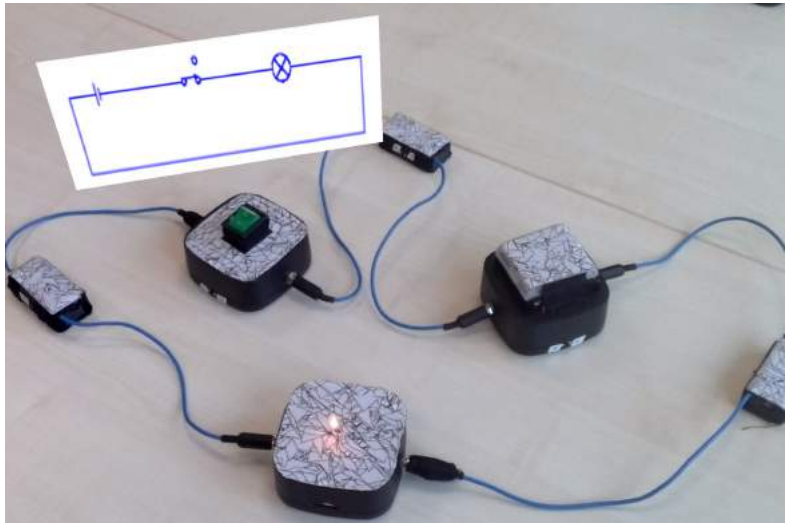
Real-Time Schematic Visualization



AR-symbols of single components, touch-highlighting

AR-schematic of an incomplete circuit





AR-schematic of a complete circuit

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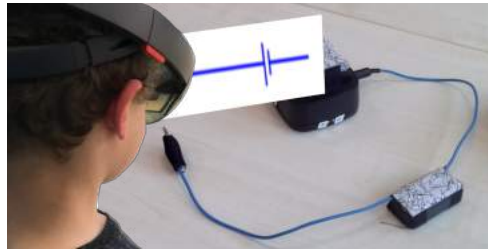
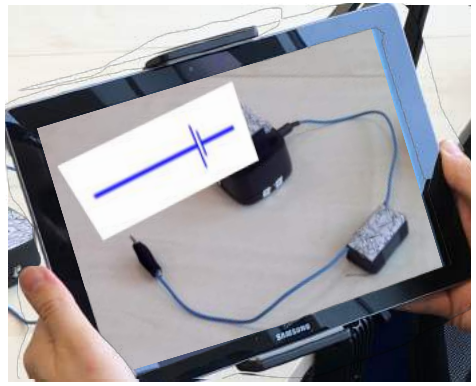
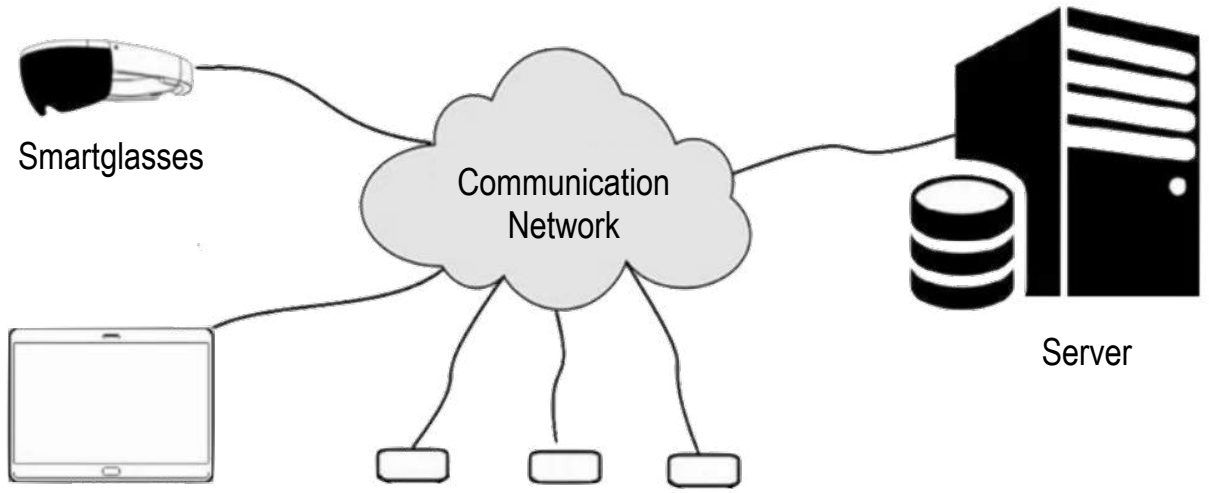
AR-Toolkit: Operation Mode







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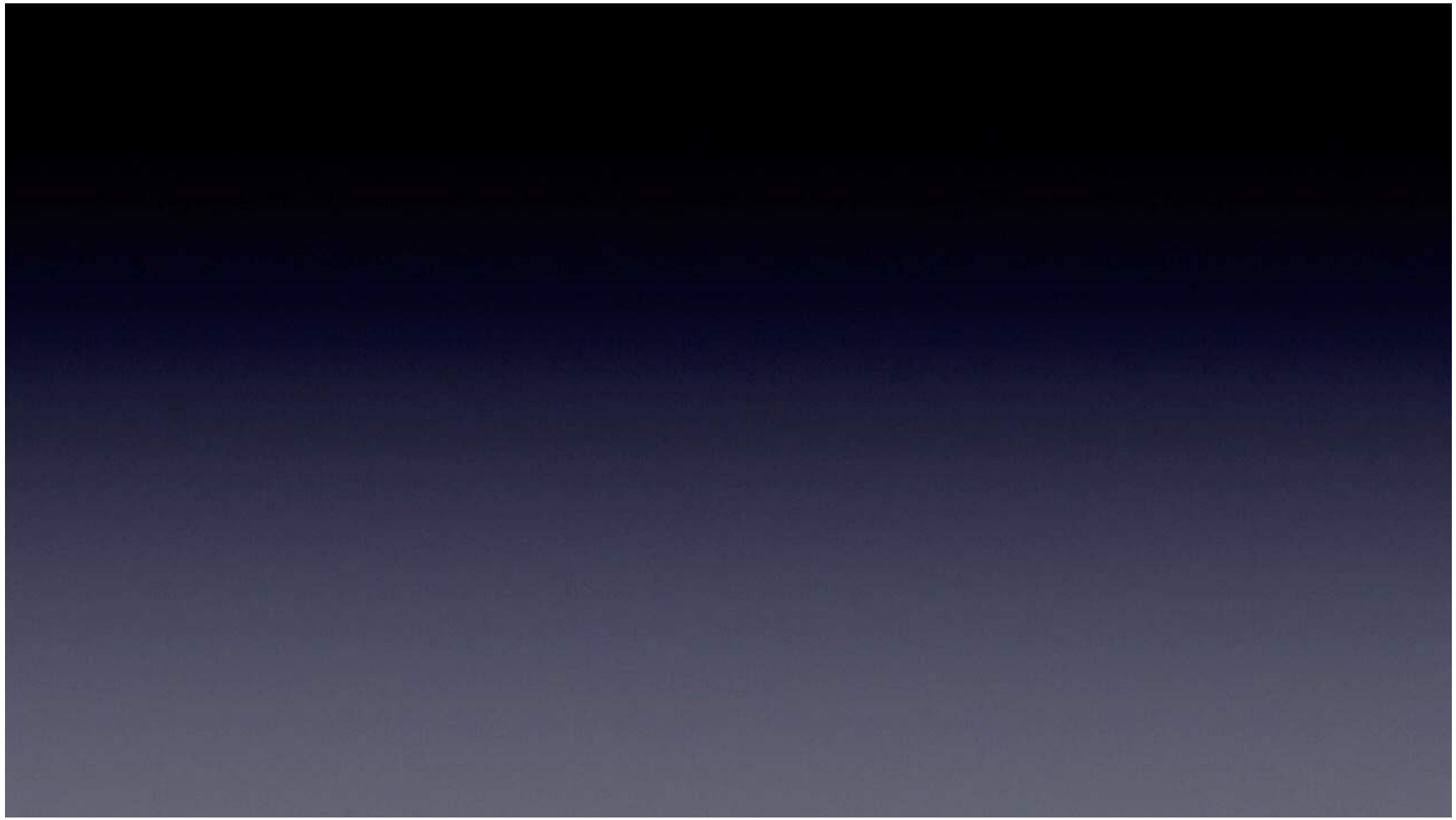
AR-Toolkit: Demonstration



Technical Improvement

- Detection and visualization of parallel circuits
- Addition of more components
- Reduction of box size, assimilation to the appearance of common electrical tools for education
- Optimization of AR-stability, minimization of reaction time

Outline

- Theoretical Background: Augmented Reality (AR) in Education
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- Demonstration: AR-Toolkit for Electrical Circuit Schematics
- **Outlook and Discussion: Applicability of the AR-Toolkit**

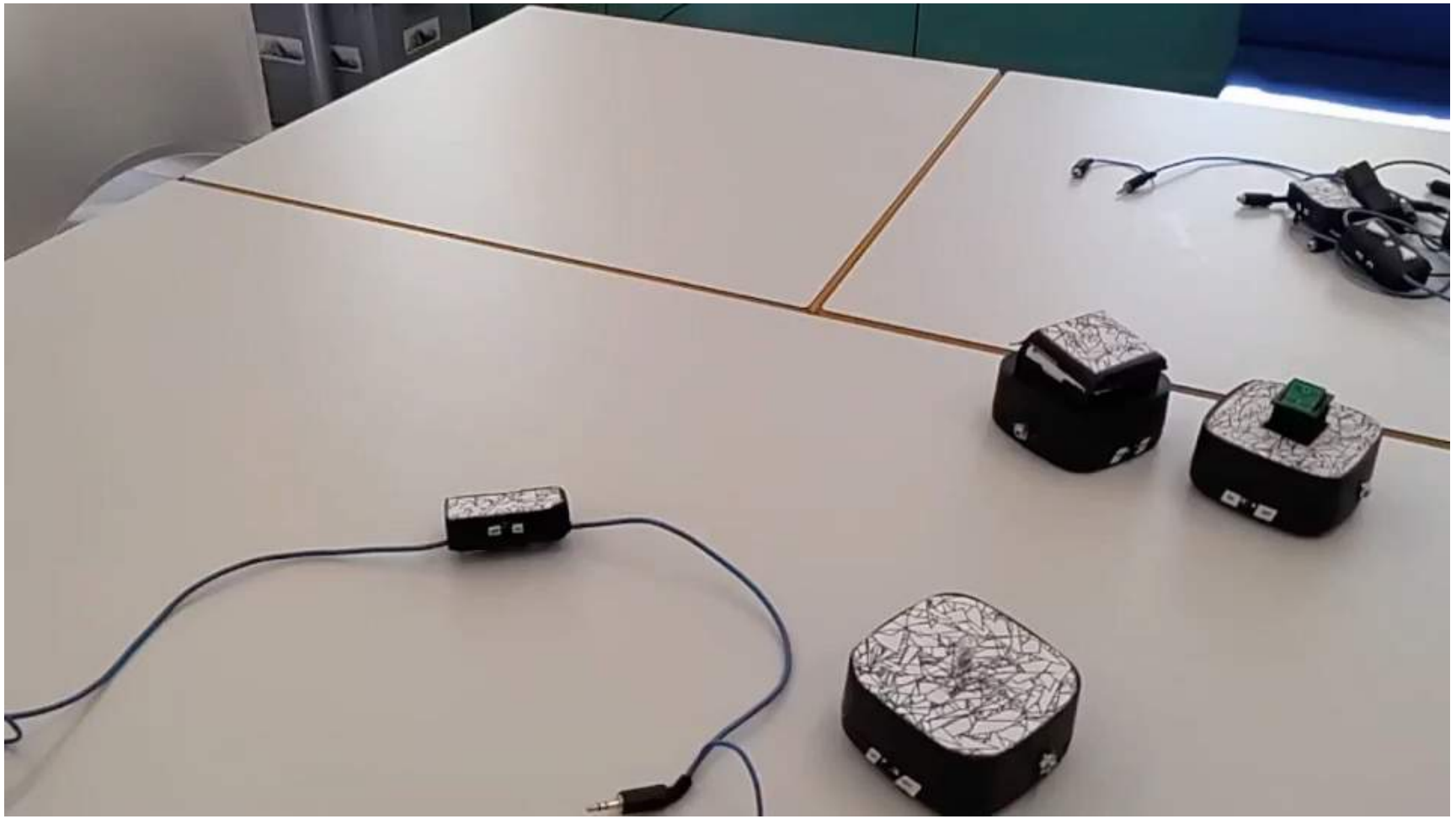
Primary Education

- Introduction into electrical circuits and electrial circuit schematics
- Step-by-step-explanation of the assembly of an eletrical circuit (schematic)
- Support for the process of abstraction from the actual circuit to the simplified circuit schematic

Secondary and higher education

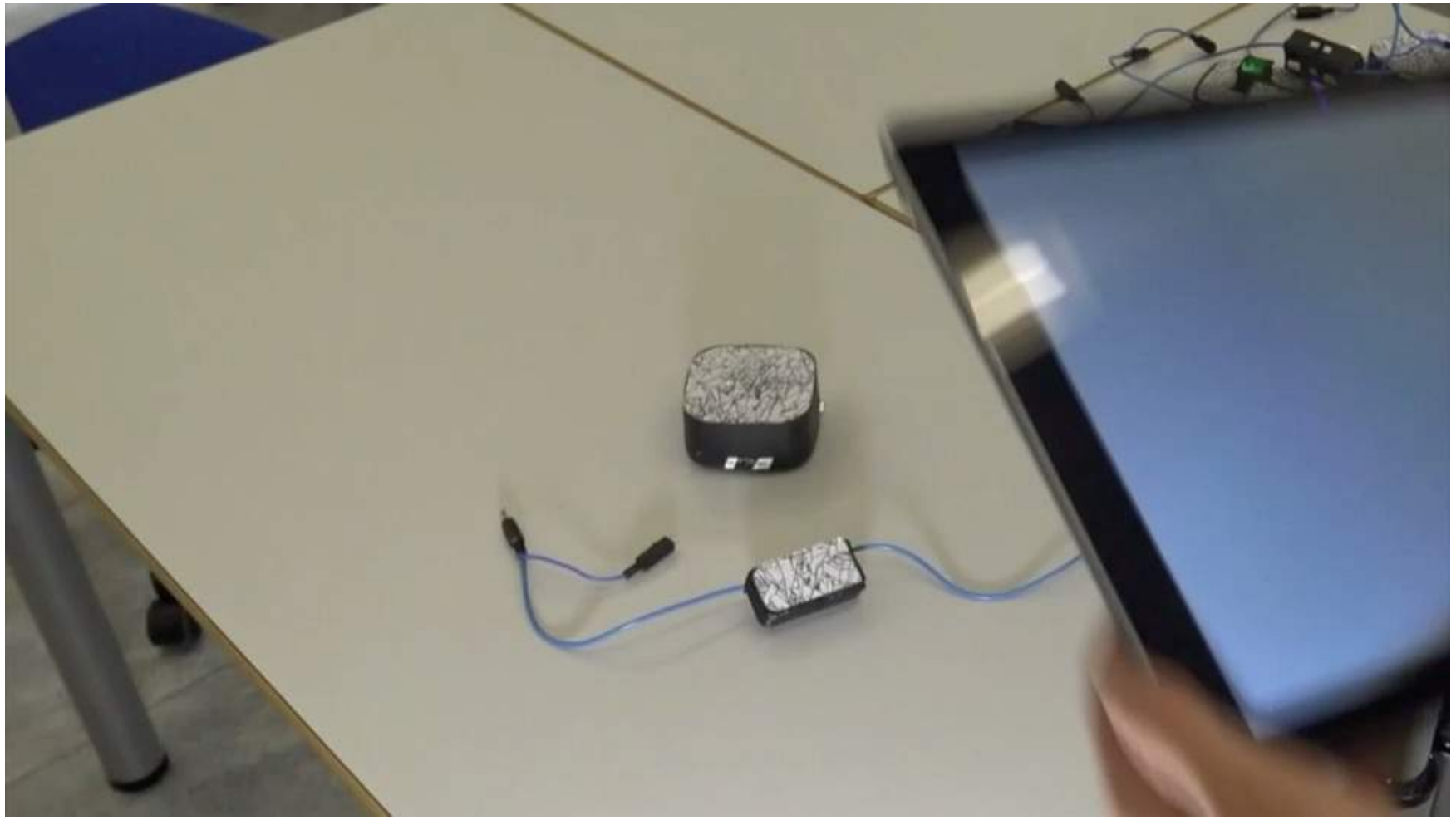
- Support for the process of abstraction from the actual circuit to the simplified circuit schematic (early secondary education)
- Differentiation between serial and parallel circuits (early secondary education)
- Support for operating in highly complex electrical circuits (late secondary and higher education)

AR-Toolkit: Demonstration



Demo-Video:
AR-smartglasses
POV-camera

AR-Toolkit: Demonstration



Demo-Video:
Tablet-AR

Discussion Summary

- Differences in use and applicability between the handheld device version and the head-mounted device version
- Prevailing flaws require further technical development
- Outlook: Empirical study is being carried out to assess the applicability of the toolkit for educational purposes

Take-Home

Take-Home

- AR in (physics) education can faciliate the acquisition of (representational) competencies by connecting real objects with additional information in real-time
- The presented AR-toolkit for real-time visualization of electrical circuit schematics represents a first-stage prototype of a didactically substantiated usecase for AR in physics education
- Further technical optimization is required to enable its use everyday education and training

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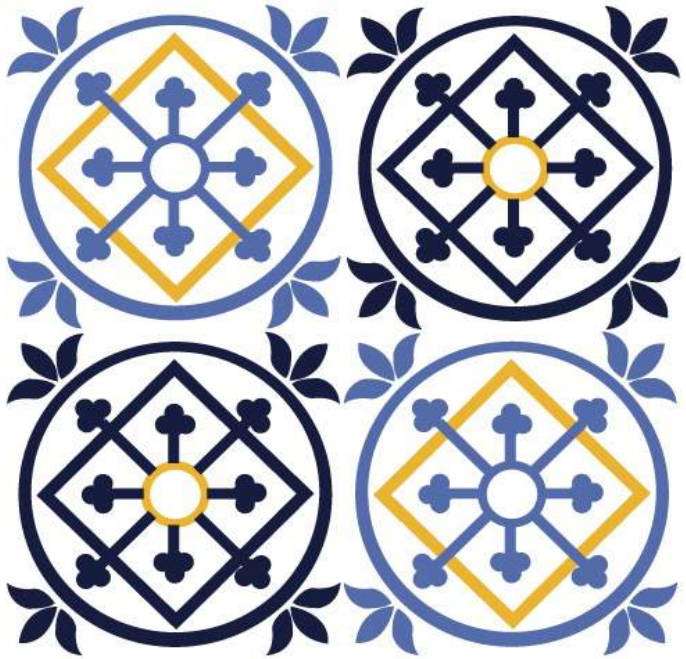

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Thank you very much for joining the workshop!

We are looking forward to receiving your questions and engaging in discussion.