University of Stuttgart
Institute of Educational Science (IfE)
Vocational Education focused on Teaching Technology (BPT)

Teaching Session
5th International AR VR Conference Munich

The Application of Virtual Reality in Physics Education: Virtual Physical Sensor Laboratory (VPSL)

Qi Guo, M. Ed.

Prof. Dr. Bernd Zinn

University of Stuttgart
Institute of Educational Science (IfE)
Department of Vocational Education focused on Teaching Technology (BPT)

Content

- Research Background
- Introduction of Virtual Physical Sensor Laboratory (VPSL)
- Evaluation
- Discussion & Conclusion

RESEARCH BACKGROUND

RESEARCH BACKGROUND

VR for training and learning

- Training and learning with VR
  - Development of IT, digitalization, automation (Zinn 2017)
  - **Simulation** in VR (Lin et al., 2013; Bosch et al., 2015) offers the possibilities of training in difficult situations (Blümel, Jenewein & Schenk 2010), including the training of the processing performance of mental rotation (Ariali & Zinn 2018)
  - The realization of **Human-Object-Interaction** helps to transfer learning content into practices and improves **learning interest** (cf. Cavazza, Charles & Mead 2002).
  - The **perceived usability** of VR-applications have positive effects on the **use intention** of VR Technology based on Technology Acceptance Model (cf. Pletz & Zinn 2018)
  - Effects of learning with Mixed-reality-simulation is affected by (1) technical aspects (e.g. **usability**), (2) characters of learners (e.g. **motivation**) as well as (3) **methodological-didactic design** (e.g. sequences of learning process) (cf. Jahnke 2016; Cameirão et al. 2010; Chang et al. 2010).

RESEARCH BACKGROUND

Immersive elements in VR

- **Immersion** benefits new perspectives, situated learning and knowledge transfer (Dede 2009). **Spatial presence**, **flow**, **social presence**, **engagement** as well as **authentity** have significant influence on situative interest of learning in multimedia E-learning environments (Sun & Rueda 2012).
- **Immersion**: the sensation of being in a completely different environment that takes over your attentions and perceptions (Murray 1999)
- **Spatial presence:** the extent to which one feels present in the created circumstances rather than one's own physical location (Witmer & Singer 1998; Weibel & Wissmath 2011)
- **Flow**: the optimal mental state of intrinsic motivation, being fully immersive in a highly engaging activity (cf. Rheinberg, Vollmeyer & Engeser 2003; Csikszentmihalyi 1999), effected by **spatial presence** and **Usability** of the VR environment (cf. Zinn, Guo & Sari 2016).

RESEARCH BACKGROUND

VR Applications for Schools

- Application of VR in the educational field
  - Financial and personnel aspects
  - IT-infrastructures in schools
  - Didactic concerns

- VR system of VPSL
  - PC required VR system vs Standalone and mobile VR system (cf. Ariali & Zinn 2018)

➔ **Oculus Go**

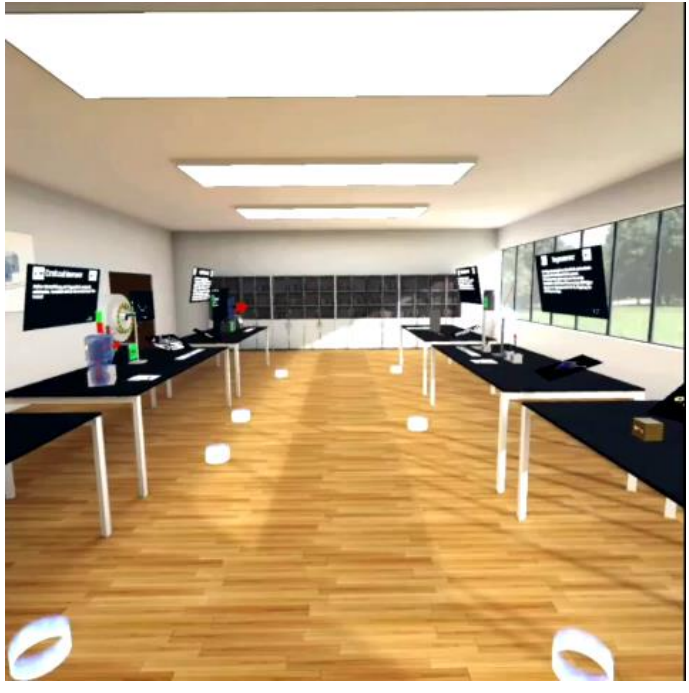
INTRODUCTION OF VPSL

INTRODUCTION OF VPSL

- New Location in the 3D virtual world: Virtual Laboratory
- Content Focus: Physical Sensor
- Evaluation of VPSL concerning spatial presence, flow experience, usability and learning motivation.
- Hardware: Oculus Go
- Software: VPSL (Virtual Physical Sensor Laboratory)
  - Development platform: Unity
  - 3D-Model building: Stechup & Blender

INTRODUCTION OF VPSL

- Environment
  - A room
  - 6 experiements with sensors
  - 1 projection screen



INTRODUCTION OF VPSL

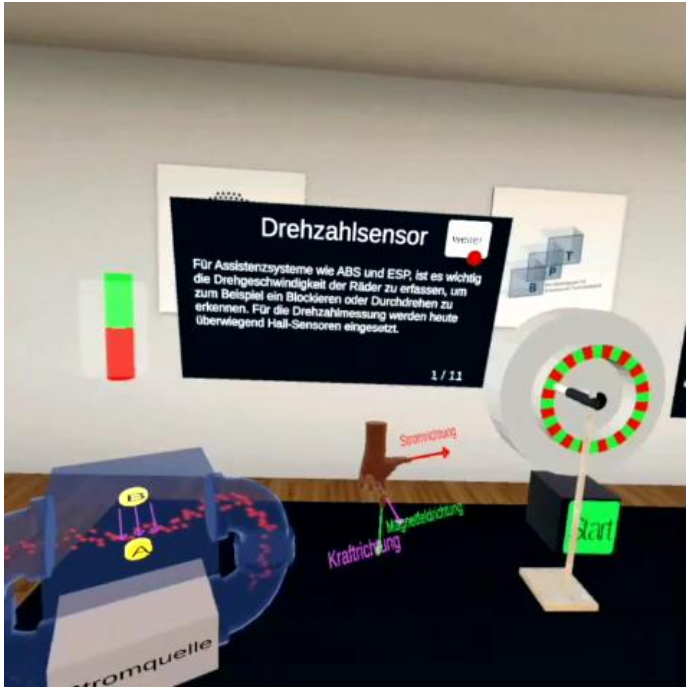
- Introduction screen
  - Basic interations
  - Simple introductions of sensors in the lab

INTRODUCTION OF VPSL

- Demo experiment
  - Try the interations with controller
    - Picking up
    - Teleporting
    - Sliding the button

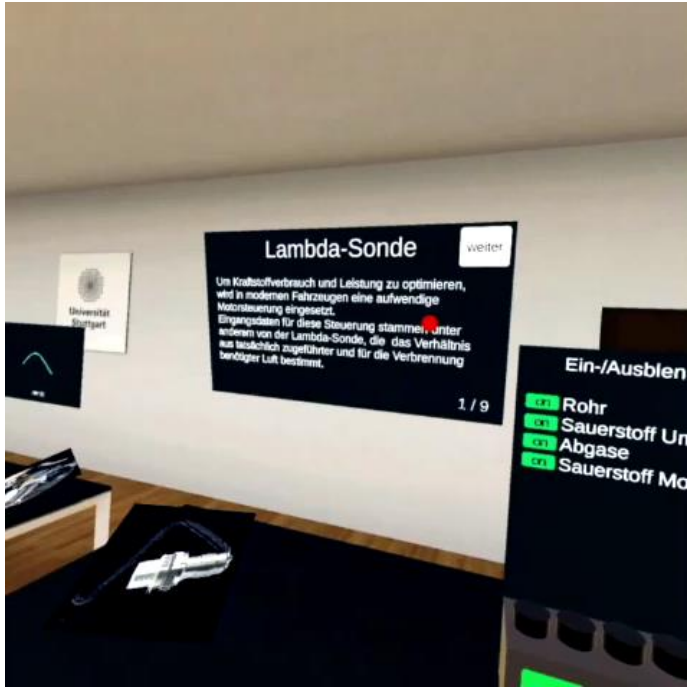
INTRODUCTION OF VPSL

- Experiment 1
- Rotation speed sensor
  - Hall effect
  - The changing of the magnetic field
  - Lorentz force
  - Left hand rule
- Interactions
  - Changing the position of a magnet to affect the diversion of the electrons
  - Starting and changing the speed of the wheel to change the displayed analog sine curves on the oscilloscope



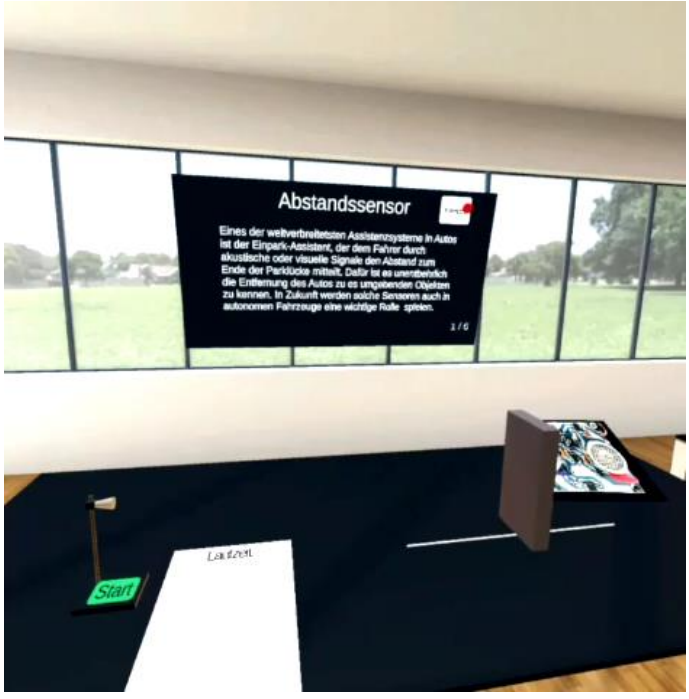
INTRODUCTION OF VPSL

- Experiment 2
- Lambda sensor
  - Partial pressure
  - Electric field
  - Potential and voltage
- Interactions
  - Starting the engine
  - Switching on and off the visualization of the pipe, oxygen and exhaust gas
  - Changing the amount of the fuel for the engine



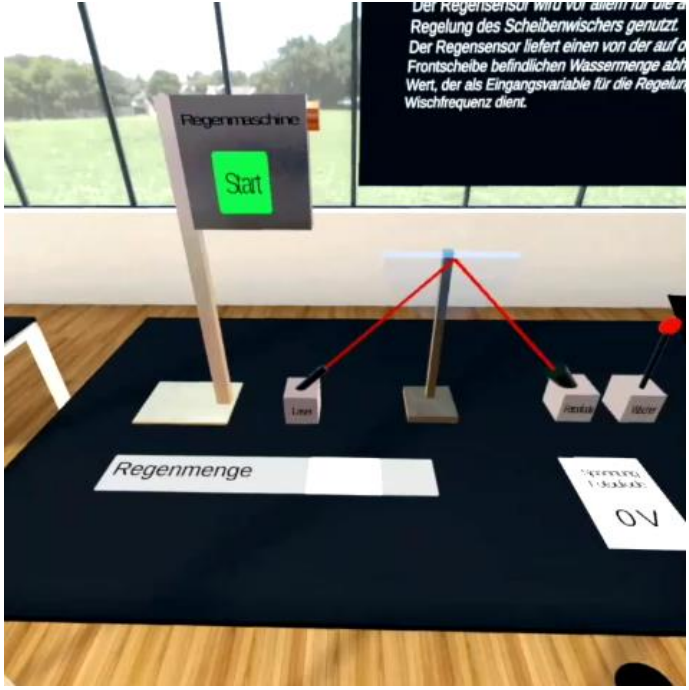
INTRODUCTION OF VPSL

- Experiment 3
- Distance sensor
  - Ultrasonic sensor
  - Wave speed
  - Distance, speed and time
- Interactions
  - Starting the ultrasonic engine
  - Changing the distance



INTRODUCTION OF VPSL

- Experiment 4
- Rain sensor
  - Led and photodiode
  - The principle of total internal reflection
- Interaction
  - Changing the amount of rainwater



INTRODUCTION OF VPSL

- Experiment 5
- Force sensor
  - piezoelectric effect
  - Crystal structure
  - Charge and voltage
- Interactions
  - Picking the cubes up and putting them on the crystal

EVALUATION

Expert Review

EVALUATION

Expert Review

- 18 experts
  - Students and academic researchers in the major of Pedagogics (n = 9), Software (n = 4) and Natural Sciences (n = 5) with interests in the technological and pedagogic senses.
  - Focuses: knowledge transfer, usability, technical and professional knowledge

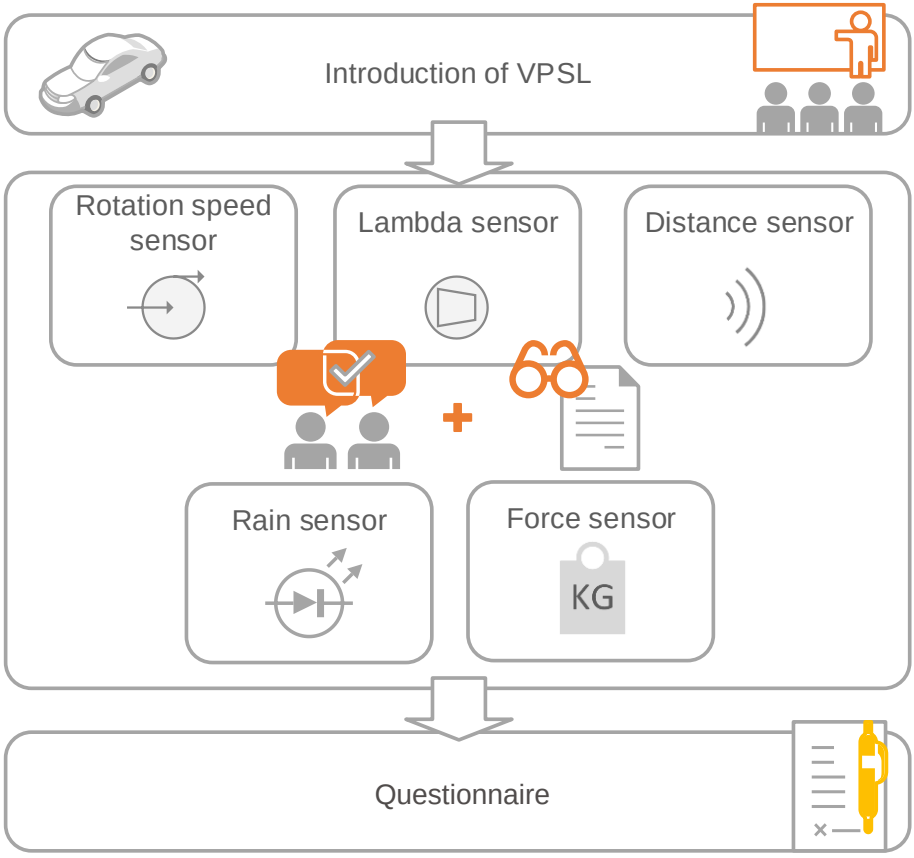
- Results
  - interesting, educational, understandable, appropriate to the teaching content
  - Expectations of improvement:
    - Text: the amount of text; the graphical representation
    - Gamification: import of gaming elements could benefit
    - Interaction: Objects are hard to pick up

  ➔**Update** based on the results of expert reviews

Student Survey

EVALUATION

Student Survey

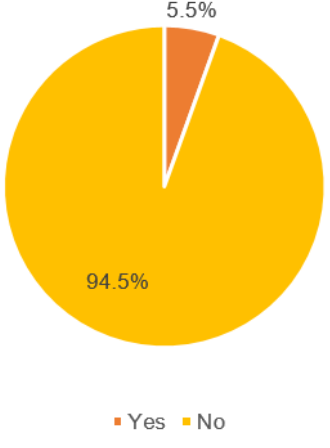


EVALUATION

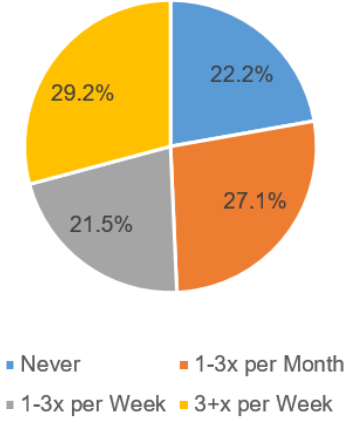
Student Survey - Participants

- Students in vocational eduation (mechanical and electronic technicians for automation technology) (n = 145)
- Male: n = 134 (92.4%)
- Age: M = 18.6, SD = 2.24, Min = 15, Max = 26

- Do you have a VR Glass? (n = 145)



- How often do you play computer or console games? (n = 144)



EVALUATION

Instrument

- Motivation (Prenzel et al. 1996)

Dimensions	Items	Cronbach's α
Perceived overloading	3	.766
Perceived competence	3	.805
Relevance attribution	3	.788
Intrinsic motivation	3	.905
Identified motivation	3	.714

- Spatial Presence (MEC-Spatial Presence Questionnaire of Vorderer et al. 2004; Wirth et al. 2008)

Dimensions	Items	Cronbach's α
Domain specific interest	8	.878
Spatial situation model	8	.840
Attention allocation	8	.936
Visual spatial imagery	8	.866
Possible actions	8	.871
Suspension of disbelief	8	.748
Higher cognitive involvement	8	.830
Self-location	8	.925

EVALUATION

Instrument

- Usability (Usability-Fragebögen Isonorm 9241/10; Isometrics of Gediga et al. 1999)

Dimensions	Items	Cronbach's α
Suitability for the task	5	.769
Self-descriptiveness	5	.790
Controllability	5	.798
Anticipation conformity	5	.891
Customizability	5	.803
Suitability for learning	5	.722

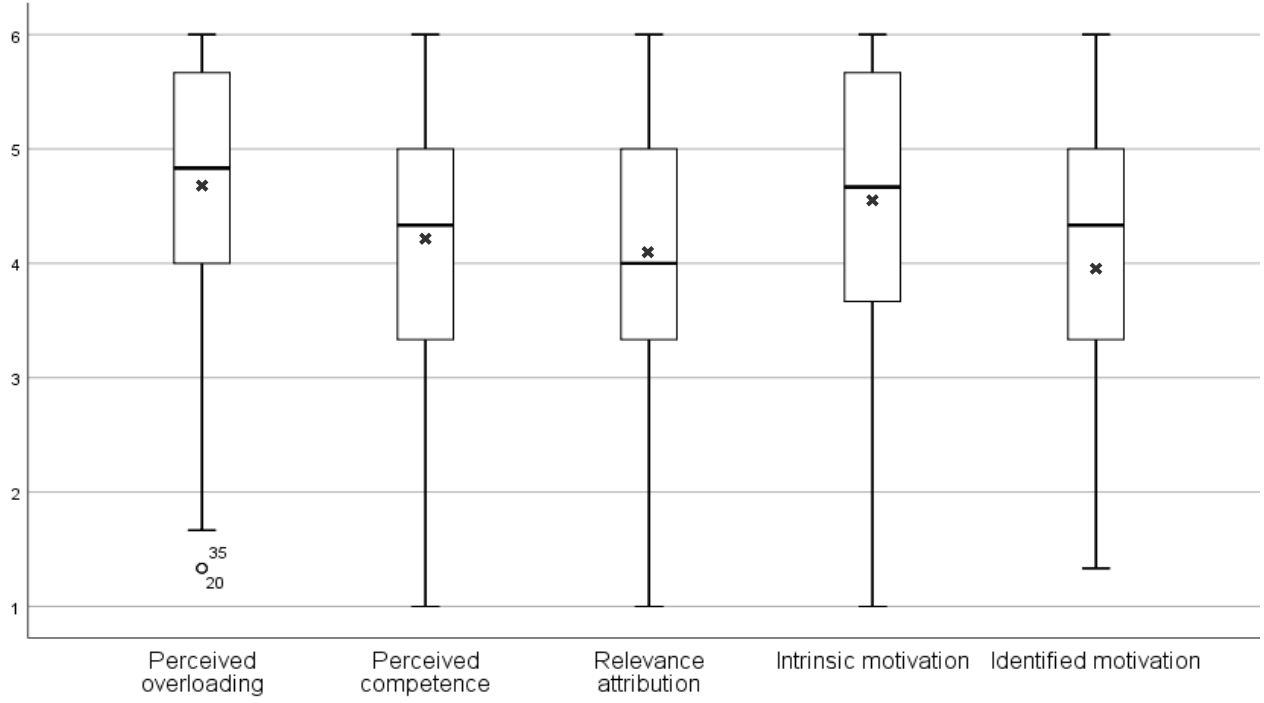
- Flow (Flow Shortscale of Rheinberg et al. 2003)

Dimensions	Items	Cronbach's α
Fluency of performance	6	.804
Absorption by activity	4	.639
Perceived Importance	3	.849

EVALUATION

Results

- Motivation

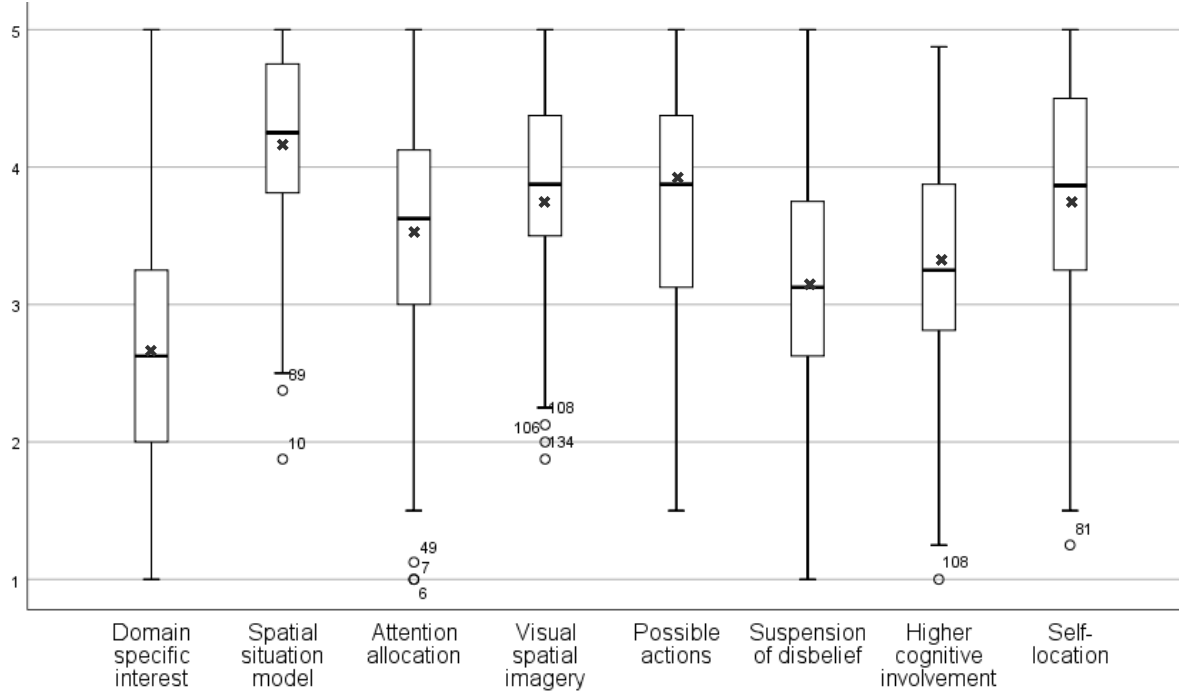


- The participants have high learning motivation in learning in VPSL. (“In the VPSL, I understood the learning content well.”)

EVALUATION

Results

- Spatial Presence

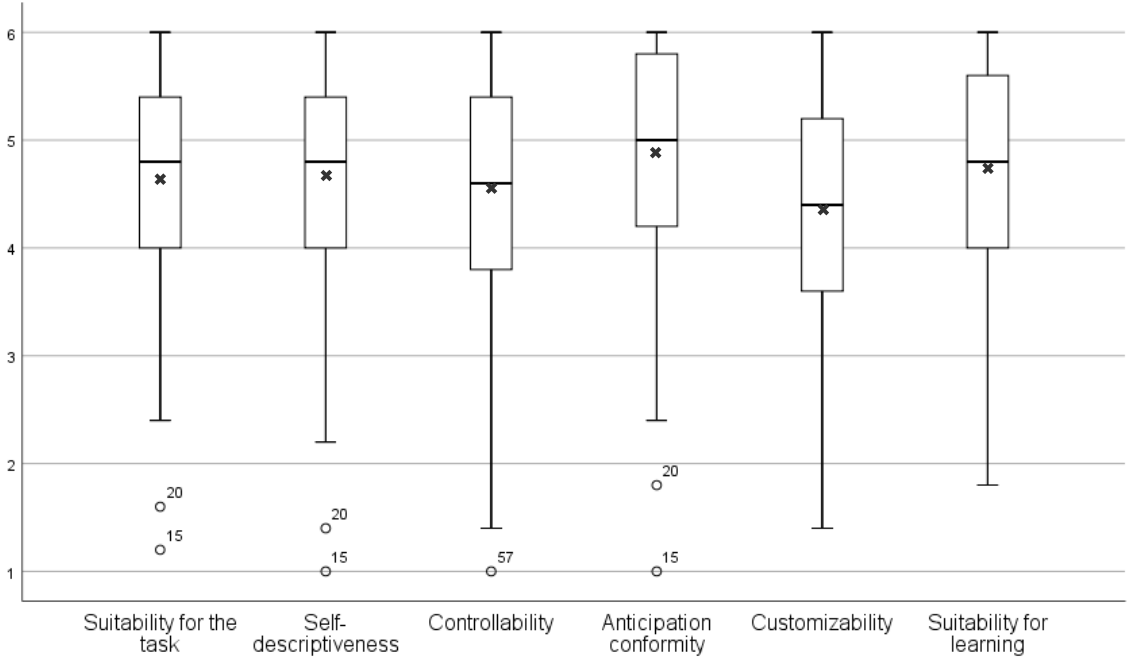


- The evaluation of spatial presence indicate that the participants have good immersive presence in VPSL. (e.g. I felt that I was part of the shown environment. – self location)

EVALUATION

Results

- Usability

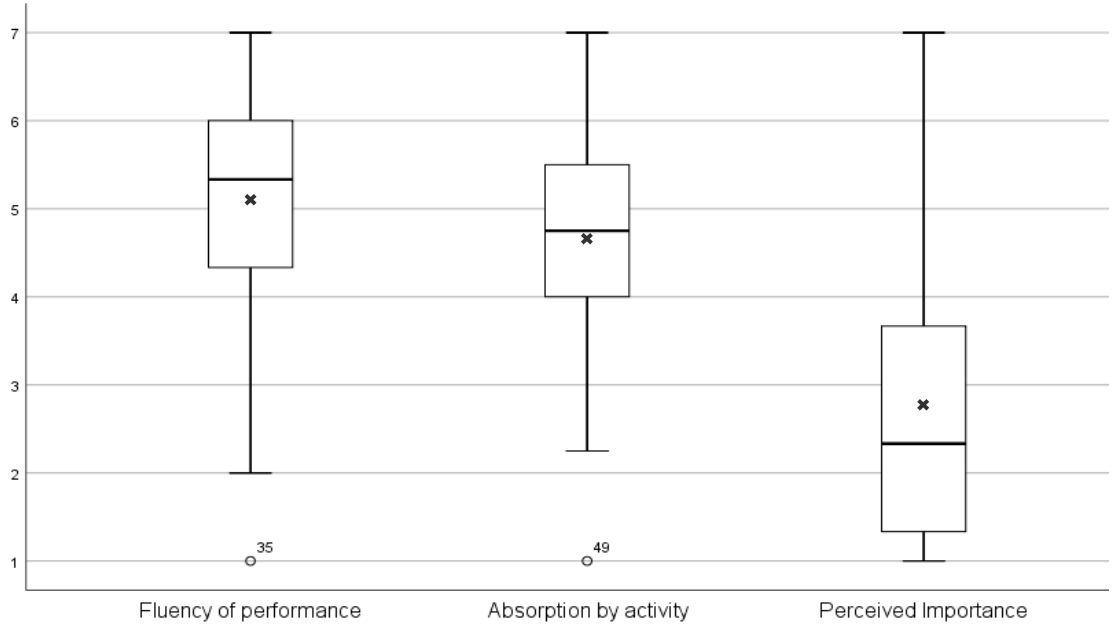


- The participants gives positive values to the above dimensions of usability of VPSL. (“The application has unnecessary interrupts of working”. – Controllability, revsersed)

EVALUATION

Results

- Flow



- The flow experience of fluency of performance and absorption by activity are also highly valued (e.g. “It was easy for me to focus.” – Absorption by activity).
- Perceived (outcome) importance, (e.g. “I can not make any mistakes”, indicates the flexibility of VPSL.

DISCUSSION & CONCLUSION

Summary

- The descriptive statistic analysis of usability, spatial presence and flow indicates overall positive evaluations of VPSL.
- Limitations of VPSL:
  - Limited learning content without levels or customizable points (Usability)
  - Learning content is not completely matching the school content (Motivation)
  - Visual and audio effects to be optimized (Usability)
  - Motion sickness
- Requirement of the application:
  - Requirement for the students: Basic knowledge of physical learning content
  - Requirement for the learning and training design: Introduction and training of the using of the VR-Systems; The students should take the course in pairs with one VR-System and conduct the experiments in turns because of safety.

DISCUSSION & CONCLUSION

Further study points for the application

- Whether a VR application improves the understanding of physical laws
  - Cognitive effects
- Whether the cooperative multiplayer version improves the learning effects
- Whether gamification components improves the learning motivation
  - Setting with different levels of difficulties
- Whether the sex ratio has effects on the virtual learning in VPSL

University of Stuttgart
Institute of Educational Science and Psychology (IfE)
Vocational Education focused Teaching Technology (BPT)

Thank you!

Qi Guo, M. Ed.

e-mail guo@ife.uni-stuttgart.de
phone +49 (0) 711 685-84363
www.uni-stuttgart.de/bpt

University of Stuttgart
Institut für Erziehungswissenschaft
Berufspädagogik mit Schwerpunkt Technikdidaktik (BPT)
Azenbergstraße 12
70174 Stuttgart