

# XR-Labore im Kontext der Ingenieurdidaktischen Forschung & Praxis HIS | Forum Labore 2023

Prof. Dr. Dominik May | Didaktik der Technik | Bergische Universität Wuppertal



- Zu meiner Person
- Cross Reality – Was ist das?
- Cross Reality, Online Labs und Engineering Education Research – Wie kommt das zusammen?
- Beispiele der University of Georgia
- Fragen und Diskussion

Seit 2023 Professor am Lehrstuhl Didaktik der Technik an der BUW (davor University of Georgia, USA & TU Dortmund)

Neue Medien in der Ingenieurausbildung, Labore und Cross-Reality-Spaces in der Lehre (& transnationale Lehre)

10 geförderte Forschungsprojekte (ca. 10 Mio. EUR und 1,5 Mio. US\$ Fördergelder)

Editor-In-Chief des „International Journal of Emerging Technologies in Learning (iJET)“



iJET

Präsident der „International Association of Online Engineering“

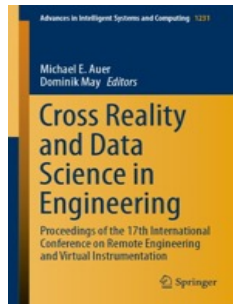


IAOE.

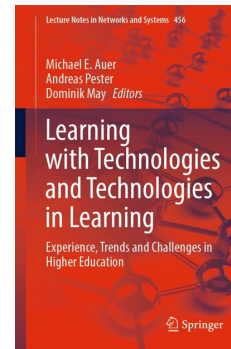
# Publikationen

- 8 Keynotes zum Thema Engineering Education Research und Cross-Reality
- ca. 120 Publikationen in Form von Zeitschriftenartikeln, Buchbeiträgen und Konferenzbeiträgen

Auer, M. E., & May, D. (Eds.). (2020). **Cross Reality and Data Science in Engineering**. Cham: Springer International Publishing



Auer, Michael E., Pester, A., & May, D. (2022). **Learning with Technologies and Technologies in Learning** (1st ed.). Cham: Springer International Publishing.



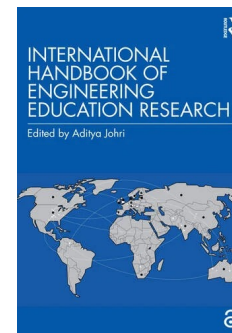
May, D., Terkowsky, C., Boehringer, D., & Varney, V. (Guest Eds.). (exp. 2023). **Online Laboratories in Higher Engineering Education** (Special Issue EJEE). T&F



Terkowsky, C., May, D., Haertel, T., Lensing, K., Frye, S., Ortelt, T. R., & Sabrina, H. (Eds.). (2020). **Labore in der Hochschullehre - Didaktik, Digitalisierung, Organisation**. Bielefeld: wbv Publikation.



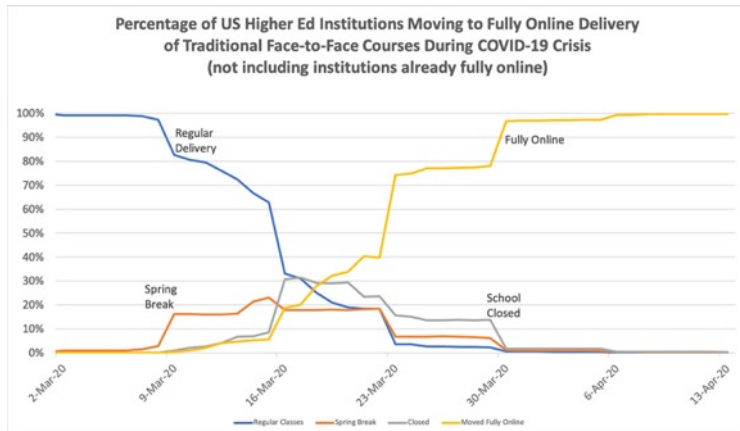
Johri, A. (Ed.). (2023). **International Handbook of Engineering Education Research** (1st ed.). Routledge.



May, D., Jahnke, I., & Moore, St. L. (Guest Eds.). (exp. 2023). **Online Labs and Virtual Experimentation in Higher Education** (Special Issue JCHE). Springer.



# “Online Education” in 2020



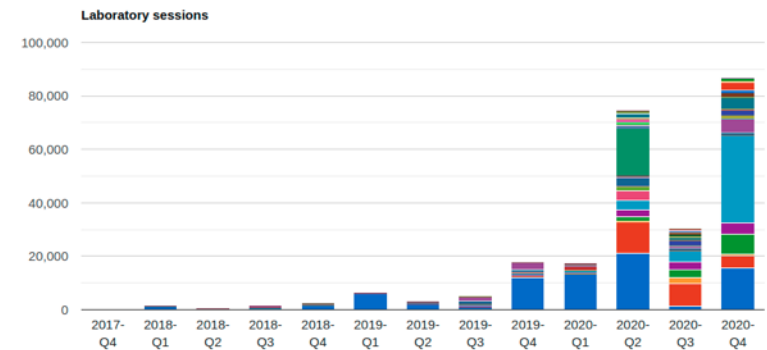
<https://spectrum.ieee.org/tech-talk/at-work/education/how-online-learning-kept-higher-ed-open-during-the-coronavirus-crisis>



<https://www.visualcapitalist.com/zoom-boom-biggest-airlines/>

	2019	2020	Total
New Registered Users	8M	31M	76M
	5M	10M	35M
	1.3M	5M	15M
	350k	800k	2.3M

<https://www.classcentral.com/report/the-second-year-of-the-moc/>



LabsLand via mail

# Cross Reality – Was ist das?

# “Cross Reality” Google Search



# Was ist Cross Reality?

Paradiso and Landay (2009):

*“We call the ubiquitous mixed reality environment that comes from the **fusion of these two technologies [ubiquitous sensor/actuator networks and shared online virtual worlds] cross reality**. Similarly, cross-reality’s virtual digs aren’t just filled with inanimate data—they’re also social environments, populated with human-driven avatars and other representations of residents and sensor data.”*

Lauren Good in WIRED (05/2019):

*„So... What is XR?“ - It's a real thing but also, not a real thing. Depending on who you ask, XR can either encompass a bunch of immersive video standards; suggest an **intensified media experience**; or just serve as a catchall phrase for AR and VR—**marketing speak, really.**“*

Jim Malcolm, general manager of HumanEyes (same article):

*“XR does not refer to any specific technology. **It’s a bucket for all of the realities, [AR, MR, VR]**”*

See also:

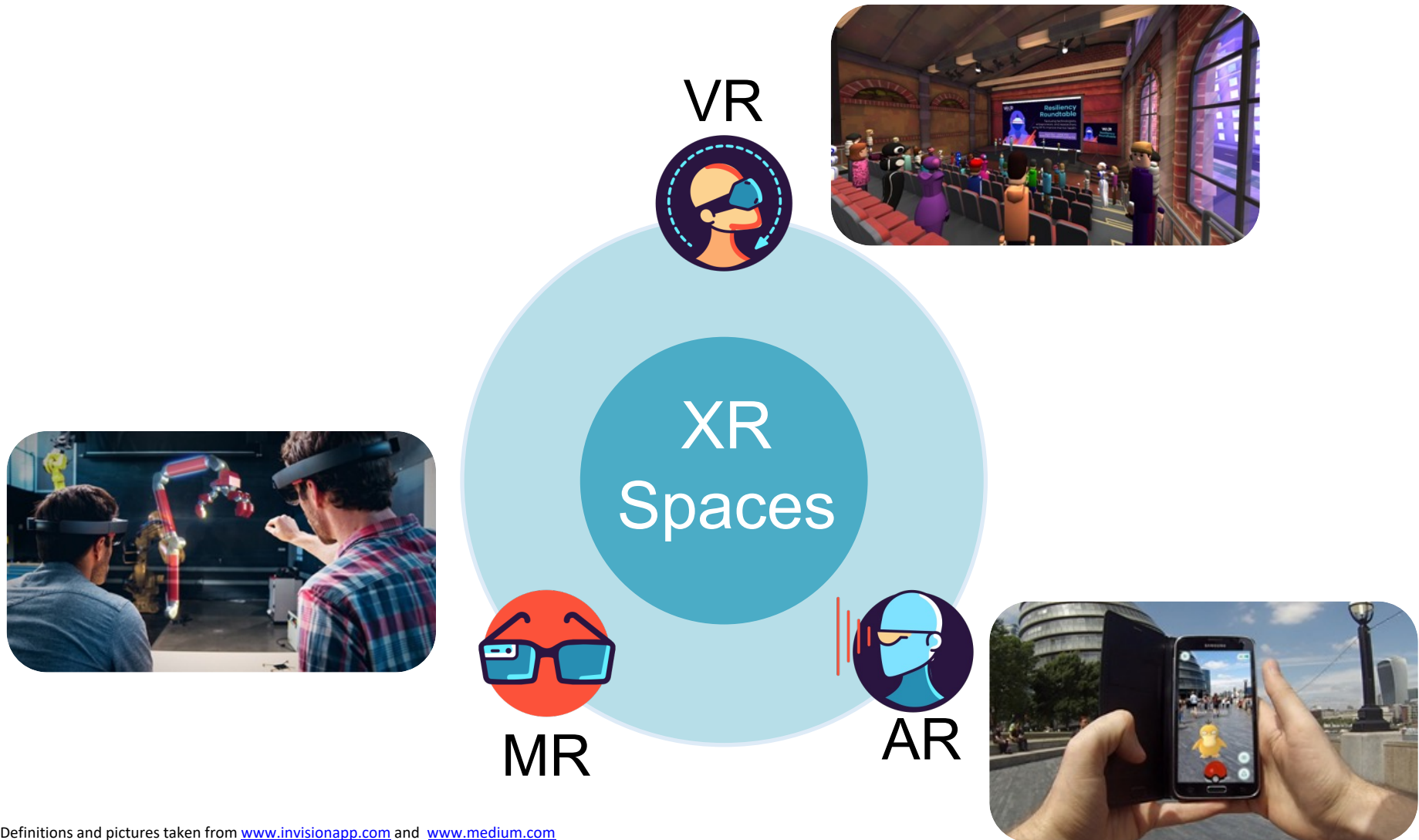
- Paradiso and Landay (2009): Cross-Reality environments
- <https://www.wired.com/story/what-is-xr/>
- Mann et al (2018): All Reality: Virtual, Augmented, Mixed (X), Mediated (X,Y), and Multimeditated Reality



***Extended Reality (XR) [...] refers to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables. Extended Reality includes all its descriptive forms like the Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR). In other words, XR can be defined as an umbrella, which brings all three Reality (AR, VR, MR) together under one term, leading to less public confusion. (www.medium.com)***

**Extended reality (XR) refers to all real and virtual environments combined together**, where the interaction between human and machine occurs through interactions generated by computer technology and hardware. XR technologies consist of virtual reality (VR), mixed reality (MR) and augmented reality (AR).

(Doolani et al. (2020). A Review of Extended Reality (XR) Technologies for Manufacturing Training. Technologies 8(77). pp. 1-20)



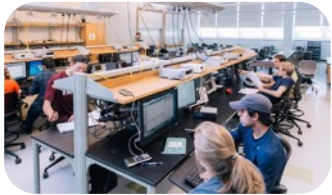
Definitions and pictures taken from [www.invisionapp.com](http://www.invisionapp.com) and [www.medium.com](http://www.medium.com)

# Cross Reality, Online Labs und Engineering Education Research – Wie kommt das zusammen?

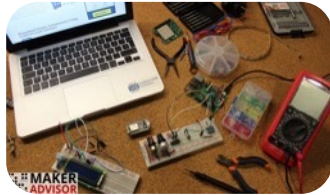
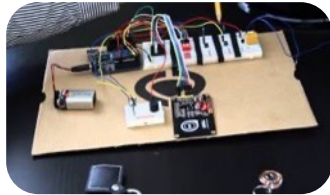


# Learning Labs in der Ingenieurausbildung

## f-2-f labs



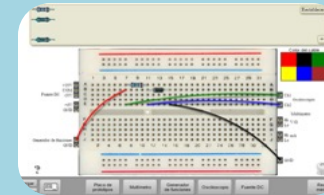
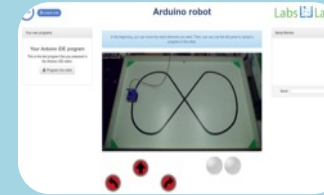
## take-home lab kits



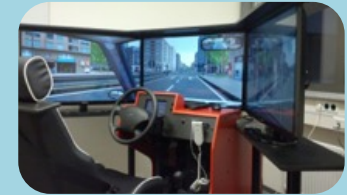
## AR labs



## remote labs



## virtual labs

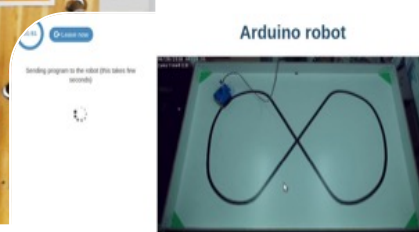


Level der Digitalisierung und Virtualisierung

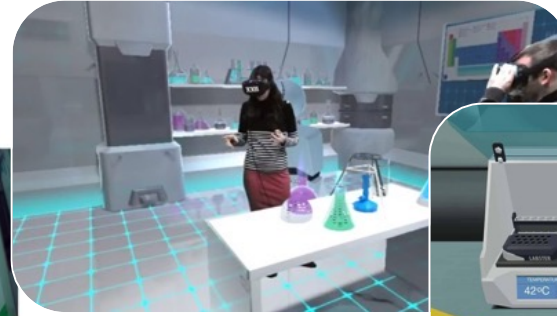
# Labs “across” realities: XR Labs



*Augmented  
reality*



*Mediated  
reality*



*Mixed  
reality*



*Simulated  
reality*

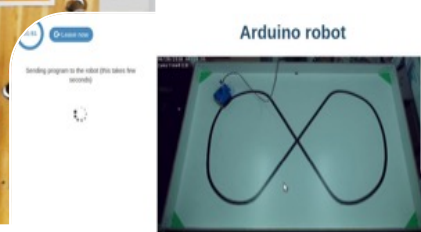
- ✓ Theorie “erleben”
- ✓ Dinge sichtbar machen
- ✓ Flexibilität in Zeit und Ort
- ✓ Resistent gegen Beschädigung
- ✓ Zugang zu sonst nicht zugänglichen Versuchen
- ✓ Organisatorische und räumliche Vorteile
- ✓ etc.

- ✗ Komplexe Modellierung
- ✗ Kostenintensive Entwicklung
- ✗ Entkoppelung des Labs von realer Welt
- ✗ Entkoppelung Lehrperson und SuS
- ✗ Ernsthaftigkeit der Erfahrung
- ✗ Fehlende soziale Interaktion
- ✗ etc.

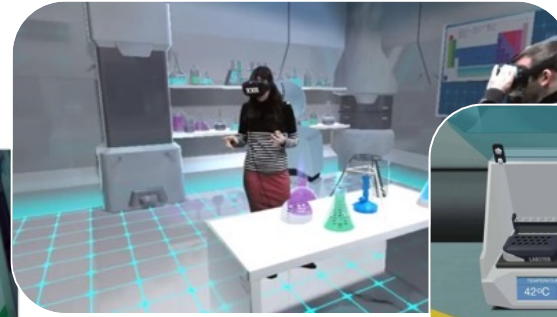
# Labs “across” realities: XR Labs



*Augmented  
reality*



*Mediated  
reality*



*Mixed  
reality*



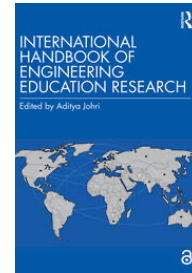
*Simulated  
reality*





## 24 Online Laboratories in Engineering Education Research and Practice

Dominik May, Gustavo R. Alves, Alexander A. Kist, and Susan M. Zvacek



**Abstract**  
Labore als Lehr-Lernumgebung sind Bestandteil der natur- und ingenieurwissenschaftlichen Experimentalvorlesung bis hin zu virtuellen Laboren im Internet. *“[...] It becomes*

### 1 Introduction

Over the last decades, technology development and the Internet have shaped how we play and work. Among other innovations, these advances have made their way into education and have led to the development of online laboratories. The advent of those new forms of technology-enhanced instruction in the area of laboratory-based teaching and learning was briefly discussed in the first edition of this very handbook. Johri and Olds's (2014) one chapter discussed recent developments on the use of information technology in engineering education at that time (Madhavan & Lindsay, 2014). However, only one part of that chapter formed the discussion of remotely accessible experiential learning environments. In this chapter, we discuss the evolution of online laboratories and their impact on engineering education. We also discuss the challenges of online laboratories and provide recommendations for their implementation. We also discuss the challenges of online laboratories and provide recommendations for their implementation.

*“Educational research in this field is focused on developing new educational settings for the use of online laboratories and on fundamentally understanding how these new types of instructional laboratories influence both the faculty and the student experience. Gaining this fundamental understanding of the sociotechnical instructional reality introduced by online laboratories is highly relevant, as students should be given the opportunity to use all laboratory formats, depending on the targeted learning goal, the available equipment, or individual personal preferences of students or even faculty.” (May, Alves, Kist, & Zvacek 2023)*

**Schlüsselwörter:** Labordidaktik, forschendes Lernen, Online-Labore, Ingenieurdidaktik  
**Addition:** experimentelle Lernumgebung

By doing so, we hope to make this chapter helpful and interesting for a more diverse audience, including online laboratory experts and complete newcomers to this field. We also believe that many of the innovations and developments around online laboratories in the context of COVID-19 have not yet been sufficiently assessed outside of that unique situation due to the lack of time. Hence, the insights might not yet be of great value for the times after the pandemic. Nevertheless, we do

DOI: 10.4324/9781003287483-29  
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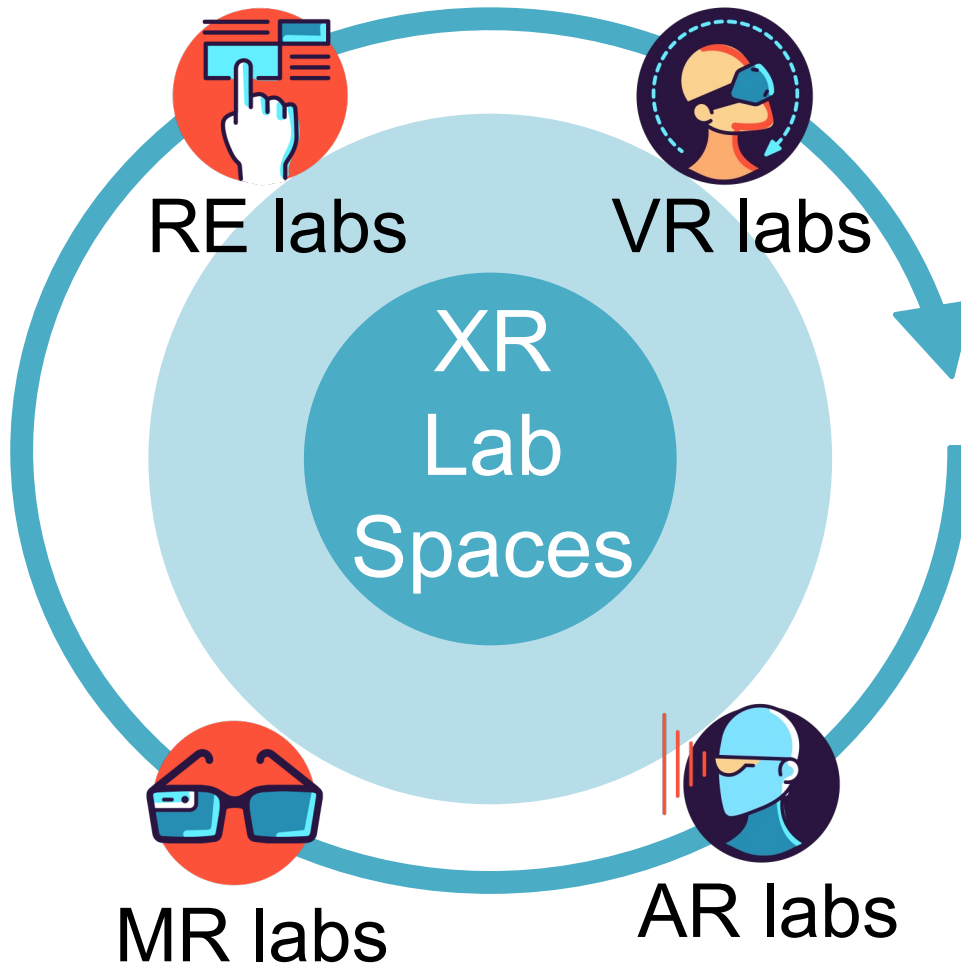
contexts (so-called Industry 4.0). However, the laboratory at a German university reflects the industry agenda offer a limited educational development.

as instructional laboratories instead of competence-based learning (Kist et al. 2020)

to reflect the industry agenda offer a limited educational development.

categories of content

# Ziel: Entwicklung eines dynamischen XR Lab Ecosystems

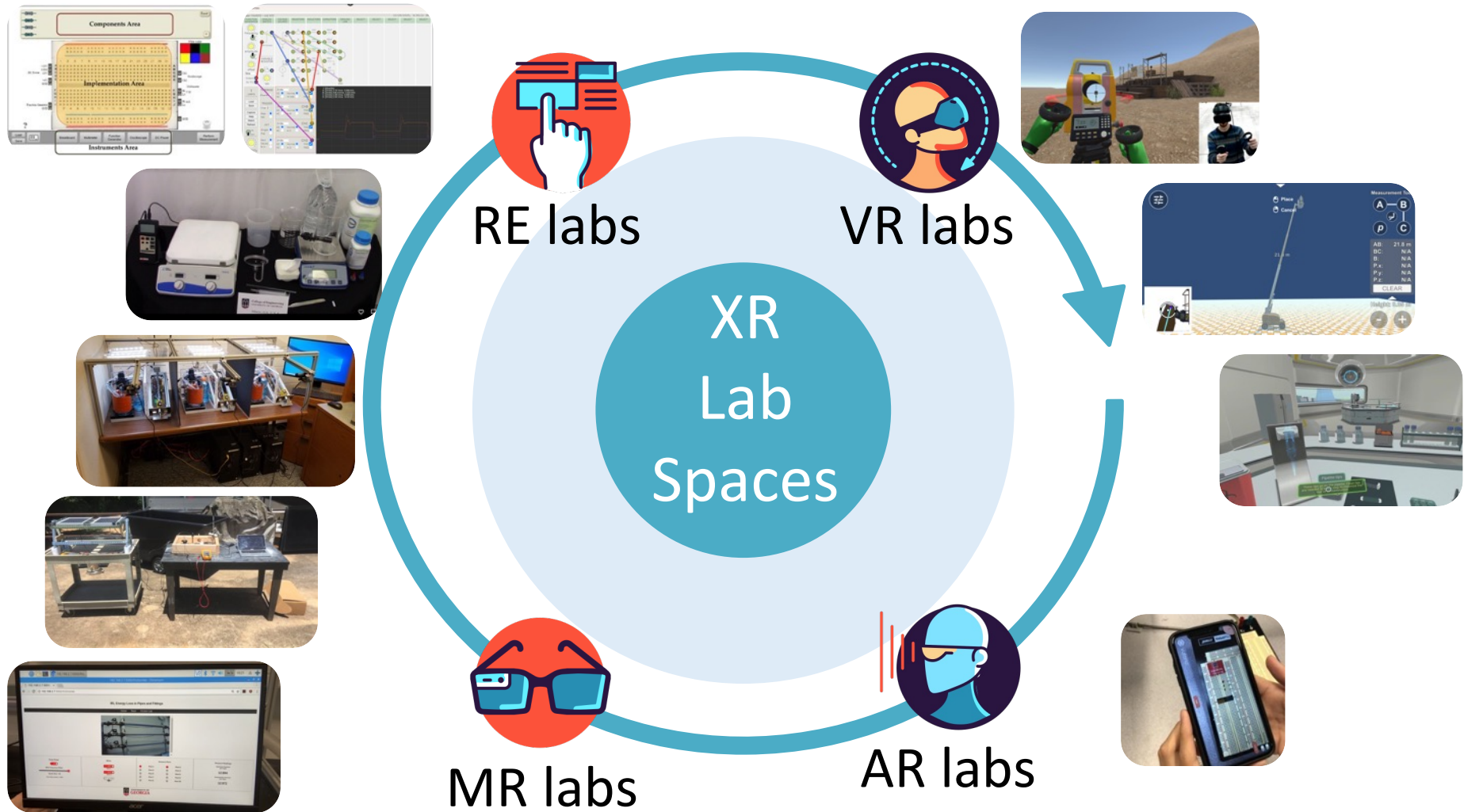




# Beispiele der University of Georgia

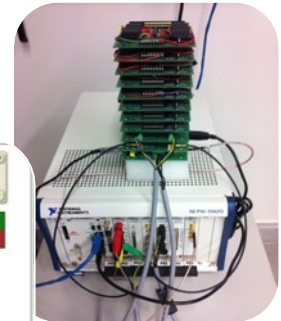
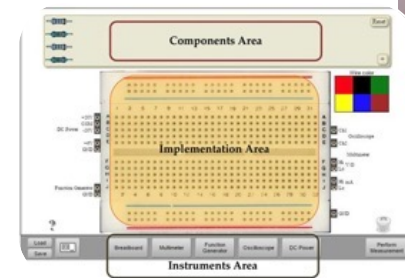


# XR Lab Spaces an der UGA

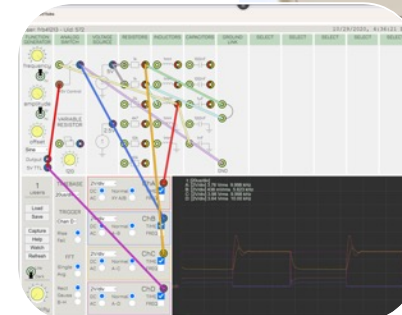


- **Faculty perspective**
  - Theory: Diffusion of Innovations and Propagation of Innovation Framework
- **Student perspective**
  - Theory: Cognitive and emotional student engagement
- **User-Experience perspective**
  - Theory: User-centered design

Labs  Land



**EMONA**  
INSTRUMENTS PTY LTD



Mixed-Methods-Design in all three trusts

# Remote labs in electrical engineering education (NSF project)

RQ: How do **faculty** experience a top-down mandated, time-constrained, and rapid transition to exclusively online-based laboratory modules in engineering courses along the continuum of resistance towards the wholesale embrace of educational technologies?

1. „Expand the capacity“

2. „Individualize the teaching process“

3. „Higher flexibility“

4. „Does not fit to teaching approach“

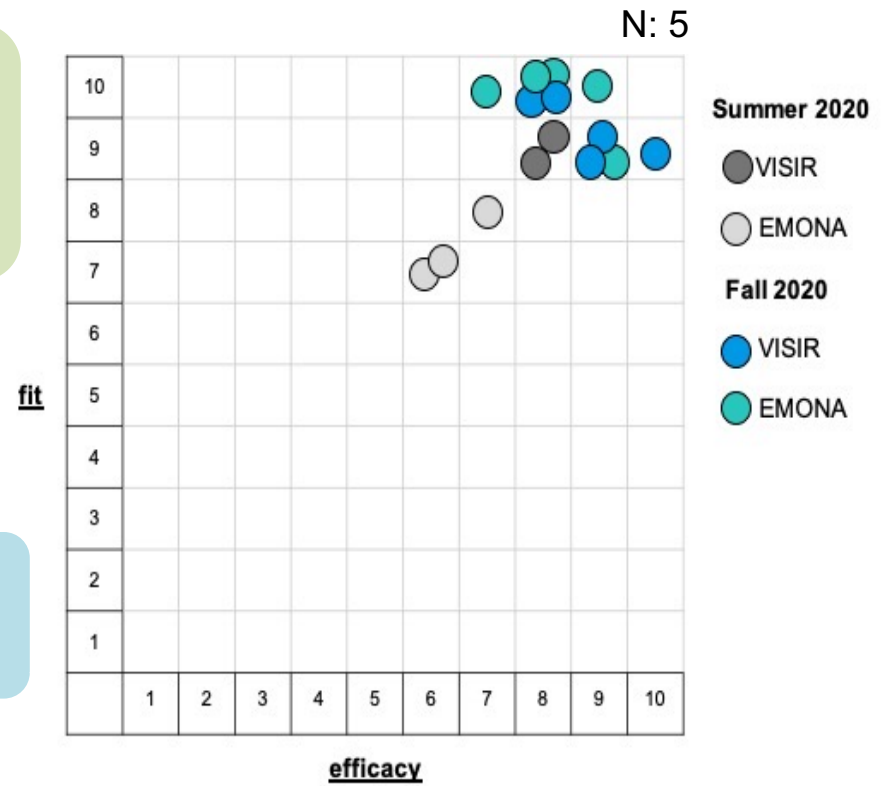
5. „Lack of classroom interaction“

6. „More focussed discussion“

7. „More prep-time“

8. „Lack of time for testing“

- Self-reflection
- Interview



# Remote labs in electrical engineering education (NSF project)

RQ: How does exclusively online laboratory instruction and online experimentation impact **students'** learning experiences in terms of engagement, investigated through self-regulation and motivation?

## Topic: Learning Compatibility

*„I like going in-person because I get to use hands. I get to see how you actually make the connections“*

## Topic: Questions and Inquiry

*„Sometimes my question that I was asking or my problem would get skewed a little bit in translation to the professor, and then as I'd email back, I'd get half the answer I needed“*

## Topic: Planning and Coordination

*„It's really easy, it being online, to feel tempted that you can just do something else during the lab time and then come back and do it over the weekend or some other day. I would just advise people to keep to the schedule“*

- Pre-Post-Survey
- Interviews

May, D., Morkos, B., Jackson, A., Hunsu, N., Ingalls, A., & Beyette, F. R., Jr. (2022). Rapid transition of traditionally hands-on labs to online instruction in engineering courses. *European Journal of Engineering Education*. <https://doi.org/10.1080/03043797.2022.2046707>

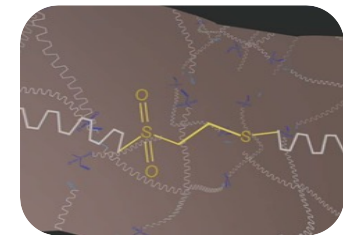
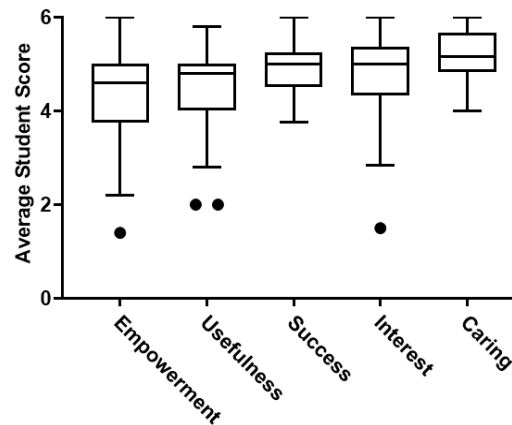
- Senior-level Tissue Engineering class, 45 students
- Tissue Engineering Virtual lab by Labster
- Realistic scenario and lab environment



Labster

Theory: Jone's MUSIC model of motivation

**e**Mpowerment  
**U**sefulness  
**S**uccess  
**I**nterest  
**C**aring

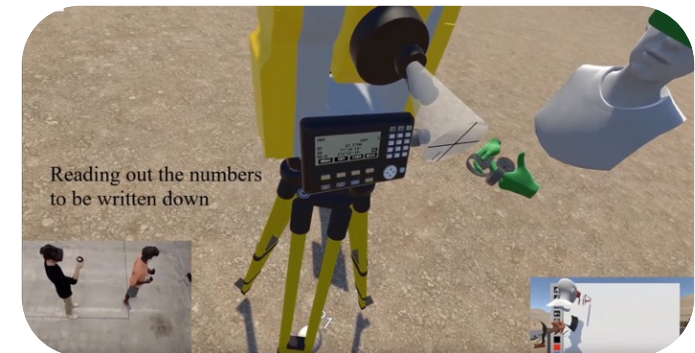


- MUSIC survey
- Interviews

B. D. Jones, "Motivating students to engage in learning: The MUSIC model of academic motivation," *International Journal of Teaching and Learning in Higher Education*, vol. 21, no. 2, pp. 272-285, 2009

# Student interaction in immersive land surveying virtual reality (internal)

- Land surveying virtual reality tool
- Learning outcomes, collaborative learning engagement in VR environment, verbal student-student interaction
- Individual vs collaborative use in pairs
- 45-item online questionnaire



Perceived ease of use

Representational fidelity

Immediacy of control

Presence

Control and active learning

Perceived enjoyment

Perceived usefulness

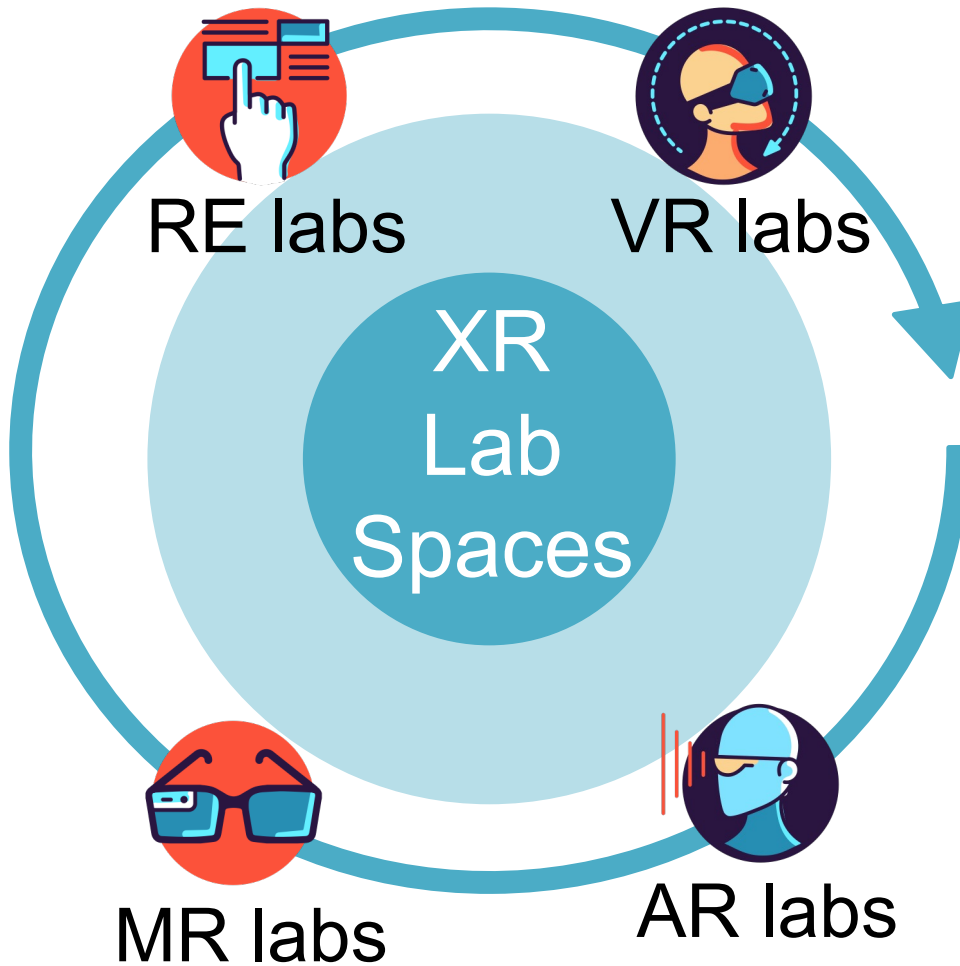
Perceived learning effectiveness

Satisfaction

Behavioral intention to use

- Online questionnaire
- Observation

# Ziel: Entwicklung eines dynamischen XR Lab Ecosystems





## STE2024 – International Conference on Smart Technologies & Education Smart Technologies for a Sustainable Future

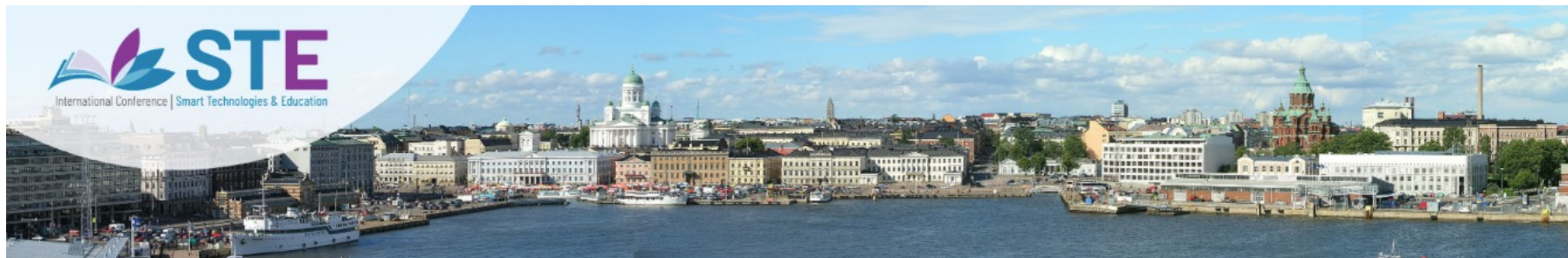
### Date and Venue

- 6–8 March 2024, Arcada University of Applied Sciences, Helsinki, Finland



### Overview

- The International Conference on Smart Technologies & Education (STE) is the successor of the REV Conferences and the annual conference of the International Association of Online Engineering ([IAOE](#)) together with the Edunet World Association ([EWA](#)) and the International Education Network ([EduNet](#)).
- STE 2024 is an annual event dedicated to the fundamentals, applications and experiences in the field of Smart Technologies, Online, Remote, and Virtual Engineering, Virtual Instrumentation and other related new technologies



# XR-Labore im Kontext der Ingenieurdidaktischen Forschung & Praxis

## HIS | Forum Labore 2023

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