THM TECHNISCHE HOCHSCHULE MITTELHESSEN

MICRO The Remote Lab for Embedded Systems

Hands-On from Afar:

The Future of Embedded Systems Education with the MICRO Remote Lab

Real Hardware. Remote Access. Student-Built.

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Introduction

Jakob Czekansky, M.Sc.

- **Fulltime Lecturer** at University of Applied Sciences Mittelhessen – Germany
  - **Main focus:** *Embedded Systems, Microcontroller Programming,*

    Full Stack Software Development, Remote Laboratories
- **Project Lead** in the open teaching and research project **MICRO**
- **PhD candidate** with *Prof. Dr.-Ing. Dominik May*

“How can we bring the hands-on feel of a physical lab to a remote environment?”

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Introduction

GOLC Award 2025

awarded by the

IAOE (International Association of Online Engineering)

and the

GOLC (Global Online Laboratory Consortium)

at the

22nd International Conference on Smart Technologies & Education

in *April 2025* in *Santiago de Chile*.

Global Online Laboratory Consortium

GOLC Online Lab Award

The GOLC Online Laboratory Award 2025 in the category

"Remotely Controlled Experiments"

is presented to

MICRO – The Remote Lab for Embedded Systems

Submitted by:

Jakob Czekansky, Diethelm Bienhaus, Justin Sauer, Leon Kraft, Tim-Niclas Ruppert, Jurij Schum, Lars Merke, Vivien Reuter, André Ehret, Kevin Klauser, Maximilian Djubajlo, Alexander Gockel, Tymoteusz Mucha, Luis Philipp Handschuh, & Onur Melik Sen
University of Applied Sciences Mittelhessen, Germany

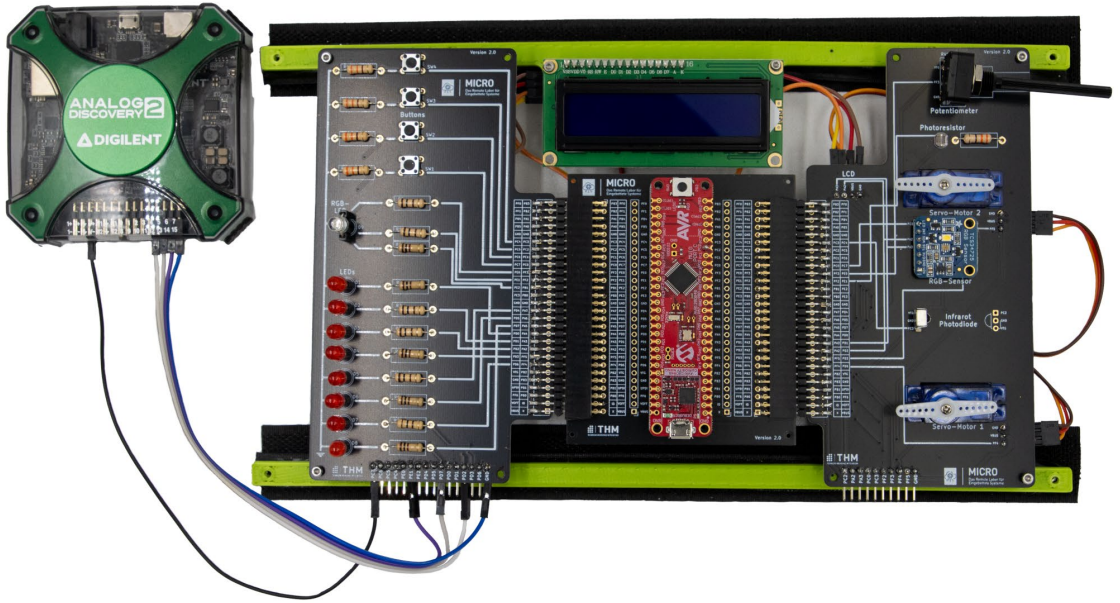
Awarded during the 22nd International Conference on Smart Technologies & Education – STE 2025 – "Smart Technologies for an All-Electric Society" in Santiago, Chile

Valérie Varney	Karsten Henke	Alexander Kist	Rania Hussein	Unai Hernández Jayo
GOLC President & IAOE Vice-President	Selection Committee	Selection Committee	Selection Committee	Selection Committee

Why Embedded Systems Need Real Labs

Challenges in Engineering Education

- Real-world systems require physical interaction
- Simulations can’t replace timing, feedback, or errors
- Traditional labs: limited time, space, and flexibility
- High equipment costs and maintenance burden
- Not accessible for all students (location, time, ability)
- Need for a more inclusive, scalable lab model



The COVID Catalyst

From Campus Closure to Web-Based Control

- Sudden lockdown → physical labs unavailable
- Initial solution: mail out MCU hardware kits
- Result: high support demand, setup issues, frustration
- Students lacked guidance, feedback, and visibility
- Instructors couldn't see or support what students were doing
- Led to the core question: *"Can we move the entire lab online — for real?"*

Introducing MICRO – The Remote Lab

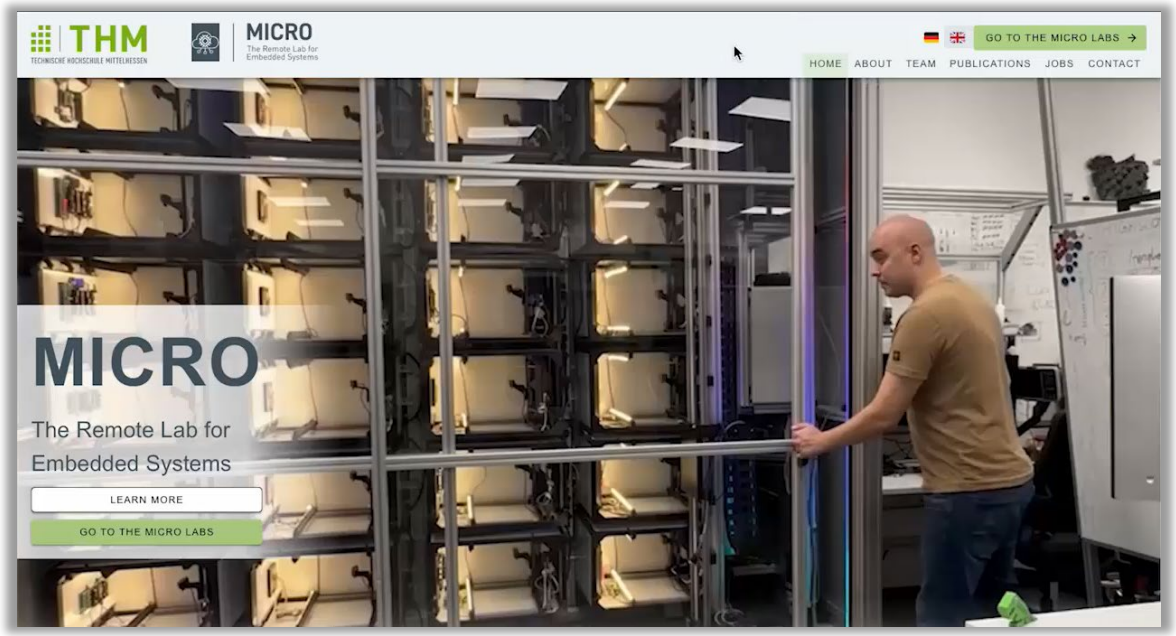
A Student-Built Remote Lab Platform

- Web-based platform for real-time access to real hardware
- Upload firmware, interact via browser, watch live camera feed
- No simulation – actual microcontroller behavior
- Peripherals, UART, analog/digital I/O, signal tools
- Built entirely by student teams
- Used across courses, fully integrated into teaching

How It Works – A Quick Overview

Student Workflow

1. Login with university credentials
2. Reserve a MICRO station
3. Upload compiled firmware via browser
4. Interact using virtual controls (buttons, sliders, …)
5. Watch real hardware through live camera feed
6. Analyze signals using integrated logic tools
7. All in one browser window — no local setup needed



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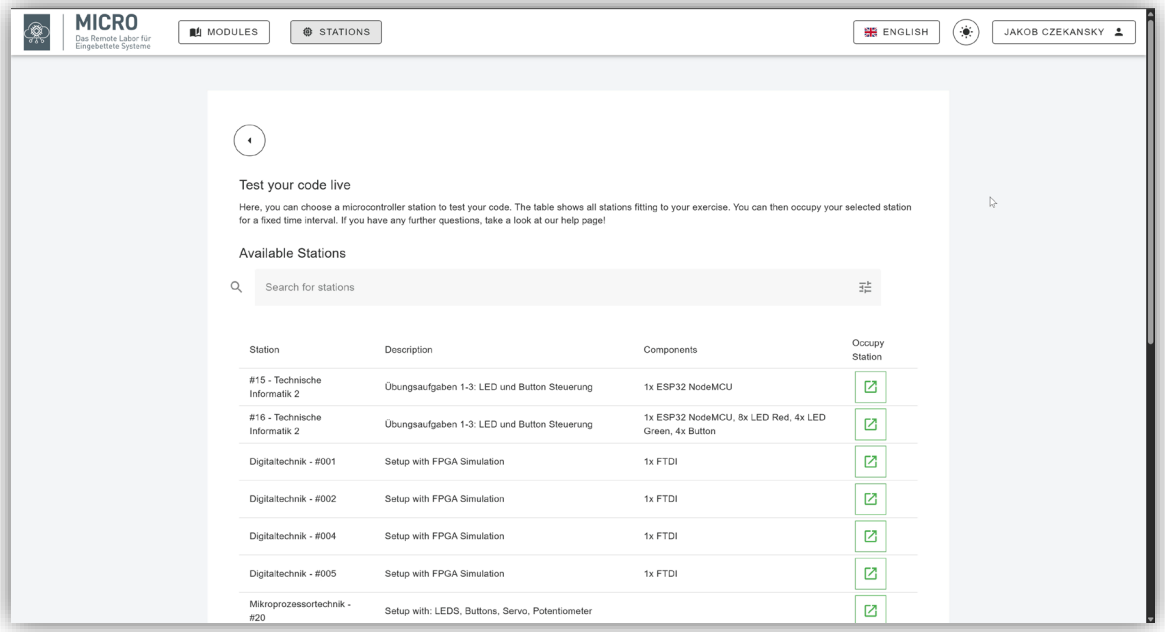


Live Demo

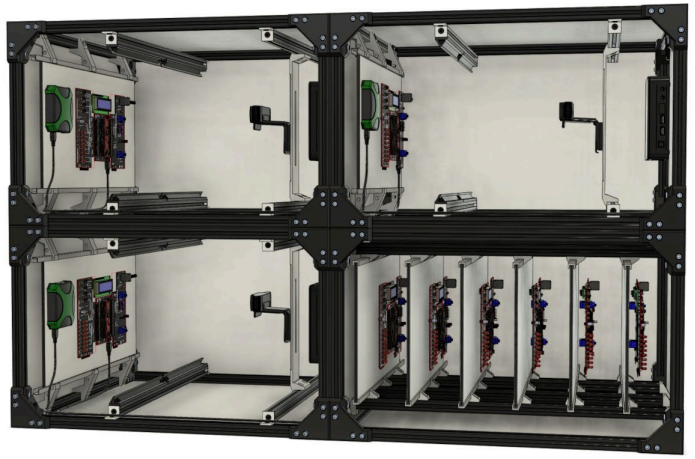
Let's see MICRO in action.

https://micro.mni.thm.de/

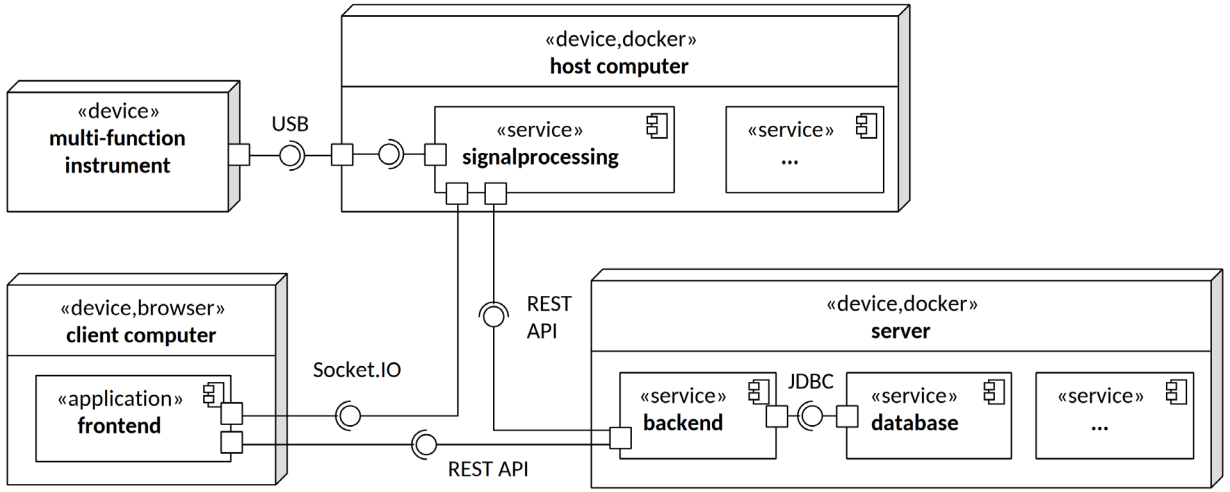
… follow me to the MICRO Labs

The Technology Behind It

From Browser to Board – What Powers MICRO Under the Hood



- Modular hardware cubes with MCUs, webcams, logic tools
- Vue.js frontend, Spring Boot backend, PostgreSQL database
- WebSockets for real-time control and feedback
- Signal analysis via Analog Discovery + pydwf
- Secure, scalable system with NGINX proxy
- Built and maintained entirely by students



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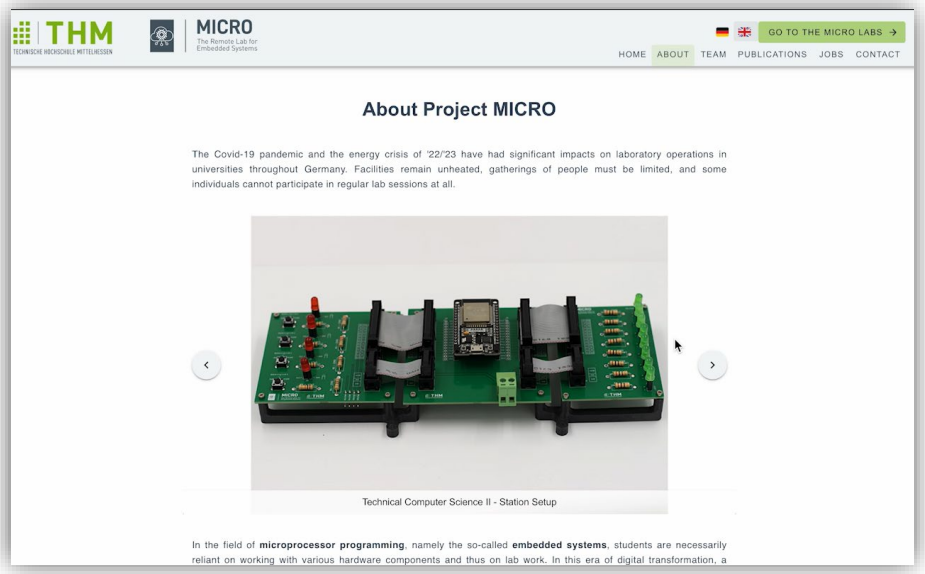
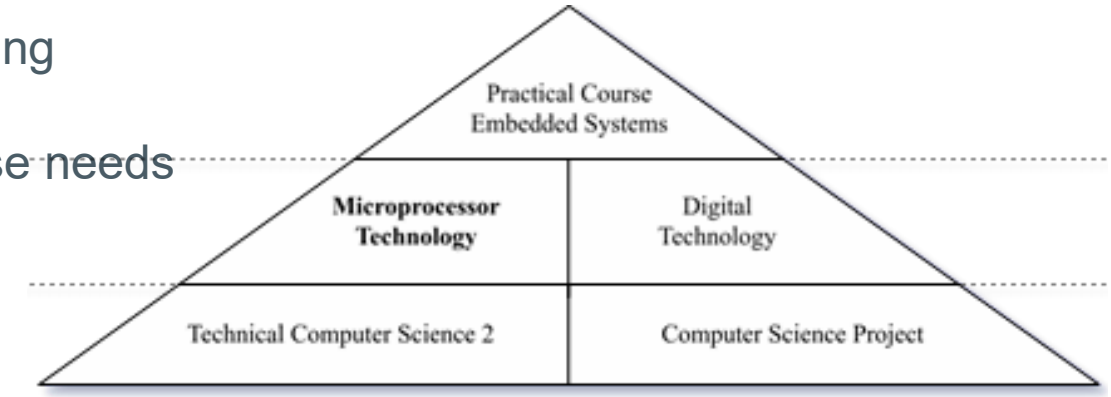
Designed for Education

Flexible, Scalable, and Fully Integrated Into Teaching

- Used in 4 core modules across embedded and digital tech
- 100+ students per semester, active weekly use
- 24/7 browser-based access — no lab scheduling needed
- Integrated with LMS: documentation, submission, tracking
- Supports remote learners, international students, diverse needs
- Reduces instructor workload while improving feedback





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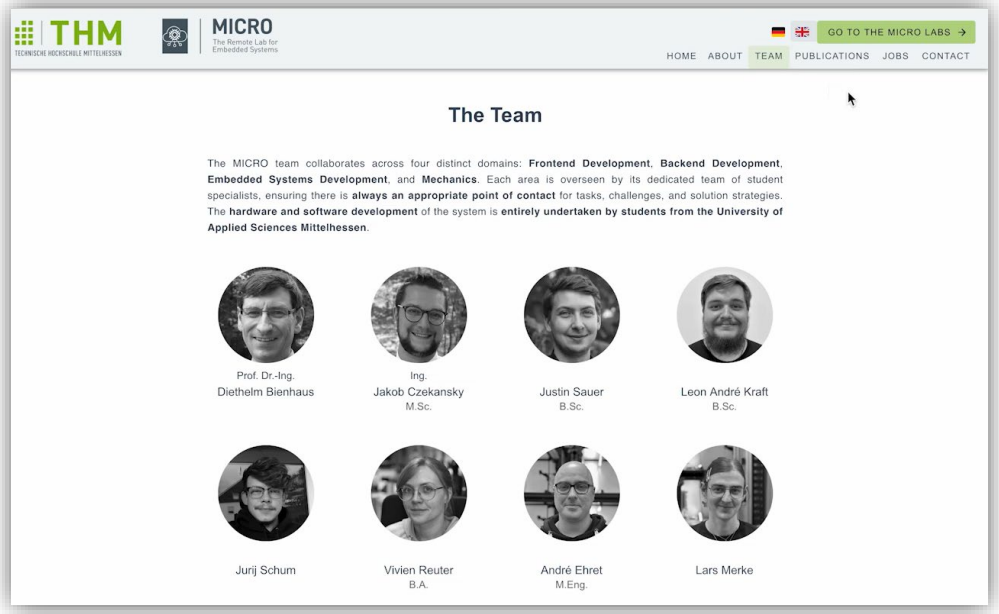
Built by Students, for Students

Real Responsibilities, Real Impact, Real Learning

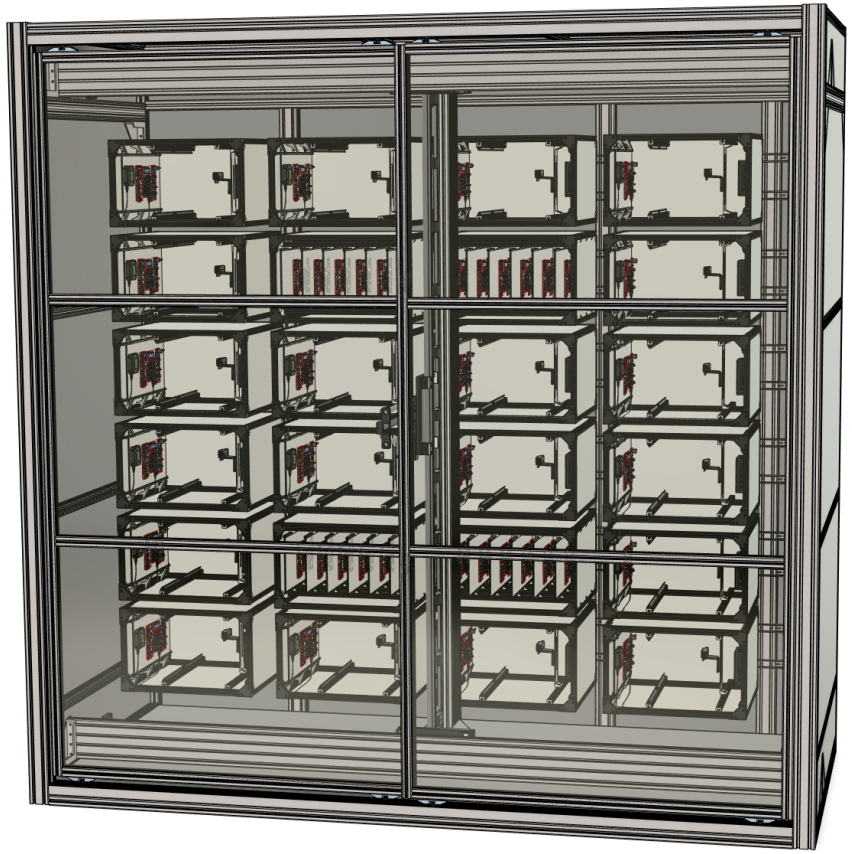
- Students developed frontend, backend, and infrastructure
- Designed and fabricated custom PCBs and lab hardware
- Agile workflows: Git, CI/CD, DevOps practices
- From course users to platform contributors
- Practical experience leads directly to career opportunities
- Student ownership fosters motivation and improvement



What's Next?

Expanding MICRO's Reach, Capability, and Community

- MACRO: robotic tray-swapping for modular experiment sets
- New hardware types: audio, sensors, complex I/O
- Improved accessibility: screen readers, keyboard navigation
- Plan to open-source the platform
- Interest from other institutions → potential for collaboration
- Goal: grow an international, student-driven remote lab ecosystem



Lessons Learned

What MICRO Taught Us About Teaching, Technology, and Trust

- Remote labs can be equal — or superior — with the right design
- Real hardware matters: timing, noise, and physical behavior
- Flexibility improves access, equity, and student confidence
- Simulations can’t replace authentic embedded experience
- Students thrive when given real responsibility
- Empowering learners leads to lasting impact

Thank you

very much for your interest and your attention!

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Let's **Discuss**, **Exchange** Ideas, and **Collaborate**!