Self-determined distance learning by virtual twins in undergraduate control systems labs

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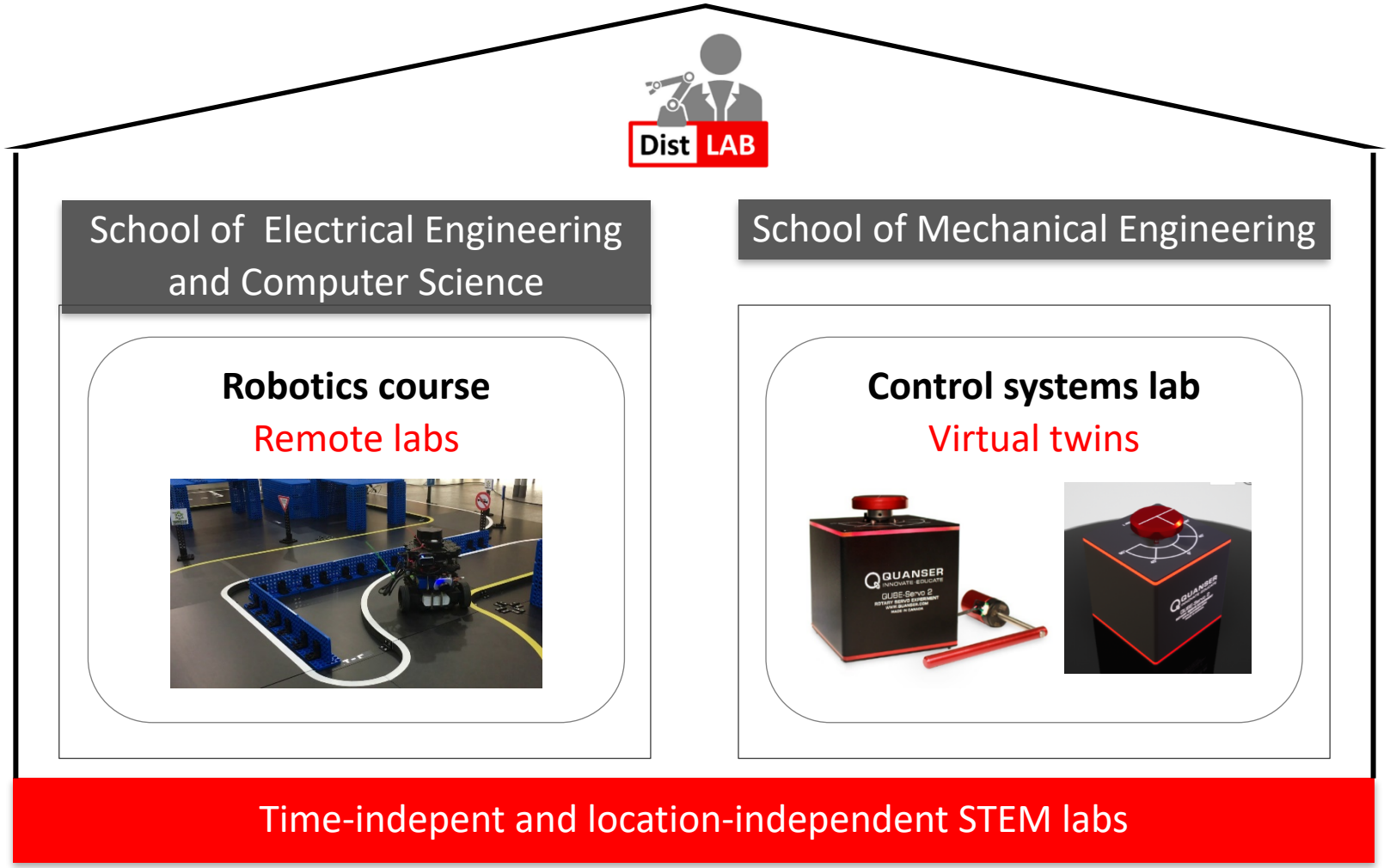
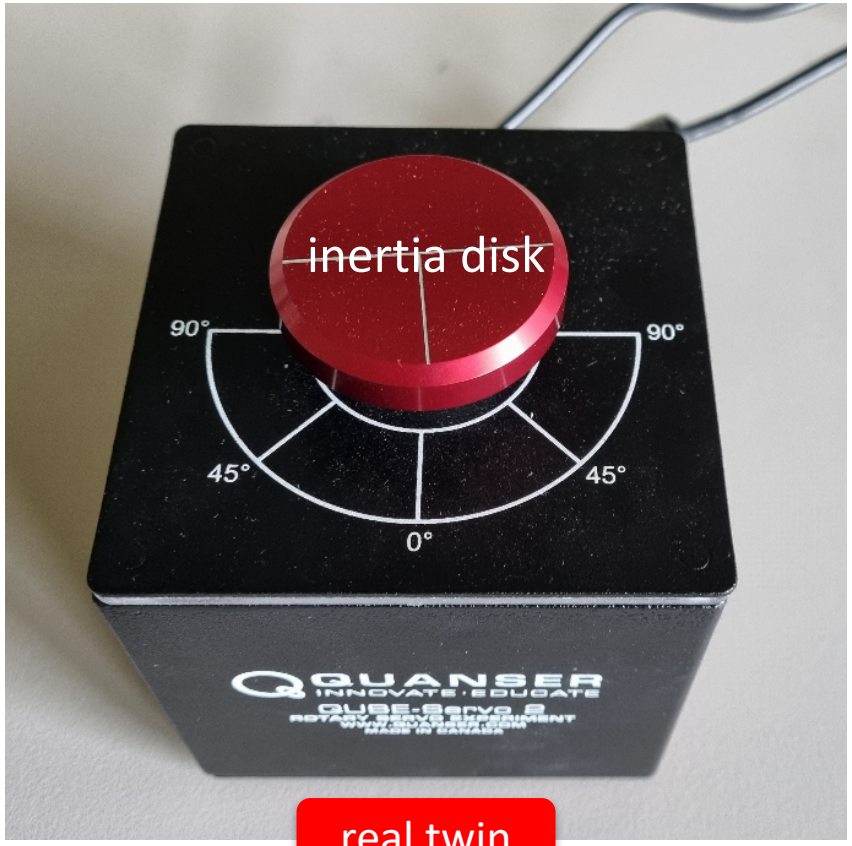
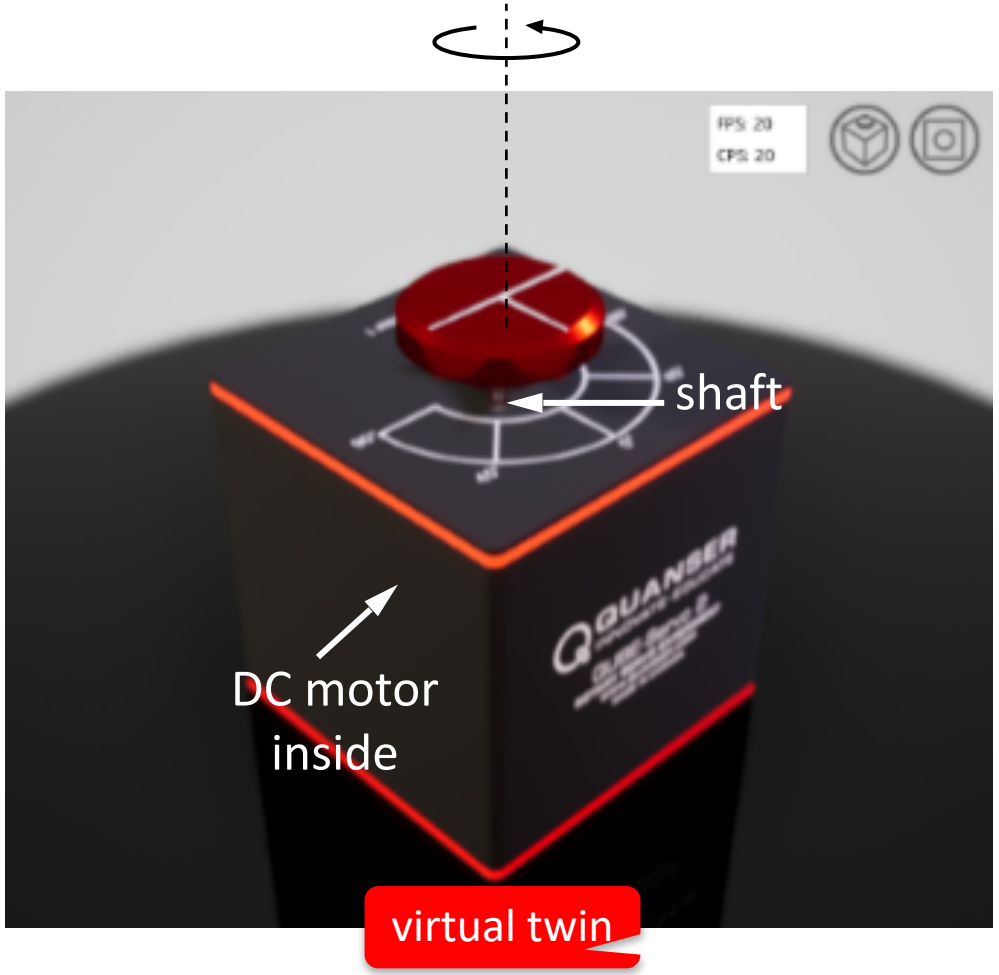
The DistLab project at Stralsund University provides off-campus and 24/7 access to robotics labs and control systems labs. It is currenly implemented by two faculties.

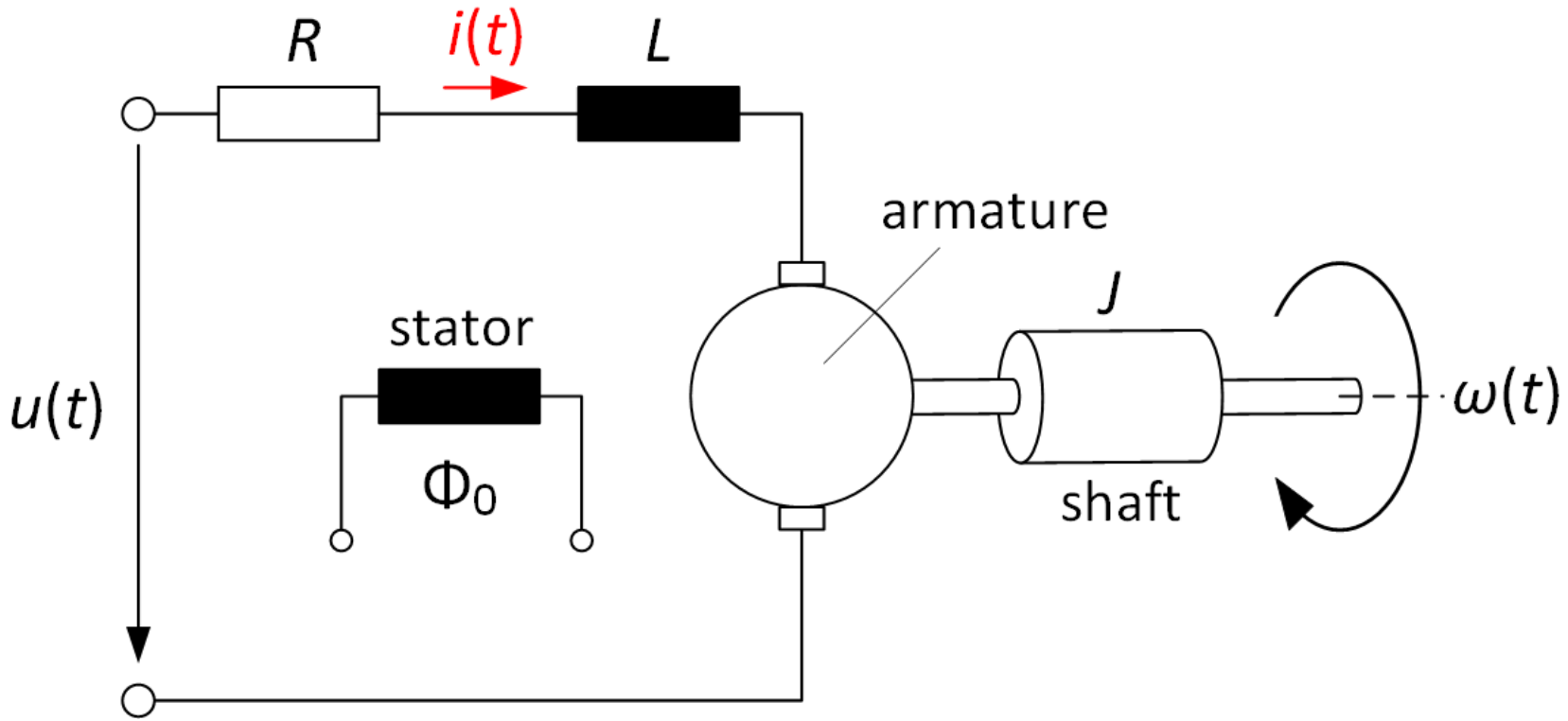


In the control systems lab, each real device is doubled by a virtual twin. A typical lab experiment from Quanser is the control of an inertia disk that is driven by a DC motor

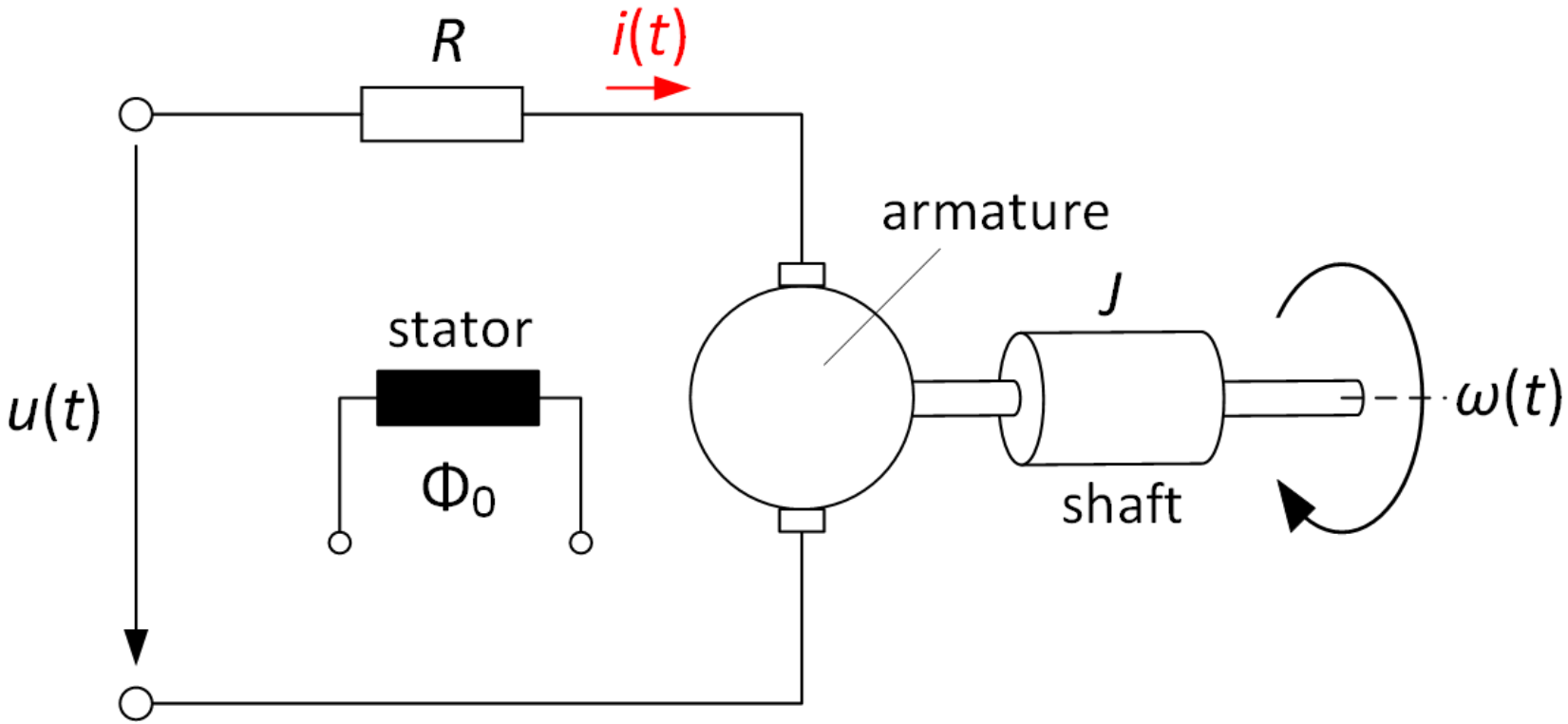




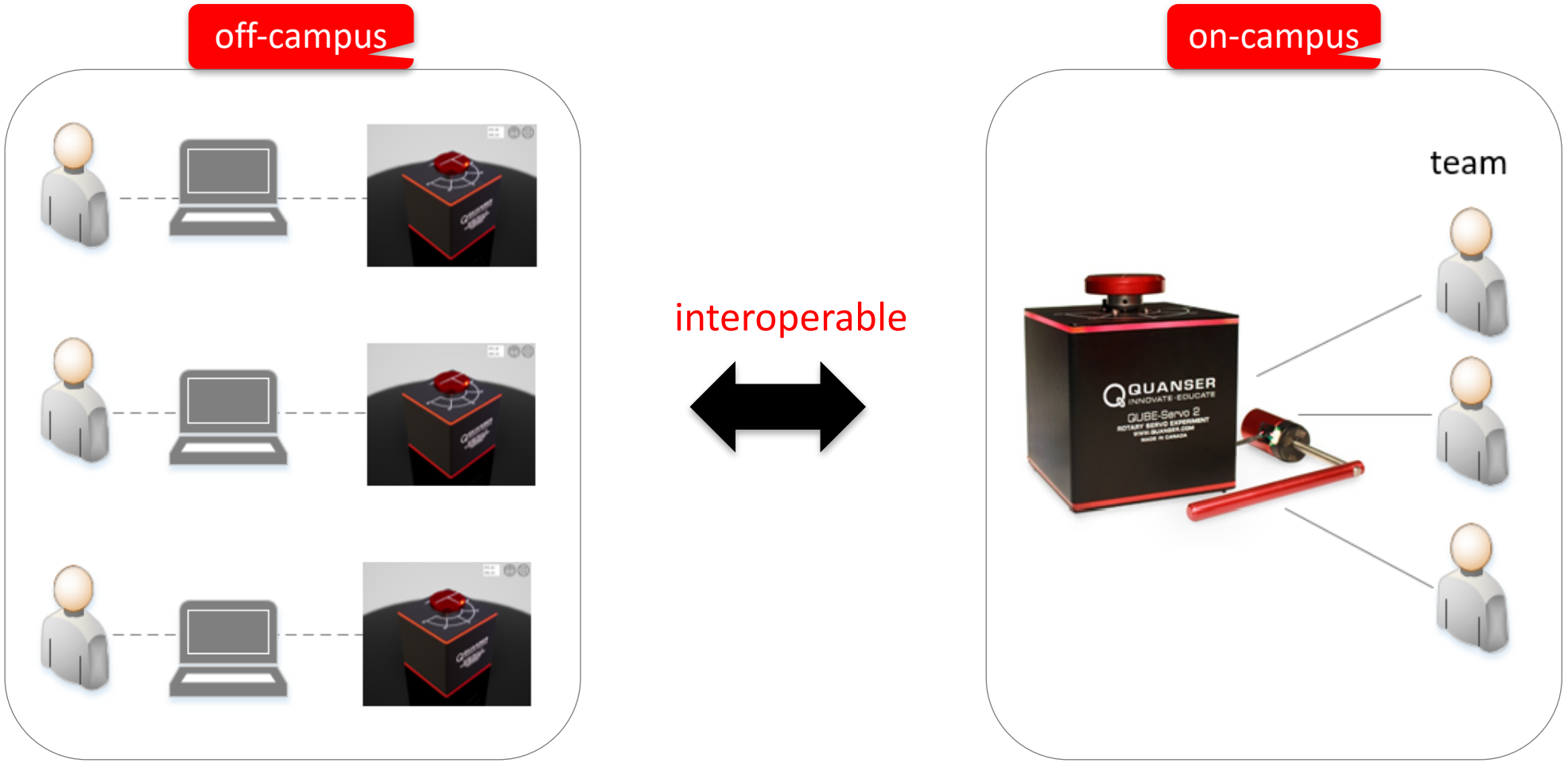
A DC motor is an electro-mechanical system that consists of an armature circuit and a rotating shaft. The shaft speed $\omega(t)$ is controlled by the armature voltage $u(t)$



By omitting the inductance *L* in the armature circuit, the complexity of the system is reduced to 2nd order. This makes understanding for students easier

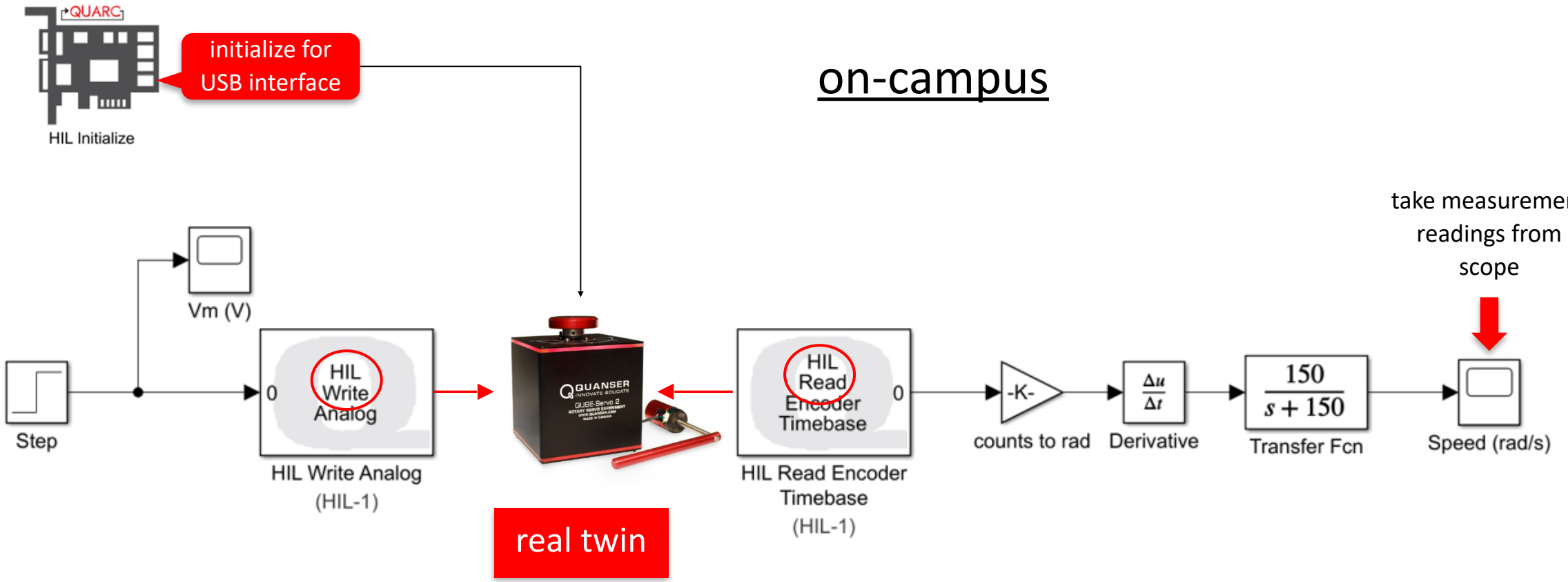


The traditional on-campus learning situation, using the real twin, is paired and supplemented by an off-campus learning situation using the virtual twin



- While the off-campus learning situation corresponds to the virtual twin, the on-campus situation corresponds to its real counterpart. Virtual and real twin behave almost identically.
- Students perform their lab tasks in an »off-campus mode« a couple of weeks before repeating them on-campus in »hands-on mode«.
- Simulink models that students have been developed off-campus are interoperable with the real twin on-campus.
- Since no lab attendence time restrictions apply, virtual twins offer students the benefit of self-determined learning.

A typical lab experiment is the recording of the step response of a DC motor by running a simple Simulink model. When on-campus, all write and read calls are directed against the USB interface



adapted from Quanser Inc. “Step Response Modeling” (2021)

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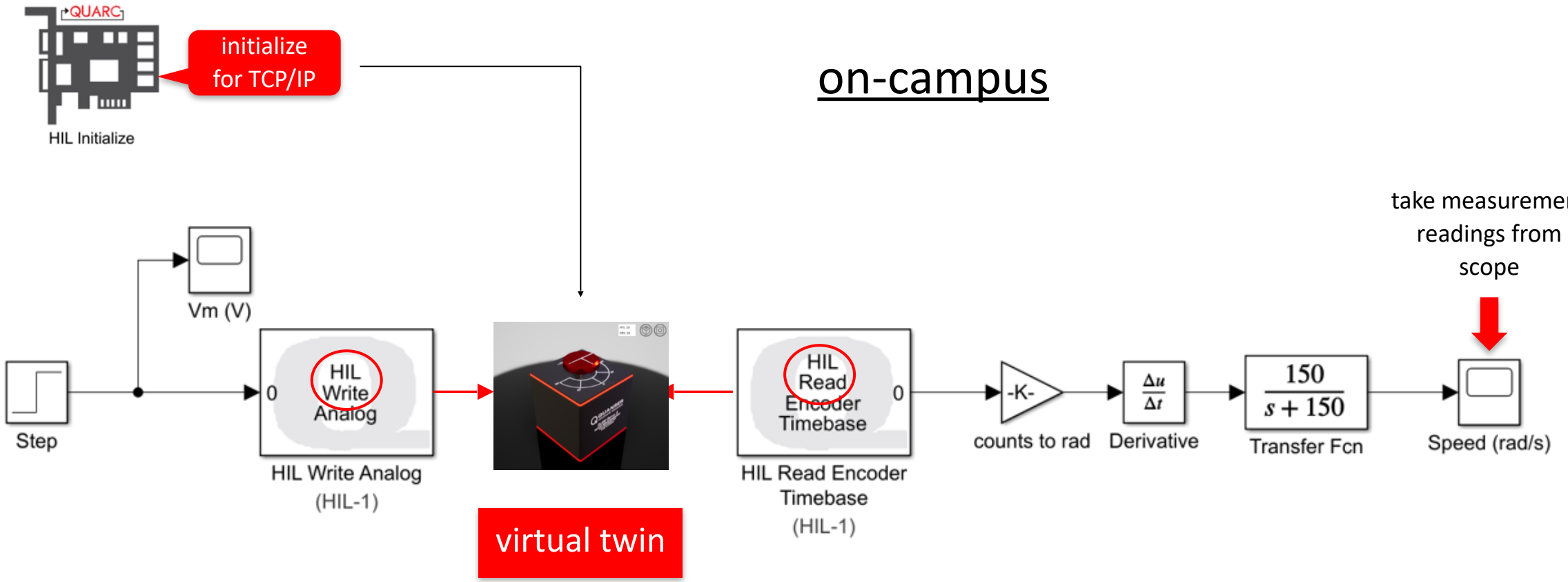
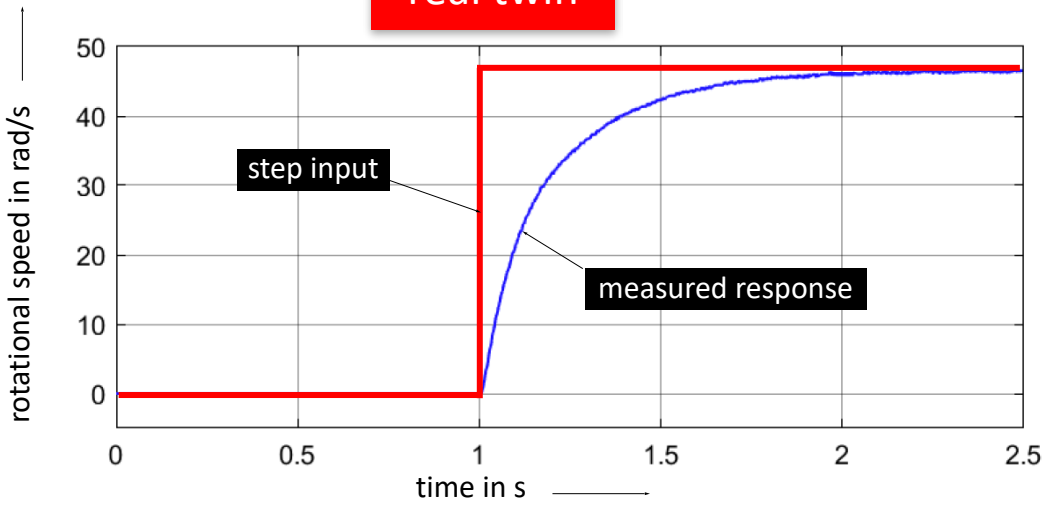


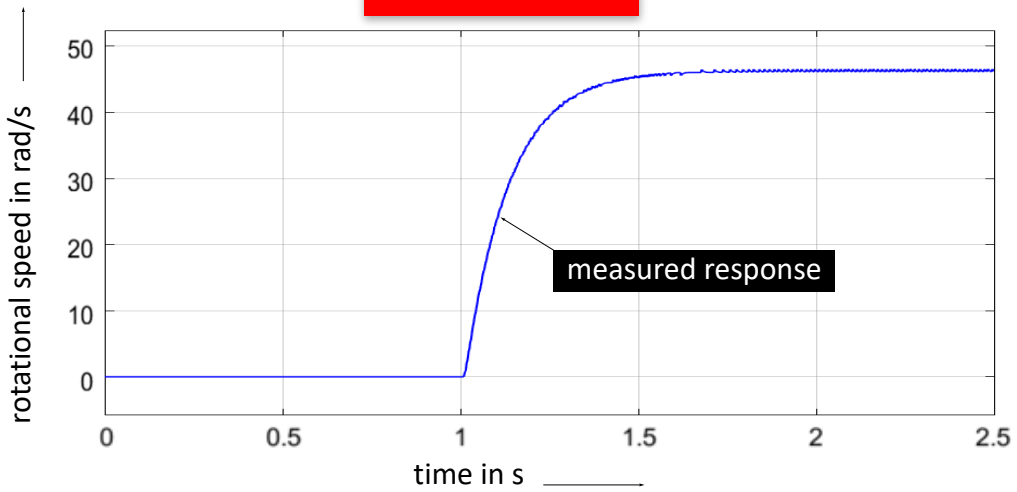
adapted from Quanser Inc. “Step Response Modeling” (2021)

In both learning situations, on-campus and off-campus, the step response is measured by a scope. Both measurements are comparable

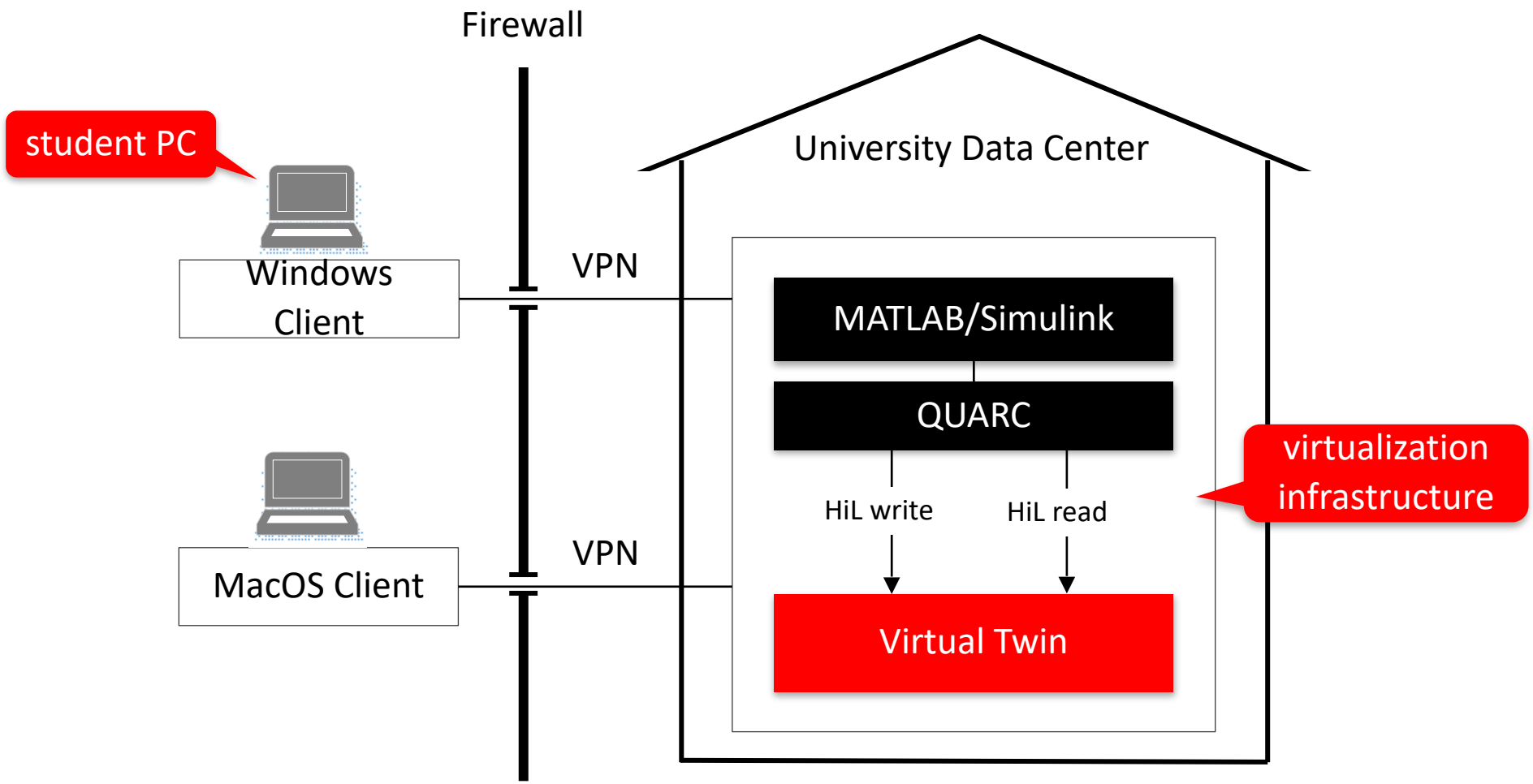
real twin



virtual twin



In the future, the whole virtualization infrastructure will be centrally hosted by the university‘s data center. This has the benefit that student PCs are only thin clients



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Stiftung Innovation in der Hochschullehre

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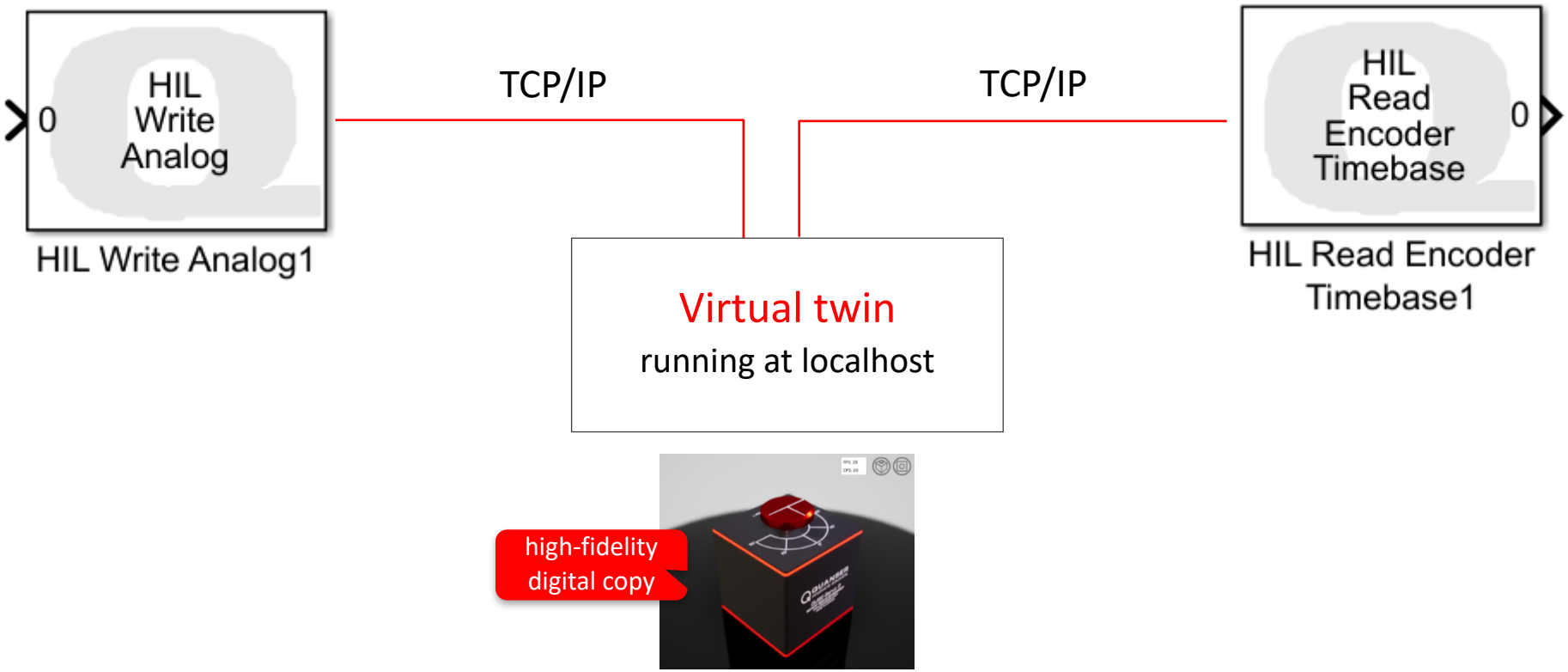
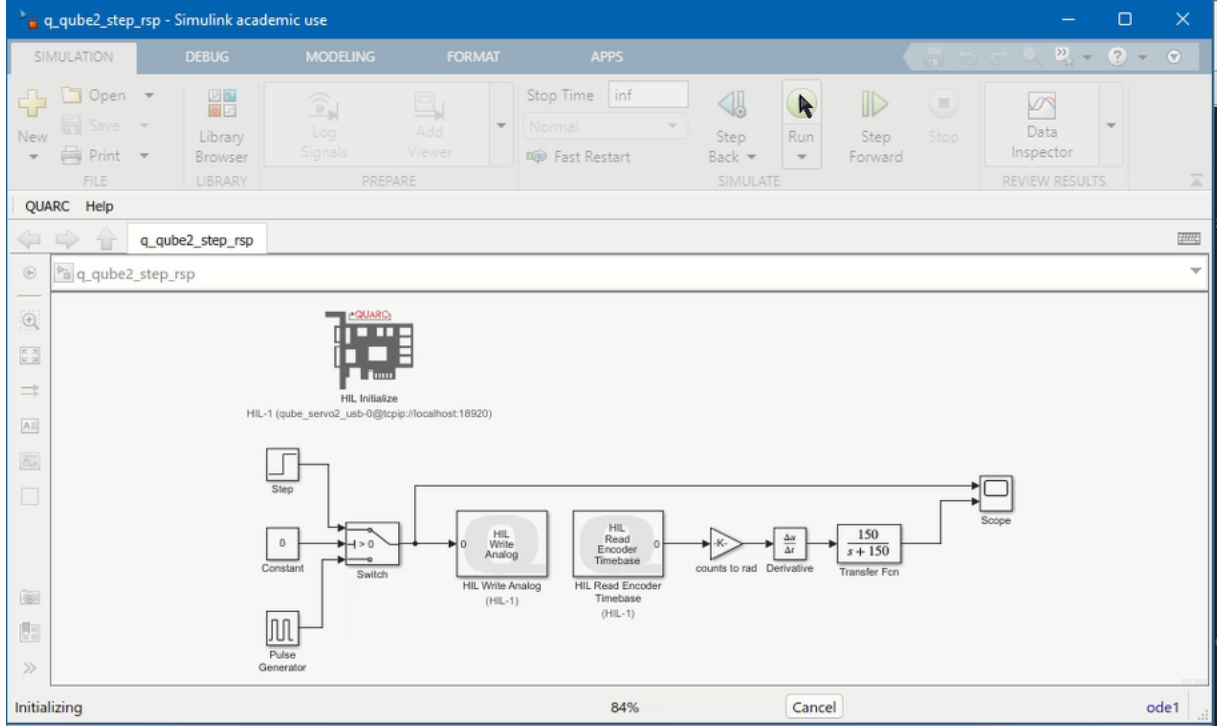
Backup slides

In virtual labs, the interaction with the hardware is replaced by TCP/IP calls against a high-fidelity digital copy that runs on the student‘s computer




q_qube2_step_rsp - Simulink academic use
SIMULATION
DEBUG
MODELING
FORMAT
APPS
Open
New
Save
Print
Library Browser
Log Signals
Add Viewer
Stop Time
inf
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
Data Inspector
FILE
LIBRARY
PREPARE
SIMULATE
REVIEW RESULTS
QUARC
Help
q_qube2_step_rsp
HIL Initialize
HIL-1 (qube_servo2_usb-0@tcpip://localhost:18920)
Step
Constant
Switch
Pulse Generator
HIL Write Analog
(HIL-1)
HIL Read Encoder Timebase
(HIL-1)
counts to rad
Derivative
Transfer Fcn
Scope
Initializing
84%
Cancel
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Quanser Interactive Labs
QUBE-SERVO 2
90°
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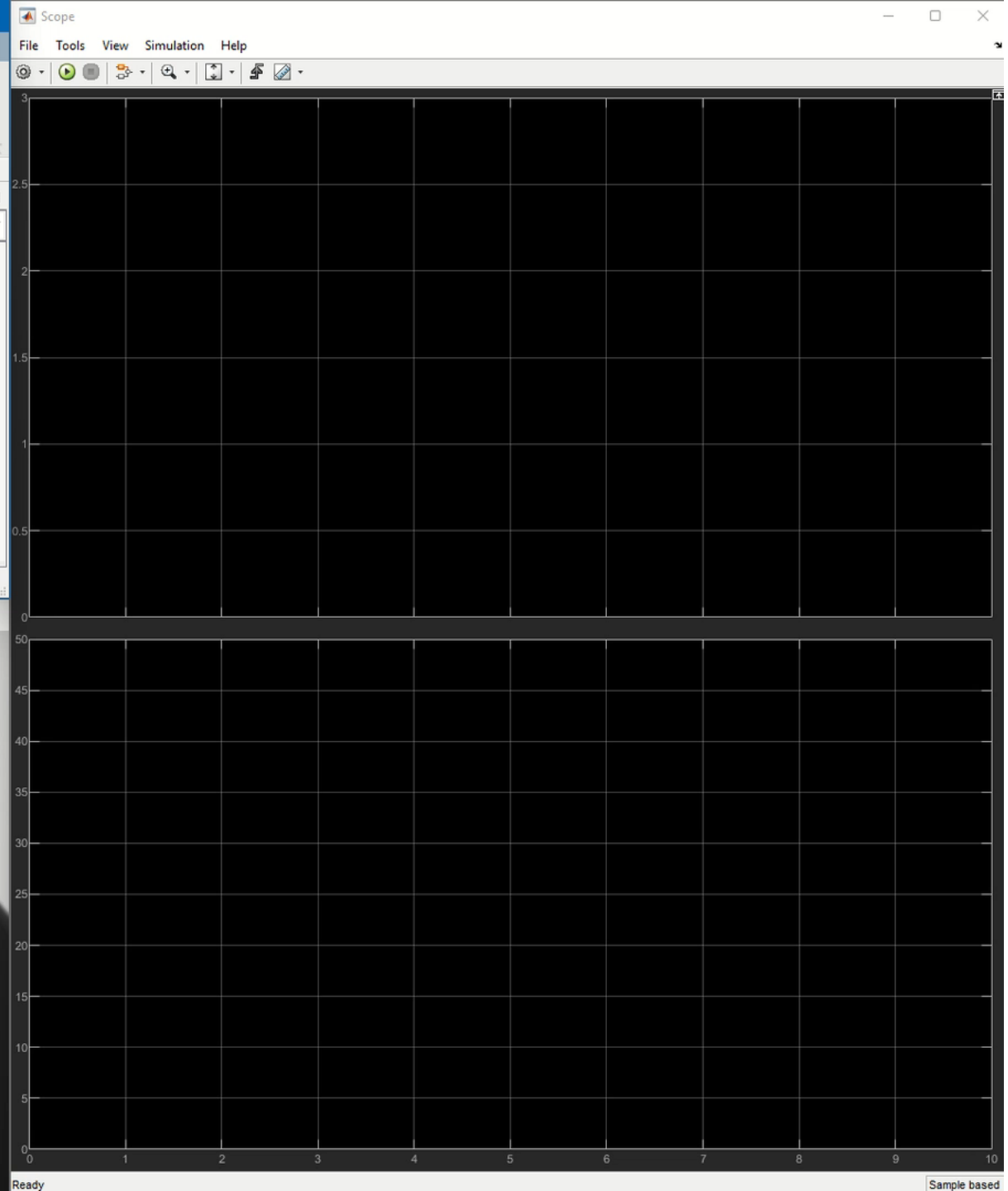
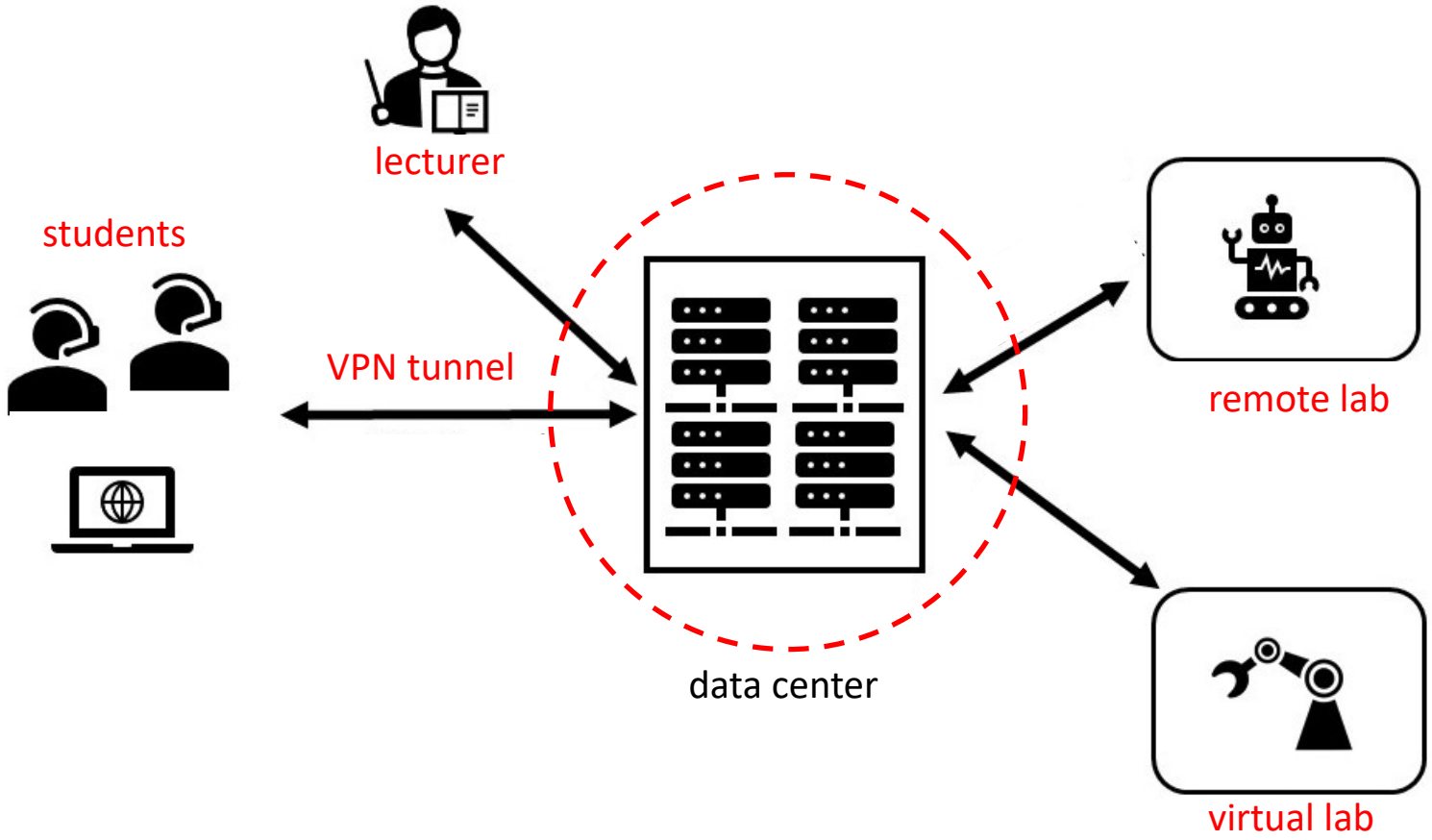
QUANSER
INNOVATE · EDUCATE
QUBE-Servo 2

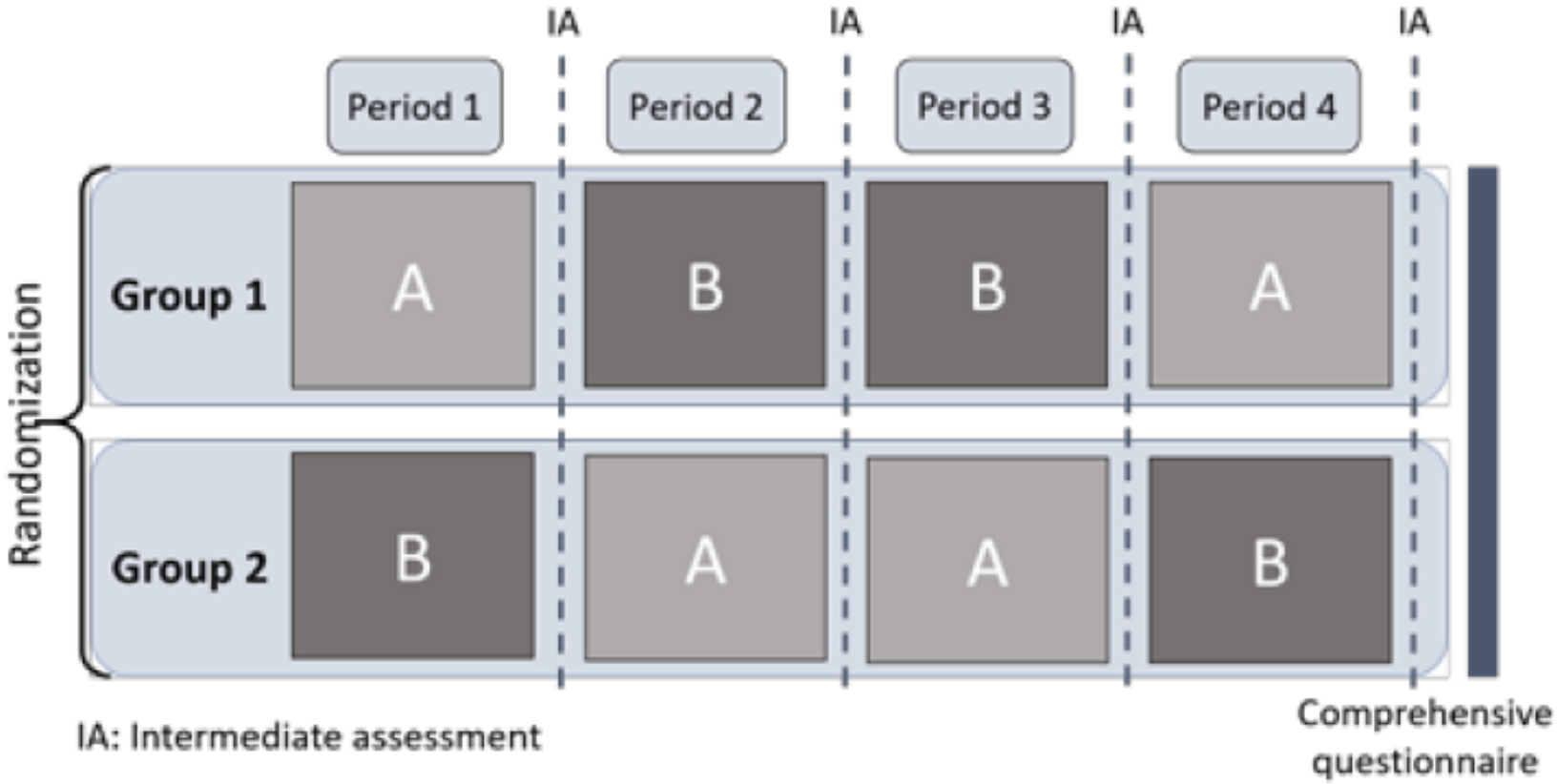

Scope
File
Tools
View
Simulation
Help
Ready
Sample based

In the future, the university‘s data center will be the central hub for access to the remote labs as well as to the virtual labs



Source: Ch. Bunse, L. Kennes, J.-Ch. Kuhr: SEENG'22, May 17 (2022) Pittsburgh
https://doi.org/10.1145/3528231.3528355

The evaluation of the distance labs will follow a randomized, controlled cross-over design



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A: novel teaching with DistLab approach
B: traditional teaching, only on-campus labs