PLENUM
Plenary multi-user development arena for future industrial workspaces

Selected Multi-user VR demonstrators from the PLENUM project

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PLENUM Project Intro

Project Scope

The PLENUM project will develop a **multiuser digital twin** solution and **multiuser XR platform** to address the industry need for model- and simulation driven development, assessment, and optimization of production systems.
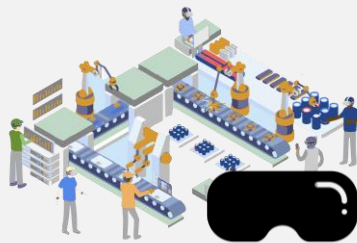
Core drivers are:
- **Workplace design** optimization
- **Ergonomics** (Biomechanical, cognitive)
- Scalable multi-user **XR for training**
- Increased **multi-aspect sustainability**

The PLENUM project was approved by Vinnova as part of the *Advanced Digitalisation Programme*
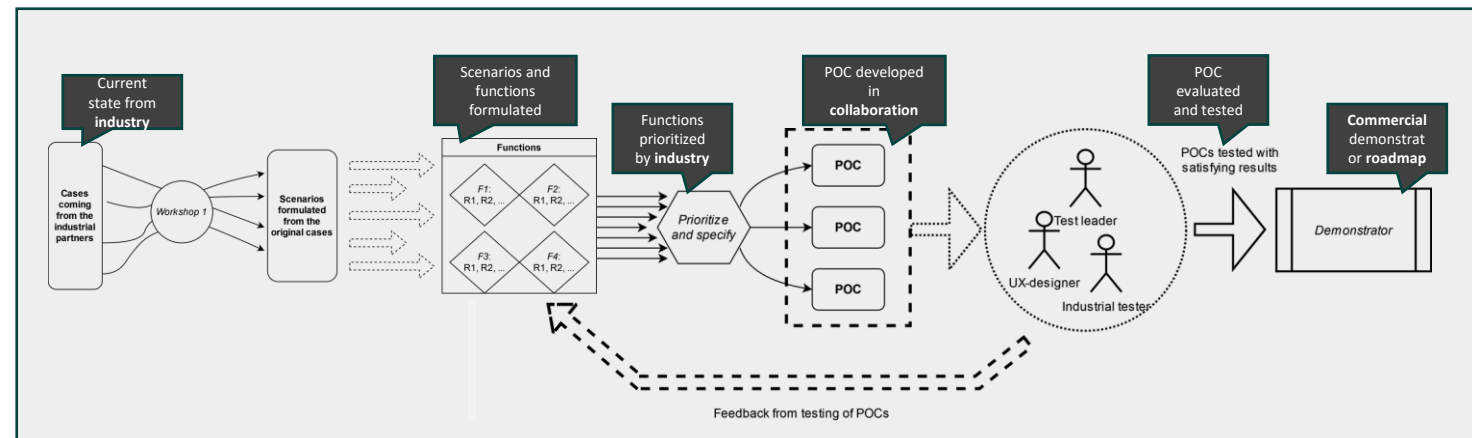
Multi-user VR training
- The creation of a multi-user virtual environment for operator training in VR

A growing need for training:

- An aging workforce in need of continuous training

- New industrial shift requiring new skills

- New digital technology introduced in our factories

- Competition and demand requires shorter ramp ups and faster product changeovers

70%
of global workforce will need to upskill
(*Future of Jobs report, World Economic Forum, 2020*)

~260 000
Industry workers in need of training in Sweden
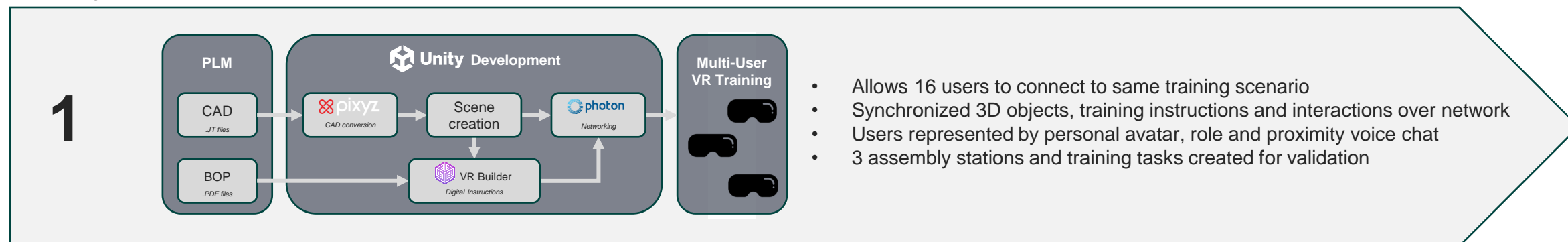(*Teknikföretagen, 2021, Future of Jobs report 2020*)

Pull cable

Today's operator need to communicate and exist in a collaborative setting!

1 Exemplify a possible methodology for the creation of multi-user VR environment for operator training purposes

2 Provide insights and discussion on the potential benefits and application areas of multi-user VR for operator training at OEMs

2024-05-24

Multi-user VR training
- The creation of a multi-user virtual environment for operator training in VR

Development

1

PLM

CAD
.JT files

BOP
.PDF files

Unity Development

pixyz
CAD conversion

Scene creation

photon
Networking

VR Builder
Digital Instructions

Multi-User VR Training

- Allows 16 users to connect to same training scenario
- Synchronized 3D objects, training instructions and interactions over network
- Users represented by personal avatar, role and proximity voice chat
- 3 assembly stations and training tasks created for validation
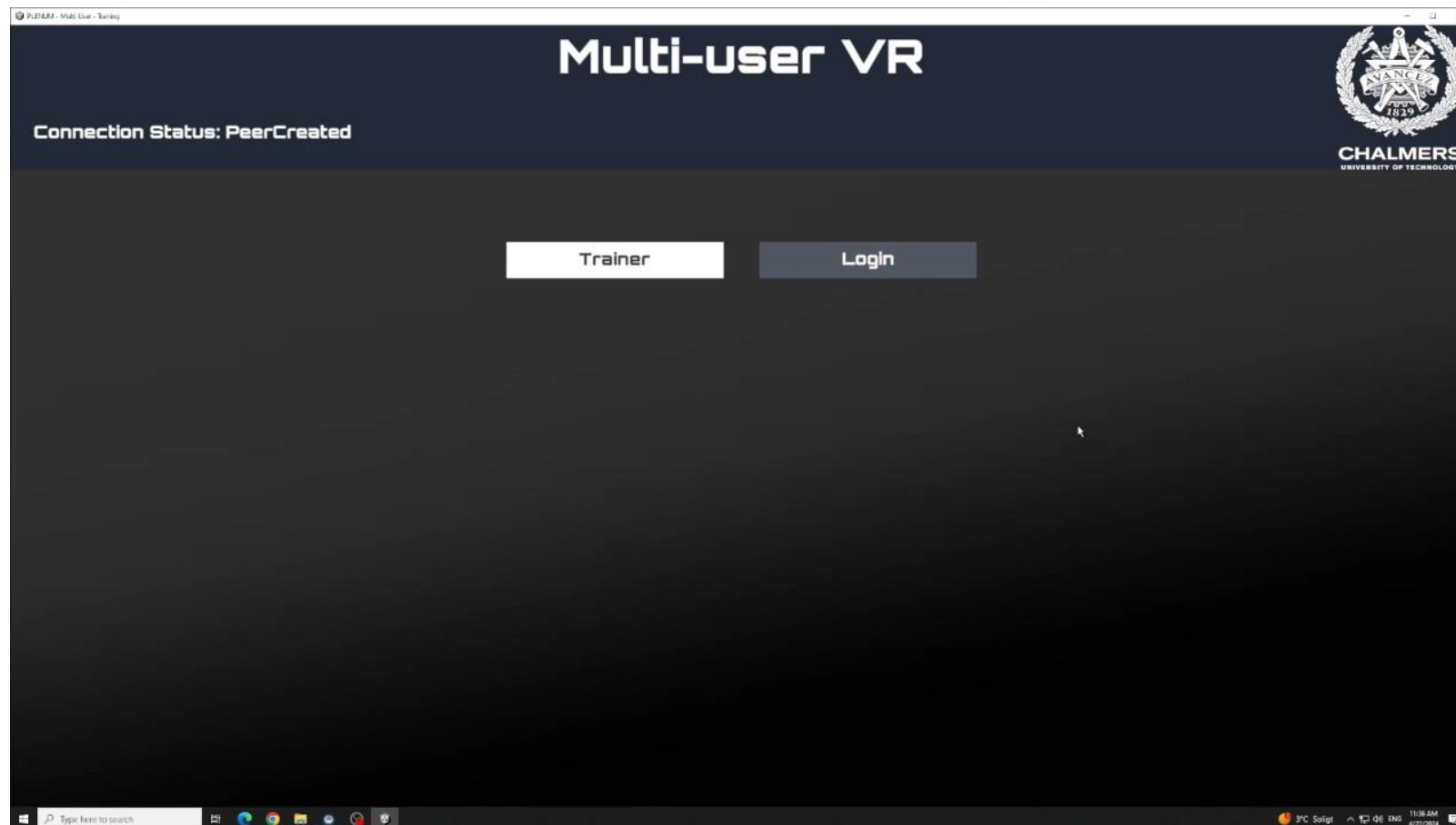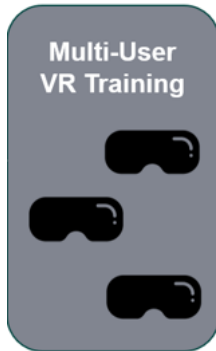
Focus Group

2

2 focus groups were held with 2 teams at Volvo Cars in Torslanda
- Shop Engineering Team – Designs future workstations and work instructions
- Plant Launch Team – Drives the operator training for new plants or product launches
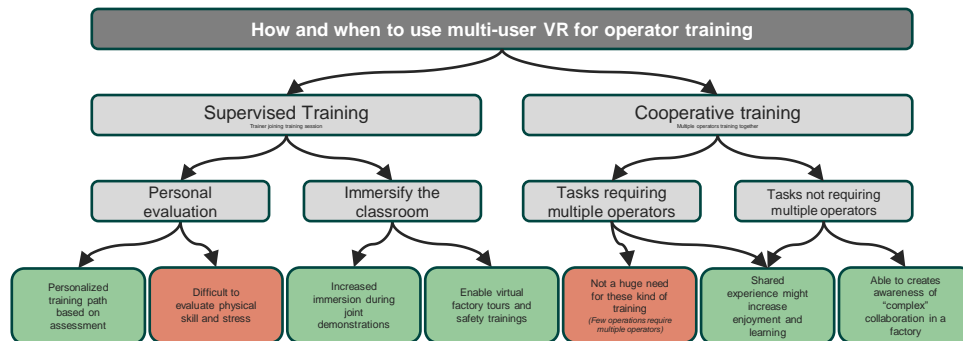
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Multi-user VR training
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Conclusion

✓ Multi-user VR for OEM operator training has potential in multiple areas. It should be considered as a potential tool to tackle upcoming upskilling needs

However:

…Exact use cases and best practices are still to be defined on when and where to apply multi-user VR for best results

…The creation of VR environments for operator training is still very time consuming and more efforts towards scalability and automatic training creation is needed
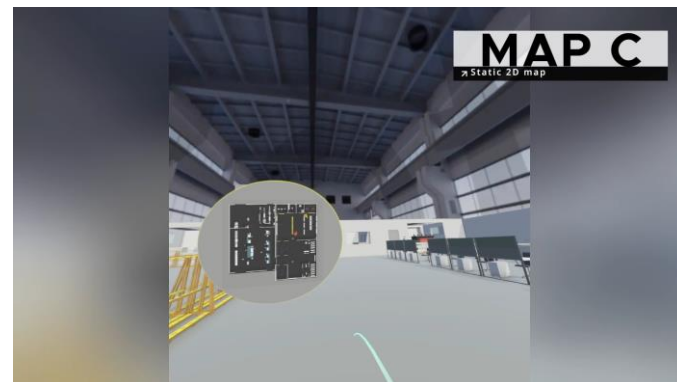
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Multi-user VR Mini Map
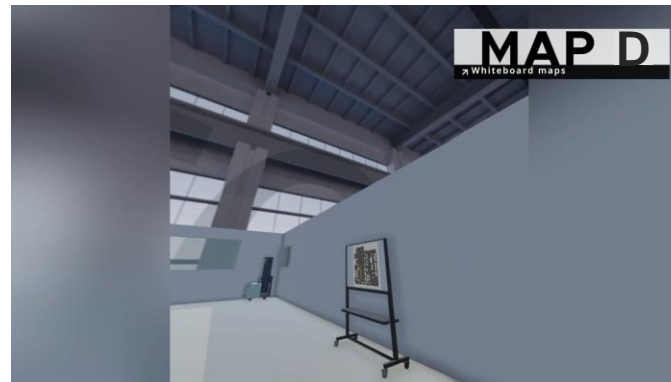## - VR Interaction for efficient virtual manufacturing: Mini Map for multi-user VR navigation platform
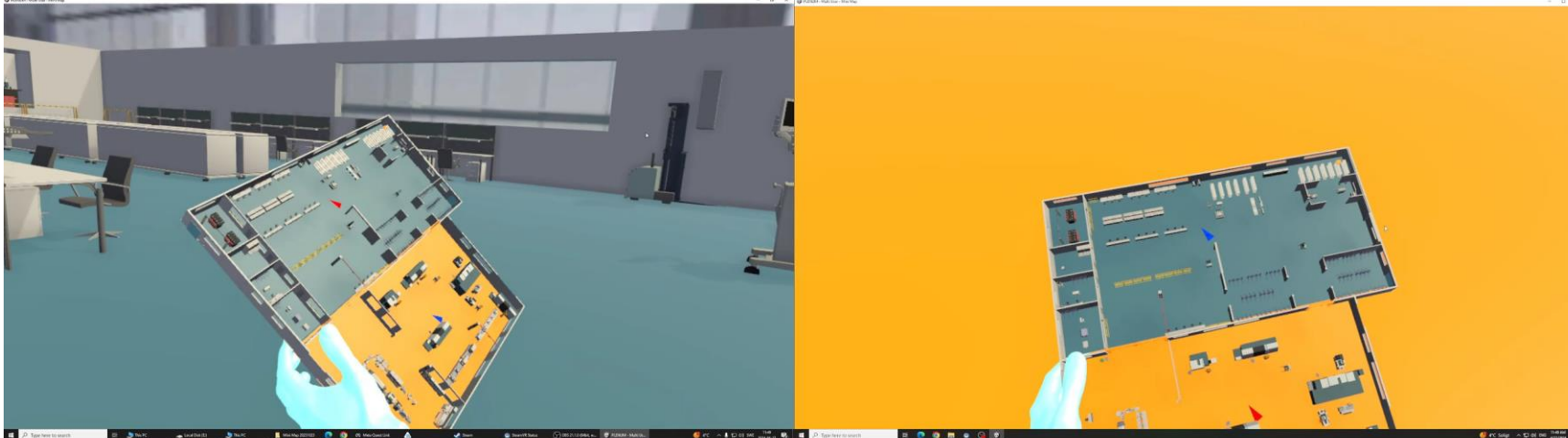

IPAD

3D Doll House Map

3D UI Floating Menu Map

2D GUI Map

Whiteboard Fixed Map

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Experiment design with NASA Raw TLX Index to assess cognitive load

Literature study+3D game exploration

Unity Photon Networking VR Builder

Randomize →

Mini map trial order

ACD
BCA
CEB
BDA
DEA
…

(Random groups allowed)

Instruction →

Participants in pair, Test duration: 15 mins

With supervision →

Trials 5 mins

1st trial

NASA Raw TLX

Trail

Tests 10 mins

Other 2 tests

NASA Raw TLX

Tests

Test group amount:10 (20 students)
Validated data streams: 40
Unvalidated data streams: 20 (first trials)
The Raw TLX is weighted according to the study objectives.

Microsoft forms →

Validated data stream:

ACD
BCA
CEB
BDA
DEA
…

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Result

Weighted cognitive load assessment of 5 mini map prototypes

E.3D UI Floating Menu Map

D. Whiteboard Fixed Map

C.2D GUI Map

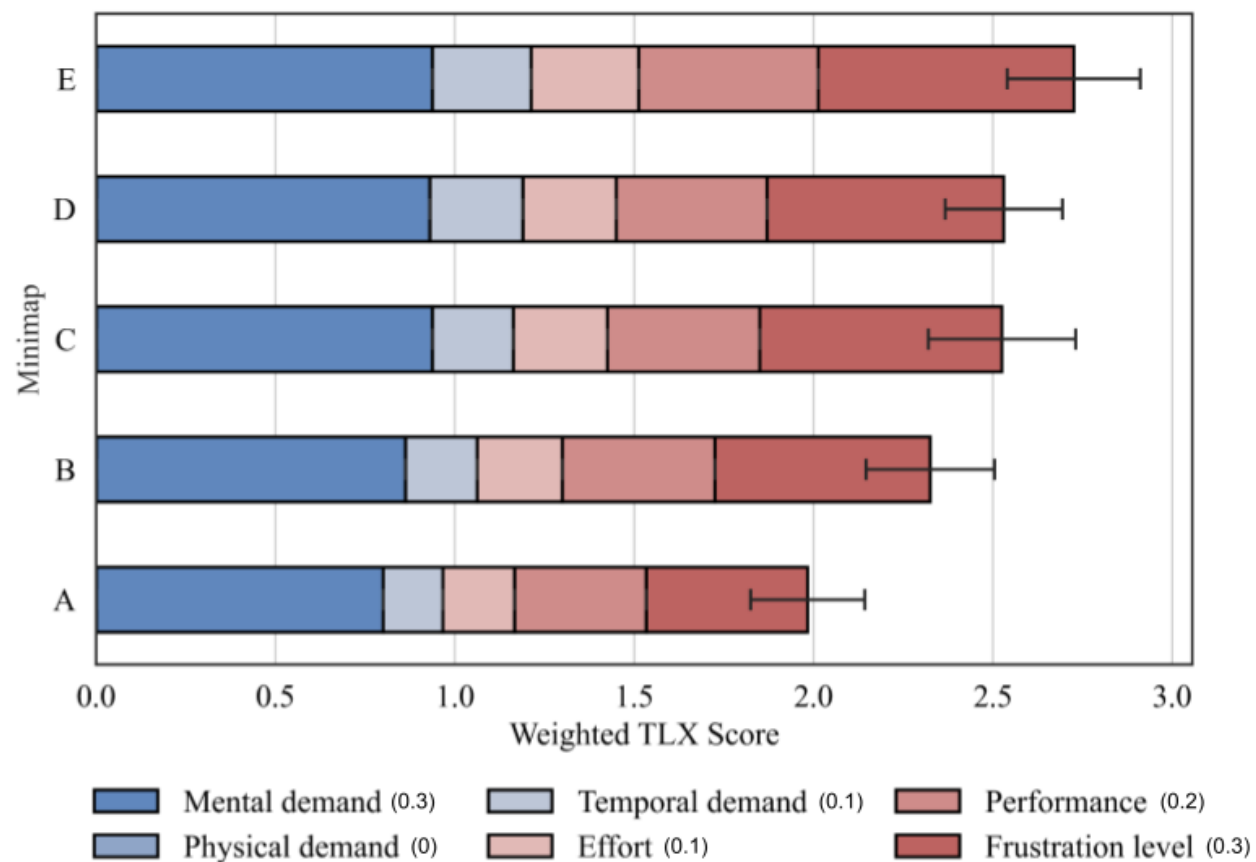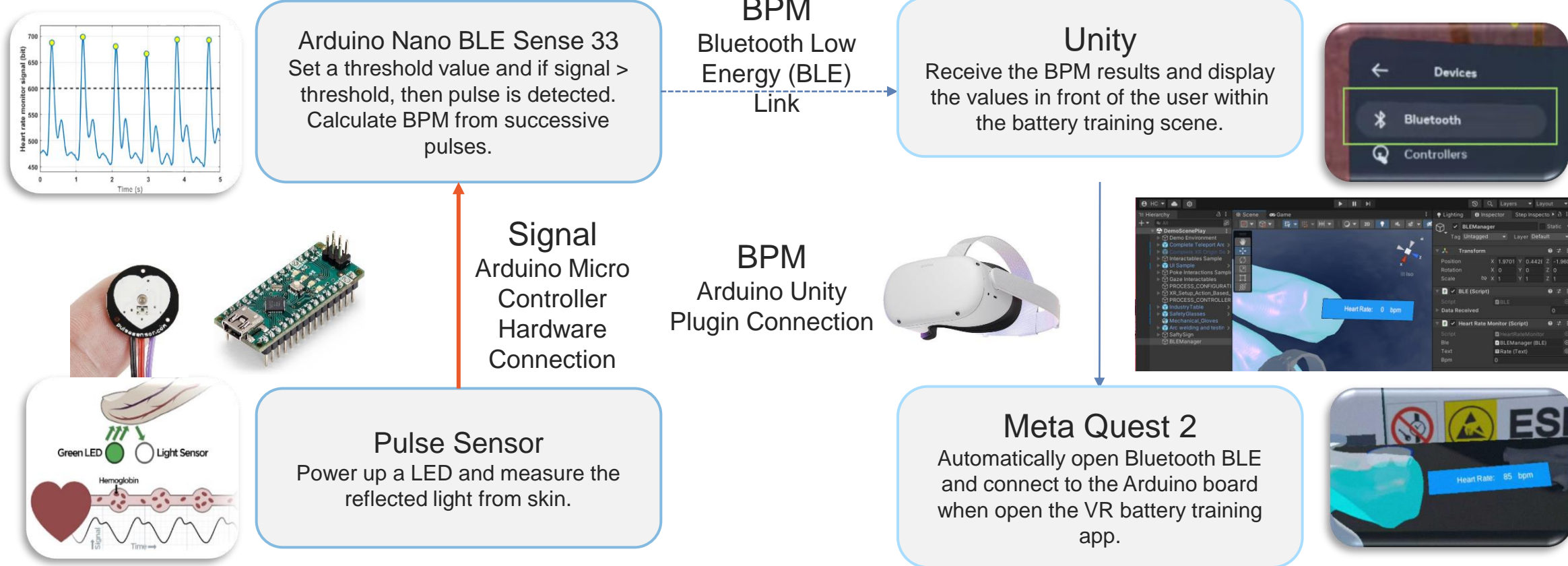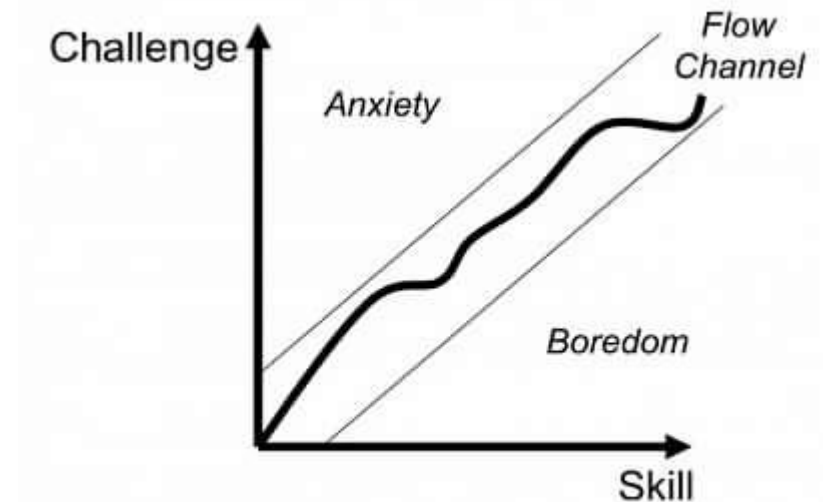B.3D Doll House Map

A.IPAD

Minimap — Weighted TLX Score

Legend:
- Mental demand (0.3)
- Physical demand (0)
- Temporal demand (0.1)
- Effort (0.1)
- Performance (0.2)
- Frustration level (0.3)

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Innovating virtual training with human – centered design
Cognitive load optimization through customization

Arduino Nano BLE Sense 33
Set a threshold value and if signal > threshold, then pulse is detected. Calculate BPM from successive pulses.

BPM
Bluetooth Low Energy (BLE) Link

Unity
Receive the BPM results and display the values in front of the user within the battery training scene.

Signal
Arduino Micro Controller Hardware Connection

BPM
Arduino Unity Plugin Connection

Pulse Sensor
Power up a LED and measure the reflected light from skin.

Meta Quest 2
Automatically open Bluetooth BLE and connect to the Arduino board when open the VR battery training app.

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Innovating virtual training with human – centered design
Cognitive load optimization through customization

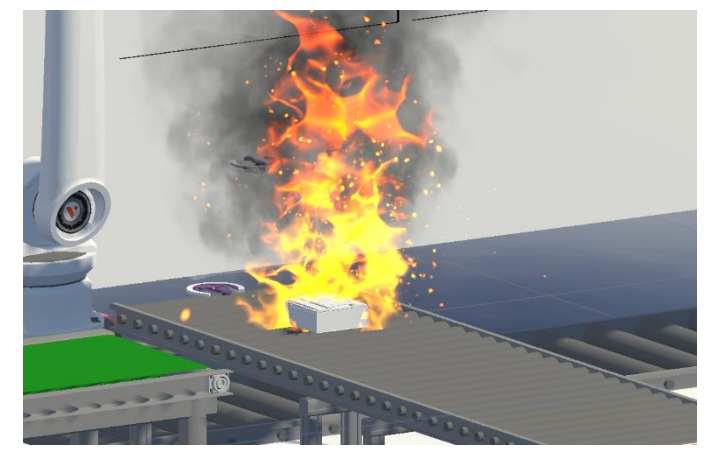"Flow" concept by Mihaly Csikszentmihalyi.   Drawn by Senia Maymin.

Innovation trigger

Current situation

Vision

Long VR session – difficult
Easily dizzy
Fatigue
Mental stress
Less long-term memorization

Customized VR session – optimized difficulty level in risk simulation
Less dizzy with intuitive interaction
Easy and intuitive
Mental flow
Long term memorization

Adoption: HRV as key variable

Impact model

Sequential training in VR

Sequential instruction with events, no customization

- Safety instruction
- Stress
- Risk simulation

Innovative training control with biofeedback for optimized cognitive load

Customized assigned tasks, based on the biofeedback data, BPM and HRV, without sequential instruction

HRV 66 ms

> The emergency fire event only happens when the HRV is higher than 50ms, to optimize the cognitive load

- Safety instruction
- Stress
- Risk simulation

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