



**POLITECNICO**  
MILANO 1863

# Design and Usability Evaluation of a Desktop Hand-Tracked Virtual Lab for Animal Procedure Training

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# Laboratory Animal Science (LAS)

- **Context:** A 3-year Lombardy initiative to develop a scalable digital training platform for veterinary students
- **Ethical & Regulatory Framework:** The 3Rs Principle (Replacement, Reduction, Refinement) in LAS
- **Educational Innovation:** Integrating emerging technologies (VR, Hand-Tracking) into the veterinary medicine curriculum
- **State of the Art:** passive VR observation or abstracted controller inputs

# The problem: Training Constraints

## Training Needs:

- Safe Preparation
- Standardized Practice



## Target Outcomes:

- Error Reduction
- Animal Welfare

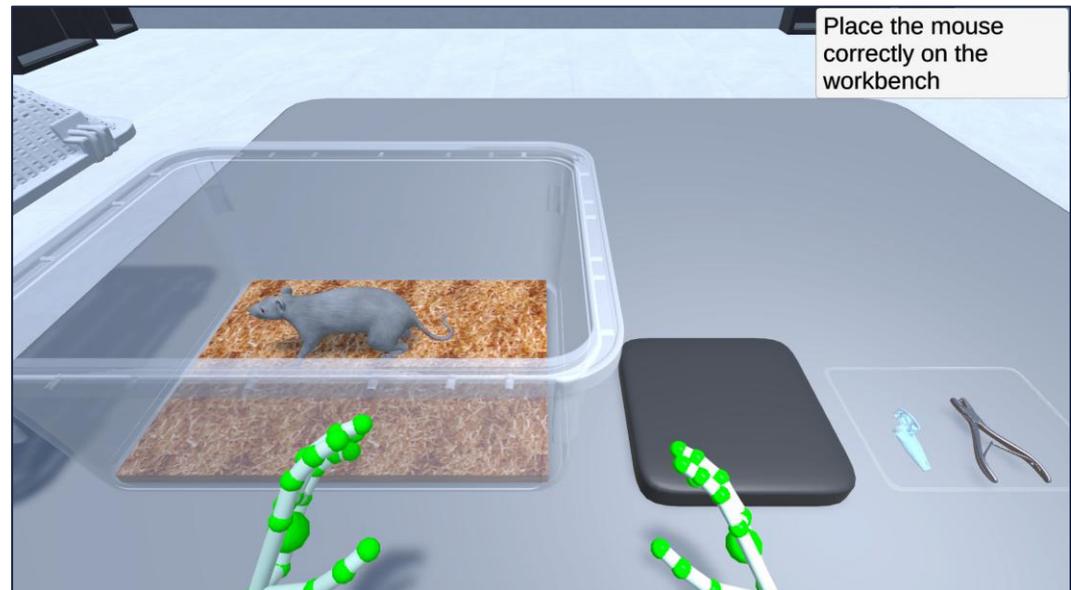
Small animal facility



# VIVARIA Platform

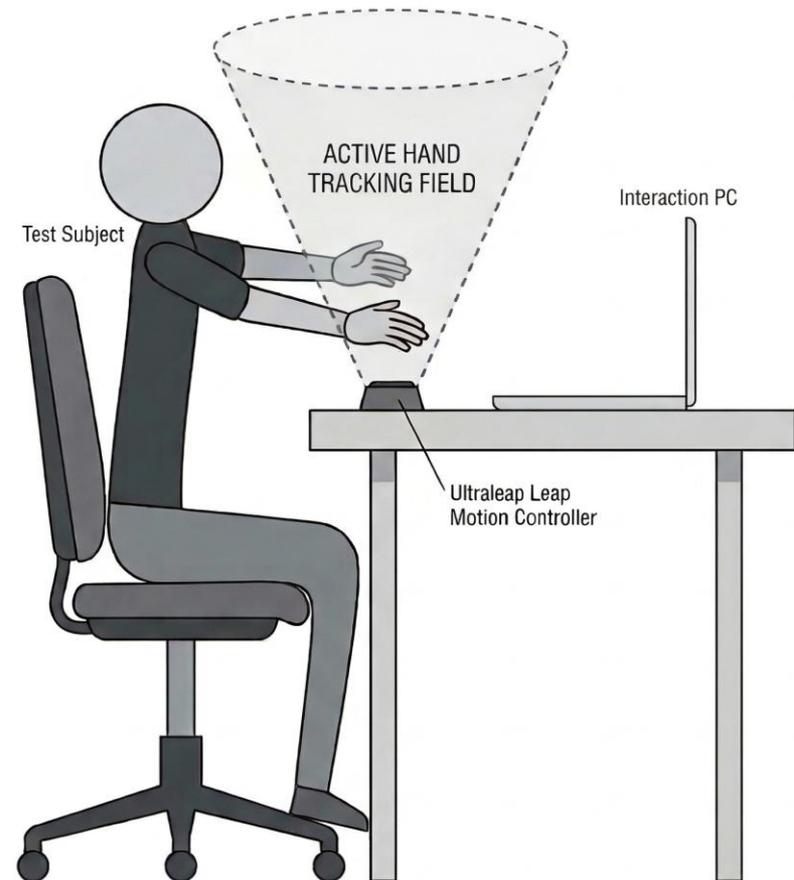
- **Core Development:** A desktop Virtual Laboratory for procedure training using hand tracking
- **Key Modules:** Interactive anatomy exploration and guided procedural training
- **Usability Tests:** Quantitative performance tracking and qualitative user feedback

Virtual Laboratory of VIVARIA platform



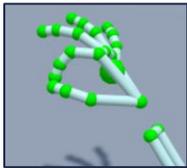
# Desktop-based Application

- **Tracking Sensor:** Ultraleap 3Di configured in manual desktop mode
- **Development Stack:** Built in Unity Engine utilizing the Ultraleap Tracking Plugin
- **Ergonomic Calibration:** Profile-aware anthropometric scaling to normalize hand placement

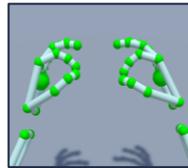


# Training Modules & Interaction Design

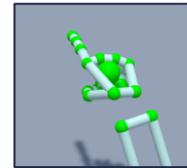
Procedure	Description
Login	User profile registration/retrieval
Practice	Anatomy exploration and tool handling
Cage transfer	Transfer of mouse across cages
Ear biopsy	Tissue sampling with sample storage
Blood collection	Vascular puncture and sample collection
Injection	Abdominal needle positioning and syringe actuation
Euthanasia	Suppression of the mouse by CO <sub>2</sub> gas



Pinch



Double pinch



Pointing



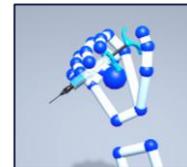
Controls access



Mouse



Needle

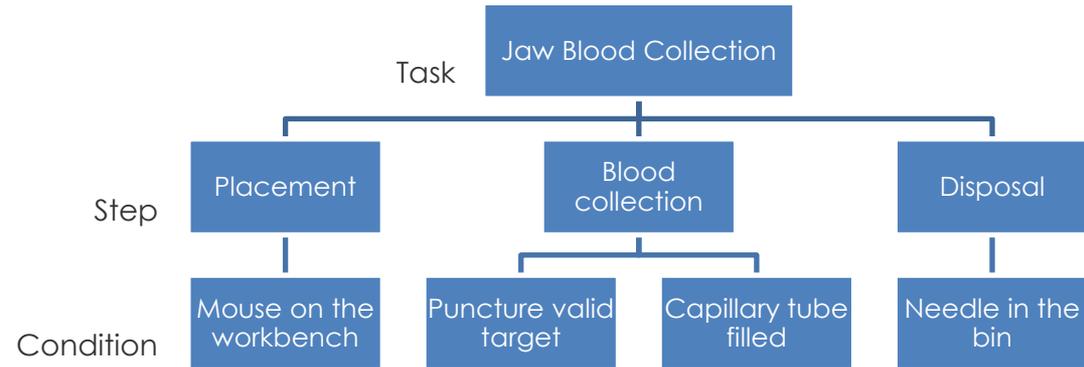


Syringe



Biopsy clamp

# Software architecture: Tasks



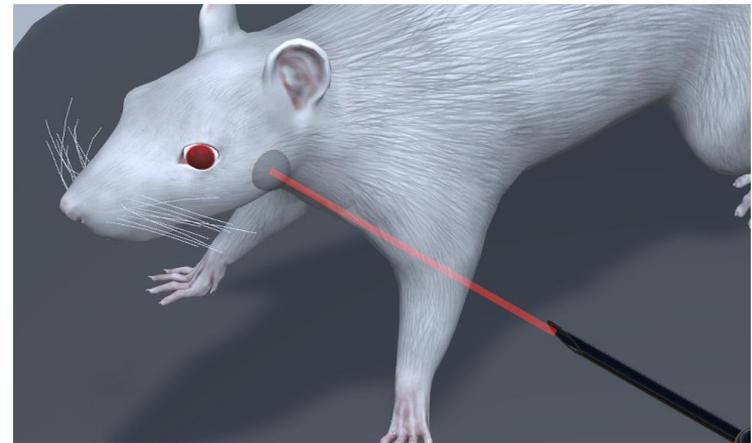
## Step monitoring:

- Time
- Errors (critical vs non-critical)
- Number of grabs
- Type of grab

# Interaction and scaffolding

**Goal:** reduce technical limitations of hand-tracking in desktop mode

- **Physics Simplification:** reduced physics interactions.
- **Error Recovery:** Return-to-origin mechanics for dropped instruments.
- **Guided Attention:** Visual outlining for relevant objects.
- **Depth Perception Aids:** Needle-tip projection.
- **Actions feedback:** Multi-sensory (audio/visual) feedback for interactions.

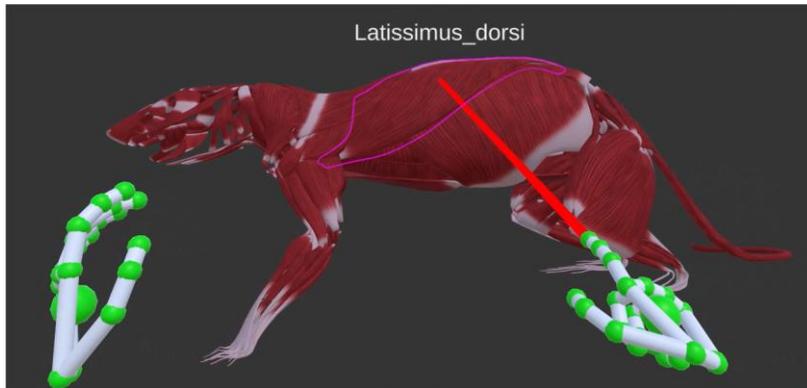


# Virtual Environment Practice

**Goal:** Interactive familiarization prior to procedural tasks

- Model Manipulation
- Organ Identification
- Anatomical Filtering
- Cross-Section Analysis

- Grab, move objects in space, release them
- Manipulate objects using one or both hands



# The laboratory procedures

## Intraperitoneal injection



## Ear biopsy



**Tasks** requiring high accuracy and two-hand coordination

# Test Protocol



- **Participants:** N=20 (9 Veterinary Medicine students, 11 Non-specialists).
- **Evaluated Procedures:** 1. Mouse Cage Transfer 2. Jaw Blood Collection 3. Intraperitoneal Injection
- **Session Duration:** ~15 minutes per participant.

# Data Collection & Metrics

## Objective Data (Automated Logging)

- **Total Completion Time:**  
Duration from task start to finish
- **Task & Step Attempts:**  
tracking of errors during tasks

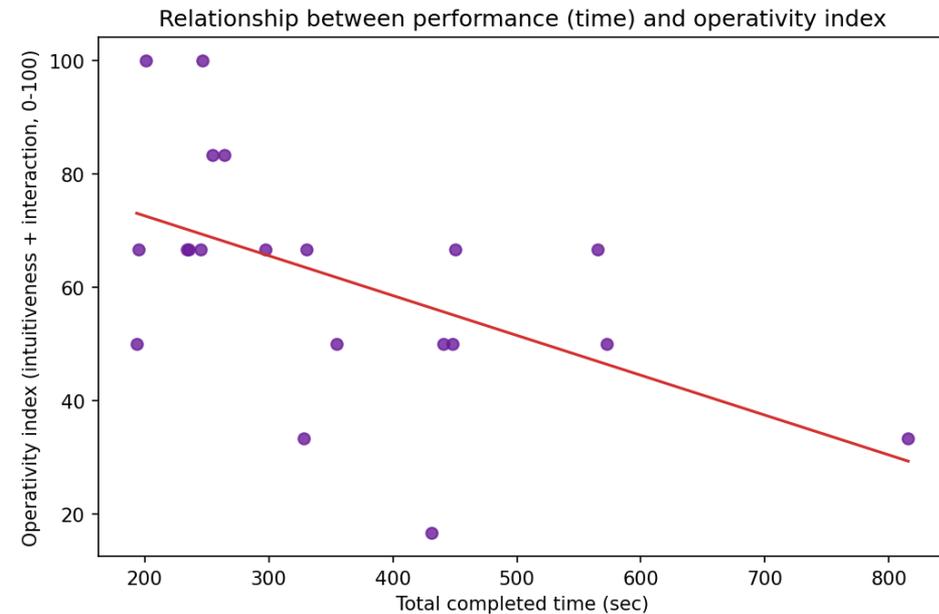
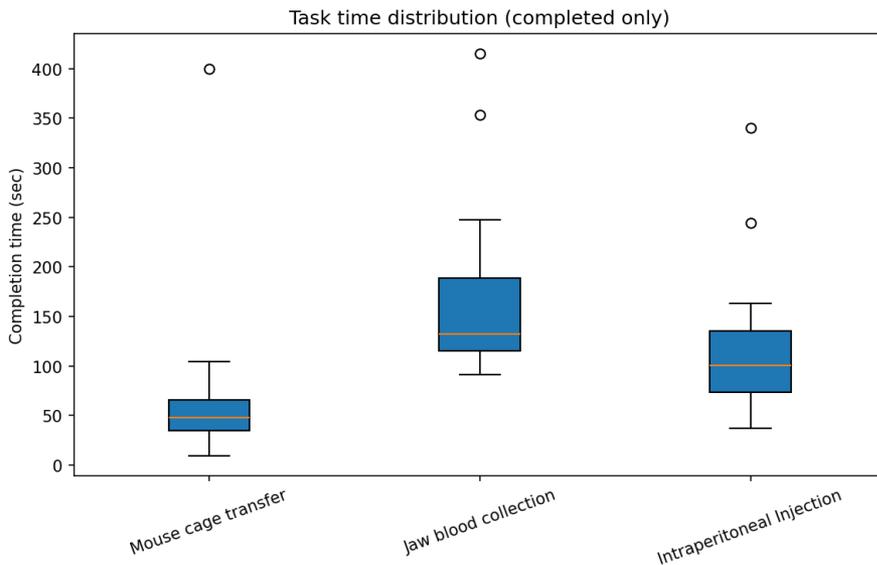
## Subjective Feedback (Custom Questionnaire)

- **Prior Experience:** familiarity with hand tracking and VR technologies
- **Learning Outcomes:** Perceived comprehension of the procedures
- **Usability & Controls:** Control intuitiveness and interaction ease
- **General Feedback:** Perceived realism, physical comfort, and educational value

# Overall Performance

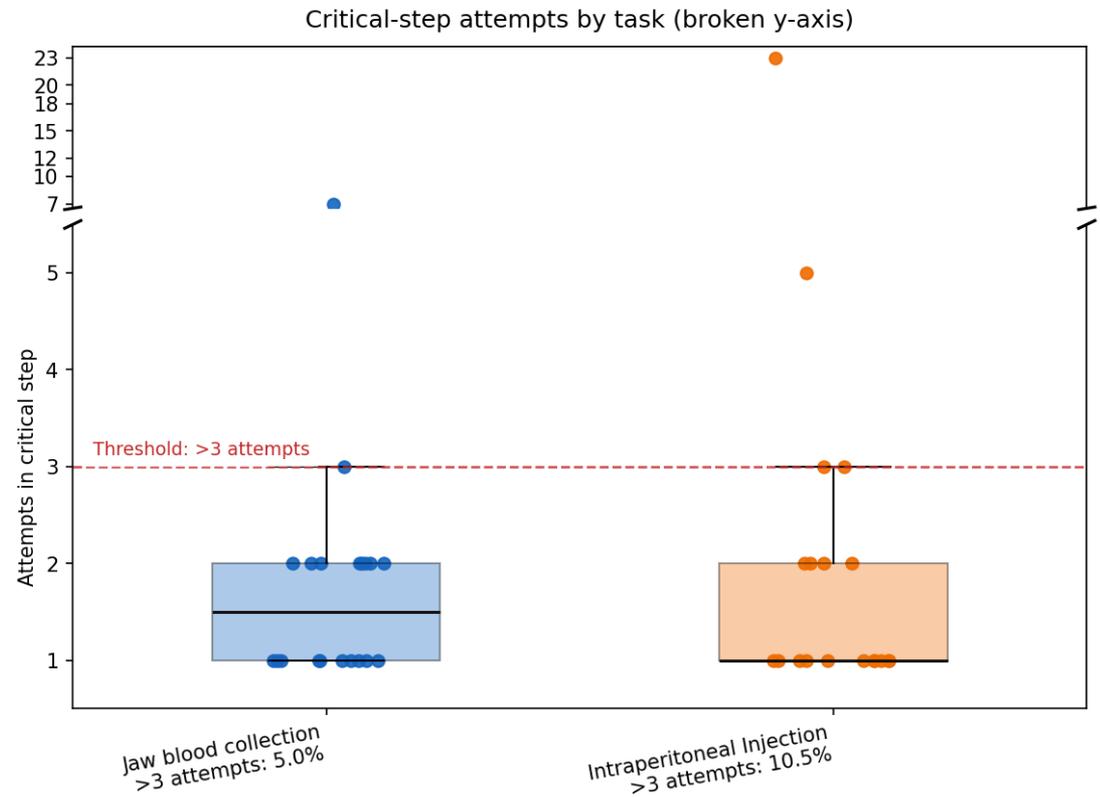
Task	<i>n</i>	Completion (%)	Median time (s)
Cage transfer	20	95.0	47.6
Jaw blood	20	95.0	132.1
Injection	19	94.7	100.3

**Performance correlation:** strong relationship ( $\rho = -0.5374$ ,  $p = 0.0177$ ) between operativity index and total completion time



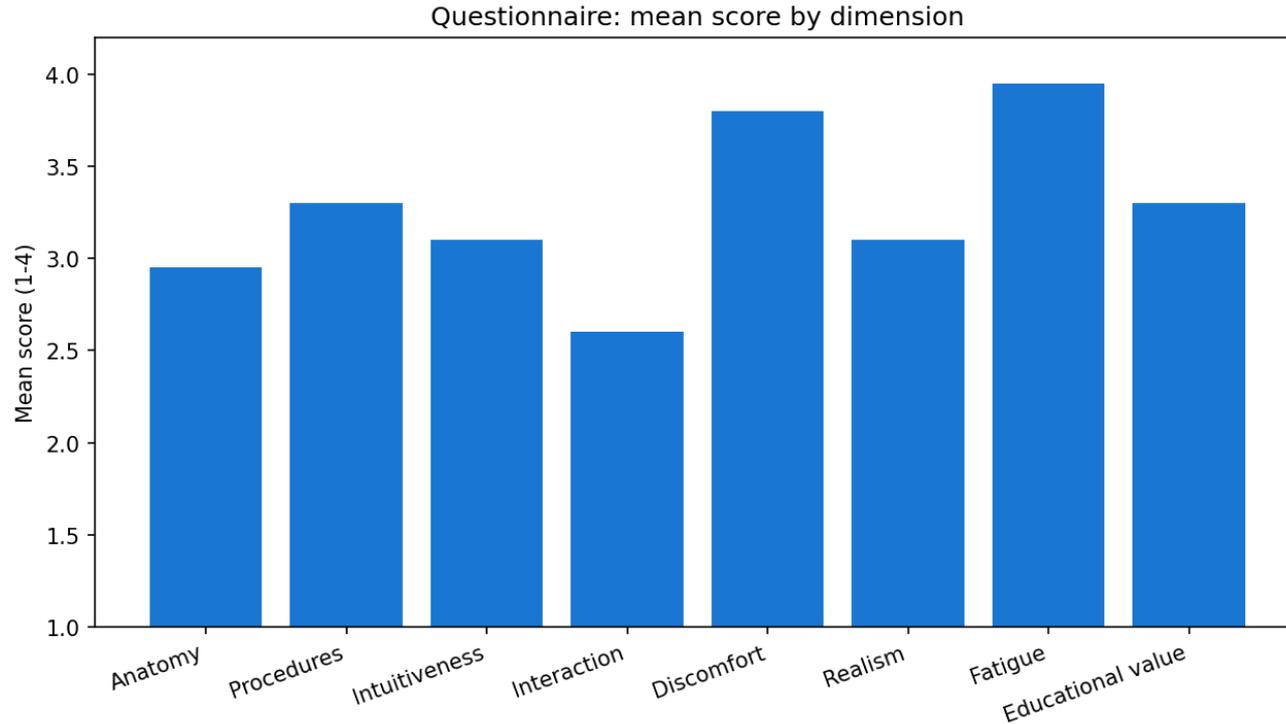
# Step-Level Analysis

- **Complex object interactions:** Critical steps require high precision and good depth perception
- **Fast Motor Adaptation:** users cleared the hardest steps in 3 attempts or fewer (95% and 89.5%)



# Subjective Evaluation (Questionnaire)

- **Educational Efficacy:** Good perceived value in procedural learning
- **Ergonomics:** Minimal physical discomfort and fatigue
- **System Realism:** Positive feedback regarding the virtual environment
- **Object interaction:** 2.6 mean score, room for improvement



# Discussion & Conclusions

## Conclusions:

- **System Feasibility:** Demonstrated the viability of a desktop hand-tracked virtual laboratory
- **Scaffolding and feedback:** Mitigated technical limitations of the setup
- **State-of-the-Art Gaps:** Enabling quantitative analysis for objective skill assessment
- **Ethical Impact:** Safe and repeatable practice aligned with 3Rs

## Current Limitation:

Desktop monitors lack depth perception, creating bottlenecks in high-precision tasks