Establishing the Transfer Validity of a VR Umbilical Venous Catheter Simulation

Harris Nisar[1], Dr. Nicole Rau[2], Dr. Taylor Gohman[1], Dr. Avinash Gupta[3], and Dr. M. Jawad Javed[1]

1. Research Engineer, Health Care Engineering Systems Center (HCESC), UIUC; 2. University of Illinois College of Medicine at Peoria, Division of Neonatology; 3. Teaching Assistant Professor Industrial and Enterprise Systems Engineering Department, University of Illinois Urbana Champaign, IL, USA

Agenda

1. **Background:** Provide some motivation and introduce the UVC placement
2. **Methods:** How we developed the VR simulator for the UVC placement
3. **Results:** Realism and usability study & Transfer validity study
4. **Ongoing and Future Work**

Teaching of Neonatal Procedures

Traditionally

1. See One

2. Do One

3. Teach one

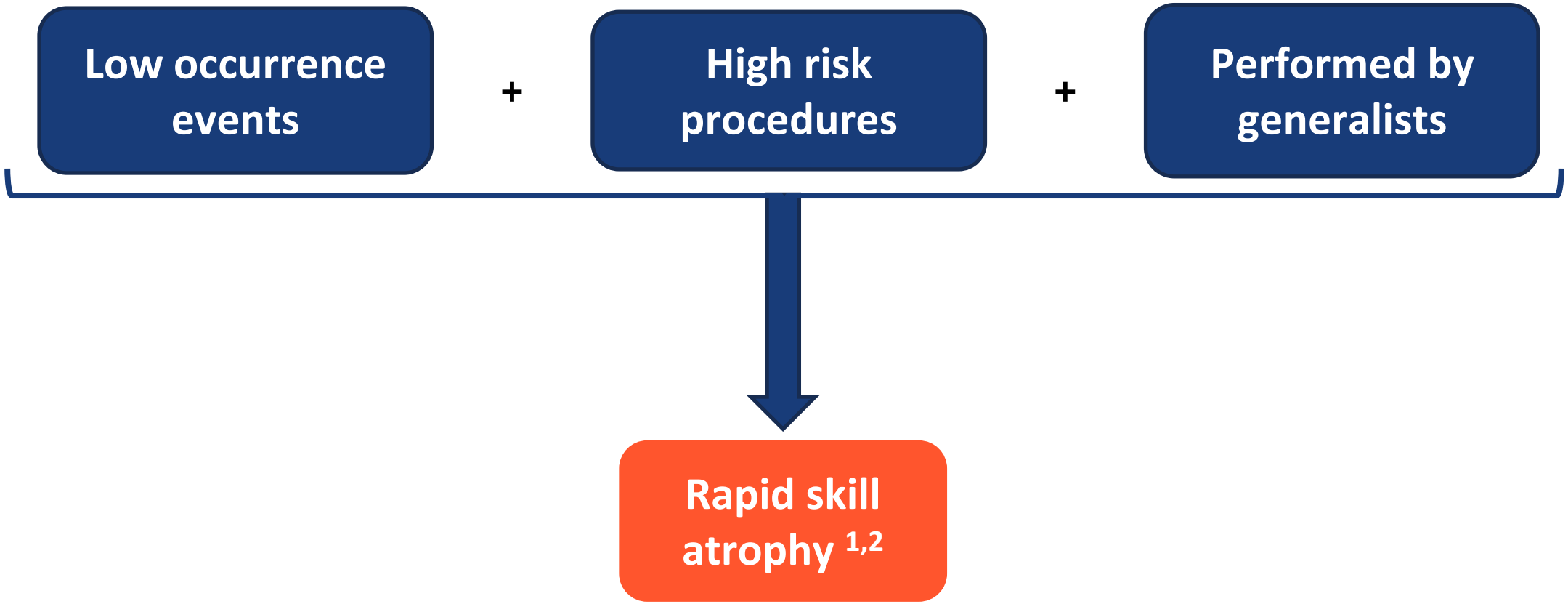
* Images generated with AI

Challenges

Reduction in trainee exposure to procedures due to:

- Duty hour restrictions
- Increased advanced practice providers
- Fewer months in the NICU

Current State of Education for Neonatal Procedures



[1]Fisher J, et al. Clinical skills temporal degradation assessment in undergraduate medical education. PMID: 29344523; PMCID: PMC5757151.
[2]Smith KK, et al. doi: 10.1016/j.resuscitation.2008.02.007.

Enter Virtual Reality (VR)

Proven effective in **high-stakes** domains

Gaining traction in **surgical education** [1,2]

Accessible and scalable with current hardware

[1]Andersen SA, et al. doi: 10.1001/jamaoto.2015.1563. PMID: 26334610.
[2]Andersen SA, et al. doi: 10.1001/jamaoto.2016.0454. PMID: 27124506.

Project Objectives

To **build a VR simulation** to walk through the umbilical venous catheter (UVC) placement

To **determine the face and content validity and usability** of the simulation

To **determine the transfer validity** of the VR UVC module

Objectives for the Design

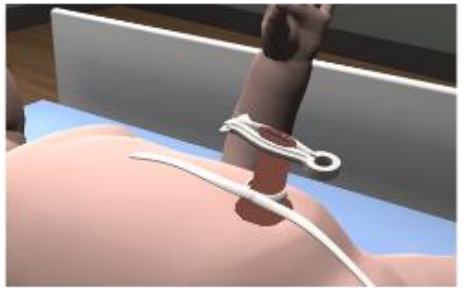
The simulator steps should match the steps of the real procedure.

The user should be able to transition between steps.

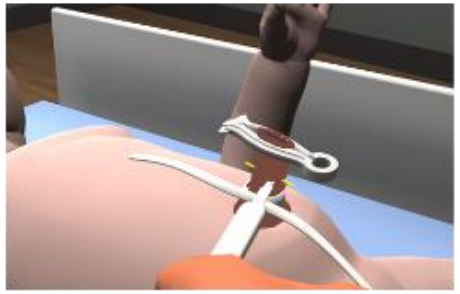
The user should be able to reset the entire procedure.

Simulation Design – Procedure Steps


1. Start

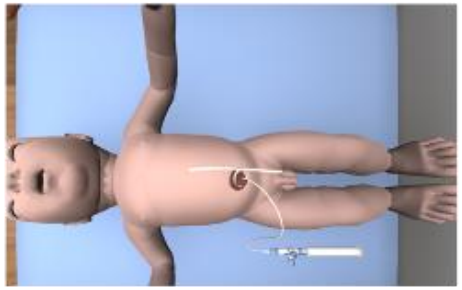



2. Clamping, 3. Tying, and 4. Cleaning the Stump



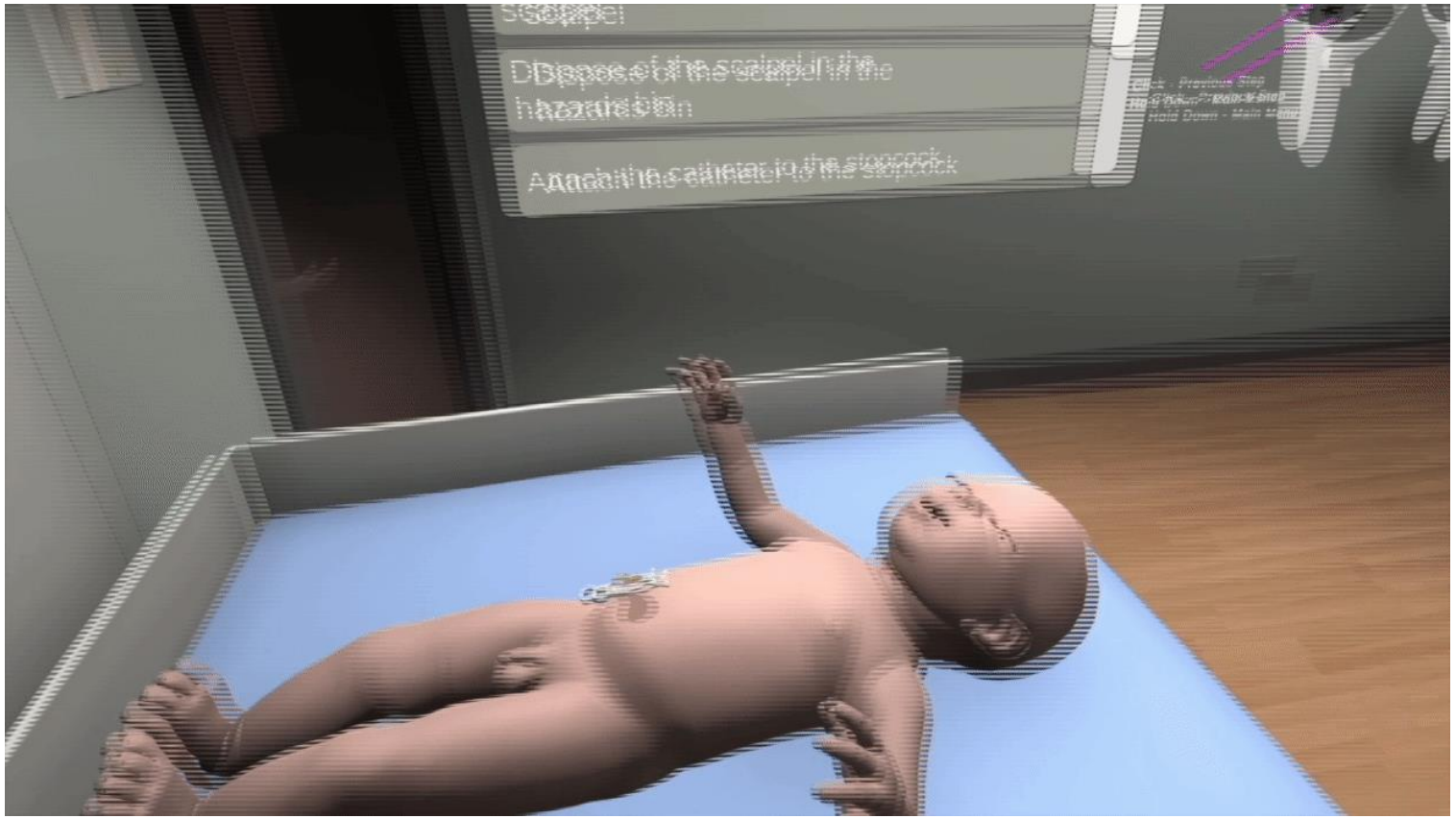

5. Cutting the Stump

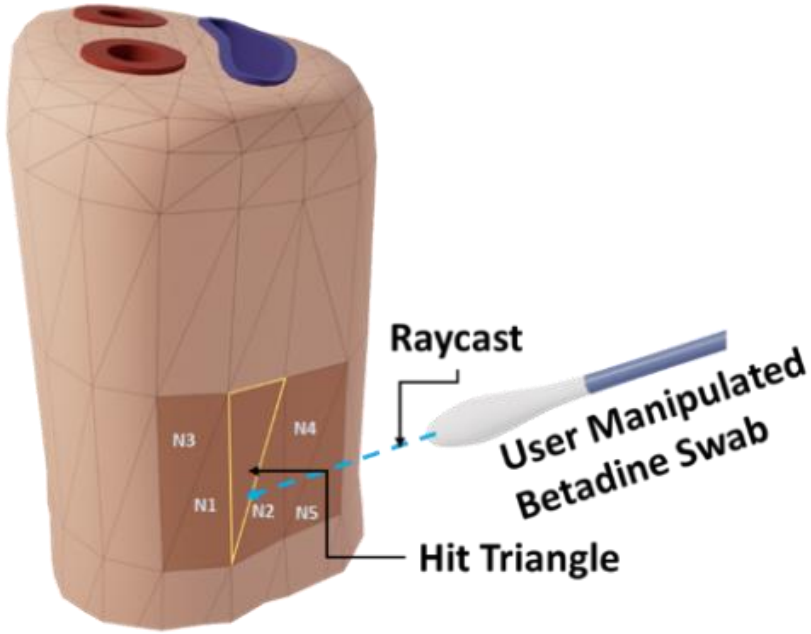

6. Catheter Preparation



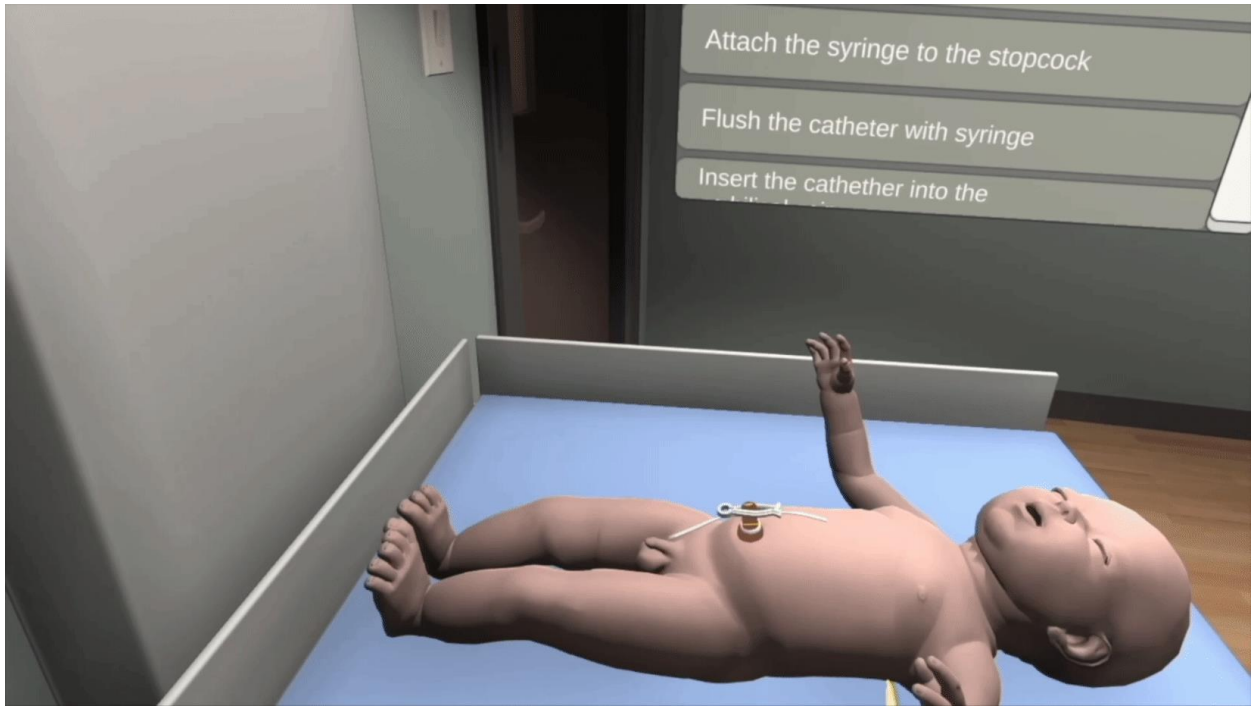

7. Catheterization

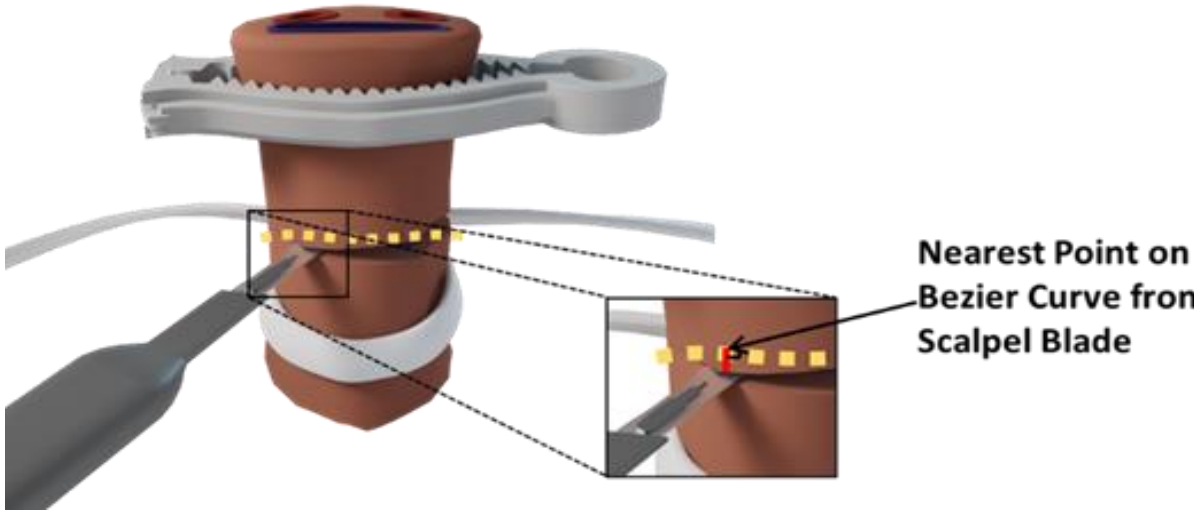
Simulation Design – Virtual Interactions



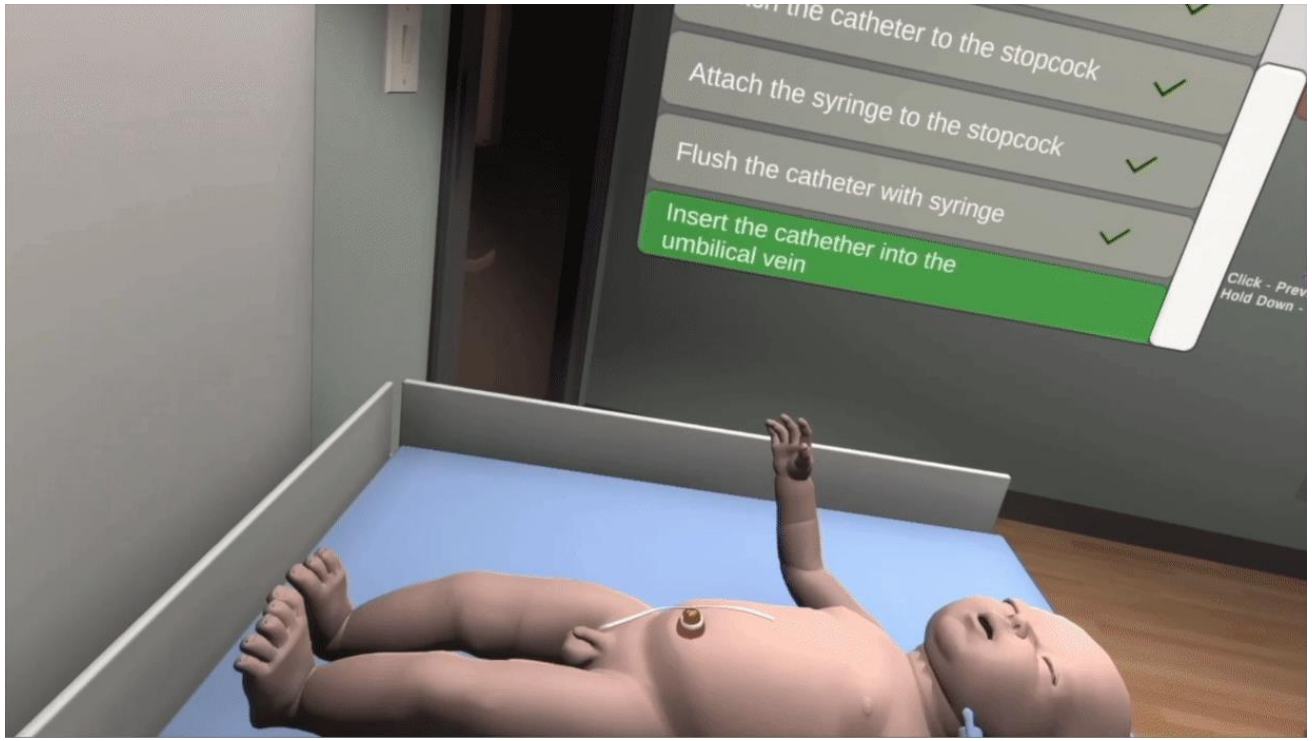


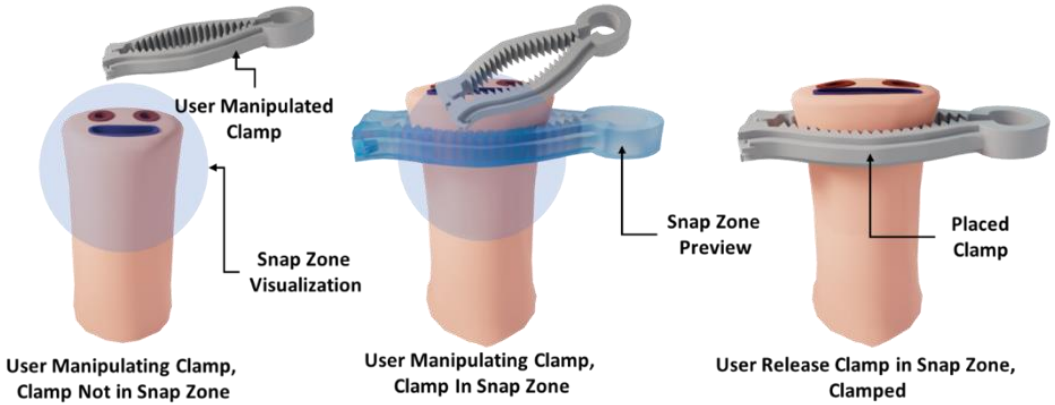
Simulation Design – Virtual Interactions



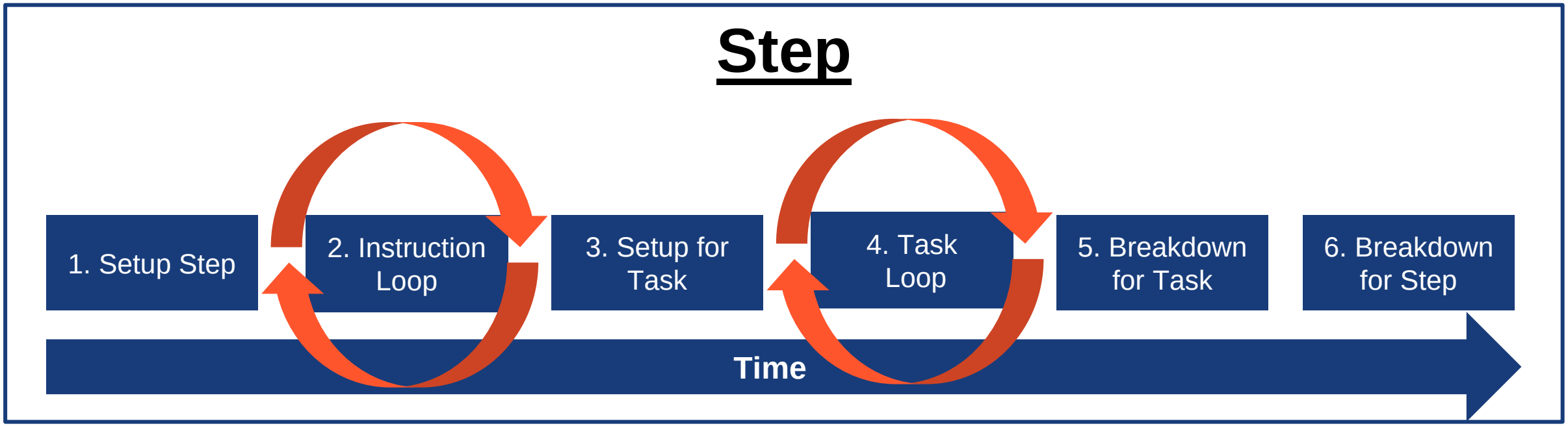


Simulation Design – Virtual Interactions

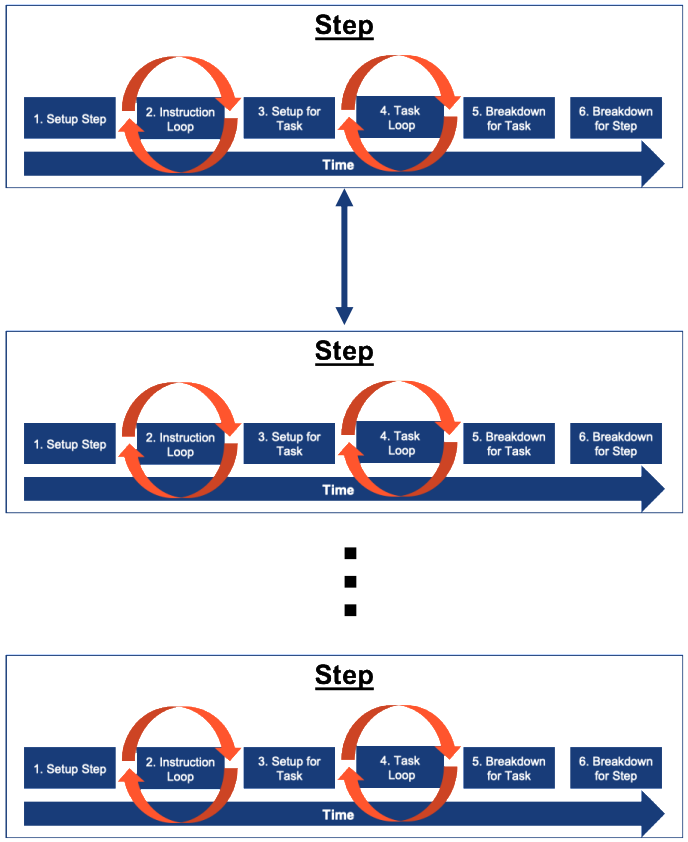


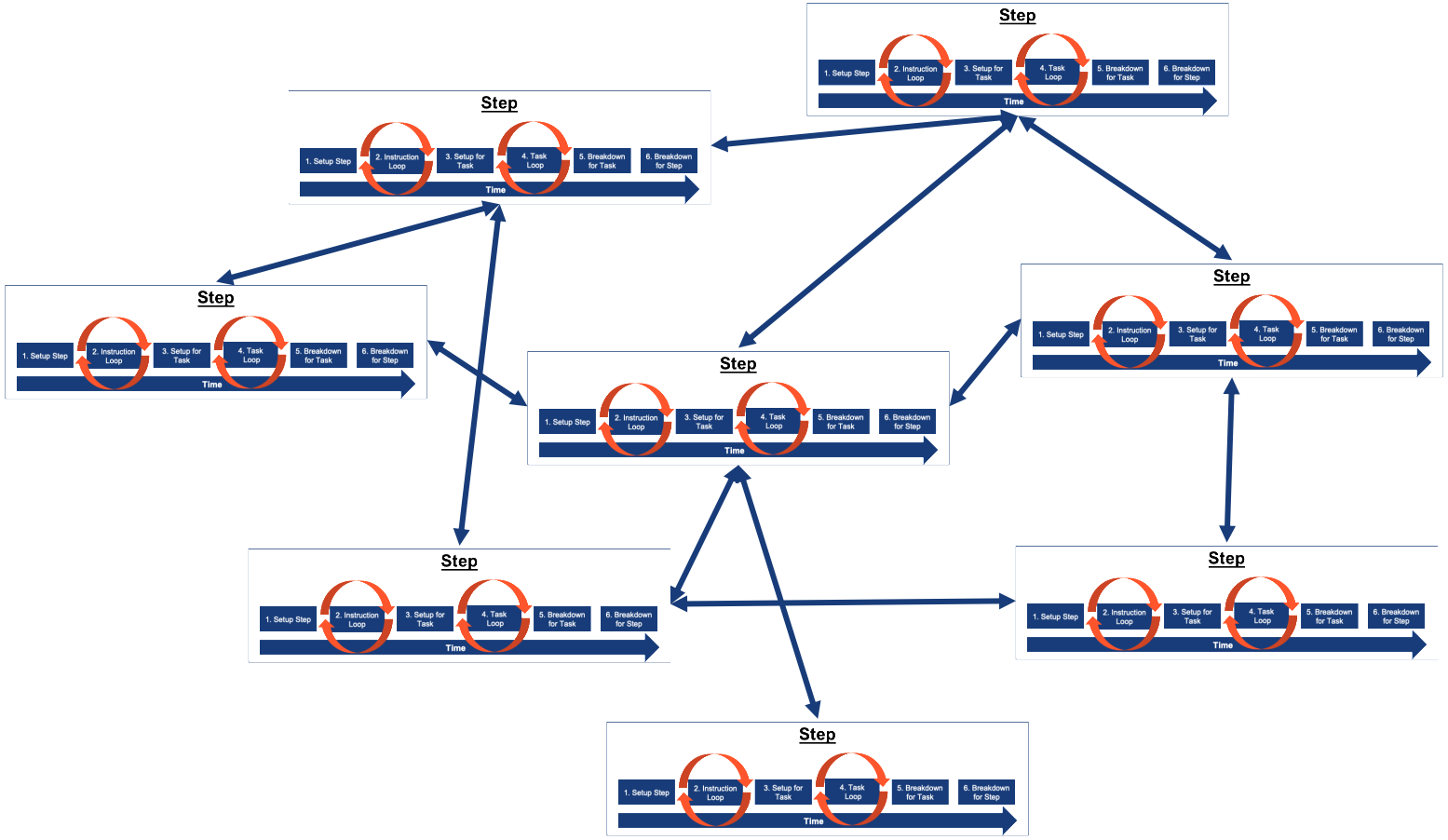


Simulation Design – Software Architecture

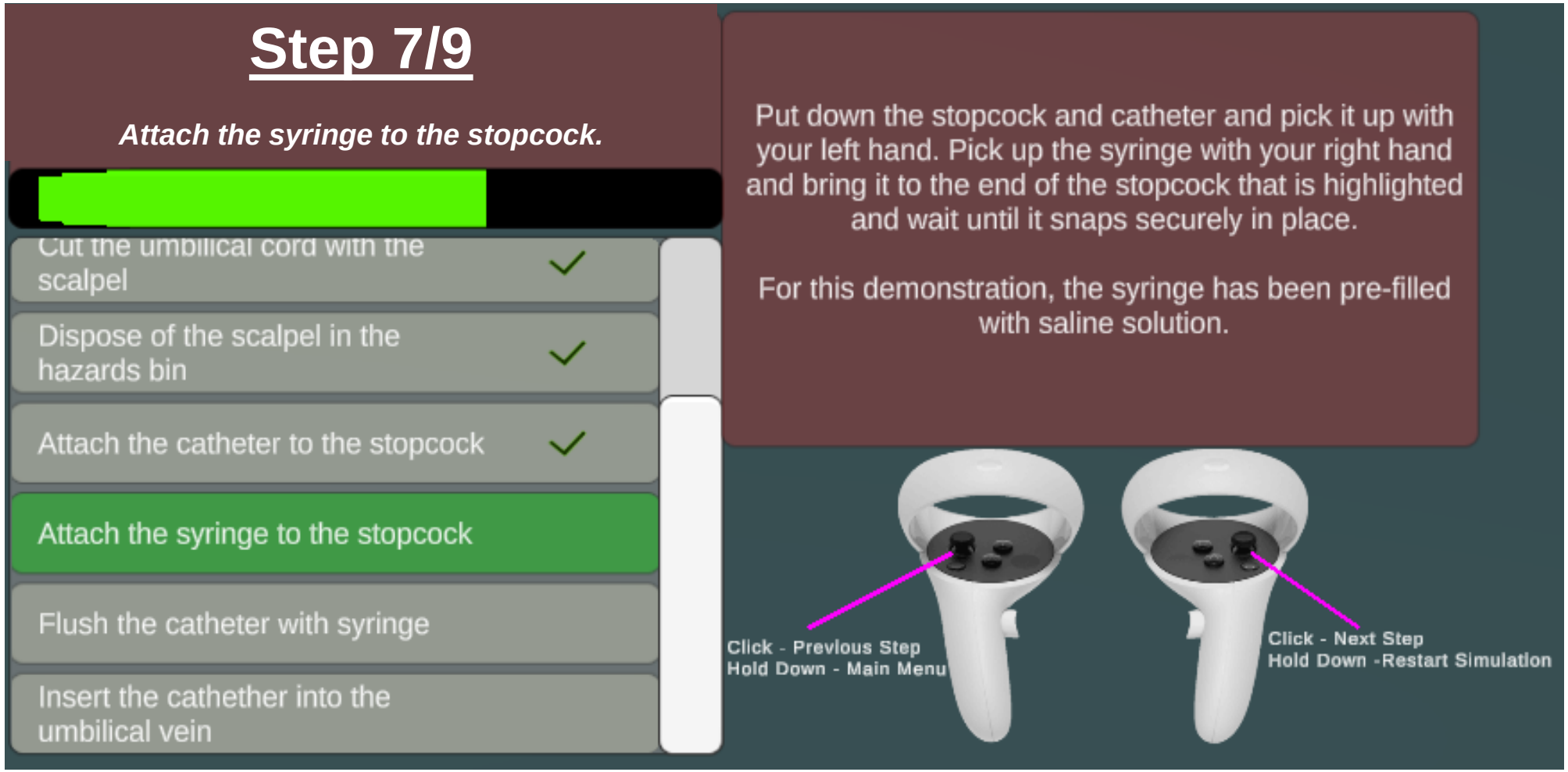


Simulation Design – Software Architecture





Interface


Step 7/9
Attach the syringe to the stopcock.
Cut the umbilical cord with the scalpel
Dispose of the scalpel in the hazards bin
Attach the catheter to the stopcock
Attach the syringe to the stopcock
Flush the catheter with syringe
Insert the cathether into the umbilical vein
Put down the stopcock and catheter and pick it up with your left hand. Pick up the syringe with your right hand and bring it to the end of the stopcock that is highlighted and wait until it snaps securely in place.
For this demonstration, the syringe has been pre-filled with saline solution.
Click - Previous Step
Hold Down - Main Menu
Click - Next Step
Hold Down -Restart Simulation

Implementation Details

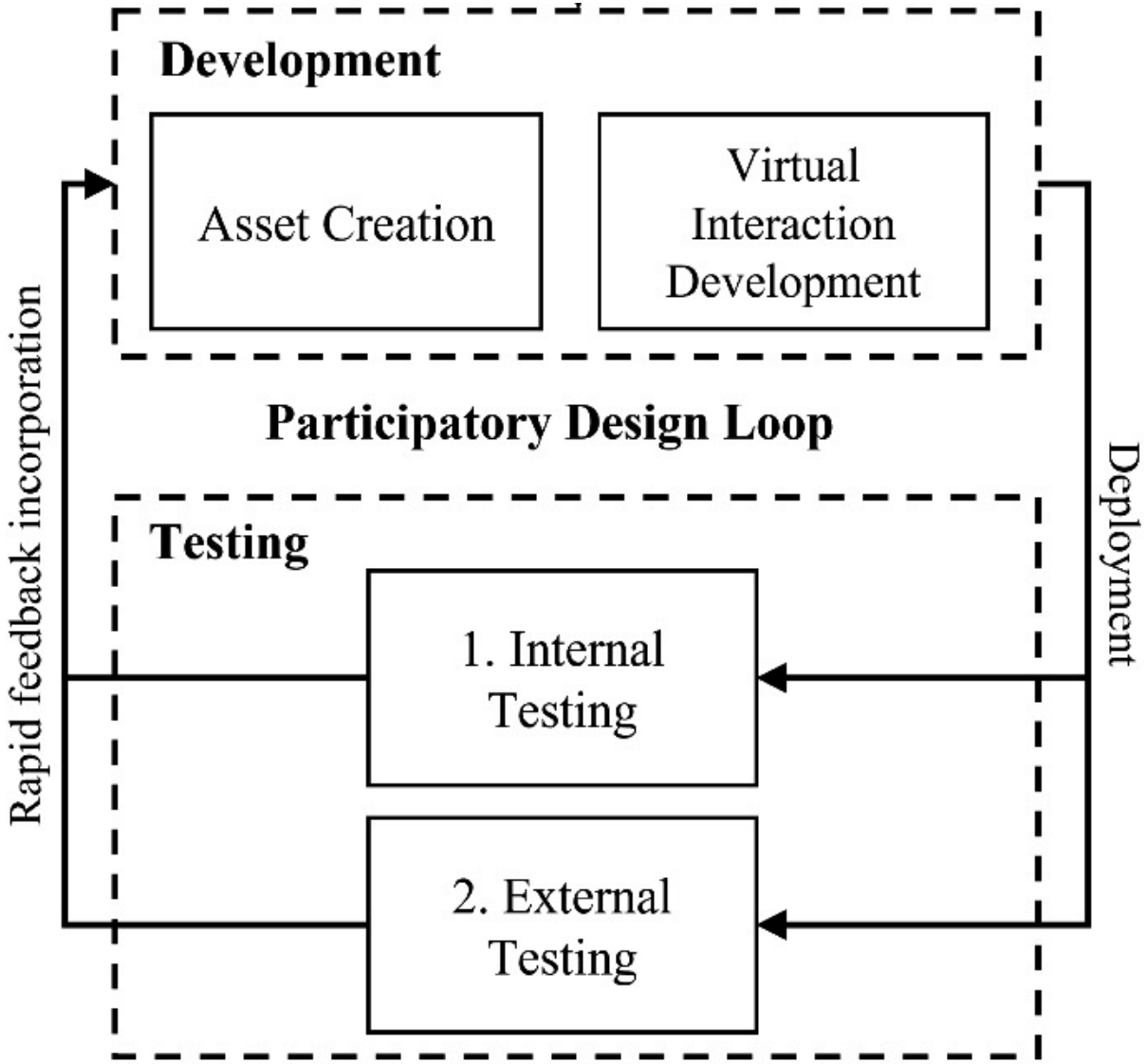
Hardware

Software

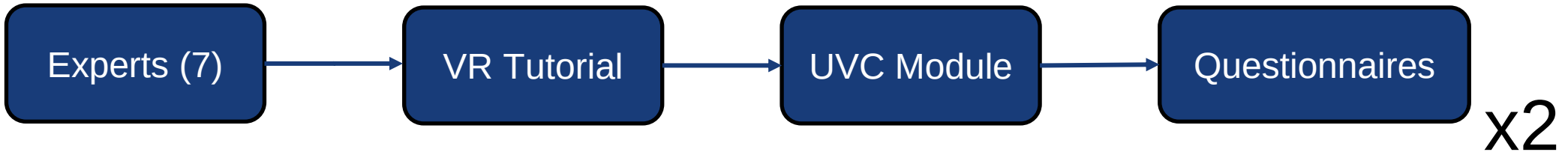
unity

AUTODESK®
MAYA®

Participatory Design Approach



Expert Evaluation – Study Design



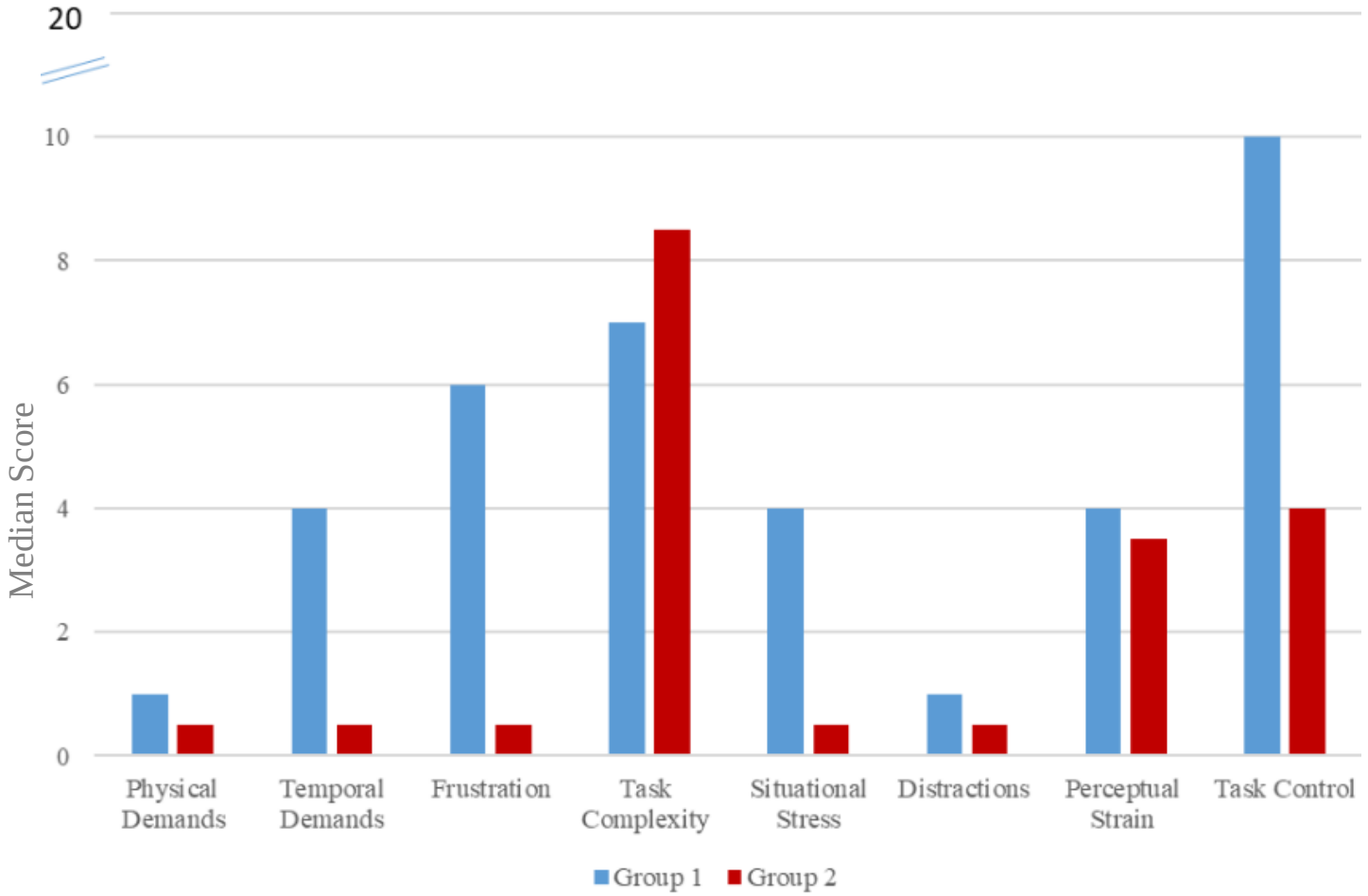
Expert Evaluation – Demographics

	Group 1	Group 2	Total
Gender			
Female	7	6	13
Male	0	1	1
Age in years, mean [range]	48 [35-65]	42 [33-67]	45 [33-67]
Years of experience, mean [range]	13 [3-28]	12 [2-37]	12 [2-37]
UVC Performance (self reported counts)			
Novice	0	0	0
Beginner	0	0	0
Proficient	0	0	0
Expert	7	7	14
VR Proficiency (self reported counts)			
Novice	6	6	12
Beginner	1	1	2
Proficient	0	0	0
Expert	0	0	0

Expert Evaluation – Face and Content Validity Results

Statement	Group 1 Median, [Range]	Group 2 Median, [Range]
The baby model is realistic	5, [4-5]	4, [4-5]
The patient preparation for UVC is realistic	4, [2-5]	4, [2-5]
The UVC tools are realistic	3, [2-4]	4, [3-5]
The instructions are very clear	4, [4-5]	4, [4-5]
The environment is realistic	4, [3-5]	4, [3-5]
The simulation was effective in teaching umbilical cord anatomical landmarks	3, [2-4]	4, [3-5]
The simulation was effective in teaching patient preparation	4, [3-5]	4, [3-5]
The simulation was effective in teaching catheter preparation	3, [2-5]	4, [2-5]
The simulation was effective in teaching UVC placement	3, [2-4]	4, [3-4]
The simulation was effective in simulating the environment	4, [3-5]	5, [3-5]
Overall teaching utility	4, [3-5]	4, [3-4]

Expert Evaluation – SIM-TLX & SUS

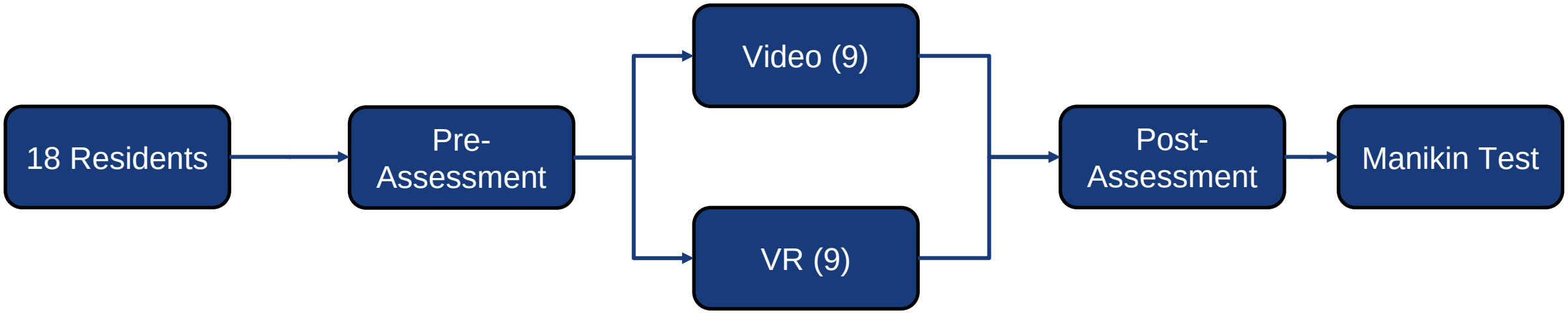


Group	SUS (mean ± std)
1	67.14 ±7.8
2	71±14.1

Expert Evaluation – Conclusion

- All 14 NNPs felt the simulation was a safe place to make mistakes
- 10/14 would recommend the simulation for new trainees
- After optimizing the simulation, each item addressing the face and content on the simulation was rated a 4 or 5/5
- SIM-TLX demonstrated low mental, physical, and cognitive load
- SUS showed above average usability

Transfer Validation – Study Design



Transfer Validation - Demographics

Demographic	Total N=18(%)	Video N=10(%)	VR N=8(%)	P Value
Residency Program				0.216 C +
Med/Peds	3 (16.7)	3 (30.0)	0 (0.0)	
Peds	15 (83.3)	7 (70.0)	8 (100.0)	
Year of Training				0.832 C +
1	4 (22.2)	3 (30.0)	1 (12.5)	
2	7 (38.9)	4 (40.0)	3 (37.5)	
3	7 (38.9)	3 (30.0)	4 (50.0)	
Gender				0.321 C +
Female	12 (66.7)	8 (80.0)	4 (50.0)	
Male	6 (33.3)	2 (20.0)	4 (50.0)	
Previous VR experience				1.000 C +
No	12 (66.7)	7 (70.0)	5 (62.5)	
Yes	6 (33.3)	3 (30.0)	3 (37.5)	
Number of NICU Rotations				0.251 W +
Mean ± SD	1.7 ± .71	1.5 ± .87	1.9 ± .44	
Missing	1	1	0	
Number of UVCs observed				0.189 C +
0	5 (27.8)	4 (40.0)	1 (12.5)	
1-2	10 (55.5)	6 (60.0)	4 (50)	
3-4	3 (16.7)	0 (0.0)	3 (37.5)	
Number of UVCs assisted				0.476 C +
0	9 (50.0)	6 (60.0)	3 (37.5)	
1-2	8 (44.4)	4 (40.0)	4 (50.0)	
3-4	1 (5.6)	0 (0.0)	1 (12.5)	
Number of UVCs performed independently				1.000 C +
0	16 (88.9)	9 (90.0)	7 (87.5)	
1-2	2 (11.1)	1 (10.0)	1 (12.5)	

+Exact test; T t-test; C Chi-square test; W Wilcoxon rank-sum test

Transfer Validation - Comfort

Steps of UVC insertion, mean ± SD (range)	Video			Virtual Reality			P Value
	Pre N=10	Post N=10	P Value	Pre N=8	Post N=8	P Value	
q1. Attach stopcock to catheter and attach saline flush to stopcock	3.2 ± 1.32 (1-5)	4.6 ± 0.97 (2-5)	*0.0156* [S+]	2.88 ± 0.83 (2-4)	4.13 ± 0.64 (3-5)	*0.0156* [S+]	*0.909* [W+]
q2. Flush the catheter and side port with the saline flush	3.3 ± 1.42 (1-5)	4.6 ± 0.97 (2-5)	*0.0313* [S+]	2.88 ± 0.83 (2-4)	4.13 ± 1.13 (2-5)	*0.0156* [S+]	*0.952* [W+]
q3. Place the clamp on the umbilical cord	3.1 ± 1.1 (1-4)	4.8 ± 0.42 (4-5)	*.0039* [S+]	3 ± 0.93 (2-4)	4.25 ± 0.71 (3-5)	*0.0313* [S+]	*0.534* [W+]
q4. Clean the umbilical cord and surrounding area	3.1 ± 1.37 (1-5)	4.9 ± 0.32 (4-5)	*0.0078* [S+]	3.38 ± 0.92 (2-4)	4.75 ± 0.46 (4-5)	*0.0078* [S+]	*0.626* [W+]
q5. Place an umbilical tie at the base of the umbilical cord	2.7 ± 1.16 (1-4)	4.8 ± 0.42 (4-5)	*0.0020* [S+]	1.88 ± 0.99 (1-4)	4.13 ± 0.64 (3-5)	*0.0078* [S+]	*0.746* [W+]
q6. Cut the umbilical cord with a scalpel	3.3 ± 1.06 (2-5)	4.6 ± 0.52 (4-5)	*0.0195* [S+]	2.38 ± 1.06 (1-4)	4.38 ± 0.52 (4-5)	*0.0078* [S+]	*0.231* [W+]
q7. Identify the umbilical vein	3.1 ± 0.99 (2-5)	4.9 ± 0.32 (4-5)	*0.0078* [S+]	3.25 ± 0.89 (2-4)	4.63 ± 0.52 (4-5)	*0.0078* [S+]	*0.250* [W+]
q8. Introduce the catheter into the umbilical vein	2.2 ± 0.79 (1-3)	4.9 ± 0.32 (4-5)	*0.0020* [S+]	2.88 ± 1.13 (1-4)	4.5 ± 0.53 (4-5)	*0.0078* [S+]	*0.029* [W+]
q9. Pull back on the saline flush to check for blood return	3 ± 1.05 (1-4)	4.3 ± 1.06 (2-5)	*0.0234* [S+]	3 ± 0.93 (2-4)	4.63 ± 0.52 (4-5)	*0.0078* [S+]	*0.443* [W+]

[*]Exact test; [T]t-test; [C]Chi-square test; [S]Wilcoxon signed rank test

Transfer Validation – Manikin Performance

Variables	Total N=18(%)	Video N=10(%)	VR N=8(%)	P Value
Total time				0.029 [W +]
N	14	8	6	
Mean ± SD	191.6 ± 75.2	225.3 ± 80.9	146.6 ± 35.9	
Percent score				0.259 [W +]
N	18	10	8	
Mean ± SD	88 ± 10.69	90.1 ± 11.58	85.375 ± 9.55	

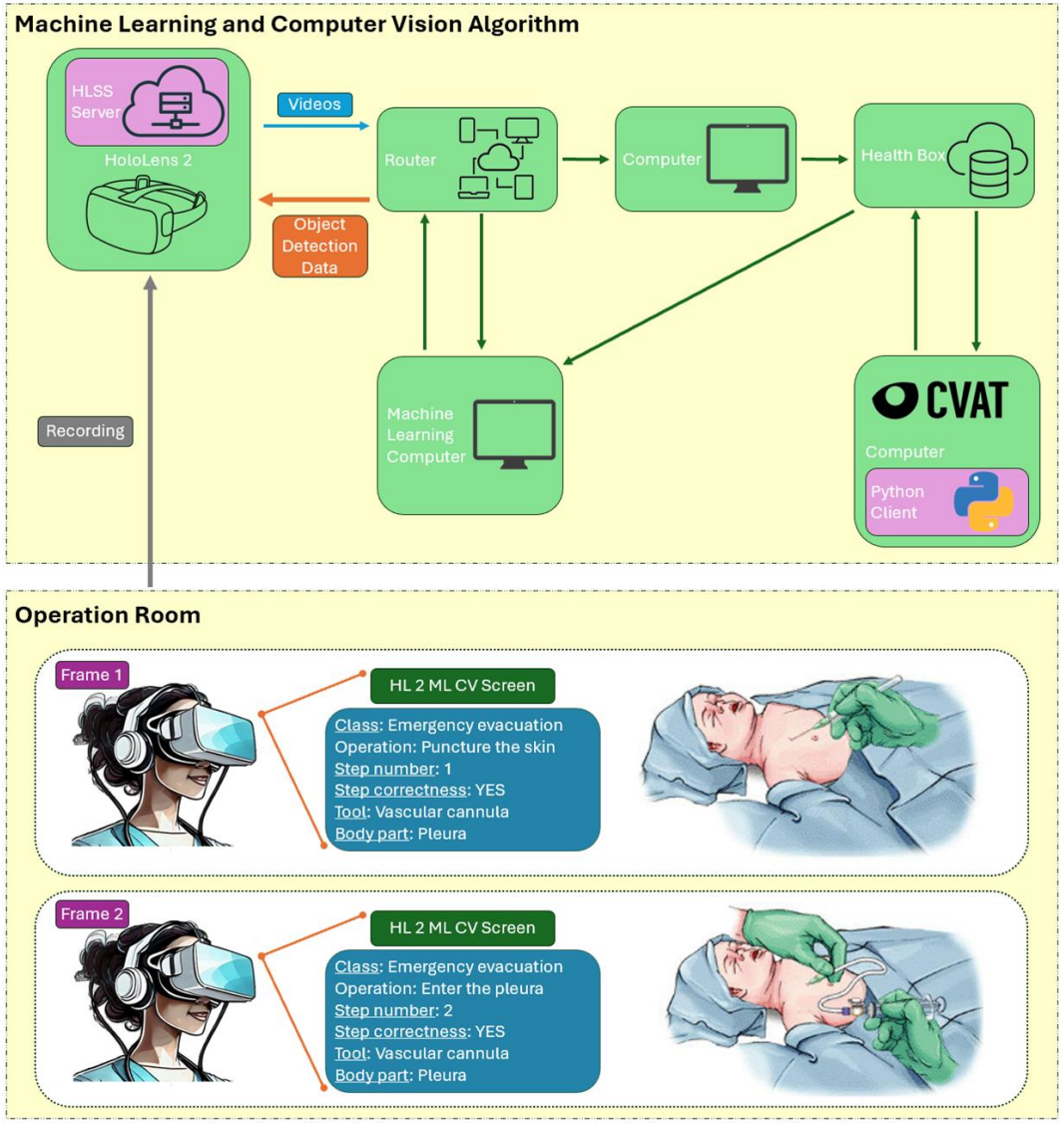
[+]Exact test
[T]t-test; [C]Chi-square test; [W]Wilcoxon rank-sum test

Transfer Validation – Conclusion

- Both the VR module and video increased users comfort to independently perform the steps of UVC insertion
- Users of the VR module were able to correctly perform the steps on a manikin
  - Established transfer validity
- Participants in the VR group performed the procedure faster than the video group
  - May not be clinically significant

Ongoing and Future Work

1. Longitudinal study for UVC simulator
2. Validating a virtual reality assessment mode for UVC
3. Developing a guided mixed reality simulator
4. Collecting egocentric video data from experts



Thank you!!!

Questions?

PIs and Clinical Collaborators

Dr. Nicole Rau, MD, MS

Dr. M. Jawad Javed, MD

Dr. Avinash Gupta, Ph.D.

Dr. Taylor Gohman, D.O.

Students

Sonam Jain

Sreenidhi Vijayaraghavan

Arnav Shah