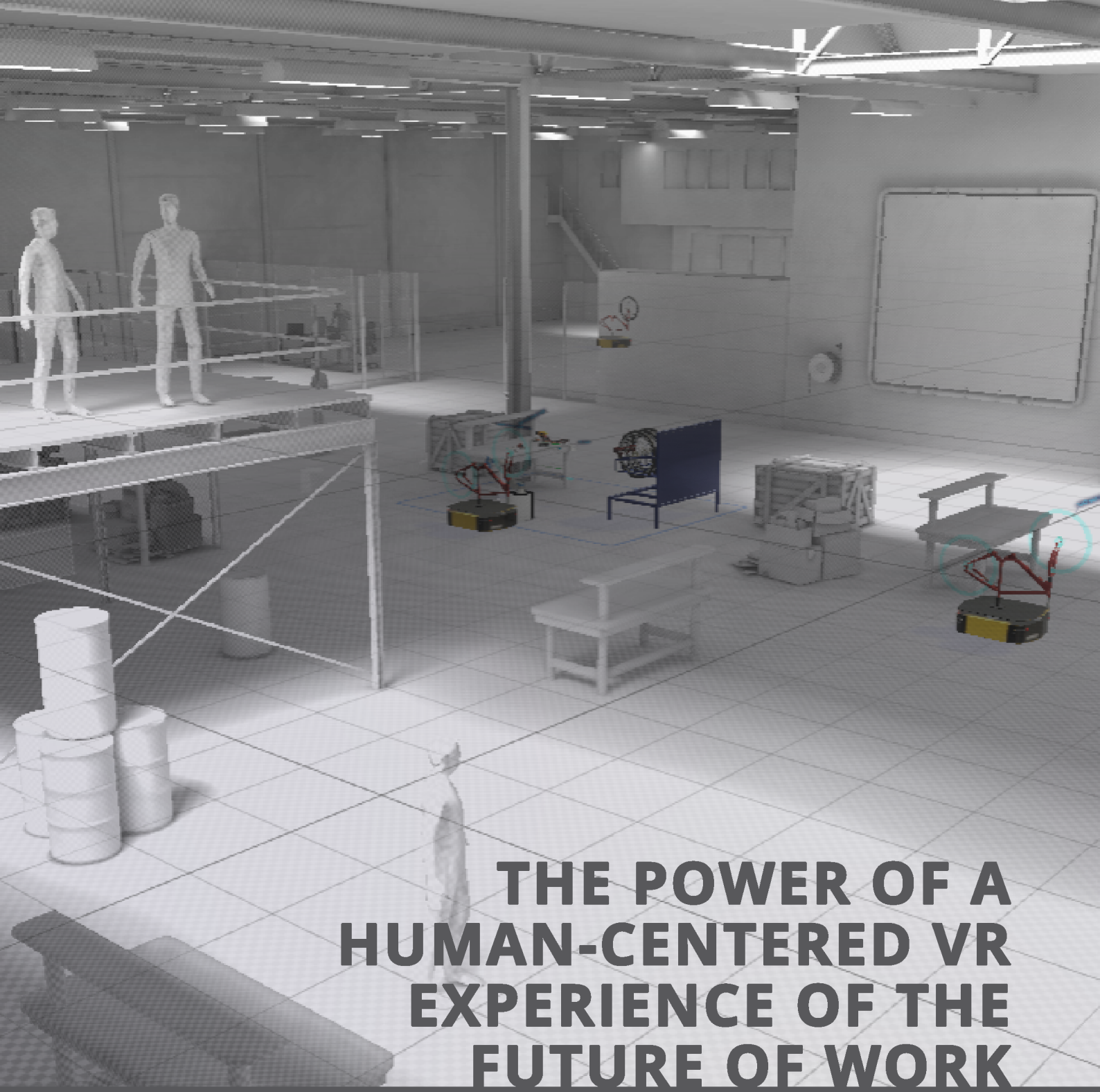

THE POWER OF A HUMAN-CENTERED VR EXPERIENCE OF THE FUTURE OF WORK

Appendix by **Pak Long Cheung**

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M.Sc. Integrated Product Design

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A. INTERVIEW SETUPS

PRELIMINARY TEST

1	How did it go?	Encouragement cues: Can you elaborate on your experience? Elaboration cues: How did this affect you? Clarification cue: What do you mean with <it went well, couldn't find/do it, ...>
2	Can you tell me about the impression you get from the virtual environment?	Encouragement cues: Can you elaborate on your impression? Elaboration cues: How does this affect you? Clarification cues: what do you mean with <smooth/joyful/frustrating experience, (not) ready to go, It's the future, ...>
3	Can you tell me how the technology of VR should work in order to facilitate positive experiences?	Encouragement cues: Have you had similar experiences? Elaboration cue: How does this add or decrease value to you?
4	Any other feedback or remarks?	

RITE ITERATIONS

1	How did it go?	Encouragement cues: Can you elaborate on your experience? Elaboration cues: How did this affect you? Clarification cue: What do you mean with <it went well, couldn't find/do it, ...>
2	Can you tell me something about the videos you saw in the introduction?	Elaboration cue: How does this add or decrease value to you?
3	Can you tell me about the impression you get from the virtual environment?	Encouragement cues: Can you elaborate on your impression? Elaboration cues: How does this affect you? Clarification cues: what do you mean with <smooth/joyful/frustrating experience, (not) ready to go, It's the future, ...>
4	Any other feedback or remarks?	

INDUSTRY PROFESSIONALS

ACCELL PRODUCT DESIGNER		
1	**Ik ben erg benieuwd naar je rol als Industrieel ontwerper binnenin Accell**	Aanmoediging: Kun je me iets meer vertellen/uitleggen over ...? Verheldering: Wat bedoel je met ...?
2	**Kun je me iets vertellen over de huidige gaan van zaken als het gaat om de assemblagelijn?**	>> Er wordt dus gebruik gemaakt van computers en automatisatie: Of niet? Aanmoediging: Wordt er gebruik gemaakt van computers en automatisatie? Verheldering: Hoe ondersteunend en/of essentieel zijn deze? Verheldering: Wat is de toegevoegde waarde hiervan voor de industrie? Werknemers? Consumenten? Verheldering: Wat bedoel je met ...?
3	**Zijn er inefficiënties hierin naar jouw mening? Welke?**	Verheldering: Hoe uiten deze inefficiënties zich? Verheldering: Kun je me vertellen wat dit betekent voor de fabrieksmedewerker? En de consument?
4	**Hoe ziet de toekomst eruit naar jouw mening voor de industrie?**	Verheldering: Wat is daarvoor nodig? Verheldering: Wat is de toegevoegde waarde als je het vergelijkt met de huidige gang van zaken?
	Heb je contact met de fabrieksmedewerker?	Verheldering: Kun je me iets vertellen over hun werk, hun dag? Verheldering: Hoe worden ze ingewerkt? **Zijn er nog andere dingen die ik vergeten ben om te vragen waarover je wilt vertellen?**

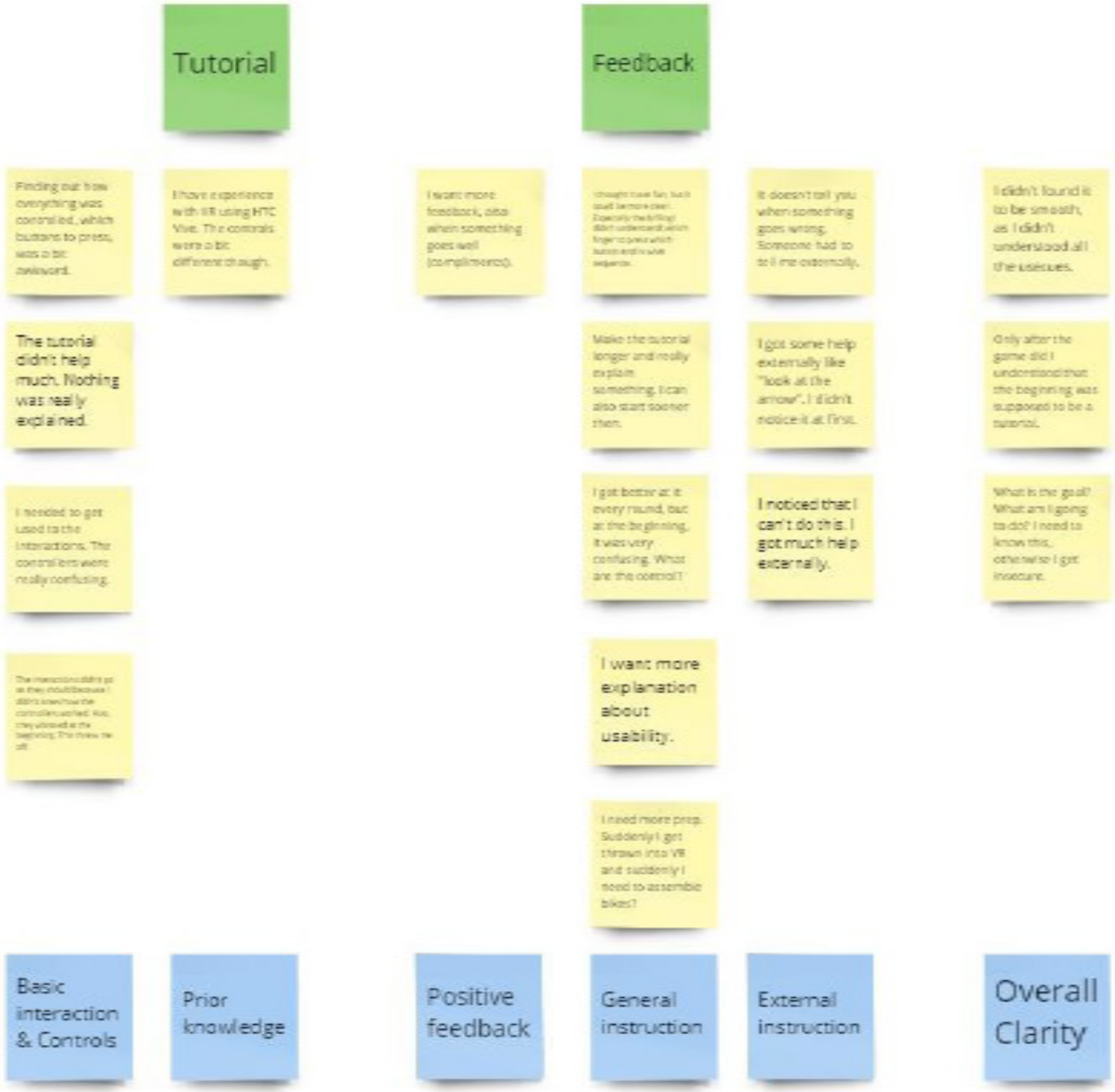
INDUSTRY PROFESSIONALS

ACCELL LIFESTYLE AND INNOVATION MANAGER		
1	**Ik ben erg benieuwd naar uw rol als manager lifestyle innovation & technology binnenin Accell**	Aanmoediging: Kun je me iets meer vertellen/uitleggen over ...? Verheldering: Wat bedoel je met ...?
2	**Hoe snel kunnen eventuele voorgedragen vernieuwingen toegepast worden?**	Verheldering: Waar ligt dit aan? Verheldering: Is dat een sterkte of een zwakte in uw optiek?
3	**Zijn er inefficiënties hierin naar jouw mening? Welke?**	Verheldering: Hoe uiten deze inefficiënties zich? Verheldering: Kun je me vertellen wat dit betekent voor de fabrieksmedewerker? En de consument?
4	**Hoe ziet de toekomst eruit naar jouw mening voor de industrie?**	Verheldering: Wat is daarvoor nodig? Verheldering: Wat is de toegevoegde waarde als je het vergelijkt met de huidige gang van zaken?
5	**Heb je contact met de fabrieksmedewerker?**	Verheldering: Kun je me iets vertellen over hun werk, hun dag? Verheldering: Hoe worden ze ingewerkt? **Zijn er nog andere dingen die ik vergeten ben om te vragen waarover je wilt vertellen?**
6	**Tot slot, kun je me wijzen naar iemand die me hier meer over kan vertellen? Bijvoorbeeld een fabrieksmedewerker, een andere productontwerper of een R&D engineer?**	

B. CLUSTERS

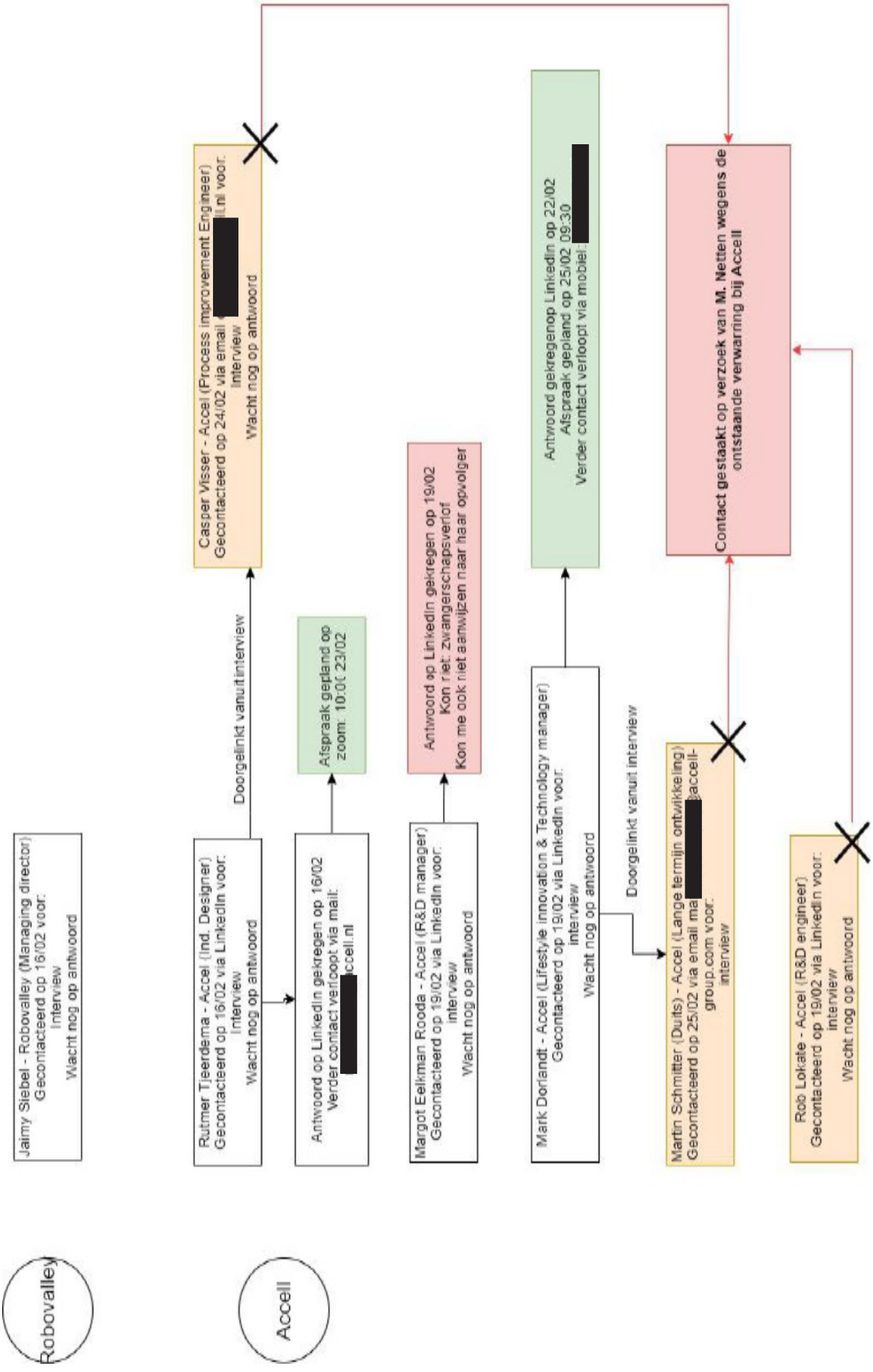
PRELIMINARY TEST: INTERVIEW DATA

RECLUSTER

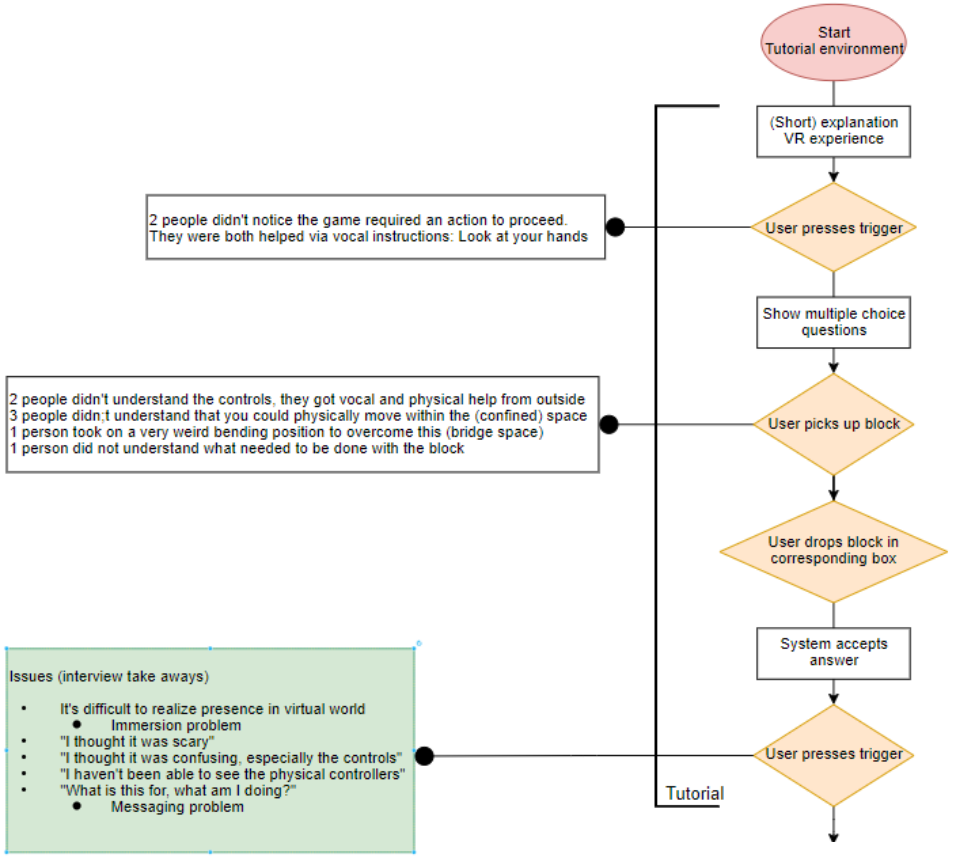

Tutorial
Feedback
Finding out how everything was controlled, which buttons to press, was a bit awkward.
I have experience with VR using HTC Vive. The controls were a bit different though.
I want more feedback, also when something goes well (compliments).
It doesn't tell you when something goes wrong. Someone had to tell me externally.
I didn't found it to be smooth, as I didn't understood all the usecases.
The tutorial didn't help much. Nothing was really explained.
Make the tutorial longer and really explain something. I can also start sooner then.
I got some help externally like "look at the arrow". I didn't notice it at first.
Only after the game did I understood that the beginning was supposed to be a tutorial.
I needed to get used to the interactions. The controllers were really confusing.
I got better at it every round, but at the beginning, it was very confusing. What are the controls?
I noticed that I can't do this. I got much help externally.
What is the goal? What am I going to do? I need to know this, otherwise I get insecure.
I want more explanation about usability.
I need more prep. Suddenly I get thrown into VR and suddenly I need to assemble bikes?
Basic interaction & Controls
Prior knowledge
Positive feedback
General instruction
External instruction
Overall Clarity

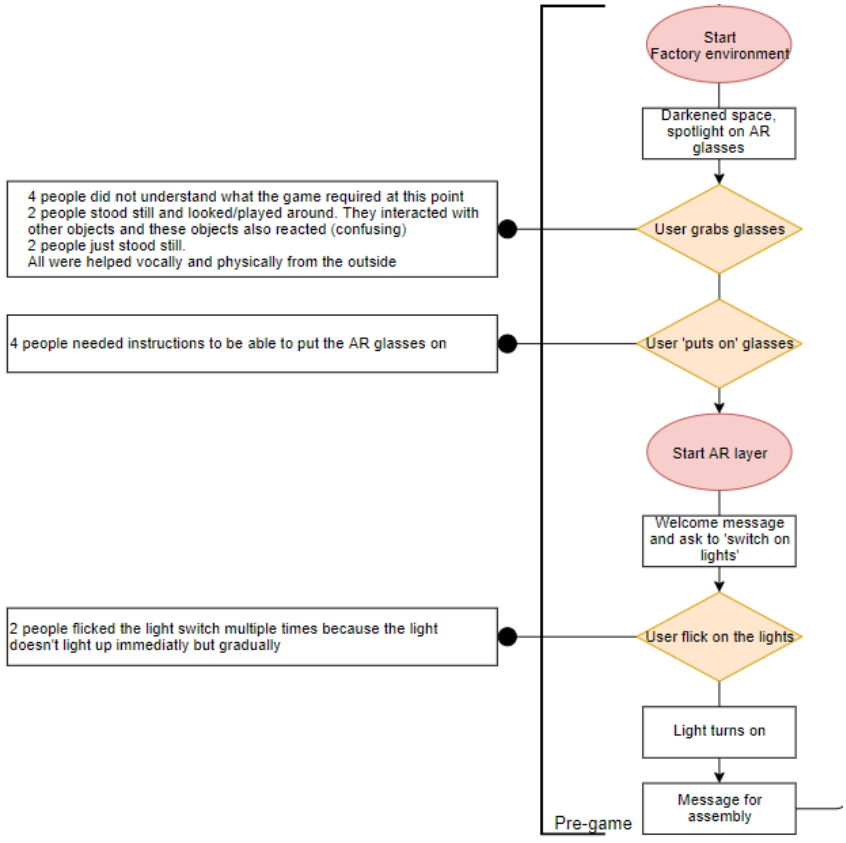

Game
Immersion
I found it to be fun and satisfying to get something done.
Scary, but it all ended well because the tasks are simple.
It was very industrial looking; very cold.
Make it a bit more cosy. Maybe some music or plants?
Maybe some colleagues. You're really solo in the world right now.
The interactions are very intolerant.
I found it difficult to comprehend being in another world.
Cool! It really was like some kind of dream.
Everything was very neat and clean.
I would try to make the surroundings less sterile and more cosy.
Scary, there are no people and the space is very bright and spacious.
The text is sometimes hard to read from the background.
I thought it was real fun.
Once you got used to it, it went well, I did needed to grab a specific wheel every round, why?
More textures in the work environment.
It wasn't really lively, but it was clear.
Weird to see no other people.
There are people looking at me while I'm making mistakes. I feel stupid because of this.
Everything is pretty simple and straight-forward.
The surroundings are simple, you can tell that the world is fake.
Overall
Sequencing
Surroundings Too clean
Surroundings Somber ambiance
Surroundings Lonely
Other

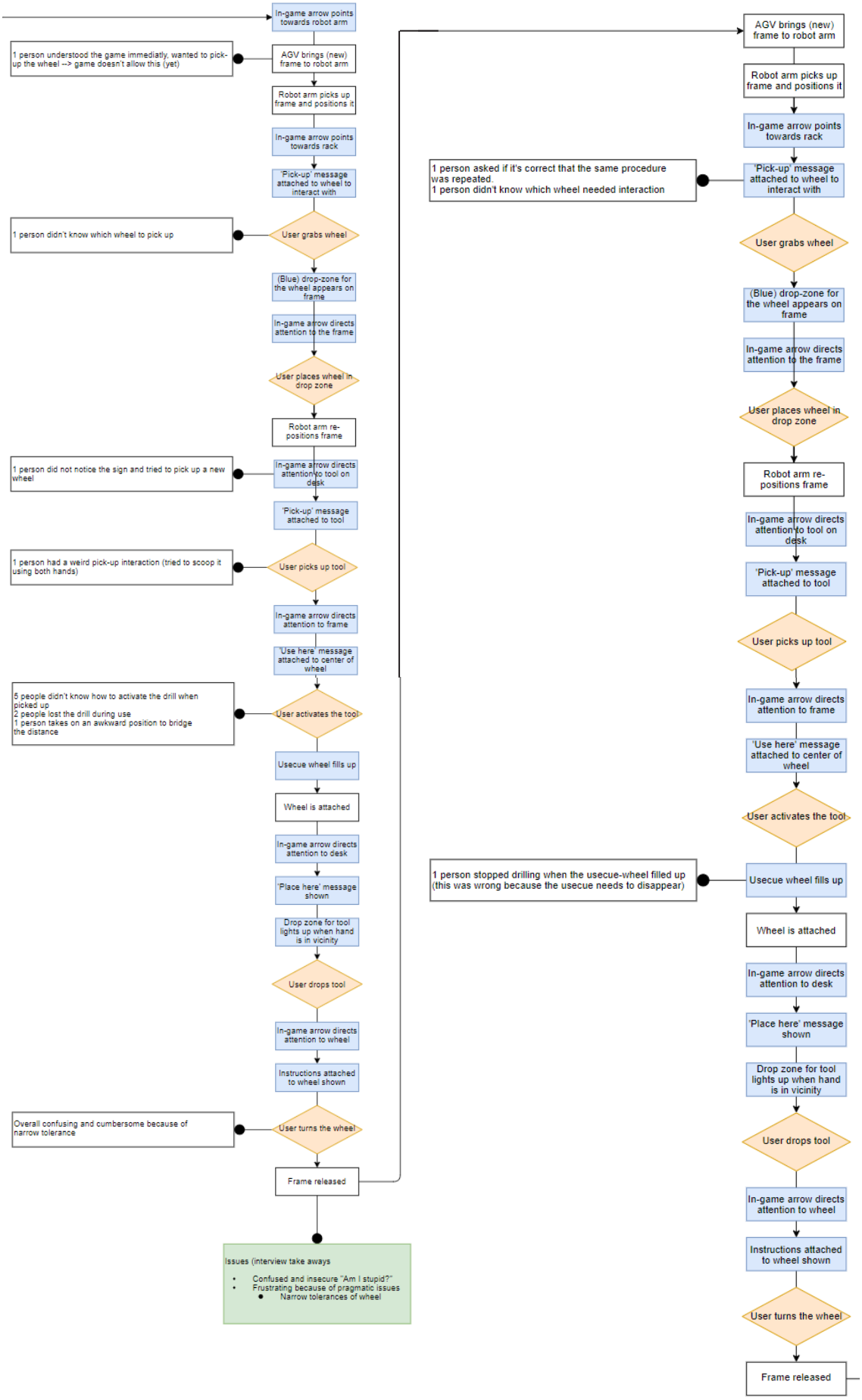
C. CONTACTFUNNEL INDUSTRY PROFESSIONALS

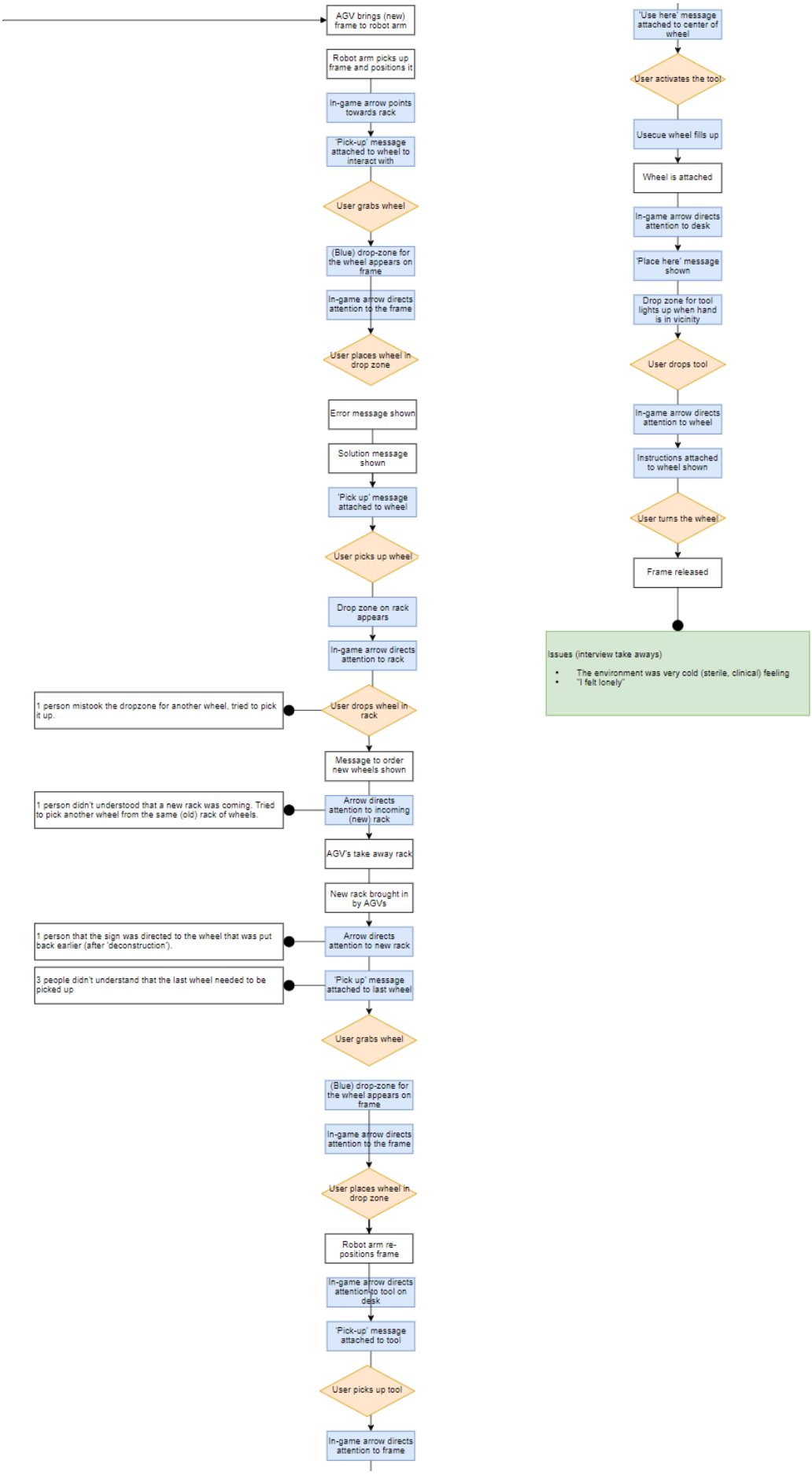


D. FLOWCHART AND PRELIMINARY TAKE-AWAYS






In-game arrow points towards robot arm
1 person understood the game immediatly, wanted to pick-up the wheel --> game doesn't allow this (yet)
AGV brings (new) frame to robot arm
Robot arm picks up frame and positions it
In-game arrow points towards rack
'Pick-up' message attached to wheel to interact with
1 person didn't know which wheel to pick up
User grabs wheel
(Blue) drop-zone for the wheel appears on frame
In-game arrow directs attention to the frame
User places wheel in drop zone
Robot arm re-positions frame
1 person did not notice the sign and tried to pick up a new wheel
In-game arrow directs attention to tool on desk
'Pick-up' message attached to tool
1 person had a weird pick-up interaction (tried to scoop it using both hands)
User picks up tool
In-game arrow directs attention to frame
'Use here' message attached to center of wheel
5 people didn't know how to activate the drill when picked up
2 people lost the drill during use
1 person takes on an awkward position to bridge the distance
User activates the tool
Usecue wheel fills up
Wheel is attached
In-game arrow directs attention to desk
'Place here' message shown
Drop zone for tool lights up when hand is in vicinity
User drops tool
In-game arrow directs attention to wheel
Instructions attached to wheel shown
Overall confusing and cumbersome because of narrow tolerance
User turns the wheel
Frame released
Issues (interview take aways
Confused and insecure "Am I stupid?"
Frustrating because of pragmatic issues
Narrow tolerances of wheel
AGV brings (new) frame to robot arm
Robot arm picks up frame and positions it
In-game arrow points towards rack
1 person asked if it's correct that the same procedure was repeated.
1 person didn't know which wheel needed interaction
'Pick-up' message attached to wheel to interact with
User grabs wheel
(Blue) drop-zone for the wheel appears on frame
In-game arrow directs attention to the frame
User places wheel in drop zone
Robot arm re-positions frame
In-game arrow directs attention to tool on desk
'Pick-up' message attached to tool
User picks up tool
In-game arrow directs attention to frame
'Use here' message attached to center of wheel
User activates the tool
1 person stopped drilling when the usecue-wheel filled up (this was wrong because the usecue needs to disappear)
Usecue wheel fills up
Wheel is attached
In-game arrow directs attention to desk
'Place here' message shown
Drop zone for tool lights up when hand is in vicinity
User drops tool
In-game arrow directs attention to wheel
Instructions attached to wheel shown
User turns the wheel
Frame released


AGV brings (new) frame to robot arm
Robot arm picks up frame and positions it
In-game arrow points towards rack
'Pick-up' message attached to wheel to interact with
User grabs wheel
(Blue) drop-zone for the wheel appears on frame
In-game arrow directs attention to the frame
User places wheel in drop zone
Error message shown
Solution message shown
'Pick up' message attached to wheel
User picks up wheel
Drop zone on rack appears
In-game arrow directs attention to rack
User drops wheel in rack
1 person mistook the dropzone for another wheel, tried to pick it up.
Message to order new wheels shown
Arrow directs attention to incoming (new) rack
1 person didn't understood that a new rack was coming. Tried to pick another wheel from the same (old) rack of wheels.
AGV's take away rack
New rack brought in by AGVs
Arrow directs attention to new rack
1 person that the sign was directed to the wheel that was put back earlier (after 'deconstruction').
'Pick up' message attached to last wheel
3 people didn't understand that the last wheel needed to be picked up
User grabs wheel
(Blue) drop-zone for the wheel appears on frame
In-game arrow directs attention to the frame
User places wheel in drop zone
Robot arm re-positions frame
In-game arrow directs attention to tool on desk
'Pick-up' message attached to tool
User picks up tool
In-game arrow directs attention to frame
'Use here' message attached to center of wheel
User activates the tool
Usecue wheel fills up
Wheel is attached
In-game arrow directs attention to desk
'Place here' message shown
Drop zone for tool lights up when hand is in vicinity
User drops tool
In-game arrow directs attention to wheel
Instructions attached to wheel shown
User turns the wheel
Frame released
Issues (interview take aways)
The environment was very cold (sterile, clinical) feeling
"I felt lonely"

E. LITERATURE STUDY APPROACH AND NOTES

WILDCARDS: * ? $

- Wom?n = Woman and Women
- Comput* = Computer, Computers, Computation, Computerization etc.
- *reality = virtual-reality, augmented-reality, mixed-reality, physical-reality etc.

o * replaces a group of letters (including no letters)
o ? replaces one letter
o $ replaces 0 or 1 letter(s)

PROXIMITY OPERATORS:

- PRE/n: Virtual PRE/3 reality = virtual precedes the word reality by ≤ 3 words
- W/n: Virtual W/50 reality = virtual must appear within 50 words of energy. Order doesn't matter
- Thumb-rule:

o n=3-5: the words appear in the same phrase
o n=ca. 15: the words appear in the same sentence
o n=ca. 50: the words appear in the same paragraph

Double quotations to search for phrases: "virtual reality" & "solar energy"
You can narrow your search down by only using the concepts in the Title, Abstract and Keyword(s).
Publication year can also be used to further narrow your search down
Also Document types:

- Articles (Scientific)
- Reviews (Scientific)
- Letter (Generally scientific)
- Conference papers (More and more peer-reviewed conference papers, therefore they are getting increasingly valuable to use)

Graduation Question:

To what extent does an **intuitive virtual reality** experience support the imagining of future scenarios?

Sub-questions:

- What are the UX and UI design rules and guidelines for virtual reality?
- What are the factors involved in human-centered design, and which of these can be used for virtual reality experiences?
- How can virtual reality experiences be more easily adopted by inexperienced users?
- How can inexperienced users overcome the fear of unfamiliar technologies?
- How can imagining future scenarios be stimulated?

	Concepts: combine with **AND**	
Search terms: Combine with **OR**	Concept 1: intuitive	Concept 2: virtual reality
	intuitive	Virtual PRE/3 reality
	User PRE/3 friendly	

Search Querry 1 – SCOPUS

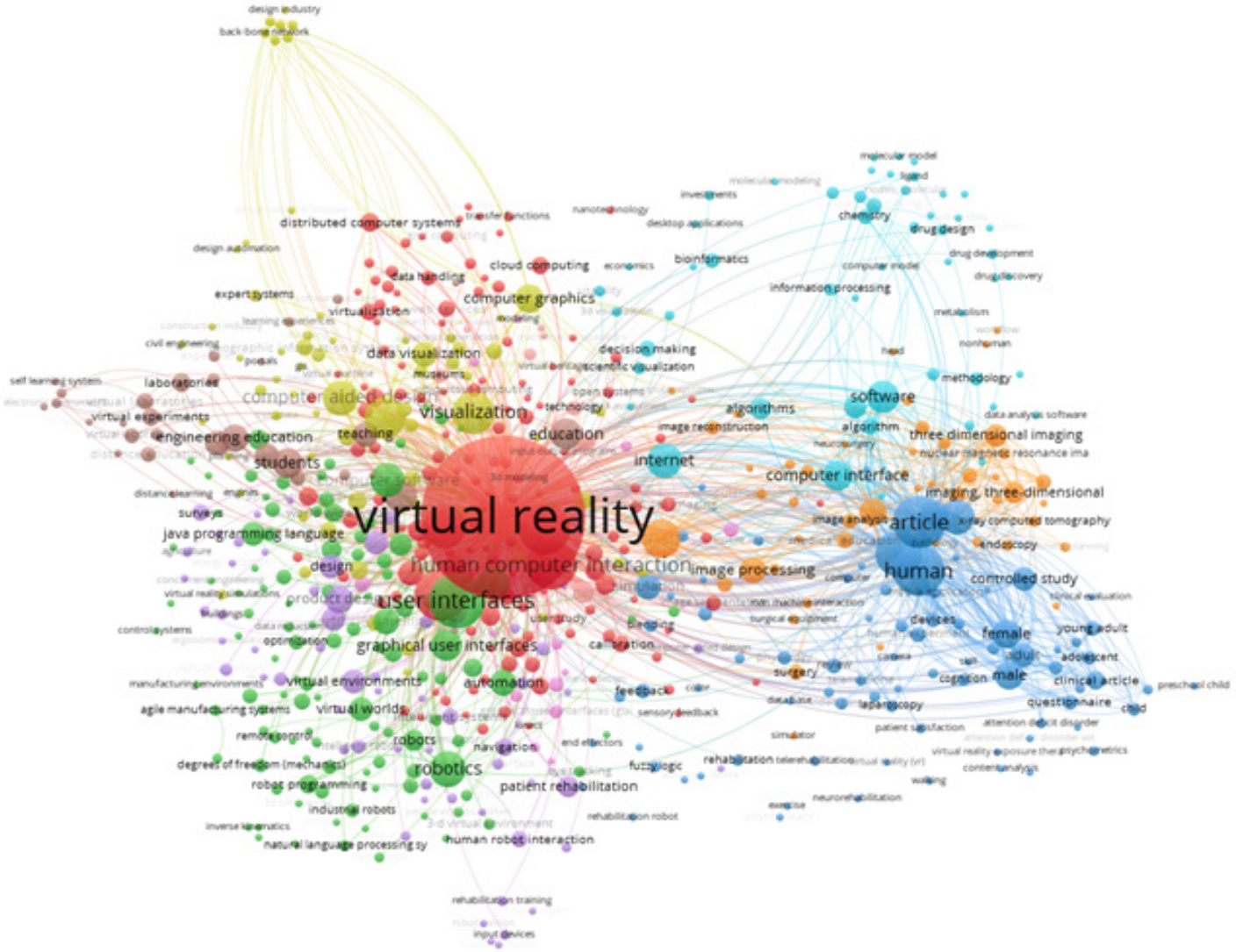
1. (search terms concept 1): intuitive OR user PRE/3 friendly
2. (search terms concept 2): virtual PRE/3 reality
3. (concepts combined): (intuitive OR user PRE/3 friendly) AND (virtual PRE/3 reality)

Actual search:

(
TITLE-ABS-KEY (intuitive OR user PRE/3 friendly)
)
AND (
TITLE-ABS-KEY (virtual PRE/3 reality)
)

Results: 635 documents

Export to .csv Import in VOS viewer to visualize connected keywords and their importance:



Sample of papers varies way too much! Research question needs to be more specific and the keywords needs more attention.

What are the **design criteria** for a **user-friendly** virtual reality experience?
Keywords:
- design criteria
- user-friendly
- virtual reality

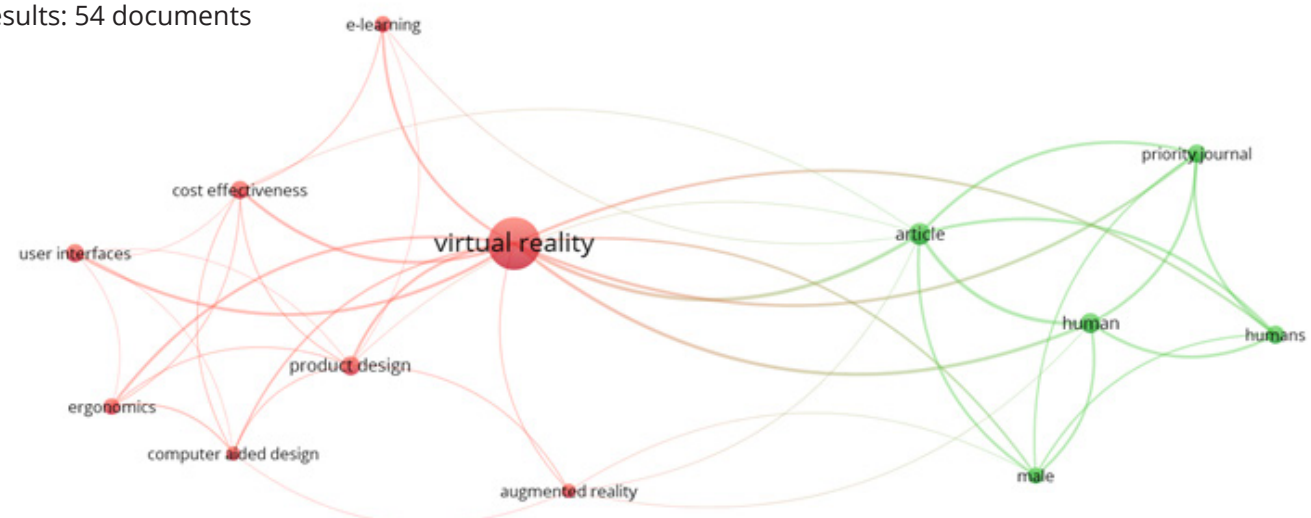
	Concepts: combine with **AND**		
Search terms: Combine with **OR**	Concept 1: criteria	Concept 2: user-friendly	Concept 3: virtual reality
	criteria	User PRE/0 friendly	Virtual PRE/3 reality
	guideline*	Human PRE/0 friendly	VR
	factor*	intuitive	

Search Querry 2 – SCOPUS

1. (search terms concept 1): criteria OR guideline* OR factor*
2. (search terms concept 2): (user OR human) PRE/0 friendly OR intuitive
3. (search terms concept 3): virtual PRE/3 reality OR vr
4. (concepts combined): (criteria OR guideline* OR factor*) AND ((use* OR human) PRE/0 friendly OR intuitive) AND (virtual PRE/3 reality OR vr)

Actual search:

(
TITLE-ABS-KEY (guideline* OR factor* OR criteria)
)
AND (
TITLE-ABS-KEY ((user OR human) PRE/0 friendly OR intuitive)
)
AND (
TITLE-ABS-KEY (virtual PRE/3 reality OR vr)
)
Results: 54 documents



What stands out: The keyword map seems to be much more relevant to the research question. Adding experience might tailor the results further.

What are the **criteria** for a **user-friendly VR experience**?

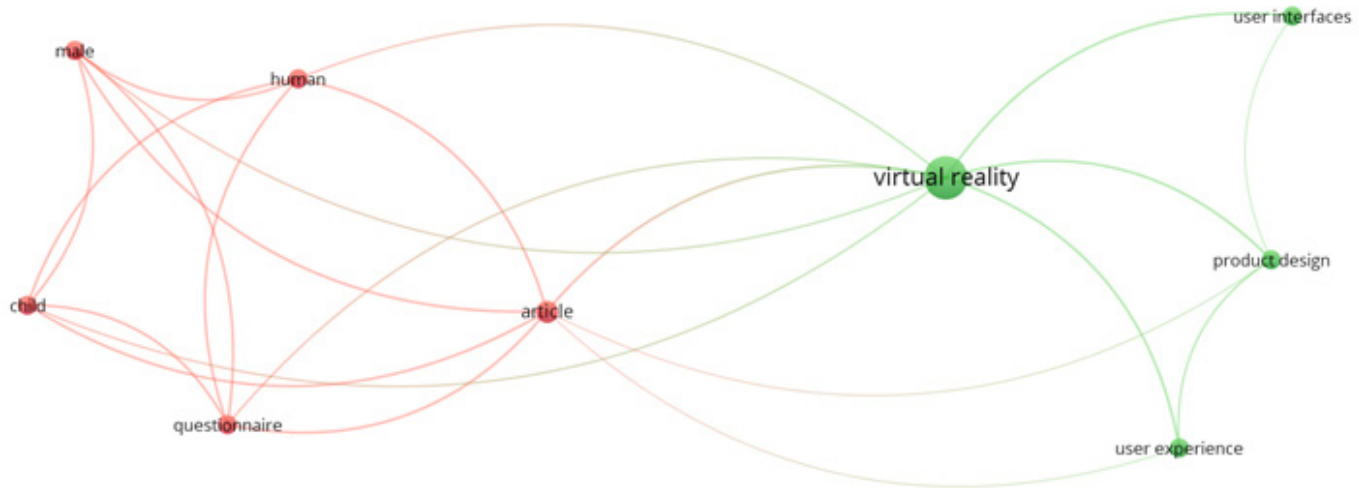
	Concepts: combine with **AND**			
Search terms: Combine with **OR**	Concept 1: criteria	Concept 2: user-friendly	Concept 3: virtual reality	Concept 4: experience
	criteria	User PRE/0 friendly	Virtual PRE/3 reality	Experience*
	guideline*	Human PRE/0 friendly	VR	UX
	factor*	intuitive		

Search Querry 3 – SCOPUS

1. (search terms concept 1): criteria OR guideline* OR factor*
2. (search terms concept 2): (user OR human) PRE/0 friendly OR intuitive
3. (search terms concept 3): virtual PRE/3 reality OR vr
4. (search terms concept 4): experience OR UX
5. (concepts combined): (criteria OR guideline* OR factor*) AND ((use* OR human) PRE/0 friendly OR intuitive) AND (virtual PRE/3 reality OR vr) AND (experience OR UX)

Actual search:

(
TITLE-ABS-KEY (guideline* OR factor* OR criteria)
)
AND (
TITLE-ABS-KEY ((user OR human) PRE/0 friendly OR intuitive)
)
AND (
TITLE-ABS-KEY (virtual PRE/3 reality OR vr)
)
AND (
TITLE-ABS-KEY (experience* OR UX)
)
Results: 14 documents



What stands out: Keywords are interesting because of the relation with product design.

Revisit Query 1:
What is a **user-friendly user-interface** for **virtual reality experience**?

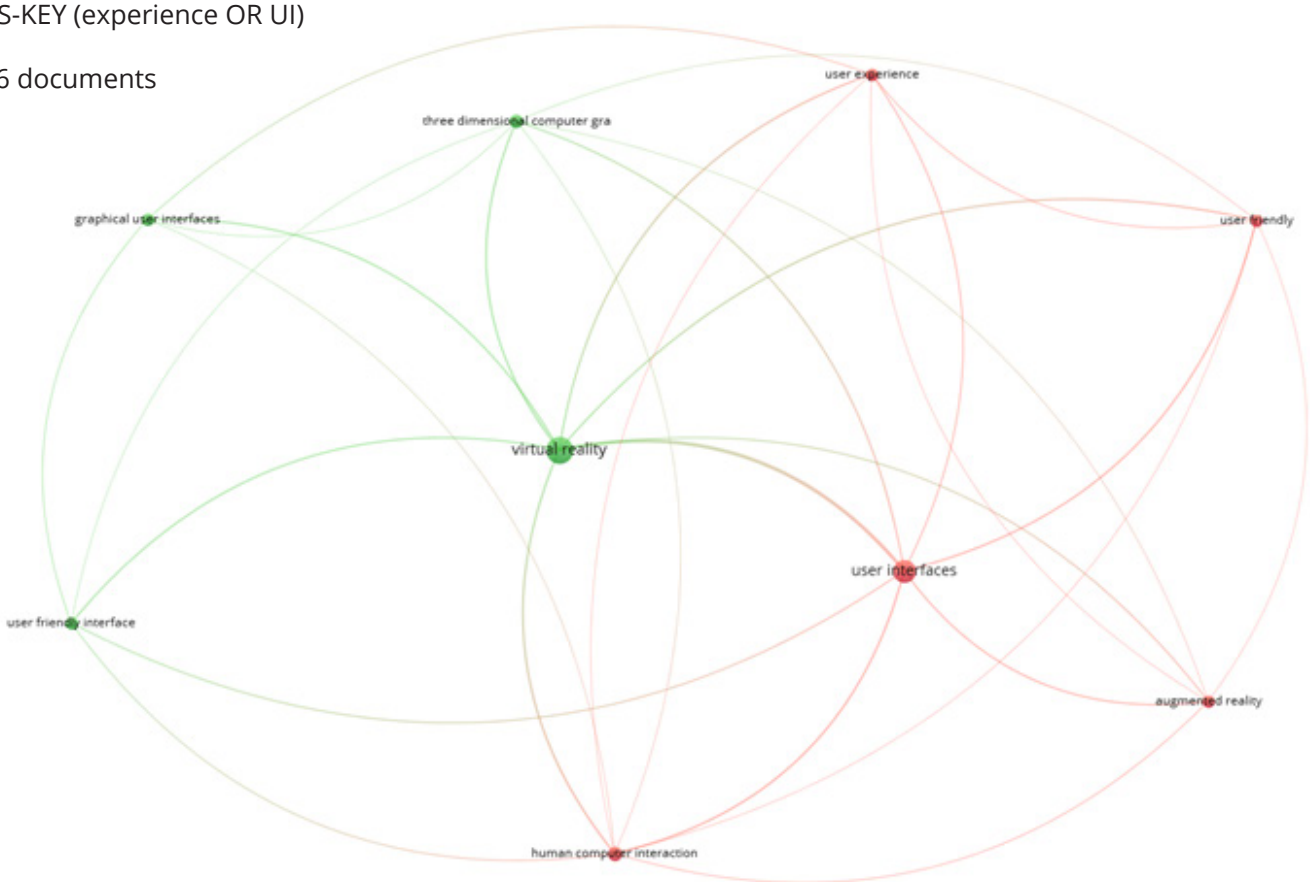
	Concepts: combine with **AND**			
Search terms: Combine with **OR**	Concept 1: intuitive	Concept 2: virtual reality	Concept 3: User interface	Concept 4: experience
	intuitive	Virtual PRE/3 reality	User* PRE/0 interface	experience
	User* PRE/3 friendly	VR	UI	UX

Search Querry 4 – SCOPUS

1. (search terms concept 1): intuitive OR user* PRE/3 friendly
2. (search terms concept 2): virtual PRE/3 reality OR vr
3. (search terms concept 3): user* PRE/0 interface OR UI
4. (search terms concept 4): experience OR UX
5. (concepts combined): (intuitive OR user* PRE/3 friendly) AND (virtual PRE/3 reality OR vr) AND (user* PRE/0 interface OR UI) AND (experience OR UX)

Actual search:

(
TITLE-ABS-KEY (intuitive OR user* PRE/3 friendly)
)
AND (
TITLE-ABS-KEY (virtual PRE/3 reality OR vr)
)
AND (
TITLE-ABS-KEY (user PRE/0 interface OR UI)
)
AND (
TITLE-ABS-KEY (experience OR UI)
)
Result: 26 documents



#	Topic	Pre-Notes	Notes
	(Criteria, Guidelines, Factor), (intuitive, user/human-friendly), (Virtual Reality, VR), (User Experience, UX), (User interface, UI)		
1	Measurement methods to examine effects of 3D stimuli on the human visual system	QUERY2: Possibly interesting; what is the best placement for text?	
2	Implementing Virtual Reality technology for safety training in the precast/ prestressed concrete industry	QUERY2: Interesting!	Using SSQ, SUS and PQ to measure discomfort, system usability and experience respectively. Sound is part of VR experience! More below
3	Ergonomic analysis in manufacturing process. A real time approach	QUERY2: Possibly interesting: Human interaction in workplace → increase flexibility	
4	A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda	QUERY2: Interesting!	Interesting element of design and its relation with learning. Very comprehensive review with interesting links to other papers!
5	A new hybrid dynamic modelling approach for process planning	QUERY2: Probably not	
6	A user-centric design approach for smart product-service systems using virtual reality: A case study	QUERY2: Interesting!	Not really applicable since its manner of user centric design has to do with measuring physiological effects using Functional near-infrared spectroscopy
7	Exoskeleton-centered process optimization in advanced factory environments	QUERY2: Possibly interesting for HRI, not for VR	
8	Why do we need digital human models?	QUERY2: No	
9	Advances in artificial reality and tele-existence	QUERY2: Possibly interesting (Journal) chaptersVR: ~~457 (:), 1253, 1293, 1305, 143, 207, 324 (maybe), 361 (maybe)~~ ChaptersHRI: 249	Journal: papers are very technical with little concrete conclusion for development or making VR UX more intuitive.
P457	A Virtual Reality Training System for Robot Assisted Neurosurgery		Immersiveness gained through prototyping physical robot arm for VR play
P1253	Indoor Environment Modeling for Interactive VR – Based Robot Security Service		Not relevant; paper is about using a robot to scan indoor environment and how this can be translated into digital 3d models.
P1293	Enhanced 3D Interaction with Augmented Visual Information		Provided solution not really applicable, problem also not noticed by preliminary test participants
P1305	Research and Application of Virtual Reality in the Field of Web-Based Education		Too brief and short
P143	A Tangible User Interface for Remote Collaboration System Using Mixed Reality	No	Not AR or VR
P207	Enhancing Immersiveness in AR-Based Product Design		Too much AR focussed (e.g., hand occlusion in mobile phone)
P324	A Collaborative Virtual Reality Environment for Molecular Modeling		Very much tailored towards features to enable molecular studies. Not much to be found for criteria for intuitive VR experiences in conclusion nor a mention in the intro
P361	A Scalable HLA-Based Distributed Simulation Framework for VR Application		Not relevant. This is about management of nodes and servers and development in order to increase the scalability of VR
P249	Exploring Human-Robot Interaction Through Telepresence Board Games		Interesting for HRI, not for criteria for intuitive VR
10	Introduction of innovative retail systems based on immersive environments	QUERY2: Possibly, a lot of focus is on retail and selling products	
11	The Effect of Learning-Based Adaptivity on Students' Performance in 3D-Virtual Learning Environments	QUERY2: No	
12	A Web-Based Platform for Collaborative Product Design, Review and Evaluation	QUERY2: No	
13	Design Guidelines for PDA User Interfaces in the Context of Retail Sales Support	QUERY2: No	
14	A Fine-Grained Performance-Based Decision	QUERY2: No	

	Model for Virtualization Application Solution		
15	A New Protein–Peptide Docking Webserver Using an Incremental Approach	QUERY2: No	
16	A virtual reality platform for multisensory integration studies	QUERY2: Possibly interesting	Interesting experiment and take-away about reaction time and placement of stimulus. Rest is not really applicable to the research question
17	Head-Worn Display-Based Augmented Reality System for Manufacturing	QUERY2: Interesting!	Paper spends a lot of time to figure out a system to superimpose information to relevant objects that might need service. No VR principles could be distilled, but benefits of using AR in industries are elaborated on.
18	Evaluating Museum Virtual Tours: The Case Study of Italy	QUERY2: Possibly	
19	Ergonomic Evaluations and Design Interventions for Shop-Floors Dealing with Chemical Conversion Coatings: Case Study from India	QUERY2: No	
20	Functional analysis in MR urography — made simple	QUERY2: No	
21	Handedness Effect and Its Implication for Designing Two-Handed Interactive Applications in Virtual Reality	QUERY2: Yes	
22	Ergonomics Perspective in Agricultural Research: A User-Centred Approach Using CAD and Digital Human Modeling (DHM) Technologies	QUERY2: No	
23	Virtual Ergonomics Evaluation of a Design Concept of Manual Powered Portable Paddy Thresher Suitable for Hilly Region Agriculture	QUERY2: No	
24	Communication system and team situation awareness in a multiplayer real-time learning environment: application to a virtual operating room	QUERY2: No	
25	User Experience Design for Green IT Products Through Wearable Computing and Quantified Self	QUERY2: No	
26	Towards the factory of future An integrated approach of material-processes-information-human being	QUERY2: No	
27	Virtual Immersive Educational Systems: The case of 360◦ video and co-learning design.	QUERY2: Possibly	Too short and rather superficial
28	Virtual Immersive Educational Systems: Early Results and Lessons Learned	QUERY2: Possibly interesting	Is about the use of 360 videos
29	The Research of Dongba Culture Virtual Museum Based on Human Factor Engineering	QUERY2: Interesting	
30	Implementing Virtual Reality technology for safety training in the precast/ prestressed concrete industry	QUERY3: Interesting → double with paper #2	
31	A user-centric design approach for smart product-service systems using virtual reality: A case study	QUERY3: Interesting → double with paper #6	
32	Handedness Effect and Its Implication for Designing Two-Handed Interactive Applications in Virtual Reality	QUERY3: Interesting → double with paper #21	
33	User Experience Design for Green IT Products Through Wearable Computing and Quantified Self	QUERY3: No	
34	A VR-based user interface for the upper limb rehabilitation	QUERY4: Possibly interesting	Interesting read, very much focused on tests in order to provide the best rehabilitation program. Not much about VR principles in general

35	Immersive VR and Embodied Learning: The Role of Embodied Affordances in The Long-term Retention of Semantic Knowledge	QUERY4: Possibly	No results, just an experiment proposition.
36	A Human-Centered Approach to Designing Gestures for Natural User Interfaces	QUERY4: Possibly	Interesting if no controllers were used in VR but only the gesture based system. Not the case for this research question
37	Students' Attitude Toward Learning and Practicing English in a VR Environment	QUERY4: Possibly	Very much focused on education; learning english to be specific. There are some interesting take aways when it comes to motivation and attitude. These can be found below.
38	Developing immersive VR experience for visualizing cross-cultural relationships in music	QUERY4: No	
39	Toward Virtual Reality-based Evaluation of Robot Navigation among People	QUERY4: Super interesting for VR test HRI	
40	A User-Centered Virtual Reality Game System for Elders with Balance Problem	QUERY4: Possibly	Small study with a very brief conclusion (literally one sentence). Interesting to read what is important for rehab and VR, not necessarily helpful when it comes to the elements used.
41	COMBINATION OF VIRTUAL AND PHYSICAL OBJECTS IN USER-CENTERED DESIGN OF A MOBILE WORK MACHINE CABIN	Extra paper access granted: Possibly	Paper is about the creation of virtual environments, not reality. It is interesting tho how this choice was made. Because of the goal of the prototype (test and improve endproduct using user evaluation) and the choice for and environment with physical steering wheel and chair in order to increase immersiveness/realness
42	Collaborative Work in Augmented Reality: A Survey	Extra paper access granted: No	
43	Design, User Experience, and Usability: Theories, Methods, and Tools for Designing the User Experience	Extra paper access granted: Interesting chapters: 383, 425, 624, 678, 773 2014 version of paper #46	
P383	Applying the User Experience Questionnaire (UEQ) in Different Evaluation Scenarios		
P425	Heuristic Inspection to Assess Persuasiveness: A Case Study of a Mathematics E-learning Program		
44	Collaborative Work in Augmented Reality: A Survey	Extra paper access granted: double with #42	
45	Heuristics and Fuzzy Multi-Criteria Decision Making for Evaluating Museum Virtual Tours	Extra paper access granted: Interesting	
46	Design, User Experience, and Usability: Theories, Methods, and Tools for Designing the User Experience	Doris recommendation; Interesting chapters: 3, 14, 40, 112, 125, 141, 277, 509, 573, 73, 2018 version of paper #43	
P3			
P14			
P40			
P112			
P125			
P141			
P277			
P509			
P573			
P73			
47	INFLUENTIAL FACTORS IN DESIGN AND IMPLEMENTATION OF VIRTUAL REALITY TECHNOLOGY	Doris recommendation;	
48	Assisted Human-Robot-Interaction for Industrial Assembly	Doris recommendation;	
49	A Review on Cybersickness and Usability in Virtual Environments	Doris recommendation;	
50	Comparing Human Factors for Augmented Reality Supported Single-User and Collaborative Repair Operations of Industrial Robots	Doris recommendation;	
51	A proxemics game between festival visitors and an industrial robot	Doris recommendation;	

52	It's your turn! - A collaborative human-robot pick-and-place scenario in a virtual industrial setting	Doris recommendation;	
53	PRESENCE QUESTIONNAIRE	Doris recommendation;	
54	Reflecting on the Design Process for Virtual Reality Applications	Doris recommendation;	
55	CoBot Studio VR: A Virtual Reality Game Environment for Transdisciplinary Research on Interpretability and Trust in Human-Robot Collaboration	Doris recommendation;	

F. QUALTRICS QUESTIONNAIRES

SYSTEM USABILITY SCALE

TU Delft

Hi!

In this last part of the study you will answer a few questions about the usability of the game. Please answer the questions truthfully, especially when the experience was lacking.

Please fill out your initials, middle name (if applicable) and surname. These will be used in the consent form. On the next page more information about the use of the data will be given.

This part of the study will take no more than 5 minutes.

What are your initials?

For instance: A.B.

What is your middle name (if applicable)?

For instance: van de

What is you surname?

For instance: Jansen

TU Delft

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

My questions have been answered satisfactorily. I understand that film, photo, and video material or editing thereof will only be used for analysis and/or scientific presentations.

I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant:
Date: **7 Aug 2021**

I give consent:

Yes	No
○	○

→

TU Delft, Faculty of Industrial Design Engineering
Master Thesis: "The power of a human-centered VR experience of the Future of Work"
Name: Pak Long Cheung
E-mail: p.l.cheung@student.tudelft.nl

TU Delft

Thanks for the given consent!
Please read the statements carefully before giving a score in the questions below.

For each of the following statements, please mark one box that best describes your reactions to the test today.

	Strongly disagree		Neutral		Strongly agree
I think that I would like to use Virtual Reality frequently.	○	○	○	○	○
I found Virtual Reality unnecessarily complex.	○	○	○	○	○
I thought Virtual Reality was easy to use.	○	○	○	○	○
I think that I would need the support of a technical person to be able to use Virtual Reality.	○	○	○	○	○
I found the various functions in Virtual Reality were well integrated.	○	○	○	○	○
I thought there was too much inconsistency in Virtual Reality.	○	○	○	○	○
I would imagine that most people would learn to use Virtual Reality very quickly.	○	○	○	○	○
I found Virtual Reality very cumbersome (awkward) to use.	○	○	○	○	○
I felt very confident using Virtual Reality.	○	○	○	○	○
I needed to learn a lot of things before I could get going with Virtual Reality.	○	○	○	○	○

→

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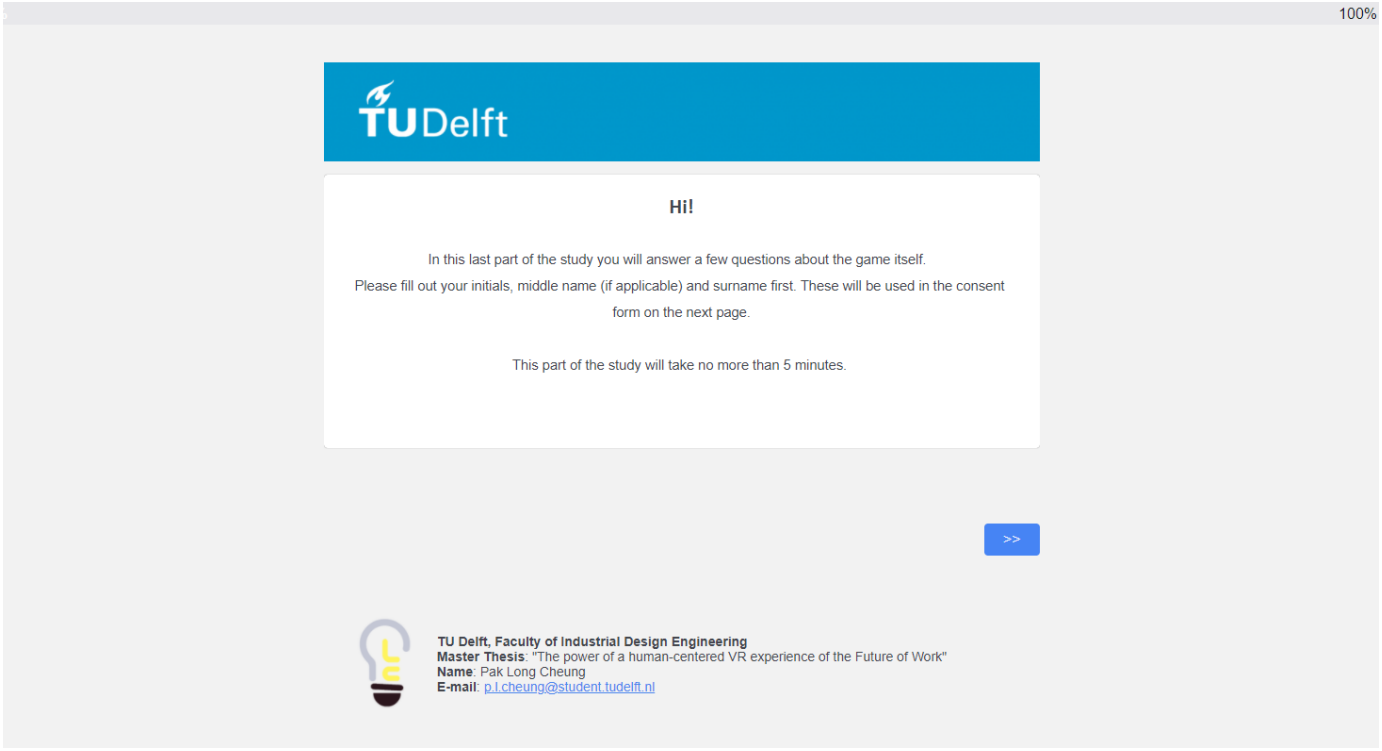
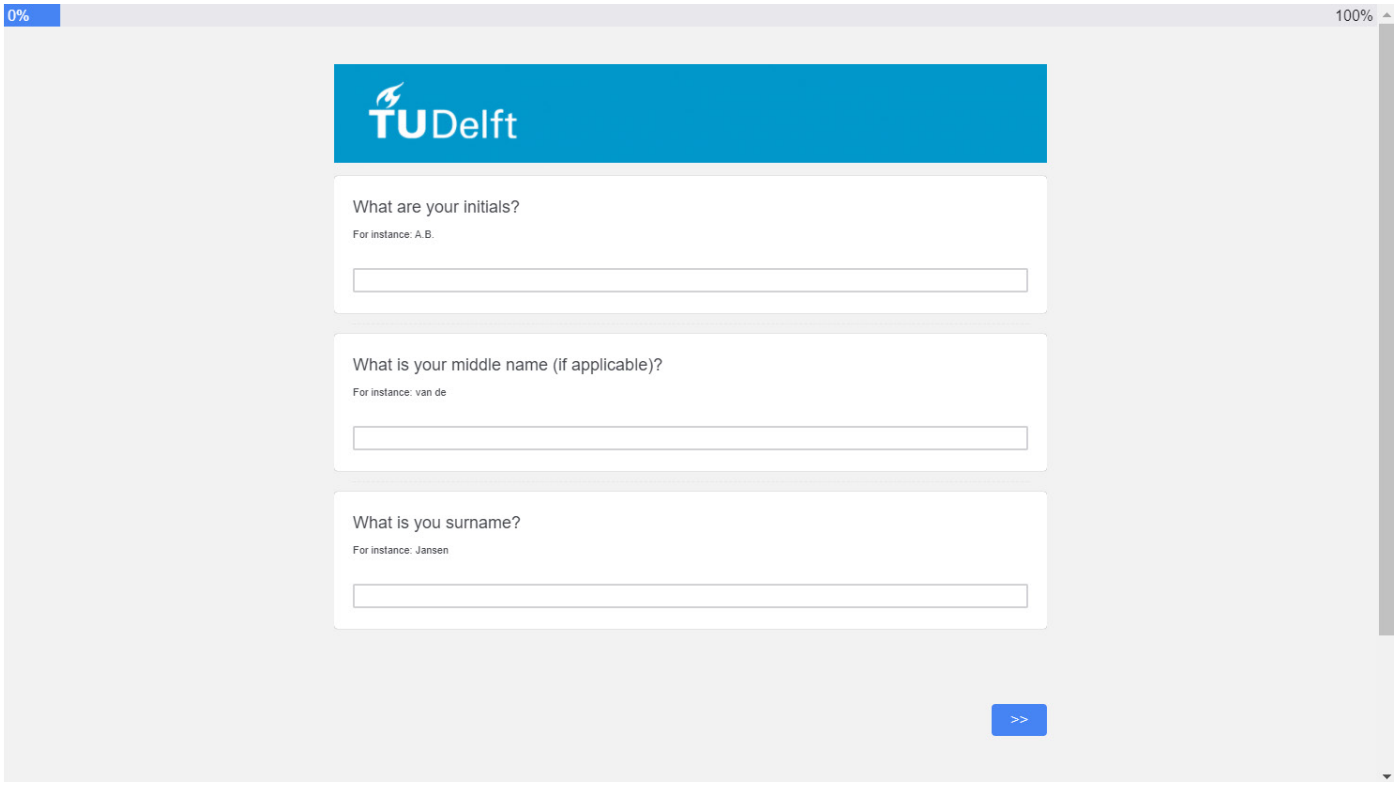
Master Thesis: "The power of a human-centered VR experience of the Future of Work"
Name: Pak Long Cheung
E-mail: p.l.cheung@student.tudelft.nl

PRESENCE QUESTIONNAIRE





TUDelft

Thanks for the given consent!

In the following questionnaire, characterize your experience in the environment by marking the appropriate box of the 7-point scale, in accordance with the question content and descriptive labels.

Please consider the entire scale when making your responses, as the intermediate levels may apply. Answer the questions independently in the order that they appear.

Do not skip questions or return to a previous question to change your answer.

How much were you able to control events?

Not at all			Somewhat			Completely
○	○	○	○	○	○	○

>>

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Master Thesis: "The power of a human-centered VR experience of the Future of Work"
Name: Pak Long Cheung
E-mail: p.l.cheung@student.tudelft.nl

TUDelft

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

My questions have been answered satisfactorily. I understand that film, photo, and video material or editing thereof will only be used for analysis and/or scientific presentations.

I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant:
Date: **9 Sep 2021**

I give consent:

Yes	No
○	○

>>

TUDelft

How responsive was the environment to actions that you initiated (or performed)?

Not responsive			Moderately responsive			Completely responsive
○	○	○	○	○	○	○

>>

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How much did the visual aspects of the environment involve you?

Not at all			Somewhat			Completely
○	○	○	○	○	○	○

>>

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TUDelft

How natural was the mechanism which controlled movement through the environment?

Extremely artificial			Borderline			Completely natural
○	○	○	○	○	○	○

>>

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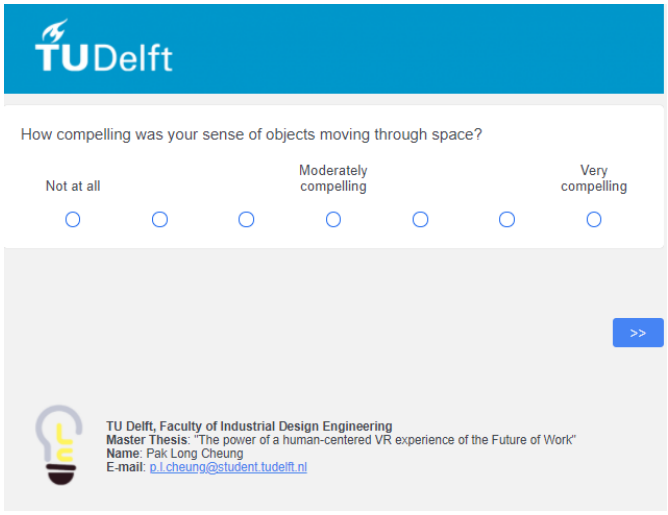
TUDelft
How compelling was your sense of objects moving through space?
Not at all
Moderately compelling
Very compelling
>>
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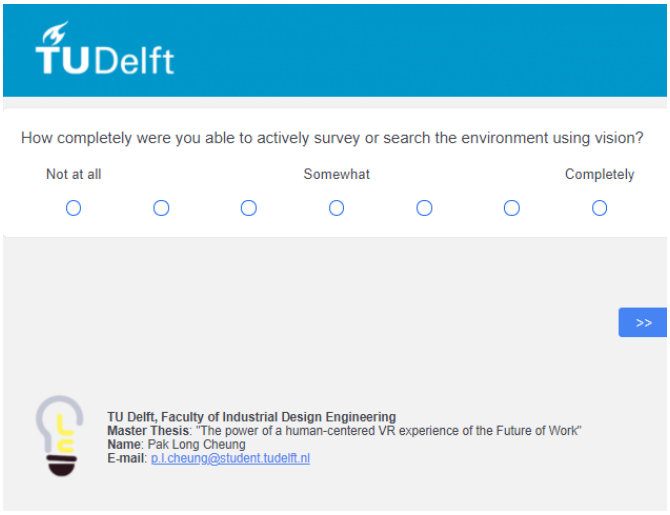
TUDelft
How completely were you able to actively survey or search the environment using vision?
Not at all
Somewhat
Completely
>>
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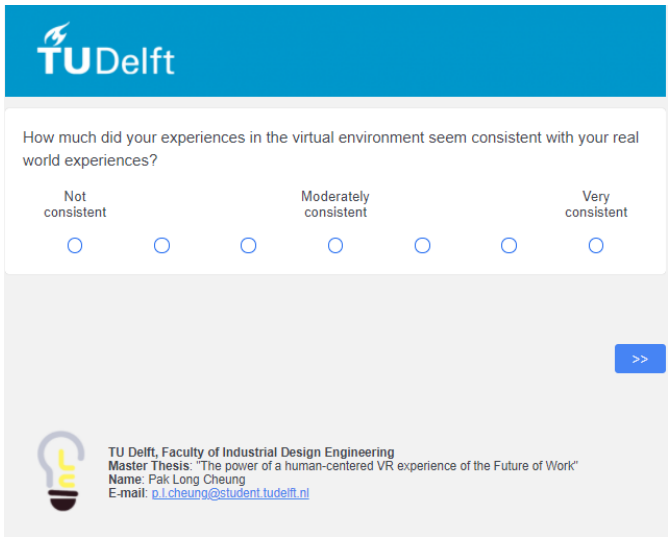
TUDelft
How much did your experiences in the virtual environment seem consistent with your real world experiences?
Not consistent
Moderately consistent
Very consistent
>>
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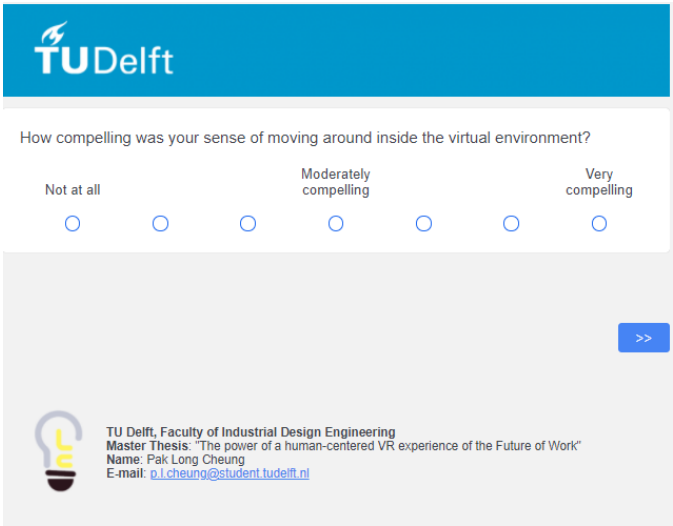
TUDelft
How compelling was your sense of moving around inside the virtual environment?
Not at all
Moderately compelling
Very compelling
>>
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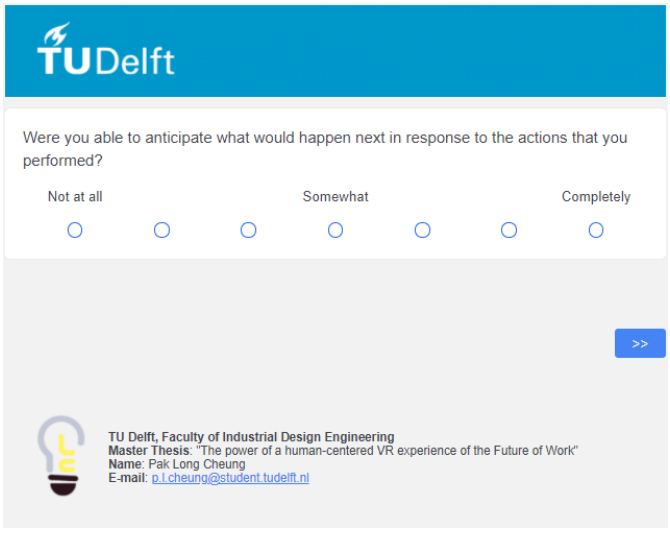
TUDelft
Were you able to anticipate what would happen next in response to the actions that you performed?
Not at all
Somewhat
Completely
>>
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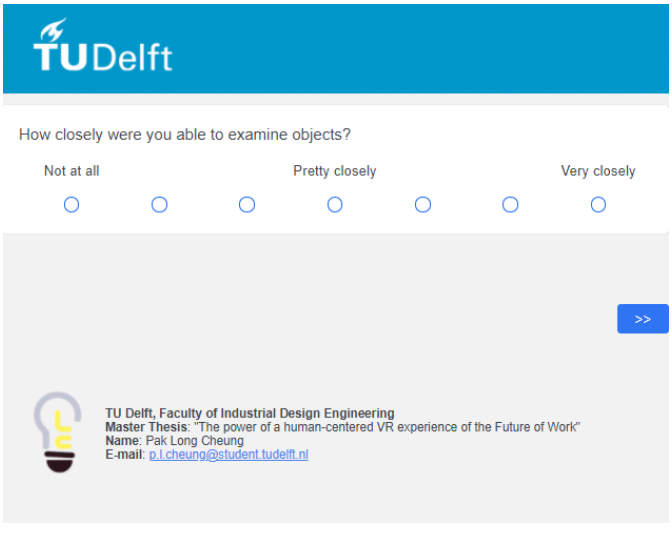
TUDelft
How closely were you able to examine objects?
Not at all
Pretty closely
Very closely
>>
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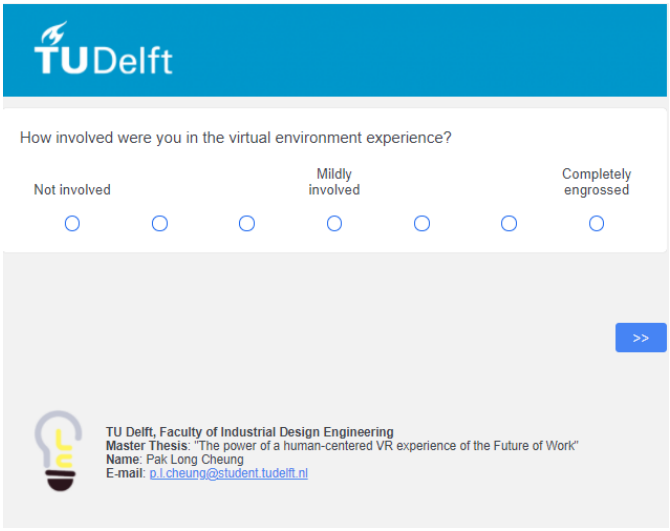
TUDelft
How involved were you in the virtual environment experience?
Not involved
Mildly involved
Completely engrossed
>>
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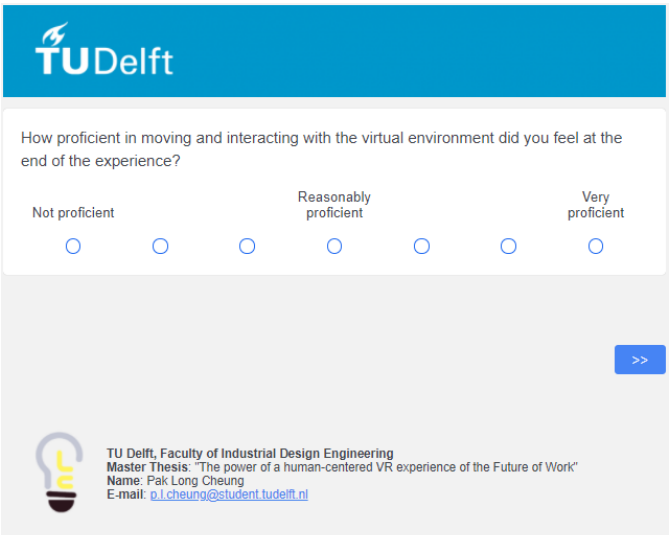
TUDelft
How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?
Not proficient
Reasonably proficient
Very proficient
>>
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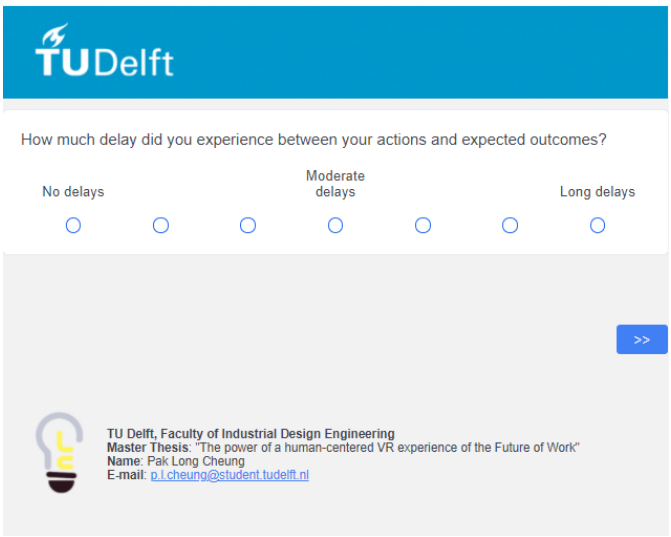
TUDelft
How much delay did you experience between your actions and expected outcomes?
No delays
Moderate delays
Long delays
>>
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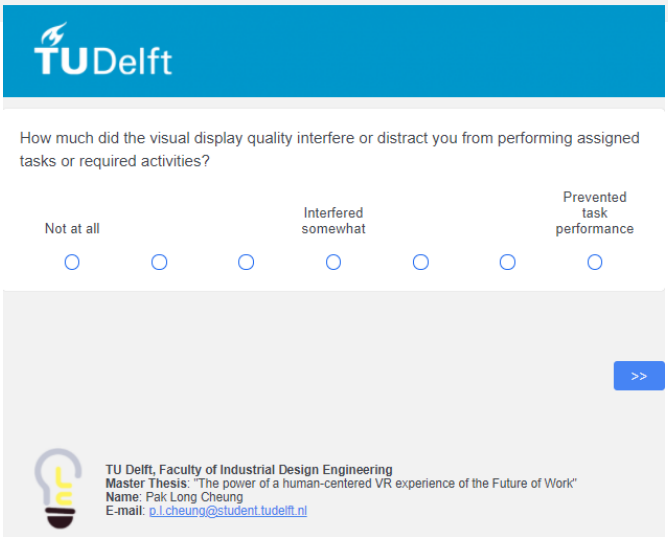
TUDelft
How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?
Not at all
Interfered somewhat
Prevented task performance
>>
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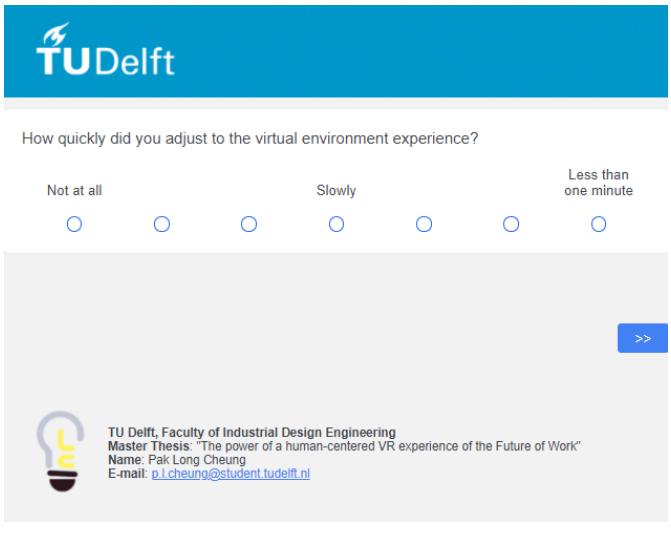
TUDelft
How quickly did you adjust to the virtual environment experience?
Not at all
Slowly
Less than one minute
>>
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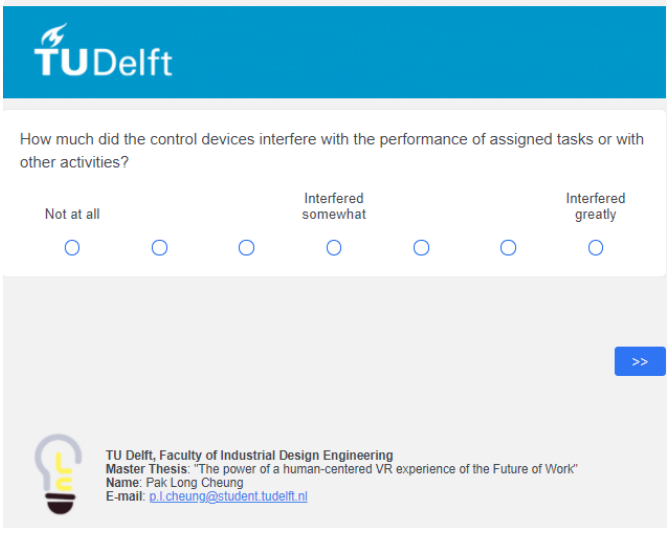
TUDelft
How much did the control devices interfere with the performance of assigned tasks or with other activities?
Not at all
Interfered somewhat
Interfered greatly
>>
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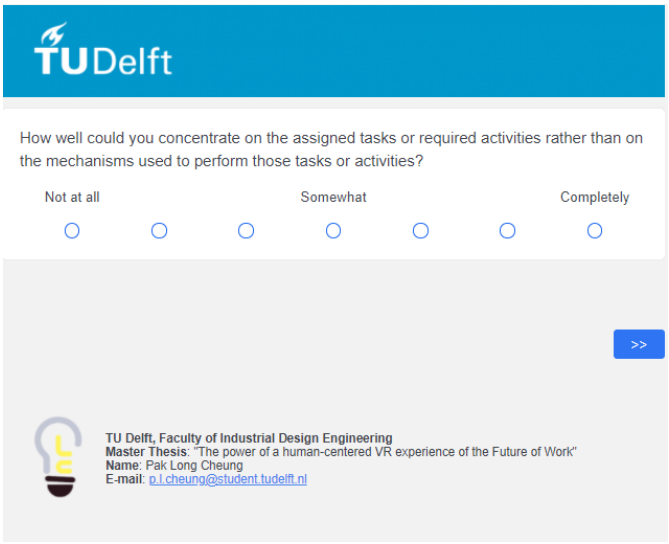
TU Delft
How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?
Not at all
Somewhat
Completely
>>
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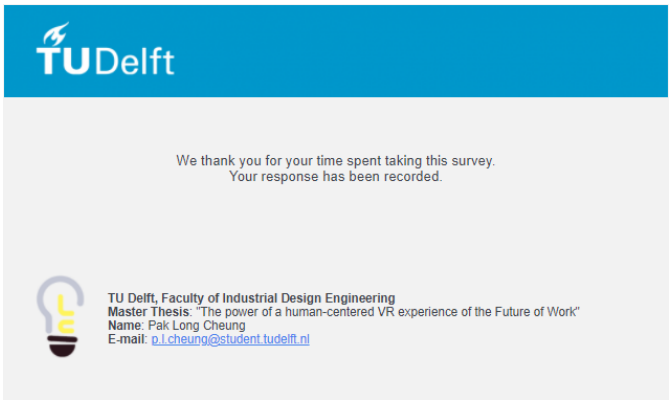
TU Delft
We thank you for your time spent taking this survey.
Your response has been recorded.
TU Delft, Faculty of Industrial Design Engineering
Master Thesis: "The power of a human-centered VR experience of the Future of Work"
Name: Pak Long Cheung
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G. SPSS

RAW SUS SCORES

Name	Participant	Prototype	Q1	Q2	Q3	Q4	Q5	Q6
Felipa	0	1,0	4	2	4	4	4	2
Berg	1	1,1	5	1	5	4	5	1
Moonen	2	1,2	4	2	5	1	5	1
Dongen	3	1,2	5	1	4	1	5	2
Heesakker:	4	1,3	3	1	5	2	4	1
Jansen	5	1,3	4	1	4	1	5	3
Kwa	6	1,3	4	2	3	2	5	2
Busser	7	1,3	4	2	3	1	4	1
Stijn	8	1,4	5	1	5	1	5	1
Avastia	9	1,4	5	2	4	1	4	2
Celik	10	1,5	5	1	5	5	5	4
Weijgers	11	1,5	3	2	2	3	4	1
Mohapatra	12	1,6	4	1	4	2	4	2
Alfen	13	1,6	4	2	3	3	5	1
Berden	14	1,6	4	1	5	1	5	1
Groot	15	1,6	5	1	5	2	4	1

Q6adj	Q7adj	Q8adj	Q9adj	Q10adj	SUS
3,00	3,00	2,00	2,00	3,00	65,00
4,00	3,00	4,00	3,00	4,00	87,50
4,00	4,00	3,00	3,00	4,00	90,00
3,00	3,00	4,00	2,00	4,00	87,50
4,00	4,00	3,00	4,00	3,00	85,00
2,00	3,00	4,00	3,00	3,00	82,50
3,00	1,00	2,00	3,00	4,00	70,00
4,00	1,00	3,00	3,00	4,00	75,00
4,00	3,00	4,00	3,00	4,00	95,00
3,00	2,00	3,00	3,00	4,00	80,00
1,00	3,00	1,00	4,00	4,00	72,50
4,00	3,00	1,00	3,00	3,00	62,50
3,00	2,00	3,00	3,00	3,00	75,00
4,00	3,00	4,00	1,00	4,00	75,00
4,00	4,00	4,00	4,00	4,00	97,50
4,00	4,00	4,00	4,00	4,00	95,00

Q7	Q8	Q9	Q10	Q1adj	Q2adj	Q3adj	Q4adj	Q5adj
4	3	3	2	3,00	3,00	3,00	1,00	3,00
4	1	4	1	4,00	4,00	4,00	1,00	4,00
5	2	4	1	3,00	3,00	4,00	4,00	4,00
4	1	3	1	4,00	4,00	3,00	4,00	4,00
5	2	5	2	2,00	4,00	4,00	3,00	3,00
4	1	4	2	3,00	4,00	3,00	4,00	4,00
2	3	4	1	3,00	3,00	2,00	3,00	4,00
2	2	4	1	3,00	3,00	2,00	4,00	3,00
4	1	4	1	4,00	4,00	4,00	4,00	4,00
3	2	4	1	4,00	3,00	3,00	4,00	3,00
4	4	5	1	4,00	4,00	4,00	0,00	4,00
4	4	4	2	2,00	3,00	1,00	2,00	3,00
3	2	4	2	3,00	4,00	3,00	3,00	3,00
4	1	2	1	3,00	3,00	2,00	2,00	4,00
5	1	5	1	3,00	4,00	4,00	4,00	4,00
5	1	5	1	4,00	4,00	4,00	3,00	3,00

RAW PRESENCE DATA

Initials	Middle nar	Surname	Consent	Possibility1	Possibility1	Realism1	Realism2	Realism3
B.J.B.		Riepen	1	5	4	5	6	6
R.R		Roos	1	5	6	4	5	5
J.S.B.R.		Burgos Rar	1	6	6	5	6	5
K.		Lamein	1	5	4	5	5	5
R.A		Chakoetoe	1	6	5	6	6	6
G.D.M		Merien	1	5	6	5	5	5
N.		Pinedo	1	4	4	5	5	3
K.D.		Domacasse	1	6	5	6	4	6
C.A		Anthony	1	5	6	5	4	5
A.		De Groot	1	5	5	4	4	2
A.D.		Minnema	1	5	5	5	6	4
M.L.		Janssens	1	3	4	2	4	3
N.		Wiersma	1	4	5	1	3	3
D.K.M.		Scheltema	1	2	4	5	5	5
M.A.H	van	Boeckel	1	6	5	5	5	4
M.E.		Volberda	1	6	5	5	6	5
R.		Moleman	1	4	5	4	6	6
J.		Kim	1	4	3	2	4	5

SelfEval1	SelfEval2	INVQoI2	INVQoI3	Possibility1	SumRealis
5	5	1	5	5	35
5	6	0	3	4	34
6	6	0	1	6	39
6	6	2	5	6	33
4	6	0	4	6	38
5	5	1	0	6	32
4	6	0	3	4	32
5	6	0	0	6	34
5	5	6	5	5	35
4	5	4	3	4	27
6	5	2	3	6	34
3	4	3	3	2	25
6	5	0	3	4	20
5	5	0	3	3	34
5	5	3	1	4	31
6	6	2	6	6	38
6	4	2	5	4	37
4	4	4	3	4	26

Realism4	Realism5	Possibility1	Possibility1	Realism6	Possibility1	Possibility1	Realism7	INVQoI1
5	4	4	6	5	4	5	4	2
5	4	5	5	5	6	5	6	4
6	5	6	6	6	6	6	6	1
5	3	5	5	5	3	4	5	3
5	4	5	5	5	6	5	6	3
4	3	3	6	4	6	5	6	1
4	4	5	5	5	4	5	6	1
6	0	3	6	6	6	5	6	2
6	4	3	6	5	6	6	6	0
3	4	6	5	5	3	3	5	3
5	4	4	5	5	3	6	5	1
4	3	4	5	5	3	4	4	2
1	3	4	5	4	3	4	5	1
6	3	4	4	5	4	5	5	0
3	5	6	5	4	3	5	5	1
5	6	3	6	5	5	6	6	2
6	4	4	5	6	2	5	5	1
2	4	5	5	5	4	4	4	2

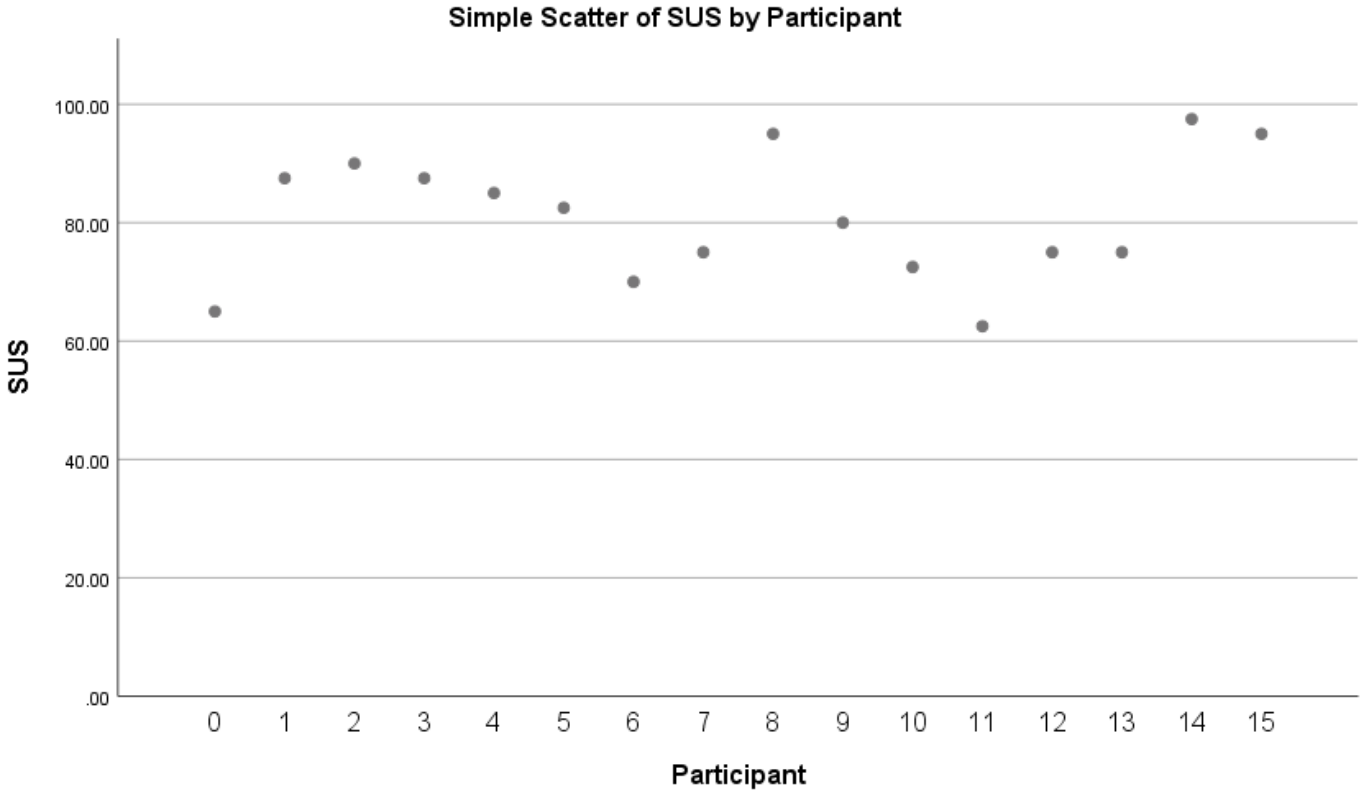
SumPossib	SumPossib	SumSelfEv	QoIRevers	QoIRevers	QoIRevers	sumQoI	totalScore
19	14	10	4	5	1	10	88,00
21	15	11	2	6	3	11	92,00
24	18	12	5	6	5	16	109,00
19	13	12	3	4	1	8	85,00
21	17	10	3	6	2	11	97,00
20	17	10	5	5	6	16	95,00
18	13	10	5	6	3	14	87,00
20	17	11	4	6	6	16	98,00
20	17	10	6	0	1	7	89,00
21	10	9	3	2	3	8	75,00
19	15	11	5	4	3	12	91,00
16	9	7	4	3	3	10	67,00
18	11	11	5	6	3	14	74,00
14	12	10	6	6	3	15	85,00
22	12	10	5	3	5	13	88,00
20	17	12	4	4	0	8	95,00
18	11	10	5	4	1	10	86,00
17	12	8	4	2	3	9	72,00

SUS DATA ANALYSIS OUTPUT

```
COMPUTE Q2adj=5 - Q2.
EXECUTE.
COMPUTE Q3adj=Q3-1.
EXECUTE.
COMPUTE Q4adj=5-Q4.
EXECUTE.
COMPUTE Q5adj=Q5-1.
EXECUTE.
COMPUTE Q6adj=5-Q6.
EXECUTE.
COMPUTE Q7adj=Q7-1.
EXECUTE.
COMPUTE Q8adj=5-Q8.
EXECUTE.
COMPUTE Q9adj=Q9-1.
EXECUTE.
COMPUTE Q10adj=5-Q10.
EXECUTE.
DATASET ACTIVATE DataSet0.

SAVE OUTFILE='C:\Users\Pak_l\Desktop\SUS.sav'
  /COMPRESSED.
COMPUTE SUS=(Q1adj+Q2adj+Q3adj+Q4adj+Q5adj+Q6adj+Q7adj+Q8adj+Q9adj+Q10adj) * 2.5.
EXECUTE.

GET
  FILE='C:\Users\Pak_l\Desktop\SUS.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
* Chart Builder.
GGRAPH
  /GRAPHDATASET NAME="graphdataset" VARIABLES=Participant SUS MISSING=LISTWISE REPORTMISSING=NO
  /GRAPHSPEC SOURCE=INLINE
  /FITLINE TOTAL=NO.
BEGIN GPL
  SOURCE: s=userSource(id("graphdataset"))
  DATA: Participant=col(source(s), name("Participant"), unit.category())
  DATA: SUS=col(source(s), name("SUS"))
  GUIDE: axis(dim(1), label("Participant"))
  GUIDE: axis(dim(2), label("SUS"))
  GUIDE: text.title(label("Simple Scatter of SUS by Participant"))
  SCALE: linear(dim(2), include(0))
  ELEMENT: point(position(Participant*SUS))
END GPL.
```



PQ DATA ANALYSIS OUTPUT

```
FREQUENCIES VARIABLES=SumRealism SumPossibilityToAct SumPossibilityToExamine SumSelfEval sumQoI
    totalScore
  /STATISTICS=STDDEV MEAN
  /ORDER=ANALYSIS.
```

Frequencies

Statistics

		SumRealism	SumPossibilityToAct	SumPossibilityToExamine	SumSelfEval	sumQol
N	Valid	18	18	18	18	18
	Missing	0	0	0	0	0
Mean		32.44	19.28	13.89	10.22	11.56
Std. Deviation		5.044	2.296	2.826	1.309	3.053

Statistics

		totalScore
N	Valid	18
	Missing	0
Mean		87.3889
Std. Deviation		10.35908

```
MATRIX DATA VARIABLES groups rowtype_ totalScore /factor=groups.
BEGIN DATA
1 N_SCALAR 101
2 N_SCALAR 18
1 MEAN 104,39
2 MEAN 87,39
1 SD 18,99
2 SD 10,36
END DATA.
ONEWAY
totalScore BY groups
/MATRIX=IN(*)
/CONTRAST=-1 1
/STATISTICS DESCRIPTIVES WELCH.
```

Descriptives

totalScore

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	101	104.390000	18.9900000	1.8895756	100.641136	108.138864
2	18	87.390000	10.3600000	2.4418754	82.238093	92.541907
Total	119	101.818571	18.9338178	1.7356602	98.381492	105.255651

ANOVA

totalScore

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4415.143	1	4415.143	13.635	.000
Within Groups	37886.613	117	323.817		
Total	42301.756	118			

Robust Tests of Equality of Means

totalScore

	Statistic[a]	df1	df2	Sig.
Welch	30.315	1	40.958	.000

a. Asymptotically F distributed.

Contrast Coefficients

	groups	
Contrast	1	2
1	-1	1

Contrast Tests[a]

		Contrast	Value of Contrast	Std. Error	t
totalScore	Assume equal variances	1	-17.000000	4.6039066	-3.693

Contrast Tests[a]

		Contrast	df	Sig. (2-tailed)
totalScore	Assume equal variances	1	117	.000

a. Tests assuming unequal variances cannot be computed if matrix input is used.

```
DATASET ACTIVATE DataSet1.
MATRIX DATA VARIABLES groups rowtype_ Realism /factor=groups.
BEGIN DATA
1 N_SCALAR 101
2 N_SCALAR 18
1 MEAN 29,45
2 MEAN 32,44
1 SD 12,04
2 SD 5,04
END DATA.
ONEWAY
Realism BY groups
/MATRIX=IN(*)
/CONTRAST=-1 1
/STATISTICS DESCRIPTIVES WELCH.
```

Descriptives

Realism

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	101	29.450000	12.0400000	1.1980248	27.073153	31.826847
2	18	32.440000	5.0400000	1.1879394	29.933667	34.946333
Total	119	29.902269	11.2989305	1.0357713	27.851160	31.953378

ANOVA

Realism

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	136.581	1	136.581	1.070	.303
Within Groups	14927.987	117	127.590		
Total	15064.568	118			

Robust Tests of Equality of Means

Realism

	Statistic[a]	df1	df2	Sig.
Welch	3.141	1	58.821	.082

a. Asymptotically F distributed.

Contrast Coefficients

	groups	
Contrast	1	2
1	-1	1

Contrast Tests[a]

		Contrast	Value of Contrast	Std. Error	t	df
Realism	Assume equal variances	1	2.990000	2.8899095	1.035	117

Contrast Tests[a]

		Contrast	Sig. (2-tailed)
Realism	Assume equal variances	1	.303

a. Tests assuming unequal variances cannot be computed if matrix input is used.

```
MATRIX DATA VARIABLES groups rowtype_ possibilityToAct /factor=groups.
BEGIN DATA
1 N_SCALAR 101
2 N_SCALAR 18
1 MEAN 20,76
2 MEAN 19,28
1 SD 6,01
2 SD 2,30
END DATA.
ONEWAY
possibilityToAct BY groups
/MATRIX=IN(*)
/CONTRAST=-1 1
/STATISTICS DESCRIPTIVES WELCH.
```

Descriptives

possibilityToAct

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	101	20.760000	6.0100000	.5980174	19.573551	21.946449
2	18	19.280000	2.3000000	.5421152	18.136237	20.423763
Total	119	20.536134	5.6263631	.5157679	19.514774	21.557495

ANOVA

possibilityToAct

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33.463	1	33.463	1.058	.306
Within Groups	3701.940	117	31.641		
Total	3735.403	118			

Robust Tests of Equality of Means

possibilityToAct

	Statistic[a]	df1	df2	Sig.
Welch	3.362	1	66.745	.071

a. Asymptotically F distributed.

Contrast Coefficients

	groups	
Contrast	1	2
1	-1	1

Contrast Tests[a]

		Contrast	Value of Contrast	Std. Error	t
possibilityToAct	Assume equal variances	1	-1.480000	1.4391243	-1.028

Contrast Tests[a]

		Contrast	df	Sig. (2-tailed)
possibilityToAct	Assume equal variances	1	117	.306

a. Tests assuming unequal variances cannot be computed if matrix input is used.

```
MATRIX DATA VARIABLES groups rowtype_ qualityOfInterface /factor=groups.
BEGIN DATA
1 N_SCALAR 101
2 N_SCALAR 18
1 MEAN 15,37
2 MEAN 11,56
1 SD 5,15
2 SD 3,05
END DATA.
ONEWAY
qualityOfInterface BY groups
/MATRIX=IN(*)
/CONTRAST=-1 1
/STATISTICS DESCRIPTIVES WELCH.
```

Descriptives

qualityOfInterface

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	101	15.370000	5.1500000	.5124442	14.353325	16.386675
2	18	11.560000	3.0500000	.7188919	10.043271	13.076729
Total	119	14.793697	5.0691485	.4646881	13.873489	15.713906

ANOVA

qualityOfInterface

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	221.767	1	221.767	9.232	.003
Within Groups	2810.393	117	24.020		
Total	3032.159	118			

Robust Tests of Equality of Means

qualityOfInterface

	Statistic[a]	df1	df2	Sig.
Welch	18.625	1	37.039	.000

a. Asymptotically F distributed.

Contrast Coefficients

	groups	
Contrast	1	2
1	-1	1

Contrast Tests[a]

		Contrast	Value of Contrast	Std. Error	t
qualityOfInterface	Assume equal variances	1	-3.810000	1.2539121	-3.038

Contrast Tests[a]

		Contrast	df	Sig. (2-tailed)
qualityOfInterface	Assume equal variances	1	117	.003

a. Tests assuming unequal variances cannot be computed if matrix input is used.

```
DATASET ACTIVATE DataSet1.
MATRIX DATA VARIABLES groups rowtype_ possibilityToExamine /factor=groups.
BEGIN DATA
1 N_SCALAR 101
2 N_SCALAR 18
1 MEAN 15,38
2 MEAN 13,89
1 SD 4,90
2 SD 2,83
END DATA.
ONEWAY
possibilityToExamine BY groups
/MATRIX=IN(*)
/CONTRAST=-1 1
/STATISTICS DESCRIPTIVES WELCH.
```

Descriptives

possibilityToExamine

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	101	15.380000	4.9000000	.4875682	14.412679	16.347321
2	18	13.890000	2.8300000	.6670374	12.482674	15.297326
Total	119	15.154622	4.6678384	.4279000	14.307263	16.001980

ANOVA

possibilityToExamine

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33.917	1	33.917	1.564	.214
Within Groups	2537.151	117	21.685		
Total	2571.068	118			

Robust Tests of Equality of Means

possibilityToExamine

	Statistic[a]	df1	df2	Sig.
Welch	3.252	1	38.166	.079

a. Asymptotically F distributed.

Contrast Coefficients

	groups	
Contrast	1	2
1	-1	1

Contrast Tests[a]

		Contrast	Value of Contrast	Std. Error
possibilityToExamine	Assume equal variances	1	-1.490000	1.1913978

Contrast Tests[a]

		Contrast	t	df	Sig. (2-tailed)
possibilityToExamine	Assume equal variances	1	-1.251	117	.214

a. Tests assuming unequal variances cannot be computed if matrix input is used.

```
MATRIX DATA VARIABLES groups rowtype_ selfEvalOfPerformance /factor=groups.
BEGIN DATA
1 N_SCALAR 101
2 N_SCALAR 18
1 MEAN 11,00
2 MEAN 10,22
1 SD 2,87
2 SD 1,309
END DATA.
ONEWAY
selfEvalOfPerformance BY groups
/MATRIX=IN(*)
/CONTRAST=-1 1
/STATISTICS DESCRIPTIVES WELCH.
```

Descriptives

selfEvalOfPerformance

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
1	101	11.000000	2.8700000	.2855757	10.433426	11.566574
2	18	10.220000	1.3090000	.3085343	9.569050	10.870950
Total	119	10.882017	2.7029706	.2477809	10.391343	11.372690

ANOVA

selfEvalOfPerformance

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.295	1	9.295	1.275	.261
Within Groups	852.819	117	7.289		
Total	862.114	118			

Robust Tests of Equality of Means

selfEvalOfPerformance

	Statistic[a]	df1	df2	Sig.
Welch	3.442	1	52.104	.069

a. Asymptotically F distributed.

Contrast Coefficients

	groups	
Contrast	1	2
1	-1	1

Contrast Tests[a]

		Contrast	Value of Contrast	Std. Error
selfEvalOfPerformance	Assume equal variances	1	-.780000	.6907360

Contrast Tests[a]

		Contrast	t	df	Sig. (2-tailed)
selfEvalOfPerformance	Assume equal variances	1	-1.129	117	.261

a. Tests assuming unequal variances cannot be computed if matrix input is used.

H. RITE INTERVIEW MINUTES AND CONSENT TESTS

RITE INTERVIEW MINUTES AND CONSENT

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

My questions have been answered satisfactorily. I understand that film, photo, and video material or editing thereof will only be used for analysis and/or scientific presentations.

I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **T.F. - Felipa**
Date: **4 Jul 2021**

- Hoe ging het?

Het begin ging een beetje stroef. <Wat ging stroef?> Het leren omgaan met je hand was wennen vooral. Uiteindelijk ging het wel.

- Wat ging er in je om toen je de wereld in kwam?

Dit is net een Sci-Fi film. Eindelijk maak ik di teen keer mee.

- Kun je omschrijven wat je zag in de filmpjes?

Hmm.. Ze waren een beetje vaag. Ik zag een persoon met z'n rug naar mij toegekeerd. Ik merk nu dat we hetzelfde deden, maar dat had ik niet door aan he begin. Ik zag ook niet goed dat hij fietsen in elkaar aan het zetten was.

<Merkte je de AR-laag op die geactiveerd werd?>
Nee. Ik zag van alles op een tafel, ik had niet door dat het om de bril ging. Het is ook een beetje raar om de bril op te zetten aangezien ik de headset op heb.

<Wat heb je net gedaan?>
Ik weet niet goed welke woorden ik moet gebruiken, maar ik heb met behulp van AR of VR een fiets in elkaar gezet. Ik kreeg instructies via de bril.

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

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Name participant: **E.A. van de Berg**
Date: **8 Jul 2021**

- Hoe ging het?

Ik geloof wel goed. Instructies waren opzicht duidelijk, ik kon alles lezen en het voelde niet gehaast. Het grijpen ging alleen even niet lekker. Voor de rest, alles wat ik nodig had was telkens zichtbaar op het juiste moment. Alleen dat snoer is wel vervelend.

- Kun je me vertellen over de videos die je zag in de introductie?

De videos staan me niet erg bij, ze trokken niet echt m'n aandacht. Ik dacht dat ze over hetzelfde gingen als de afbeeldingen? Je zag wel iets meer van de omgeving. De afbeeldingen waren wel heel duidelijk. Het knopje voor grijpen moest ik wel even opzoeken.

<Kun je me vertellen over de eerste video>? (in-game footage)
Echt geen idee.

<Kun je me vertellen over de tweede video> (AR layer)
1 van de 2 videos was een context video. Je zag iemand VR gebruiken. Ik wist toen ik dit bekeek dat dit een voorbeeld van het spel is.

- Kun je me vertellen wat je zojuist hebt beleefd in VR?

Het was een soort instructie of workshop. Ik stond als hoofdpersoon in een werkplaats en kreeg als opdracht om fietsen in elkaar te zetten. Fietsen kwamen naar met toe terwijl ik in de fabriek stond.

<Worden fietsen nu ook zo in elkaar gezet?>
Nee nu je dit zegt; nee. Ik kreeg instructies, oja met een bril. Ik zag daarmee instructies en die vertelde me wat ik moest doen.

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

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I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **E.A. Moonen**
Date: **19 Jul 2021**

- Hoe ging het?

Goed! Ik had het gevoel dat ik alles wel door had; wat er moest gebeuren en waar ik iets moest doen. Ik liep nergens vast.

- Kunt je me iets vertellen over de video's die je zag in VR?

Ik heb niet heel goed opgelet. De eerste video ging over dat iemand een fiets in elkaar zette. De tweede ging over VR (researcher's note: she said VR, but meant AR, as the video was about AR). Bij de eerste video had ik door dat het over het spel ging vanwege de frames enzo. Bij de tweede video zag ik die extra layer, dus ik herkende het daarvan

- Wat heb je zojuist beleefd in VR?

Ik heb "Job Simulator" gespeeld. Dit deed mee een beetje daaraan denken. Het was een spel dat een fabrieksmedewerker nabootst, specifiek het gedeelte van het wiel zetten op een frame.

<Worden fietsen nu ook zo gemaakt?>
Nee niet op deze manier, maar wel met robots. Alles zit dan meer vast aan bedradingen enzo. Het is deels hand- en robotwerk. Het deed me een beetje denken aan Industry 4.0.

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

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I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **J.J van Dongen**
Date: **20 Jul 2021**

- Hoe ging het?

Best prima, instructies waren duidelijk. Het enige wat ik raar vond was die border. Dat maakte me een beetje onzeker. Het was alsof ik in het donker was en heel erg voorzichtig moest zijn. Dat draadje haalde me er ook telkens uit

<Hoe kwam het dat je niet door had dat je je om moest draaien?>
Er stond iets van kijk achter je, dus dat deed ik. Ik wist niet dat ik me echt moest omdraaien

- Kun je me iets vertellen over de video?

Nee, iets over het spel?

- Wat heb je zojuist beleefd?

Ik werd in een fabriek gedropt die er een beetje creepy uitzag in het begin. Het was een erg donkere fabriek.

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

My questions have been answered satisfactorily. I understand that film, photo, and video material or editing thereof will only be used for analysis and/or scientific presentations.

I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **J.F. Heesakkers**
Date: **20 Jul 2021**

- How did it go?

I think it went well. I performed the tasks; which were quite straight-forward and well explained. I thought I needed to assemble two wheels to the frame. So, I was surprised it ended so quicky.

- Can you tell me about the videos you saw?

I saw some robots rolling around, an AR layer, I didn't really focus on the videos. I was more focussed on the controls.

<Did you know the first video was displaying the game?>
Yes, you told me I was going to assemble bicycles. I saw a frame and some wheels, so the connection wasn't that hard.

<Did you not see the task to turn off the lights at the end?>
I did, I just wanted to play around and see what was possible.

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

My questions have been answered satisfactorily. I understand that film, photo, and video material or editing thereof will only be used for analysis and/or scientific presentations.

I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **F.M. Jansen**
Date: **20 Jul 2021**

- Hoe ging het?

Wel prima, de plaatjes hielpen heel erg samen met de trillingen. Ik hoefde niet echt na te denken. Ik raakte wel in de war tussen grip en trigger, maar voor iets wat ik een halve minuut eerder had geleerd ging het best soepel. Boren ging ook best makkelijk. Het voelde heel natuurlijk.

- Kun je me vertellen over de videos die je zag in VR?

Een introductie in de factory of the future. Iets over AR, ik moet zeggen dat ik het niet heel erg heb geregistreerd. Het moest denk ik een voorproefje voorstellen. Ik wist niet dat ik er echt informatie uit moest halen

- Wat heb je zojuist beleefd in VR?

Een simulatie van een fabriek in de toekomst waar ik een fiets in elkaar gezet heb met behulp van een AR bril. Ik was aan het ervaren hoe die nieuwe fabriek is, samen met de bril.

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

My questions have been answered satisfactorily. I understand that film, photo, and video material or editing thereof will only be used for analysis and/or scientific presentations.

I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **F.S.S. Kwa**
Date: **20 Jul 2021**

- How did it go?

Good! It was really nice. It's really immersive, once you put on the headset it really feels like you're in another factory and not in the applied labs anymore. The factory is also super spacious.

<Can you clarify what you mean with immersive?>
The visuals are quite realistic and the movements are also super responsive. Because of the small delay, it feel really intuitive. The controllers also respond well. It helps that you see them in VR too. You could hear the sounds from the applied labs though, if that wasn't there or the experience had sounds it would've been complete!

<Can you tell me what the spacious environment did to you?>
Because it was so spacious, I felt like I was really there. It is such a different environment compared to where we are right now.

<Why did you constantly press the trigger when the videos were being shown?>
I wanted to see what happened. I was done reading and waiting for it to be finished. I didn't know how much longer the videos would play.

- Can you tell me about the video you saw in VR?

They were really slow. You put the AR glasses on and something with interaction during the game? I saw you do something with your hands.

- What did you just experienced in VR?

I assembled a wheel on the frame of a bike.

<Do you think bicycle assembly currently goes like this as well?>
It was more of a future world. There were autonomous robots driving around, kind of like with Industry 4.0.

Consent form

Responsible researcher: Pak Long Cheung

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Name participant: **P. Busser**
Date: **20 Jul 2021**

- Hoe ging het?

Ja opzicht wel goed. Aan het begin, dat knikken was raar. Omdat hij hem niet in 1 keer pakte dacht ik 'huh doe ik nou wat fout'. De pijlen enzo waren erg duidelijk. Je ziet dingen gebeuren, dus je weet het wel.

<Aan het begin was je net even sneller dat het spel, hoe kwam dat?>
Ik dacht meteen 'joe ik ga beginnen'. Ik had het pijltje nog niet gezien, maar wel de banden, dus ik wilde dingen doen daarmee. Later had ik pas door da tik even moest wachten

- Kun je me iets vertellen over de video's die je zag?

Niet gezien

- Wat heb je zojuist beleefd in VR?

Sta voor stap ervaring hoe je een fiets in elkaar moet zetten. Ik was in een grote loods met allemaal karretjes die dingen voor me brachten.

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Name participant: **J.S. van Stijn**
Date: **20 Jul 2021**

- Hoe ging het?

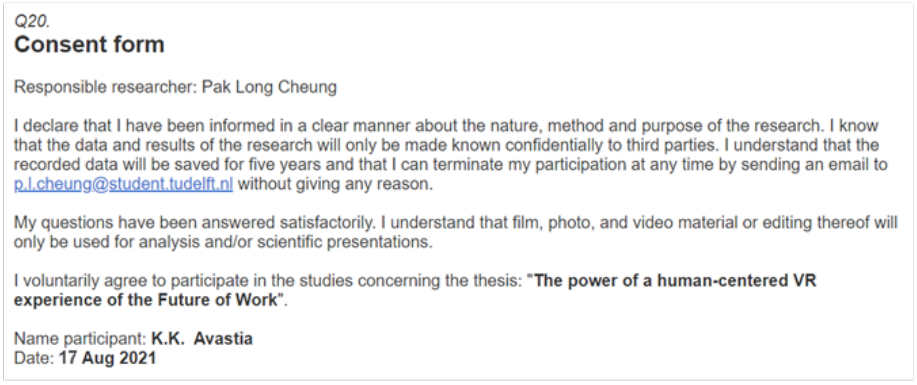
Ik vond het goed gaan. Het voelde heel natuurlijk, ik liep soms wel voor. Ik moest echt de pijlen volgen. Als je dat doorhebt gaat dat prima. Zeker bij de wielen, ik wilde die 2e al pakken maar ik moest de eerste nog vastzetten. Het was allemaal heel natuurlijk.

- Kun je me vertellen over de video's die je zag in VR?

Ik zag jou, it didn't really register. Ik heb ook niks gehoord. Tekst heb ik ook niet heel goed op gelet. Ik zag jou dezelfde dingen uitvoeren die ik moest doen. Een voorvertoning van wat er gaat komen.

- Wat heb je zojuist beleefd in VR?

Ik maakt fietsen. Ik hoefde niet echt van mijn stipje af want alles werd naar me toegebracht. Allemaal robots en fietsen die langskomen.



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Name participant: **K.K. Avastia**
Date: **17 Aug 2021**

- Hoe ging het?

Wel prima. Ik was alleen aan het begin gedesoriënteerd omdat de controller op de grond lag. Het ligt er ook aan wie dit speelt. Ik heb eerder een spel gespeeld in VR. Hierdoor snapte ik de trigger, de grab button moest ik wel even aan wennen. Dit ging minder vanzelf dan bij de trigger, hier moest ik even over nadenken. Maar als je het door hebt gaat het vanzelf.

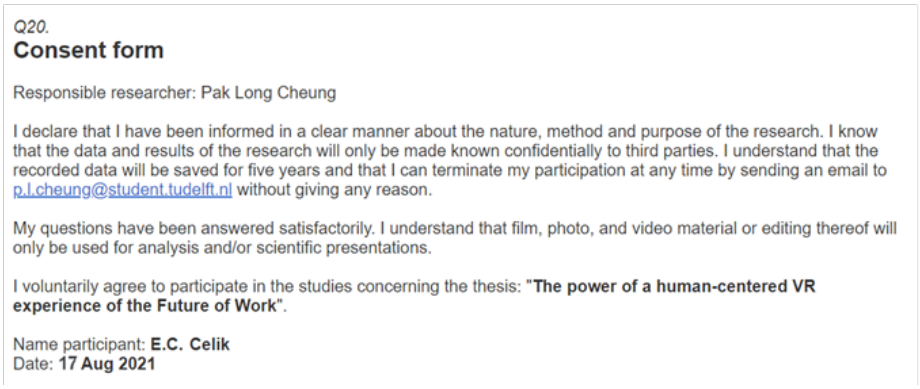
- Kun je me iets vertellen over de videos die je zag?

Ik zag dat er iemand in de fabriek stond. Er reden robots rond en jij was aan het samenwerken met 1 van de robots om dingen in elkaar te zetten. De instructies waren erg duidelijk. Ik dacht eigenlijk dat het een soort laadscherm was.

<Hoe wist je dat je de bril op moest zetten?>
Ik zag de bril, dus ik zette hem op. Dit gebeurde ook in de video's namelijk.

- Wat heb je zojuist beleefd in VR?

Ik heb samengewerkt met een robot. De robots zijn ingesteld om bepaalde handeling uit te voeren. Ze deden constant dezelfde taak en ik heb de taak samen met hun afgemaakt. De fietsframe werd gebracht, band erop gezet, vastgemaakt. Daarna ging de robot weer verder.



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Name participant: **E.C. Celik**
Date: **17 Aug 2021**

- Hoe ging het?

Ging goed; thans, de uitleg was wel goed. De side-button was relatief moeilijk te vinden, maar toen er stond squeeze en look at your hands begreep ik het wel. De disembodied handen helpen ook met de plaatsing. Qua instructies was het super. Wel zag ik alleen controller in m'n rechterhand.

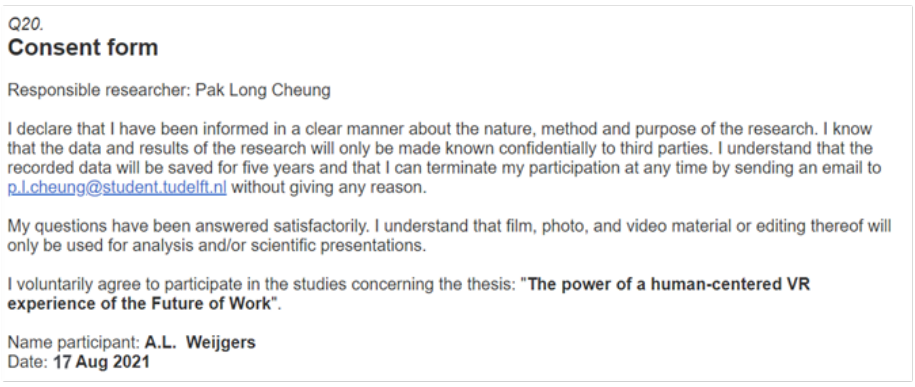
- Kun je me iets vertellen over de video's die je zag?

Iemand was in het midden van een werkomgeving. Er was een robotarm en er reden twee caddies rond die bijvoorbeeld een rek met fietsenbanden komt brengen.
In het tweede filmpje zag je jou de bril opzetten en de AR laag.

- Wat heb je zojuist beleefd in VR?

Ik werd gedropt in een werkhal. Ik moest een bril op doen die me instructies gaf terwijl ik fietsen in elkaar zette. Een frame werkt aangereikt door een robotarm. Ik moest een wiel plaatsen en die zette ik vast. Daarna was het klaar.

<Denk je dat fietsen op deze manier wordt geassembleerd op dit moment?>
Ja zou kunnen, maar zonder de AR. Vroeger had je een assemblagelijn, en nu denk ik dat er meer dingen worden gebracht door middel van die caddies.



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Name participant: **A.L. Weijgers**
Date: **17 Aug 2021**

- Hoe ging het?

De fiets heeft z'n wiel, dus blijkbaar ging het goed. Die kabel zat wel echt in de weg. Het spel geeft wel een heel goed beeld van wat de bedoeling is in de toekomst.

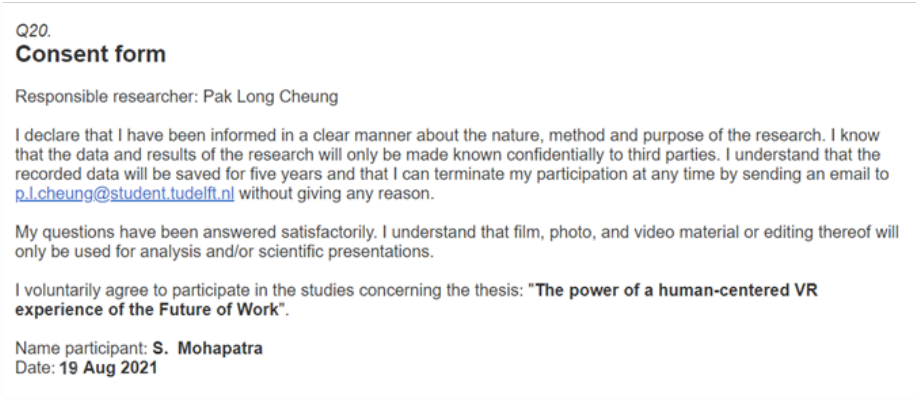
<Had je het idee dat je er was?>
Ja

- Kun je me iets vertellen over de videos die je zag?

Er werd getoond wat er zometeen ging gebeuren; fietsen in elkaar zetten in VR. De VR (moet AR zijn, maar participant kent het verschil niet) geeft aan wat je moet doen.

- Wat heb je zojuist beleefd in VR?

Ik heb gezien hoe de toekomst in fietsenfabrieken eruit zou kunnen zien.



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Name participant: **S. Mohapatra**
Date: **19 Aug 2021**

- How did it go?

It was nice, clear instructions. I was a bit confused with the trigger, which hand was supposed to give the input? I used my right hand throughout.

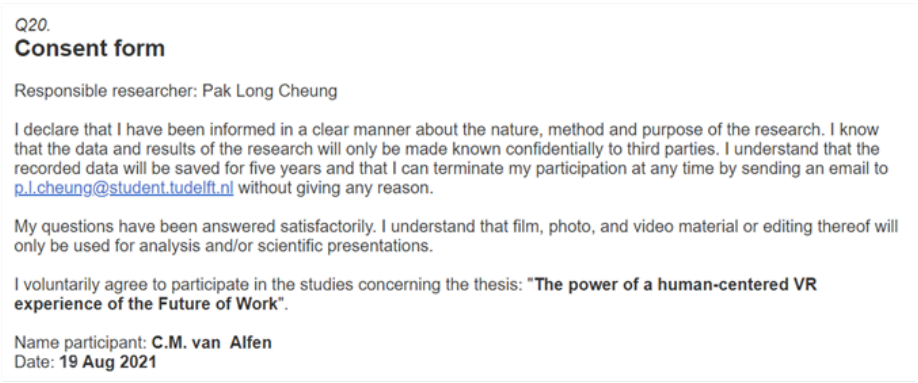
<You had some troubles with the light switch, why?>
I noticed the switch, but it was located outside the boundary, so I was confused for a moment.

- Can you tell me about the videos you saw in VR?

They were informative videos about the factory; how to use AR, what was needed. The videos were adequate but could take a larger portion of the screen. I might feel more involved. Also, I briefly looked away during the videos and missed some parts. It might be nice to pause the videos when people look away.

- What did you experience in the VR game?

A little peak into the future. It was really nice. The system instructed me what to do.
Some instructions fell behind the controller model btw. The box and container were really nice.



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Name participant: **C.M. van Alfen**
Date: **19 Aug 2021**

- Hoe ging het?

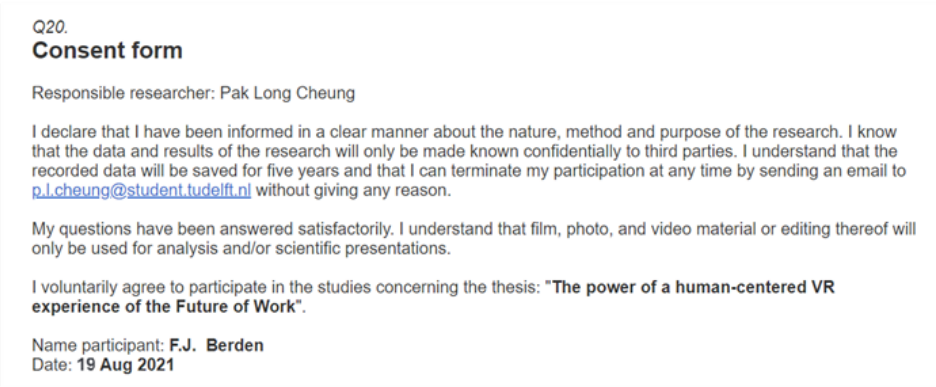
Ja het was heel nice. Ik ben over het algemeen vrij skeptisch over zulk soort technologie (ik ben best Old-Skool en schrijf alles ook nog in een boekje bijvoorbeeld), maar sinds een jaar geleden begint dit wel echt wat te worden! Alles is super accuraat en reëel!

- Kun je me vertellen over de videos die je zag in VR?

Dat was jij. Er kwamen AGVs langs met wielen die ik gebruikte.

- Wat heb je zojuist beleefd in VR?

Ik was in SAMXL, er staan was mensen om je heen en er bewegen robots. Het is een echte werkdag.
Ik miste wel duidelijk geluiden, maar dat zal ongetwijfeld er nog bij komen. De feedback van de controllers waren erg nice!



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Name participant: **F.J. Berden**
Date: **19 Aug 2021**

Goed, het ging allemaal best soepel. Het voordeel van die controllers is dat ze ook meetrillen. Je zou ook kunnen denken aan het toevoegen van gestures. Zoals bij het opzetten van de bril, wil je echt dat mensen ernaartoe lopen en opzetten? Dit kan ook met een gesture bijvoorbeeld. De HUD was wel super vet!
Als je eenmaal de controllers door hebt (gemasterd) dan zijn interacties echt intuïtief!

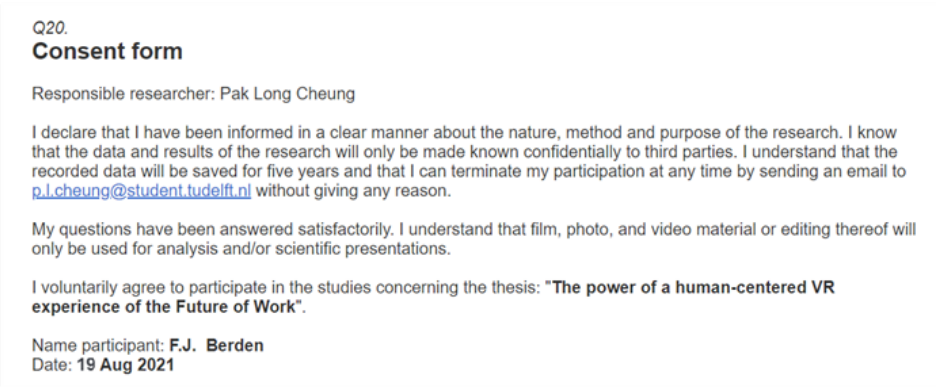
- Kun je me vertellen over de videos die je zag in VR?

De video's gaven duidelijk aan wat er van je wordt verwacht. Zodra ik in de setting stond wist ik wat er moest gebeuren.
Het ging over de communicatie van mens en robot door middel van instructies via AR (Freek snijdt heel erg het raakvlak aan met human-robot interaction zonder dit concreet te benoemen). Ik denk wel dat er meer indicators kunnen zijn met wat ze gaan doen.

- Wat heb je zojuist beleefd in VR?

Een soort van factory simulator; een fabrieksmedewerker in de toekomst. Ik heb samengewerkt met robots door middel van het vervullen van de opdrachten in de HUD.

Het scenario is erg haalbaar. Ik heb niet het gevoel dat dit in de verre toekomst ligt omdat alles al bestaat.



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Name participant: **F.J. Berden**
Date: **19 Aug 2021**

- Hoe ging het?

Ja was makkelijk te volgen. Alles was duidelijk aangegeven, misschien heb ik weinig moeite met orienteren, maar zelfs als je de richting kwijt was werd er aangegeven waar je heen moest kijken. Heb geen enkel moment moeite mee gehad,

- Kun je me vertellen over de videos die je zag in VR?

Iets te klein, staat me niet heel goed bij. Ik heb een scenario gezien waarbij de techniek kan worden toegepast, iemand die in de workplace gebruik maakt van ar.

- Wat heb je zojuist beleefd in VR?

Ik was in een fiets assembly line in een fabriek met mijn eigen workspace, tafeltje, nja, rechts wiel. Robot arm recht voor me. De robotarm gaf frames aan
<Heb je het idee dat het er nu ook zo aan toe gaat?>
Ja, minder robotisch, maar wel grote gelijkenissen. Ik ben er nooit zelf geweest. Iemand heeft een workstation en een reeks frames, om de wielen kloppend te assembleren.

PQ CONSENT

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Name participant: **J. Kim**

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Name participant: **R. Moleman**

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Name participant: **M.E. Volberda**

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Name participant: **M.A.H van Boeckel**

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Name participant: **D.K.M. Scheltema**

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Name participant: **N. Wiersma**

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Name participant: **M.L. Janssens**

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Name participant: **A.D. Minnema**

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Name participant: **A. De Groot**

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Name participant: **C.A Anthony**

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Name participant: **K.D. Domacasse**

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Name participant: **N. Pinedo**

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Name participant: **G.D.M David Merien**

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

My questions have been answered satisfactorily. I understand that film, photo, and video material or editing thereof will only be used for analysis and/or scientific presentations.

I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **R.A Chakoetoe**

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

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I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **K. Lamein**

Consent form

Responsible researcher: Pak Long Cheung

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I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **J.S.B.R. Sebastian Burgos Ramos**

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

My questions have been answered satisfactorily. I understand that film, photo, and video material or editing thereof will only be used for analysis and/or scientific presentations.

I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **R.R Roos**

Consent form

Responsible researcher: Pak Long Cheung

I declare that I have been informed in a clear manner about the nature, method and purpose of the research. I know that the data and results of the research will only be made known confidentially to third parties. I understand that the recorded data will be saved for five years and that I can terminate my participation at any time by sending an email to p.l.cheung@student.tudelft.nl without giving any reason.

My questions have been answered satisfactorily. I understand that film, photo, and video material or editing thereof will only be used for analysis and/or scientific presentations.

I voluntarily agree to participate in the studies concerning the thesis: "**The power of a human-centered VR experience of the Future of Work**".

Name participant: **B.J.B. Riepen**

I. PROBLEM DISCOVERY RATE AND SAMPLE SIZE

In order to determine the right sample size for usability tests and developments, the method of C.W. Turner (Turner et al FIXME) “cumulative binomial probability formula” has been applied.
The individual problem discovery rates (P) of the preliminary study with students and researchers ranged from 0.2222 to 0.6666, averaging on 0.3889 for that sample. Because small sample estimates of p are almost always inflated according to Hertzum and Jacobsen, Lewis (and this paper) proposes a method for an accurate assessment of true proportions of problem discovery rates and the (small) sample size: combining a normalization procedure with a discounting method (Good-Turning).
The Good-Turning method reduces (not eliminates) the overestimation of problem discovery rates as a result of small sample p estimates. It makes use of a statistical language model, which produces an unnormalized probability distribution or score through ranking, in order to reduce the overestimation. By contrast using the normalization procedure will yield slightly underestimated problem discovery rates. It assumes that with a bigger sample size, the probability distribution will resemble that of a normal distribution. Applying each procedure to the initial estimated value of p, and averaging the two, will yield a highly accurate estimate of the problem discovery rate the method in the paper argues.
Using this computed problem discovery rate p, the percentage of success (no to minimum errors encountered) can be set to different values with the binomial distribution formula. This can be used to calculate the needed sample size (n) for the related chance of success and the mean problem discovery rate: 1-(1-p)^n
P estimation

$$p1 := \frac{5}{9} : p2 := \frac{6}{9} : p3 := \frac{2}{9} : p4 := \frac{2}{9} : p5 := \frac{3}{9} : p6 := \frac{3}{9} : nSubjects := 6 : Pest := evalf\left(\frac{(p1+p2+p3+p4+p5+p6)}{nSubjects}\right);$$

$$Pest := 0.3888888889$$

Good turning: $\rho_{GT\text{-}adj} = \frac{\rho est}{1+\frac{E(N1)}{N}}$;

Normalizing: $\rho_{Norm\text{-}adj} = (\rho est - \frac{1}{n})(1 - \frac{1}{n})$

ρ_{est} = Average problem discovery rate,
n = number of test participants

$P_{adj} = \frac{1}{2}(\rho_{GT\text{-}adj} + \rho_{Norm\text{-}adj})$

$$n := 6 : PnormAdj := \left(Pest - \frac{1}{n}\right)\cdot\left(1 - \frac{1}{n}\right);$$

$$PnormAdj := 0.1851851852$$

Averaging Ps

$$Padj1 := \frac{1}{2}\cdot(PgtAdj1 + PnormAdj)$$

$$Padj1 := 0.2175925926$$

Setting the binomial distribution formula from 70% to 99% (with increments of around 5%)

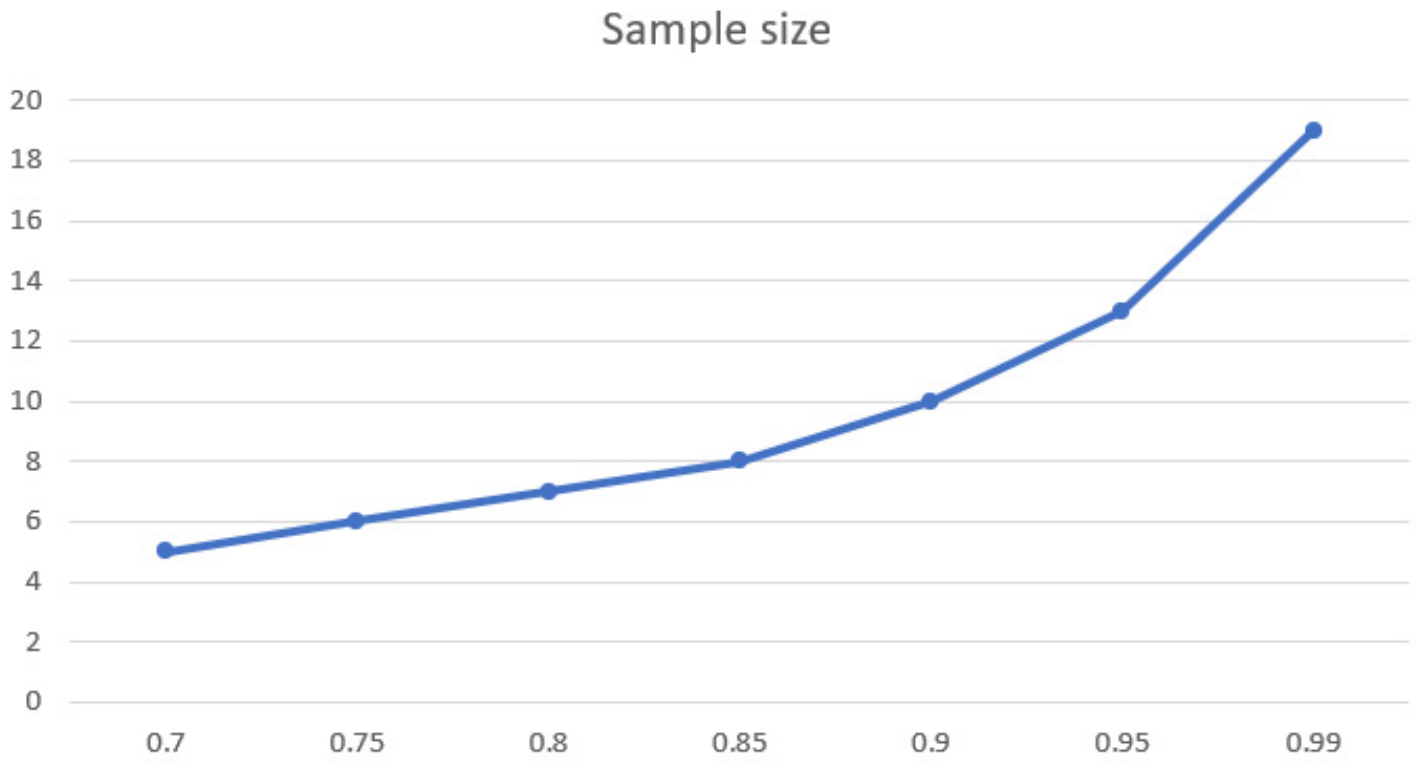
$$Perrorfind := \begin{bmatrix} 0.7 \\ 0.75 \\ 0.8 \\ 0.85 \\ 0.9 \\ 0.95 \\ 0.99 \end{bmatrix}$$

$$eq1 := 0.7 = 1 - 0.7824074074^{nsample}$$
$$eq2 := 0.75 = 1 - 0.7824074074^{nsample}$$
$$eq3 := 0.8 = 1 - 0.7824074074^{nsample}$$
$$eq4 := 0.85 = 1 - 0.7824074074^{nsample}$$
$$eq5 := 0.9 = 1 - 0.7824074074^{nsample}$$
$$eq6 := 0.95 = 1 - 0.7824074074^{nsample}$$
$$eq7 := 0.99 = 1 - 0.7824074074^{nsample}$$

Solving the equation for n (minimal amount of participants for the related chance of success):

4.906570673
5.649588788
6.558969466
7.731365067
9.383763860
12.20855825
18.76752772 **(6)**

Graph of the answers at (5) and (6):



J. GRADUATION BRIEF

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME
Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Cheung 4697
initials: P.L. given name: Pak Long
student number: 4283937
street & no.:
zipcode & city:
country:
phone:
email:

Your master programme (only select the options that apply to you):
IDE master(s): IPD / DHI / SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: Honours Programme Master
specialisation / annotation: Medisign / Tech. in Sustainable Design / Entrepeneurship

SUPERVISORY TEAM **
Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: D. Aschenbrenner dept. / section: IDE
** mentor: J. Henny dept. / section: IDE
2nd mentor:
organisation:
city: country:
comments (optional):

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF
To be filled in by the chair of the supervisory team.

chair D. Aschenbrenner date 08 - 02 - 2021 signature Dr. Doris Aschenbrenner Digital unterschrieben von Dr. Doris Aschenbrenner Datum: 2021.02.10 14:48:07 +01'00'

CHECK STUDY PROGRESS
To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 30 EC
Of which, taking the conditional requirements into account, can be part of the exam programme 30 EC

★ YES all 1st year master courses passed

NO missing 1st year master courses are:

List of electives obtained before the third semester without approval of the BoE

name J. J. de Bruin date 10 - 02 - 2021 signature J. J. de Bruin, SPA Digitally signed by J. J. de Bruin, SPA Date: 2021.02.10 17:02:00 +01'00'

FORMAL APPROVAL GRADUATION PROJECT
To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ★ APPROVED ○ NOT APPROVED

Procedure: ★ APPROVED ○ NOT APPROVED

- remark: title is vague / title could be more clear

comments

name Monique von Morgen date 16 - 02 - 2021 signature

Initials & Name P.L. Cheung 4697 Student number 4283937

Title of Project The power of a human centered VR experience of the Future of Work

TU Delft

Personal Project Brief - IDE Master Graduation

The power of a human centered VR experience of the Future of Work — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 08 - 02 - 2021 — 02 - 07 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

'Industry 4.0' is a future scenario of an industry where humans closely collaborate with robots. With the help of different technologies and co-bots, workers' physical, sensory and cognitive capabilities will be enhanced; making the (traditionally) labour-intensive work accessible for a much broader audience (i.e., elderly workers and people with disabilities).
Currently, within the TU Delft, the described scenario has been developed in virtual reality for the bicycle industry. Although the bicycle market has gone through changes regarding consumer needs over the years (e.g. customization), the same cannot be said about the manufacturing process. The variety of bicycle parts and the intricacy of assembly makes the, already quite conservative industry, very reliant on manual labour.

Researchers within the TU Delft have build a VR-experience as a tool to provide a glimpse of how the implementation of industry 4.0 within their factory could look like. Ultimately, in order to support the transition to industry 4.0.

Preliminary testing together with Robohouse (december 2020) have indicated that users run into troubles with this developed experience on both the cognitive and physical side (e.g. they don't understand it, they can't perform basic tasks in it). In order to paint the picture correctly, the scenario should not only be presented realistically, but also have the correct 'feel' to it. Human factors need to be taken into consideration much more largely and further development of the experience is therefor needed.

Who are the main stakeholders?
The (bicycle) industry: are quite conservative and operates as they a century ago. They value cost-effectiveness of solutions and the validation of its workings.
Factory worker: are they main carriers of the (physical) burden today. They value reduced labour-intensive work, accessible for a larger audience, for a relatively longer period of time. Also, the reduction of mental stress in general.
Consumer: More sustainable and fast delivery (and maybe cheaper) of customized goods.
Researchers from TU Delft engaged with the Future of Work: SamXL and Robohouse.

What opportunities do you see?
The VR-experience is a non-intrusive and cost-effective tool to paint the projected future. In order to do so effectively however, the experience needs to match the behaviour of end users more intuitively. Also (hypothesis), with an effective UI and understanding of the VR-experience (as a player); the experience can serve as a powerful tool for ergonomic and interaction studies and tests.

What limitations do you see?
To make the VR-experience 'intuitive' for humans might prove challenging because of the great variety of human factors but also due to the novelty of VR in general. Industry 4.0 involves robots collaborating with humans. For this team-work to go well, the collaboration needs to be engineered with a human centred approach. Although prototyping and testing might be done in VR sustainably and effectively, the real validation still needs to be done physically (in VR) eventually, rather than only using models and data.

space available for images / figures on next page

Personal Project Brief - IDE Master Graduation

TU Delft

introduction (continued): space for images

image / figure 1: Current VR scenario of 'Industry 4.0' for the bicycle industry

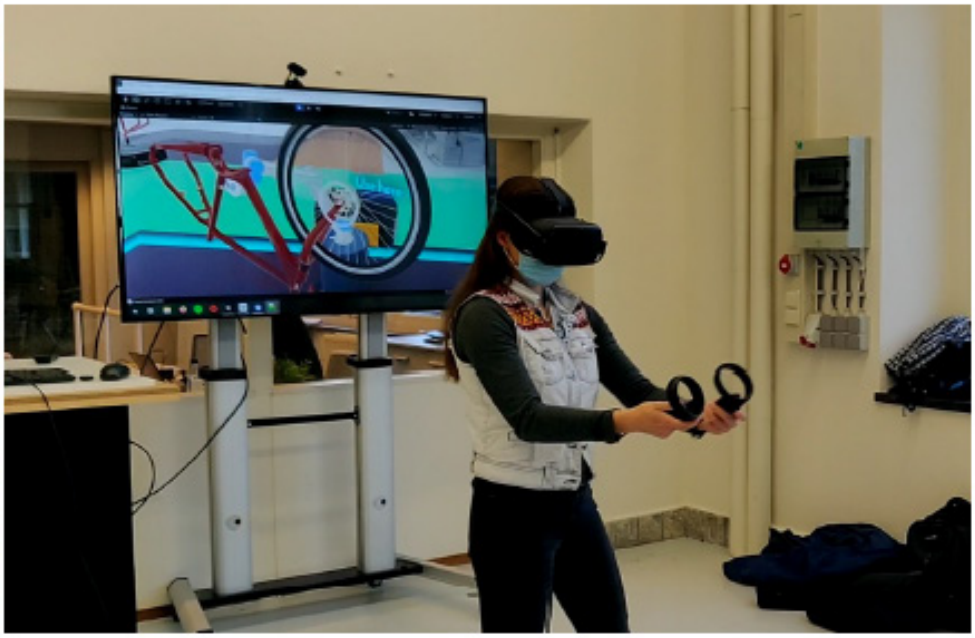


image / figure 2: Participant of the preliminary test with Robohouse in december 2020

Initials & Name P.L. Cheung 4697 Student number 4283937

Title of Project The power of a human centered VR experience of the Future of Work

TU Delft

Personal Project Brief - IDE Master Graduation

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

What is your concrete domain of interest?
Immersive experiences, storytelling and testing in virtual reality. How can humans adopt to VR more comfortably?

What is in the specific focus of your project?
Continue develop the VR-experience with human factors in mind to relieve the interaction problems mentioned in the preliminary testing in the introduction. This will allow the projected scenario to be experienced much more smoothly, while also allowing the VR-experience to be used for further studies.

What solution space can you foreseen?
Develop a more effective and fun tutorial for the users, prior to entering the experience. Also, a user-interface that is more intuitive than the existing one. If time allows it: a case study to test the hypothesis mentioned in 'the opportunities I see' as well.
What are the major issues to be addressed?
Make the experience more usable and fluid for the players so:
1. The user is able to carry out bicycle manufacturing tasks in VR [effectiveness].
2. The user can be motivated to imagine a possible Future of Work scenario.
3. The user is satisfied and excited about the future [No feeling of fear].

What gives you confidence that the project is manageable?
There are many researchers actively conducting studies in this field, so there is not necessarily a scarce of experts in my immediate surroundings even though the field is novel.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

~~Explorative study on envisioning the Future of Work scenarios in VR: human-robot interaction development and testing~~ applied for bicycle manufacturing.

What are the design criteria for making a Virtual Reality experience more user friendly so users are able to imagine scenarios of the Future of Work ?
I am going to create a user-interface and/or a tutorial within the existing VR-experience. A case study of how, when players grasps their presence in VR more comfortably, the environment can be used for further experimenting and testing. I am convinced that a important factor influencing this could be robot legibility which means the users are able to understand what the robot will do next.
I am going to conduct a literature study in order to gain state-of-the-art insights and combine these with testing results of the VR-experience as means to uncover design flaws within the existing experience. Previous study have indicated the existing prototypes only cover functional aspects of the manufacturing process and miss the emotional aspect entirely; so there is still much to gain in this area.
After, use the RITE method to rapidly iterate on solutions of the problems. Finally, a small case study will be done to demonstrate the power of the VR-experience.
It is important to methodologically plan and approach the development.
My expected contribution is to make the developed VR-experience more human friendly. Give an example (and maybe insight) in how the environment can be used further, outside of the scope of immersive storytelling (i.e. for conducting studies).

Initials & Name P.L. Cheung 4697 Student number 4283937

Title of Project The power of a human centered VR experience of the Future of Work

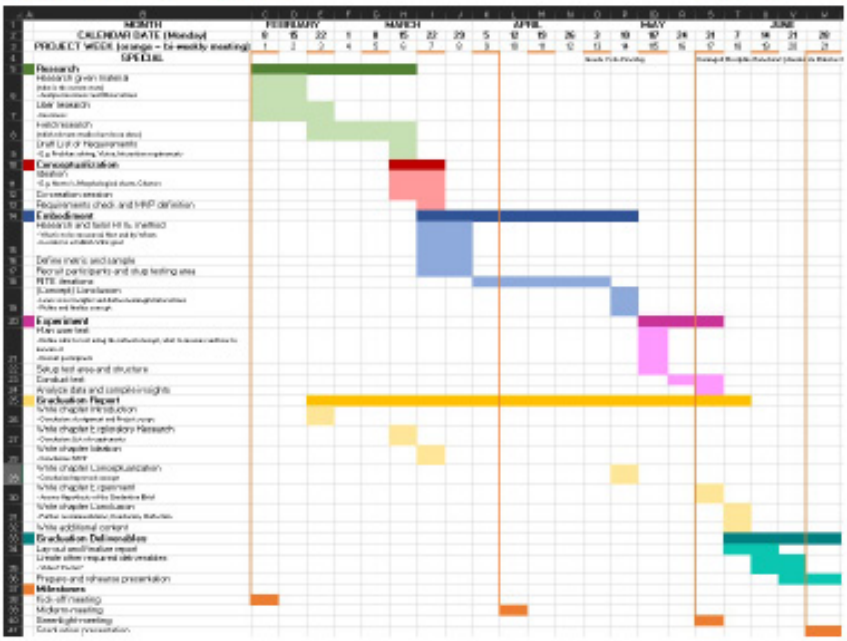
TU Delft

Personal Project Brief - IDE Master Graduation

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 8 - 2 - 2021 2 - 7 - 2021 end date



What will be the deliverable(s)?
A solution to better the experience and play of players within the developed VR-experience.

How do you allocate 800 hours?
One block equals a full time work week (5 x 8 hours) = 40 hours. Allocation of hours can be seen in the Gantt chart.

What instrumentation you will need?
An Oculus Quest.

What external (third-party) knowledge you (may) need?
The developed VR experience

Do you intent to publish or to generate IP?
Yes. Eventually the graduation can contribute to a publication on a Special issue on Virtual Reality and Robots

Initials & Name P.L. Cheung 4697 Student number 4283937

Title of Project The power of a human centered VR experience of the Future of Work

TU Delft

Personal Project Brief - IDE Master Graduation

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

What is your motivation?
With every (disruptive) technology, a new era of innovation can be triggered. Although the novelty of VR and AR is wearing off, the implementation of this immersive technology is still relatively fuzzy. There is a wide implementation possible in different industries, but what value can it add? How can this technology support our world and maybe even help solve the challenges we face?
I am extremely excited about the future of XR and how it will change our foreseeable future.

What are your competences?
Design thinking has been embedded into me during the course of my bachelors and masters. In my elective space I have always opted for code-related courses, even in other faculties. In my experience, hardcore-coders are quick to lose themselves in features that does not necessarily resonate with their end-users; while designers lack the skill to establish features (and maybe knowledge to know the limitations of the technology). With my education and electives, I want to bridge this gap so the end-product will make sense to all stakeholders (designers, developers and end-users).

What new do you want to learn?
XR integrates many disciplines into one product. I would like to learn to adapt my existing skills to fit this environment and get hands-on experience within this field. The novelty of the field also requires me as a designer to learn new skills (i.e. work with Unity) and further develop existing skills (i.e. conducting research).
As motivated before, a new platform to create upon is appearing; as designer from the TU in Delft, I want to be involved in this technology in every step along the way!

Which are your most important ambitions?
To get hands-on experience within the field of XR, develop myself as a designer within the field and position myself within the XR-network of Delft. After the graduation, I would become more comfortable with what UX and human factors means in this interdisciplinary field, making not only the project, but also myself a valuable addition to this novel area.

What is the risk and how do you want to manage it?
Because of the novelty of the technology, experts might be lacking in my own network. I want to start building this up/mitigate this by actively participating in the XR network of Delft using my student assistant job.
Also, because VR needs specific (contact) tools and powerful computers to operate, COVID-19 might prove to be a troublesome for prototyping and testing. I am a member of the resident-committee of the student-housing I live in. I plan to use this connection to sample in my immediate surroundings if COVID-19 continues to prohibit ('unnecessary') outdoor activities.

What you are uncertain about?
The code-heavy side of the technology: I'm sure I will be assisted by the research team. COVID-19 and its implications.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Initials & Name P.L. Cheung 4697 Student number 4283937

Title of Project The power of a human centered VR experience of the Future of Work