A Study on Virtual Reality Workspace to Improve Work Efficiency

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Resume of the presenter

Experience

- B.M. Hokuriku University (2017)
- M.K. Japan Advanced Institute of Science and Technology(2020)
- Ph. D Student at Information Science, JAIST (2020~)

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Tianshu Xu

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Interest

- Virtual Reality / Mixed Reality
- Office Automation
- Machine Learning

Experience

- B.E. Osaka University (1998)
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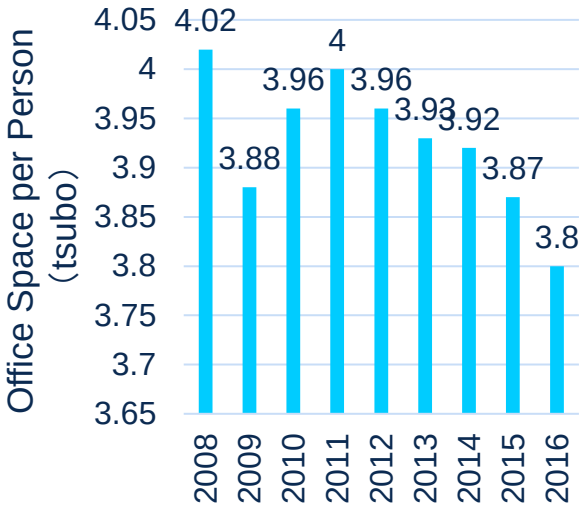
Research Keywords

- Distance Learning
- Web-based Learning
- E-Learning
- Gamification

Background



OPWS (Open-Plan Work-Space)

- OPWS is very popular all over the world.
- Many employees to work together in the wall-less, partition-less environment.

OPWS shortcomings

- Noise
- Low level of privacy protection
- Stress
- Conflict

……

Reduces work efficiency

Extra cost

- Most of the proposals suggest creating an additional workspace that needs **extra cost**.
- Workspace for per person is decreasing year by year.

VRWS (Virtual Reality Work-Space)

- VRWS is a virtual personal workspace independent of OPWS. (privacy)
- HMD and noise-canceling earphones can help to reduce the auditory and visual interference in the workspace. (noise, coworker's movement, etc.)

VRWS has great potential to solve the problems that occurs in OPWS.

Three picture from left to right: https://bunshun.jp/articles/-/2293; https://jouwerk.solidariteit.co.za/en/noise-the-bane-of-the-open-plan-office/; Xymax Real Estate Institute, "Office tenants of office buildings in Tokyo 23 Wards", Research Report| Xymax Real Estate Institute, September 21, 2016;

Objective and Research Question

Designing VRWS which can deal with personal work efficiency, and identify the factors which in virtual reality affect work efficiency.

RQ1: How VRWS handle work efficiency?

RQ2: What factors that affect work efficiency in VRWS?

Hypothesis:

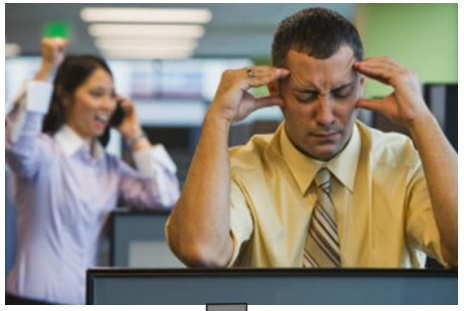
Hy 1: VRWS can help to improve personal work efficiency.

Hy 2:The solutions to improve the shortcomings of OPWS also can apply to VRWS.

Work Efficiency Measurement: Working time in the same workload.

Related Works

OPWS



Extra Cost

+

Design Standards

Good Efficiency

Previous Research:

- A controlled sound environment;
- Good lighting;
- Plenty of natural light;
- Avoiding visual interference;
- Avoiding auditory interference;
- Avoiding extra stress;
- Privacy protection.

Existing VRWS

VRchat

Oculus Virtual Desktop

No Design Standards

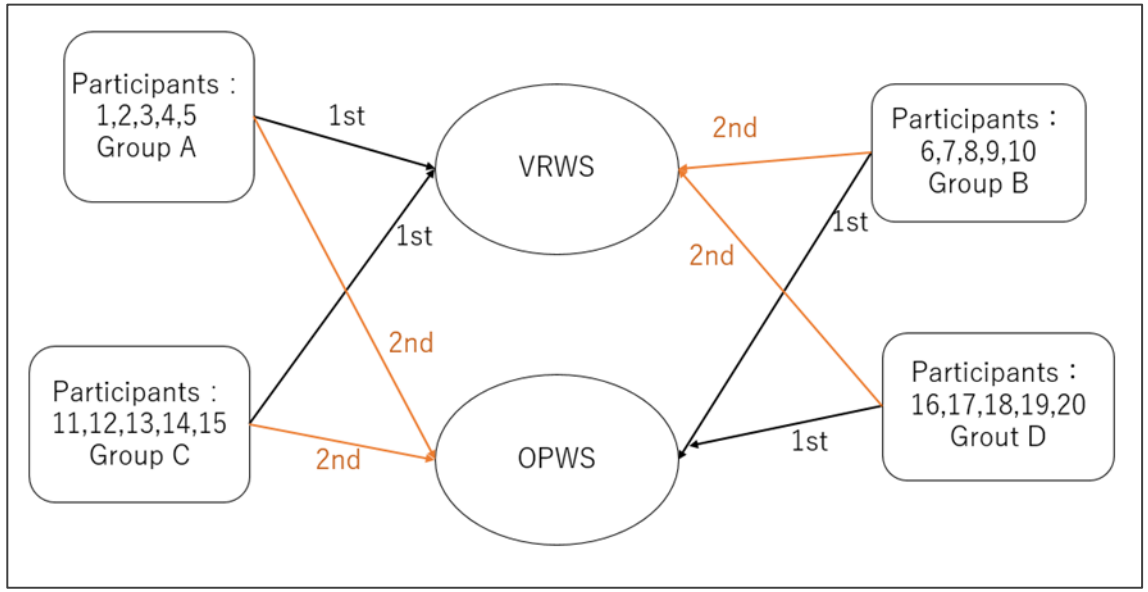
The design of the VR environment relies entirely on personal customization.

It is hard to believe that work efficiency would benefit from these VR environments.

OPWS picture: https://jouwerk.solidariteit.co.za/en/noise-the-bane-of-the-open-plan-office/
VRchat picturehttps://www.vrcw.net/world/detail/wrld_f9ed0d91-a1f4-4d1e-a237-547d245ef607
Oculus Virtual Desktop picture: www.roadtovr.com/virtual-reality-desktop-compared-oculus-rift-htc-vive

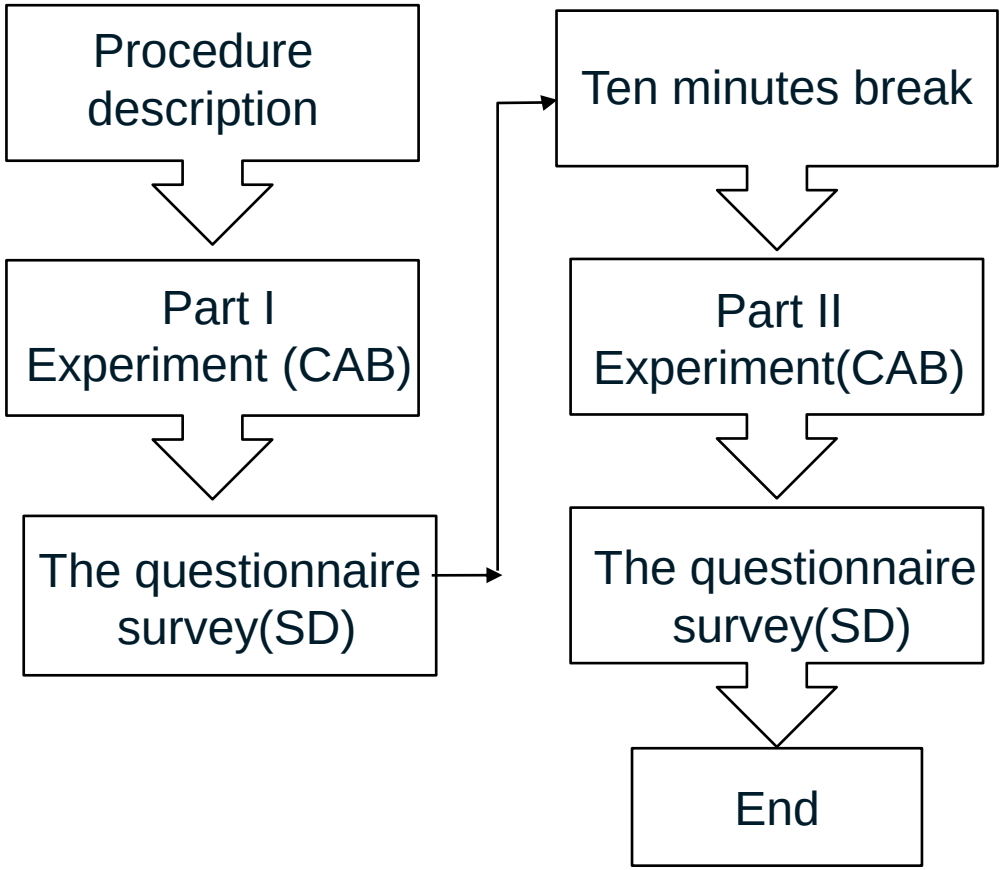
Experiment

Experiment condition for each group:

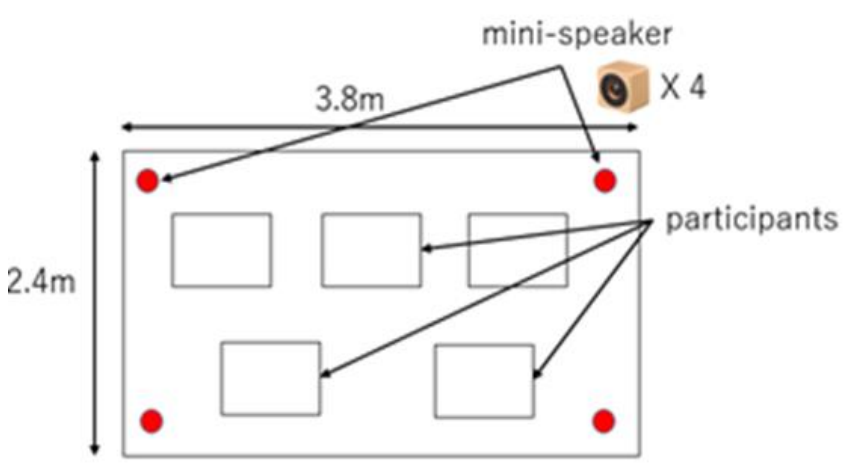


- 20 postgraduate students participated in the experiment.
- Each experiment should be controlled within 50 minutes.
- Participants only can use mouse to answer CAB test.

Experimental process:



Design of OPWS



Experimental arrangements in the CAVE system

The scene of the experiment in the CAVE system

It is difficult to find a typical noisy OPWS in the area where the author lives. In order to control experimental settings, we decided to use the CAVE (Cave Automatic Virtual Environment) system to simulate a typical noisy OPWS.

Design of VRWS

VRWS with excellent OPWS characteristics would expect to maintain or improve work efficiency.

Excellent OPWS characteristics:

- Without visual and auditory interference
- With good lighting
- Sufficient natural light
- Privacy protection

VRWS with excellent OPWS characteristics:

Avoiding Visual and Auditory Interferences:

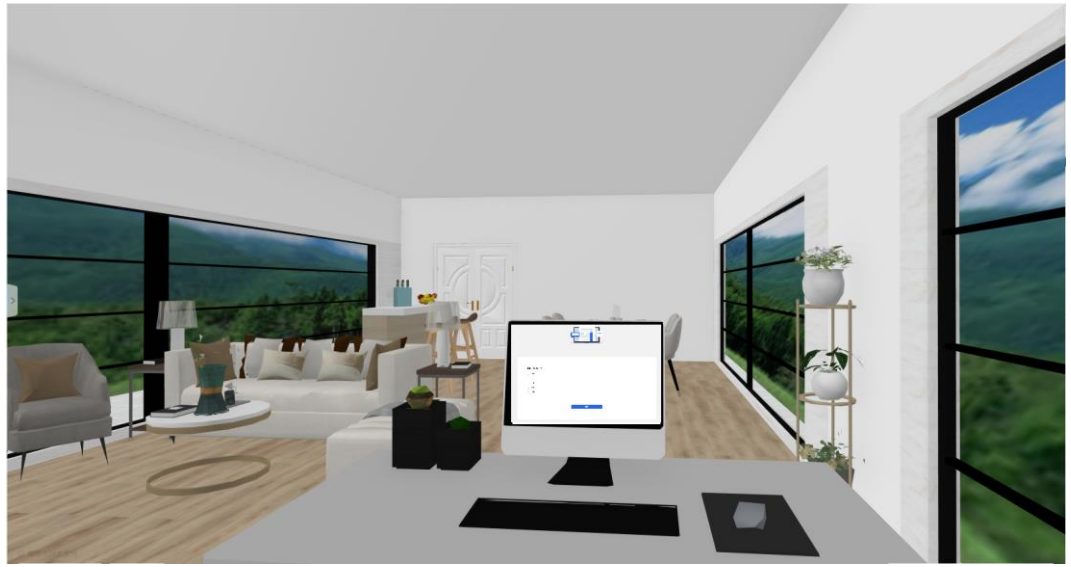
1. HMD and noise-canceling earphones

Good Lighting and Sufficient Natural Light:

1. Increased the brightness of the model;
2. Floor-to-ceiling windows to replace the walls;

Privacy:

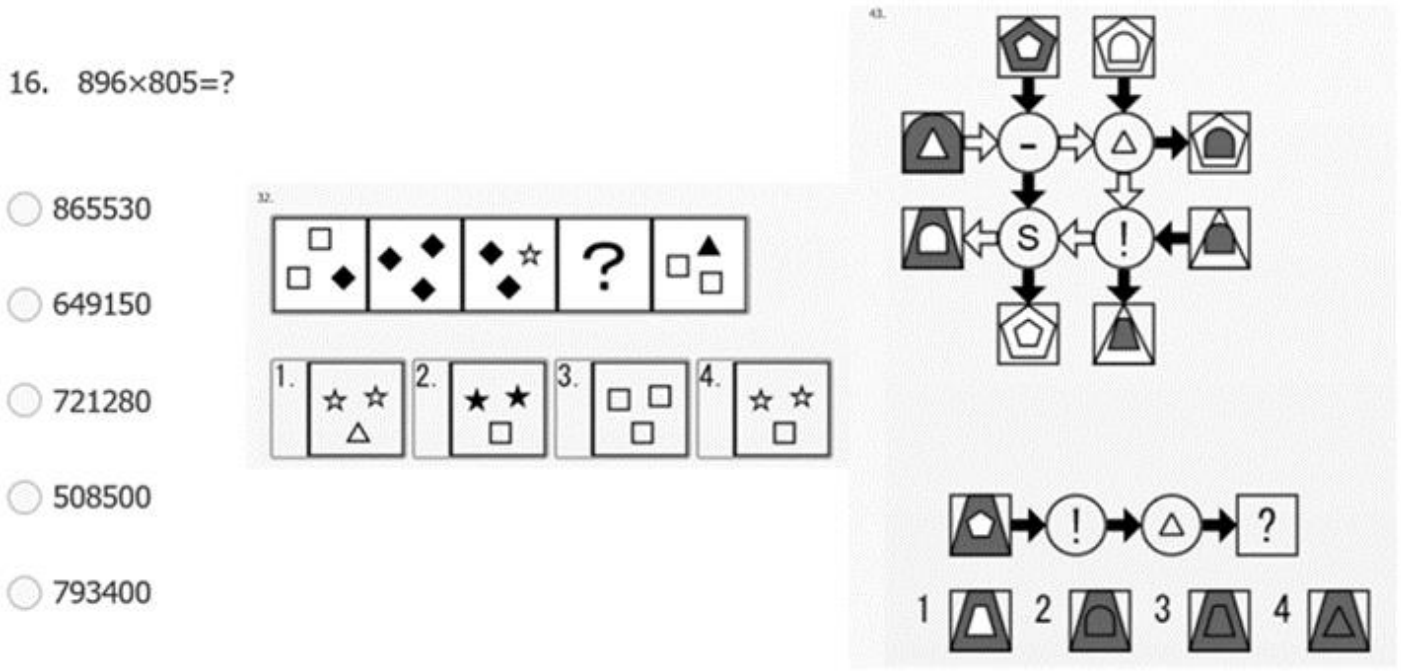
1. Designed VRWS that could not share the workspace but only can use one by one.



User's vision in VRWS

CAB Test

CAB: Cognitive Assessment Battery



Mental arithmetic question. Logical reasoning question. Cipher question.

S. Ellbin, N. Engen, I. H. Jonsdottir, A. I. K. Nordlund, “Assessment of cognitive function in patients with stressrelated exhaustion using the Cognitive Assessment Battery (CAB),” Journal of Clinical and Experimental Neuropsychology, vol. 40, no. 6, pp. 567-575, 2018.

SD

1.	Narrow view	Broad view
2.	High psychological pressure	Low psychological pressure
3.	Non-free atmosphere	Free atmosphere
4.	Uncomfortable	Comfortable
5.	Ill-lighted	Well-lighted
6.	Getting tired	Not tired
7.	Strange feeling	Natural feeling
8.	Graceless	Grace
9.	Not-relaxing	Relaxing
10.	Depressed	Cheerful
11.	Hard to work	Easy to work
12.	Noisy in movement	Not noisy in movement
13.	Not enjoyable	Enjoyable
14.	Noisy in sound	Not noisy in sound
15.	Unmotivated	Motivated
16.	Inefficient	Efficient

Negative ← → Positive

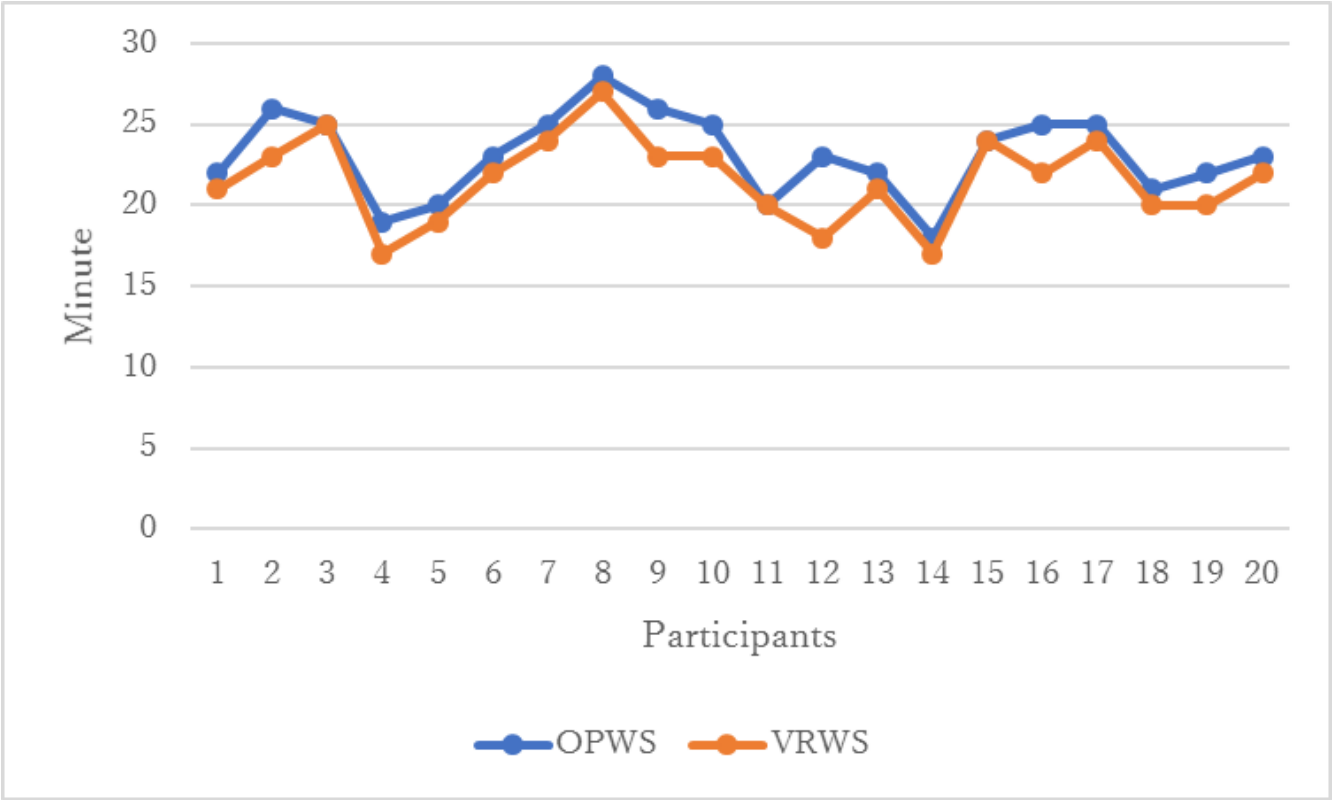
1 2 3 4 5 6 7

Results

In each conditions, the participants were requested to answer 45 CAB test. The times in the table show the time for answer to all the test. Compare the different times for each participant in each conditions as shown in the right picture.

Participants	OPWS (min)	VRWS (min)
1	22	21
2	26	23
3	25	25
4	19	17
5	20	19
6	23	22
7	25	24
8	28	27
9	26	23
10	25	20
11	20	18
12	23	21
13	22	17
14	18	24
15	24	22
16	25	24
17	21	22
18	22	24
19	23	20
20	25	24

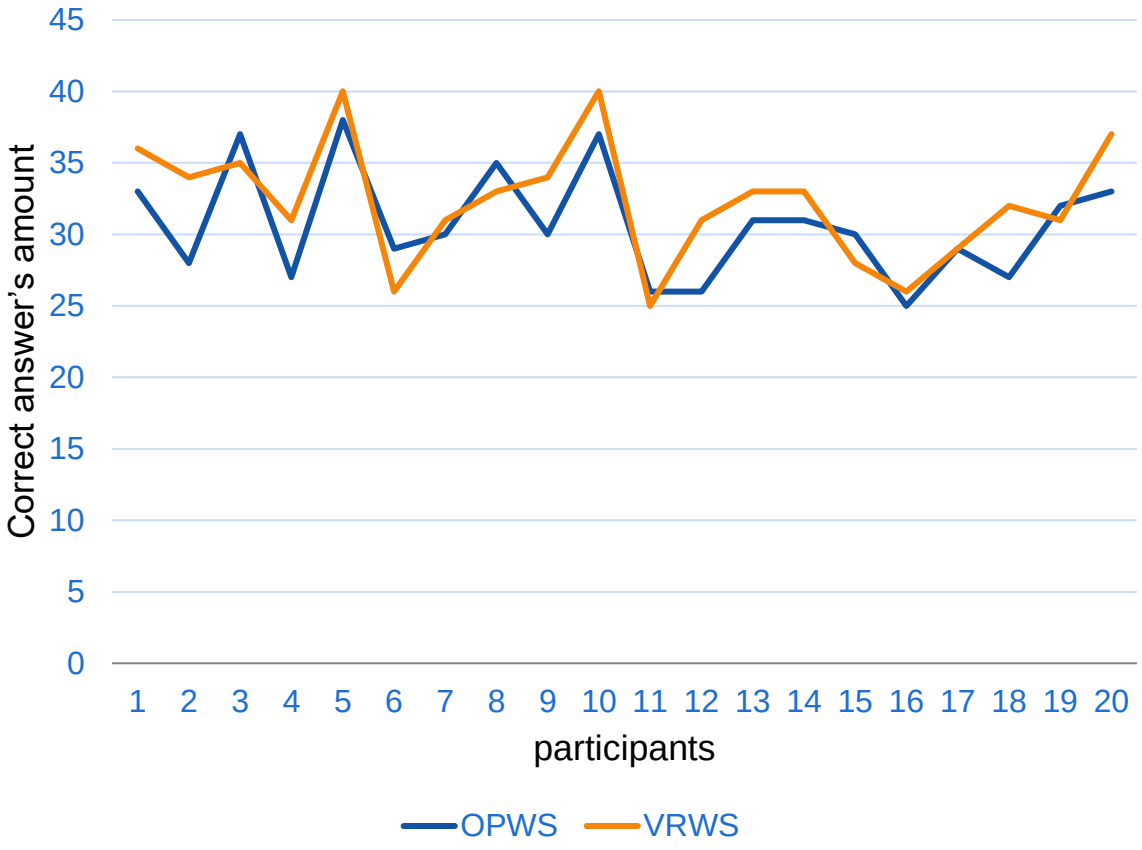
Time differences in each setting



Different times for each participant in OPWS and VRWS

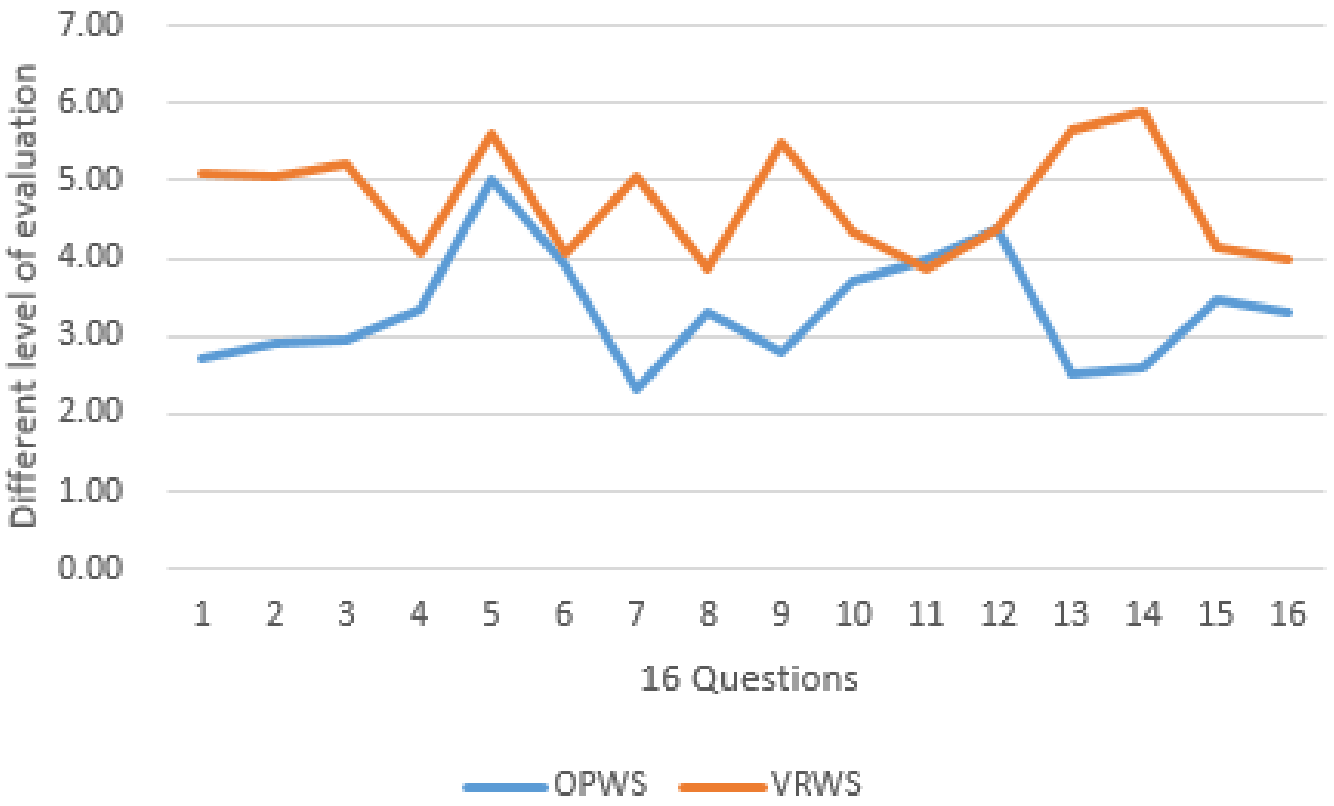
Results

participants	Correct Answer		
	OPWS	VRWS	difference
1	33	36	-3
2	28	34	-6
3	37	35	2
4	27	31	-4
5	38	40	-2
6	29	26	3
7	30	31	-1
8	35	33	2
9	30	34	-4
10	37	40	-3
11	26	25	1
12	26	31	-5
13	31	33	-2
14	31	33	-2
15	30	28	2
16	25	26	-1
17	29	29	0
18	27	32	-5
19	32	31	1
20	33	37	-4



The correct answer of the two conditions

Results



The average of the two groups' results

Apparent difference:

- No.1 "Broad view"
- No.2 "Low psychological pressure"
- No.3"Free atmosphere"
- No.7 "Natural feeling"
- No.9 "Relaxing"
- No.13 "Enjoyable"
- No14 "Not noisy in sound"

Results

T-test result:

T-test results on CAB test

t-test				
Items	Environment(average ± SD)		t	p
	OPWS(N=20)	VRWS(N=20)		
Correct Answer	30.70 ± 3.85	32.25 ± 4.22	-1.214	0.232
Time Difference in Two Experiments	23.10 ± 2.61	21.60 ± 2.66	1.798	0.08

T-test result on questionnaire

t-test				
Question Number	Environment(average ± SD)		t	p
	OPWS(N=20)	VRWS(N=20)		
Q1: Broad view	2.70 ± 0.98	5.10 ± 1.25	-6.753	0.000**
Q2: Low psychological pressure	2.90 ± 1.21	5.05 ± 1.00	-6.13	0.000**
Q3: Free atmosphere	2.95 ± 1.39	5.20 ± 1.20	-5.476	0.00**
Q4: Comfortable	3.35 ± 1.39	4.05 ± 0.89	-1.901	0.066
Q5: Well-lighted	5.00 ± 1.08	5.60 ± 0.94	-1.878	0.068
Q6: Not tired	3.90 ± 1.17	4.05 ± 1.10	-0.419	0.678
Q7: Natural feeling	2.30 ± 0.86	5.05 ± 1.15	-8.568	0.000**
Q8: Grace	3.30 ± 1.22	3.85 ± 1.14	-1.476	0.148
Q9: Relaxing	2.80 ± 0.89	5.50 ± 1.15	-8.301	0.000**
Q10: Cheerful	3.70 ± 0.86	4.35 ± 1.23	-1.938	0.06
Q11: Easy to work	4.00 ± 1.12	3.85 ± 1.35	0.382	0.704
Q12: Not noisy in movement	4.40 ± 1.64	4.40 ± 1.10	0	1
Q13: Enjoyable	2.50 ± 1.10	5.65 ± 1.09	-9.098	0.000**
Q14: Not noise in sound	2.60 ± 1.39	5.90 ± 0.72	-9.424	0.000**
Q15: Motivated	3.45 ± 1.43	4.15 ± 0.81	-1.901	0.067
Q16: Efficient	3.30 ± 1.42	4.00 ± 1.03	-1.789	0.082
*p<0.05 **p<0.01				

Discussion

VRWS with excellent OPWS characteristics:

Avoiding Visual and Auditory Interferences

- Significant Difference: Q2, Q3, Q9, Q14
  - » Compared with the noisy OPWS, the elegant and comfortable virtual environment design and private use features could play a role in preventing psychological pressure.
- Non-significant difference: Q12

Good Lighting and Enough Natural Light

- Significant Difference: Q1, Q7, Q9, Q13
  - » The floor-to-ceiling windows significantly improves the participant's vision. Also easier for natural light through the windows to enter the room.
- Marginally Significant Difference: Q5

Privacy

- Significant Difference: Q2,Q3,Q13
  - » Privacy design of the VRWS provides reduce psychological pressure on the workers.
- Marginally Significant Difference: Q4, Q10, Q15, Q16
- Non-significant difference: Q6, Q11

Work efficiency

- Time differences in each setting and the correct answer of the two conditions are non-significant difference.

Conclusion

Designing VRWS which can deal with personal work efficiency, and identify the factors which in virtual reality affect work efficiency.

- **This research initiated a design standard for the VRWS, which can support other people to create more efficient VRWS.**

RQ1: How VRWS handle work efficiency?

- **We found that the existing findings in OPWS design have potentials to be a design standard for VRWS.**

RQ2: What factors that affect work efficiency in VRWS?

- **Avoiding visual and auditory interference, with good lighting and sufficient natural light, and privacy protection, would expect to maintain or improve work efficiency.**

Contributions:

- **There was no design standard created for VRWS before. This research initiated a design standard for the VRWS, which can support other people to create more efficient VRWS.**