

pre-activity survey					
Question No.	1	2	3	4	5
raw tally count					
Y	31		18		
N	8		22		
1		1		2	7
2		5		19	1
3		10		17	28
4		5		1	1
5		1		1	2
6		16			
percentage					
Y	78%		45%		
N	20%		55%		
1		3%		5%	18%
2		13%		48%	3%
3		25%		43%	70%
4		13%		3%	3%
5		3%		3%	5%
6		40%			

free comments by students

- I personally found it hard to answer the first three questions as I am not familiar with the topics. Thank you for your time and effort.
- I think VR headset is an amazing idea for the field of chemistry, it may enhance the learning and the understanding of molecules.
- A dizzy feeling as an effort from VR headset. Also, I am concerned that it will not meet my expectations.
- I am a bit concerned that the VR headset might make me dizzy.
- I am excited to use VR for organic chemistry and I feel like it would really picture the molecules.

olfactory test			
Question No.	1	2	3
raw tally count			
Y	0		
N/0	40	0	
1		3	0
2		9	3
3		14	28
4		14	9
percentage			
Y	0%		
N/0	100%	0%	
1		8%	0%
2		23%	8%
3		35%	70%
4		35%	23%

observations from researchers

The smell of two enantiomers are somewhat similar but after a familiarization, majority of students (70%) identified them better than a random chance (> 2 correct in 4 attempts) through our double blind test. Most of the students (92.5%) agreed that the smelling activity is helpful for them to learn stereochemistry. The purity of the compounds were verified by polarimeter below. We suspect that cotton wool is a chiral substrate and may influence the result. Other non-chiral materials (e.g. sponge) should be used in future experiments.

Na lamp – 589 nm at 20.0 °C
 (S)-(+)-Carvone: 100 µL/dL in DCM
 (R)-(-)-Carvone: 100 µL/dL in DCM

PerkinElmer High Precision Polarimeter 341

no comments from students

post-activity survey																
Question No.	1	2	3	4a	4b	4c	4d	4e	4f	4g	4h	5a	5b	5c	5d	5f
raw tally count																
Y	27		22													
N	13		18													
1		0		2	12	0	1	18	12	0	0	5	5	19	2	8
2		9		4	23	2	0	16	20	2	3	6	15	7	4	8
3		2		20	2	20	19	4	4	17	13	14	9	8	3	5
4		24		14	3	18	20	2	4	21	24	13	3	4	8	10
5		3										1	7	1	22	8
6		0														
percentage																
Y	68%		55%													
N	33%		45%													
1		0%		5%	30%	0%	3%	45%	30%	0%	0%	13%	13%	48%	5%	20%
2		23%		10%	58%	5%	0%	40%	50%	5%	8%	15%	38%	18%	10%	20%
3		5%		50%	5%	50%	48%	10%	10%	43%	33%	35%	23%	20%	8%	13%
4		60%		35%	8%	45%	50%	5%	10%	53%	60%	33%	8%	10%	20%	25%
5		8%										3%	18%	3%	55%	20%
6		0%														

free comments by students

- It would be beneficial if we got to use it ourselves as we are only the molecules on the projector.
- Very fun and exciting, wants to play again.
- Sometimes, it is hard to see the molecule in VR; maybe they should have label on it.
- VR is fun, I think more exposure to it could really improve understanding.
- I think the internet should be fixed so the session can be continued without distractions.
- Maybe need to try the more stable software/website next time for a smooth version of the instruction and demonstration.
- I would like to hear more details about each structure, for instance why do molecules have mirror image.

statistical tests			
	Y	N	total
UCLA	4	8	12
MUIC	27	13	40
total	31	21	52
p	0.0476	(Fisher exact test)	

ref: <https://www.programiz.com/r/online-compiler/>
 ref: <https://www.medcalc.org/calc/fisher.php>

✓ p-value is confirmed by R (programming language)

UCLA: "I would like to see more 3D and augmented reality tools used in future classes."

MUIC: "I wish to see more VR application used in future classes."

UCLA: 10.1021/acs.jchemed.2c01131 Table 3 (Question 7) MUIC: post-activity survey (Question 4g)

O	SA	A	D	SD	total
UCLA	4	6	1	1	12
MUIC	24	13	3	0	40
total	28	19	4	1	52

E	SA	A	D	SD	total
UCLA	6.46	4.38	0.92	0.23	12
MUIC	21.5	14.6	3.08	0.77	40
total	28	19	4	1	52

(O-E) ² /E	SA	A	D	SD	total
UCLA	0.94	0.6	0.01	2.56	
MUIC	0.28	0.18	0	0.77	
total					

χ^2	5.33
p	0.15

ref: <https://www.statology.org/chi-square-test-of-independence-excel>