University of Glasgow

END. ENGINEERING DESIGN.

Bridging Engineering & Education

Tech for Enhanced Training

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Summary – March 2024

1) **LCs research in my lab:** Applications for training and teaching purposes.

2) Technologies for Enhanced Training Experience: XR in engineering education.

- Teaching real-world engineering challenges + Hands-on experience in a controlled environment.
- People learn better *collaboratively*. AR/VR can bring people together in the same environment.
- Physiological real-time data from participants to understand engagement in the VR environment.

University of Glasgow

- Lead the Engineering Design Research Group at **Glasgow University**.

- Scotland Chair of the IEEE Education Society.

- Chair of UK:iLRN Chapter

- Recently interested in developing **interactive** technologies that have a **measurable** impact on the way we **learn**.

Research Interests

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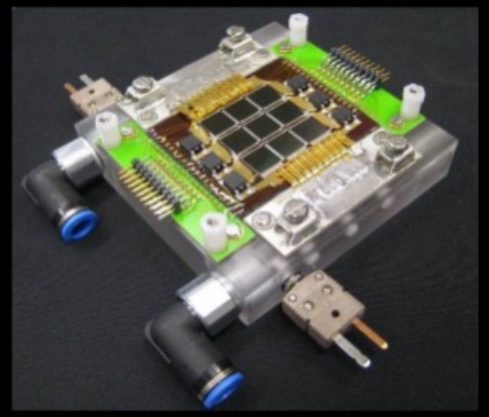
END

ENGINEERING DESIGN

- Home
  - Projects
    - Sensing & Signal Processing
    - Energy Harvesting
    - Design for Learning
  - Team
  - Resources
  - Publications
  - Initiatives
  - Contact

CURRENT RESEARCH THEMES AND PROJECTS:

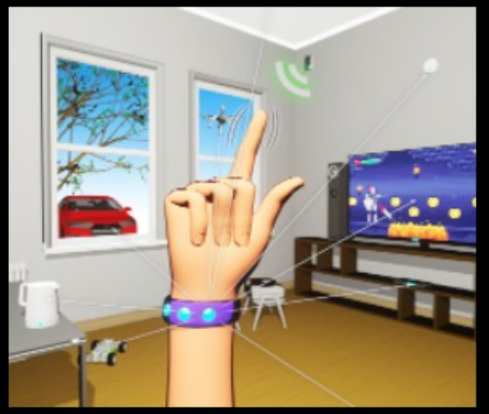


Energy Harvesting

Energy scavenging from light, motion and RF sources.

Design for Learning

Improving the design and delivery of curricula using technology.

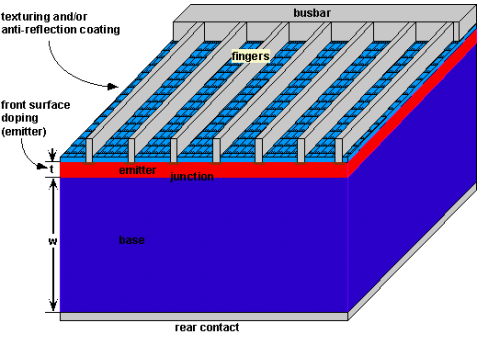


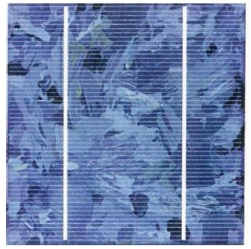
Sensing & Signal Processing

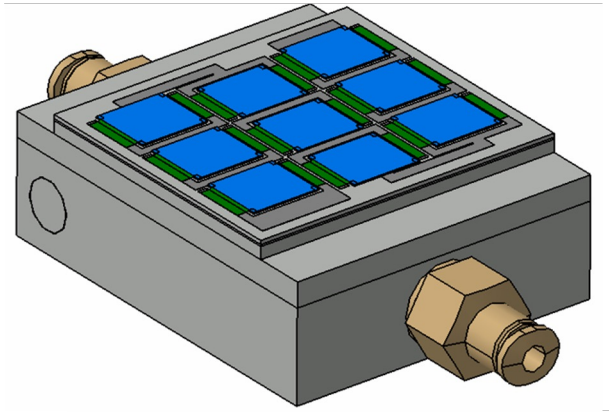
Our work has focussed on hand and eye gesture recognition.

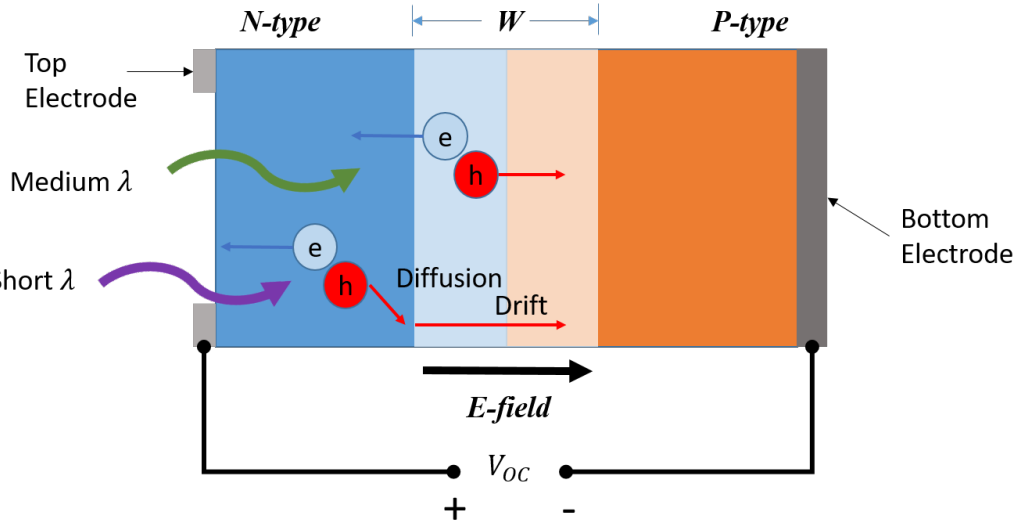
Energy Harvesting

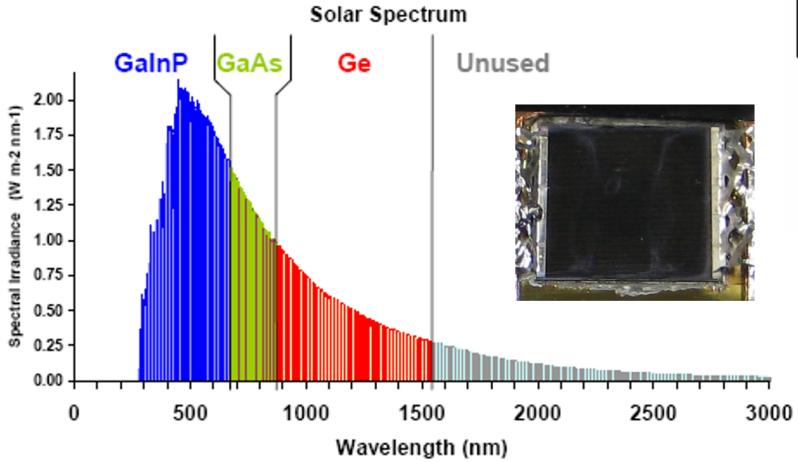
University of Glasgow

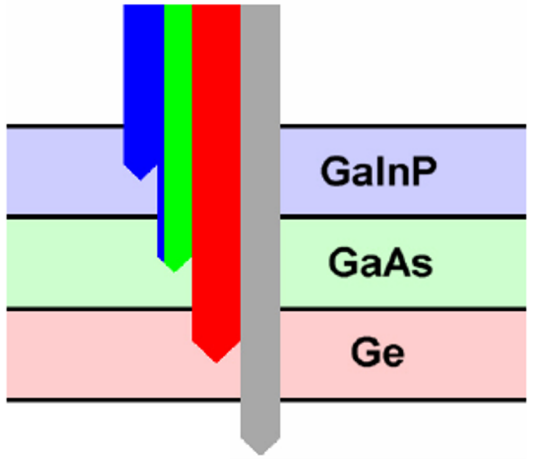


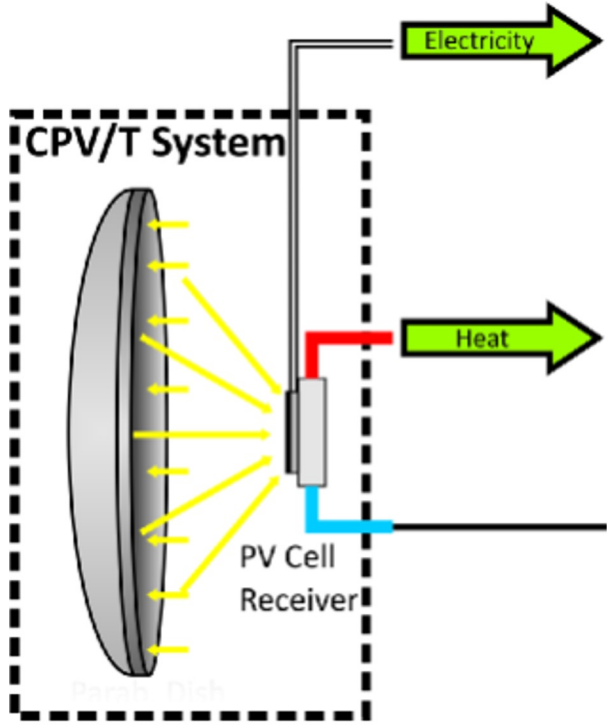








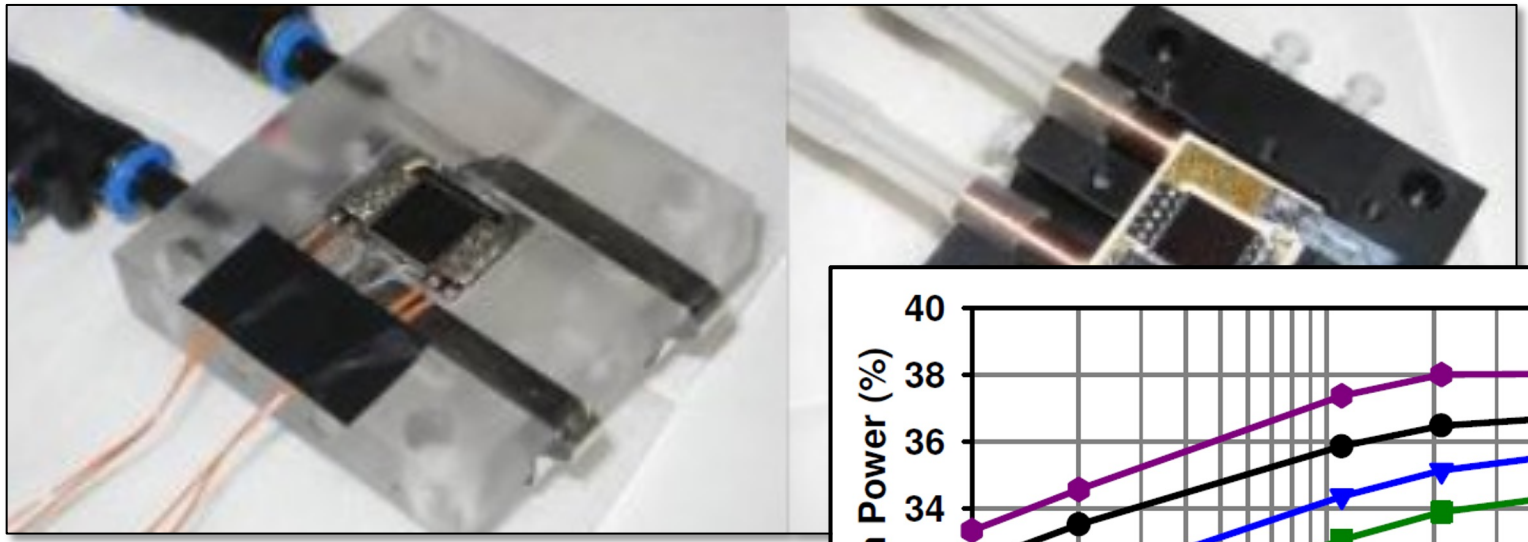


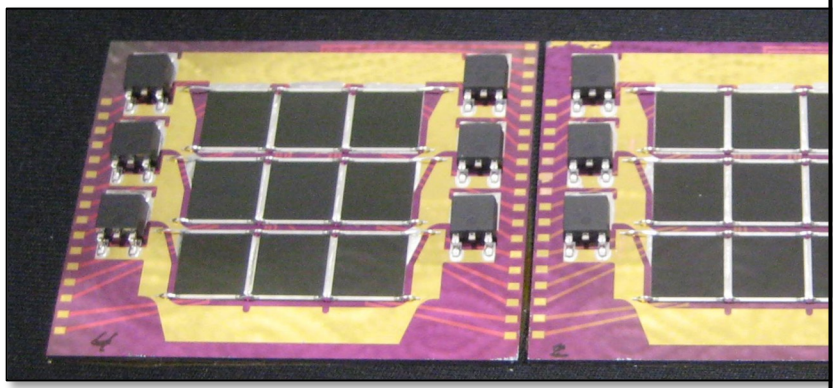


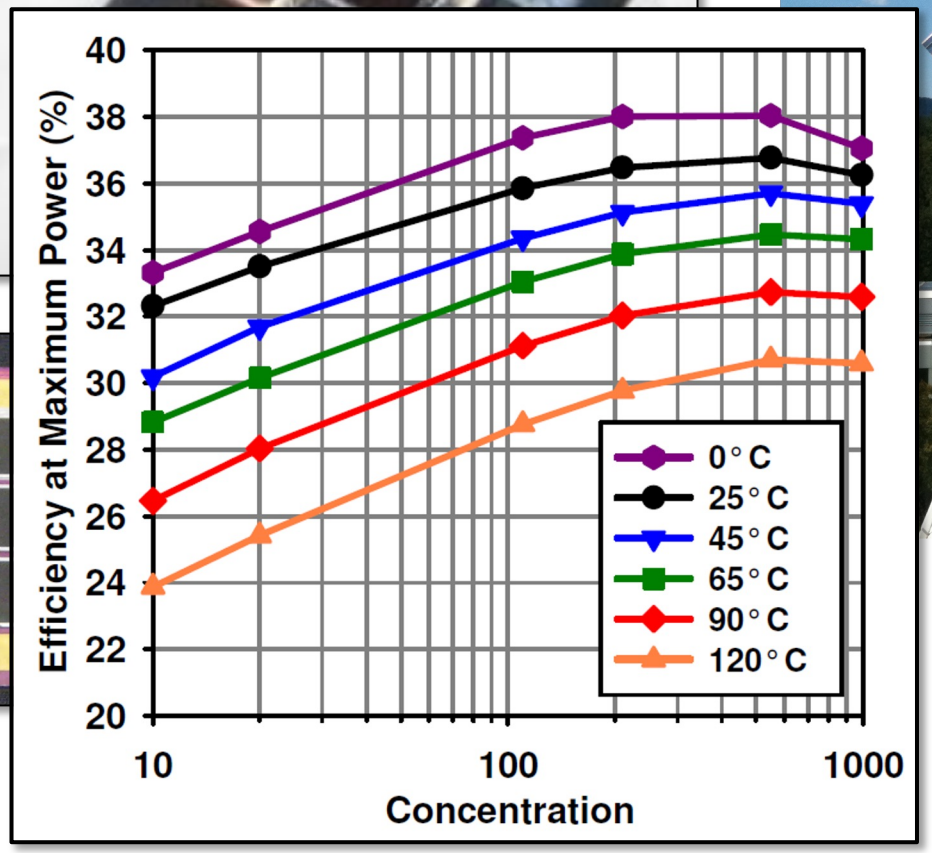
Sunlight carries photons with various energies.
Cell material has specific "band gap" energy.

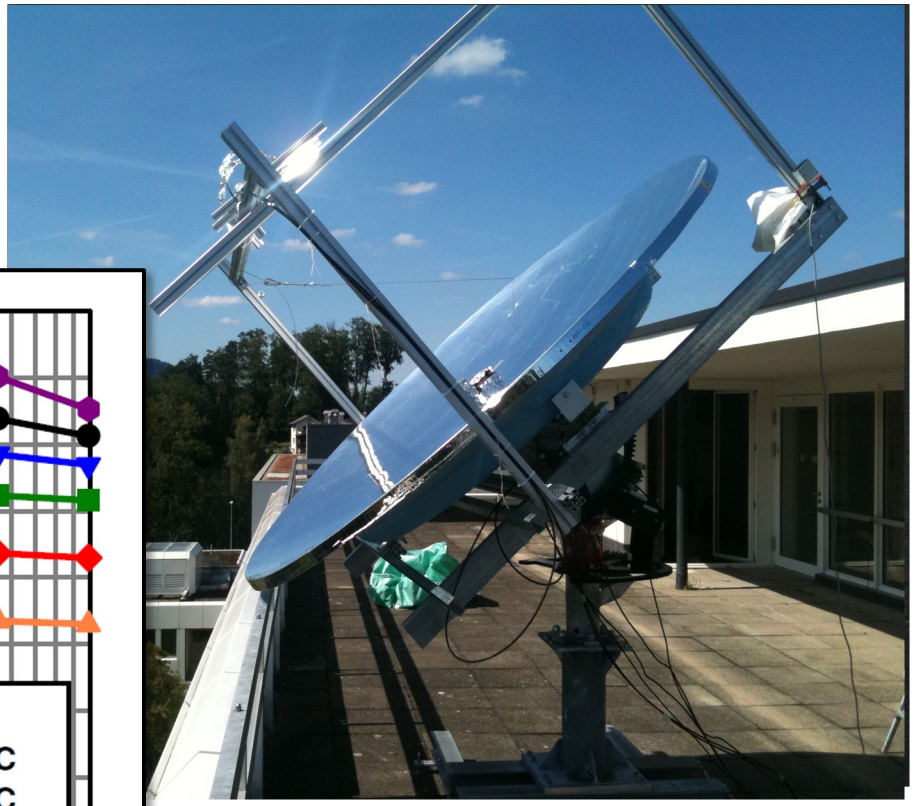
Patent Numbers: US009985147B2, US20160322933, US9437766, US20160322933

Energy Harvesting



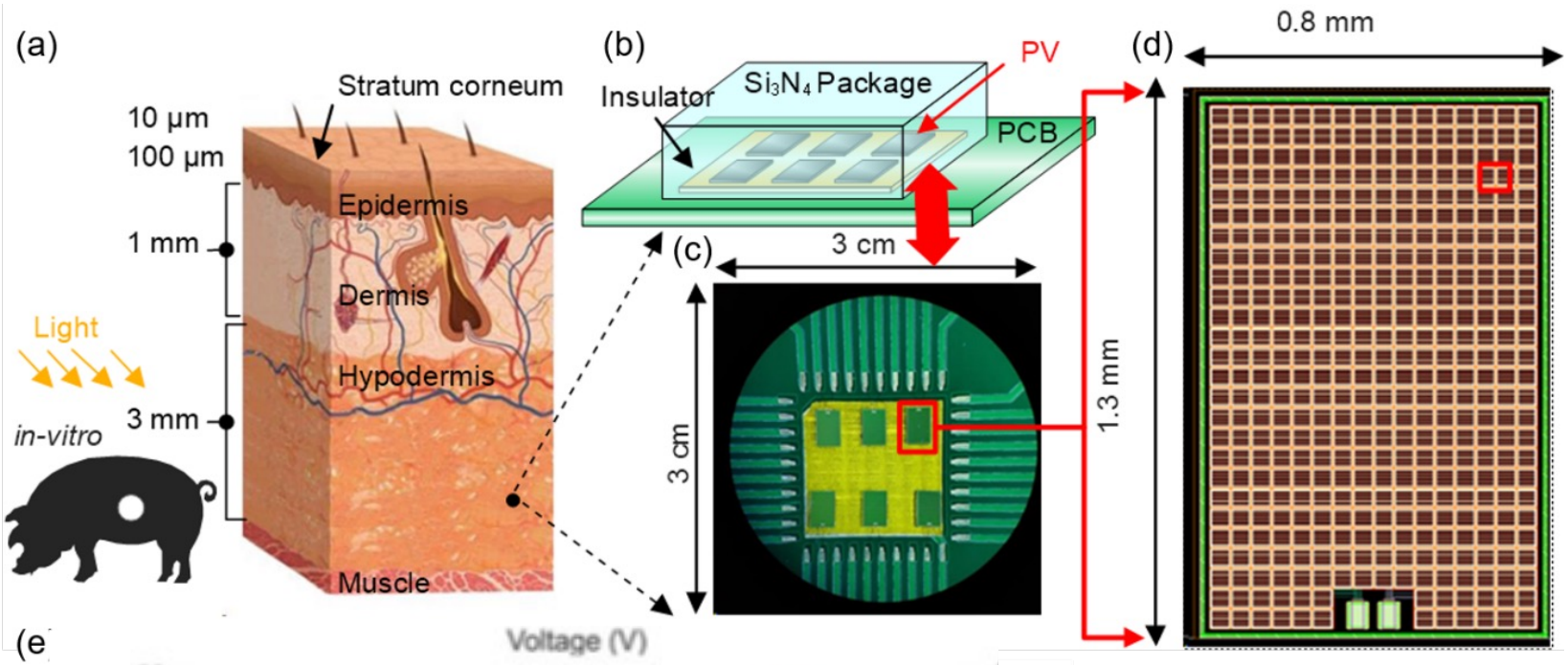


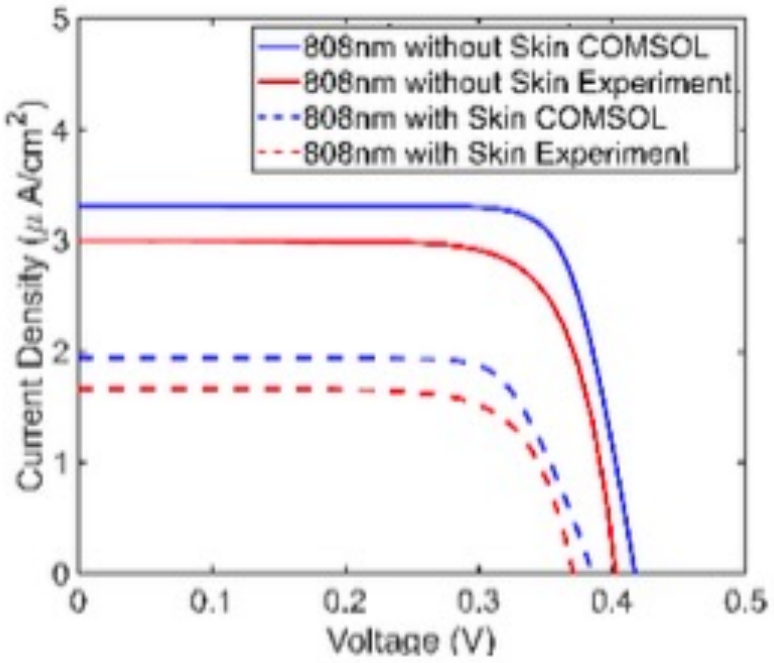


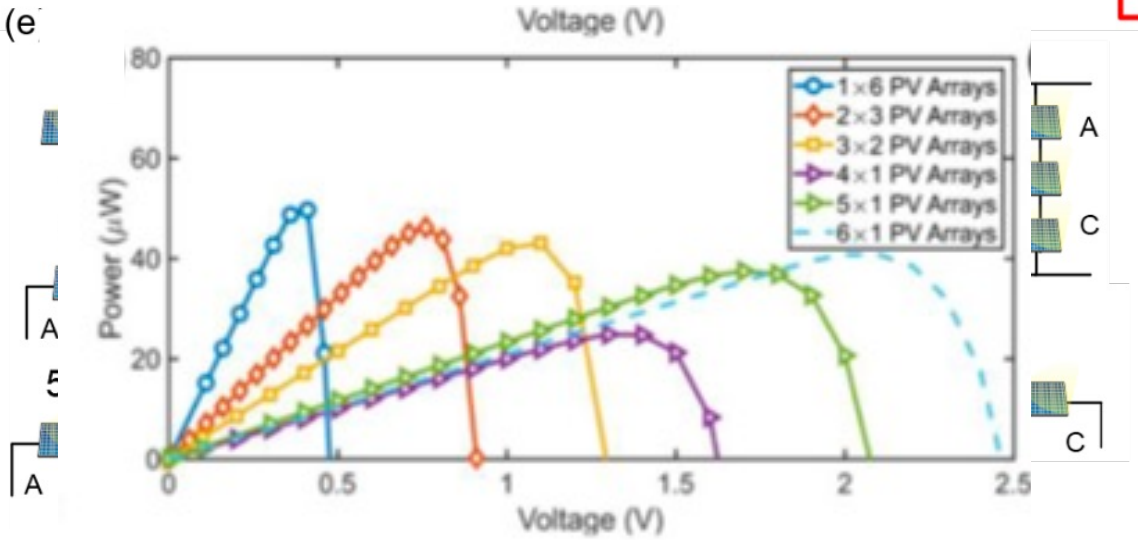


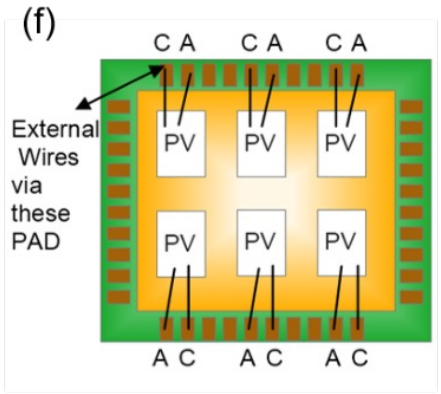
Patent Numbers: US009985147B2, US20160322933, US9437766

Energy Harvesting









$$I_{total} = MI_L - MI_0\left[\exp\left(\frac{qV_{total}}{nkTN}\right) - 1\right]$$

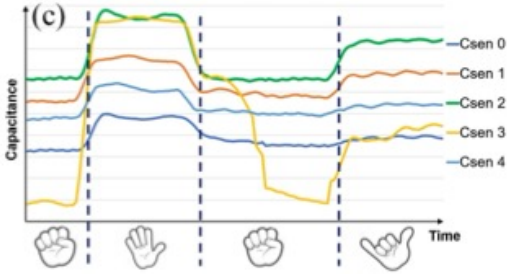
References:

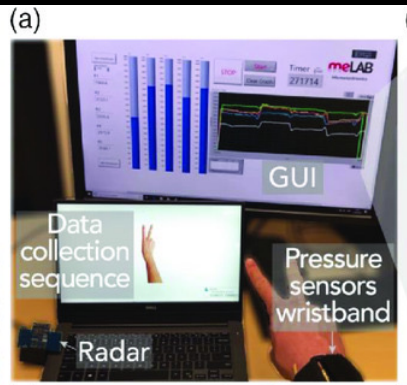
(2023) Self-powered implantable CMOS photovoltaic cell with 18.6% efficiency. IEEE Transactions on Electron Devices, 70(6), pp. 3149-3154. (doi: 10.1109/TED.2023.3268630)

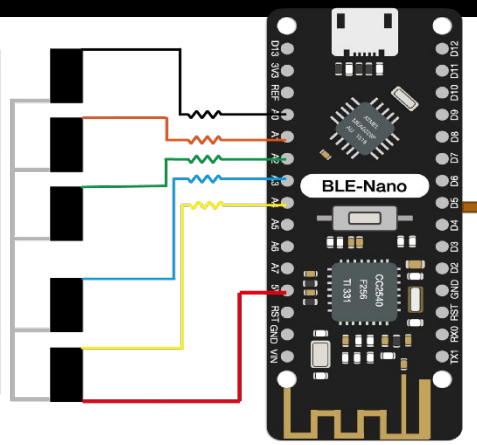
(2020) Self-powered implantable medical devices: photovoltaic energy harvesting review. *Advanced Healthcare Materials*, 9(17), 2000779. (doi: 10.1002/adhm.202000779)

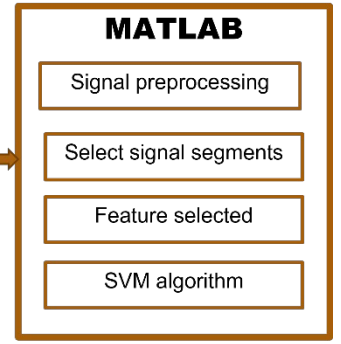
(2021) Simulation of crystalline silicon photovoltaic cells for wearable applications. *IEEE Access*, 9, pp. 20868-20877. (doi: 10.1109/ACCESS.2021.3050431)

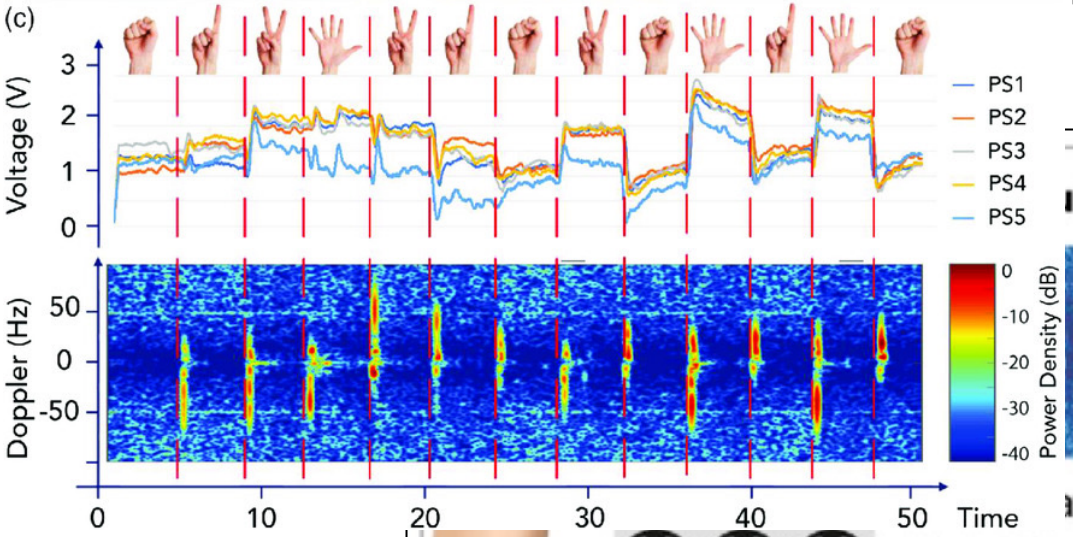
Gesture Recognition

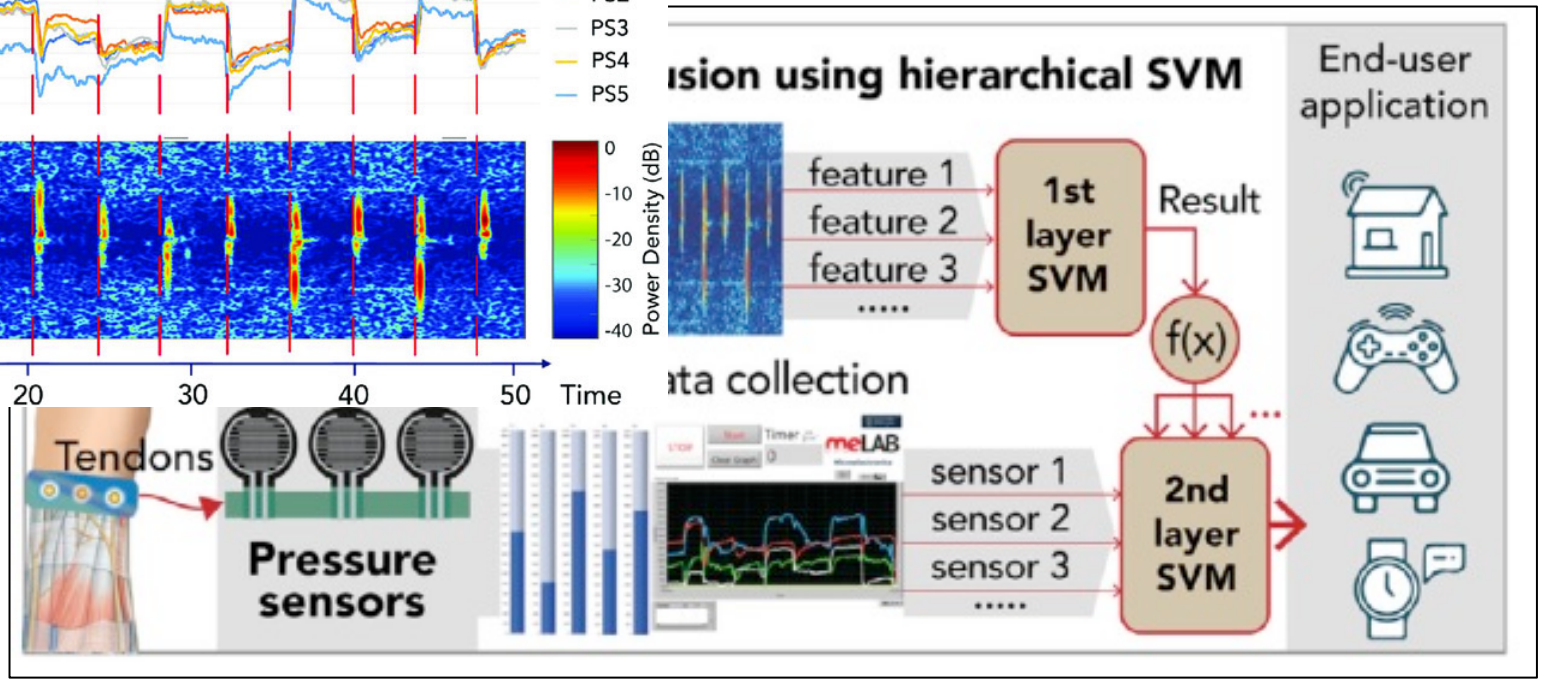










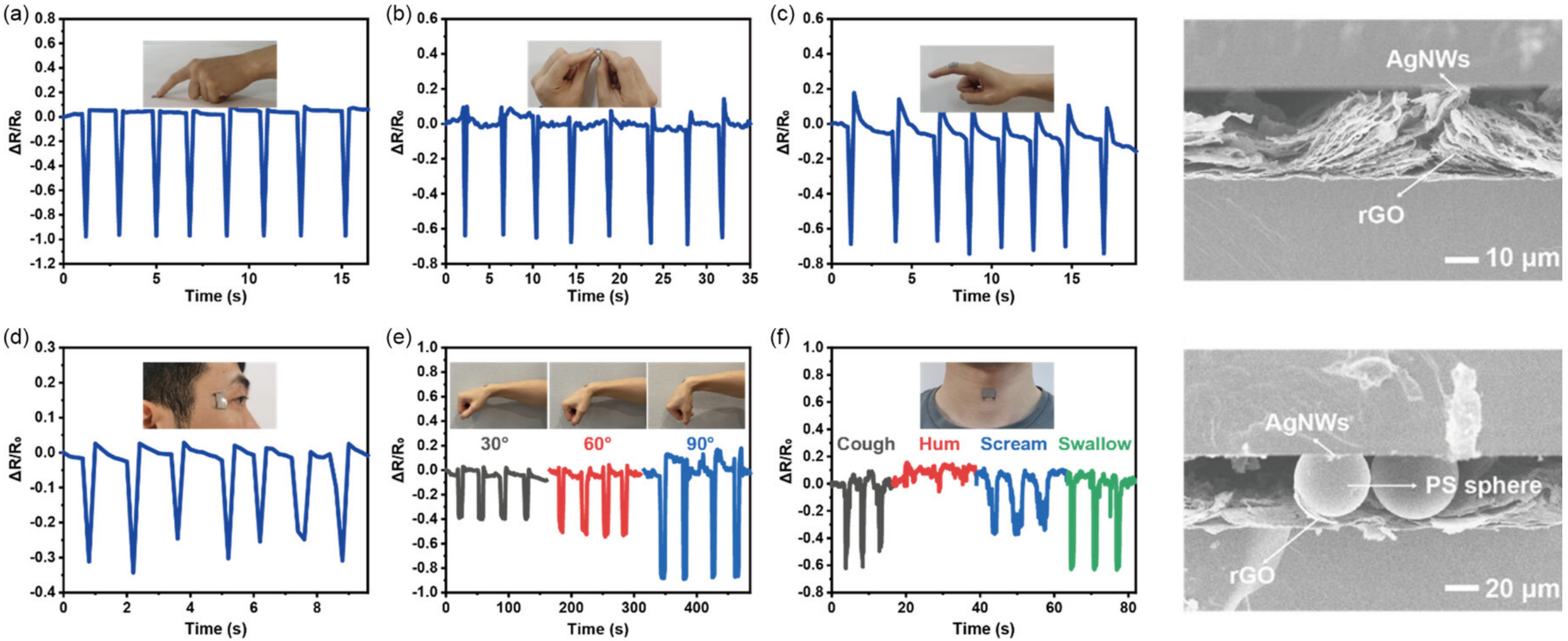


References:

(2019) Fusion of wearable and contactless sensors for intelligent gesture recognition. *Advanced Intelligent Systems*, 1(7), 1900088.

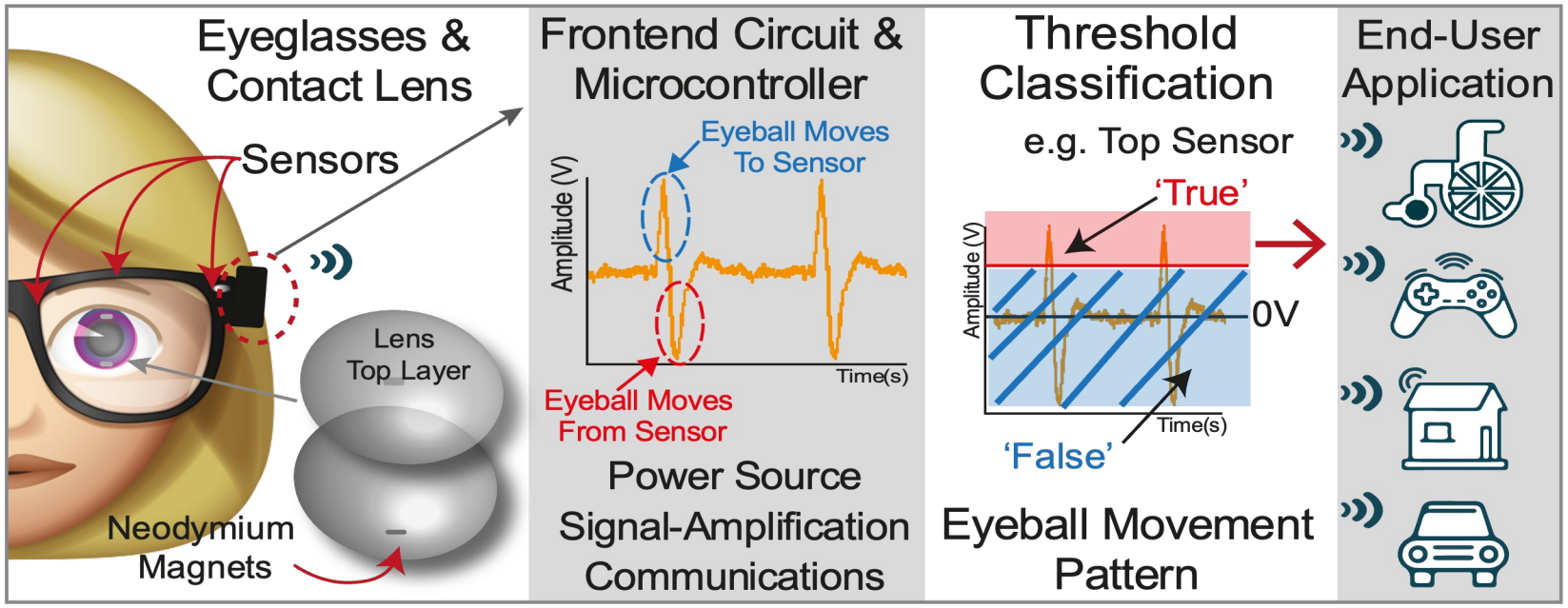
(2019) Wrist-worn gesture sensing with wearable intelligence. *IEEE Sensors Journal*, 19(3), pp. 1082-1090.

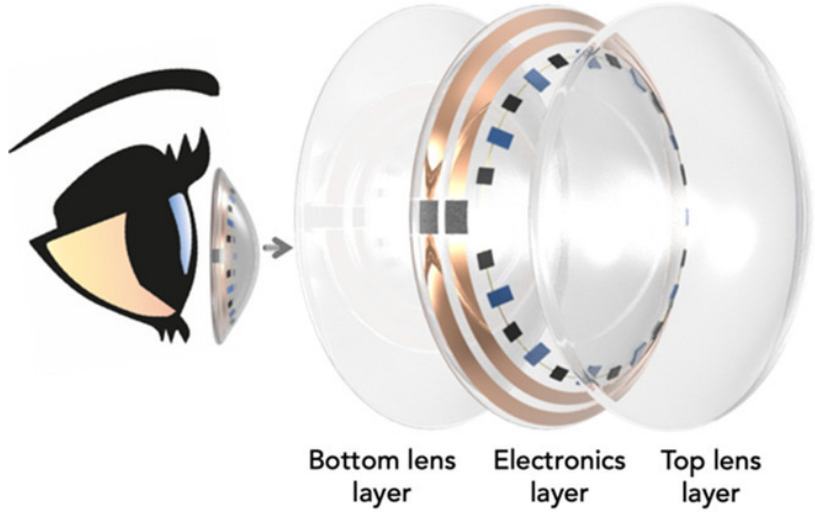
Gesture Recognition

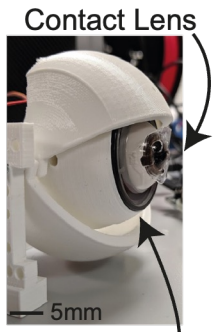


(2023). Speech Recognition Using Intelligent Piezoresistive Sensor Based on Polystyrene Sphere Microstructures. Advanced Intelligent Systems, 2200427.

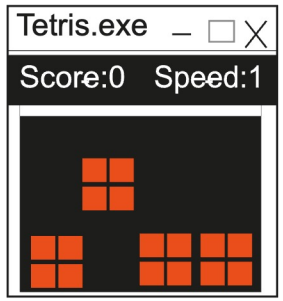
Gesture Recognition



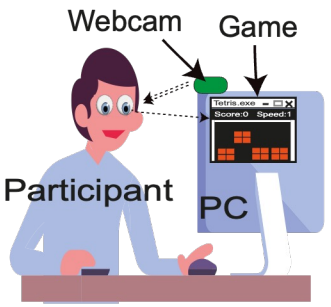




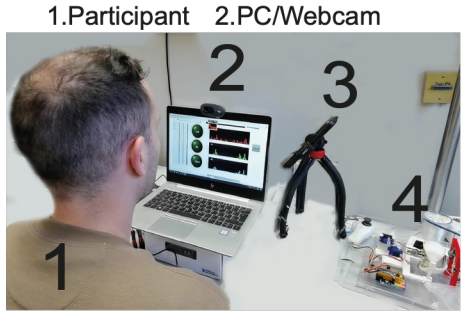
Eye Model
(a)



Tetris Game
(b)



Eye Recording
(c)



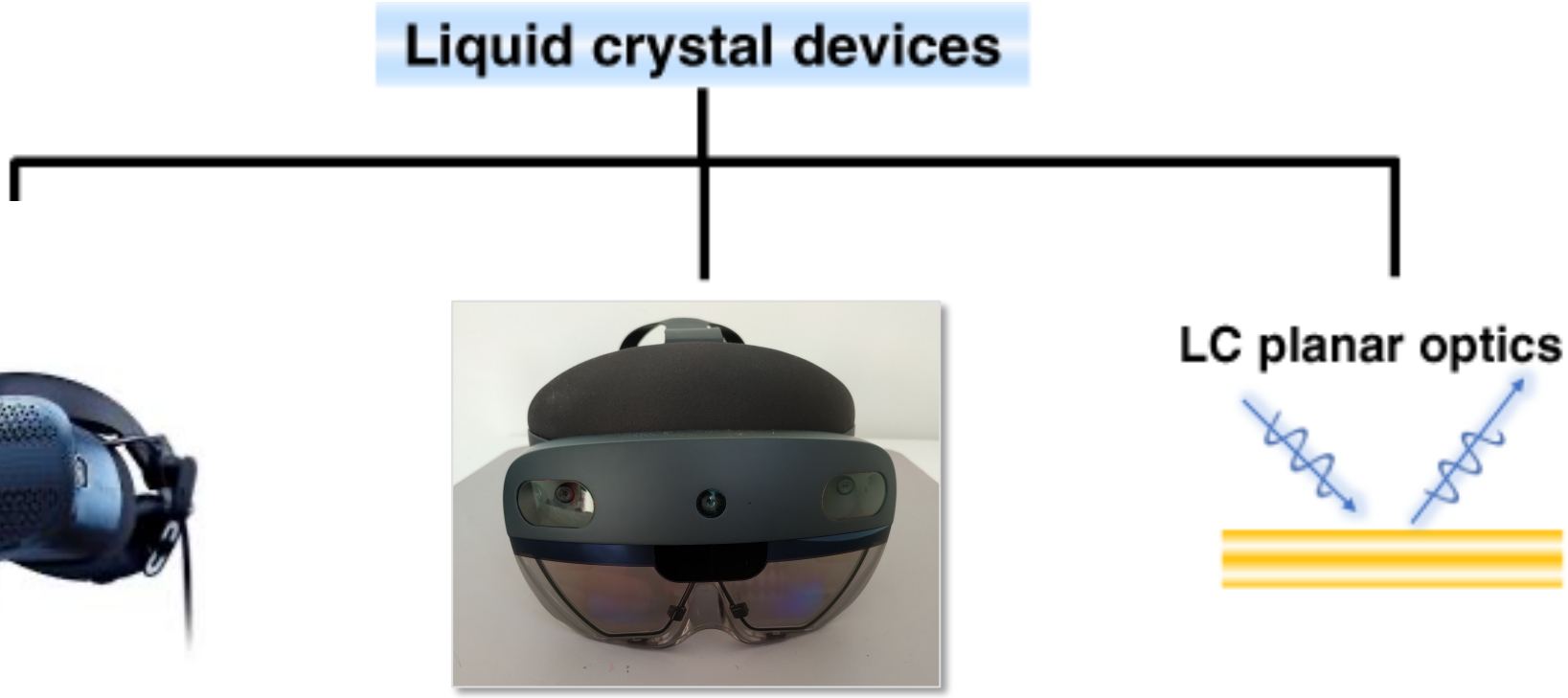
Experiment Setup
(d)

References:

(2020) Spintronic sensors based on magnetic tunnel junctions for wireless eye movement gesture control. *IEEE Transactions on Biomedical Circuits and Systems*, 14(6), pp. 1299-1310.

(2020) Electronic contact lens: a platform for wireless health monitoring applications. *Advanced Intelligent Systems*, 2(4), 1900190

LCs for AR/VR



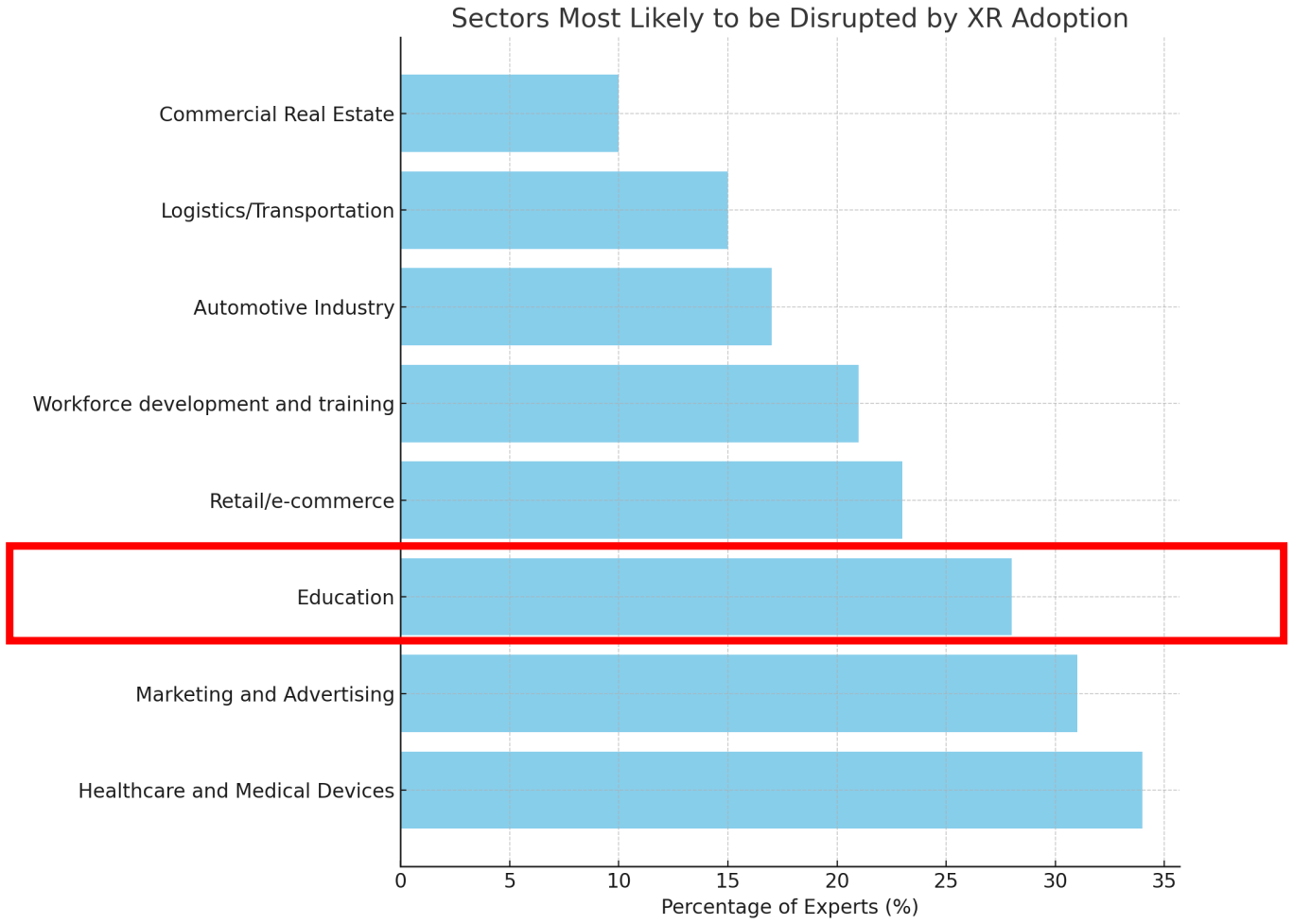
Pros: Cost and power consumption
Cons: Viewing Angle, Screen Door Effect, Slow response time

Pros: high-resolution, contrast and resolution.
Cons: More expensive, bulkier and lower brightness.

LC SLMs in holographic displays.
Pros: Resolution enhancement, field-of-view widening for AR and VR systems.
Cons: Cost, brightness.

Yin, K., Hsiang, EL., Zou, J. *et al.* Advanced liquid crystal devices for augmented reality and virtual reality displays: principles and applications. *Light Sci Appl* 11, 161 (2022). https://doi.org/10.1038/s41377-022-00851-3

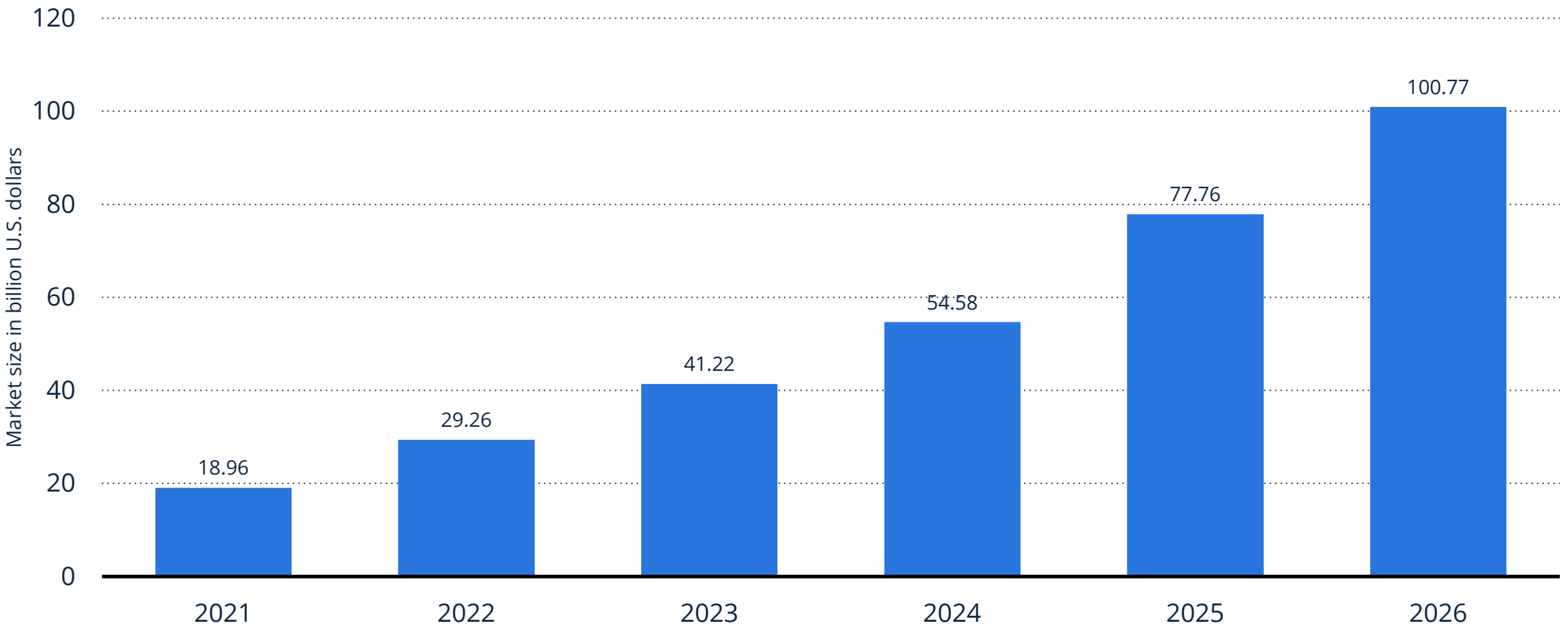
Why XR?



statista

Source: https://www.statista.com/statistics/1185060/sectors-disrupted-immersive-technology-xr-ar-vr-mr/

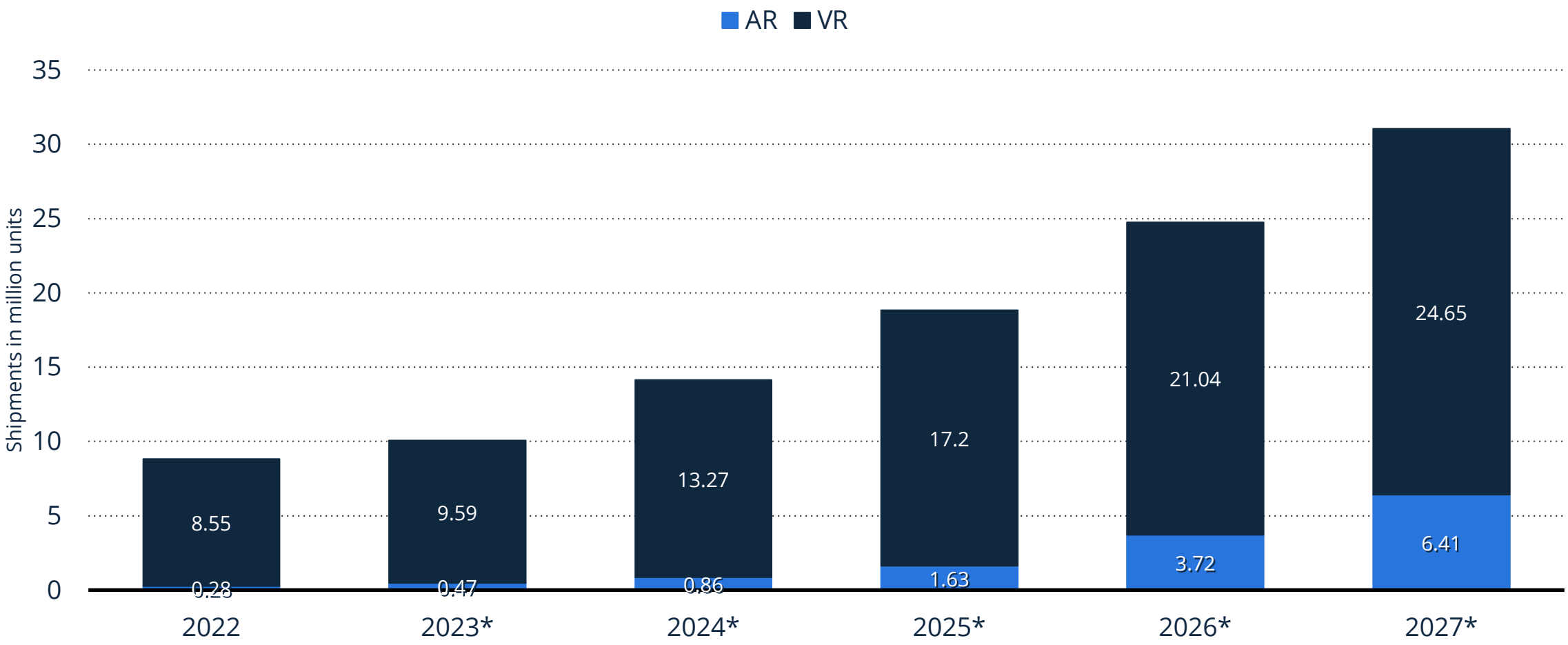
XR Worldwide Market



Note(s): Worldwide; 2021 to 2023
Source(s): ARtillery Intelligence

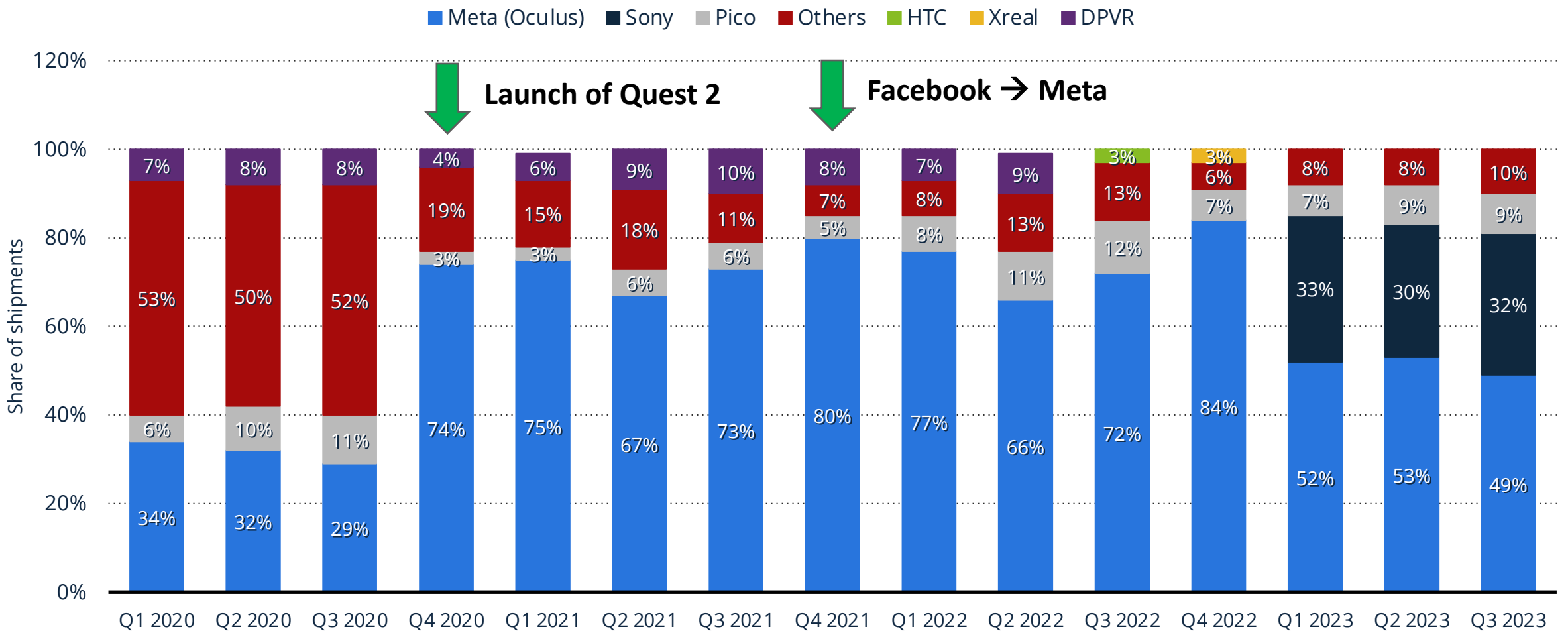
statista

XR Worldwide Shipments



Source: Statista

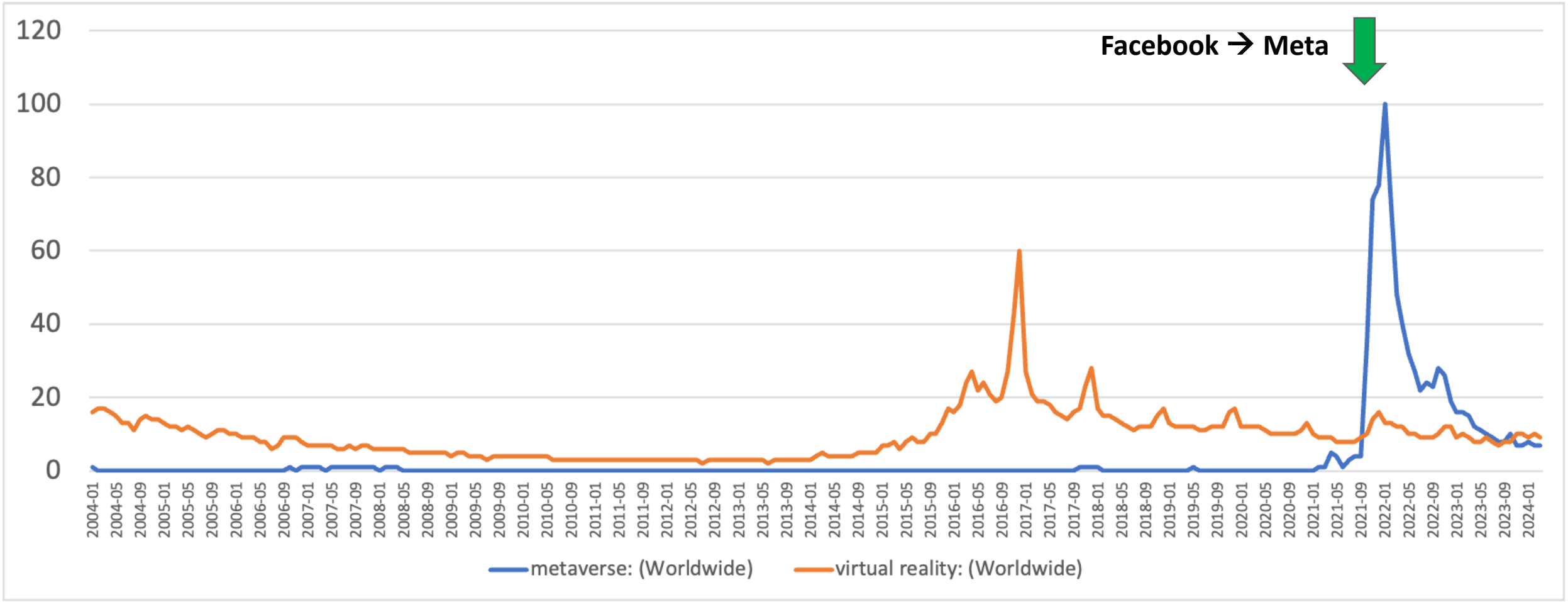
XR Vendor Shipment Share



Meta was the leading extended reality (XR) headset vendor in terms of shipments in 2023, occupying 49 percent of the market in the third quarter of the year. Meta's device range includes the Quest pro and Quest 3, with the latter released in 2023. Sony ranked second among vendors, accounting for around 32 percent of shipments.
Source: Counterpoint Research

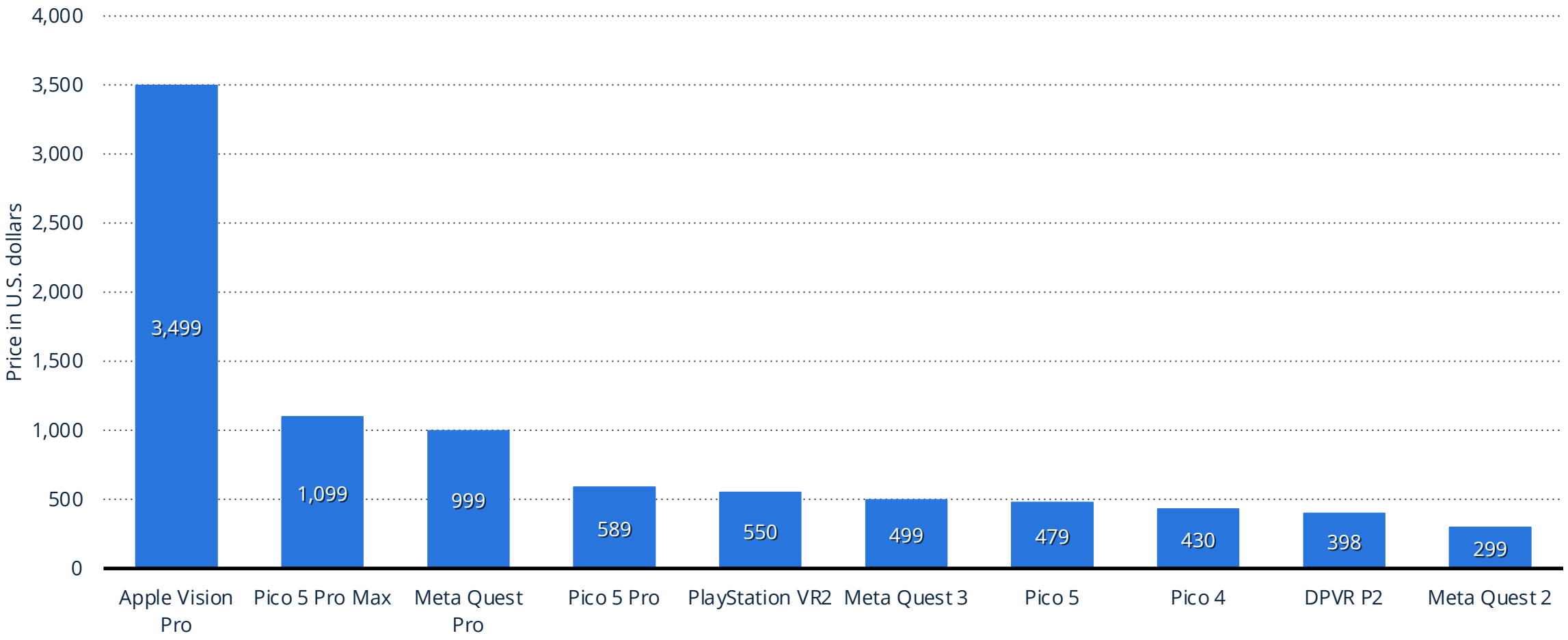
statista

XR Vendor Shipment Share



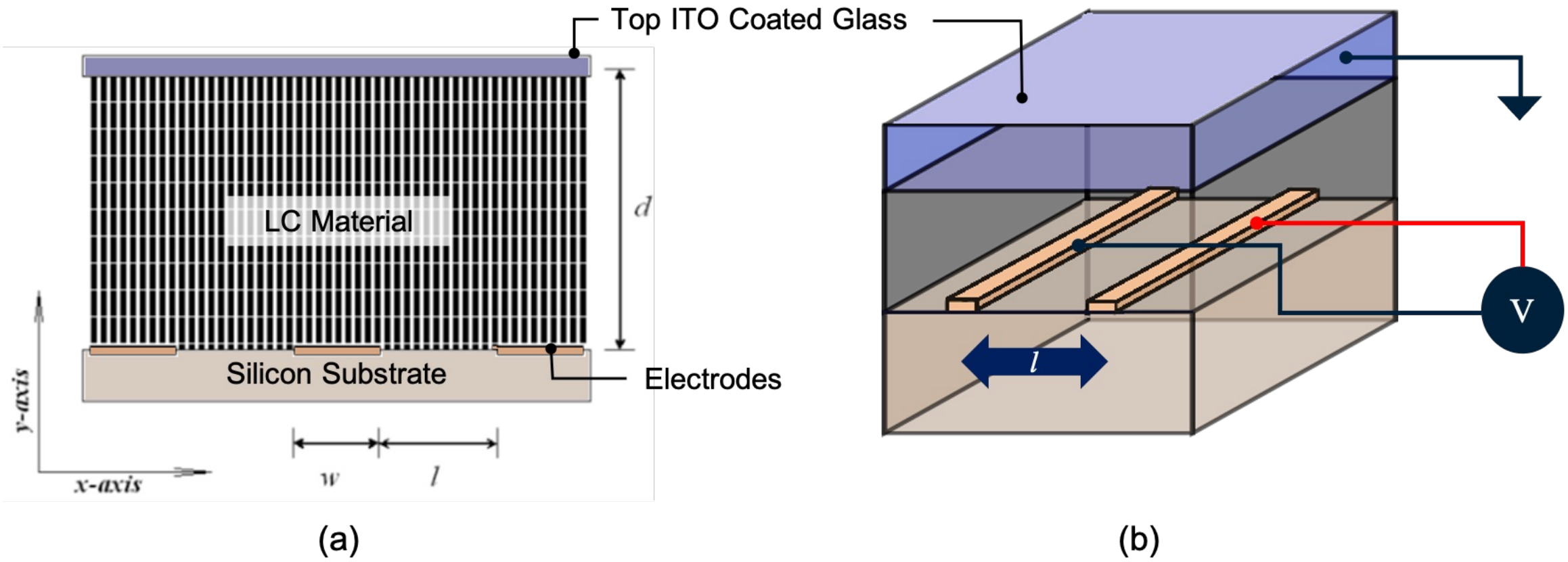
XR HMD Prices

University of Glasgow



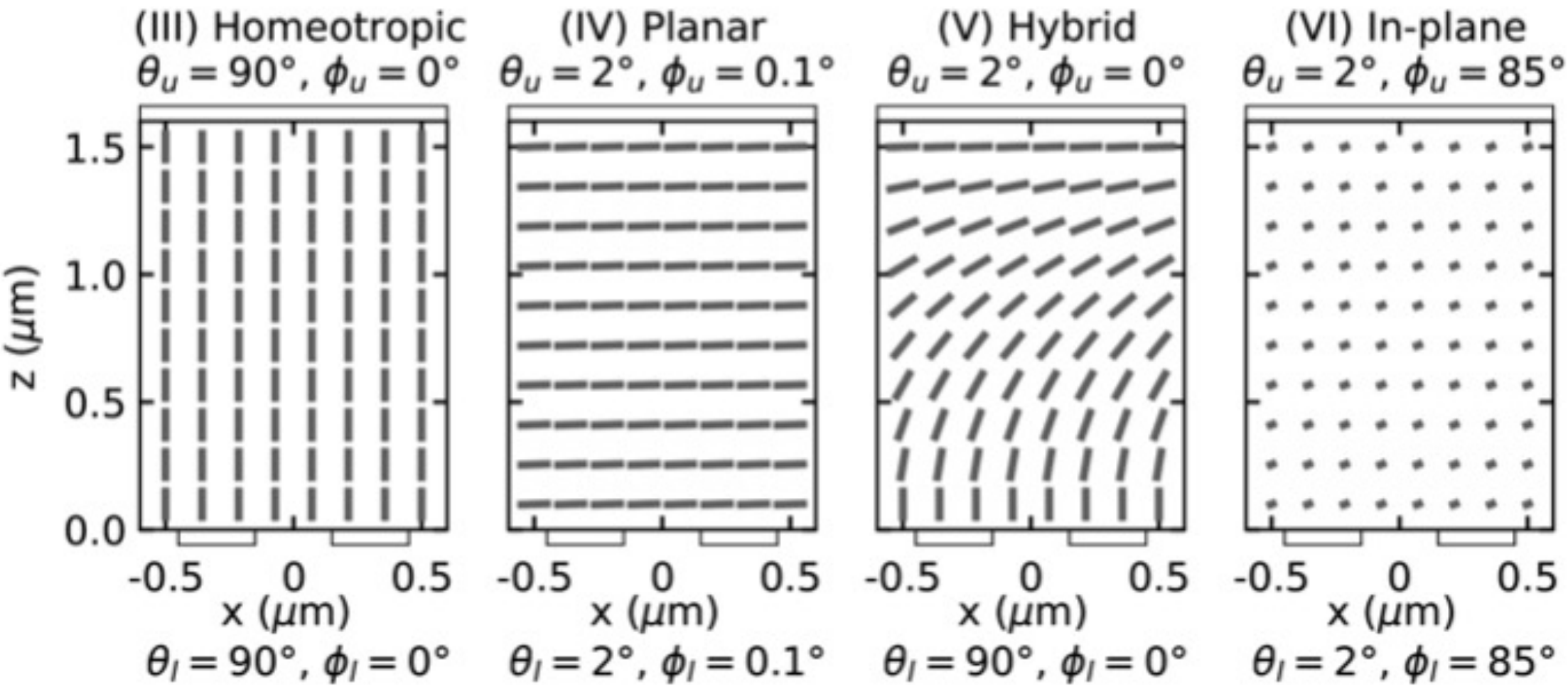
statista

Fringing Fields in LC devices



Schematic diagram of LC cell

LC Alignment – What do we mean?

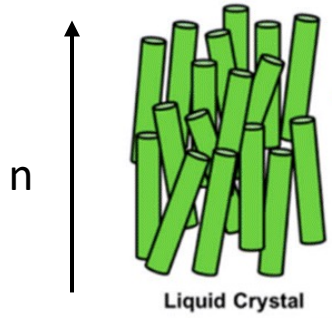


Reconfigurable Devices - Defects

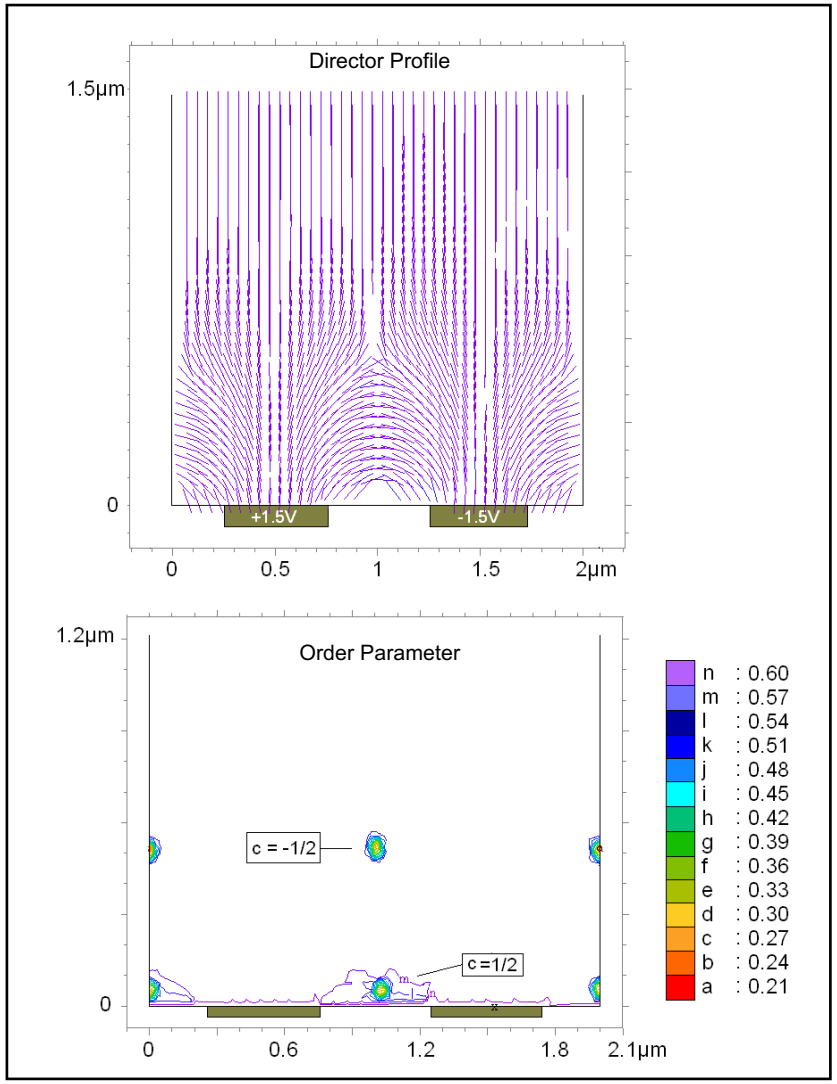
$$Q = S(n \otimes n) - \frac{1}{3}S.I$$

$$F_{es} = \frac{1}{2}\epsilon_0(\epsilon E).E = \frac{1}{2}\epsilon_0\epsilon\nabla U.\nabla U$$

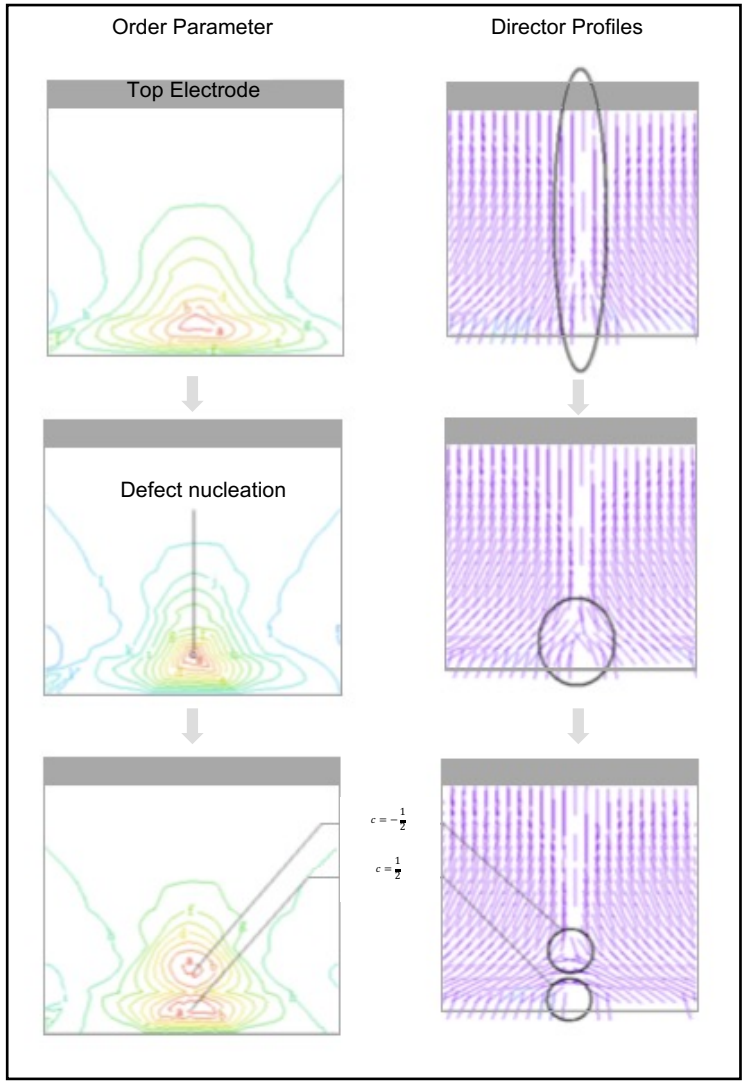
$$F = \int_V \left(\frac{K}{2}\nabla Q^2 + \sigma(Q) - \frac{1}{2}\epsilon_0\epsilon\nabla U.\nabla U\right)dv$$



(2021) Reconfigurable surfaces using fringing electric fields from nanostructured electrodes in nematic liquid crystals. Advanced Theory and Simulations, 4(7), 2100058. (doi: 10.1002/adts.202100058)

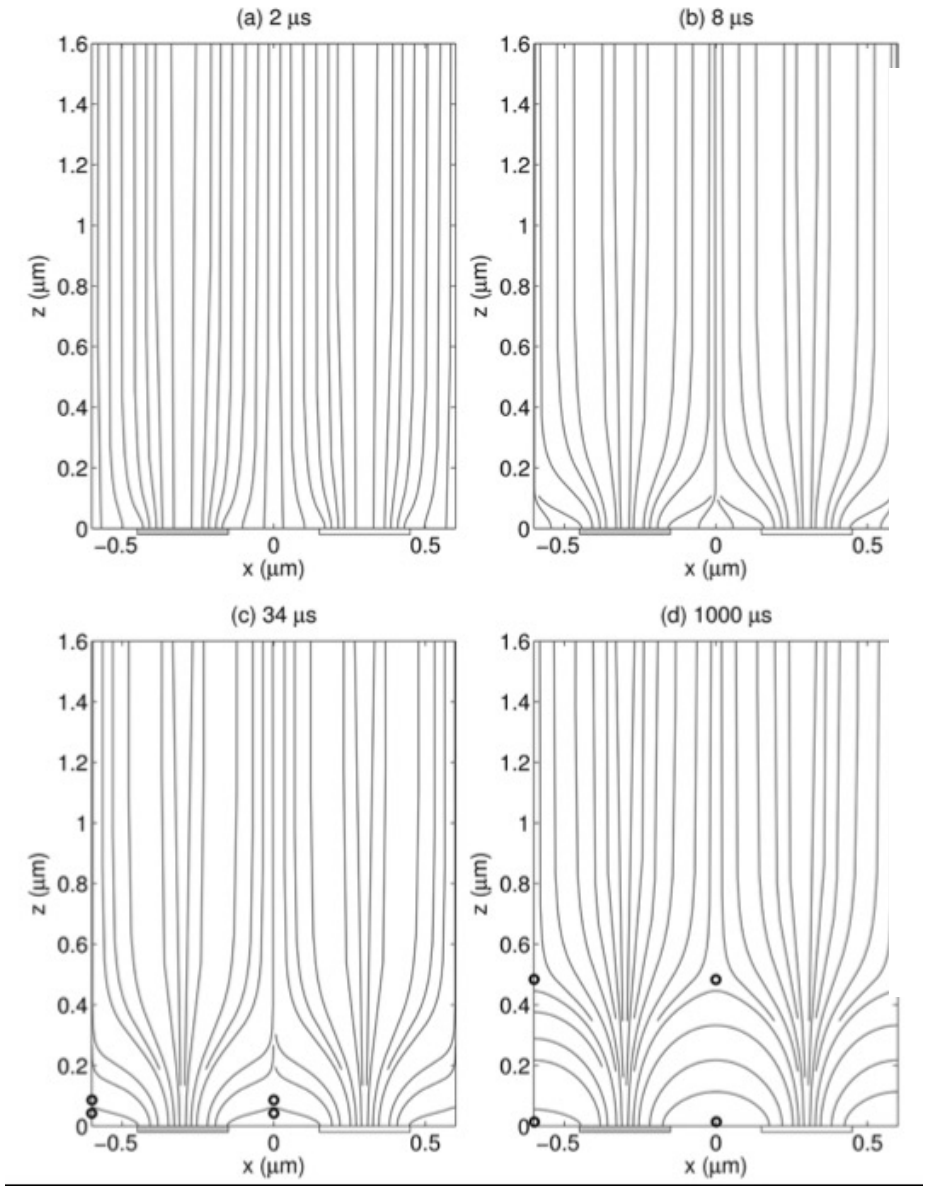


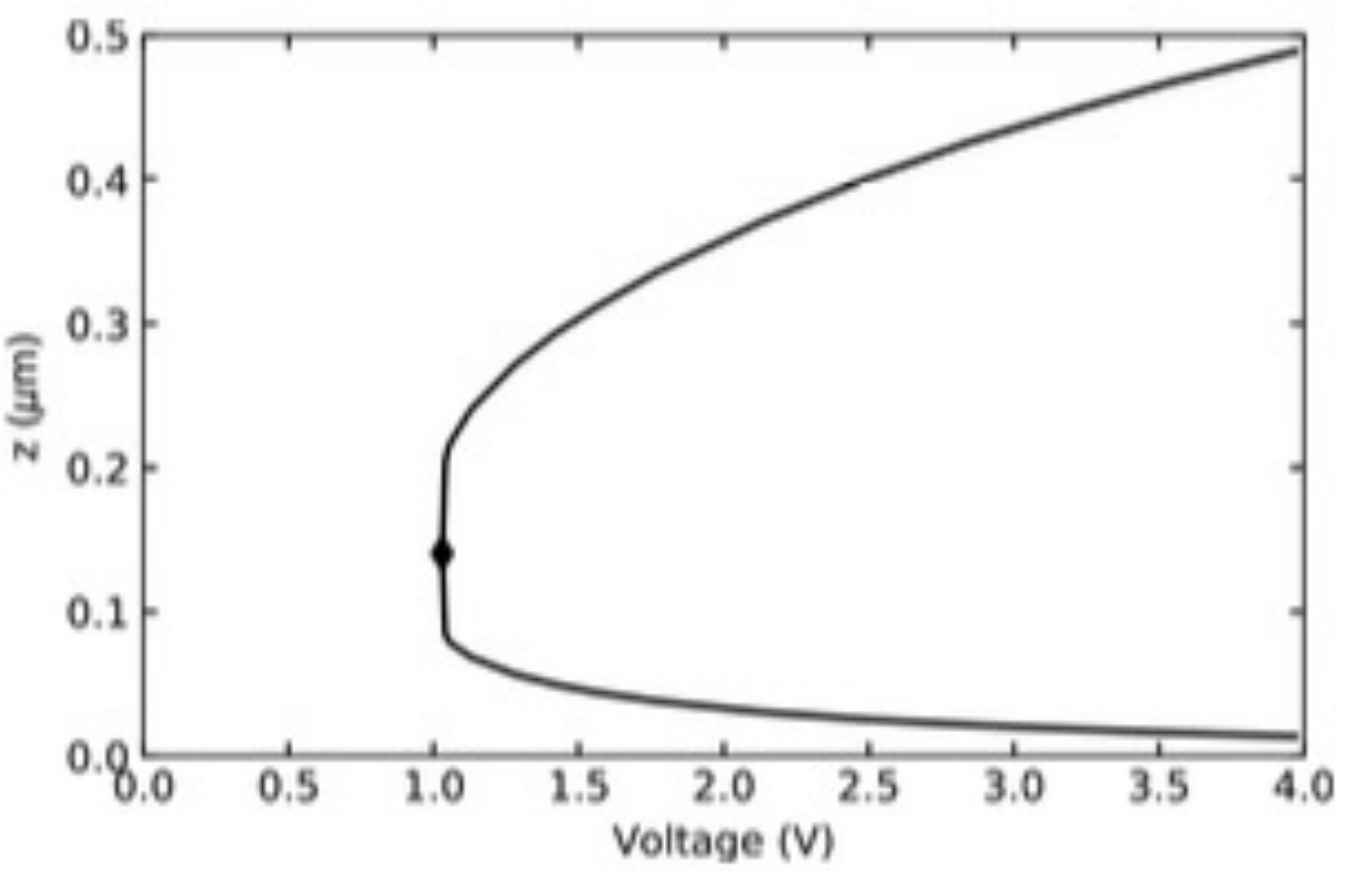
(a)



(b)

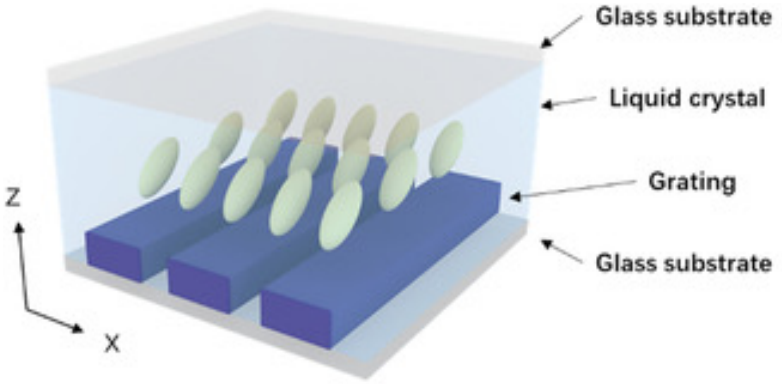
Reconfigurable Devices - Defects



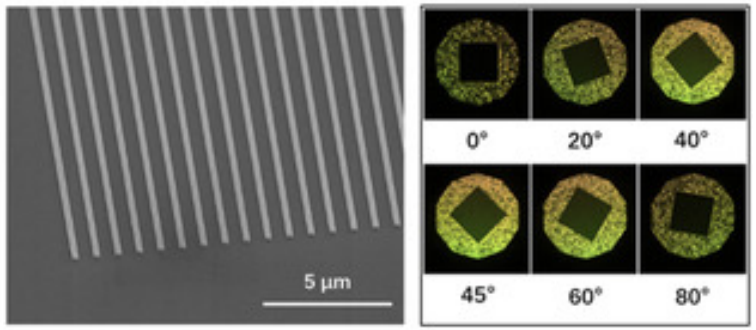


(2021) Hydrodynamics of fringing-field induced defects in nematic liquid crystals. Journal of Applied Physics, 130, 134701. (doi: 10.1063/5.0062532)

LC Alignment



A



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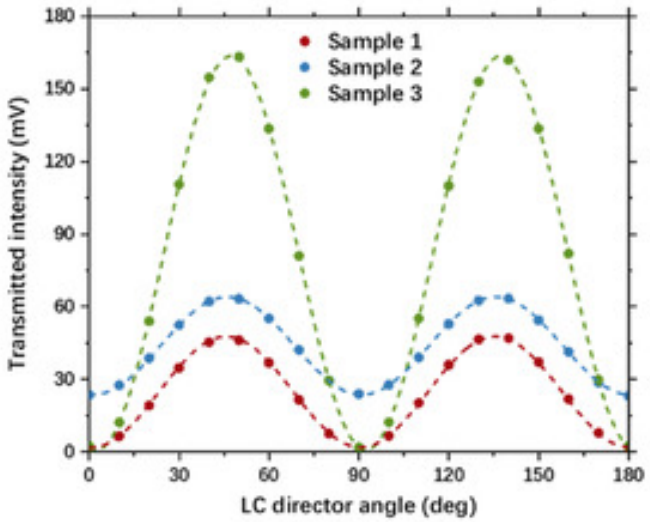

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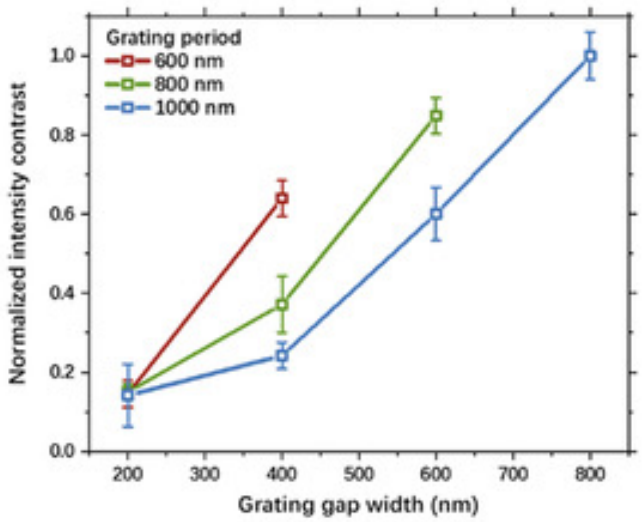
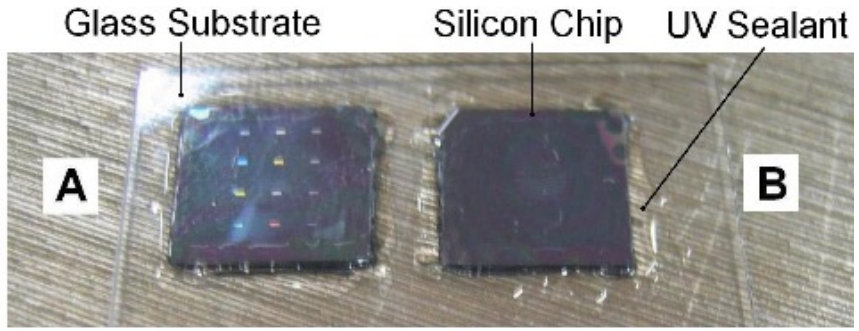
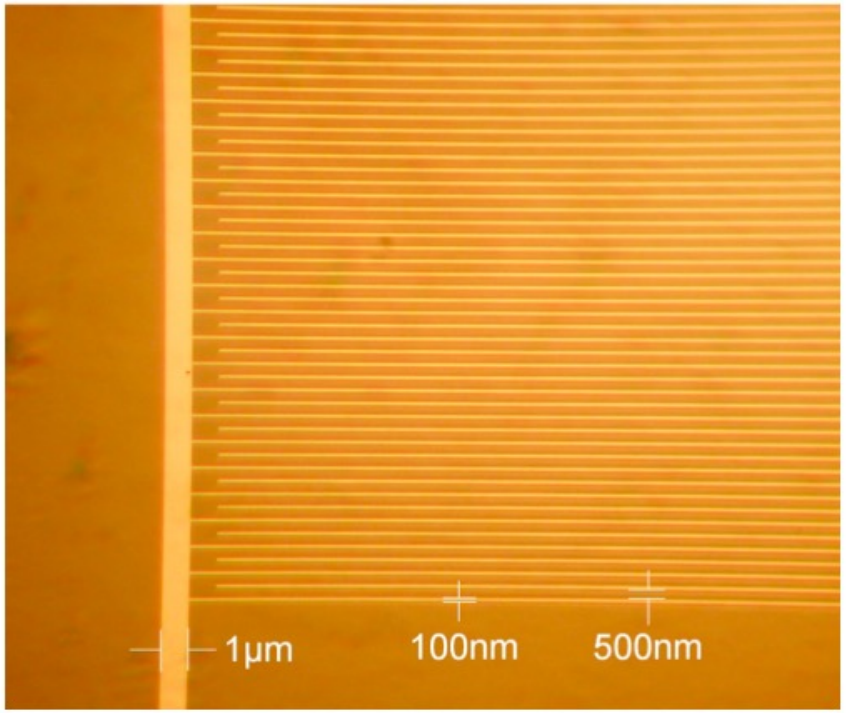


D

Chang, X., Pivnenko, M., Singh, A., Wu, W., Shrestha, P., & Chu, D. (2024). Dielectric Meta-Atoms with Liquid Crystal Alignment Effect for Electrically Tunable Metasurface. Advanced Devices & Instrumentation, 5, 0040.



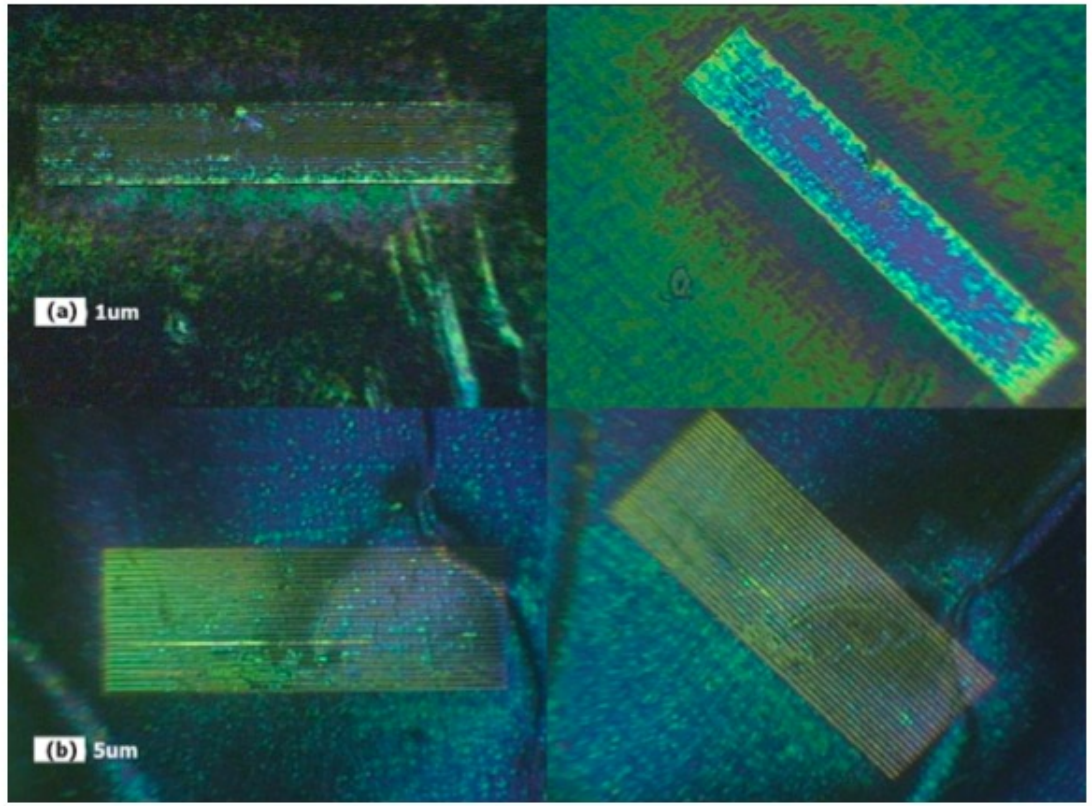


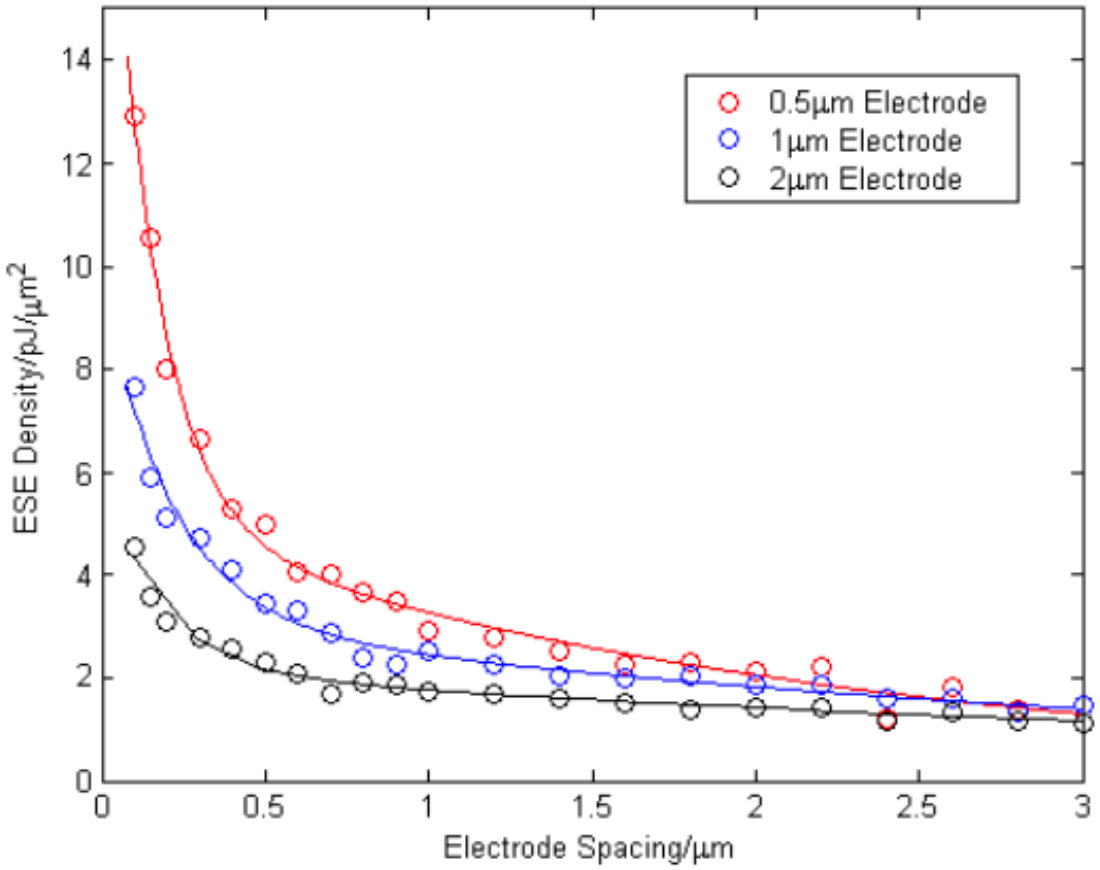
Ghannam, R. , Collings, N., Crossland, W. and Wilkinson, T. (2006) Topological Alignment of NLCS Using Nanoscale Metallic Grooves. In: SPIE Optics and Photonics 2006, San Diego, CA, USA, 13-17 Aug 2006, 63320H. (doi: 10.1117/12.680299)

Fringing Field Effects in LCoS

University of Glasgow

LC Alignment





ESE Density for a constant symmetric voltage of $\pm 5\ V$

Fringing Field Effects in LCoS

University of Glasgow

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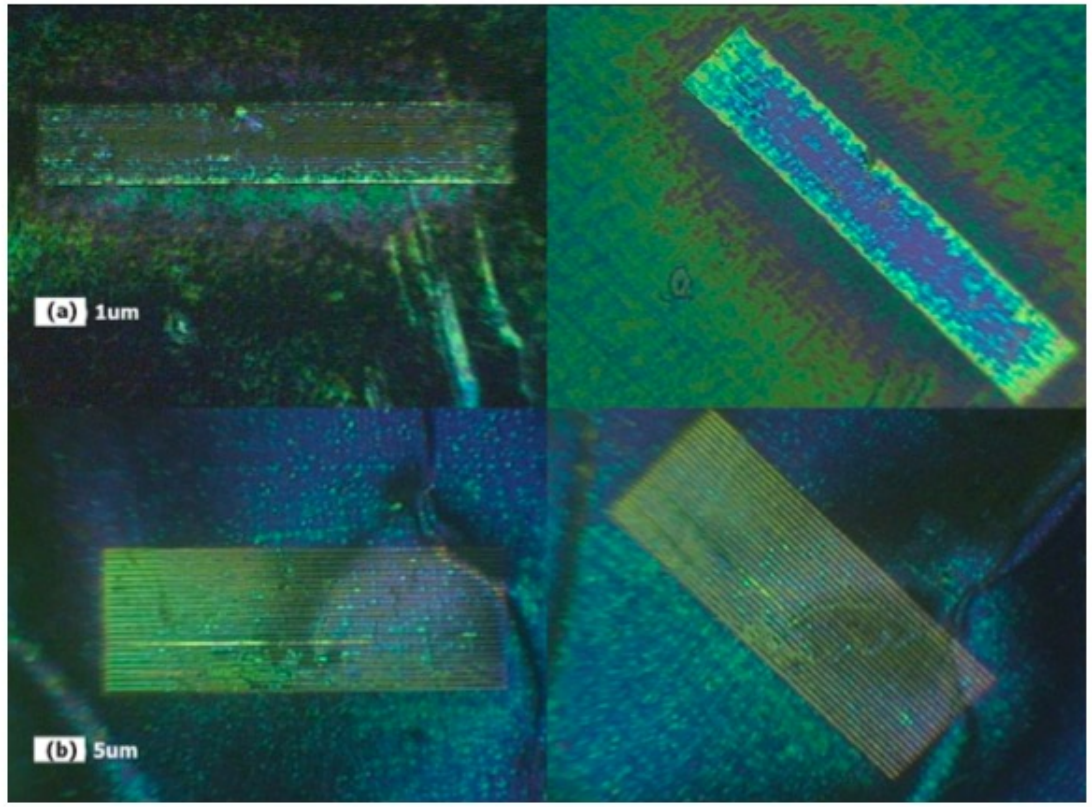
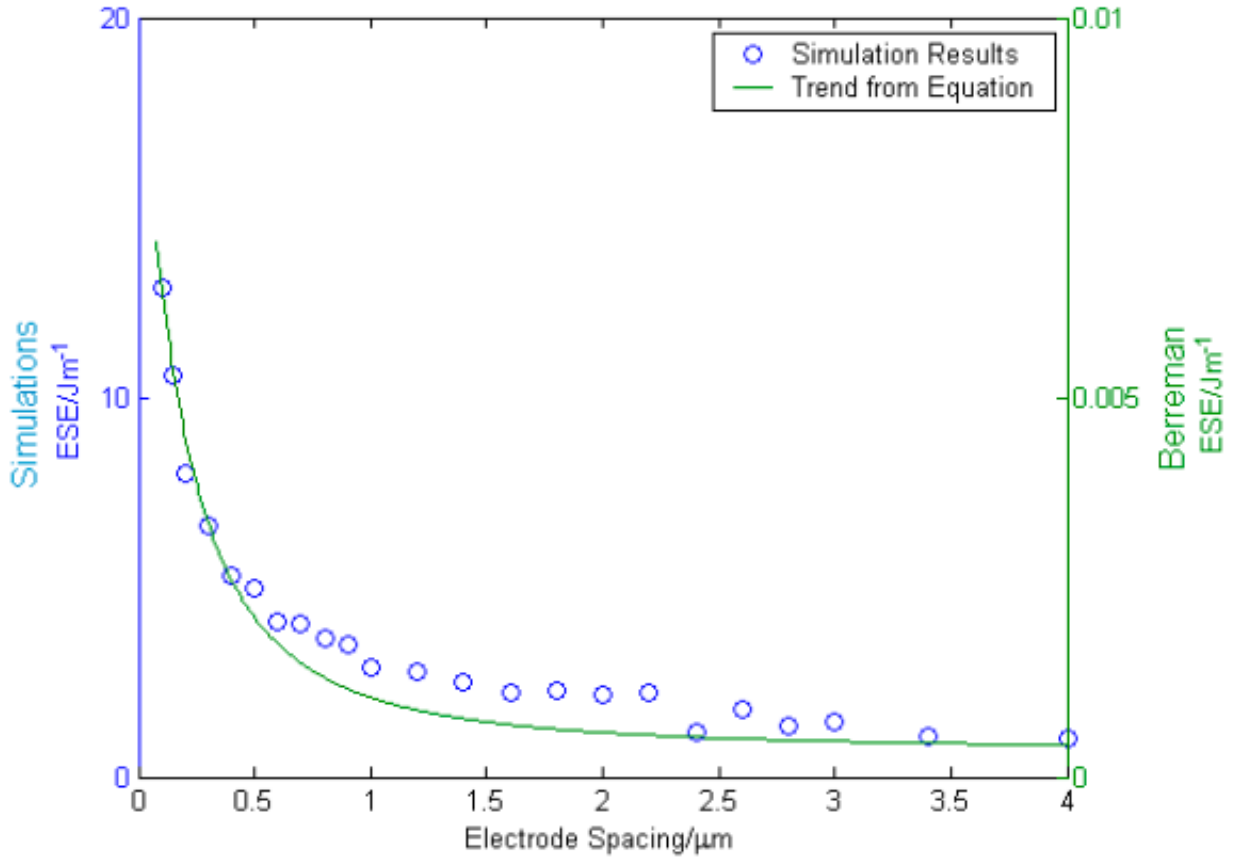


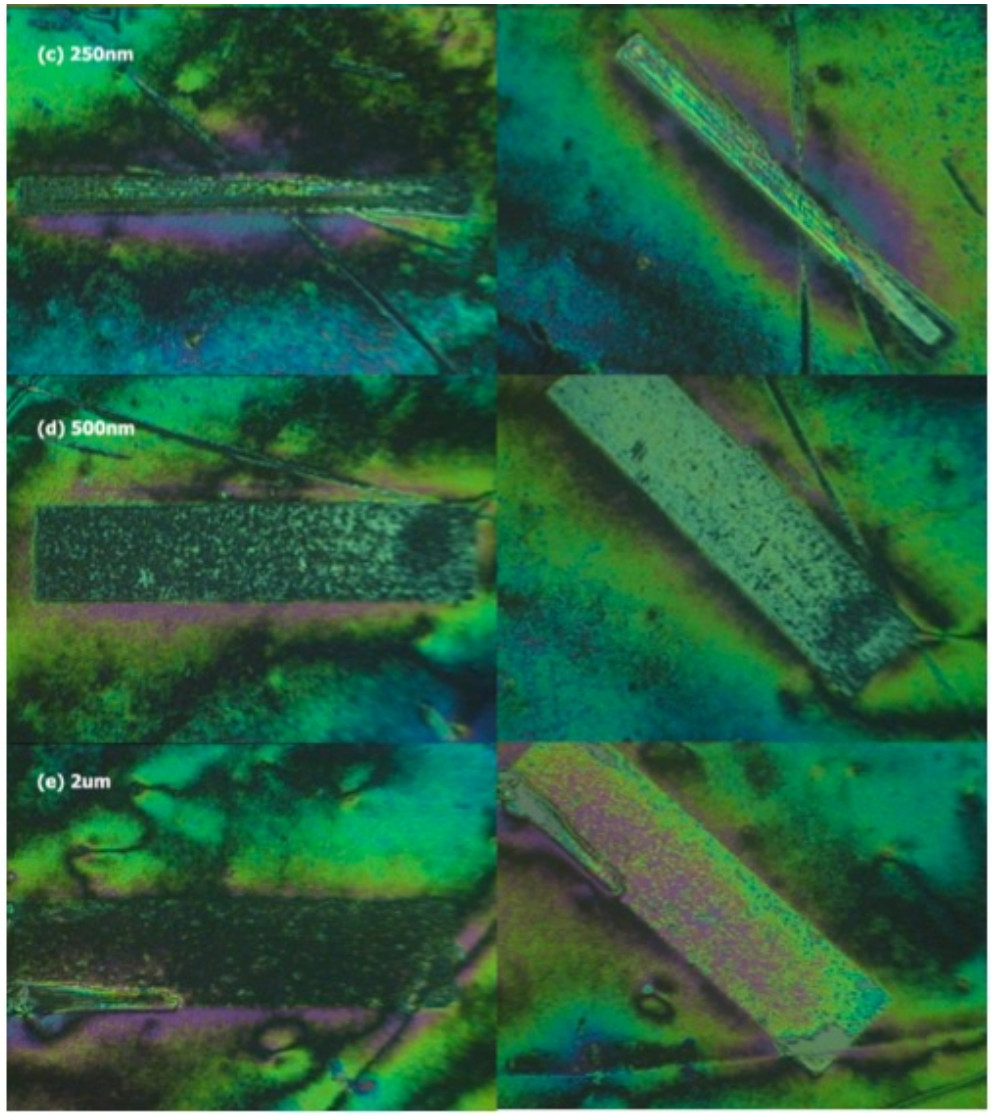


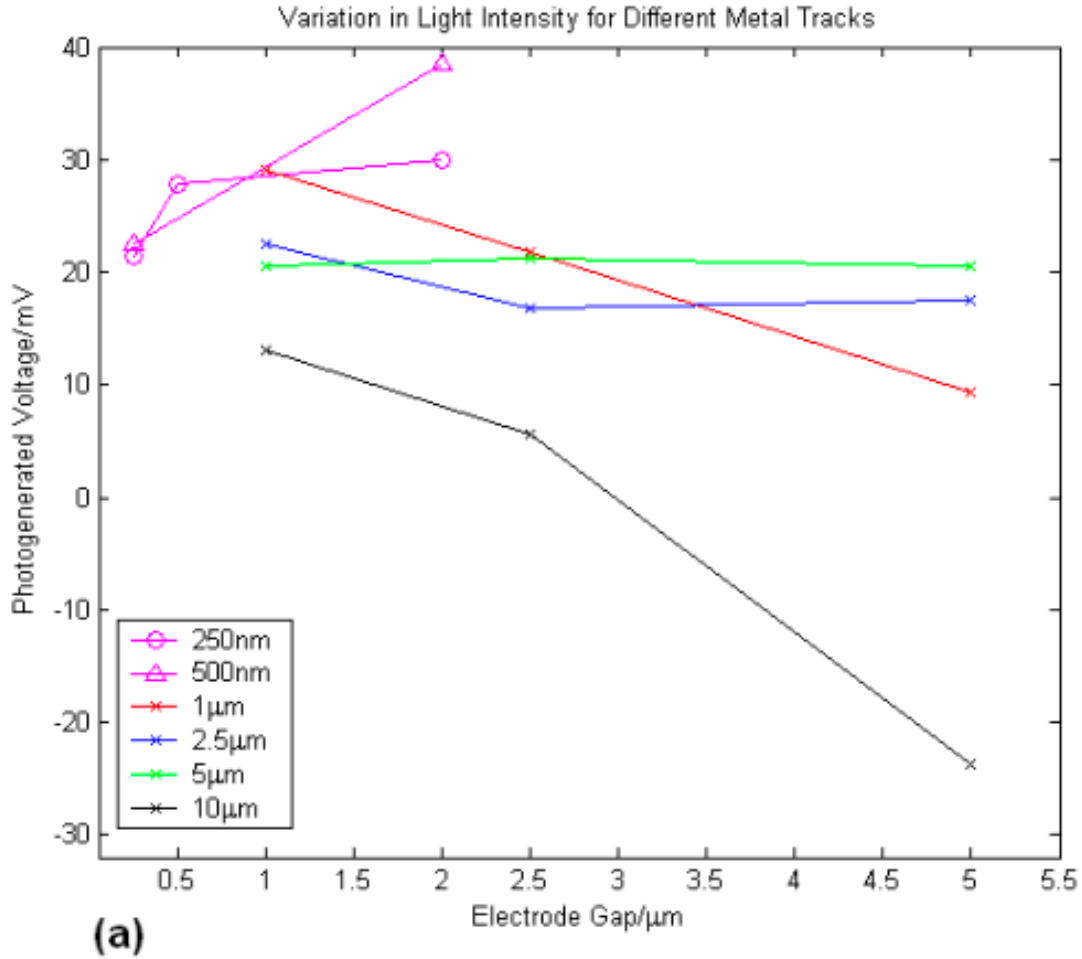
Comparison between Berreman and LdG simulations ESE for a constant symmetric voltage of $\pm 5\ V$

Dwight W. Berreman (1973) Alignment of Liquid Crystals by Grooved Surfaces, Molecular Crystals and Liquid Crystals, 23:3-4, 215-231, DOI: 10.1080/15421407308083374

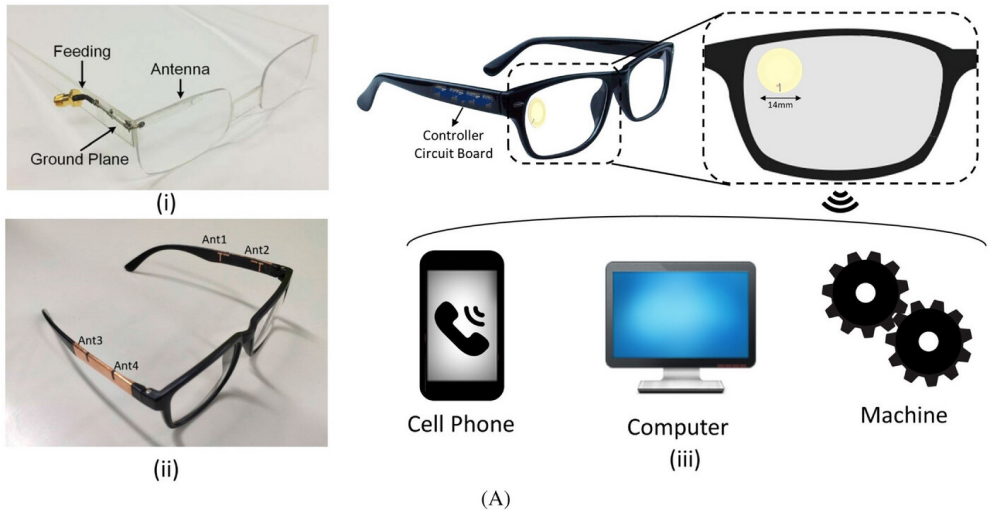
Fringing Field Effects in LCoS

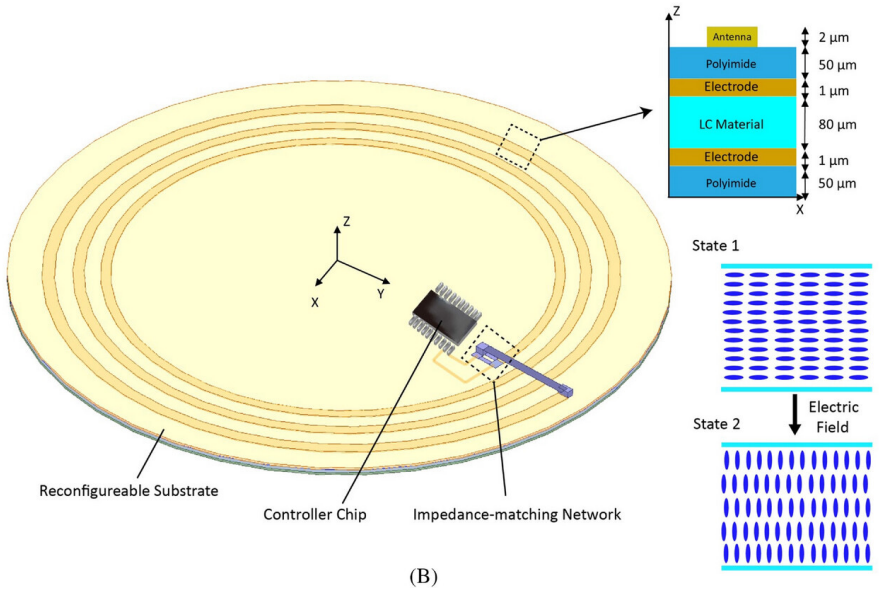
University of Glasgow

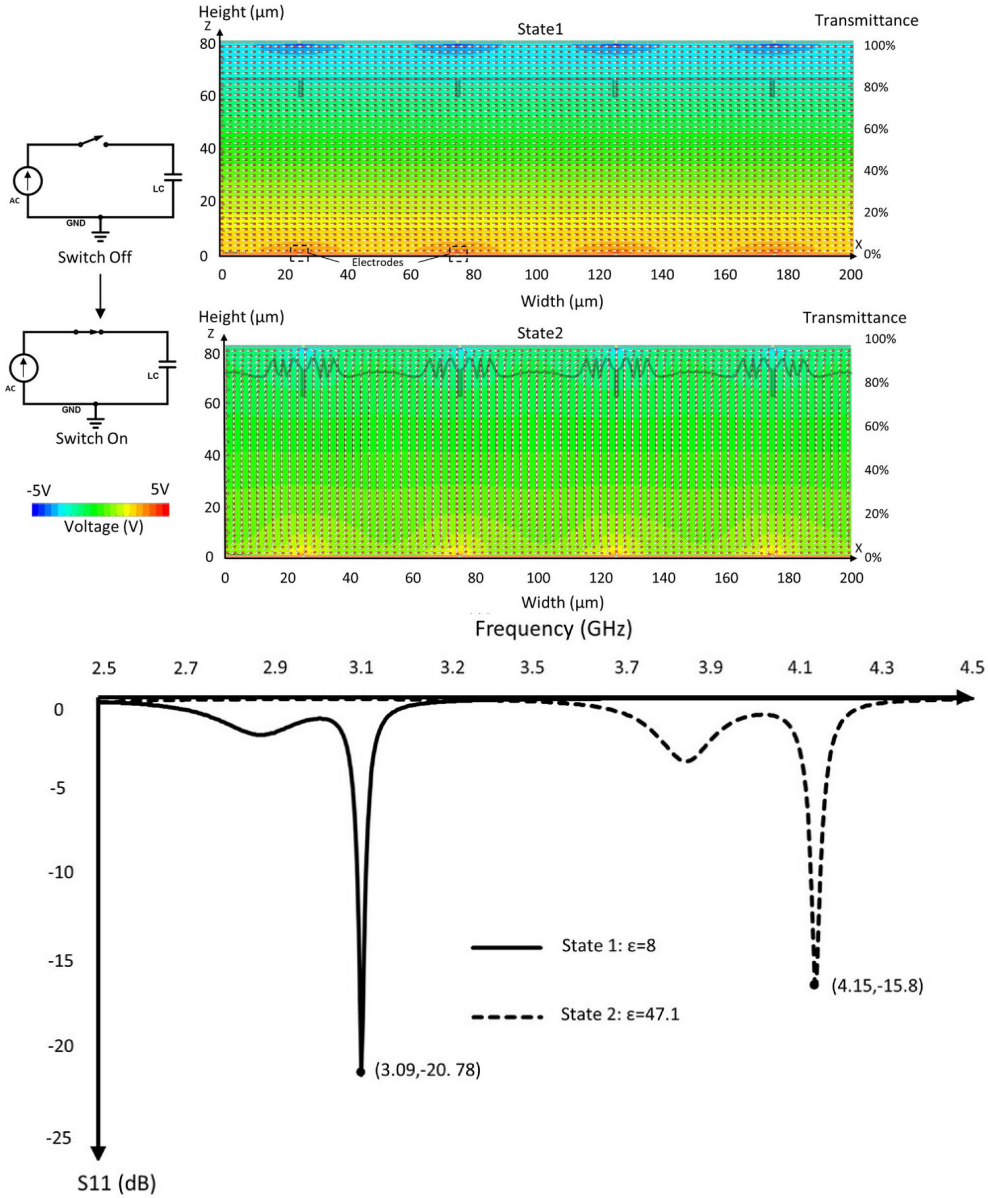




LC Tunable Antenna



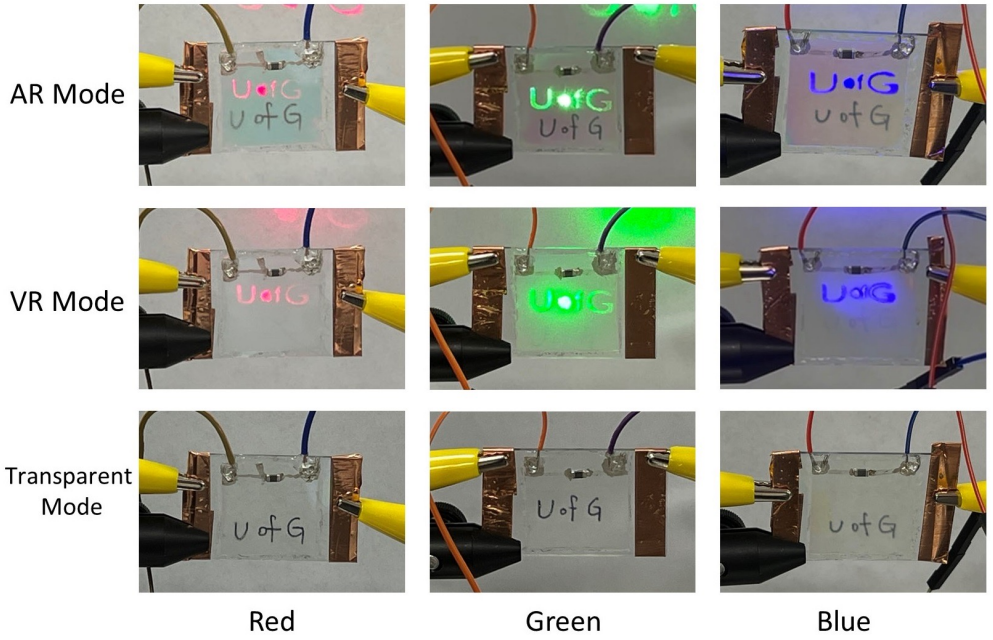


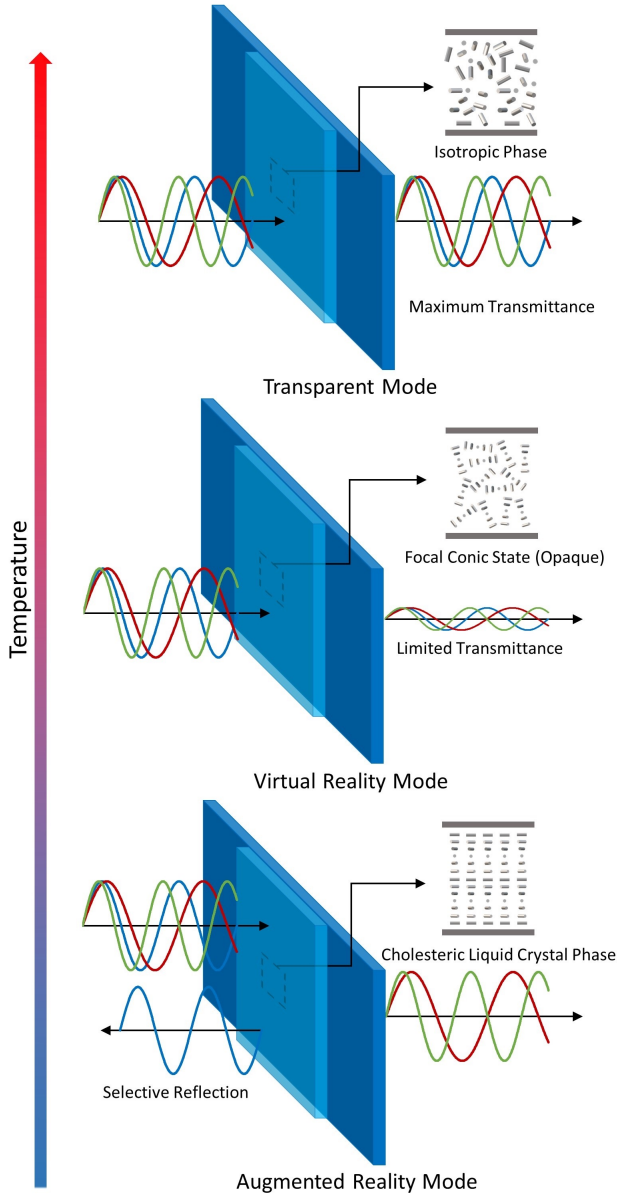


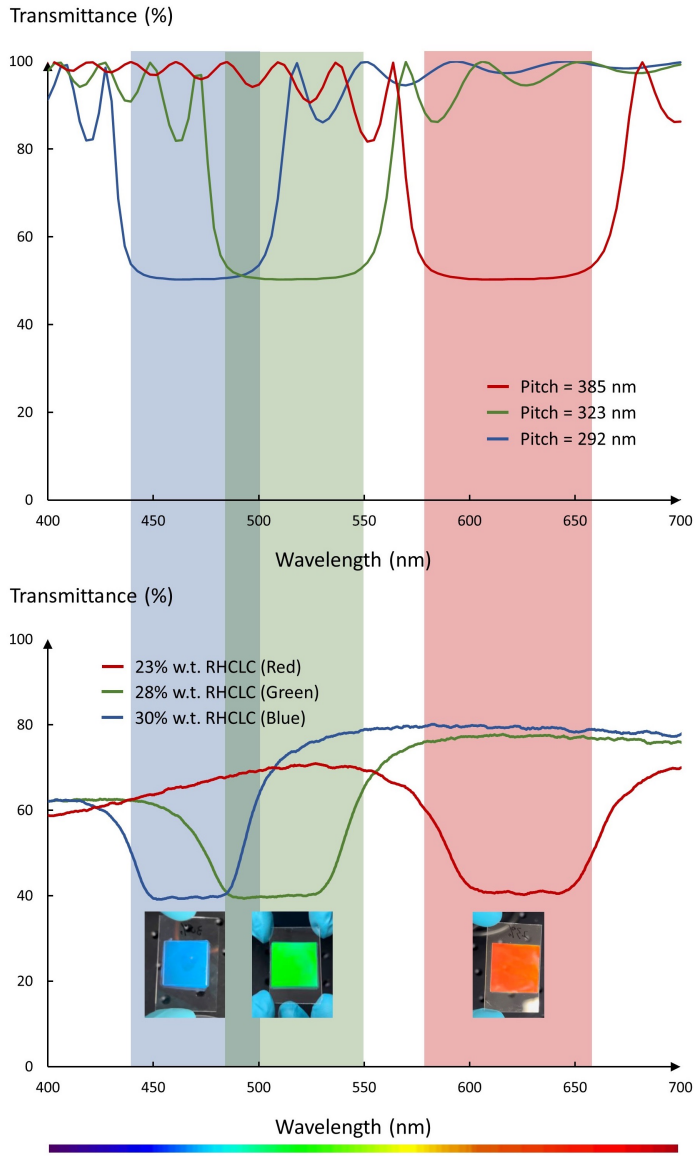
(2023) Reconfigurable wearable antenna for 5G applications using nematic liquid crystals. Nano Select, 4(8), pp. 513-524. (doi: 10.1002/nano.202200209)

Thermal Control AR Lens

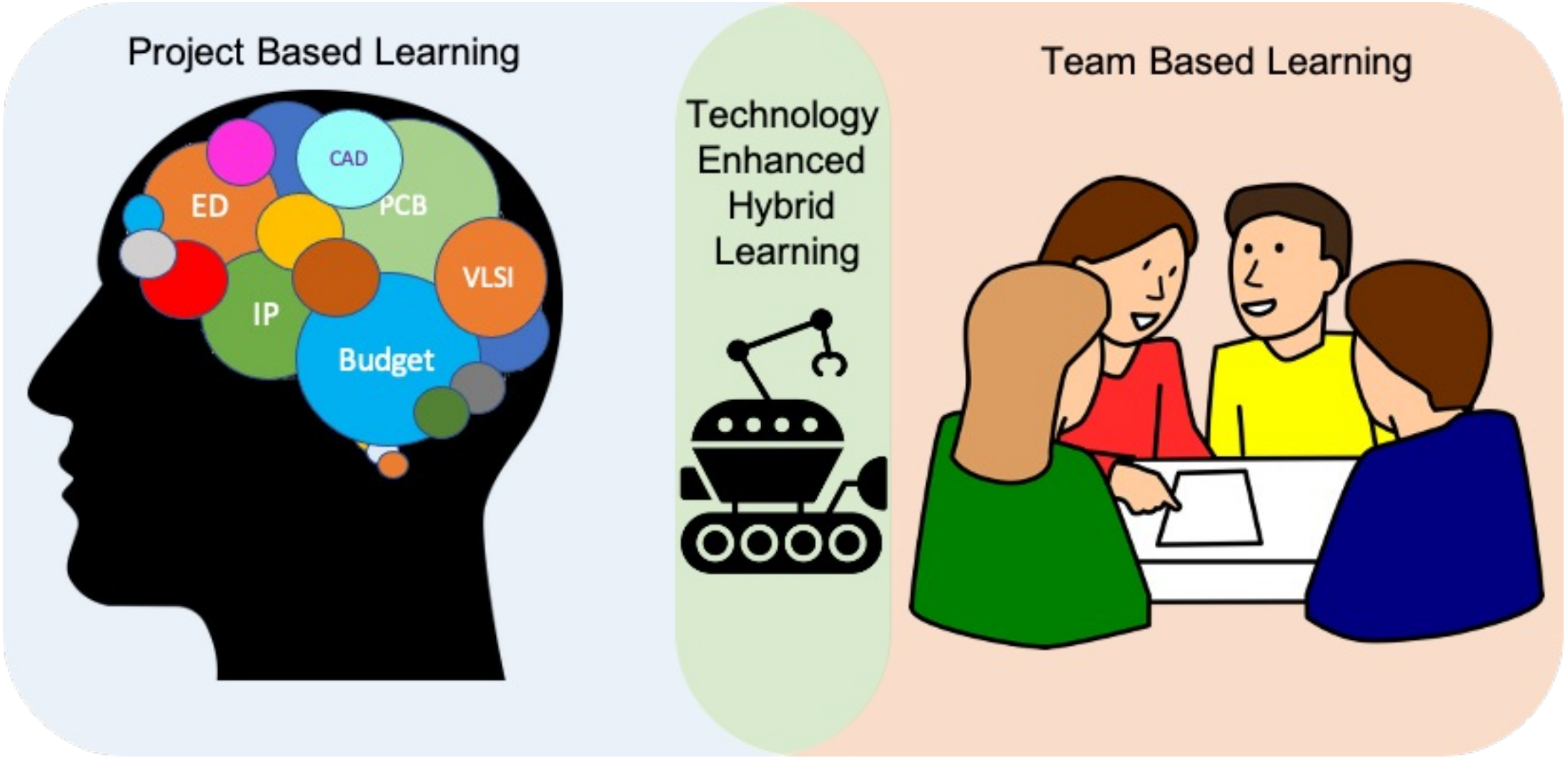
Transparent Mode | Augmented Reality Mode | Virtual Reality Mode







“Technology Enhanced Hybrid Learning”



TDPS – Module Design

University of Glasgow

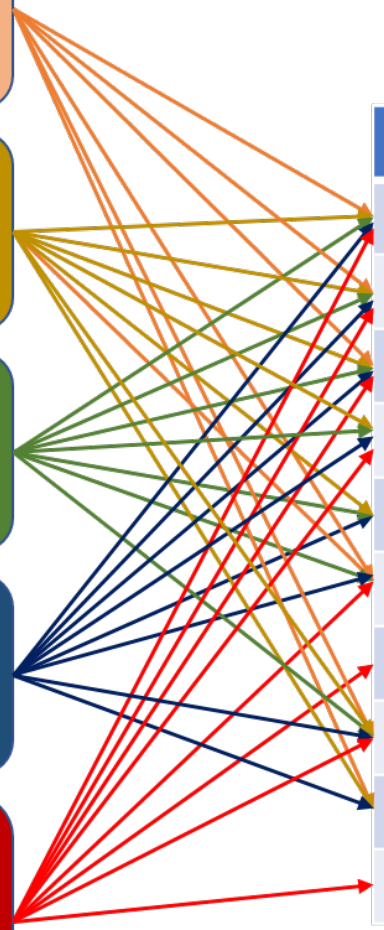
Task 1 - Involves instructing the rover to follow a meandering path. The rover should detect edges, colours and lines.

Task 2 - Involves finding a bridge and cross it. The bridge consists of a wire mesh.

Task 3- Once the rover has crossed the bridge, it should find an arch, go through it and stop.

Task 4 - In this task, the rover should demonstrate that it can carry and release an item.

Task 5 - The rover should stop and transmit a radio message at 433 MHz to a laptop. The message must include the team number, team member names and time of day (24-hour clock).



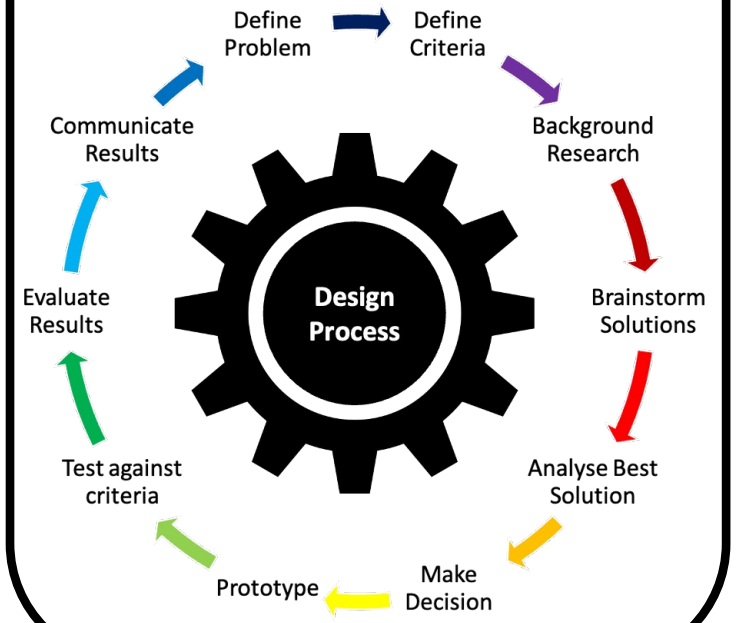
Course Code	Course Name
1005	Programming
1008	Microelectronic Systems
2004	Embedded Processors
2022	Circuit Analysis & Design
3001	Dynamics & Control
3003	Electronic System Design
3018	Comm. Principles & Systems
3020	Digital Circuit Design
3022	Power Electronics
3029	Communication Circuit Design

TDPS – Current Status

University of Glasgow

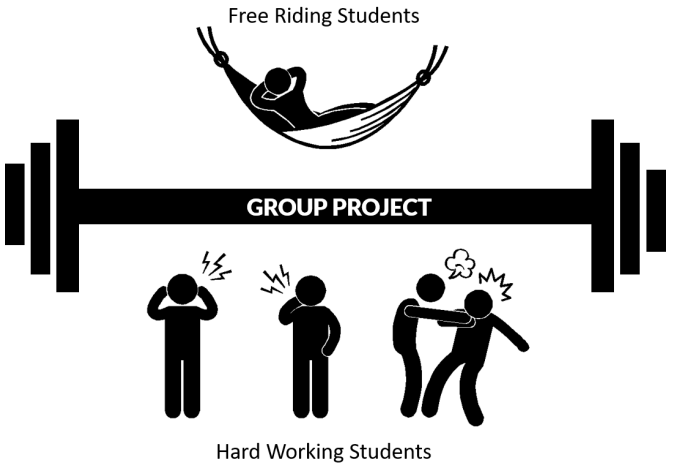
Principles of Design

Introduction and definition to the design process.



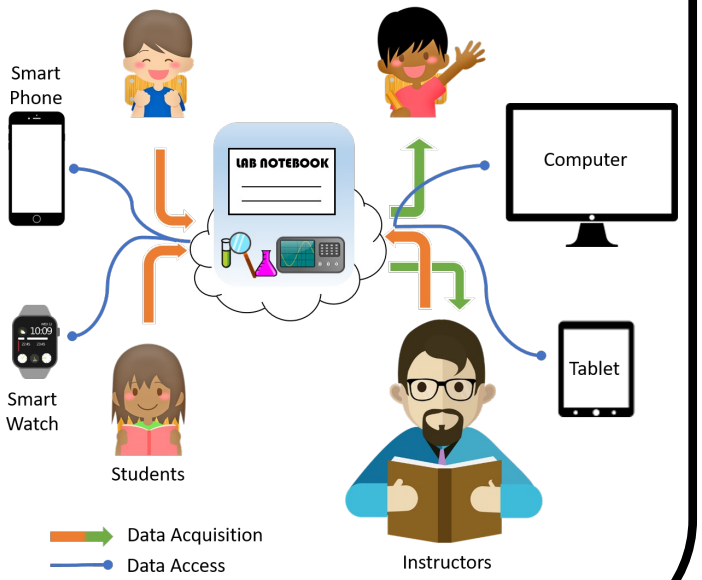
Teamwork

Identify characteristics of effective teams & stages of team development



Working with Data

ICT tools to facilitate teamwork and collaboration



TDPS Module

University of Glasgow

Team Design Project: A Case Study

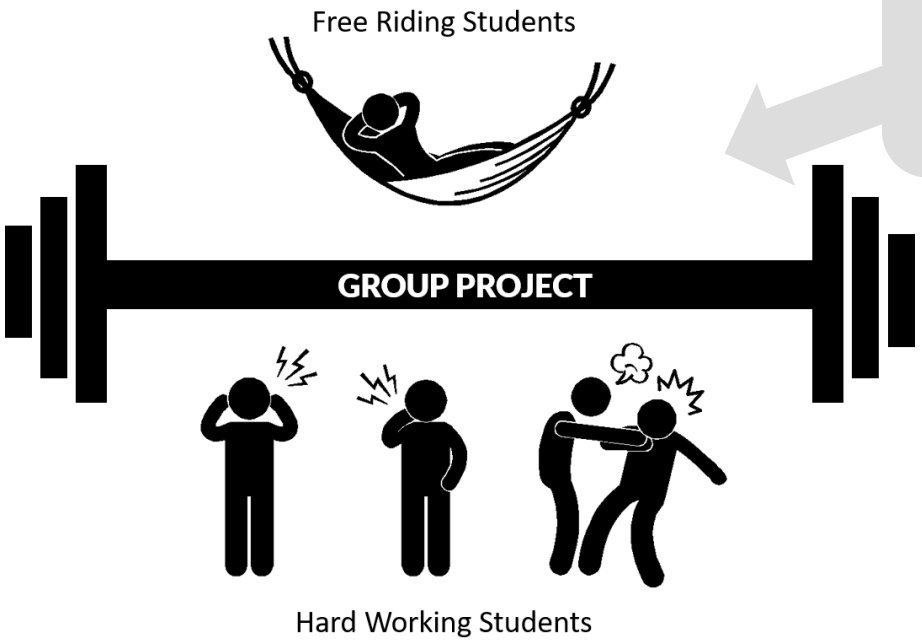
Engineering students invited to work in teams to develop an electronic system

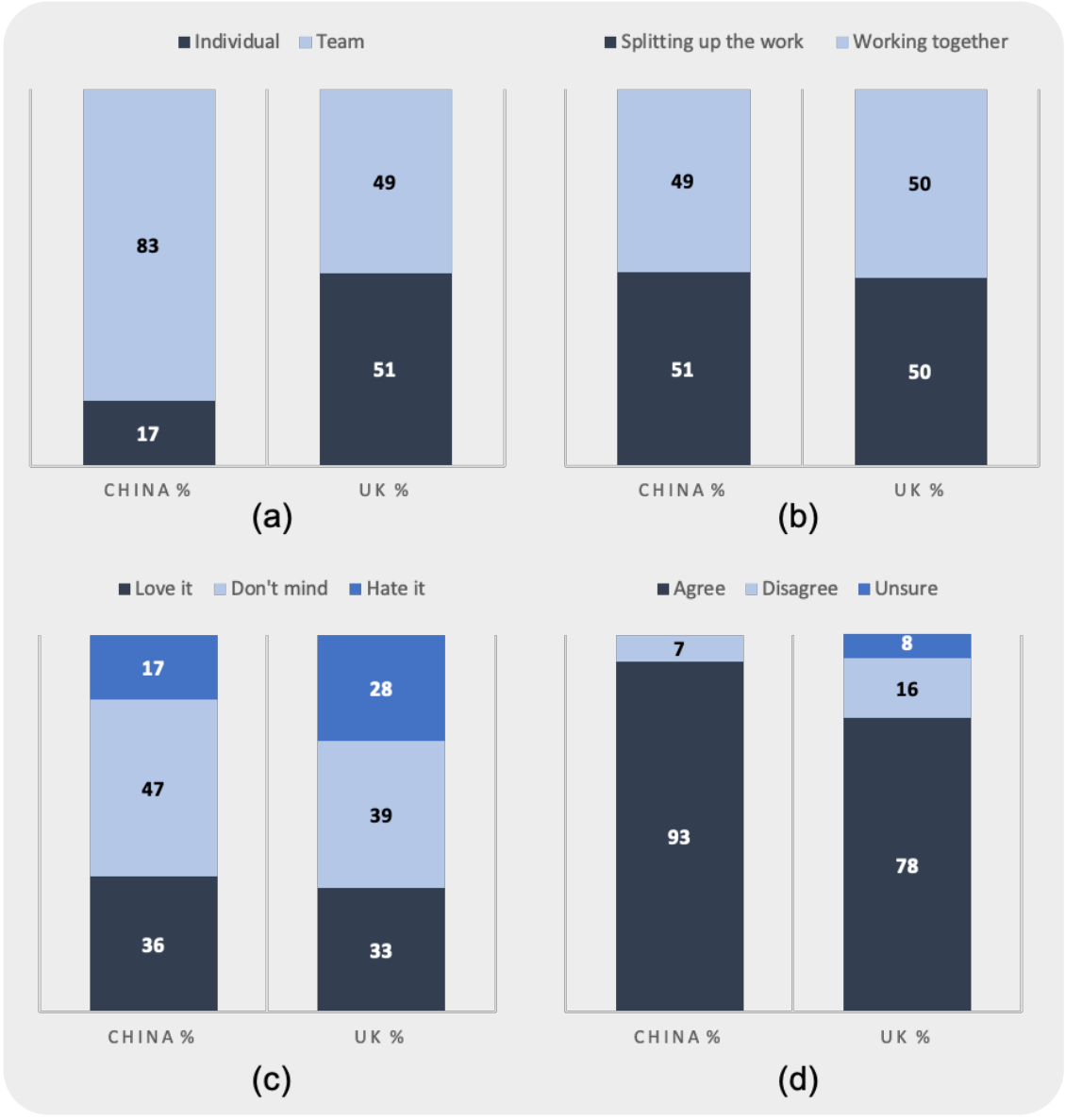
TDPS Module

University of Glasgow

Comparison between British and Chinese student experiences

Students disliked group projects



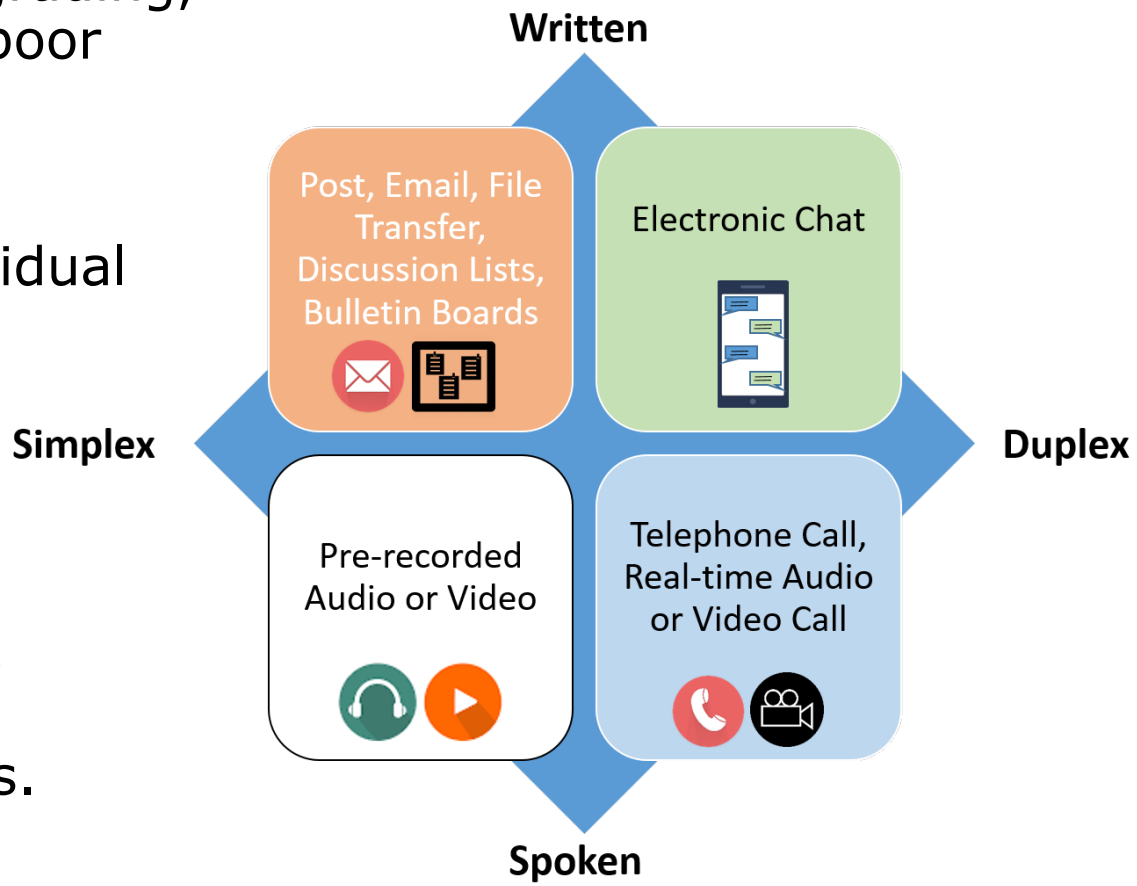


(2023) Teaching undergraduate students to think like real-world systems engineers: a technology-based hybrid learning approach. Systems Engineering, 26(6), pp. 728-741. (doi: 10.1002/sys.21683)

Students & Teamwork

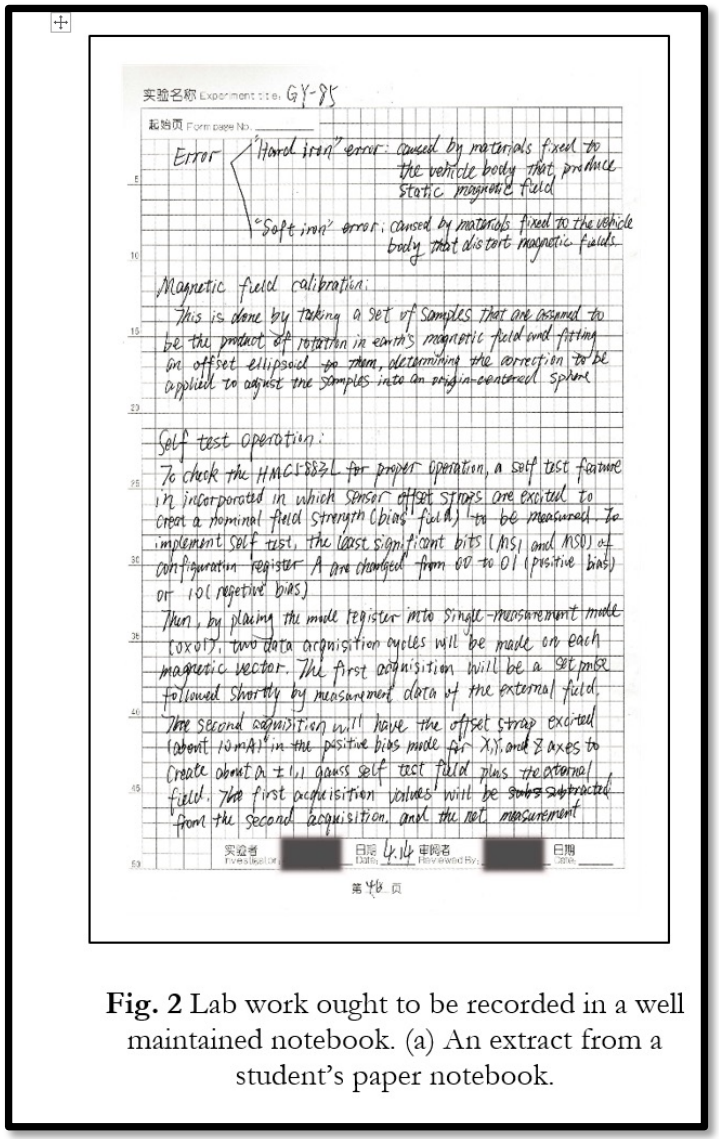
Reflections:

- Students disliked working in Teams – Unfair grading, free riding students, lack of communication, poor organization, …, etc.
- Supervisors found difficulty in assessing individual contributions to group projects properly.
- Students needed to submit a lab notebook.
- Decided to investigate whether Electronic Lab Notebooks (ELNs) can be used to facilitate teamwork and collaboration between students.



(2023) Teaching undergraduate students to think like real-world systems engineers: a technology-based hybrid learning approach. Systems Engineering, 26(6), pp. 728-741. (doi: 10.1002/sys.21683)

Paper Notebooks



实验名称 Experiment title: GY-85

起始页 Form page No.

Error
- "Hard iron" error: caused by materials fixed to the vehicle body that produce static magnetic fields
- "Soft iron" error: caused by materials fixed to the vehicle body that distort magnetic fields

Magnetic field calibration:

This is done by taking a set of samples that are assumed to be the product of rotation in earth's magnetic field and fitting an offset ellipsoid to them, determining the correction to be applied to adjust the samples into an origin-centered sphere

Self test operation:

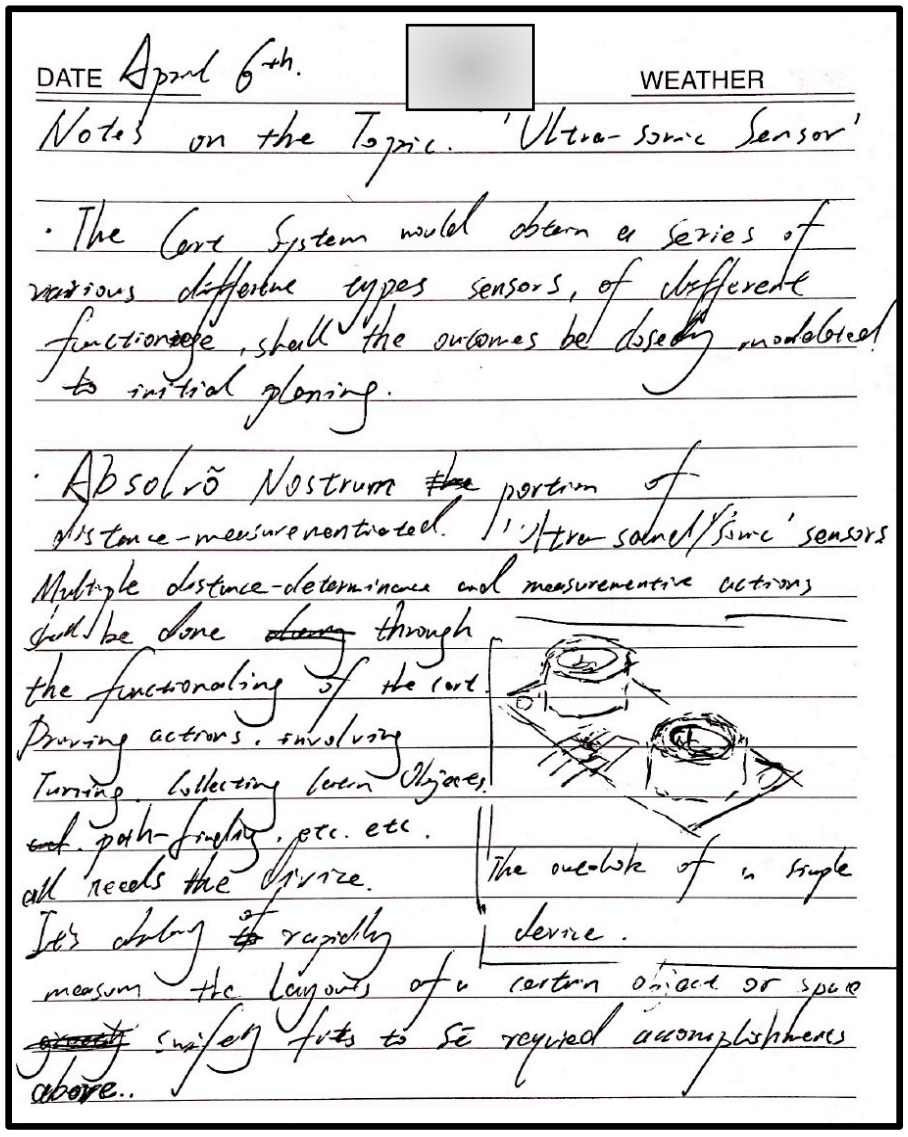
To check the HMC5883L for proper operation, a self test feature is incorporated in which sensor offset straps are excited to create a nominal field strength (bias field) to be measured. To implement self test, the least significant bits (MS1 and MS0) of configuration register A are changed from 00 to 01 (positive bias) or 10 (negetive bias)

Then, by placing the mode register into Single-measurement mode (0x01), two data acquisition cycles will be made on each magnetic vector. The first acquisition will be a set pulse followed shortly by measurement data of the external field. The second acquisition will have the offset strap excited (about 10mA) in the positive bias mode for X, Y, and Z axes to create about a ±1.1 gauss self test field plus the external field. The first acquisition values will be subtracted from the second acquisition, and the net measurement

实验者 Investigator [redacted] 日期 Date 4.14 审阅者 Reviewed By [redacted] 日期 Date

第 46 页

Fig. 2 Lab work ought to be recorded in a well maintained notebook. (a) An extract from a student's paper notebook.



DATE April 6th. [redacted] WEATHER

Notes on the Topic. 'Ultra-Sonic Sensor'

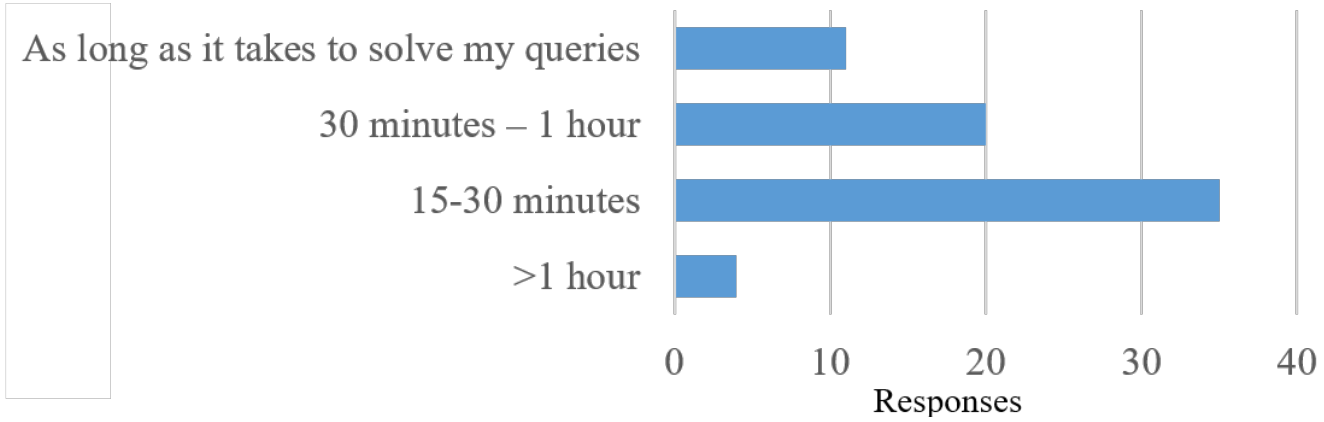
· The Core System would obtain a series of various different types sensors, of different functionalities, shall the outcomes be closely monitored to initial planning.

· Absolvõ Nostrum ~~the~~ portion of distance-measurement related 'Ultra sound/Sonic' sensors Multiple distance-determinance and measurementive actions shall be done ~~during~~ through the functionaling of the cart. Driving actors, involving Turning, collecting certain Objects, ~~and~~ path-finding, etc. etc. all needs the device. Let's daring ~~to~~ rapidly measure the layouts of a certain object or space ~~exactly~~ swiftly fits to se required accomplishments above..

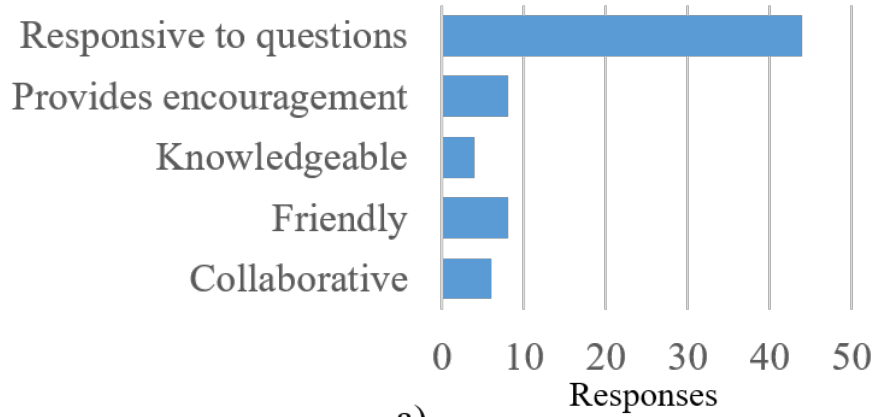
The one-take of a single device.

Mentorship

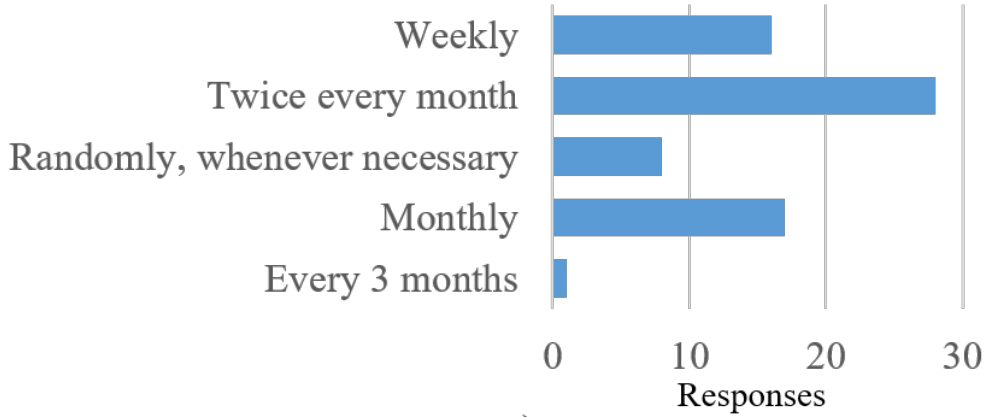
Students wanted **quick**, **short** and relatively **frequent** responses or feedback.



b)



a)



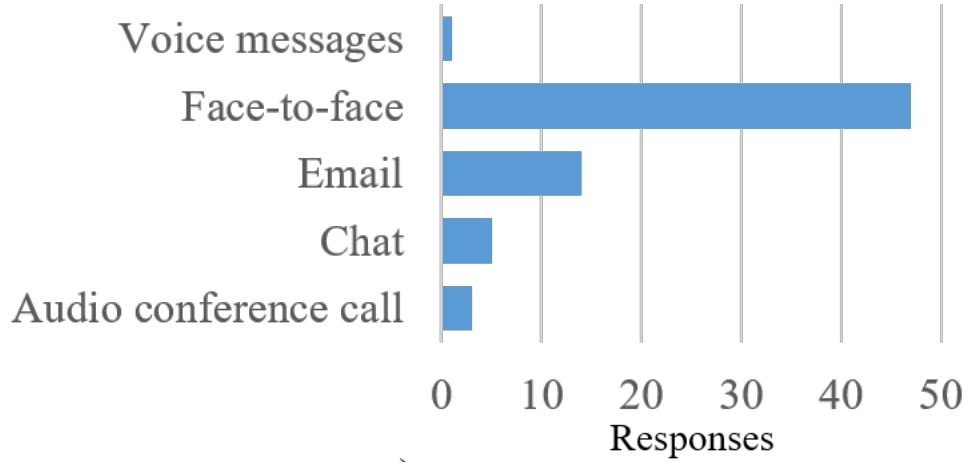
c)

(2020) Remote supervision of engineering undergraduates in a transnational programme between Scotland and China. International Journal of Engineering Education, 36(4), pp. 1333-1339.

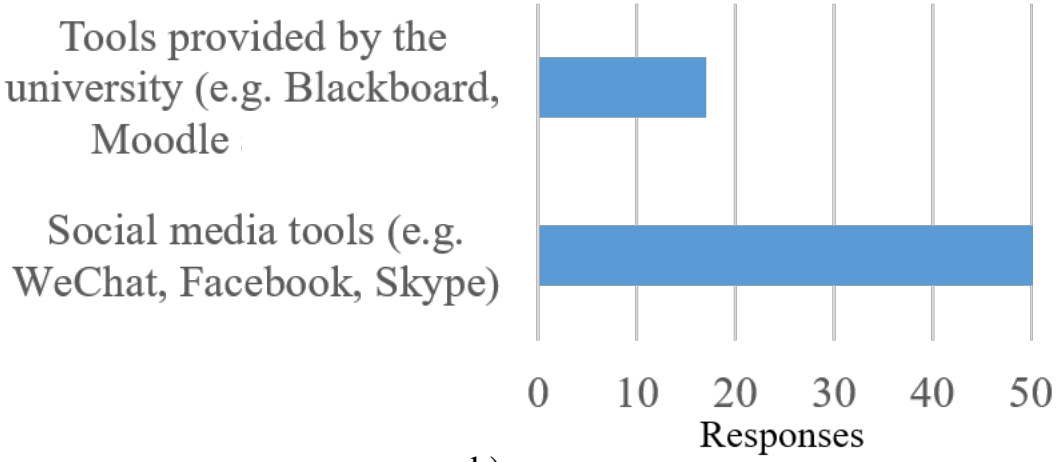
(2023) Interdisciplinary project-based learning: experiences and reflections from teaching electronic engineering in China. IEEE Transactions on Education, 66(1), pp. 73-82. (doi: 10.1109/TE.2022.3186184)

Mentorship - How?

- Students wanted to “see” their supervisors.
- They wanted to use something similar to a social engagement tool.



a)



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Tools: ELNs

SciNote

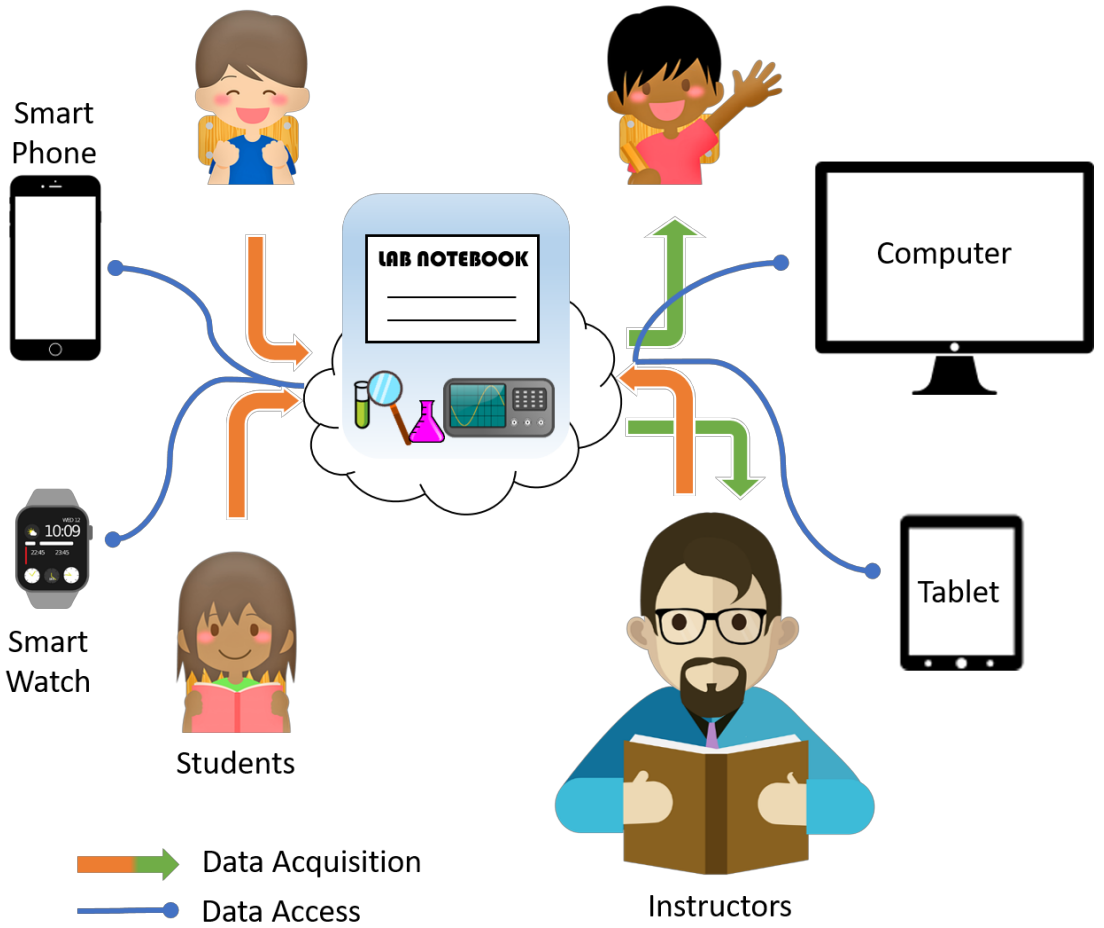
OneNote

labarchives Research Notebook

RSpace

eLabFTW

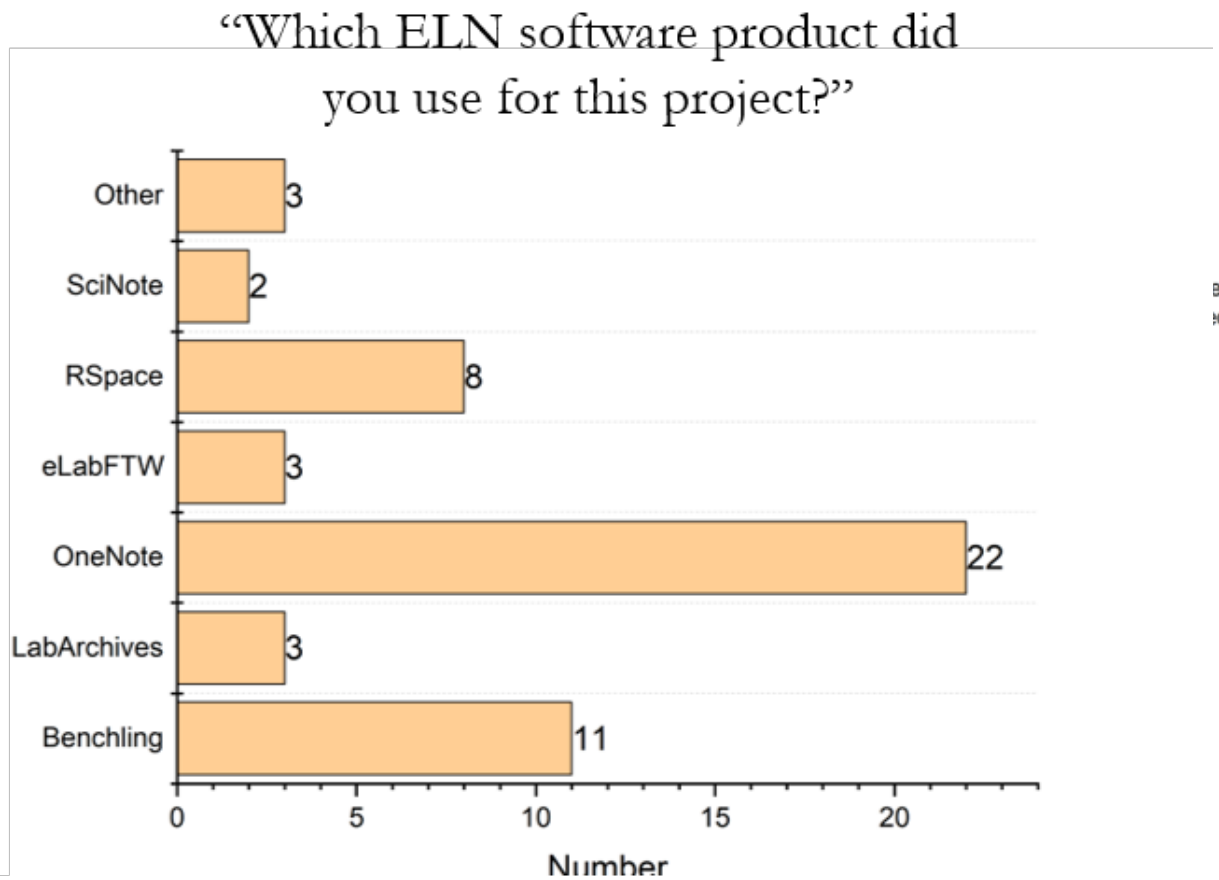
Benchling

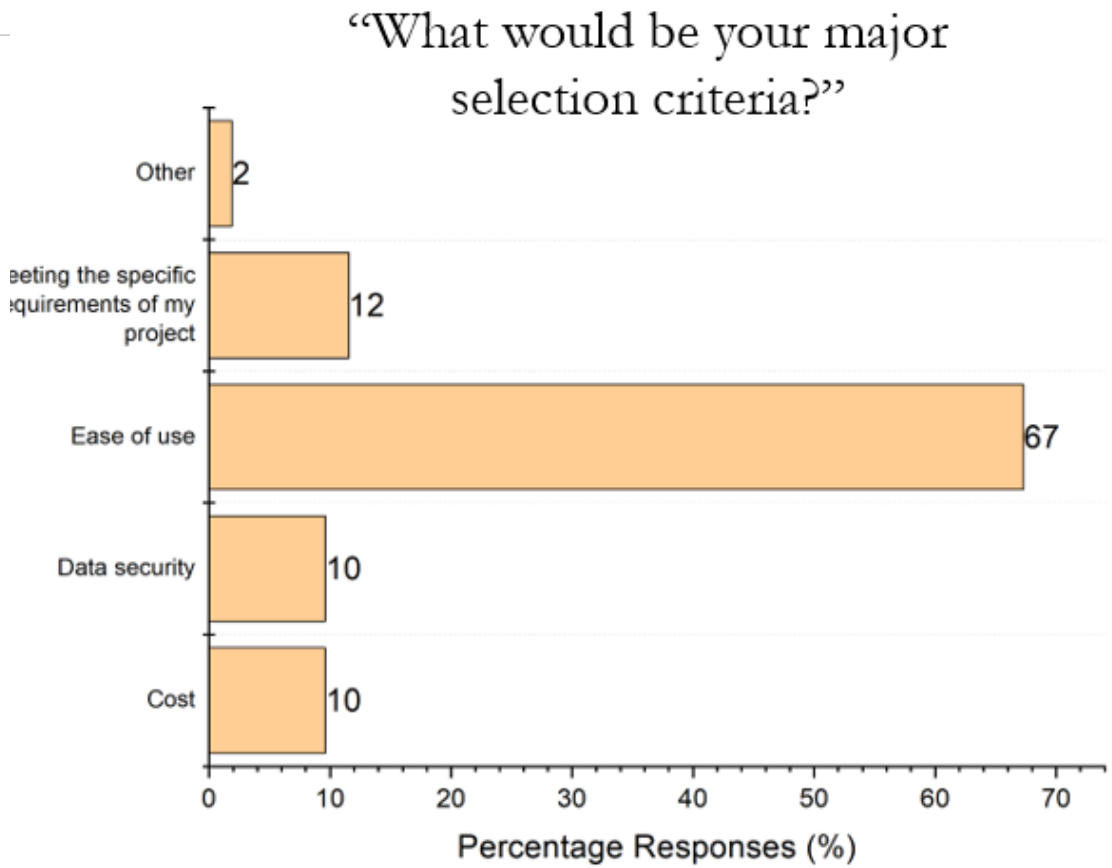


ELNs and their accessibility from any location and device. They enable students to exchange information and to collaborate in real time. They also enable instructors to provide feedback and assess student work as it is being performed.

Tools: ELNs

Project Results





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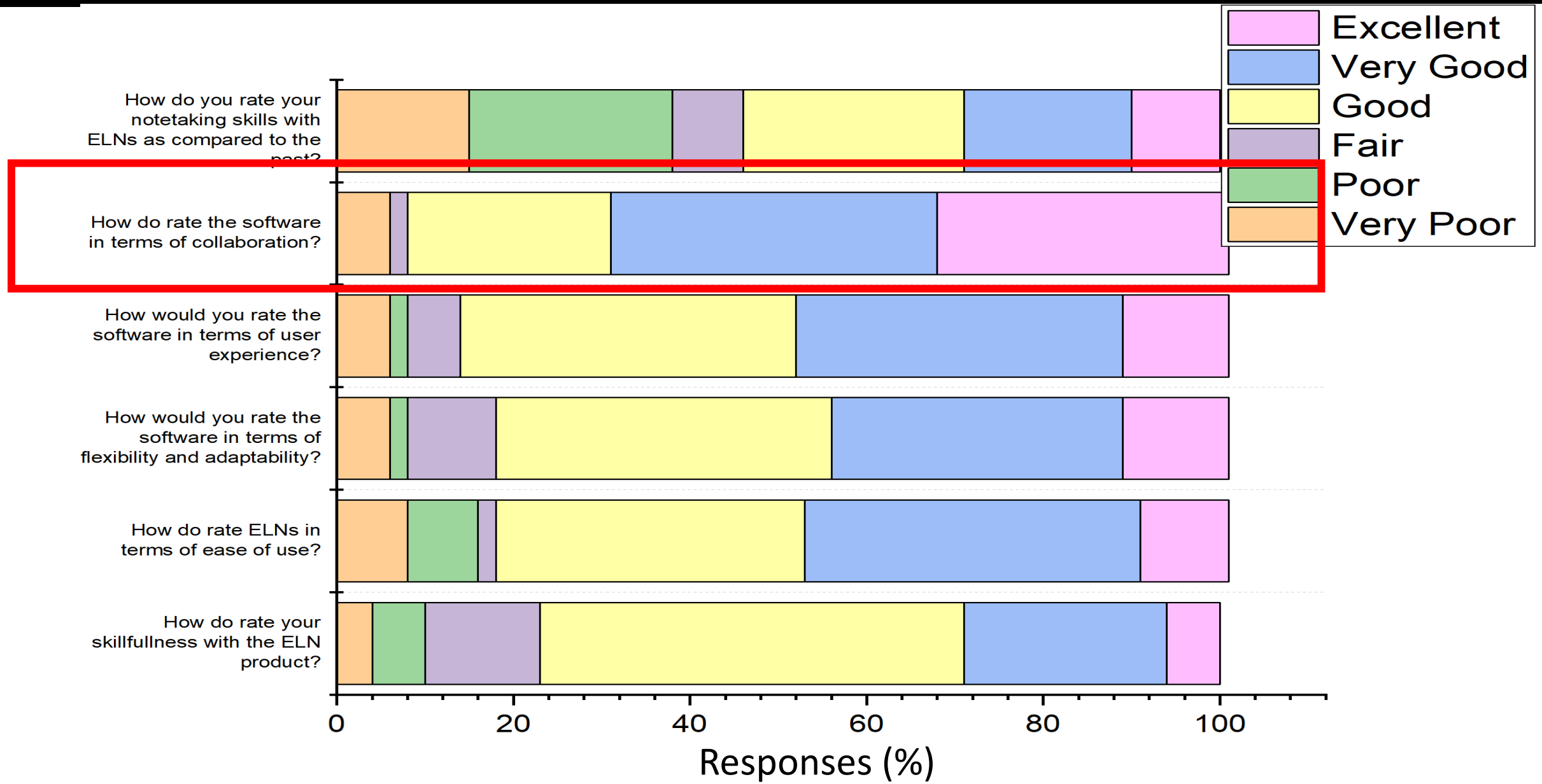
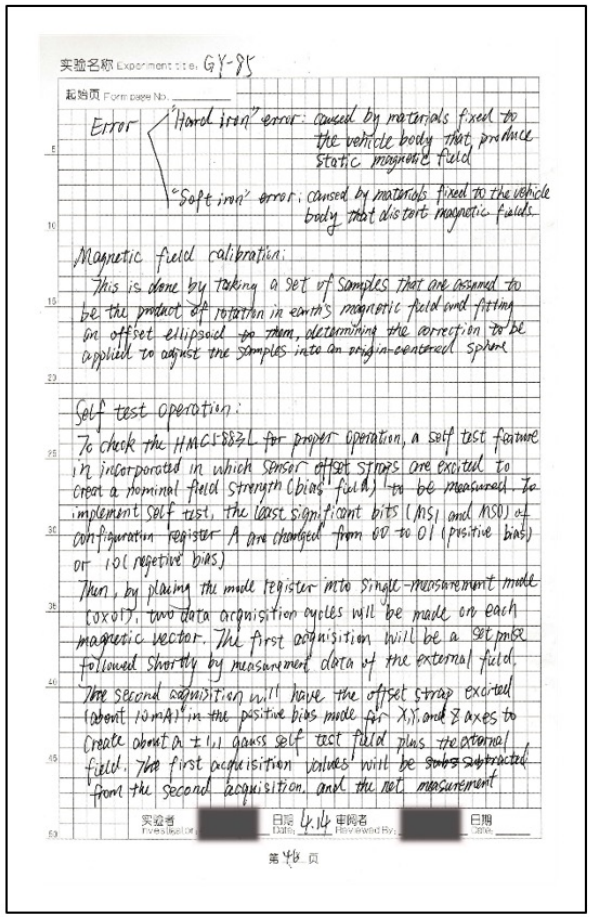
Tools: ELNs


Excellent
Very Good
Good
Fair
Poor
Very Poor
How do you rate your notetaking skills with ELNs as compared to the past?
How do rate the software in terms of collaboration?
How would you rate the software in terms of user experience?
How would you rate the software in terms of flexibility and adaptability?
How do rate ELNs in terms of ease of use?
How do rate your skillfullness with the ELN product?
0
20
40
60
80
100
Responses (%)

Results: ELNs



实验名称 Experiment title: GY-85

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Then, by placing the mode register into single-measurement mode (0x01), two data acquisition cycles will be made on each magnetic vector. The first acquisition will be a set pulse followed shortly by measurement data of the external field. The second acquisition will have the offset strap excited (about 10mA) in the positive bias mode for X, Y, and Z axes to create about a ±1.1 gauss self test field plus the external field. The first acquisition values will be ~~subtracted~~ from the second acquisition, and the net measurement

实验者 [redacted] 日期 4.16 审阅者 [redacted] 日期 _____

第 4/8 页

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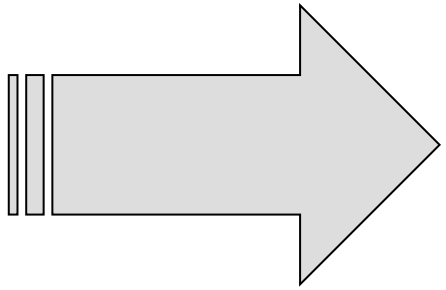
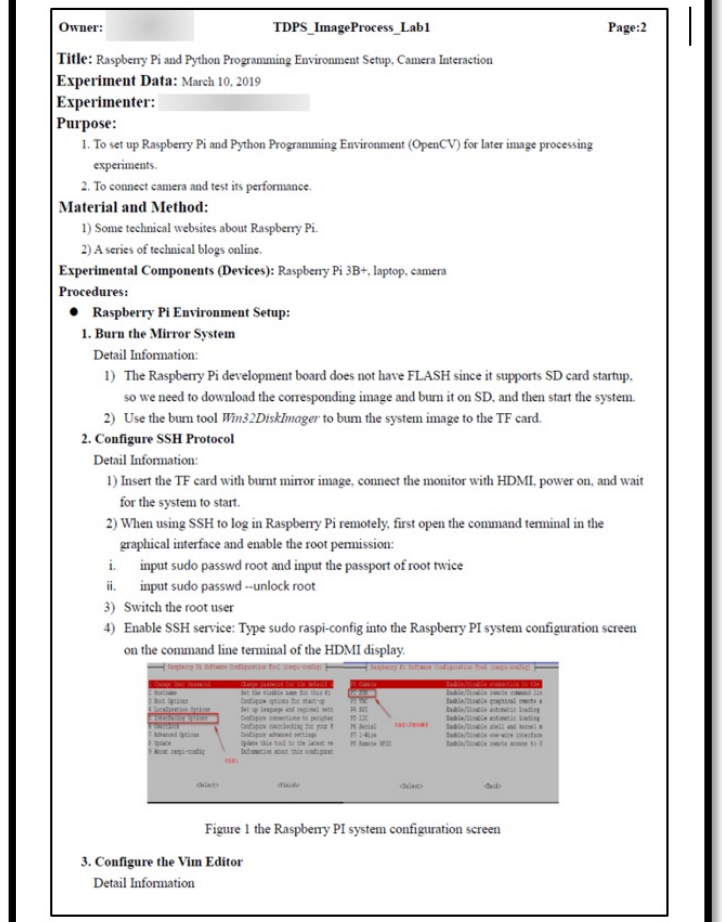




Owner: [redacted] **TDPS_ImageProcess_Lab1** **Page:2**

Title: Raspberry Pi and Python Programming Environment Setup, Camera Interaction
Experiment Data: March 10, 2019
Experimenter: [redacted]
Purpose:
1. To set up Raspberry Pi and Python Programming Environment (OpenCV) for later image processing experiments.
2. To connect camera and test its performance.

Material and Method:
1) Some technical websites about Raspberry Pi.
2) A series of technical blogs online.

Experimental Components (Devices): Raspberry Pi 3B+, laptop, camera

Procedures:

- **Raspberry Pi Environment Setup:**

1. Burn the Mirror System

Detail Information:
1) The Raspberry Pi development board does not have FLASH since it supports SD card startup, so we need to download the corresponding image and burn it on SD, and then start the system.
2) Use the burn tool *Win32DiskImager* to burn the system image to the TF card.

2. Configure SSH Protocol

Detail Information:
1) Insert the TF card with burnt mirror image, connect the monitor with HDMI, power on, and wait for the system to start.
2) When using SSH to log in Raspberry Pi remotely, first open the command terminal in the graphical interface and enable the root permission:
   i. input sudo passwd root and input the passport of root twice
   ii. input sudo passwd --unlock root
3) Switch the root user
4) Enable SSH service: Type sudo raspi-config into the Raspberry PI system configuration screen on the command line terminal of the HDMI display.

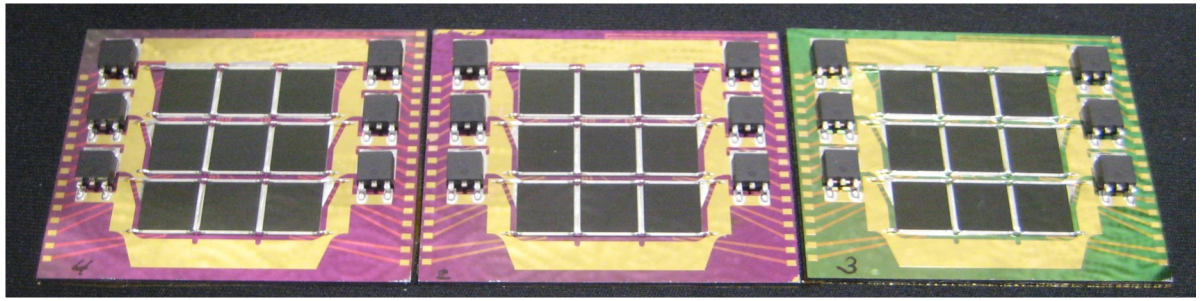
Figure 1 the Raspberry PI system configuration screen

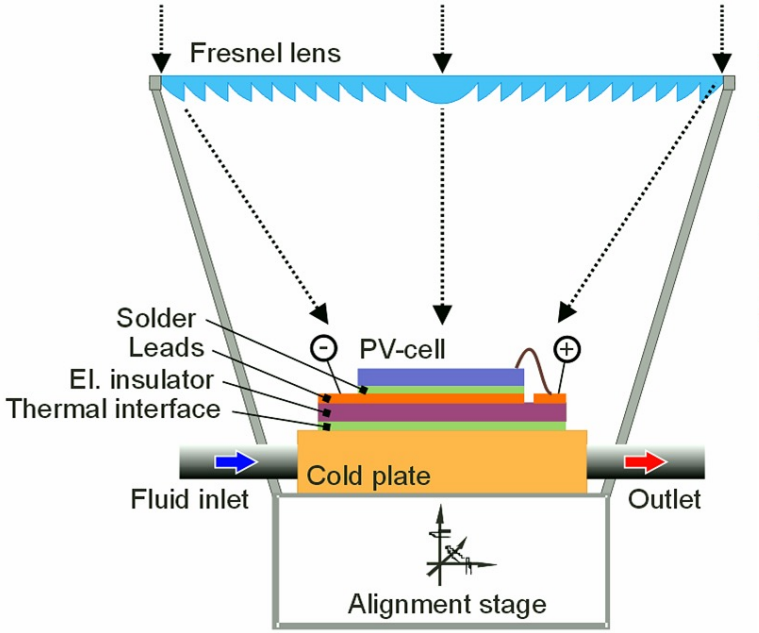
3. Configure the Vim Editor

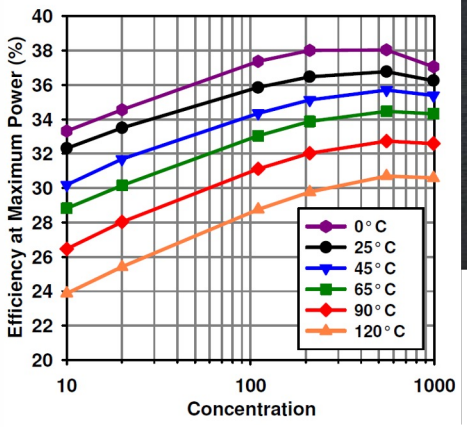
Detail Information

Fig. 3 An extract from a student lab notebook, which was developed using a dedicated ELN software product.

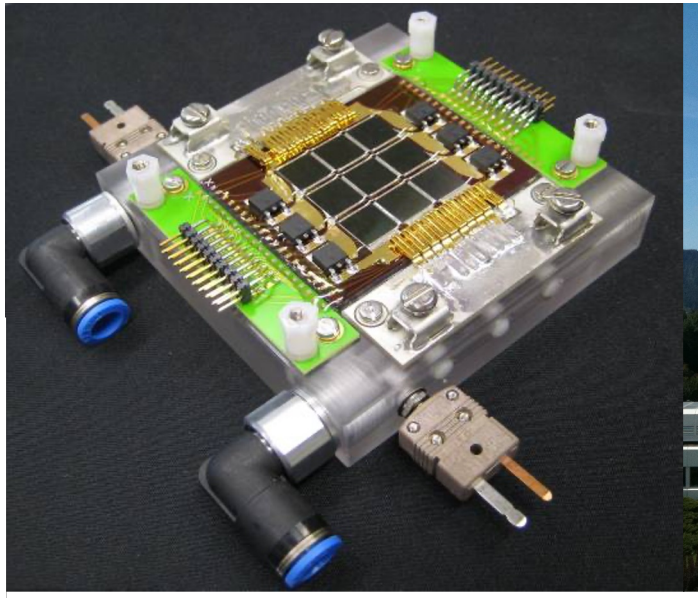
PV System Design







MCM Performance @ different concentrations and temperatures

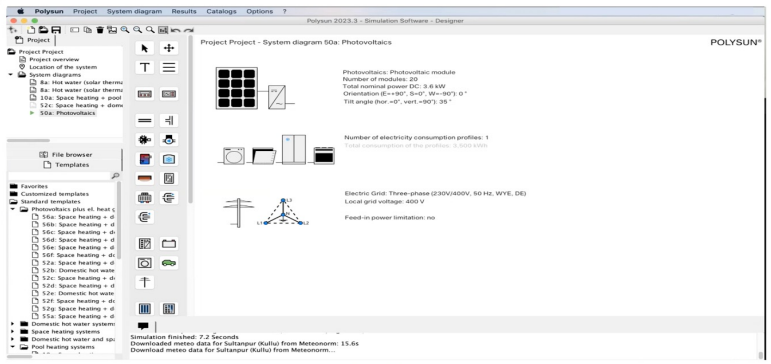


Assembled Multichip Module (MCM) with 9 PV Cells

CPV System in Zurich

Design and simulation process is complicated and requires expert domain knowledge. It also requires working together in teams

University of Glasgow



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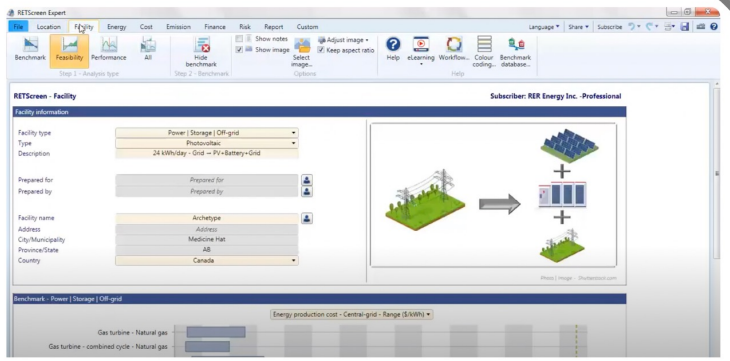

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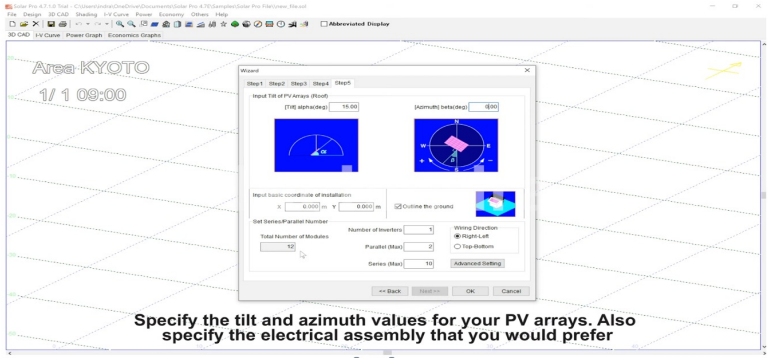

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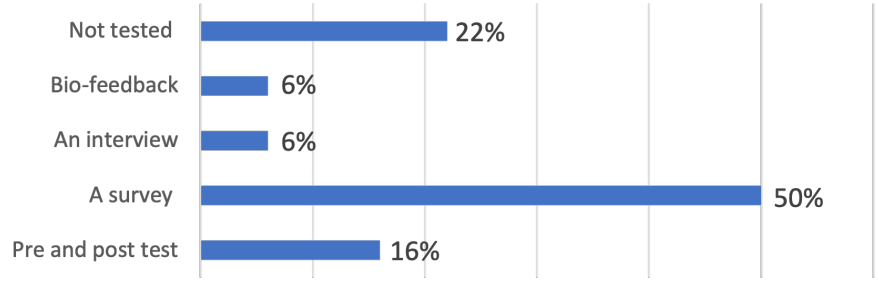

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Solar Pro

Eliciting Feedback – Surveys vs Sensors

University of Glasgow

University of Glasgow | College of Science & Engineering

School of Computing Science
University of Glasgow
18 Lilybank Gardens
Glasgow G12 8QQ
Tel.: +44 141 330 3718
Julie.Williamson@glasgow.ac.uk

Glasgow, May 10, 2023

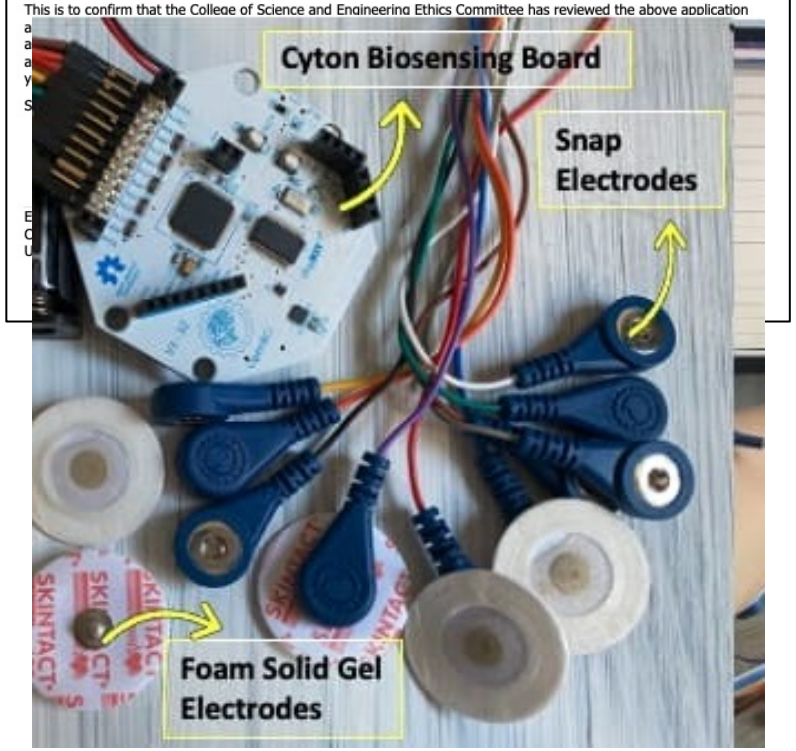
Ethical approval for:

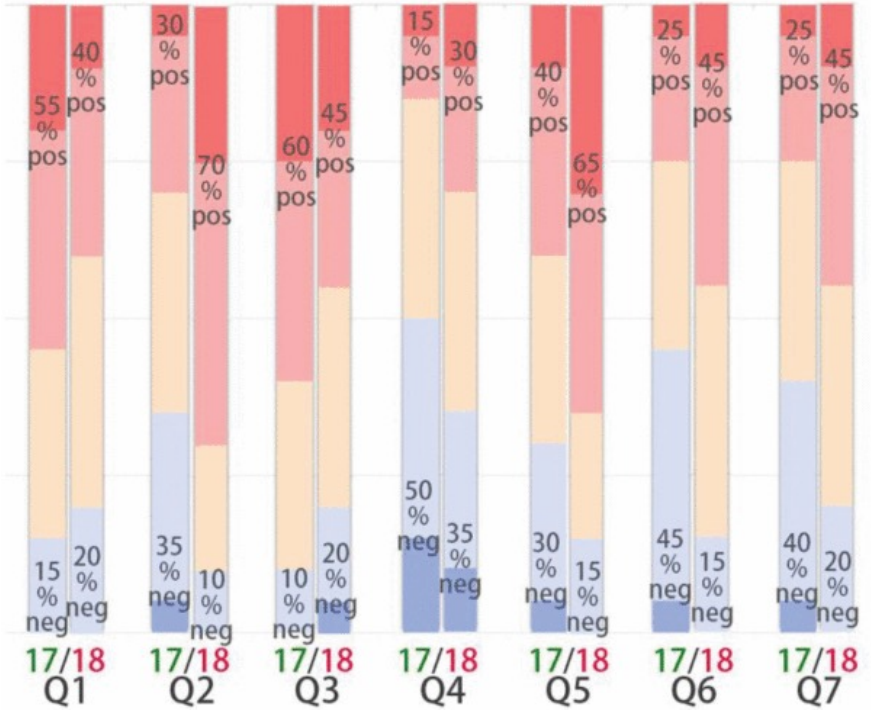
Application Number: 300220144

Project Title: Teaching AI to Undergraduate Engineering Students Using MATLAB

Lead Researcher: Dr Rami Ghannam

This is to confirm that the College of Science and Engineering Ethics Committee has reviewed the above application





students' feedback(2017/2018)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Q1. The instructor clearly presented the learning objectives of the course	0/0	3/4	6/8	7/6	4/2
Q2. The instructor engaged the class in productive discussions	1/0	6/2	7/4	5/9	1/5
Q3. The course provided rich content	0/1	2/3	6/7	7/5	5/4
Q4. I understand most of the course knowledge	3/2	7/5	7/7	2/4	1/2
Q5. The aquired knowledge is worthwhile my effort	1/0	5/3	6/4	6/7	2/6
Q6. I had a great team working experience in the course	1/0	8/3	6/8	4/7	1/2
Q7. The course has increased my affinity to electronics in general	1/0	7/4	7/7	4/7	1/2
Q8. I prefer this new form of courses? (In 2018)	-/1	-/2	-/4	-/8	-/5

Eliciting Feedback – "Realtime"

Eliciting Feedback – "Realtime"

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Results

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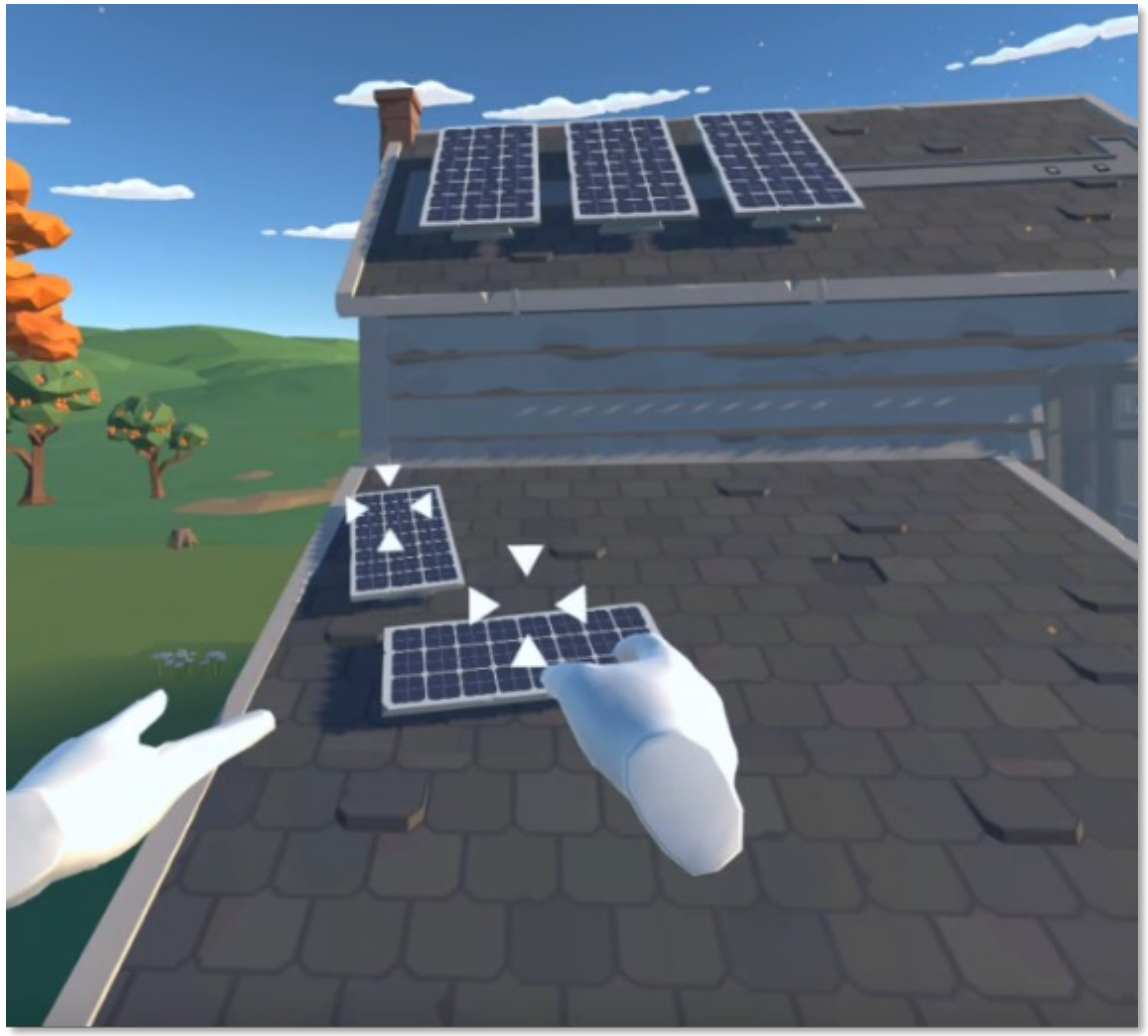

AR/VR/XR Work

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Made with unity

Extended Reality

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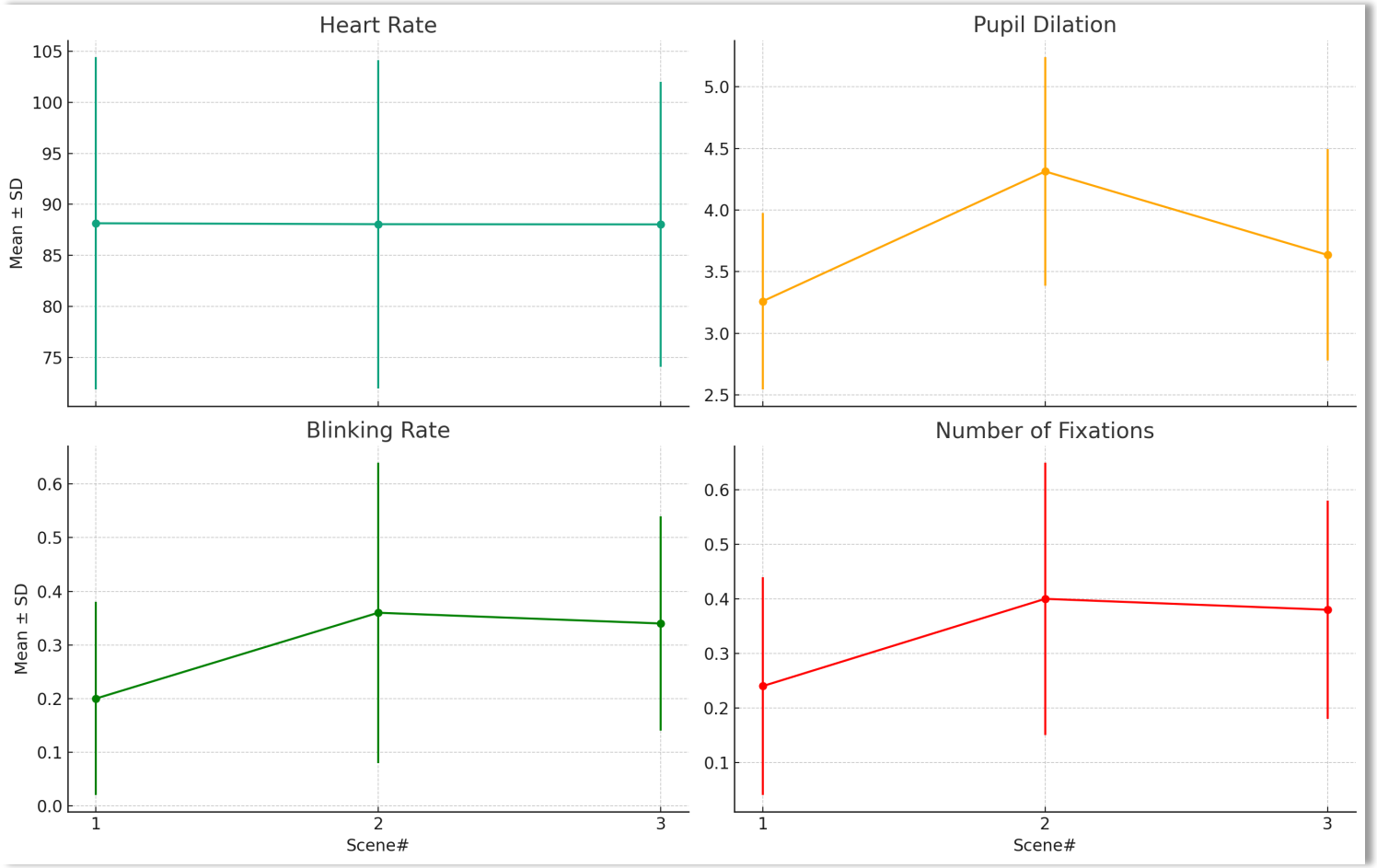
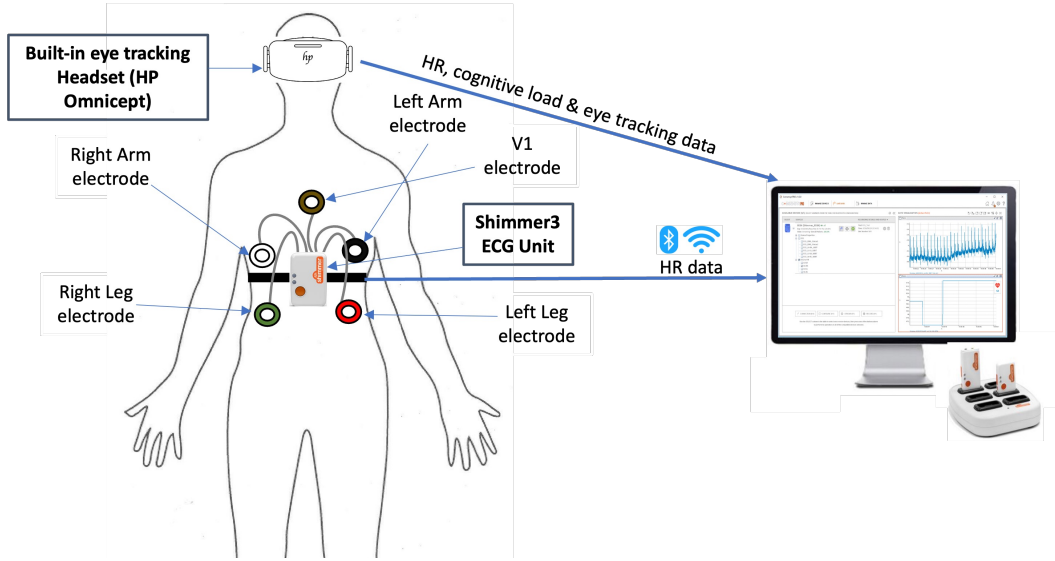
	Mean	SD
Satisfied	4.44	0.73
Engaged	4.67	0.50
Excited	3.67	0.71

Some Results





Increased engagement or excitement in 3D environment in comparison with 2D

2024. Solar Energy Systems Design using Immersive Virtual Reality: A Multi-Modal Learning Approach. *Under Review*

REEDA Project - Hackathon

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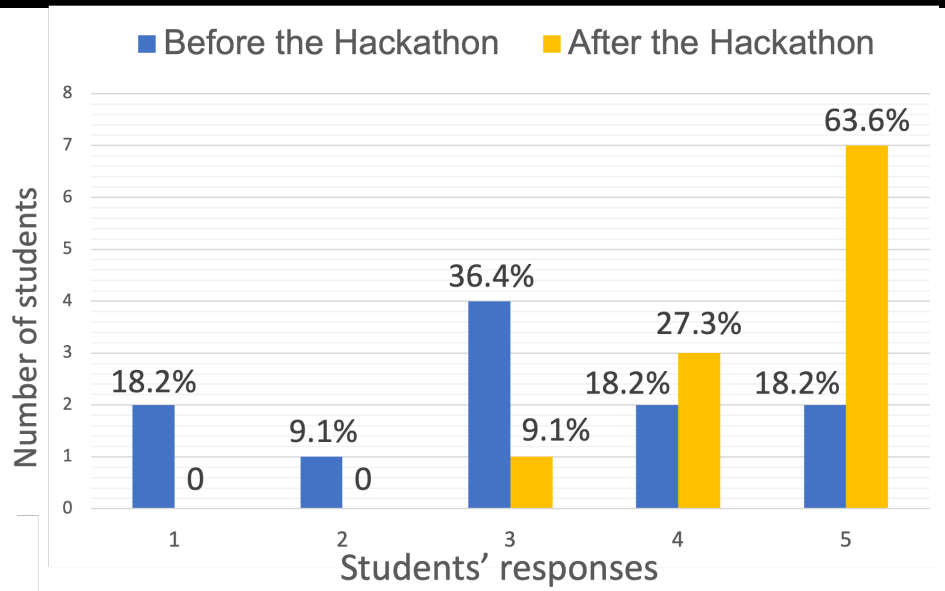
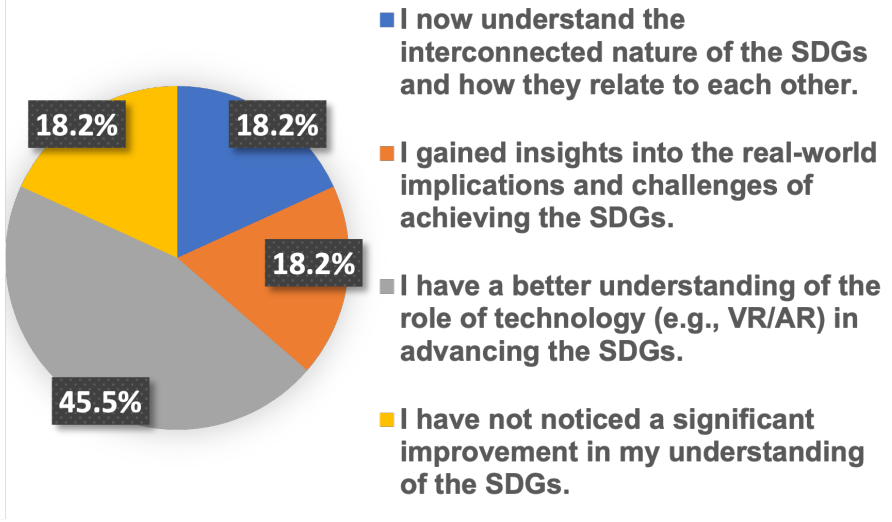
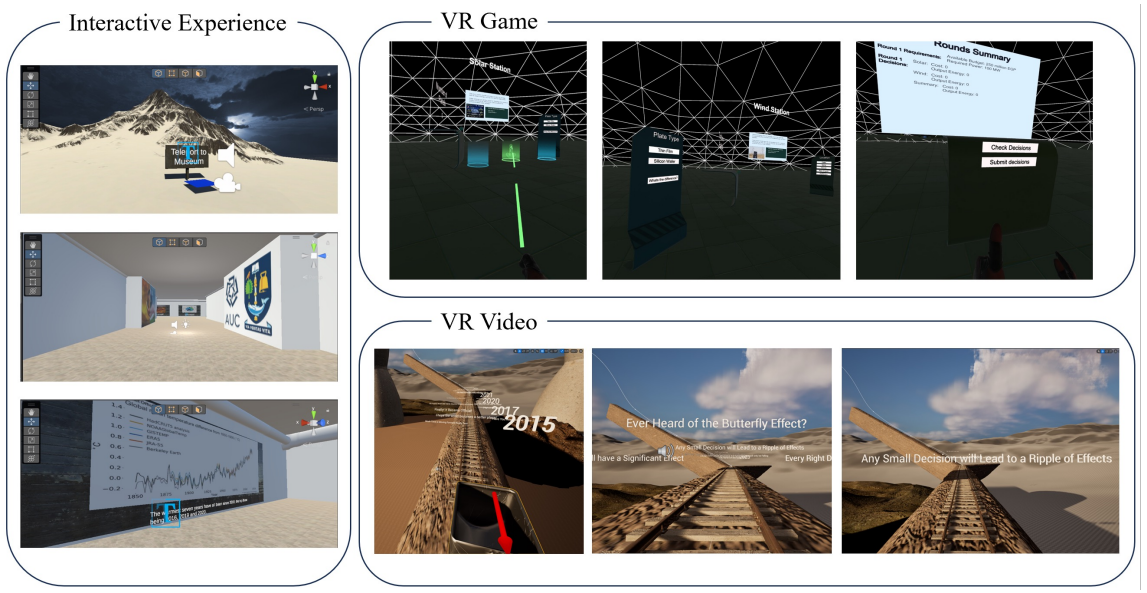
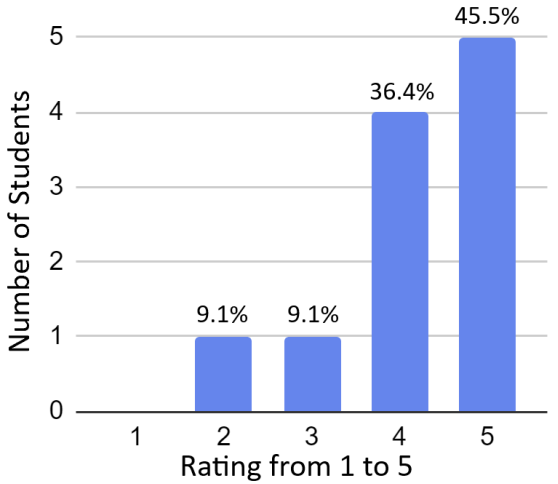
Hackathon Video link:
https://youtu.be/oByg9jLqu1U

REEDA Project - Hackathon









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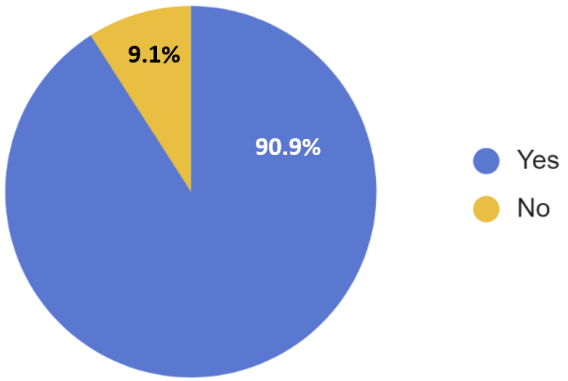

(B)

(2024) Empathy, education and awareness: a VR hackathon's approach to tackling climate change. Sustainability, (Accepted for Publication)

Integrated Systems Design Project - ISDP

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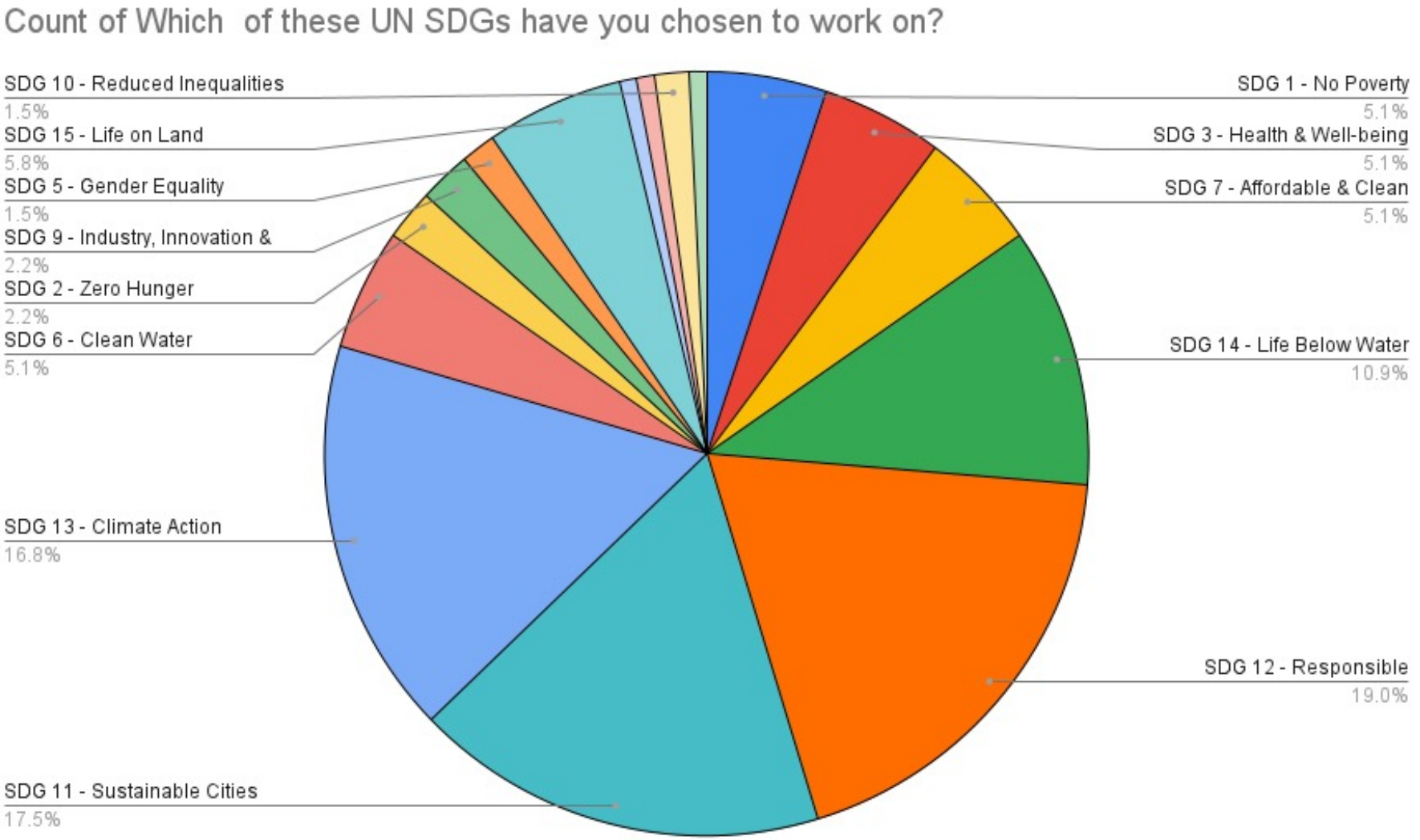

Integrated Systems Design

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%	Deliverable	Time	Contribution
		SEMESTER 1	
10	Initial concept ‘pitch’	Week 8	Individual/Group
		SEMESTER 2	
30	Group showcase + Demo	Week 7	Group
30	Final Report	Week 8	Group
30	Self-Reflection Evaluation report	Week 9	Individual
100	**-- TOTAL --**		

ISDP4

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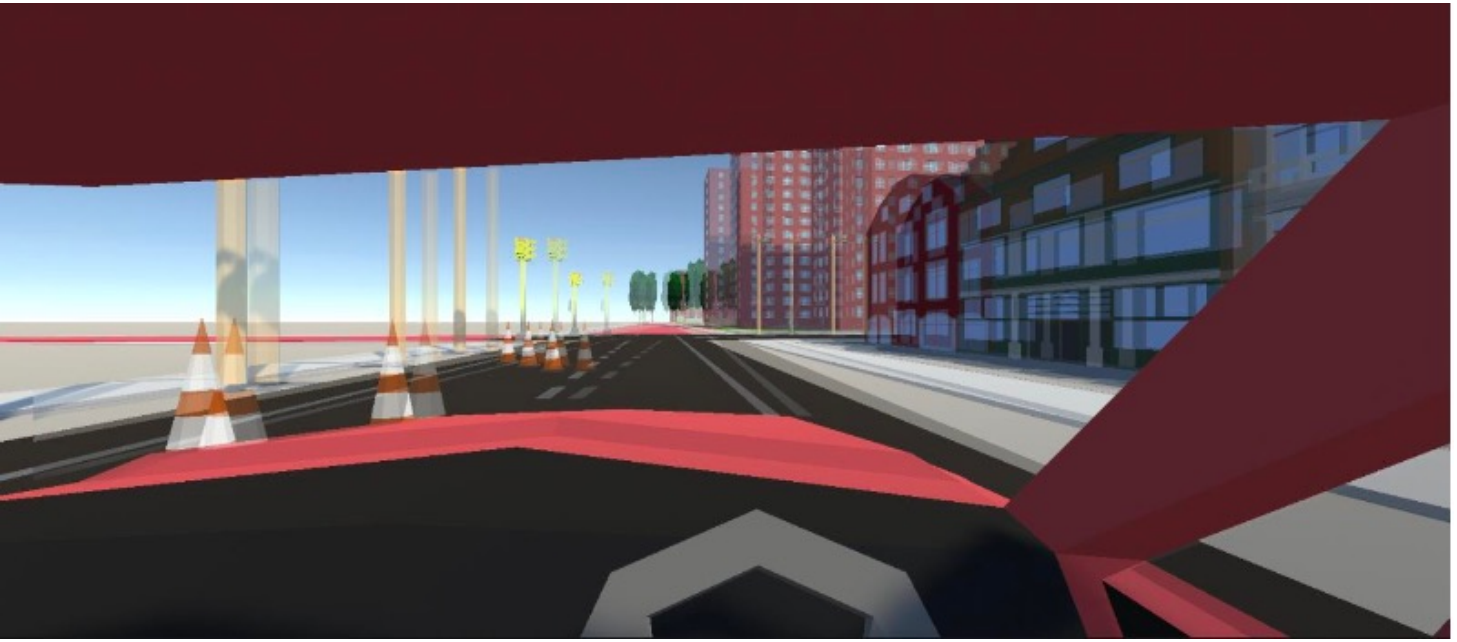
ISDP4 – Student Projects



ISDP4 – Student Projects

Figure 10 -VR screenshot of the underwater environment developed for the MVP.

Figure 11 VR screenshots of the informative areas developed for the MVP

Immersive Learning - Glasgow

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Call for Papers and Proposals

Conference theme: "Tech4Good"

June 3 – 5, 2024	Online & in Virtual Reality
June 10 – 13, 2024	Glasgow, Scotland; University of Glasgow

https://www.immersivelrn.org/iLRN2024

University of Glasgow

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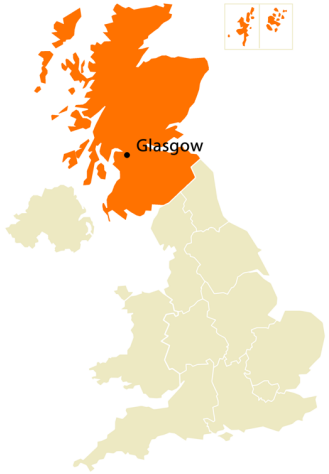

Thank you!