

# Active Learning and Interactive Electronics for Teaching Engineering

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



- Scotland Chair of the IEEE Education Society.

#iLRN

- Chair of UK:iLRN Chapter



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



# Research Interests

## ENGINEERING DESIGN

Home

Projects

Sensing & Signal  
Processing

Energy Harvesting

Design for Learning

Team

Resources

Publications

Initiatives

Contact

## END PROJECTS

### 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 focused on hand and eye gesture recognition.

# UoG + UESTC Partnership



**2013** - Electronics and Electrical Engineering (EEE).

**2016** - EEE with Communications.

**2019** - EEE with Microelectronics.



# “Technology Enhanced Hybrid Learning”

Project Based Learning



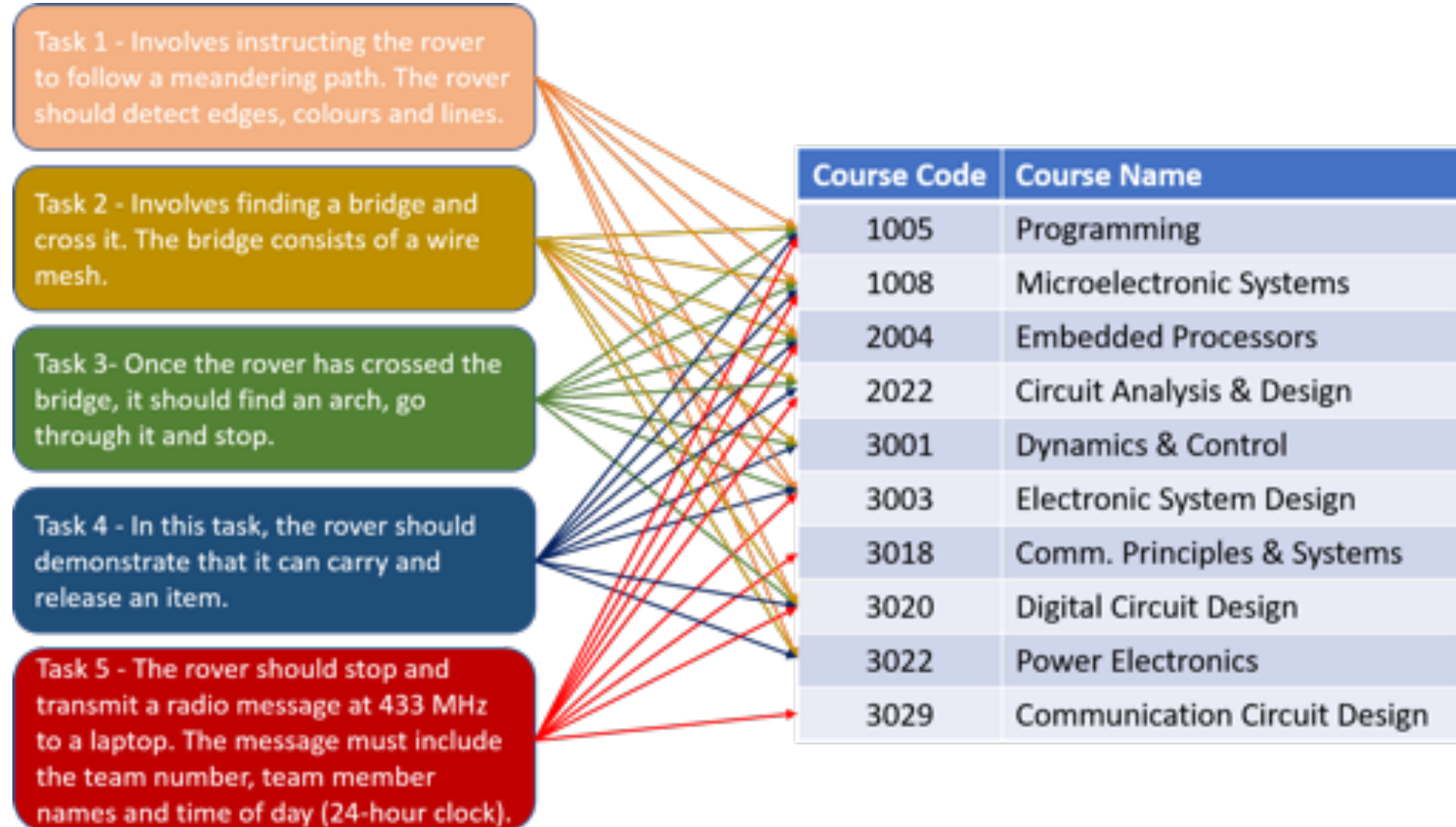
Technology Enhanced Hybrid Learning



Team Based Learning



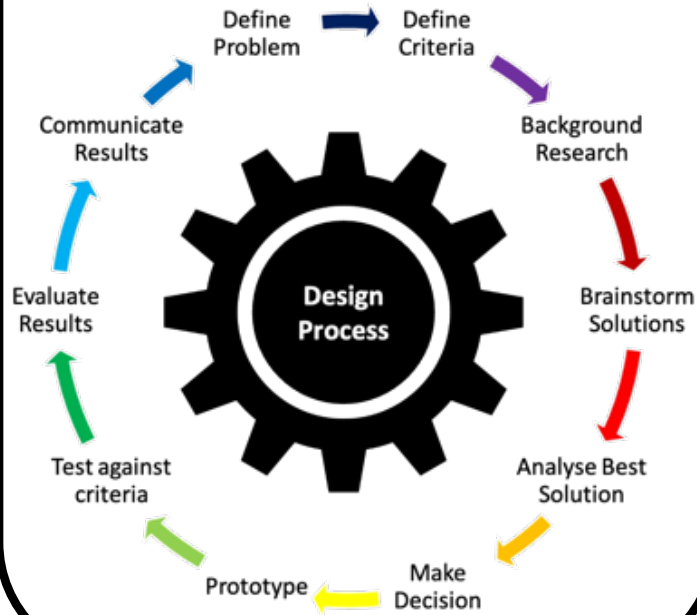
# TDPS – Module Design



# TDPS – Current Status

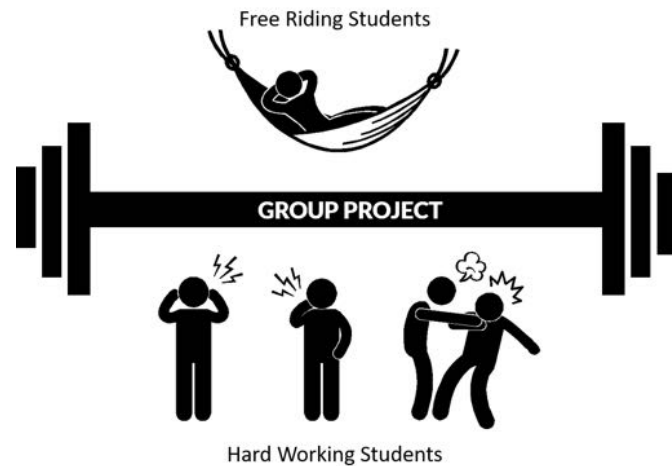
## Principles of Design

Introduction and definition to the design process.



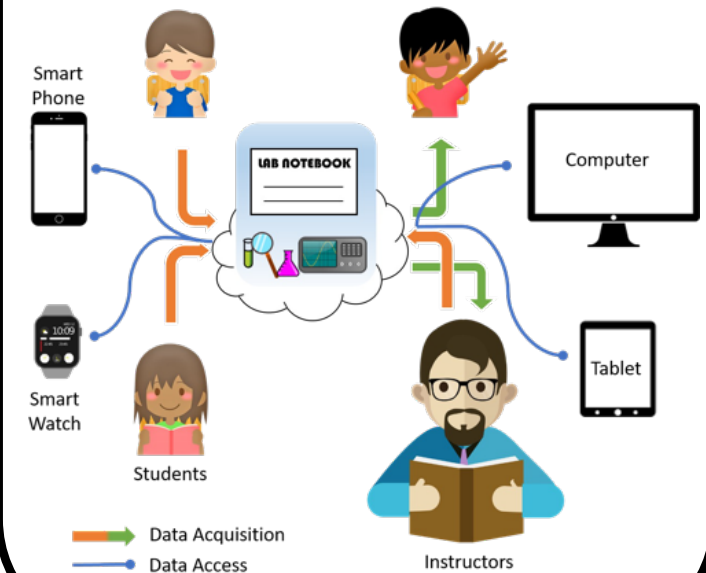
## Teamwork

Identify characteristics of effective teams & stages of team development



## Working with Data

ICT tools to facilitate teamwork and collaboration



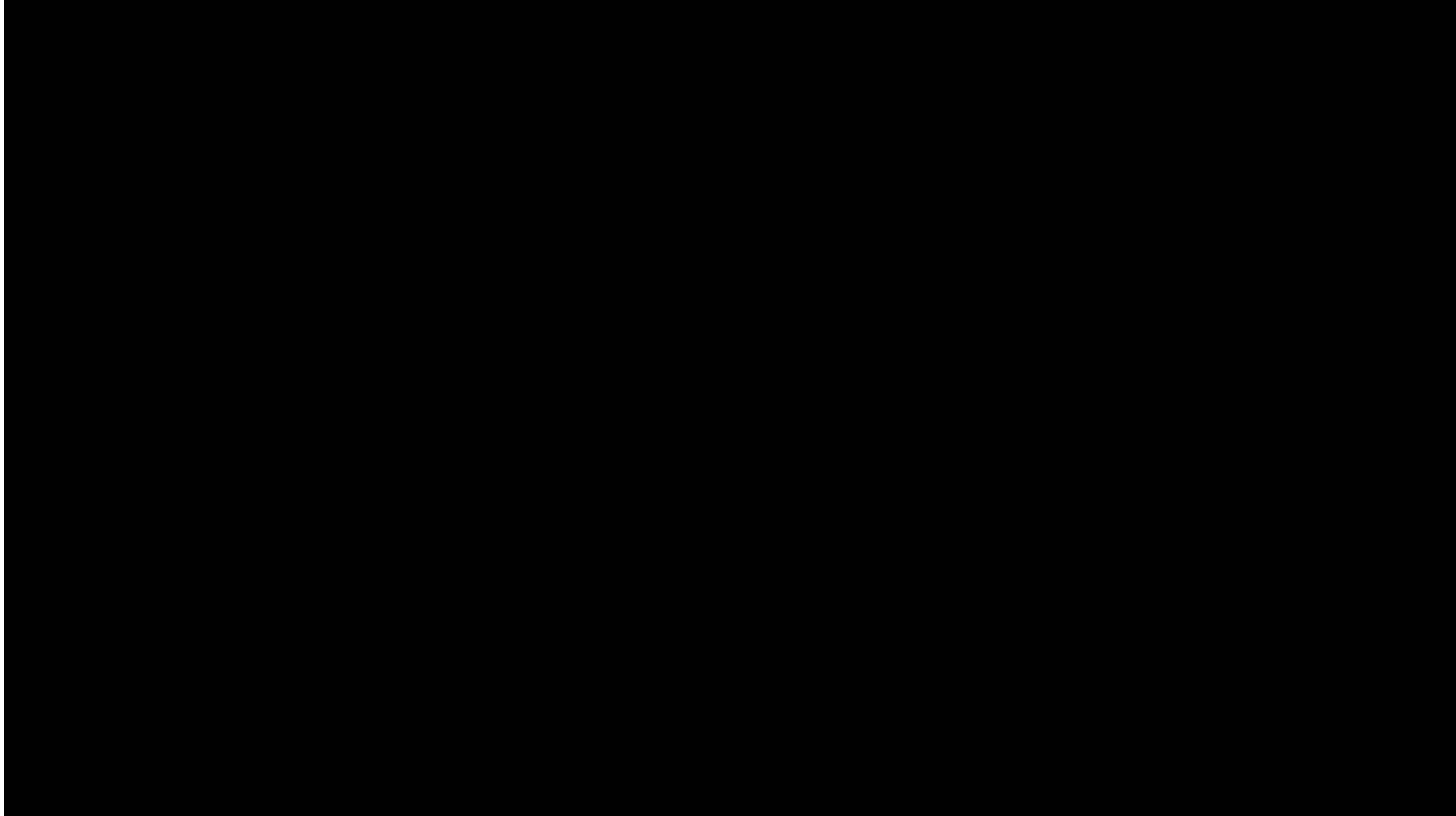
## Team Design Project: A Case Study

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





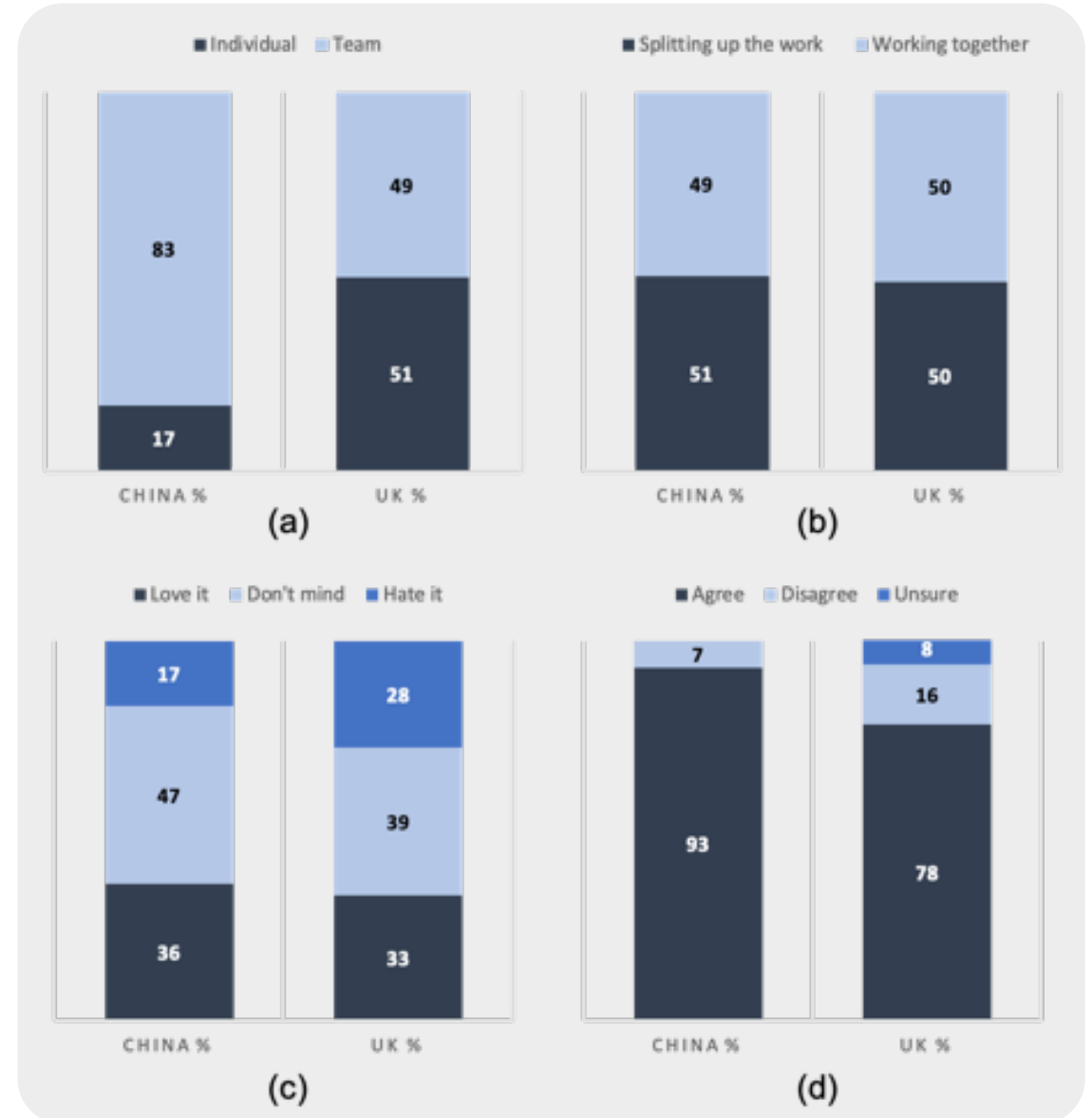
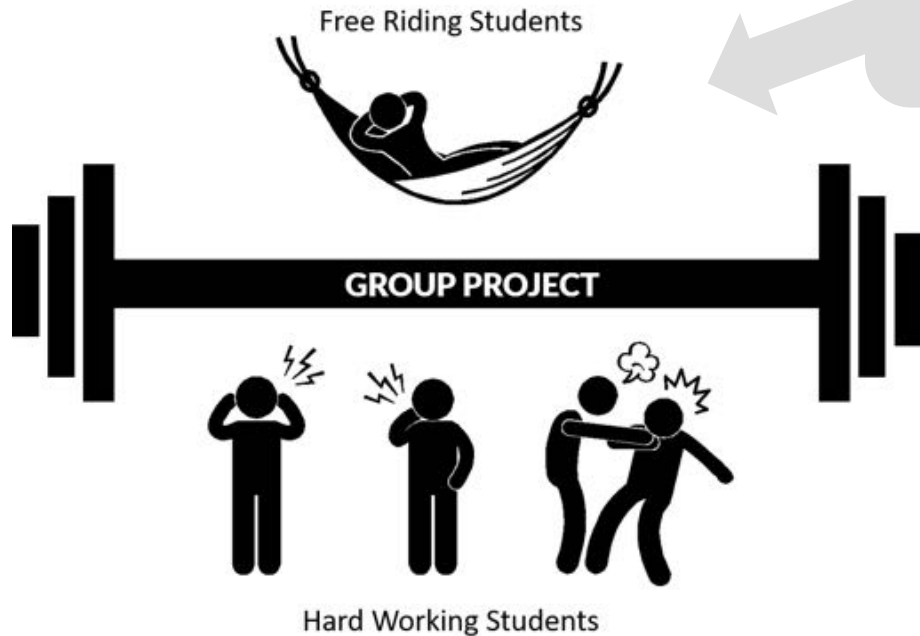
# TDPS – Student Sample



# TDPS Module

Comparison between British and Chinese student experiences

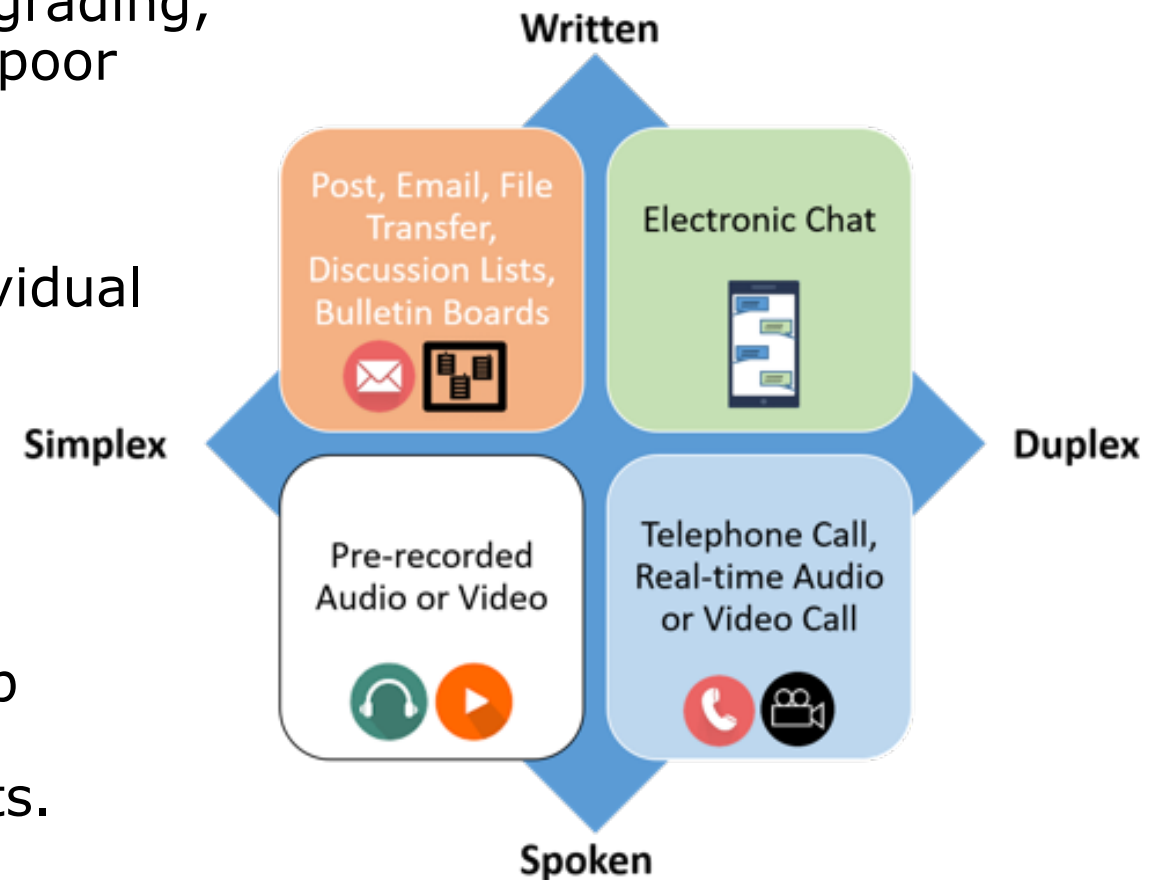
Students disliked group projects



# 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.



# Paper Notebooks




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

DATE April 6<sup>th</sup>. [REDACTED] WEATHER

Notes on the Topic. 'Ultra-sonic Sensor'

- The Core System would obtain a series of various different types sensors, of different functions, shall the outcomes be closely monitored to initial planning.
- Absorbō Nostrum the portion of distance-measurement. 'Ultra-sonic' sensors Multiple distance-determinations and measurement actions will be done ~~done~~ through the functioning of the out. Proving actions, involving Turning, collecting beam objects, and path-finding, etc. etc. all needs the advice. It's duty of rapidly measure the legends of a certain object or space ~~accuracy~~ ~~sniffer~~ fits to be required accomplishments above..

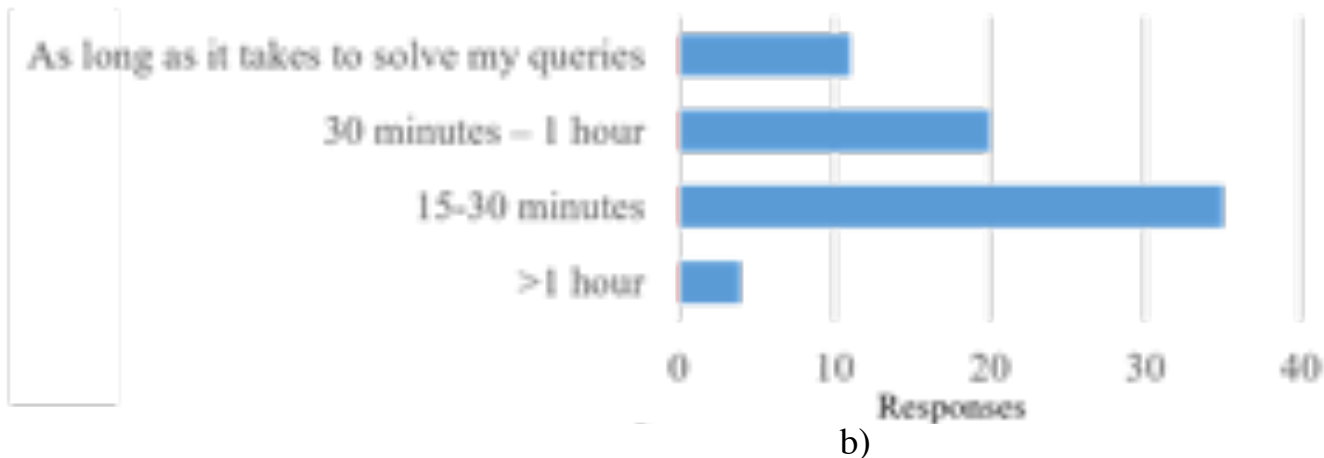


The one-bit of a single derive.



# Mentorship

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

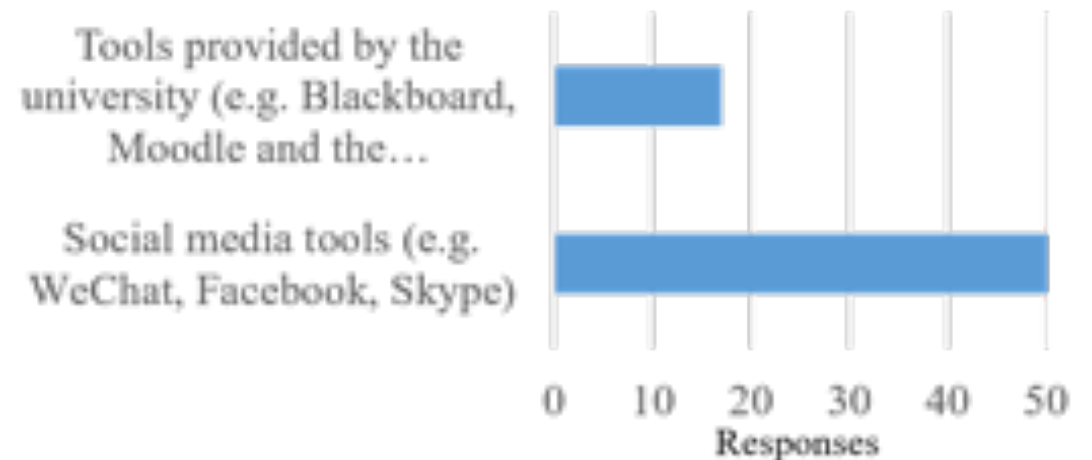


# Mentorship - How?

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



a)



b)

# Tools: ELNs

SCINOTE

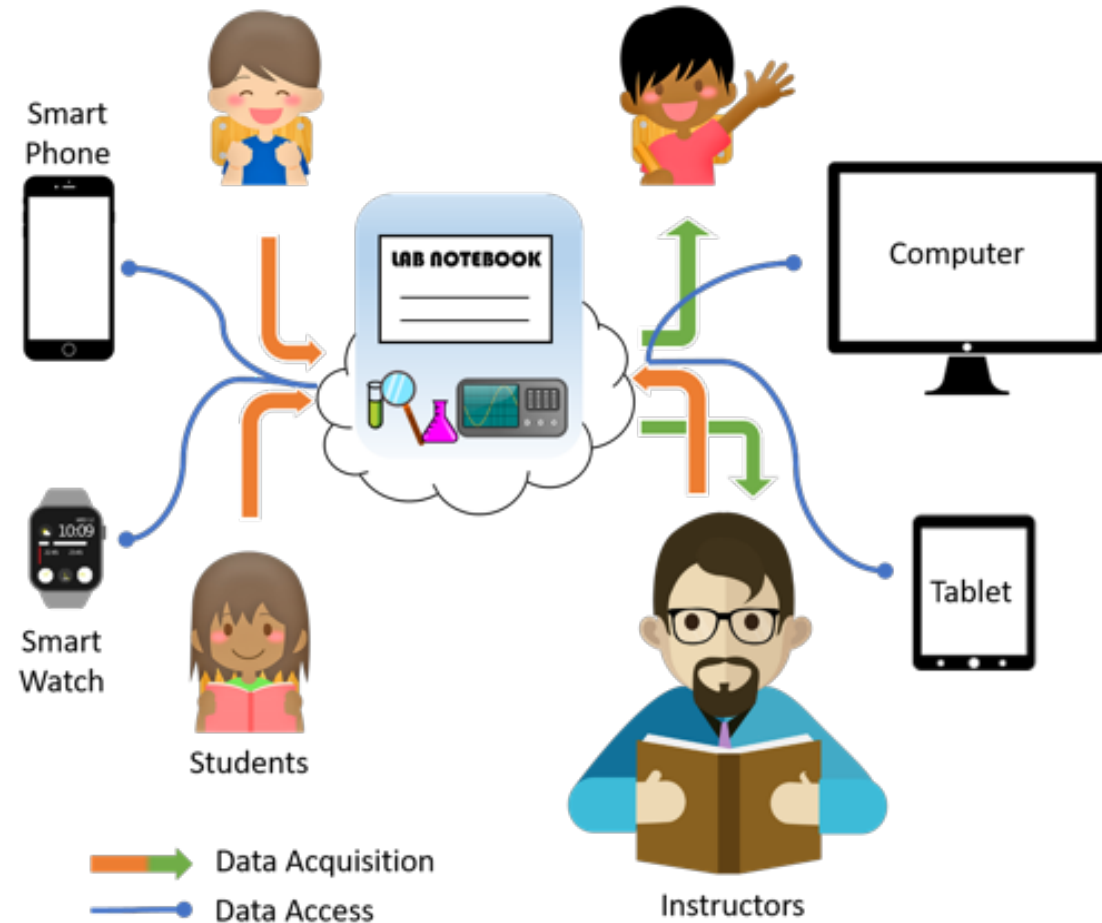
OneNote

labarchives  
Research Notebook

RSpace

eLabFTW

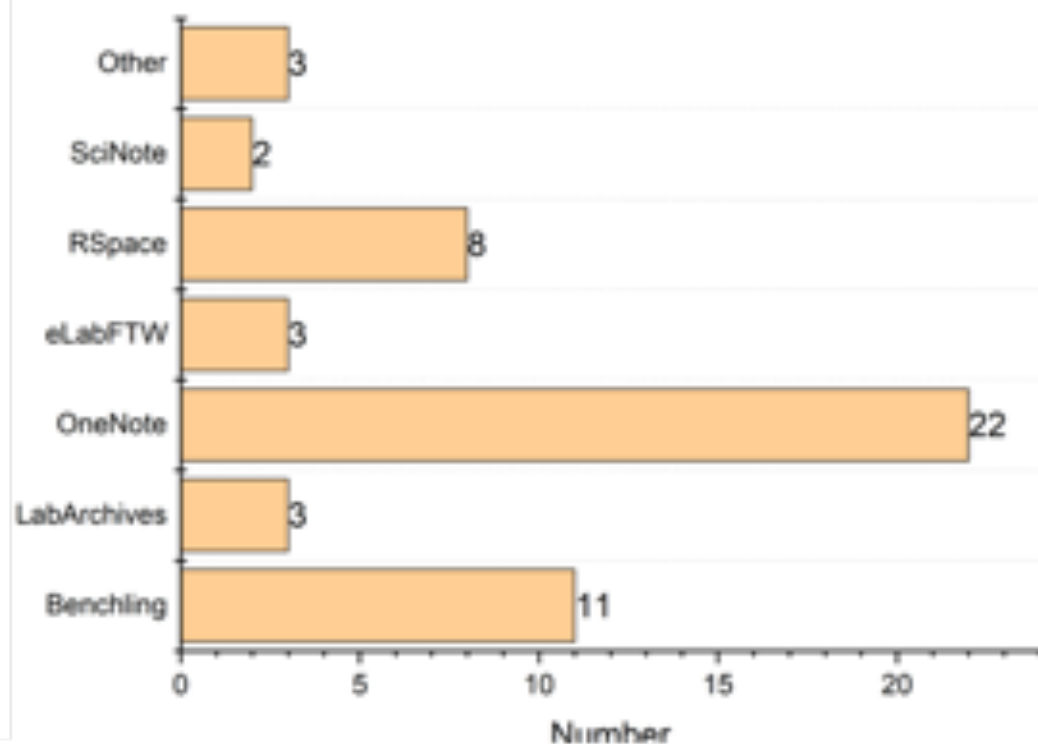
Benchling



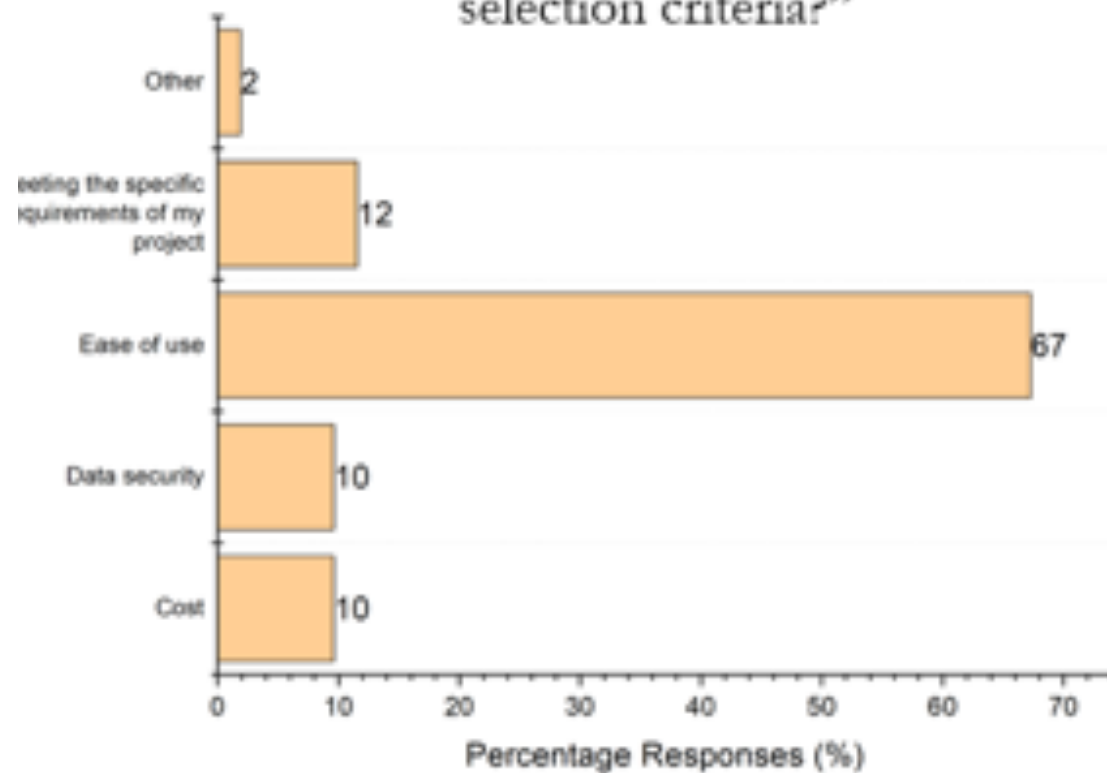
ELNs and their accessibility from any location and device. They enable students to exchange information and to collaborate in real time. They also enable instructors to provide feedback and assess student work as it is being performed.

## Project Results

“Which ELN software product did you use for this project?”

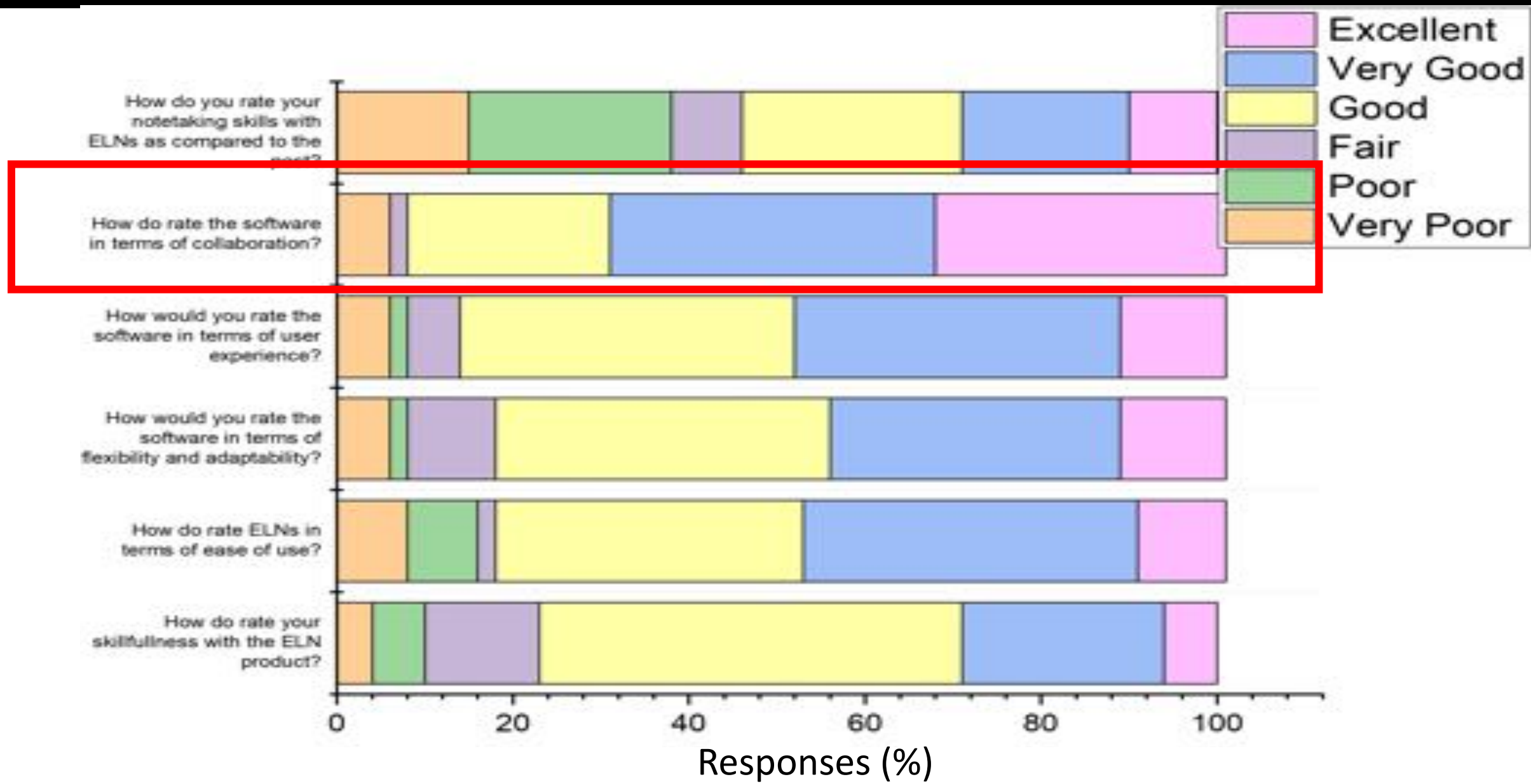


“What would be your major selection criteria?”





# Tools: ELNs



# Results: ELNs



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

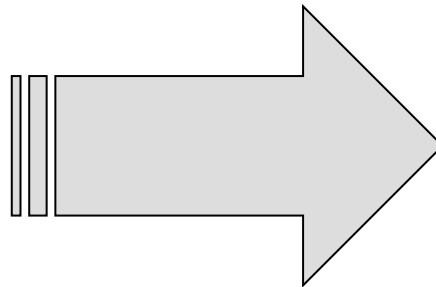
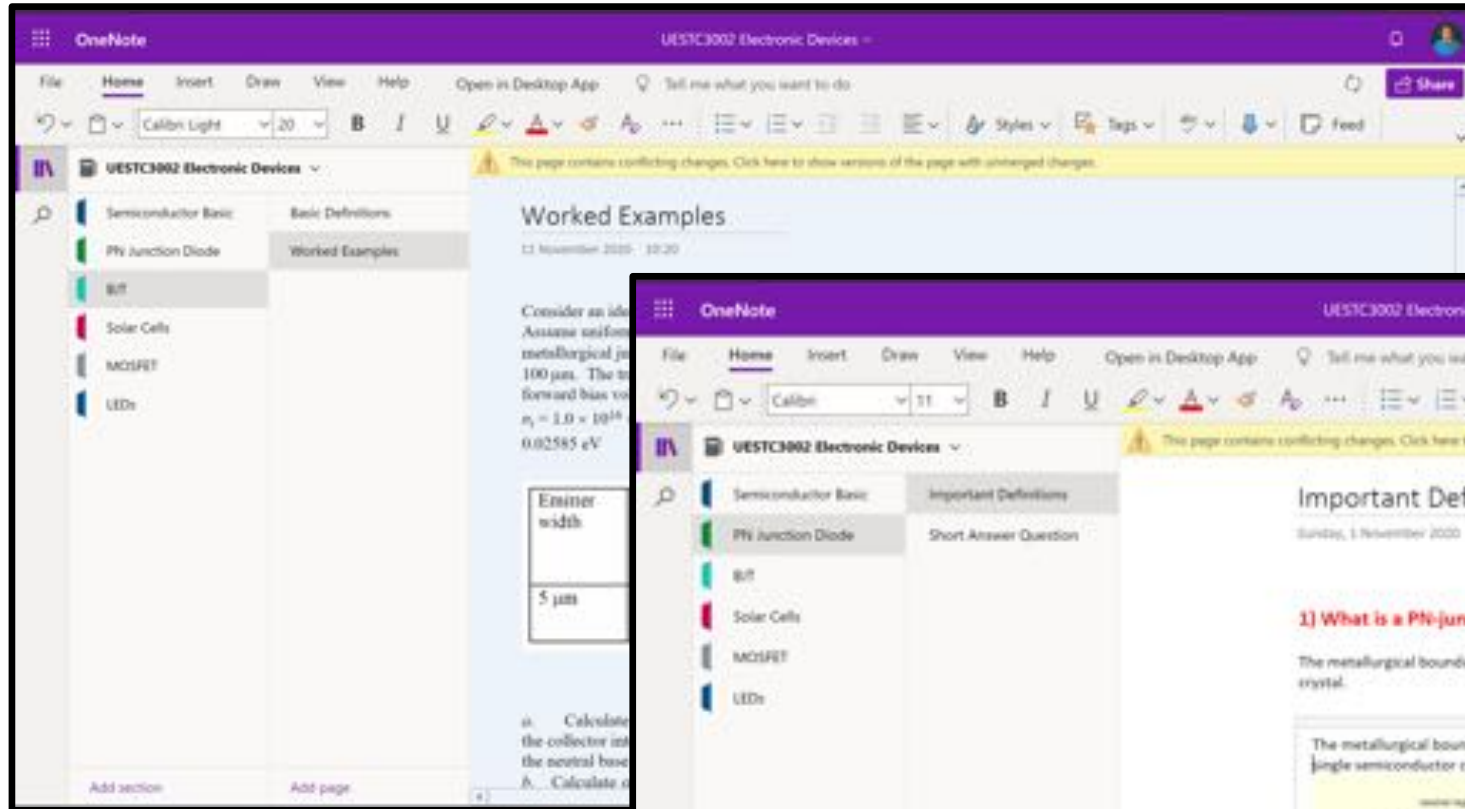


Fig. 3 An extract from a student lab notebook, which was developed using a dedicated ELN software product.

# Results: ELNs



OneNote window: UESTC3002 Electronic Devices

File Home Insert Draw View Help Open in Desktop App Tell me what you want to do

Calibri Light 20

UESTC3002 Electronic Devices

- Semiconductor Basic
  - Basic Definitions
  - Worked Examples
- PN Junction Diode
- BIT
- Solar Cells
- MOSFET
- LEDs

### Worked Examples

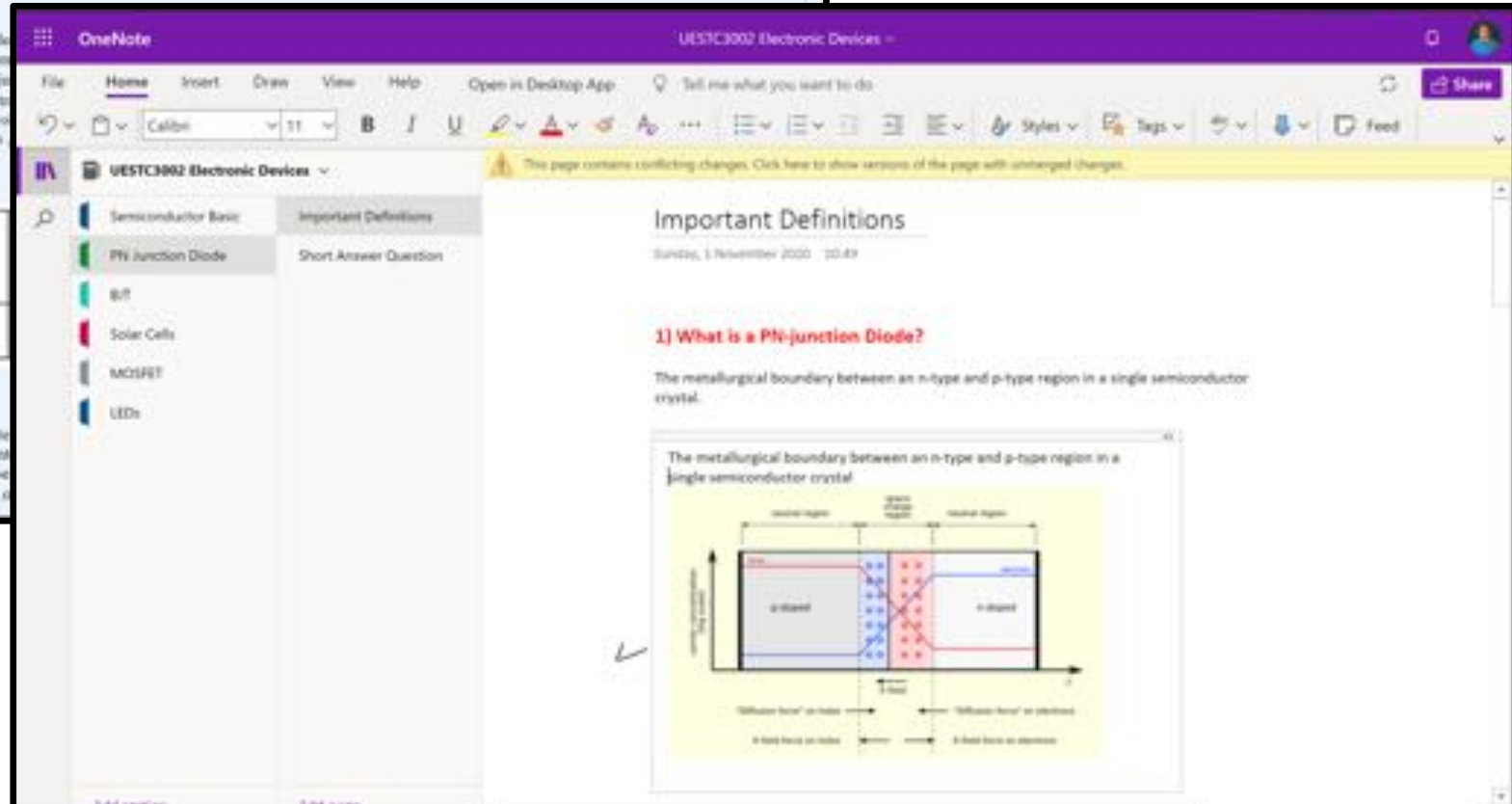
12 November 2020 10:20

Consider an ideal  
Assume uniform metallurgical junction  
100  $\mu\text{m}$ . The forward bias voltage is  
 $n_i = 1.0 \times 10^{10} \text{ cm}^{-3}$   
0.02585 eV

Emitter width
5 $\mu\text{m}$

Calculate the collector current  
the neutral base  
Calculate the

Add section Add page



OneNote window: UESTC3002 Electronic Devices

File Home Insert Draw View Help Open in Desktop App Tell me what you want to do

Calibri 11

UESTC3002 Electronic Devices

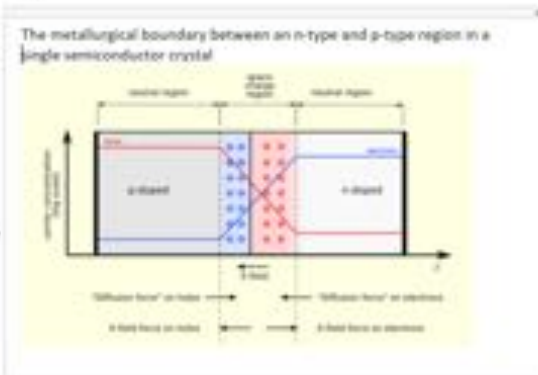
- Semiconductor Basic
  - Important Definitions
  - Short Answer Question
- PN Junction Diode
- BIT
- Solar Cells
- MOSFET
- LEDs

### Important Definitions

Sunday, 1 November 2020 10:49

#### 1) What is a PN-junction Diode?

The metallurgical boundary between an n-type and p-type region in a single semiconductor crystal.



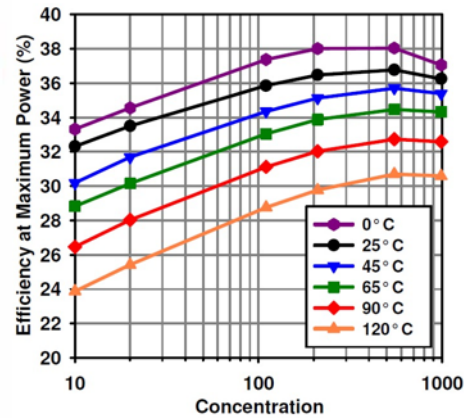
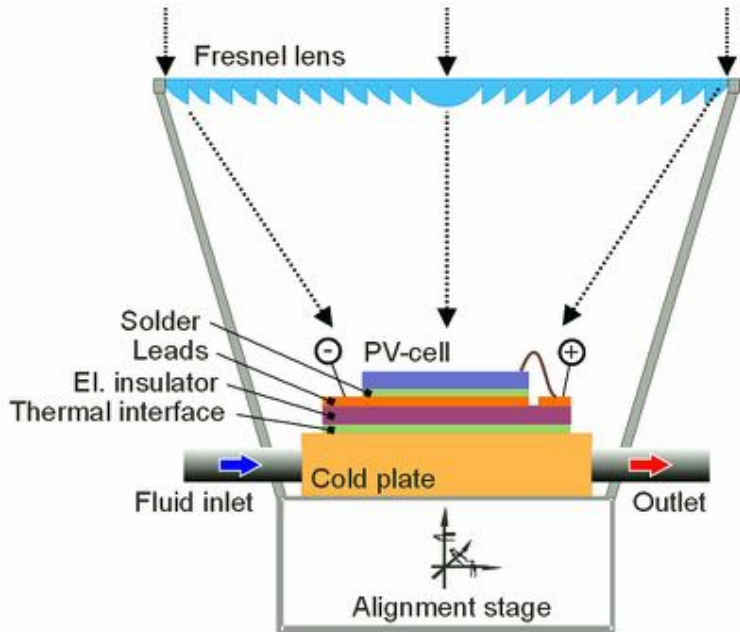
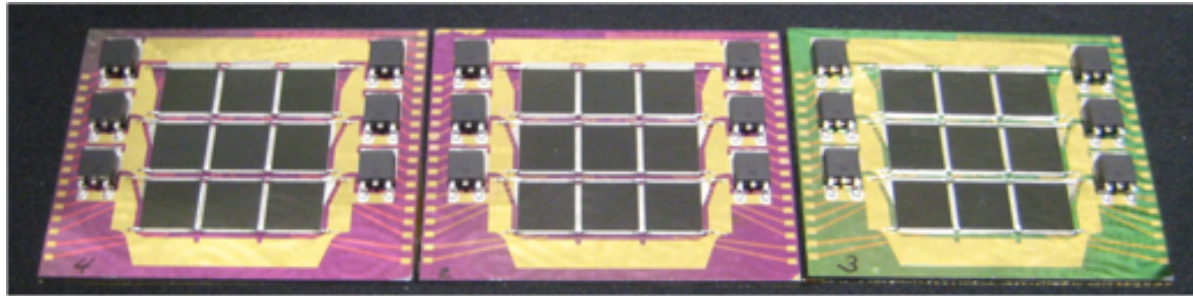
The metallurgical boundary between an n-type and p-type region in a single semiconductor crystal

The diagram shows a rectangular cross-section of a PN-junction diode. The left side is labeled 'n-region' and contains blue dots representing donor atoms. The right side is labeled 'p-region' and contains red dots representing acceptor atoms. A vertical line in the center is labeled 'Metallurgical Boundary'. On either side of this boundary, there is a shaded region labeled 'Depletion Region'. Arrows point from the depletion regions towards the metallurgical boundary, indicating the direction of the electric field. Labels at the bottom indicate 'n-Region Fermi level' and 'p-Region Fermi level'.

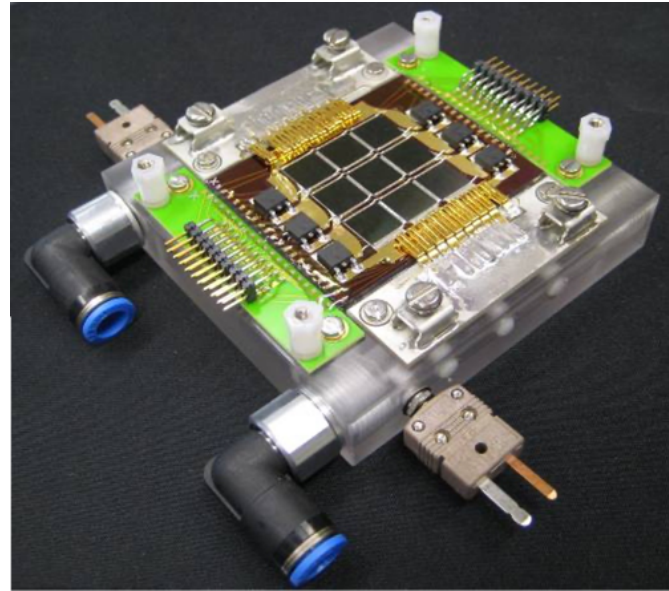




# PV System Design



MCM Performance @  
different concentrations and  
temperatures



Assembled Multichip Module (MCM) with  
9 PV Cells



CPV System in Zurich

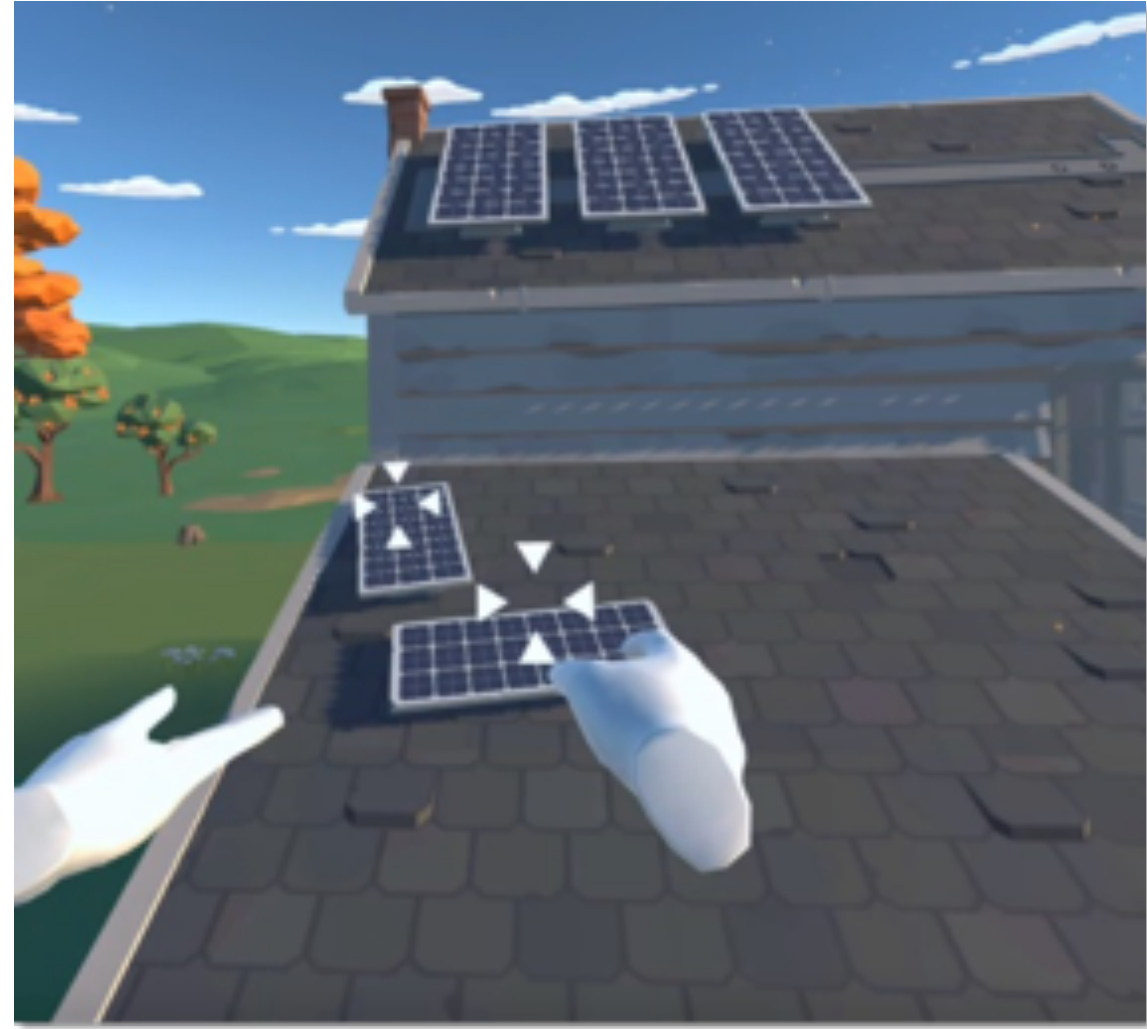
Design and simulation process is complicated and requires expert domain knowledge. It also requires working together in teams

# Extended Reality





# Results



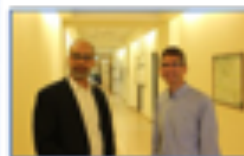
# AR/VR/XR Work



Made with



# REEDA Project - Hackathon



HACKATHON

## CAIRO'S VR EMPATHY HACKATHON: TACKLING CLIMATE CHANGE WITH VR

JULY 4TH, 5TH, & 6TH 2023

WIN A VR HEADSET!



Join us for an innovative 3-day hackathon where students from diverse disciplines come together to learn, design and build VR experiences focused on key United Nations Sustainable Development Goals

This year, we're tackling Quality Education (SDG 4), Affordable and Clean Energy (SDG 7), Sustainable Cities and Communities (SDG 11), and Climate Action (SDG 13)

Harness the power of VR to raise awareness, educate and propose solutions to these global issues

Located at the AUC New Campus

Open to all university students, irrespective of the major

For more information, please contact  
Zahwa and Sultan:  
zahwaelsayed@aucegypt.edu  
abdelrahmansultan@aucegypt.edu



APPLY HERE!



REEDA is developed by a consortium of premier institutions from both the UK and Egypt to help raise awareness around 4 important UN Sustainable Development Goals (SDGs) using the "metaverse"



Hackathon Video link:

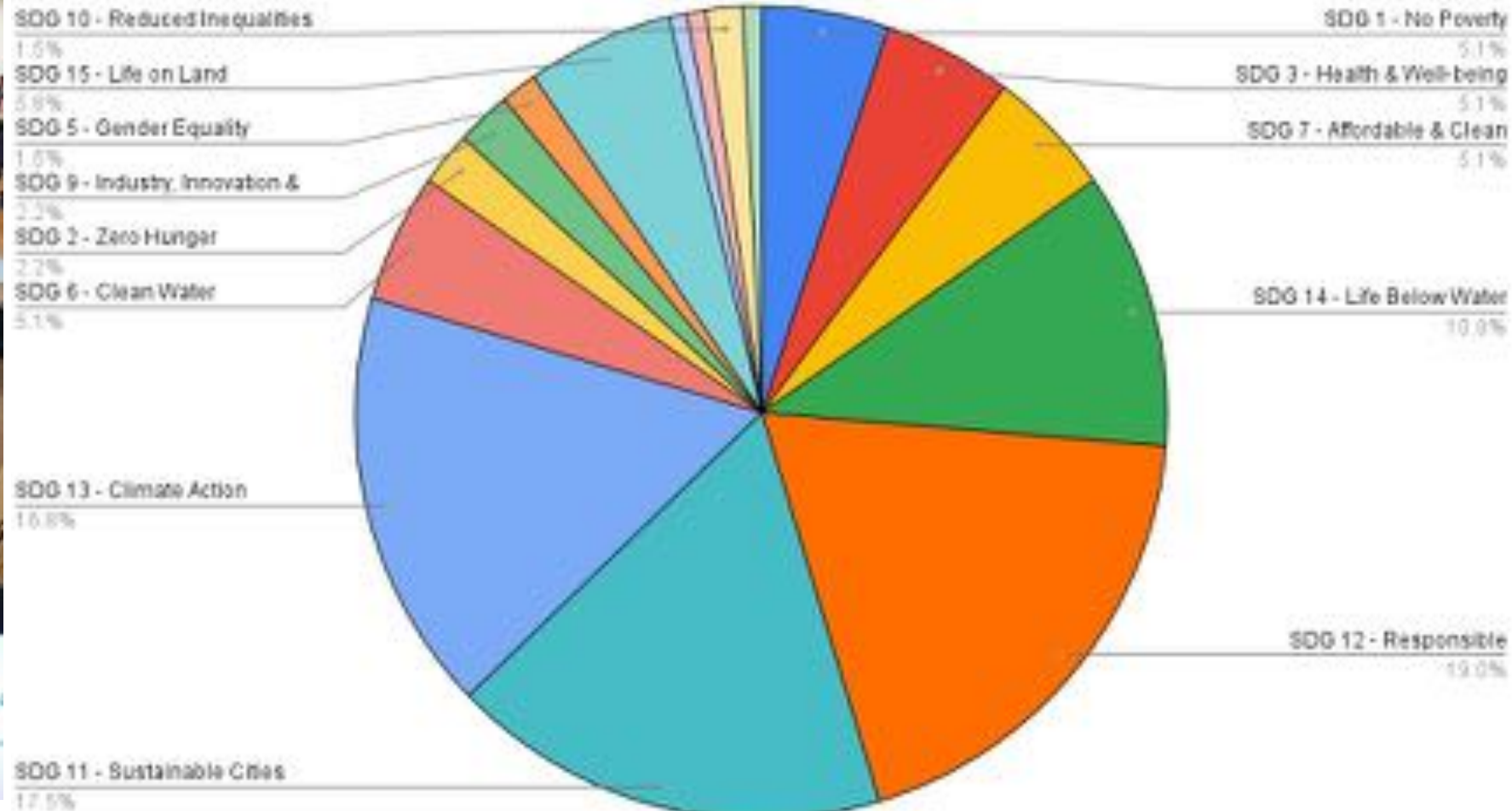
<https://youtu.be/oByg9jLqu1U>



# Integrated Systems Design Project - ISDP



Count of Which of these UN SDGs have you chosen to work on?



# Integrated Systems Design Project - ISDP

%	Deliverable	Time	Contribution
<b>SEMESTER 1</b>			
10	Initial concept 'pitch'	Week 8	Individual/Group
<b>SEMESTER 2</b>			
30	Group presentation + Demo	Week 7	Group
30	Final Report	Week 8	Group
30	Self-Reflection Evaluation report	Week 9	Individual
100	-- TOTAL --		







# ISDP4 – Student Projects



**Edufem**  
EMPOWERING WOMEN'S SAFETY

A WOMAN'S  
**WALK HOME**  
THE VR EXPERIENCE

Let's change these statistics...



Test your knowledge!

Links to Helplines



Thank you,  
Team 23

ARE YOU BRAVE ENOUGH?



**Edufem** Team 23

# 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



# Eliciting Feedback



University of Glasgow | College of Science & Engineering



Glasgow, May 10, 2023

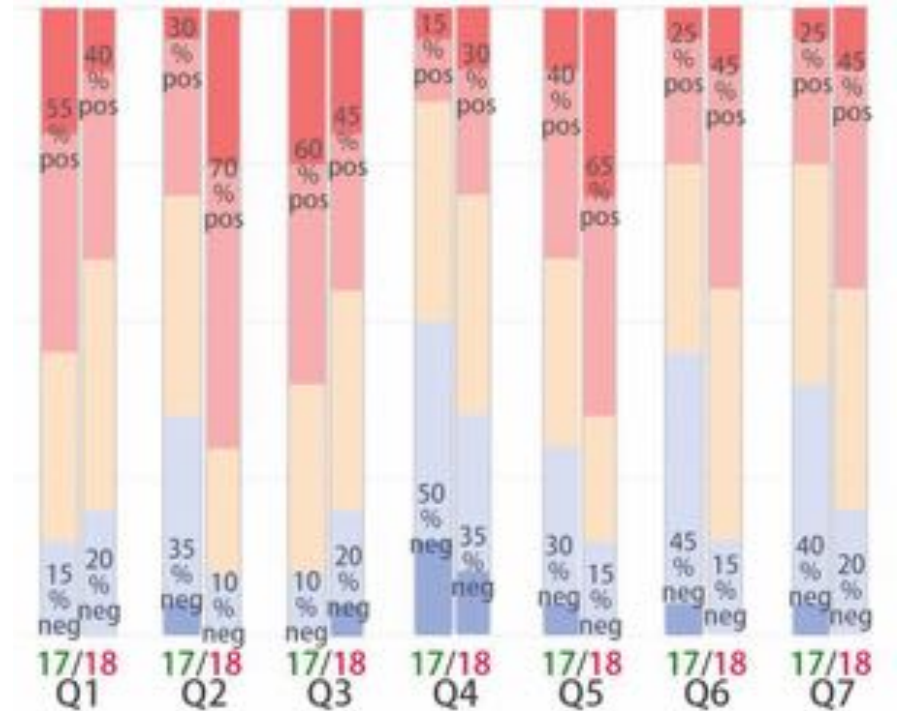
**Ethical approval for:**  
 Application Number: 300220144  
 Project Title:   
 Lead Researcher: Dr Rami Ghannem

This is to confirm that the College of Science and Engineering Ethics Committee has reviewed the above application and **approved** it. Please keep this letter for your records. Also please download and read the Collated Comments associated with your proposal. This document contains all the reviews of your application and can be found below the approval letter on the Research Ethics System. These reviews may contain useful suggestions and observations about your research protocol for improving it. Good luck with your research.

Sincerely,



Ethics Officer  
 College of Science and Engineering  
 University of Glasgow



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 acquired 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”





**Immersive Learning Research Network**

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## iLRN 2024

### 10th International Conference of the Immersive Learning Research Network

#### 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



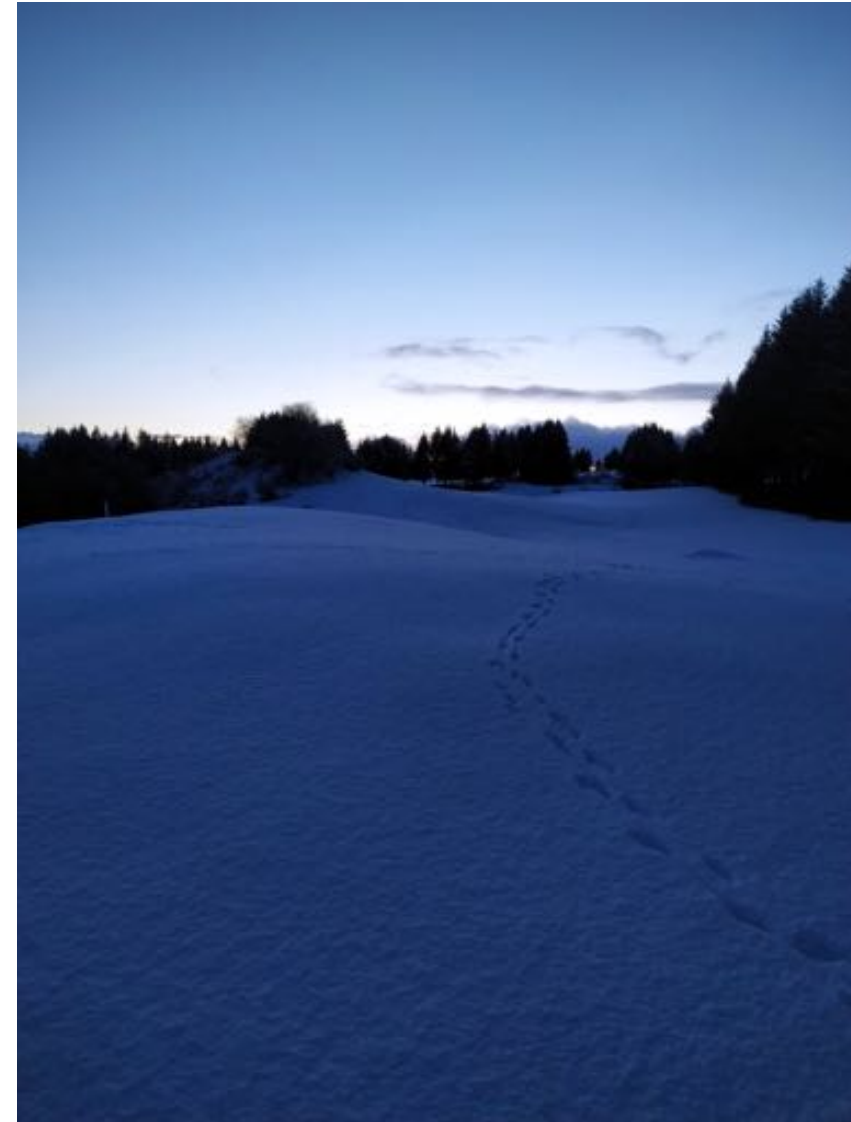
The logo for iLRN 2024 Scotland features a grid background. On the left is a unicorn head, and on the right is a figure holding a staff. The text "iLRN 2024" is prominently displayed in the center, with "SCOTLAND" below it. At the bottom, there are smaller icons of a person and a globe, along with the text "Hosted by the University of Glasgow".

# References

- Fan, H., Xie, H., Feng, Q., Bonizzoni, E., Heidari, H. , McEwan, M. P. and Ghannam, R. (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).
- Khosravi, S., Bailey, S. G., Parvizi, H. and Ghannam, R. (2022) Wearable sensors for learning enhancement in higher education. *Sensors*, 22(19), 7633. (doi: 10.3390/s22197633) (PMID:36236732) (PMCID:PMC9573685).
- Khosravi, S. and Ghannam, R. (2021) Calling all engineers: we need you! *IEEE Potentials*, 40(5), pp. 14-17. (doi: 10.1109/MPOT.2021.3073885).
- Ghannam, R. , Hussain, S. , Hua, F. and González, M. Á. C. (2021) Supporting team based learning using electronic laboratory notebooks: perspectives from transnational students. *IEEE Access*, 9, pp. 43241-43252. (doi: 10.1109/ACCESS.2021.3065611)
- Ghannam, R. (2020) Do you call that a lab notebook? *IEEE Potentials*, 39(5), pp. 21-24. (doi: 10.1109/MPOT.2020.2968798)
- Ghannam, R., Curia, G., Brante, G., Khosravi, S. and Hua, F. (2020) Implantable and wearable neuroengineering education: a review of postgraduate programmes. *IEEE Access*, 8, pp. 212396-212408. (doi: 10.1109/ACCESS.2020.3040064)
- Ghannam, R. and Ahmad, W. (2020) Teaching teamwork to transnational students in engineering and technology. *Compass*, 13(2), (doi: 10.21100/compass.v13i2.1040).
- Fan, H., Wu, X., Ghannam, R., Feng, Q., Heidari, H. and Imran, M. A. (2020) Teaching embedded systems for energy harvesting applications: a comparison of teaching methods adopted in UESTC and KTH. *IEEE Access*, 8, pp. 50780-50791. (doi: 10.1109/ACCESS.2020.2980336).
- Ghannam, R., Hussain, S. , Abbasi, Q. H. and Imran, M. A. (2020) Remote supervision of engineering undergraduates in a transnational programme between Scotland and China. *International Journal of Engineering Education*, 36(4), pp. 1333-1339.



- AlQallaf, N., Ayaz, F., Bhatti, S., Hussain, S. , Zoha, A. and Ghannam, R. (2022) Solar Energy Systems Design in 2D and 3D: A Comparison of User Vital Signs. In: ICECS 2022: 29th IEEE International Conference on Electronics, Circuits & Systems, Glasgow, UK, 24-26 October 2022. <https://doi.org/10.1109/ICECS202256217.2022.9971065>.
- Khan, A. R., Bokhari, S. M., Khosravi, S., Hussain, S. , Ghannam, R. , Imran, M. A. and Zoha, A. (2022) Feature Selection Mechanism for Attention Classification Using Gaze Tracking Data. In: ICECS 2022: 29th IEEE International Conference on Electronics, Circuits & Systems, Glasgow, UK, 24-26 October 2022. <https://doi.org/10.1109/ICECS202256217.2022.9970936>.
- Khosravi, S., Khan, A. R., Zoha, A. and Ghannam, R. (2022) Employing a Wearable Eye-tracker to Observe Mind-wandering in Dynamic Stimuli. In: 29th IEEE International Conference on Electronics, Circuits and Systems (ICECS 2022), Glasgow, UK, 24-26 October 2022. <https://doi.org/10.1109/ICECS202256217.2022.9970787>.
- Wang, X., Li, X., Chen, B. and Ghannam, R. (2022) Psychophysiological Approach for Measuring Social Presence in A Team-Based Activity: A Comparison Between Real and Virtual Environments. In: 29th IEEE International Conference on Electronics, Circuits and Systems (ICECS 2022), Glasgow, UK, 24-26 October 2022. (<https://doi.org/10.1109/ICECS202256217.2022.9970857>)
- AlQallaf, N., Chen, X., Ge, Y., Khan, A., Zoha, A. , Hussain, S. and Ghannam, R. (2022) Teaching Solar Energy Systems Design using Game-Based Virtual Reality. In: IEEE Global Engineering Education Conference (EDUCON2022), Tunis, Tunisia, 28-31 Mar 2022, pp. 956-960. ISBN 9781665444347 (doi: 10.1109/EDUCON52537.2022.9766460).
- Khan, A. R., Khosravi, S., Hussain, S. , Ghannam, R. , Zoha, A. and Imran, M. A. (2022) EXECUTE: Exploring Eye Tracking to Support E-learning. In: IEEE Global Engineering Education Conference (EDUCON2022), Tunis, Tunisia, 28-31 March 2022, pp. 670-676. ISBN 9781665444347 (doi: 10.1109/EDUCON52537.2022.9766506).
- Khosravi, S., Khan, A. R., Zoha, A. and Ghannam, R. (2022) Self-Directed Learning using Eye-Tracking: A Comparison between Wearable Head-worn and Webcam-based Technologies. In: IEEE Global Engineering Education Conference (EDUCON2022), Tunis, Tunisia, 28-31 March 2022, pp. 640-643. ISBN 9781665444347 (doi: 10.1109/EDUCON52537.2022.9766468).
- Ghannam, R., Curia, G., Brante, G., Fan, H. and Heidari, H. (2020) Wearable Electronics for Neurological Applications: a Review of Undergraduate Engineering Programmes. Transnational Engineering Education Using Technology Workshop (TREET 2020), Glasgow, UK, 31 Jul 2020. ISBN 9781728188515 (doi:10.1109/TREET50959.2020.9189753).
- Xeni, N., Ghannam, R., Georgiev, V., Adamu-Lema, F., Badami, O. and Asenov, A. (2020) The Use of TCAD Simulations in Semiconductor Devices Teaching. Transnational Engineering Education Using Technology Workshop (TREET 2020), Glasgow, UK, 31 Jul 2020. ISBN 9781728188515 (doi:10.1109/TREET50959.2020.9189752).
- Fan, H., Zhang, J., Li, Y., Feng, Q., Fang, K., Wen, H., Lin, L., Qi, X., Diao, X., Bonizzoni, E., Maloberti, F., Ghannam, R., Heidari, H. (2020) Innovative Engineering Education in Circuits and Systems. In: 2020 IEEE International Symposium on Circuits and Systems, Seville, Spain, 17-20 May 2020, ISBN 9781728133201 (doi:10.1109/ISCAS45731.2020.9180649).
- Ghannam, R., Abbasi, Q. H. and Hussain, S. (2020) Improving Student Engagement in a Transnational Engineering Education Programme Using Piazza. In: UK & Ireland Engineering Education Research Network Annual Conference (EERN 2019), Coventry, UK, 16-17 Dec 2019, ISBN 9780993424571.



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Thank you!