

for

CPCECPR Conference 2023

Smart Education: Pedagogical Innovation and Learning Analytics

**Providing Research Experience to
Undergraduate Students in the Latest
Technological Environment for
Professional Development**

Dr. Edmond Lam

Dr. Anand Vyas

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Outline of Presentation

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 - Engineering Research Development
 - Teaching & Learning (T&L) Areas and Engineering Research Opportunities
 - Future Trends in Science and Engineering Research
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Introduction

- Current global market demands a constant update and upgrade in technology thus requiring the workforce to be well versed with innovative technology.
- Curriculum that offers opportunities for students to carry out research, study specific engineering challenges and build specialization in focused areas of interest is necessary.
- This multi-faceted approach to education can prepare students to enter the workforce to make a significant and immediate impact.

Introduction (cont'd)

- Many mechanical engineers engage in the design and manufacturing of various types of tools, components, devices and machines and thus contribute to giving relief to humans from manual work. Some work in the areas of air-conditioning, automotive, heating and refrigeration engineering.
 - Electrical engineers engage in various areas from making electrical energy available for consumption to circuits and devices.
 - In addition, Building Engineers with management capabilities engage in planning the design and construction of buildings, structures, and are involved in management of environmental protection facilities concerning ventilation, water and waste as well as coordinating with various types of professionals as Project Manager.
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Introduction (cont'd)

- At PolyU SPEED, Mechanical Engineering, Electrical Engineering and Building Engineering and Management are a few popular programs in engineering amongst many others.
 - Undergraduate students in these programs are very much involved in rigorous theory-based coursework, and in addition, their involvement in research for their projects also benefits them.
 - Research at their level is conducted via literature search and experimentation that encompasses several others.
 - The fact that students opting for specific program does not restrict them to having a specific job type or role in their future career.
 - The necessary skills “critical thinking” and “problem solving” become relevant especially when industries do not emphasize picking candidates from a specific discipline; instead, they solicit and recruit engineers from any discipline.
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Introduction (cont'd)

- In all programs, they **learn** via theory, receive hands-on experience in laboratories and **research opportunities** teaching them thorough designs and effective implementation of engineering solutions, which in turn helps prepare students to make an impact on society.

Introduction (cont'd)

- Academic institutions are encouraging faculty to expand undergraduate research opportunities.
 - Such opportunities assist students in learning the scientific process as well as important research skills (such as problem solving and communication), and they improve the recruitment and retention of highly qualified students.
 - One of the benefits of involving students in research work in their studies is skills acquisition, both specific to laboratory work and skills related to presenting scientific work (McSweeney et al., 2018).
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Introduction (cont'd)

- Although the benefits of involving students in research work in their studies are enormous, becoming a researcher is a complex endeavor that needs multiple stages of learning (Sun et al., 2020).
 - According to Millspaugh and Millenbah (2006), *advisors frequently receive assistance in meeting long-term research objectives while also assisting future scientists in the development of their careers.*
 - Furthermore, the current global market heavily utilizes and requires a constant update and upgrade in technology, requiring the workforce to be well versed in innovative technology.
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Introduction (cont'd)

- This is especially true in the field of **engineering**, where technology encompasses the systematic study of the structure and behavior of the functional world, which is closely related to engineers' work.
 - *Industry 4.0 lays the groundwork for a social and technological transformation that will dramatically alter the global landscape (Javaid et al., 2022).*
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Engineering Research Developments

Mechanical Engineering

Combustion, Green Fuel, Advanced Materials, Robotics, Acoustics, Computational Fluid Dynamics

Electrical Engineering

Electric Vehicle, Vision-based Control Robotics

Building Engineering and Management

Green building, carbon emissions, drones for safety

T&L Areas and Engineering Research Opportunities

Mechanical Engineering

- In the current situation, research opportunities for undergraduates in Mechanical Engineering is directly linked with some of the T&L areas such as design & manufacture, advanced materials, operations of a wide range of mechanical components, devices & systems, heat transfer, and robotics.
- Example: area where students learn and strengthen their knowledge like: Heating, Ventilation and Airconditioning (HVAC) - Students learn principles of thermodynamics, fluid dynamics and heat transfer.
 - Utilize and apply their knowledge in buildings, vehicles, trains etc.

T&L Areas and Engineering Research Opportunities (cont'd)

- Example: area where students learn and strengthen their knowledge like: Composites fabrication, methods of material testing
 - Utilize and apply their knowledge in architecture, infrastructure.
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T&L Areas and Engineering Research Opportunities (cont'd)

Electrical Engineering

- In the current situation, research opportunities for undergraduates in Electrical Engineering is directly linked with some of the T&L areas such as the practice of Electrical Engineering, solid-state circuits, development of large-scale integrated circuits, traditional background in circuit analysis, power control units.
- Example: area where students learn and strengthen their knowledge like: Power inverters, electric motor battery
 - Utilize and apply their knowledge in Electric Vehicles, Electric Power controls.

T&L Areas and Engineering Research Opportunities (cont'd)

Building Engineering and Management

- In the Current situation, research opportunities for undergraduates in Building Engineering and Management is directly linked with some of the T&L areas such as Building service systems; materials, structures and construction technology; geotechnical engineering, quality and safety management in terms of reliability and risk engineering; environmental impact and assessment; building information modelling, sustainability and temporary work design.
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T&L Areas and Engineering Research Opportunities (cont'd)

- Example: area where students learn and strengthen their knowledge like: Building infrastructure, building services installation, safety inspections by drones, maintenance technology.
 - Utilize and apply their knowledge in Indoor environment, Environmental impact and assessment, temporary work design, construction material testing, green materials for design, anti-heat stress working uniform.
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Future Trends in Science and Engineering Research

- Science and engineering research will be even more influential in future.
 - Artificial intelligence will become more prevalent with natural language processing and machine learning advancement.
 - Artificial intelligence can better understand us and perform more complex tasks.
 - Hard to predict which technologies will define the next century.
 - Increasing interconnection of computers will transform work, communications, entertainment, and education.
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Future Trends in Science and Engineering Research (cont'd)

- Example: Cars that drive and park themselves and voice-operated devices that can control lighting or music are becoming increasingly common.
 - The above engineering trend is likely to spread to other products and processes, such as robotics and manufacturing equipment.
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Future Trends in Science and Engineering Research (cont'd)

Following the rise of the machines ...

- Humans will be outgrown by computers becoming more intelligent.
 - The convergence of computing, robotics and nanotechnology could give rise to self-replicating machines.
 - Moreover, there is a possibility of not only downloading intelligence into a machine but downloading consciousness too.
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Future Engineers: Challenges Ahead

- Future work environment is anticipated to be characterized by continuous change and increasing complexity.
 - The challenges that may arise not only from the need for flexible technical solutions, but also from managing complex socio-technical systems, and contribute tangibly to the sustainable development.
 - Our Graduates with the ability to understand both complex technological processes and social skills will be increasingly sought.
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Preparing Engineers for Future

- There will be a need for amendments in engineering programmes with the objective to train engineers to enter and remain in the future technology-intensive labor market.
 - From software to new technologies will need to be developed and included in the curriculum.
 - Funds and other resources may need to be injected.
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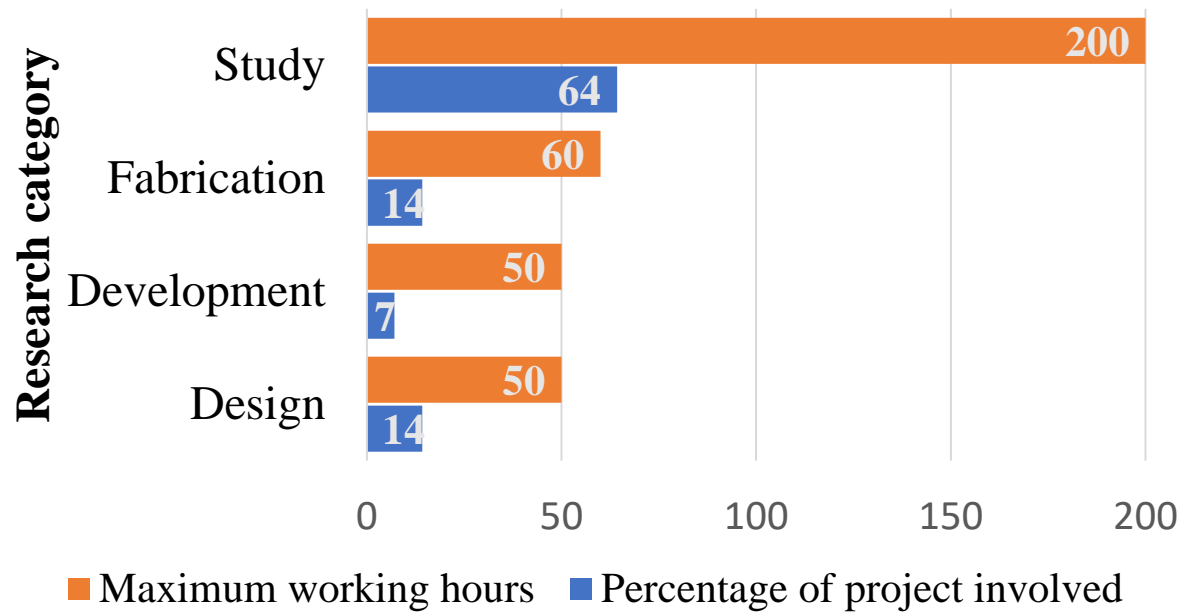
Student Project Supervision

- The student project scheme allows students to use the latest technologies taught in courses in a practical setting.
 - It also gears the student up to develop their research capabilities.
 - Each student is assigned a project supervisor, under whom the student works as an undergraduate research assistant.
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Summary of Undergraduate Student Projects in 2021

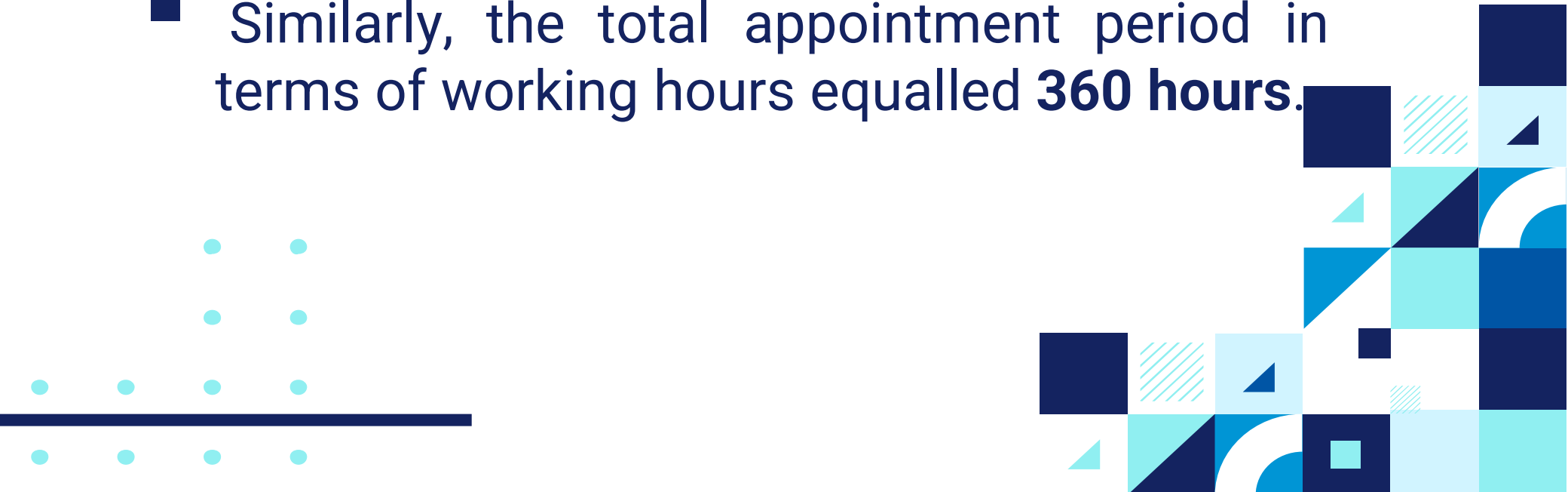
The projects span topics that focused on **design, development, fabrication** and **investigative studies** on current subject areas in the field of engineering.

Research focus and number of hours used



Summary of Undergraduate Student Projects in 2021 (cont'd)

- The total used budget for these 14 research projects totaled about **\$26,000 HKD**.
- Similarly, the total appointment period in terms of working hours equalled **360 hours**.



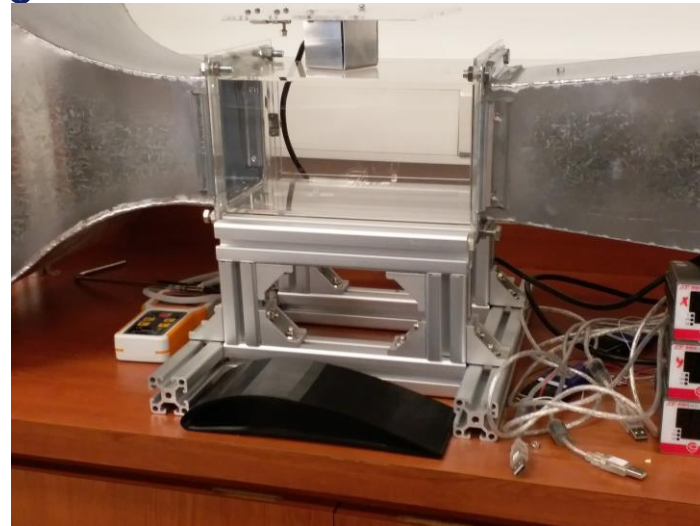
Summary of Undergraduate Student Projects in 2021 (cont'd)

- Six, out of the fourteen undergraduate students' projects conducted within an appointed period in the year 2021 were arbitrarily selected and summarized in this section.
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Design of an Acoustic Wind Tunnel for Noise Measurement:

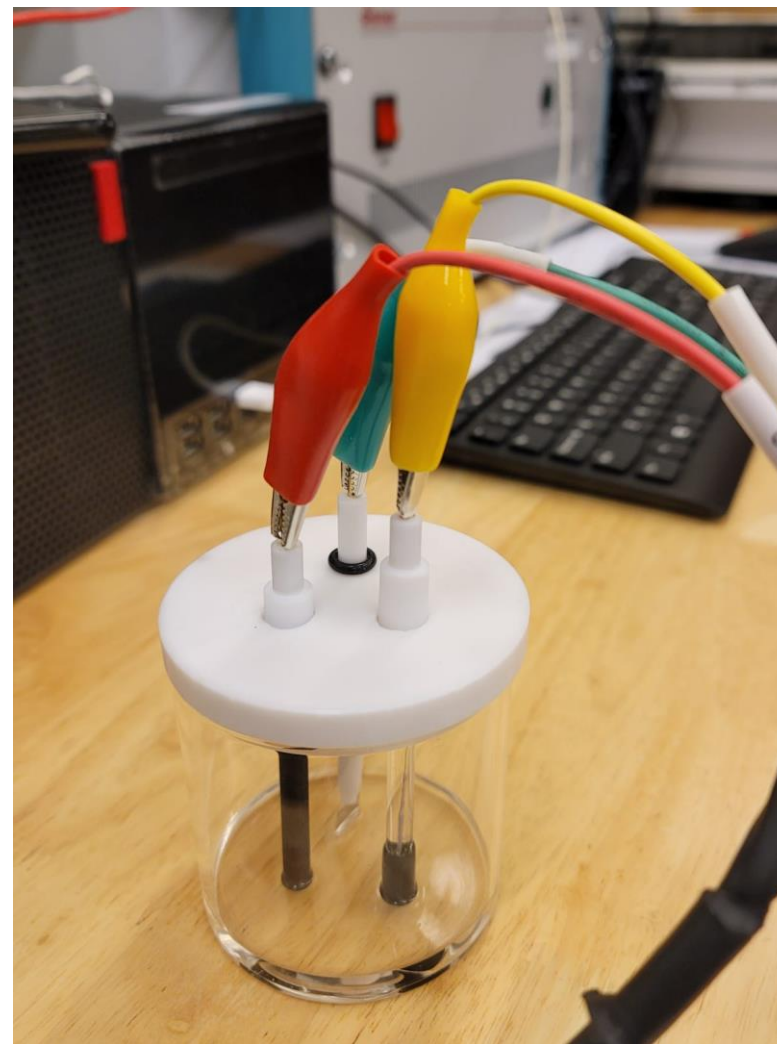
- This project focused on reviewing existing acoustic wind tunnel designs and setups in the market and comparing the specifications for different applications.
- It also aimed to design an acoustic wind tunnel for measuring noise emission by an electrical motor.
- Design criteria include the quality of the airflow in the test section and the wind tunnel as well as acoustic measurements which are influenced by the background noise from the testing lab or the wind tunnel machinery.



**Design of Acoustic
Wind Tunnel**

Electrical testing on the ambient-condition fabrication of coin-type lithium ion cell:

- To achieve the research aim, the student conducted a comprehensive literature survey for the fabrication of coin-type lithium-ion cells under ambient conditions with different compositions.
- During this project, the student learnt how to perform a lithium cell experiment within the glove box.
- The glove box not only provides safety precautions but also prevents material exposure to air or water vapor, which can lead to degradation or inaccurate result.



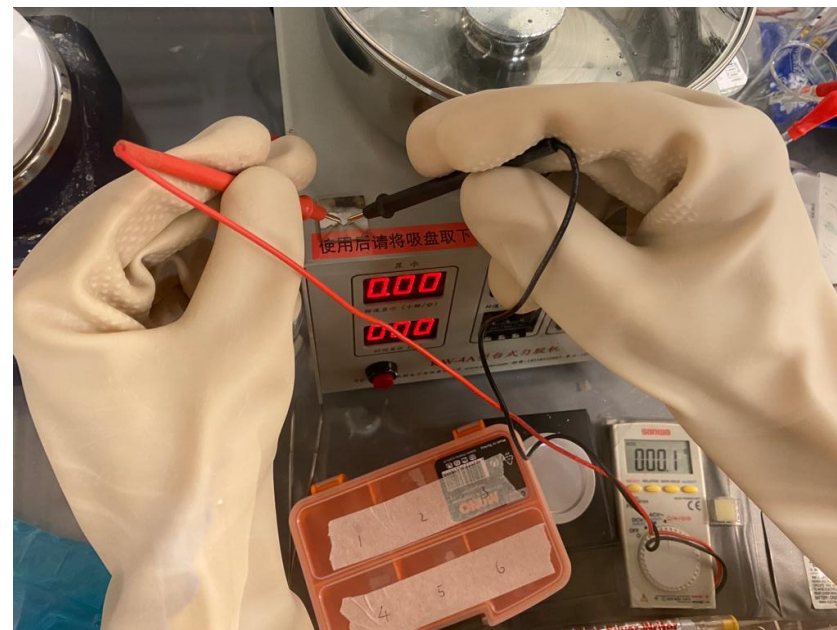
To test the electrical performance of coin-type lithium ion cell with different compositions under ambient condition

Optoelectrical testing on the ambient-condition fabrication of lead-based perovskite solar cell:

Optoelectronics is the study and application of electronic devices and systems that locate, detect, and control light

In this project, the student learnt the basic principle of the photovoltaic effect in a solar cell.

It was observed that under the absorption of light, electric current flows in the circuit by the photovoltaic effect.

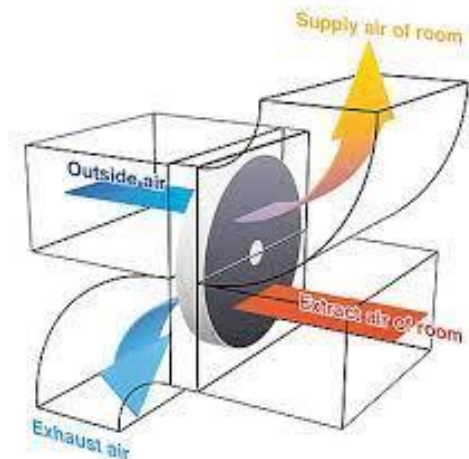
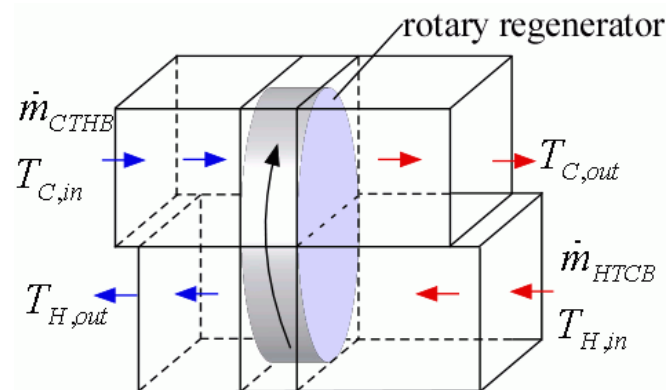


To test the optoelectrical performance of lead-based perovskite solar cell with different compositions under ambient condition.



Study of the waste heat recovery potential from air-conditioning systems in Hong Kong:

- The objective of this project is to study the energy consumption and waste heat rejection from refrigeration and air-conditioning systems in Hong Kong and the possible conversion of the waste heat to a secondary source of energy for useful purposes.
- It was discovered that air-conditioning need takes up around 20% of electricity which means that there is a huge amount of waste heat produced every year.



Energy Recovery Wheel

Enhancing mechanical properties of Green composite materials:

- The objectives of this project were to (i) **design and fabricate Green composite material**, and (ii) **study the ultraviolet (UV) effect on the mechanical properties of composites**.
- It was discovered that certain chemical treatments can significantly alter the thermal properties of green composite materials, such as increasing thermal conductivity or decreasing thermal resistance.



Mechanical properties test-Three-point bending tests to determine properties by employing universal testing machine and compare with published work.

Study of Sound Absorption Performance of Textile Materials after Chemical Treatment:

- The primary objectives of the research were to apply a chemical treatment to textile materials under various conditions, evaluate sound absorption performance through experiments, and suggest optimal treatment conditions for textile materials with good absorption performance.
- Among various treatment methods, the student learnt that the application of graphene oxide (GO) on a material surface can provide certain enhancements.



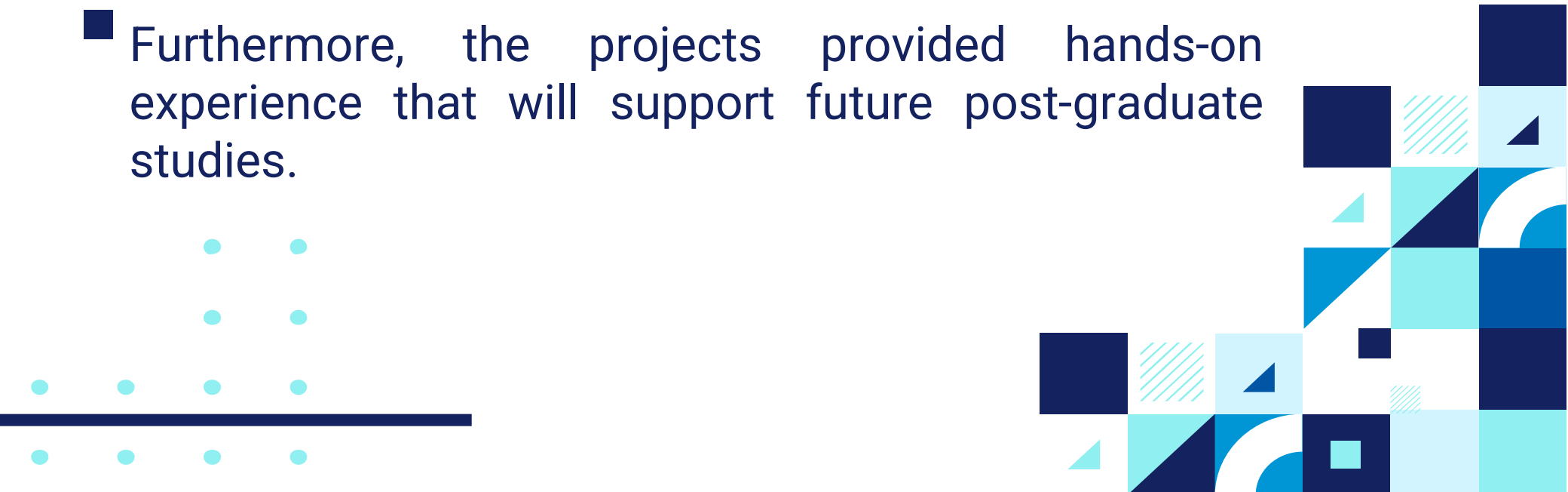
Treatment on Textile Material

Reflections on Undergraduate Student Project Supervision

- The program provides students with design skills, particularly knowledge of how to use computer-aided tools for design and testing.
- Students learnt how to interpret and evaluate quantitative and qualitative data.
- Aside from that, the student learned the fundamentals of retrieving publications from specific online databases.

Reflections on Undergraduate Student Project Supervision (cont'd)

- Collaboration is an essential component of scientific and technological progress. As a result, the students learned how to work effectively with senior colleagues and tutors to complete a research project.
- Furthermore, the projects provided hands-on experience that will support future post-graduate studies.



Conclusion

- In the broad-based engineering curriculum, theoretical understanding of physical systems trains students to address some of the current important technical challenges through research opportunities.
- Research experience gives them a new level of training.
- Our education system is still based on the idea of specialization, future trends in science and engineering may need to have a new model and direction for our students in terms of research opportunities for them.

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