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Driving a Sustainable University-Industry Partnership

Zainuddin Abd Manan and Sharifah Rafidah Wan Alwi

Abstract

There has been a lot of emphasis on the need for academia-industry collaboration. A successful and sustainable academia-industry partnership can result from a university's efforts in driving values in its collaboration with industry. This chapter describes a model for mainstreaming a sustainable university partnership with industry through the university's academic curriculum. The University-Industry Innovation eXchange (UNIX) internship program is a project-based industrial training scheme that is integrated with research projects to provide students with an engaging experience of working with industry for up to one year to solve practical industrial problems. Successful implementation of UNIX projects within the Universiti Teknologi Malaysia's (UTM) work-based curriculum contributes toward nurturing life-ready and job-ready graduates, development of resilient and sustainable organisation through improved operations, and enhanced university-industry partnership.

Keywords: work-based learning, sustainable partnership, university-industry innovation eXchange (UNIX), sustainable organisation, industrial training

1. University's role in driving sustainable partnership with industry

Among the key roles of a university is to educate and empower people with knowledge and skills so that they will become prosperers of lives. To effectively achieve this mission, universities must formulate a sustainable partnership with industry, government and community, apart from with other universities. In order to foster and drive a sustainable partnership, a university must begin by building a compelling case and unique offerings on how the partnership could benefit collaborators. This chapter presents the strategies and unique offerings of Universiti Teknologi Malaysia (UTM) in creating a sustainable partnership through a work-based curriculum that contributes toward nurturing life-ready and job-ready graduates, development of resilient and sustainable organisation through improved operations, and enhanced partnership with industry.

At UTM, the traditional practice of having a short industrial training or odd career days toward the end of a degree program has undergone sweeping transformation toward a customised and immersive *UTM-Industry Innovation Exchange* (UNIX) project that includes up to 50% work-based learning elements that is implemented in close collaboration with UTM industry. The partnership combines industrial training, trans-disciplinary action research and design projects that embed contemporary challenged-based topics including elements of Fourth

Industrial Revolution (4IR) as part of student learning time (SLT) to enable students to be inclusively involved in real-life problem solving that benefits industry and community.

2. UTM-industry innovation eXchange (UNIX) program

The School of Chemical and Energy Engineering, Universiti Teknologi Malaysia (UTM-SCEE) founded the “UTM-Industry Innovation Exchange” (UNIX-Internship) project back in 2010 as one of its signature global branding through creativity and innovation (GBCI) project. UNIX is aimed at value-adding, expanding and maximising the benefits of the industrial training program to university, students and the industry.

Since 1983, UTM-SCEE sends an average of 150 undergraduate students to undergo a ten-week Industrial Training (InTra) program. The purpose of InTra is to provide students with industrial exposure and experience before they graduate. This training is also designed to meet the accreditation requirements for the engineering program by the Engineering Accreditation Council of Malaysia (EAC) of Malaysia.

Over the years, UTM-SCEE received numerous feedbacks from stakeholders, especially from the industry and students regarding InTra. Most companies found that they were not able to assign InTra students with reasonably challenging projects because of the short ten weeks duration of the InTra. Most industries typically accept students for InTra just to fulfil their corporate their social responsibility (CSR) goals. Except for providing students with exposure to day-to-day industrial operations, industries generally do not expect any added-value or contributions from universities through the InTra program. As a result, there is no commitment from the industry to provide students with the opportunity to apply their knowledge to solve industrial problems.

In some cases, there are mismatches between internship training provided by the company and the students' industrial training programme requirement. In a paper reported by Ayob et al. [1], some engineering students were given tasks such as the promotion of business product and management of foreign workers, which are not related to their studies. According to the article by Feijoo et al. [2], it is emphasised on the need to introduce a more in-depth study of specific topics that could be included as an additional project scope to improve industrial training.

Many universities generally regard the InTra program as not more than a means to provide short industrial exposure to students. Students generally appreciate their short industrial exposures but found that they were not able to fully benefit from undergoing InTra. The minimum of eight weeks internship period (according to the Engineering Accreditation Council guide [3]) is typically too short for them to be immersed in projects to solve industrial problems and does not allow them to deeply apply the theories and knowledge that they have learnt over the period of their studies. Phang et al. [4] stated that a longer industrial training duration can increase the job-readiness and the future career development of engineering undergraduates. According to the authors, many parties regard the standard 10–12 weeks internship period as being too short and should be reviewed. The need for a longer industrial training duration is also supported by the study of Jamaluddin et al. [5]. In addition, Filho et al. [6] stated that, to enhance sustainability in the curricula, academia needs to develop a more engaging collaborative approaches in working with industries.

SCEE fully recognised the limitations of the traditional InTra program and the importance of offering a practical and mutually beneficial cooperation program for

the industry. In October of 2010, SCEE established the UNIX-Internship project as one of SCEE's global branding projects through creativity and innovation (Global Branding through Creativity and Innovation - GBCI).

UNIX is an innovative program to foster and facilitate a win-win" collaborative partnership via human capital development, research as well as consultancy services between UTM-SCEE and the industry. UNIX integrates three core courses offered by the UTM- SCEE, namely the (i) Industrial Training (IT) and (ii) Undergraduate Project 1 and II (UGP1 & UGP2). Integration of professional work placement and engineering research project was also introduced by Cork Institute of Technology, Ireland [7]. Their industrial attachment model includes four months of professional work placement, followed by seven months of engineering research project involving the company where the students are placed.

The objectives of the UTM-SCEE UNIX project are to:

- i. enhance graduate employability via industrial/government, project-oriented internship programs,
- ii. form a vibrant, symbiotic, and sustainable linkage between UTM and the industry/government/community
- iii. create a market-driven as well as technology-driven R & D ecosystem.

To ensure the success and effectiveness of the program, a pilot-scale UNIX-internship at SCEE was initiated by selecting 10% of the total students to undergo InTra via the UNIX program. Selected students were placed in industries that have become members of the UNIX consortium and will conduct training/activities related to pre-agreed research projects. During the InTra, students will be co-supervised by the industry as well as by a research project supervisor from SCEE. The UNIX program spans across one academic year involving UGP 1 (Semester 1), ten weeks InTra and UGP 2 (Semester 2).

2.1 Stages of UNIX implementation

The SCEE UNIX-Internship program involves three stages of implementation:

Stage 1: Project Conception

This stage involves a discussion between the UTM team comprising of the UNIX committee and the prospective research leader, and the industry. The UTM team begins by presenting the possible research topics, the offer for collaboration initiatives and UNIX as one of the possible collaborative programs for the company to consider as a starting point. The meeting is aimed to identify possible areas of collaboration and specific projects of interest to companies.

Stage 2: Appointment of Academic and Industrial Supervisors

The second stage of UNIX involves the appointment of the research and industrial supervisors with expertise relevant to the needs and interests of the industry, and in line with the academic requirements. This stage involves more detailed discussions between the supervisor and the company to come up with a project proposal that will address the needs of all parties involved.

Stage 3: Selection of students

In this stage, the UNIX committee identifies students to participate in the UNIX program based on (i) the project topics agreed upon by UTM research supervisors and UNIX consortium companies, and (ii) the performances of students in the academic as well as extra-curricular activities.

Plan/Month	Semester 1				Industrial attachment			Semester 2			
	F	M	A	M	J	J	A	S	O	N	D
Technology/process review & screening	■										
Industrial attachment (on-iste) – data collection					■						
Data analysis, optimisation and economic studies								■			

Table 1.
UNIX-internship timeline.

Typically, between 10 and 15% of the total students undergoing IT will be selected to undergo the UNIX program. Selected students will be placed in companies that have become members of the SCEE-UNIX consortium to conduct market-driven as well as industry-driven research projects that typically begins with state-of-the-art literature and technology screening during their Undergraduate Project 1 (from February until May of the academic year). This is followed by the student undergoing industrial internship attachment that involves industrial data collection and analysis by the student from June until early September. The project closes with the compilation and presentation of results and proposed solutions to the company in December. During the one-year course of UNIX, students will be supervised by an academic and an industrial supervisor. **Table 1** shows the typical UNIX-Internship timeline.

2.2 Benefits of UNIX

From the feedbacks and evaluations conducted on the industry, students, and supervisors, it has been found that the UNIX-Internship program has provided a positive learning experience that has significantly impacted the cognitive and affective domains of learning in students. Students developed problem-solving, time management, communication and team working skills during the 1-year course of continuous communication and engagement with industry. This allows them to function more effectively in learning together and in producing high-quality engineering solutions. The feedbacks also show that there is significant inculcation and drive toward sustainable development practices from the aspect of knowledge as well as behaviour. One of the most vital points of UNIX is the effectiveness of collaboration between faculty and industry in successfully solving complex and practical industrial problems. Such collaboration enriched participating students and faculties, and contributed toward sustainable development of organisations. All in all, the program has become an innovation that can sustainably provide a comprehensive and dynamic learning environment that had enhanced deep learning and instill positive behaviours among students and collaborating parties.

Follow are the multiple benefits of the UNIX program:

2.2.1 To industry

The human resource support to perform cutting-edge R & D provided by UNIX has enabled industries to:

- Gain competitive technical and commercial advantages and allow industries to achieve sustainable industrial operations. To date, UNIX has led to improved

industrial processes, productivities, and profitability as well as enhanced safety and environmental practices for more than 100 local and multinational companies in Malaysia and abroad.

- Gain access to human resources with high-level generic as well as technical skills to solve complex problems encompassing optimal operations, sustainable development, safety-health-environment, economics & project management.
- Gain access to academic resources such as R & D grants, research expertise and facilities toward enhancing a company's competitive edge.

2.2.2 *To the academia, and the nation*

UNIX enables:

- The university and the nation to create an ecosystem of market-driven R & D through synergistic industry-academia-government-community engagement.
- Students and staff to gain extended exposure and experience working and engaging on collaborative projects with industry.
- Students' employability, and faculty members' skills to be enhanced. This will ultimately contribute toward industrial and national productivity.

2.3 Sample of UNIX projects

Table 2 shows the list of industry collaboration projects that have been successfully implemented since 2006.

2.4 International Paper publication from industrial cooperation

Some samples of collaborative projects related to the sustainable development of organisations published in high impact magazine articles and journals include:

- Article in 'Chemical Engineering' magazine published with MIMOS Semiconductor Sdn Bhd [8].
- Article in 'Chemical Engineering Progress' magazine published with MIMOS Semiconductor Sdn Bhd [9].
- An international journal published with MIMOS Semiconductor Sdn Bhd in the Journal of Environmental Management, which currently has an impact factor as high as 5.65 [10].
- An international journal published with the Malaysia Energy Center (MEC) in the Renewable and Sustainable Energy Reviews Journal, which currently has an impact factor as high as 12.1 [11].

2.5 Awards & recognitions

UNIX has also led to recognition and awards such as Prince Sultan Abdul Aziz International Prize for Water [12] which is the "spin-off" results of the

Company	R&D projects	Year started	Student involvement
BERNAS	Toward a Resource-Efficient, Integrated Rice Mill Complex – Optimisation of Rice Supply Chain	2009	1 PhD
	Optimisation Rice-Husk Based CHP System	2008	1 undergrad
CCM	Development Of Math Models for Retrofit based on Minimum Water Network Technique and considering multiple contaminants	2009	1 undergrad 1 MSc
	Combined Mass and Heat Exchange Networks	2009	1 MSc
TITAN Petchem	Computational Fluid Dynamics Modelling of Ethylene Cracker Furnace	2008	2 undergrads
	Development of Soft Sensor for Ethylene Cracker	2009	1 PhD
	Steam Trap Optimisation	2008	1 MSc
Mechmar Boiler	Techno-Economic Feasibility of CDM Project from Palm Oil Waste	2008	1 MSc (part time)
Malaysian Energy Centre & Malaysian Venture Capital	Optimal-Audit, Optimal-Heat, Optimal-Water Software Development	2006	5 undergrads, 2 MSc, 2 programmers
Pan Century Oleo Chemical (PCOC)	Maximum heat recovery network and hydraulic system analysis	2007	1 undergrad
	Maximum Heat Recovery System (Pinch Analysis)	2007	1 undergrad
FELDA Oil Products	Heat recovery network retrofit	2008	1 undergrad
MIMOS Semiconductor (MySEM)	Cost Effective Minimum Water Network using graphical approach	2006	1 PhD 1 undergrad
Malaysian Newsprint Industry (MNI)	Maximum water recovery with regeneration targeting using numerical method	2006	1 MSc
	Optimisation of CHP system	2008	1 MSc
Polycore	Electrical Energy Management	2008	2 undergrad
Infineon	Overall Plant Utility Optimisation	2008	1 MSc (part time)
Ethylene Malaysia	Power recovery network	2006	1 MSc
TITAN Polymer (M) Sdn Bhd	Modelling The Product Quality and Production Rate of Propylene Polymerisation in Industry Reactors Formulation of Modelling and Simulation Algorithm for Propylene Homopolymerization Loop Reactor Artificial Neural Network Modelling of Propylene Polymerisation in Industrial Loop Reactors Development and Simulation of Hybrid Model for Propylene Polymerisation in Industrial Reactors	2008	3 MSc 4 undergrads
Kempas Edible Oil Sdn Bhd	Develop a prediction model for: Phosphoric acid and bleaching earth dosage for degumming and bleaching process, respectively,	2009	2 undergrads

Company	R&D projects	Year started	Student involvement
	in palm oil refinery. Product quality of the refined oil from degumming and bleaching process.		
Mensilin Holdings Sdn Bhd	Optimisation of decentralised electricity generation from biogas and biomass.	2010	1 PhD
Kerry Ingredients	Modelling and optimisation of Industrial Spray Dryer	2010	1 undergrad
Kerteh Petronas Gas Bhd	Modelling of Benfield CO ₂ removal system Integrated reformer Methanol with natural gas plant Life cycle analysis (LCA)	2010	2 undergrads
PPNJ, Kahang, Kluang	Performance Study of POME Treatment using SBR	2008	1 undergrad
PPNJ, Kahang, Kluang	Performance Study of POME Treatment using MBR	2009	1 undergrad
PPNJ, Kahang, Kluang	Cost Benefit Analysis of Producing PHA from POME	2010	1 undergrad
Agensi Nuklear Malaysia	Characterisation and Properties of Ethylene Vinyl Acetate/ Sepiolite Nano Composite Preparation of Polyamide-6 Polypropylene EFB Composite	2012	2 undergrads
Lembaga Minyak Sawit Malaysia (MPOB)	Study of Polylactic Acid (PLA)/Empty Fruit Bunch Fibre (EFBF) Compatibilizer With Maleic Anhydride Low Density Polyethylene/Oil Palm Mesocarp Fibre Composite Effect of Inorganic Plasticiser On Low Density Polyethylene/Palm Pressed Fibre Composite Film Polyurethane/Oil Palm Biomass Fibres Composite Foam	2012	4 undergrads
PGEO Edible Oils SdnBhd	Blending of Polymer with Shea Latex for Plastics Applications Blending Of Polymer with Shea Latex for Plastics Applications	2013	2 undergrads
Agensi Nuklear Malaysia	Suspended Solid Removal by Natual Adsorbent Oil Removal from Superabsorbent For Waste Treatment	2013	2 undergrads
Lembaga Getah Malaysia	Preparation of Nanoparticle Assembly Using Natural Rubber Latex	2013	1 undergrad
Lipidchem Sdn Bhd	Formulation of Water-soluble beta carotene powder palm oil.	2013	1 undergrad
Lipidchem Sdn Bhd	1. Formulation and pilot prototype of Water soluble MCT powder from coconut oil	2014	1 undergrad
Naturemedic Supply Sdn Bhd	1. Anti-inflammatory properties of herbal supplement for gout, R-38. 2. Anti-inflammatory and antioxidant properties of botanical drinks	2014	2 undergrads

Company	R&D projects	Year started	Student involvement
Pantai Medivest	1. Detailed Design of Heat Recovery System and Fuel Switching	2009	2 Master
Malakoff R&D Sdn Bhd	1. Feasibility of study of steam demand requirement in Tanjung Langsat industrial area	2011	1 UG
Jabatan Alam Sekitar	1. Development of Environmental Impact Assessment (EIA) guidelines for solid waste incineration plant	2011	1 PhD
Pertamina	1. Maximising heat recovery for retrofit	2011	1 PhD Student, 1 Undergrad Student
Middle Distillate Plant	1. Retrofit of Middle Distillate Refinery Plant for Utility Conservation Using Pinch Analysis	2012	3 PhD Students
Synthomer	1. Sustainable energy management system.	2012	1 MSc student
	2. Cooling load optimization	2012	1 Undergrad student
	3. Batch heat integration with exothermic reaction	2012	1 Undergrad Student
Mudra Tropika	1. Water reuse and rainwater harvesting design	2012	1 Master
UTM	1. Carbon emission reduction in UTM	2012	1 Master
Iskandar Malaysia	1. Low carbon society	2012–2015	5 PhD, 8 Master, 2 UG
Institute Development Bank	1. Draft-1 of the Green Technology Blueprint for the OIC Countries	2013	4 PhD
Evyap Sabun Sdn Bhd	1. HAZOP analysis and 3-D pipe modelling Design Gap Analysis	2013 and 2014	3 PhD students
AMR Sdn Bhd	1. Cogeneration feasibility study for hospital clinical waste heat recovery	2014	1 PhD
Johor Port Authority	1. Ships emission analysis at Johor Port and Port of Tanjung Pelepas	2015	1 Master
Sterling Engineering Sdn Bhd	1. Heat pipe operability study	2015	2 UG
UTM	1. Energy factor analysis for university	2015	1 UG
Malaysian BioXcell Sdn Bhd	Greenhouse Gas Emission Reporting System Software	2015	1 undergrad
Total			113 students

Table 2.
List of industry on our UNIX-internship program.

collaboration with MIMOS Semi-Conductor and Sultan Ismail Mosque in UTM (see **Figure 1**). **Table 3** shows the list of water savings from UNIX projects.

In addition, SCEE also won USD 100,000 Islamic Development Bank (IDB) Prize of Excellence in Science and Technology 2017, cited as an Institution having achieved outstanding contribution to a given scientific discipline” (**Figure 2**).



Figure 1.
 Prince Sultan Abdul Aziz international prize for water as a result of the UNIX program.

UTM's Sultan Iskandar Mosque	FW reduction: 95.3% WW reduction: 64.7% Savings = USD 5, 400/yr. Payback period = 5 years
MIMOS Semi-conductor (Near) Zero-Discharge Semi-Conductor Plant	FW reduction: 85.1% WW reduction: 97.7% Savings = RM 190, 000/yr. Payback period = 4 mths
CCM Chemicals Holistic Water Minimization	FW reduction: 35.8% WW reduction: 100% Savings = USD 105,000 /yr. Payback period = 1.87 yrs

Table 3.
 List of water savings from UNIX projects.



Figure 2.
 SCEE was awarded the Islamic Development Bank (IDB) prize of excellence in science and technology 2017.

2.6 Consultancy spin-off as a result of UNIX

UNIX has also spin-off to bigger industrial collaboration after the spin-off either in the form of R&D grants or consultancy projects as listed in **Table 4**.

Company	Consultancy projects	Outcomes
Greentech Malaysia	Baseline study of Energy efficiency and renewable energy award in Malaysia	A full report with extensive literature review and stakeholder analysis for energy efficiency and renewable energy award in Malaysia
Pantai Medivest Sdn Bhd	Improvement of Heat Recovery System and Fuel Switching for Pantai Medivest Sdn Bhd (PMSB) Incinerator Plant	The savings for the heat recovery system and fuel switching results in savings of RM 983, 386/year for fuel oil and RM63,612/year for electricity. The total investment is RM141, 000 with a payback period of less than two months.
Padi Beras Nasional Berhad	Design of cogeneration system for rice mill	The proposed cogen scheme manages to satisfy the total drying heat requirement as well as the boiler turndown ratio constraint while generating a maximum of 582 kW power and making full use of the limited available rice husk quantity of an average 2.3 ton/hr. The total annual power saving for this scheme is RM 547,485, and yearly diesel savings is RM 3,312,276. The project payback period is 3.34 years.
Greentech Malaysia	Development of a Hazard & Operability Studies (HAZOP) for Biomass-Based Power Generation System for Palm Oil Mills	A 3 days training module for Biomass-Based Power Generation System HAZOP for Palm Oil Mills
Greentech Malaysia	Development of UTM-GTM Energy Audit Software for Malaysian Industries and Buildings	An energy audit software that consists of macro (e.g. fuel switching, cogen) and technical level (e.g. motor, fan, chiller, compressor) analysis for current equipment/system benchmarking.
IOI Groups	Retrofit for Energy Efficiency Improvement	A detailed study that includes benchmarking, data validation and sampling, hydraulic analysis, heat integration, system troubleshooting. The cooling water pump has successfully been reduced to two from three.
MIMOS Semiconductor	UTM-MIMOS Water Minimisation Project	Savings of freshwater and wastewater bills worth RM 50 k per month with two years payback period. This is a reduction of more than 80% of freshwater consumption.

Table 4.
Consultancy projects from UNIX.

2.7 Companies' responses

Below are some sample feedbacks from the UNIX-Internship Invitations:

Response from Petlin (PETRONAS):

Dear Prof. Zainuddin,

Unfortunately, this year (2011), our student quota is pretty occupied. As per email below, we are interested with the sandwich course as below, especially now that we are embarking Energy Loss Management System (ELMS). Good to study back our energy and mass balance throughout the plant (after eight years running). Maybe to study the water balance as well. This also will benefit the student and PM Sdn Bhd very much.

2012 then? When usually the best month to start the planning? Please advise. Will put it in my calendar. So when the month comes, will trigger the need for communication and will directly communicate with you.

Regards,
Process Safety Technical Department
PM Sdn. Bhd.

Response from Indah Water Konsortium:

Dear Prof Zainuddin,

Yes, we accept students for their industrial training subject to review and acceptance by the relevant department in IW Sdn Bhd. For this, we would advise that a written letter applying for the industrial training is submitted to our Human Resource Department. The letter shall include the details of the student, discipline, faculty, etc.; training dates and duration; the name of UTM coordinator and his/her details. Should there be any preferred area for the training (e.g. Engineering Design, Environmental Management, R&D, Planning, etc.), please state it in the letter. Our HR Department will reply accordingly. Kindly ensure adequate notice period is given for IW to process the application and reply accordingly. Thanks.

Regards, Manager

Response from PL Sdn Bhd

Dear Dr. Sharifah Rafidah,

I had received a good response from my boss. He is very interested with F2C program, especially for Chemistry or Polymer majors. If you do not mind, can I arrange you to do a presentation of the F2C program at our workplace.

Here is the tentative date:

Date: 30/12/2010 or 31/12/2010

Venue: PL Sdn Bhd

Time: Please advise us.

Enclosed here is the map to our plant. Your reply is highly appreciated.

Thanks.

| Human Resource Assistant | Human Resource

| PL Sdn Bhd

3. Examples of impactful UNIX programs to contribute toward sustainable organisation

UNIX has resulted in impactful outcomes for companies driving toward a sustainable organisation. Below are some examples:

3.1 Middle distillate company

A PhD student was attached in a middle distillate company in Sarawak, East Malaysia. The company requested a study on their existing heat integration system and proposed possible measures to further improve their thermal energy recovery systems, reduce emissions and minimise utility costs. The student performed a comprehensive 'Pinch Analysis' study for the company and proposed heat recovery

retrofit measures. The study has helped the company improved its heat integration network and resulted in a reduction in 1.6 MW of energy, with annual savings of USD4.1Million. The study has also contributed to a more sustainable energy system for the company.

The student received the Vice-Chancellor Award during the 55th UTM Convocation Ceremony. In addition, he was also selected as the National Young Scientist Representative during the 65th Lindau Nobel Laureate Meeting 2015 (see **Figure 3**). He was also chosen as the top 3 finalists for the European Federation of Chemical Engineer (EFCE) Excellence Award in Recognition of an Outstanding PhD Thesis on Computer-Aided Process Engineering (CAPE).

The work also resulted in software called Optimal Site which won the Jury and Gold Award in the 16th Industrial Art and Technology Exhibition (INATEX), UTM and Silver Medal in the 14th International Conference and Exposition on Inventions by Institutions of Higher Learning (PECIPTA).

3.2 MIMOS semiconductor Sdn Bhd

Another PhD student was attached in MIMOS Semiconductor. She performed a feasibility study on water sustainability programs for MIMOS. The study predicted savings of freshwater and wastewater bills of worth Ringgit Malaysia (RM) 50 k per month with two years payback period. The savings represent a reduction of more than 80% of freshwater consumption. The water minimisation strategies holistically included measures for water elimination, reduction, reuse, outsourcing and treatment. The work produced a UTM commercial software, Optimal Water, that won several national and international product innovation awards, and resulted in joint collaborative international publications involving UTM and MIMOS. The work also won prestigious international awards such as the Saudi Prince Sultan bin Abdul Aziz International Prize for Water 2008 (Water Management Category), the Germany



Figure 3. Liew Peng yen selected as National Young Scientist Representative during the 65th Lindau Nobel laureate meeting 2015. The picture was taken with Steven Chu, former United States secretary of energy. He is the winner of the 1997 Nobel prize in physics.



Figure 4. Sharifah Rafidah Wan Alwi (front row, second from left) was selected as one of the green talents 2009 by the government of Germany.

Green Talent Award (see **Figure 4**) [13] and the Malaysia's Sarawak State 2008 Maal Hijrah Outstanding Achievement Award.

3.3 Synthomer

One undergraduate and one postgraduate student were attached in Synthomer Malaysia under the UNIX program. The undergraduate student developed software to monitor the cooling duty and scheduling of reactor for polymerisation reaction (see **Figure 5**). The software has helped the company to reduce its reactor down-time, minimise cooling requirement and optimise production.

The master student was assigned to develop a sustainable energy management system and performed an energy audit for the company. The feasibility study

Reactor information		Total of Monomer Used (Kg)		Initial Stage Amount (Kg)	CMA Duration (hours)	Feeding Period (hours)	CMA Mass Flow (kg/hr)	Reaction Period (hours)	Start Time	
Reactor	1	First Batch	1,3-Butadiene						15	
Status	On		Acrylonitrile					Clear Data Table1		
Second Batch Operation	No		Methacrylic Acid							
Second Batch operation		Second Batch	1,3-Butadiene	10	7	7	500	15	1PM	
			Acrylonitrile	10		5	300			Run R1 Batch 1
			Methacrylic Acid	10		5	100			Run R1 Batch 2
Reactor information		Total of Monomer Used (Kg)		Initial Stage Amount (Kg)	CMA Duration (hours)	Feeding Period (hours)	CMA Mass Flow (kg/hr)	Reaction Period (hours)	Start Time	
Reactor	2	First Batch	1,3-Butadiene						16	
Status	On		Acrylonitrile					Clear Data Table2		
Second Batch Operation	No		Methacrylic Acid							
Second Batch operation		Second Batch	1,3-Butadiene	NIL	NIL	NIL	NIL	NIL	NIL	
			Acrylonitrile	NIL		NIL	NIL			Run R2 Batch 1
			Methacrylic Acid	NIL		NIL	NIL			Run R2 Batch 2
Reactor information		Total of Monomer Used (Kg)		Initial Stage Amount (Kg)	CMA Duration (hours)	Feeding Period (hours)	CMA Mass Flow (kg/hr)	Reaction Period (hours)	Start Time	
Reactor	3	First Batch	1,3-Butadiene	NIL	NIL	NIL	NIL	NIL	NIL	
Status	Off		Acrylonitrile	NIL		NIL	NIL			Clear Data Table3
Second Batch Operation	No		Methacrylic Acid	NIL		NIL	NIL			
Second Batch operation		Second Batch	1,3-Butadiene	NIL	NIL	NIL	NIL	NIL	NIL	
			Acrylonitrile	NIL		NIL	NIL			Run R3 Batch 1
			Methacrylic Acid	NIL		NIL	NIL			Run R3 Batch 2

Figure 5. Output of UNIX - software for cooling duty monitoring & reactor scheduling of semi-batch free radical emulsion polymerisation.

conducted by the student managed to identify scope for annual energy savings of up to RM740,000 and recommended a sustainable energy management program for the company. UTM collaboration with Synthomer has also resulted in a memorandum of understanding (MOU) [14] that provided placement for more students to undertake various other UNIX projects.

4. Conclusion

Over the years, more than 100 public and private institutions had benefited from UNIX collaboration with UTM. Having access to UTM's R&I ecosystem, network, resources, technology, and know-how allow collaborators to add value, improve efficiency, raise competitiveness, and drive innovation that ultimately enhances the image, profitability and sustainability of their businesses. The UTM-Industry Innovation Exchange Internship Program (UNIX-Internship) transformed a routine university's conventional short exposure industrial training programs into a 1-year, value-laden, industry-oriented, project-based internship programs. It has huge potential to be a game-changer to the teaching and learning ecosystem in the following major ways:

- Sharpening of student's generic skills, including lifelong learning, problem-solving, communication, teamworking, and leadership skills, while positively impacting the cognitive and affective domains of learning among students.
- Providing students with vital practical industrial experiences of project execution and management and the skill to solve complex problems encompassing sustainable development, safety-health-environment, economic analysis & project management.
- Providing students with better career prospects through prolonged exposure and experience working and engaging with the industry.
- Providing affordable R & D support to companies toward the development of sustainable organisations. To date, UNIX has benefitted more than 100 local and multinational companies.
- Forming a vibrant, synergistic, and sustainable linkage between UTM and stakeholders (SDG17 – Partnerships for the Goals).
- Creating a culture and an ecosystem of market-driven R & D among the young students.

The works particularly provide impactful contributions toward advancing Quality education (SDG Goal #4) and Partnership for the Goals (SDG Goal #17) of the Sustainable Development Goals. The numerous UNIX projects with industries, among others, also address other specific SDG goals related to energy and water sustainability and climate action, industry innovation and sustainable consumption and production.

Apart from successfully benefitting more than 100 organisations, the UNIX project-based industrial internship program has enhanced UTM graduate employability. In addition, UNIX has formed a vibrant, synergistic and sustainable linkage between UTM and stakeholders, and created a culture and an ecosystem of market-driven R & D for universities.

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Conflict of interest

The authors declare no conflict of interest in this written chapter.

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