Teaching Research Nexus – An Australian Experience

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Abstract – **Teaching techniques and contents at institutes of higher learning must be a dynamic and seamless experience. While new concepts and technologies do not find their way into textbooks long after the research is matured and/or commercialized, Professors at Universities are in unique position to bring them into classroom much earlier benefiting from their sponsored research. This is why perhaps high ranked research Universities are able to motivate a greater proportion of final year undergraduate students to enter graduate studies. The members of the Renewable Energy and Power Systems Research Groups at Curtin University of Technology is engaged in improving undergraduate and postgraduate curriculum by injecting seeding knowledge gathered through funded research and industry contacts to bring opportunities for students and putting research equipment back into laboratories on a continuing basis. The group also established a number of unique postgraduate courses and laboratories.**

I. Introduction

The connection between teaching and research is a fundamental, distinct feature of institute of higher learning which differentiates Universities from Technical and Vocational training providers. A good learning environment at the University level will have to include continuing update of content, better interacting classrooms, modern laboratory equipment, design experience, and student support (i.e. bursaries, industry placements etc).

The belief that research contributes to educational quality and enhanced student outcomes has long been a centre piece of higher education. However, as universities have become more diversified in response to a market-driven environment, the role of discipline-based research in undergraduate learning and teaching has emerged as an issue for discussion, debate and close scrutiny [1]. While the principle of research-led learning and teaching in higher education is advocated internationally, the question of how to operationalize and optimize this nexus is yet to be fully understood. At one end of the spectrum lies the assumption that the TRN is the remit of research-led universities and an experience best integrated into later year undergraduate curricula.

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By contrast, many others argue for the need to infuse teaching with research practices and principles, regardless of the character of the university or the year level involved. A number of possibilities exist as a Teaching Research model: Research Based Teaching and Learning; Research Led Teaching & Learning; Research Infused Teaching and Learning; Problem Based Teaching and Learning etc. While some scholars argue there are distinctions to be made [2] others have used these interchangeably.

While a research led learning is appropriate for research based postgraduates, at undergraduate level perhaps a research linked learning is more applicable. At Curtin University of Technology, the engineering first year students undertake a project titled “Engineers without Border” in which students are teamed up to provide a sustainable solution to energy, water and housing need for remote areas of the World. Students are required to draw on research reports, web based materials, and contact PhD students for information and a research style presentation. This proved to be a very successful and motivational activity for the students. The feedback from students suggests that they remained quite engaged and focused in their activities in finding an economically feasible and workable solution through technology research. This example strengthens the claim made above.

There are several currencies of practicing teaching research nexus, starting from simply introducing some research findings in teaching as extended examples to students working on research based funded projects for their final year thesis. The Schools benefit from research linked curriculum, value added equipment and laboratories and often more visibility in the national and international arena through high profile researchers and research. In this paper, experiences gathered over a ten year period by the author as the Director of the Renewable Energy and Power Systems Research Group (REPSG) at Curtin University of Technology in establishing research embedded teaching is presented particularly in the field of Renewable Energy and Power Systems.

II. ABOUT THE RENEWABLE ENRGY AND POWER SYSTEMS RESEARCH GROUP

The Renewable Energy and Power Systems Research Group (REPSG) at Curtin was established in 2007 by merging two

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strong but independent research groups working on Renewable Energy/Power Electronics and Power Systems. The group generates over seventy percent of research performance index points within the Department of Electrical and Computer Engineering. Research funding for the group over the past few years exceed A$ 10M. The group comprise of six full time academics, two research associates, 15 PhD and Master degree by research students, and a number of international visitors. The group is engaged in scholarly activities that includes fundamental and industry linked research, continuing education program, organizing international conferences and publishing an international Journal. Members of the group are highly involved with the local IEEE chapter and have hosted a number of IEEE distinguished Lecturers program. The group also conducted a number of workshops/seminars/colloquiums for the local professional community. Research strengths of the group include Renewable Energy, Power Electronics applied to Renewable Energy, Power Systems, Power Quality and Harmonics, Condition Monitoring of Electrical Plant, etc. All full time academics associated with the group are fully supported by the recurrent funding of the Department of Electrical & Computer Engineering and engaged in both teaching and research.

III. THE UNDERGRADUATE POWER ENGINEERING CURRICULUM AND LINK WITH REPSG

In this section, a little description of the power engineering course taught at Curtin is given primarily to demonstrate the linkages between teaching and research strength of the members of staff in the REPSG. The first year of the course is common between all engineering departments and the second year is common with Bachelor of Engineering (Electronics and Communication) and Bachelor of Engineering (Computer Systems Engineering) options. At a time of declining student numbers in any of the three options are hoped to be neutralized by increased demand in other options. The common second year provides an opportunity of reduced workload to free up time for research. The third and fourth year of the four year long Bachelor of Engineering (Electrical Power Engineering) course is presented below:

3rd Year

Semester 1

Unit	Credit Points
Power Systems 301	*25*
Renewable Energy Principles 301	*25*
Control Systems 301	*25*
Embedded Systems Engineering 301	*25*
Total	100 cp

Semester 2

Unit	Credit Points
Power Systems Protection 302	*25*
Electrical Machines 302	*25*
Power Electronics 304	*25*
Engineering Project Management 301	*12.5*
Engineering Law 202	12.5
Total	100 cp

4th Year

Semester 1

I. Unit	Credit Points
Engineering Project 401	*25*
Power Electronic and Drives 401	*25*
Elective from List I	*25*
Engineering Economics 401	12.5
Engineering Sustainable Development 201	12.5
Total	100 cp

Semester 2

Unit	Credit Points
Engineering Project 402	*25*
Elective from List II	*25*
Instrumentation and Control 402	*25*
Electric Power Transmission & Distribution 402	*25*
Total	100 cp

Elective List I:

- Electric Utility Engineering 404
- Microprocessors 401

Elective List II:

- Renewable Energy Systems 402
- Digital Signal Processing 304

The units shown in boldfaces are generic units required by the Engineers Australia accreditation board.

IV. GOVERNMENT RESEARCH AGENCIES AND FUNDING OPPORTUNITIES FOR REPSG

Research in the tertiary sector is primarily funded by the Australian Research Council (ARC). In 2008, the two main funding categories: Linkage grants and Discovery grants accounted for $363 M out of a total $596 M ARC competitive grant budget. The other funding programs within the ARC are Linkage International and Future Fellowships. While the discovery grant scheme fund blue sky research the linkage grant scheme fund projects in partnership with industry. Industry is encouraged by the government through 125% R&D tax concession. A total of 1103 projects were funded in Australia through the linkage and discovery schemes in 2008. The success rate of the discovery and linkage projects vary year to year but typically stand around 20% and 40% respectively. Both discovery and linkage projects fund research training opportunities through Honors and Research Masters and PhD scholarships. Students funded through the linkage projects have the opportunities to work with industry engineers as well as University Professors. and developers. The members of the REPSG secured 8 discovery and linkage project over the past five years amounting to $2.5 M. A large proportion of these funding were spent on scholarships and equipment. The scholarships funded by the

ARC are leveraged to get the tuition fee waivers from the University to fund international students under the Curtin International Postgraduate Student Scholarships (CIPRS). All equipment after the grant is completed goes to the relevant laboratory within the department. Other key sources of funding in Australia at the national level come from the Commonwealth Cooperative Centre (CRC) and Centre of Excellence (CoE) programs. In each round, approximately 10 CRCs are funded on national priority research areas. Sustainable Development and Renewable Energy features highly on the priority listings. The CRCs are funded by the government to promote joint ventures between the University, R&D bodies, and the Industry. In 2003, the Renewable Energy Research group went in partnership with a number of University and Industry to successfully apply for CRC on Renewable Energy, Australian Centre for Renewable Energy (CRC-ACRE). The group attracted in excess of $3 M in funding through the CRC-ACRE at Curtin on Power Conditioning, Enabling Technologies, and Education programs of the CRC-ACRE. The research income through CRC-ACRE funded scholarships for 10 PhD students, over 12 honors degree students, and a number of international visitors. Research visitors participated in the supervision of students, guest lectures in the courses taught within the department and conducted research seminars/workshops.

At the state level, research funding is obtained from the Sustainable Energy Development Office (SEDO) from the Office of Energy. A number of top up scholarships for research students and small projects giving opportunities for undergraduate projects are funded through the SEDO.

V. MASTER OF ENGINNERING SCIENCE IN RENEWABLE ENERGY ELECTRIC POWER SYSTEMS AND ELECTRIC UTILITY ENGINEERING

The experience and resources gained through the CRC-ACRE activities enabled the Department of Electrical & Computer Engineering and the REPSG to launch a new Master of Engineering Science in Renewable Energy Electric Power Systems course. At a time, when the enrolments in undergraduate courses in Electrical & Computer Engineering are declining, demand for postgraduate courses among professional engineers in niche areas are on the rise. As a result of some strategic planning, it was agreed that the REPSG could develop a Master degree course combining their strength in Power Systems and Renewable Energy for Electrical Engineers to specialize in Renewable Energy generation, transmission and distribution. The course was designed to provide advanced training in renewable energy engineering for graduates in science and engineering. Table below shows the course structure for this course.

Year 1 Semester 1

Unit	Credit Points
Renewable Energy Principles 603	25
Renewable Energy Project 695	25
Power Systems Analysis 603	25
Power Electronics 603 OR Eco Efficiency 603	25
TOTAL	100 cp

Year 1 Semester 2

Unit	Credit Points
Renewable Energy Systems 604	25
Renewable Energy Project 604	25
Electric Power Transmission & Distribution 604	25
Engineering Investment and Analysis 660 OR Environmental Engineering Management 690	25
TOTAL	100 cp

All the engineering units mentioned in the program are resourced through staff and laboratory support from the REPSG. The projects are supervised by the members of the REPSG group. Power System Analysis and Transmission and Distribution experiments are supported through a Power Simulation Laboratory sponsored by the REPSG. This laboratory has modern ergonomic set up and high specification computers with 19 inch LCD monitors and the following softwares: ETAP, PSSE, PSCAD/EMTDC, EMTP RV, PSIM, PSPICE, DigSilent, MATLAB/SIMULINK, PVSOL, HOMER etc. Most of these software are either obtained through research grants or through sponsors of the REPSG group. The group also recently put together a Renewable Energy laboratory (Green Electrical Engineering Park) with an estimated cost of A$400K. A schematic diagram of the proposed laboratory set up is shown in Figure 1.

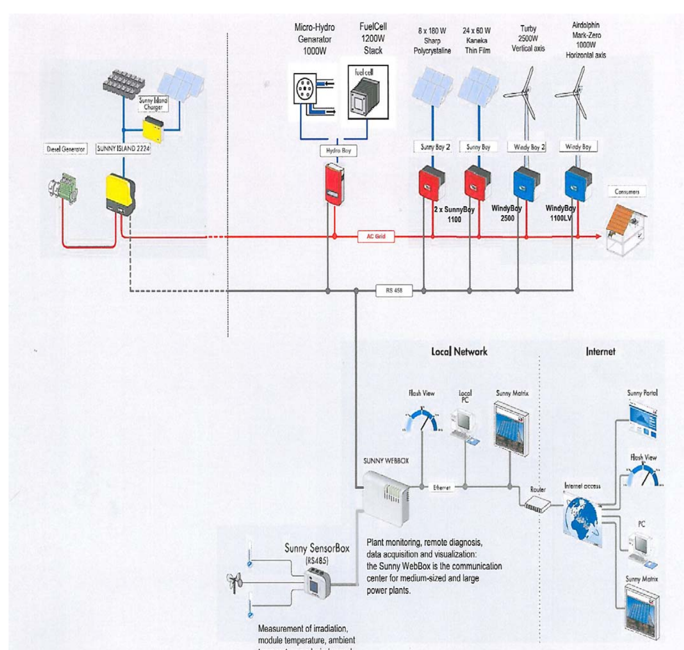

Figure 1. The Green Electrical Engineering Park (GEEP)

The list of experiments covered in the two renewable energy units are given below:

- PV Module Model using Matlab Simulink
- PV Module Simulator
- Solar Home System
- Introduction to HOMER software
- Measurement of I-V and P-V Characteristics of a typical Photovoltaic Module
- Introduction to Maximum Power Point Tracking in Photovoltaic Systems
- Maximum power point tracking with 2 PV modules
- Modeling of I-V and P-V Characteristics of a Typical Photovoltaic Module
- Simulation of a Solar Hot Water system
- Modeling of a Grid Connected PV (GCPV) System with PVSOL software
- GCPV Demonstration System
- Solar Water Pumping

The group also pioneered a spin off company, REGENPOWER, where a number of postgraduate students carry out their research work. REGENPOWER also employ a number of undergraduate students on vacation employment basis.

The group also took the lead in putting together a course in Master of Engineering Science in Electric Utility Engineering. This professional engineering course was developed in partnership with the local utility, Western Power. This course is now on the graduate training program within Western Power. Both the courses mentioned above are also fully supported by the government under the higher education assistance program for up skilling qualifications. Currently approximately 40 students enrolled in these two Master degree courses bringing in much needed financial resources to support the Department.

VI. INDUSTRY RELATIONSHIPS AND FUNDING OPPORTUNITIES FOR REPSG

The members of the REPSG are actively engaged in developing partnerships with the power engineering industry. In Australia, the USA equivalent of PSERC (Power Systems Engineering Research Consortium) is the Australian Power Institute (API). API is sponsored by all the major power utilities in the country to promote education and training within the Australian Universities. Recently, API established six centres of excellences in power engineering education on the basis of power engineering expertise, courses, and laboratories. Curtin was selected by the API as a Power Engineering Centre of Excellence. This selection was primarily due to the REPSG strength and their internationally recognized research. The API funded over $150K for Power Systems Protection laboratory equipment and ten $8K bursaries per year for undergraduate students. The API also funded the REPSG to bring internationally eminent speakers to various events organized by the group. These speakers include Professor Roy Billinton (FIEEE), Professor M A Rahman (FIEEE), Professor Bimal K Bose (FIEEE), Professor M H Rashid (FIEEE) etc. Curtin undergraduate and postgraduate students benefitted from the lectures, seminars, and workshops presented by these outstanding speakers.

The group is also actively engaged in Cooperative Engineering Enterprise Development (CEED) projects with the local power industry. The CEED project is aimed at investigating a particular issue within the enterprise in the form of a student project before a decision can be taken for a full scale project. These research projects provide undergraduate students with vacation employment, travel funding for data collection, access to industry premises, joint supervision from the University and Industry. There is no commitment from the student but often students end up accepting a position within the industry after graduation. Some of the CEED projects conducted by the group are listed below:

- SF6 Switch Gear Condition Monitoring
- Grounding system Design
- Modeling of Lightning Protection Coordination studies
- Assessment of Lightning Protection Systems in Western Power Substations
- Investigations into Pole failures in Western Power Networks
- Feasibility of Various Pole Types in Western Power Networks
- An Intelligent Transformer Load Estimation Tool
- Energy Savings in Swimming Pool using Single Phase to Three Phase Converters
- High Frequency Modeling of Transformers
- Stability Enhancement of Distributed Power Systems with Embedded Low Inertia Generators
- Demand Side Management of Non-Essential Loads

These CEED projects allow students to learn outside of classrooms that can not be normally taught within the curriculum. These projects are very popular among high achieving students and is evident during the students feedback session. Two of our students received the outstanding project award from the Australasian Committee for Power Engineering (ACPE) and the IEEE PES. Figure 2 shows results from one of the CEED project which developed an intelligent estimation of distribution transformer loads in a distribution network.

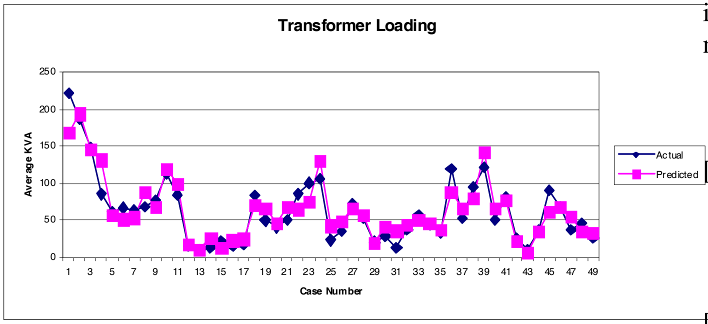

Figure 2. Estimation of Distribution Transformer Loading (CEED project)

The undergraduate student working on this project made the following comments: “Clearly, the next stage of the project is to produce highly accurate models of all seven transformer types. The main aspect discovered throughout this project is the lack of data and also the inaccessibility of the data on the company’s networks. The data that was available is also of a lower quality than what it should be. Thus, data quantity and quality need to be addressed. It is recommended that random transformers be permanently monitored (especially in the high load seasons) for each transformer type (residential, commercial, etc.). A nominal minimum figure of 100 monitored transformers per state (700 in all) would best address the needs of the model. Other possible transformer types may also be necessary and this will obviously increase the number of monitored transformers (and models). Further data sources need to be investigated including socioeconomic data. A brainstorming effort could contribute to determining some more variables. These could allow a more accurate model assuming they affect the power supply. The neural network software would need to be upgraded to allow the excess amounts of data to be included. The current software does not include enough allowance for the data size.”

The above observations made by the student clearly demonstrates that the student was introduced to the research training and benefitted from the project in augmenting his engineering knowledge in electric power transmission and distribution engineering as a result of this research-teaching nexus..

VII CONCLUSION

In this paper, experiences of the Renewable Energy Power Systems Research Group (REPSG) at Curtin University of Technology, Perth, Australia in embedding research outcome/funding/equipment/expertise in the enrichment of teaching and learning experience of the students is presented. The group’s research expertise and funding led to the development of a suite of coursework Masters program providing the department with financial stability. International reputation of the group led to the department’s recognition by the Australian Power Institute as a Centre of Excellence in Power Engineering. It is also shown how Cooperative Enterprise in Education and Development (CEED) projects with industry provide students with vacation employment and research induction. Students are introduced to extended engineering knowledge which are not normally covered in the curriculum.

VII. REFERENCES

[1] Kerri-Lee et al, “The Academic’s and PolicyMakers Guides to the Teaching-Research Nexus”, Final Report, Australian Learning & Teaching Council, November 2008.

[2] Brew, A. (2006) *Research and teaching: Beyond the divide*. New York: Palgrave Macmillan.

BIOGRAPHIES

Syed. M. Islam (S’81, M, 83, SM’93) received the B.Sc. degree in electrical power engineering from Bangladesh University of Engineering and Technology, Bangladesh in 1979, the M.Sc. and PhD degree in electrical power engineering from the King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, in 1983, and 1988 respectively.

He is currently the Chair Professor in Electrical Power Engineering and Head of Department of Electrical and Computer Engineering at Curtin University of Technology, Perth, Australia. He is the Vice Chair of the Australasian Committee for Power Engineering (ACPE) and is the Director of the Renewable Energy and Power Systems Research Group (REPSG) at Curtin. He received the IEEE T Burke Haye’s Faculty Recognition award in 2000. He received the outstanding Faculty Supervisor award in 2006 from ACPE. He has published over 140 technical papers in his area of expertise. His research interests are in Condition Monitoring of Transformers, Wind Energy Conversion, Power Quality & Harmonics and Power Systems. He has been a keynote speaker and invited speaker at many international workshops and conferences. He is a Fellow of the Engineers Australia and a Fellow of the IET.