SYDNEY UNIVERSITY ELECTRICAL ENGINEERING


# 1991 RESEARCH REPORT

*Achieving Relevance through Excellence*

# ELECTRICAL ENGINEERING EDUCATION RESEARCH GROUP

*Director: Dr Zenon J Pudlowski*

The Electrical Engineering Education Research Group (EEERG) was established in 1988 as a response to a strong demand for expertise in electrical engineering education and industrial training. The establishment of the EEERG demonstrates quite a unique development in this part of the world.

Much of the effort of the Group members is focused on a systematic and comprehensive investigation into the methodology of engineering training and modern curriculum development. The research programs and developments extend from early career orientation for young aspirants to the need for continuing education of engineers and graduates moving to industry.

### *OBJECTIVES OF THE EEERG*

The paramount objective of the EEERG has become to undertake several actions upon which to build a system that would help to make the electrical engineering training within the Department more effective and reliable.

One of the important activities was, and indeed still is, research on the theory and practice of curriculum development for engineering education. The important aim of this research is that the developed approach must ensure curriculum flexibility and must provide a better correlation between the subjects taught. A modelling method, which is extremely popular in engineering, has been implemented successfully in the curriculum development of several subjects.

A method of study plays an important role in the entire educational process. The selection of the most desirable and effective method should certainly be based upon modern achievements in educational psychology, in order to satisfy the requirements of a particular subject. Often the subject content, which in electrical engineering includes abstract notions, laws and principles, as well as highly sophisticated concepts and topics, determines the kind of method used for training. However, the chosen method must be selected not only with the constraint that this particular method is the most suitable for presentation of the specific subject content, but also making due allowance for the goals to be achieved. Therefore, much of the effort of members of the EEERG is concentrated on research concerning cognitive aspects of the thought processes taking place in training for electrical engineering and the methods of information acquisition, processing, transfer and retrieval. Thorough understanding of these aspects forms an important foundation for the subsequent investigation of cognitive processes which occur in a problem-solving situation.

Problem-solving is an important part of the teaching process in electrical engineering, and academia is fully responsible for the formation and cultivation of problem-solving techniques which form a set of skills required by its students. Therefore, numerous projects undertaken by the EEERG are dedicated to research on several interesting phenomena which occur during problem-solving. For instance, research is now being carried out on the effectiveness of knowledge-transfer involving analogue models in the early stages of electrical engineering. Many analogue models applicable to teaching practice have been developed and investigated.

Special emphasis has been placed on research into visual communication through the application of graphical forms such as drawings and diagrams. Comprehensive experimental work has been carried out to investigate those cognitive processes which appear during the stages of concept learning; pattern recognition and identification; and, finally, image creation. The important objective of this research was to provide insights into the thought process which occurs when producing and reading such images as electrical drawings and diagrams in an engineering discipline. At present, attention is being focused on the impact of drawings and images displayed on visual display terminals (VDT). The aim of this research is to investigate and evaluate the cognitive complexity of screen images and drawings used in engineering, particularly for visual communication. This research has an important application to the development of computer graphics.

Intensive research is also being carried out on the effective use of algorithms in the teaching of electrical engineering. This particular research has important implications for the development of teaching instructions specifically for computer-assisted training.

This fundamental research, involving the investigation of several important phenomena which appear in the teaching-learning process, should provide an excellent foundation for the subsequent development of an effective methodology for electrical engineering education and industrial training.

### *SELECTED RESEARCH PROJECTS IN PROGRESS*

The year of 1991 was extremely successful for electrical education research and development. The number and quality of publications produced that year demonstrates well the achievements of the Group. The key projects in which the EEERG was involved, and which are closely related to the field, are:

- The Investigation of Student Aptitude for Electrical Engineering,
- VDT Drawings and Images in Engineering Design and Work: An Evaluation of Cognitive Complexity,
- Development of Training Courseware for Computer-Investigation of Selected Electrical Machines and Apparatus,
- Burn-out Syndrome in Practising Engineers,
- A Computer Network for the Interactive Computer-Based Training System,
- An Interactive Computer-Aided Authoring Program for Engineering Education,
- Methodology of Computer-Assisted Training for Electrical Machines,
- Methods of Interfacing Computers with Electrical Apparatus,
- A Study of the Nature and Effectiveness of Electrical Engineering Curricula in Different Countries,
- The Interface of Electrical Machines and Apparatus with a Personal Computer,
- Computers in Electrical Engineering Training.

It should be noted that the second stage of the development of the aptitude test was completed. It has attracted considerable interest in local and international engineering education communities, with close to 40 institutions using it.

A computer-based training system for the investigation of selected small electrical machines was completed in 1991.

### *GRANTS*

The Group has been instrumental in receiving a substantial grant from the New South Wales Education and Training Foundation after a submission prepared by H K Messerle, Z J Pudlowski and A D Stokes,entitled *Engineering Continuing Education for Electrical Technology.* Over $360,000 was used to support educational development in 1991. The project has been extended to 1992 with Associate Professor Robin W King and Dr Zenon J Pudlowski as recipients of $140,000 for further work.

### *EUROPEAN INVOLVEMENT*

The Electrical Engineering Education Research Group is the only non-European organisation from G24 countries accepted as an associated institution in a TEMPUS scheme involving a joint international project on computer-assisted training. The project's concept is to develop computer-assisted training programs for engineering education, incorporating problems across the entire engineering profession. The work and achievements of the EEERG in the area of computer-aided training, particularly in the development

of computer-aided authoring systems and interfacing computers with electrical apparatus, have been recognised by the international engineering education community. The EEERG has been asked to further develop authoring systems and computer-aided learning systems for electrical engineering.

Apart from being involved in the development of authoring systems and computer-assisted instruction, the EEERG is pioneering work on the development of a methodology for computer-based training in electrical engineering.

### *SECOND INTERNATIONAL SYMPOSIUM FOR ENGINEERING DEANS AND INDUSTRY LEADERS*

The *Second International Symposium for Engineering Deans and Industry Leaders* was held at UNESCO Headquarters in Paris, France, 16-20 July 1991. This was a follow-up to the 1989 Symposium at Ohio State University and was sponsored by UNESCO, with appropriate engineering education groups invited to co-sponsor (eg ASEE, AAEE, Engineering Dean's Council, SEFI, IGIP).

The scientific program was developed by Donald Glower, Russel Jones, Curtis Tompkins and Dueb Lakhder. The Symposium was chaired jointly by Professor Russel C Jones, University Research Professor at the University of Delaware, USA, and Dr Boris Berkovski, Director of Engineering and Technology Division, UNESCO.

Over 150 senior engineering academics and industry leaders worldwide attended the Symposium. The interesting and stimulating discussions and group work were summarised in comprehensive recommendations addressed to several bodies concerned with engineering education, including UNESCO.

The EEERG Director was invited by the organisers to co-ordinate and chair the Symposium stream on *the development and maintenance of an information clearing house in teaching equipment, courseware, etc, used in engineering education*. A comprehensive report was prepared, including suggestions for future action plans. The Group has also been invited to organise a regional symposium, to be held in Australia for representatives from Asia, Australasia and the Pacific.

### *PARTICIPATION IN ENGINEERING EDUCATION CONFERENCES IN EUROPE*

Members of the EEERG participated in a number of international and local conferences where they presented keynote addresses and regular papers.

In September, Dr Z J Pudlowski and Dr W N Roebuck attended three conferences in Europe. The first was the International Conference on Computer-Aided Engineering Education (CAEE'91) in Prague, Czecho-Slovakia. The venue was the Czech Technical University and was under the sponsorship of UNESCO in co-operation with world and European engineering education societies. Dr Zenon Pudlowski presented a keynote address: *An overview of Computer-Aided Education for Electrical Engineering at The University of Sydney.*

The second conference was held at the Dresden Technical University and was organised by the International Society for Engineering Education (IGIP). This was their Twentieth International Symposium, entitled: *Engineering Education, 1991.*

People from some twenty countries participated in this conference which was held over a four day period. The main theme of this symposium was *Modern Training and In-Service Training of Engineers - Results and Prospects.* Dr W N Roebuck represented the EEERG at the conference.

### *EAST-WEST CONGRESS ON ENGINEERING EDUCATION*

The major European involvement for the EEERG was the organisation of the first East-West Congress on Engineering Education, held at Jagiellonian University in Cracow, Poland, 16 - 20 September 1991. Several Australian and Polish organisations such as The Institution of Engineers, Australia; the Australasian Association for Engineering Education; The University of Sydney; the International Liaison Group on Engineering Education, amongst others, co-sponsored this important international gathering. This was the first major international gathering staged by Australian academics in Central and Eastern European countries.

In addition, the Australian International Development Assistance Bureau (AIDAB) supported

financially a number of nominated academics from Poland, Czecho-Slovakia and Hungary, who submitted papers. The Group Director, Dr Zenon J Pudlowski was the Program Committee Chairman and main organiser of this Congress.

More than 100 papers from a total of 30 countries were presented at the Congress and were included in the Congress proceedings edited by Dr Pudlowski. Close to 150 delegates from all corners of the world attend the Congress. The EEERG, and indeed the Department of Electrical Engineering, were very well represented at the Congress. Profesor Trevor W Cole, Associate Professor Branka Vucetic and Dr Pudlowski presented their keynote addresses.

### *INVOLVEMENT IN CONFERENCES HELD IN AUSTRALASIA*

Group members actively participated in two conferences on engineering education in Australasia in 1991. In the second week of December, the it *Association for Engineering Education in South East Asia and the Pacific* held its Third Triennial Conference at the University of Canterbury under the theme *Engineering Education: The Way Forward.* It was sponsored by UNESCO; the Institution of Professional Engineers, New Zealand; Motorola International Inc.; Telecom Corporation of New Zealand; the British Council; and the University of Canterbury Centre for Advanced Engineering.

The aim of the Conference was to act as a forum for educators, educational managers and employers on the following themes: issues in research, recruitment and assessment; computer-aided design and engineering; curriculum; engineering education, the profession and industry; continuing education; teaching methods; management; computer-assisted teaching; national perspectives on broad issues; new directions and innovations in engineering education; and case studies. Over 90 papers were presented from 16 countries, with 110 delegates attending. Dr Zenon J Pudlowski, 1st Vice-President and Executive Director of the Australasian Association for Engineering Education, was invited to present a keynote address. He gave a comprehensive address on *Australasian Association for Engineering Education - Origins, Structure, Objectives and Activities.*

In the third week of December, the Australasian Association for Engineering Education held its Third Annual Convention and Conference at the University of Adelaide under the theme *Broadening Horizons of Engineering Education.* One hundred and sixteen delegates attended from Australia, New Zealand, the United Kingdom and the Republic of South Africa, and 71 papers were published in the Conference Proceedings. Keynote addesses were presented by Mr John M Clark on *Future Directions for Engineering Education and the Interface with Industry*; then by Professor Peter C Farrell on *Creating the Common Wealth of Australia*; and, finally, by Professor T W Cole on *Engineering Education for the Next Century.* These papers, in particular, stimulated much debate and interest, which continued throughout the Conference.

### *DEVELOPMENT OF GRADUATE DIPLOMA IN ENGINEERING EDUCATION*

The main research activity involving the EEERG in 1991 was to develop the course structure for a Graduate Diploma in Engineering Education. This task has been carried out as part of a project entitled *Continuing Engineering Education for Electrical Technology,* which is being sponsored by the New South Wales Education and Training Foundation.

The Graduate Diploma in Engineering Education relates to technology and engineering and has been developed to enable graduate engineers to broaden their career horizons through undertaking a course that will permit them to become more effective communicators, educators and trainers both in the classroom and on the job in industry and commerce.

Dr Z J Pudlowski and Dr W N Roebuck concentrated their effort on the development of the course curriculum, including 18 subject syllabi. The research work was supported by a comprehensive bibliographic search and the main assumptions were adopted after thorough discussions during several workshops. These involved education, industry and academic representatives.

### *INVOLVEMENT IN ENGINEERING EDUCATION PUBLICATIONS*

Members of the Group have actively contributed to the establishment and operation of the *AAEE Newsletter* and the *Australasian Journal of*

*Engineering Education.* The Group Director is the Editor-in-Chief and the founder of the two publications. He is also a member of the Advisory Editorial Board of the *International Journal of Applied Engineering Education.* He edited four volumes of *Conference Proceedings of the World Conference on Engineering Education for Advancing Technology* in 1989, the *Conference Proceedings of the 1st AAEE Annual Convention and Conference* in 1989, and the *Proceedings of the East-West Congress on Engineering Education* in 1991.

In addition, the Group members have published numerous papers on engineering education in several international refereed journals, in which they endeavoured to share their experiences and research findings with members of the international and local engineering communities.

### *ENGINEERING RESEARCH AND PUBLICATIONS*

Apart from being strongly involved in research and development in electrical engineering education, EEERG members worked on a number of technical projects. The most successful was the development of a unique, single-phase linear reluctance self-oscillating motor by Dr Ernest Mendrela and Dr Z J Pudlowski. Research findings concerning this new development were presented at the *AUPCEC'91 Australasian Universities Power and Control Conference* at Monash University, and were subsequently published in the *IEEE Transactions on Energy Conversion* and in the Special Issue: EECON of the *Journal of Electrical and Electronic Engineering, Australia.*

### *OVERSEAS VISITORS*

The EEERG enjoys an international reputation for its research work and publications on engineering education. Several academics from abroad have already visited the group. In 1991 Associate Professor Kevin Rochford of the University of Cape Town in South Africa received a Norman I Price Scholarship in Electrical Engineering which enabled him to spent close to four months in the Department of Electrical Engineering. Prof Rochford collaborated with Dr Pudlowski in a *Study of the Nature and Effectiveness of Engineering Education Curricula in Different Countries.*

The findings will be published in a paper accepted for inclusion in the *Australsian Journal of Engineering Education* and in the *International Journal of Electrical Engineering Education.*

### *INTERNATIONAL LIAISON GROUP ON ENGINERING EDUCATION (ILG-EE)*

The International Liaison Group on Engineering Education (ILG-EE) was set up in 1989 as a result of the second *World Conference on Engineering Education for Advancing Technology*, held at The University of Sydney. Basically, its main task is to coordinate emerging international conferences on engineering education, including the series of World Conferences. In addition, the ILG-EE's objective is to stimulate and coordinate research and development in engineering education.

The EEERG is strongly involved in the activities of the ILG-EE. The Group members have prepared four annual general meetings of the ILG-EE in different locations: Sydney, Munich, Vienna, Cracow; and actively participated in those meetings. In addition, the Group director is the Foundation Secretary of the ILG-EE and the EEERG accommodates the headquarters of the ILG-EE.

***THE GROUP STRUCTURE***

The EEERG comprises a number of principal researchers and research staff. In addition, several academics are involved in research project as associates. The Group structure is:

*Director*

Dr Zenon J Pudlowski

*Principal Researchers*

Dr Ernest A Mendrela
Dr William N Roebuck
(Chief Education Services Officer)

Other academic staff have been involved on an *ad hoc* basis.

*Research Staff*

Mr Ho Y Choi
Mr Zoran Hlebar
Mr Ross Hutton
Ms Xin Li
Mrs Ewa Worotynska
Mr Jacek Worotynski
Ms Wen Zhao

*Technical Staff*

Mr Robert Wallace
(Senior Technical Officer)

*Group Associates*

The Electrical Engineering Education Research Group and its achievements have attracted worldwide attention from engineering educators. Several overseas visitors have spent their study leave working on a number of projects carried out by the Group, or are associated with the Group.

The Group's associates are:

Professor Tadeusz Lipski, Head of Department, Faculty of Electrical Engineering, Technical University of Gdansk, Poland.

Professor Tadeusz Marek, Head of Department of Industrial Psychology and Ergonomics, Jagiellonian University, Cracow, Poland.

Dr Czeslaw Noworol, Adjunct Professor, Department of Industrial Psychology and Ergonomics, Jagiellonian University, Cracow, Poland.

Dr Wanda Osikowska, Adjunct Professor, Department of Industrial Psychology and Ergonomics, Jagiellonian University, Cracow, Poland.

Associate Professor Kevin Rochford, School of Education, University of Cape Town, Republic of South Africa.

Professor Henryk Sibilski, Institute of Electrotechnics, Warsaw, Poland.

Ms Tao Song, Automatic Control Department, Taiyuan University of Technology, People's Republic of China.

Professor Janusz Turowski, Pro-Rector, the Technical University of Lodz, Poland.

Associate Professor Shlomo Waks, Department of Education in Technology and Science, Technion, Israel Institute of Technology, Haifa, Israel.