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Innovative training for work integrated learning in electrical engineering: opportunities and challenges

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ABSTRACT: Work integrated learning (WIL) is an essential component of any engineering education programme. The balance of theory, practicals and work experience makes the diploma in electrical engineering a popular qualification with students and employers in South Africa. The Engineering Council of South Africa (ECSA) published new standards for WIL, which will allow for more flexible teaching and learning. Students will be able to apply their knowledge using various methods, not just work-based learning. The new standards will be harnessed to create a 70-credit project for those students unable to obtain work placements. In this article, the authors present and evaluate the project undertaken to investigate the new opportunities available with the new standards, and evaluate the successes and address the challenges related to the pilot project that they implemented last year.

Keywords: Work integrated learning, distance education, electrical engineering

INTRODUCTION

The concept of graduateness in higher education has become a topical issue worldwide. The quality of a graduate is not simply the ability of a student being able to pass examinations, but a measure of the student's ability to enter into the workplace, as well as the reputation of the institution itself. There is increasing emphasis on work-based learning, as it aims to integrate academic study and practical work experience. Integrating theory and practice in an engineering curriculum is mandated by a number of accreditation bodies in the world, including the Engineering Council of South Africa (ECSA).

The exit level outcomes prescribed by ECSA require engineering students to apply scientific, engineering and complementary knowledge to solve well-defined engineering problems, while also completing engineering procedural designs [1][2]. The University of South Africa (UNISA) is, therefore, mandated by ECSA to provide quality engineering education programmes, which adhere to the high standards set forth by the Washington, Sydney and Dublin accords [3].

These new standards have enabled the authors to introduce a 700-hour project into the work integrated learning (WIL) for the National Diploma in Electrical Engineering at UNISA.

NATIONAL DIPLOMA IN ELECTRICAL ENGINEERING

A student must obtain 360 credits in order to qualify for a three-year National Diploma in Electrical Engineering at UNISA. These credits are secured by passing twenty 12-credit subjects, each module consisting of a theoretical and practical component, with an additional 120 credits being awarded on completion of one year's suitable work experience, i.e. work integrated learning (WIL). A student who is unable to complete the WIL component cannot be awarded the qualification, even though the student might have passed all required academic subjects [4]. The main reason for implementing the new 700-hour project is to enable such students to finalise their studies.

WORK INTEGRATED LEARNING IN ELECTRICAL ENGINEERING

The design, monitoring and evaluation of WIL, as well as visits to industry in the engineering disciplines are structured to meet the requirements as set out in the purpose of the qualification, the required outcomes and the criteria used by the

accrediting body, ECSA. Strict guidelines exist that need to be adhered to, if worldwide accreditation is to be maintained. In the existing system, the student and mentor/training manager together draw up the appropriate WIL training programme in consultation with a UNISA representative. The first six months of WIL learning is finalised once 10 modules have been completed successfully. During this first WIL training period, generic training areas that are relevant to all areas of specialisation are dealt with [1][5][6].

The students may register for the second six months of training after successful completion of 15 modules. This second period of WIL training is specific to the student's area of specialisation, be it computer systems, clinical engineering, electronics and electronic communication, power engineering, process instrumentation or mechatronics.

In the new standards and graduate attributes, the following are seen as acceptable work integrated learning [7]:

- Work-directed theoretical learning - modules like design and industrial projects.
- Problem-based learning - the learner demonstrates the ability to gather evidence and to solve problems based on evidence and procedures relevant to electrical engineering problems.
- Project-based learning - brings together intellectual enquiry, real world problems and student engagement in meaningful work.
- Workplace learning - where students are placed in a professional practice.
- Simulation - simulated experiences that are related to the electrical engineering workplace. The authors used PLC's, HMI, VSD's and touchscreen technologies.

As a result of the new standards ECSA has published for WIL, the authors have been able to adapt the WIL programme based on these new standards and piloted a project at the Florida campus. The advantage of the new standards is that it allows more flexibility and that the work integrated modules will be funded. In the existing qualifications WIL is not funded by the government.

The intention is to develop WIL into 12 credit modules for inclusion into the main curricula. A total of six 12 credit modules will make up the 72 credits (minimum of 70 credits required) and will be a combination of the new approved WIL standards. This will be a major challenge requiring much deliberation with service providers in developing these modules for endorsement by ECSA and approval by the South African Qualifications Authority (SAQA).

The general opinion is that the WIL component in the old diploma was paramount to the successful acquisition of employment by students and, hence, should be retained in the curriculum even if in different forms. This will ensure that higher education institutions will not have the burden of having to place students in industry, as the WIL components will now be in the form of modules based on the new standards.

WIL PROJECT: AUTOMATION OF A MICRO-BREWERY

The purpose of WIL is to enable the learner to connect academic learning with workplace practice. The new standards can be summarised as follows [7]:

The qualification is primarily vocational or industry related. The programme shall have a core of integrated project work that provides a viable platform for lifelong learning. The exit level outcomes and graduate attributes of the qualification for well-defined problems are [8][9]:

- Problem-solving;
- Application of scientific and engineering knowledge;
- Engineering design;
- Investigation;
- Engineering methods, skills, tools, including information technology;
- Professional technical communication;
- Impact of engineering activity;
- Individual team work;
- Independent learning;
- Engineering professionalism;
- Workshop practical as part of an integrated project.

Students will be required to meet all the outcomes listed to be able to register professionally with the engineering council. Well defined problems are solved by using acceptable engineering standards. A wide variety of skills will need to be acquired and assessed by students in WIL for the new programme to succeed.

Project-based learning brings together intellectual enquiry, real world problems and student engagement in meaningful work. The improvements in technology and the new standards have made it possible to include simulated learning for

programmable logic controllers, variable speed drives and human machine interfaces to form part of the WIL programme. Students who were unable to find a workplace placement were invited to participate in identified projects.

In 2016, twenty six students participated in the projects at the Florida campus. These projects were all related to plant automation for a micro-brewery and included two-day training sessions on:

- Easy programmable controllers (PLC's) - enabled the students to do programming in ladder. The second session covered timers, counters and markers.
- XC programmable controllers (PLC's) - this training enabled the students to do programming in instruction list and function blocks. The second session covered analogue signals and PID loops.
- Human machine interface (HMI) - this training enabled the students to do programming in Gallileo. This covered touch screen control and visualisation.
- Variable speed drives (VSD's) - this training enabled the students to control the speed of an induction motor safely for different applications.

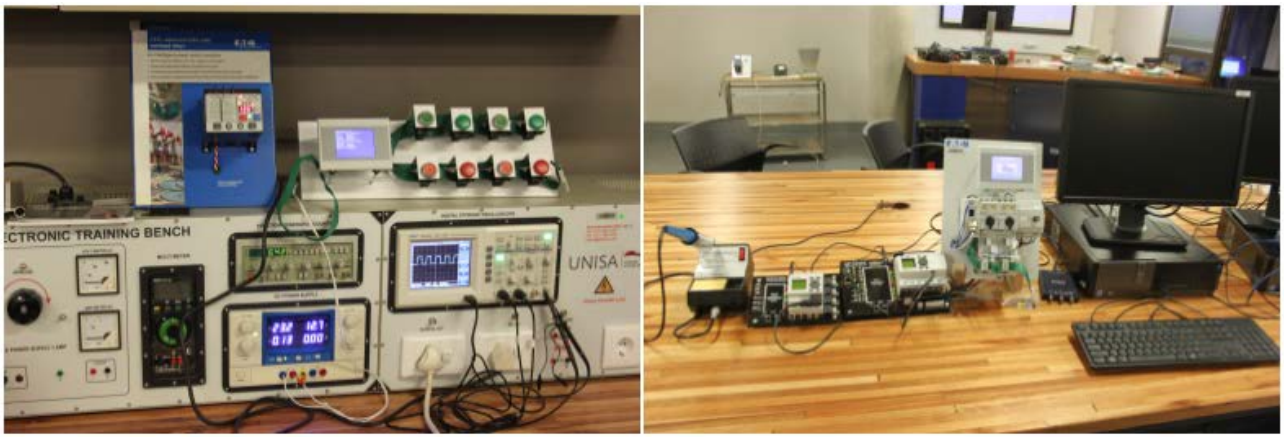

Figure 1: Training equipment used.

While training, the students were given a choice of projects in which they applied this knowledge. Projects ranged from temperature control, automating the milling process, visualisation of the brewing process and recipe control for different types of beers.

As the equipment and expertise is situated at the Florida campus, the new 70 credit WIL module was trialled in 2016. As this qualification is offered by open and distance education, videos of the training sessions were recorded and these will be used to for students that are unable to attend training sessions in the future.

Figure 2: The micro-brewery that needs to be automated.

Each student was given the software at the training sessions, so that they could do the simulations at home. This way less time was needed to be on campus. Once the students had completed their work they could link their programmes to the actual equipment on campus for final testing. As functionality counted 30% of the final mark, an accreditation

requirement, this was a very important part of the project. Students could now take readings, analyse the results and compile a portfolio. As assessment is integral to effective curriculum design and the implementation of this WIL project, students were required to present their projects at the end of the year.

Students attend training at campus and were given the Gallileo simulation software during the training. Students are now able to do a large portion of the preparation work at home. Once the students are ready to connect their designs to the actual equipment; this has to be done at the campus to meet the functionality requirement. The challenge is to enable students to do this throughout the country and this will require agreements with other institutions.

FINDINGS AND CHALLENGES

The purpose of this article is to highlight how technology enhanced learning has been used to integrate theory with practice in an electrical engineering project, which would assist students to do a 700 hour project towards their WIL.

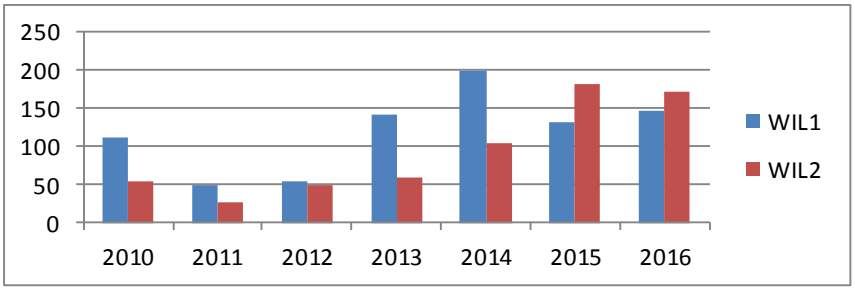

Figure 3: Number of students registered for WIL from 2010 to 2016.

There has been a significant increase in the number of part 2 WIL (students require 6 months training in their area of specialisation) students for 2016. The authors were able to offer 26 students the opportunity to partake in the projects at Florida. As 21 of these students successfully completed the project in 2016, the project will expand in 2017. A major area of concern is how to introduce the programme at other venues throughout South Africa.

The challenge will be to implement this 70 credit model for a larger group of students that are situated throughout the world making use of open and distance learning tuition model.

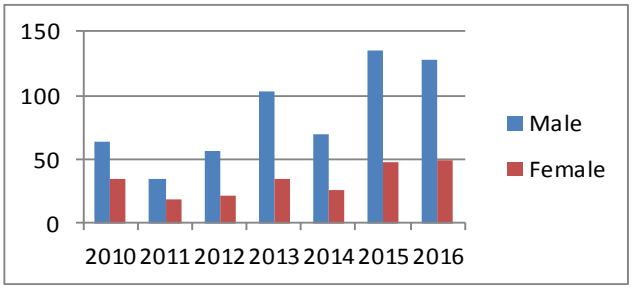

Figure 4: Number of students by gender registered for WIL from 2010 to 2016.

From 2010 to 2016 shows more than twice the number of male students registered for WIL compared to female students registrations. More promotional work must be done to promote interest in electrical engineering for women.

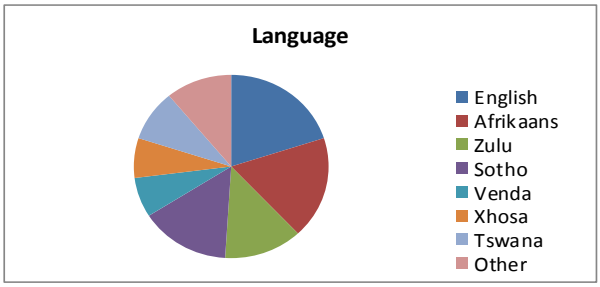

Figure 5: Languages spoken by students registered for WIL in 2016.

UNISA's language of tuition is exclusively English for electrical engineering. Most students, therefore, receive tuition in a language other than their mother tongue. Additional support must be made available to students regarding language and communication. Correspondence must be done in understandable English.

The opportunity to include the additional types of work integrated learning in the assessment approved by the accrediting body will resolve some of the challenges that open and distance learning poses. The authors will be able to include these in the new qualifications that ther are busy developing. The costs of the site visits will still remain a costly exercise.

Figure 6: Final projects of 2016 group.

The authors have piloted a programme in plant automation during 2016. The challenge is to expand this to electronics, telecommunications and power engineering.

CONCLUSIONS AND RECOMMENDATIONS

The implication for students in the past was that they had to be employed at some time in the course of their studies by an employer able to offer the relevant and necessary work integrated learning. If students were not able to complete the work integrated learning, they could not be awarded the National Diploma, even though they might have passed all the required academic subjects.

Project-based learning that brings together intellectual enquiry, real world problems and student engagement in meaningful work will enable academics to offer WIL projects on campus. Work integrated learning is an essential component of any engineering programme. The balance of theory, practicals and work experience is what makes the diploma in electrical engineering a popular qualification with students and employers.

The only way to ensure that UNISA's engineering programmes are relevant, keep abreast with modern technology, meet local and international standards and fall within the universities strategic plans, require that the Department work closely with industry, accrediting bodies and other stakeholders.

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BIOGRAPHIES

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