AN EXPERT SYSTEM FOR THE EDUCATION OF ENGINEERING STUDENTS

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Abstract: In this paper, a hardware and software environment is described for teaching and assessing against whole qualifications or unit standards. The software system provides an integrated approach to the registration, recognition of current competencies, the training path, the assessment and competency declarations, student feedback, student progress and final submission of unit standard credits of students to the national learner record database (NLRD). The hardware component of this integrated approach allows the automatic assessment of random faultfinding on real time hardware with direct feedback of faults found to the integrated database. This system ensures alignment with the South African Qualification Authority (SAQA).

Keywords: South African Qualifications Authority – SAQA, Recognition of prior learning –RPL, National qualifications framework – NQF, National learner record database – NLRD.

1. INTRODUCTION

1.1 The old educational system

Traditional training in the past was reliant on inputs from a lecturer with a test to determine whether the student had knowledge of the subject and did not concentrate on the outputs of students (Skills & Knowledge).

This 'Walk, talk and chalk' approach had deficiencies that where not addressed, especially when it came to the mentoring/coaching role of the lecturer and the method of assessing and confirming the acquired skills and knowledge.

This general pattern of assessment over-emphasises the testing of memory of information. It undervalues the learning that takes place over a period and basis judgement about the learner far too much on one major event.

The assessment (examinations, tests, scoring) of learning achievement was often seen as unfair, secretive, prejudiced or not really making decisions about the most important aspects of learning. So much emphasis was placed on the 'the exam', that strange, negative and even destructive feelings that are expressed by students towards exams is, in part, because of this experience.

In addition to the assessment, many people, universities and employers had the feeling, that both the standard (in the sense of quality) and the level of qualifications, where very different from one institution to another. This meant that a degree from one university was seen as 'inferior' or 'superior' to the same degree by another university.

1.2 The SAQA based educational system

The primary objective of SAQA is 'to create an integrated framework for learning achievement'. This framework is referred to as the National Qualifications Framework (NQF) and is outcomes/competence based. SAQA and the NQF have become demanding realities for all who are involved in education and training.

The NQF structures education and training very differently from the past. The new structure is broken up into three bands namely:

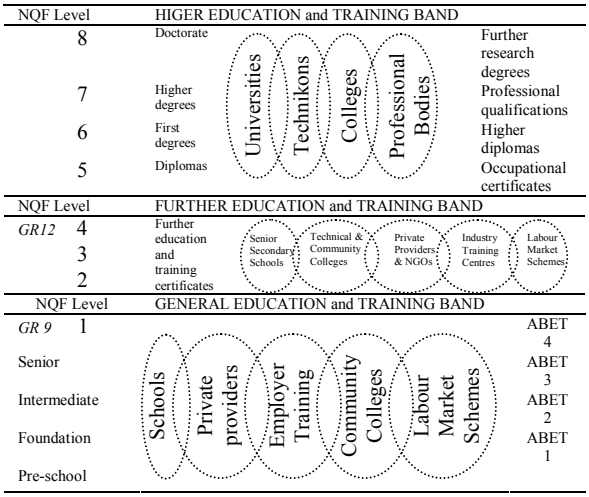
- The higher education and training band
- The further education and training band
- The general education and training band

Referring to table 1, the implication is that certification is across the band and it is a certificate in Education and Training. This implies that all educators must integrate those components of learning that have previously been categorised as 'educational' with those that have previously been categorised as 'training'. The band thus represents the appropriate learning for a range of outcomes.

In the past, learners where limited to the choice of direction and where the studies could be undertaken. The NQF captures all qualifications (no matter what level or discipline) so that learning opportunities are not tied to a single institution. Students will now be able to study what is appropriate for them, where it is

appropriate, with the focus on the combination of learning outcomes and range of competencies that are required for the particular qualification and the particular future that the student has in mind, meeting the needs of national skill priorities and strategies.

Table 1 The NQF structure



The other advantage of the NQF as illustrated in table 1, is that individual students may follow very different paths to a qualification. On the left hand side of table 1, one can trace a pattern of what has in the past, been fairly typical for most students. Starting at the bottom with pre-schools and then advancing through primary school followed by the first two years of secondary school (grade 9). Moving into the next band and completing the rest of high school (grade 12) and from there on to the higher educational (HET) band to university or Technikon.

On the right hand side starting at the bottom, a very different series of patterns becomes possible. From Adult Based Education and Training (ABET) that may be obtained from an employer, through some distance learning or community college, a general education and training (GET) certificate can be obtained. What is significant to note is that this certificate is at the same level, with the same standing, giving the same access into the FET band as would be obtained by a student that progressed through the school route. This adult learner could now continue in the FET band by going through various options of learning provision as indicated in table 1. The successful achievement of the FET certificate will be equal in standing and at the same level (NQF level 4) as the grade 12 certificate obtained via the school route. This certificate will provide the same access to the HET band for higher education and training.

What ever the opinions of the HET, FET, GET or industrial sectors are, whether positive, anxious or actually hostile towards these new developments, that the SAQA/NQF processes are intended to enhance the quality of education and training and not as reported by journalists throughout the world of 'the dumbing down' of our children and young people.

SAQA has thus put the NQF into place for the following reasons:

- To simplify the structure of qualifications
- To develop learning that is relevant to industry
- To introduce a fair assessment system
- To establish a dynamic and flexible system able to adapt quickly to new developments in education, training and labour markets
- To promote access to learning
- To provide a wide variety of routes to a qualification through appropriate articulation while ensuring standards are maintained.
- To encourage more people to participate in education and training and develop a culture of life long learning

1.3 Industries role in education and training

With this background it is clear to see that a lot of training will fall on the shoulders of industry training centers. This is apart from the experiential training of engineers and technicians in training. To have sufficient capacity and facilities and to ensure the quality of learning, assessment and record keeping, the integrated industrial expert system for the ongoing education of students in engineering fields was designed and developed to specifically cater for these SAQA needs.

In the past when an engineer or technician in training attend the experiential training phase which forms part of the degree/diploma, the student received courses of a practical nature combined with theory culminating automatically in a formal qualification after a predetermined training period. There where no assessments carried out on a national level against set standards but where based on subjective evaluations by training staff and mentors in industry. This provided a qualified Technician or Engineer to industry but not necessarily a competent one.

The experiential training of engineers and technicians will change as a result of the implementation of SAQA. Specific unit standards will be written by appropriate standard generating bodies (SGB). All accredited and registered industry training providers will have to provide experiential training against these standards with official assessments undertaken by qualified assessors registered on the NLRD.

Research has shown (Fernandez et al., 2002) that the combined teaching of experimentation and theory is essential in the education of students in the industrial/engineering fields. Combined with these two legs of education and training, in the South African context, a third leg has to be implemented so that this education and training is aligned with SAQA, in order to provide learning, Recognition of

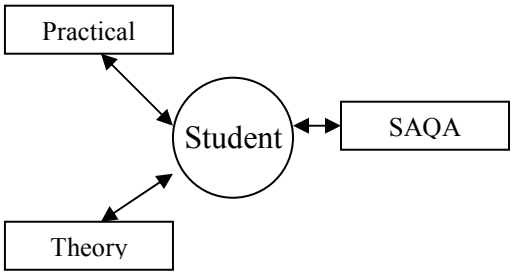


Figure 1. The three prong approach

Prior Learning (RPL) and Recognition of Current Competencies (RCC) to ensure that students are assessed, declared competent and receive qualifications according to the National Qualification Framework (NQF).

The system that has been implemented at Iscor Vanderbijlpark Steel, is graphically depicted in Figure 1. This three prong approach ensures that the theory, practical and SAQA guidelines are fully integrated under an expert software system that has been developed by using Microsoft Access.

2. Methodology

In order to ensure that the training that is provided, is aligned with the SAQA/NQF requirements, accreditation as a training provider is required from the appropriate sector education and training authority's (SETA) education and training quality assuror (ETQA).

In order to qualify for this accreditation, a very good quality assurance system needs to be in place within the company (Iscor). With this is mind a relational database was chosen (Microsoft Access) to coordinate all processes. The advantage of using a software database over a manual hardcopy archival system is obvious with respect to the flexibility, reporting, ease of use and speed of accessing the required data.

However the main reason that this technology was chosen was to implement the automatic assessments that can not be undertaken by a manual system. Even with the use of the software database, all training and assessment evidence is stored in the central archive providing dual redundancy in the case of failure of the software system.

The expert system is essentially compartmentalised into two parts; that of the data, which includes all the relevant information of the students and education and development practitioners (ETDP – Training Officers) and the other part, the randomised automatic assessments.

2.1. Data that the expert system contains

The data that is captured and stored in the database includes the following:

- Assessment/RPL/RCC results
- Moderation outcomes
- Courses completed
- Student learning styles and methods
- Archive record number
- Course evaluation feedback forms
- Unit standards achieved
- Safety talks
- Attendance registers
- Assessment and moderation tools
- ETDP's research & development/projects undertaken on a daily basis
- Courseware manuals
- Appeal procedures.
- The entire database of Iscor staff (8000 records)

2.2. Automatic assessments

The 'auto-assess' portion which is driven and captured by the database is used for four different types of assessment namely;

- Formative assessments
- Summative assessments
- RPL/RCC assessments
- Real time practical faultfinding assessments

The formative/summative and RPL/RCC assessments although very similar in nature are used at different times during the courses and qualifications. The database is loaded with thousands of questions which are related to different disciplines, courses, qualifications and unit standards.

Various assessments are set-up according to the courses, qualifications or unit standards that are to be assessed. The database will randomly generate a range of questions related to the above and the student will answer the questions on a networked computer.

After completion of the assessment and having reviewed the answers, the student terminates the assessment and the assessment is automatically marked by the database. A report of the assessment is immediately printed on the network printer and an electronic copy of the assessment is stored on the database in the snap shot format, which is a graphical picture format.

The snap shot reader is part of the Access software but needs to be installed. This format and process removes the human factor and eliminates any adjustment of marks obtained as the electronic copy is stored in this picture format and cannot be edited. The assessment report that is printed, is immediately signed by the assessor and the student, after which, it is filed in the central archive.

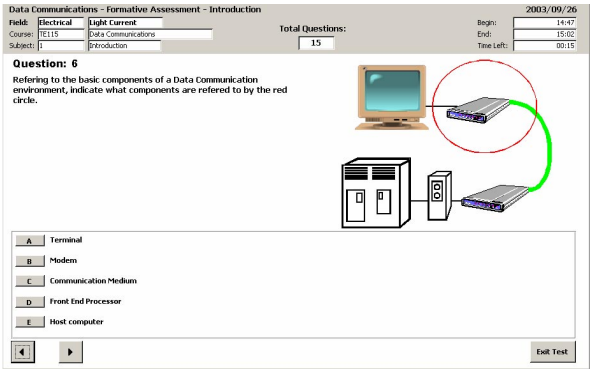


Figure 2. Randomly generated assessment

These assessments as indicated above and illustrated in figure 2, are used at different stages within the training syllabus. When a new student is registered on the system, in order not to provide training for the sake of training, the assessment is used to determine the current competencies of the student, this is done across the entire qualification or chosen engineering field and will assess all knowledge components that the specific engineering field requires the student to know (all outcomes are covered). This is a RPL process and all credits against unit standards will be issued if the student is found competent against the specific outcomes of the unit standards.

Once the training gaps or deficiencies in knowledge have been identified, the scheduler will plan a training path for the specific student in order to achieve the required qualification. This method drastically cuts down the training time that is required, which improves throughput and allows the ETDP's to concentrate on the specific learning that is required by the student in order to achieve competence in the chosen engineering discipline.

During the training courses that are provided against the specific outcomes of the unit standards, the exact same process is used except that the assessment that is chosen is a formative assessment within the scope of the learning provided for the specific course or unit standards. The outcome of the assessment will allow the ETDP to coach and mentor the student during the learning phase to ensure competencies against all the specific outcomes will be achieved.

At the end of the learning programme, in order to assess the knowledge component, once again the same assessment process will be used but this will be the summative assessment, which will be used to assess the specific outcomes of the unit standard. If competency is achieved from this assessment, the unit stand credits are automatically stored in the database. With all of the above mentioned assessments, there is no human involvement or intervention from the ETDP that can colour the results of the student.

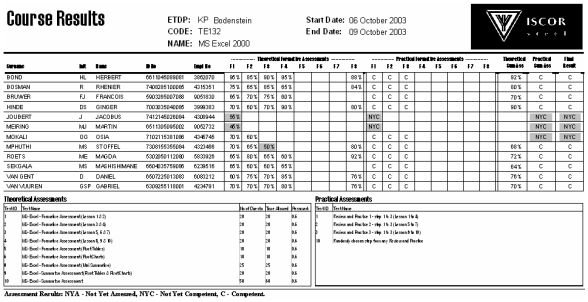


Figure 3. Assessment report per learning intervention

The practical assessment can be carried out on real time equipment at anytime during the learning programme, or qualification. As soon as the student feels confident that they are ready to be assessed they will approach the assessor and an assessment meeting will take place in order to determine what will be assessed and how it will be assessed. When the student is ready the database will randomly choose pre-programmed faults. These faults are then switched into the electrical panels for fault-finding purposes.

This automatic practical assessment has only been implemented within the electrical engineering discipline within the scope of faultfinding where it is very easy to implement.

The database randomly generates the faults that need to be placed on the various electrical panels. The fault numbers are then communicated to the various electrical panels via a multi-drop RS485 network. Presently there are 12 nodes on the network. The database transmits the data as a master and the electrical panels are all slaves. The data is addressed to the correct panel and a PIC controlled interface module obtains the correct data and switches the faults onto the panel.

Once the student is ready for the practical assessment, the assessor will start the down counter. As soon as the student has found the fault and indicated where it is, the clock is stopped and this information is transmitted to the master station, where the clock information is stored and additional assessment criteria is captured.

Once the assessments (summative and practical) have been carried out, the unit standard is automatically credited to the students profile where is will be available for reporting purposes. Figure 3. depicts the assessment report obtained from the expert system per learning intervention.

2.3 Reporting and integrity of the expert system

The integrity of the expert system is vital to the quality assurance programme and cannot be in doubt. An integrity check has thus been built into the software that performs a check on every workday per ETDP.

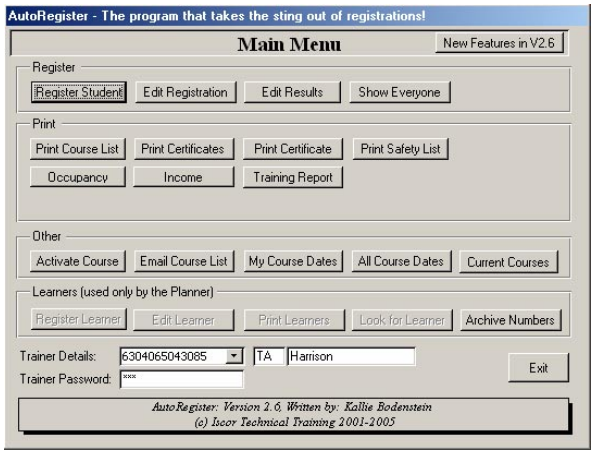


Figure 4. Main menu including the reporting

These integrity checks are based on planned actions for the ETDP per day. Whatever the ETDP is doing on a particular day, must be filled in to indicate either the number of seats that have been booked or if it is not a course that is being presented, what the activity is. There are various activities that are standard which include the following:

- Course presentation
- Research and development
- Project work
- Maintenance
- Leave
- Sick leave
- Attending of a course

The integrity test integrates with Excel and produces a calendar of the fiscal year denoting the activity that was undertaken per week day for the year. If the ETDP failed to register an activity on a particular day, it will be flagged in the spreadsheet and the activity must then be updated. If all days have been filled with an activity, then the integrity of the database is established and the data is deemed reliable.

The reporting that can be drawn from the system is unlimited and can be tailored to meet the requirements of management. A typical GUI is shown in figure 4. from which the reports may be drawn. Presently the reporting that has been implemented is as follows:

- Course lists
- Certificates of competency
- Morning safety talks
- Attendance lists
- Occupancy figures
- Financial report (income generated)
- Annual training report (SAQA requirement)
- Student evaluation forms
- Assessment results
- Student planning profile
- Assessment documentation
- Courseware
- Unit standard credits per student
- Qualification report

2.4 The national learner record database

As described above, all competencies are recorded within this expert system. In order to achieve a qualification, the student must have the required unit standard credits per qualification. Part of the registration process covers the qualification that the student is working on. The system will indicate what unit standards are outstanding and which need to be completed.

As soon as all of the unit standards have been completed, the system will provide a report which is sent to SAQA requesting the qualification to be issued to the student.
With each assessment and unit standards accredited, the information is uploaded via manual means at this time to the NLRD. The system can be further improved in the future if there can be a direct interface into the NLRD via an internet connection. This would enable seamless transfer of credits to the NLRD and would eliminate administrative errors or delays.

3. Conclusion

The integrated expert system that is outlined in this paper and depicted in figure 5, has improved the training of engineering students by ensuring that students are assessed against outcomes rather than knowledge recall. The competencies that are developed as a result of the practical and theoretical components of the unit standards have provided astounding results.

Measured over a two year period, the total call out of technical staff to maintain equipment after hours at great expense to Iscor had halved. These call outs included the artisans and the technicians that the artisans in turn called out if the artisan was not able to solve the problem.

Furthermore, the call out ratio of artisans to technicians was in the order of 70%. This was a direct result of the technology that was involved. Traditionally artisans do not receive training on advanced process control equipment.

As a direct result of this high call out ratio, the artisans where put through this programme and assessed against enterprise standards as unit standards where not available for the process control field. The outcomes of this programme reduced the artisans to technicians call out ratio to 0% measured over a three month period.

In addition, all of these courses are skills programmes and as such provide credits towards a qualification on the NQF which provides a pathway towards a qualification that was previously not available.

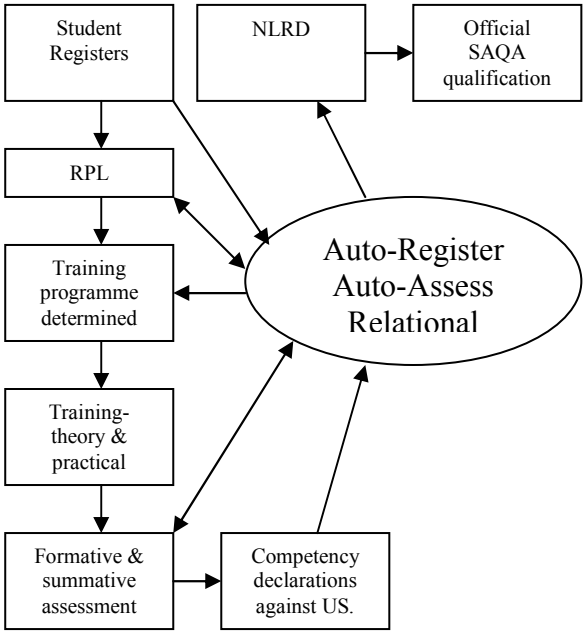


Figure 5. The integrated expert system

During the registration period, the students are also assessed to determine their learning style. This is recorded in the database and when ever they attend a course the ETDP can see what method of learning is best suited to the student.

This was found to be most valuable in providing the correct learning methods per student and speeded up the progress of students to achieve their learning outcomes.

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