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What is the 'value-add' of a Non-Destructive Testing / Evaluation Tertiary Qualification?

Ike Sikakana
Department of Non-Destructive Testing and Physics
Vaal University of Technology
Vanderbijlpark, South Africa
ike@vut.ac.za

***Abstract*—The Vaal University of Technology has been offering the National Diploma in Non-Destructive Testing (ND: NDT) to matriculants for over 20 years. In conformity with the mandated South African Universities of Technology qualification model, students that have completed the theoretical and laboratory training are required to be attached to industry for a period of time on an 'on-the-job' / in-service / experiential training component of the programme – [commonly referred to as Work Integrated Learning (WIL)]. The uptake of qualifying students by industry has had its fair share of challenges. One of the thorny issues for students offered in-service / experiential training has been the real or perceived 'non-recognition' of their tertiary education. Some industry employers consider the students to have not acquired the necessary training according to standards and specification applicable to be operational.**

The paper discusses this paradox and advances possible constructive avenues to engage with Non-Destructive Testing industry role players, so as to gain a mutually beneficial outcome. Further, an example of Non-Destructive Testing education and training in a developed country is presented. As a way forward, the need to address the 'knowledge gaps' in Non-Destructive Testing applications is advanced, especially in the context of a South Africa enjoined in a fast economically growing African continent. Lastly, it is argued that the 'knowledge gaps' are strong indicators for a Tertiary Qualification, albeit not on a mass-scale of the established level certification schemes.

Keywords — non-destructive testing; tertiary qualification; level certification; work integrated learning; education and training

1. INTRODUCTION

In the business of Non-Destructive Testing, we are all connected "professionally" and these connections should be nurtured in the interest of creating a safer world; this is according to Arnold Bereson [1]. As evidenced of this connectedness, he notes that many American Society for Non-Destructive Testing (ASNT) members, also have membership of the American Welding Society (AWS), NACE International, the American petroleum Institute (API), the American Society of Mechanical Engineers (ASME) and ASTM International. This shared membership strengthens the content and assures that scientific rigour is applied in the standards and specifications development for the evaluation of materials' integrity.

This discussion paper dissects the practice of Non-Destructive Testing education and training in South Africa with a purpose to show the connectedness of tertiary education with the level certification schemes training. Further, the paper seeks to open-up genuine discussions within the Non-Destructive Testing community for its elevation into a recognized professional career. The belief is that the Non-Destructive Testing community can initiate interaction within itself and other engineering professions so as to form an inclusive and recognized body that is accountable to society.

1.1 Certification Schemes

Non-Destructive Testing International Certification Schemes have over the past half-a-century developed and refined their training for technicians. The general entry level for training is a Grade 10, which translates to 10 years of basic education. This is especially the case for surface methods like visual testing and liquid-dye penetrant testing.

With such a low entry barrier and the certification schemes prescribed minimum of 40 contact hours for a method classroom tuition plus laboratory practice; more than 80 % of the training hours are prescribed to be hands-on / on-the-job practical experience. This practical experience must be supervised by a more experienced technician in the method [Level 2 and preferable a Level 3]. The experienced technician monitors, nurtures, guides the trainee and signs-off work completed and the hours in a logbook there-by confirming competency. After fulfilling the minimum hours of industrial experience in a method, an employer's certificate of authority to work may be granted to the trainee. Figure 1 is a typical personnel qualification and certification process flow chart [2].

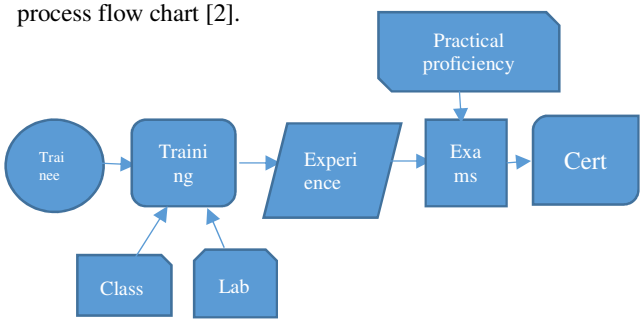

Figure 1. Qualification and certification process flowchart

This on-the-job work experience is therefore the hallmark of the Certification Schemes. The competency of the trainee technician in a particular method is thus developed through practice, albeit it can be routine / repetitive in nature. A theoretical in-depth understanding of the method is therefore not a requirement.

Nonetheless, the quality of the Non-Destructive Testing services offered in South Africa have shown a noticeable decline [3]. The question that needs to be asked is where must non-destructive inspection - as a discipline - improve? Some might speculate that these inadequacies are primarily due to minimal on-the-job workplace experiential training combined with a not well documented supervision, impacting on competency. Workplace experiential training at different industrial setting must still be standardised and thus remains a big challenge [3]. Other aspects maybe the methods of testing need to be continually revised in relation to operating conditions. This is especially true in relation to the data collected, including proper analysis so as to give reliable results. The solution, therefore, lies in the value-chain of these education and training events.

1.2 The Vaal University of Technology (VUT) Diploma

The usefulness of the diploma qualification has been challenged by some in the South African Non-Destructive Testing community. This has been narrated countless times through student industrial experiences. In the recent past (2014 – 2016), this has culminated in requests for intervention by the Department of Higher Education and Training (DHET) and the Council for Higher Education (CHE). The student complaints were initially vetted on social media discussion groups created by students - both drop-outs and those that completed the diploma. The gist of these complaints was the fact that industry required Level Certification as prescribed in the inspection codes / standard / specifications. This requirement at industry operational level, rendered the two academic years of theoretical and laboratory study as 'irrelevant' and un-ceremonially judged to be of no value by some industry stakeholders. Understandable, these sentiment are particularly strong among the service providers, and therefore students were given the impression that they had wasted their time and money by enrolling for the diploma.

Naturally, students felt betrayed, and they had to vent their frustration somewhere, and in the wisdom of some of them, where else except the government department that approved the diploma and the organisation that quality accredited it; of course all internal VUT grievances and dispute resolutions had not borne any favourable results.

The question that begs for a comprehensive response is: What measures are there within the South African Non-Destructive Testing community that assures the currency of knowledge and skills with the continued demand to make correct judgements on inspection of aging infrastructure? This is particularly true for a sizeable fleet of the power generating plants; who are past their designed production life cycle. Hence, infrastructure rehabilitation and repair must also be informed by Non-Destructive Testing.

Nonetheless, it is worth noting that well over 80 companies have offered WIL opportunities to students in various forms over the last 14 years, resulting in just over 200 diploma graduates to date.

1.3 Regional Differences

The application of Non-Destructive Testing in different regions of the world should be self-consistent, if the education and training is harmonised. This has precisely been one of the goals for the International Committee for Non-Destructive Testing (ICNDT).

Studies showing statistics on regional plant accidents attributed to non-compliance or poor implementation of Non-Destructive Testing in plant components are rare in the public domain [4].

It may be noted that a paper on differences in aviation safety records around the world has been published in May 2009 [5].

2. PILLARS OF NON-DESTRUCTIVE TESTING

Non-Destructive Testing uses diagnostic methods in the below applications pattern flow:
Inspection requirement – data collection using a procedure based on a standard – analysis of data – writing a report for the client – client to act on report.

The following embedded parameters must be accounted for during the inspection:

- Probability of detection of defects and the true or false rubric.
- Accuracy of defect detection and localization leading to final acceptance or rejection.
- Competence of personnel performing the test.
- Confidence-in and reliability of reported results.

Value-Add

Insight of defect detection in materials and their characterisation is at a milli-scale. It is therefore logical to infer that by the time the defects are observed at a milli-scale, they had been initialised at a much smaller scale (nanoscale) in the material. Thus, there is opportunity to:

- Improve on instrumentation detection capability.
- Technique improvement / innovation which contributes to validation.
- The identification of 'new' methods applications
- The use of simulation models in predicting future component behaviour.
- Focus on future industry applications, needs and possible challenges.

Most of these opportunities are encompassed and can be unraveled through fundamental and applied research. For example, knowledge of the materials composition, its response to different stresses and strains that may cause fatigue and ultimately fracture is critical.

3. KNOWLEDGE AND SKILLS DEVELOPMENT

Knowledge and skills development is a reality in today's world. Within a Non-Destructive Testing context addressing knowledge and skills must be a priority through scenario planning and project the future. The understanding of the current country needs and keeping abreast with developments requires a knowledge base. To address what needs to be there in the future using the present knowledge will undoubtedly have a lag in the skills trajectory.

The implication is that new knowledge generation is needed. To transit the 'knowledge gap', investment in tertiary education, particularly research and development centres is a necessity.

Developed countries where most of the new or innovative methods have traditionally been pioneered, are now knowledge economies. Knowledge economies address how information, ideas and innovation are created, used, circulated and adapted. South Africa as a developing country must strive to produce and circulate new knowledge. A first step in the creation of new knowledge is to understand the desires and demands of the Non-Destructive Testing end-users. Development of new skills will then be in sync with new technologies.

Critical capacities is a must to create, apply and share new knowledge on a continuous basis. This will be possible if opportunities are provided for lifelong education and training. Pseudo barriers to Non-Destructive Testing learning and communicating must be broken down. All problems and challenges that are there, must be in fact turned into opportunities for learning; more than occasions for blame and contestation.

The knowledge economy is a learning society with a differentiated education and training system.

A low entry barrier into Non-Destructive Testing will continually emphasize skill in operation of equipment and interpretation of results thereof, above knowledge acquisition.

The basis of competence is knowledge, acquired through formal and informal education. Competence can be sketched as an intersection of knowledge, the inept desire to work (translated to ability) and workplace experience [6]. It is schematically shown in figure 2, below.

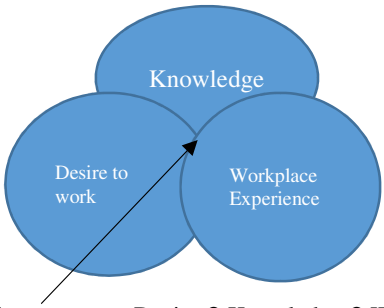

Figure 2: Competence = Desire ∩ Knowledge ∩ Workplace Experience

VUT as a public institution of higher learning, welcomes initiatives to work with private industry in pursuance of new knowledge through research and development in Non-Destructive Testing focus areas that will be relevant and at the cutting edge.

In Germany the cooperation of universities, research centres and the German Society for Non-Destructive Testing (DGZfP e.V.), is exemplary [7]. This includes the University of Applied Sciences, Fraunhofer Institute for Non-Destructive Testing IZFP and Fraunhofer Center X-ray Technology EZRT, bodes well for sustaining the Non-Destructive Testing enterprise.

4. OUTCOMES OF A TERTIARY QUALIFICATION

Bridging the knowledge gaps in Non-Destructive Testing applications, is a must. An example is that the current inspection procedures may not 'pick-up' all the relevant defects – even if applied by an experienced and competent technician. How do we mitigate against such probable scenarios?

This is where the role of a tertiary education is important. Not only should interpretation of the data be incisive, but also this should be accompanied by a thorough knowledge of the materials and equipment capabilities. An improved analysis will thus be possible; hence a reliable and informative report on component integrity.

An academic qualification in Non-Destructive Testing is a basis for knowledge that underpins the Non-Destructive Testing as applied in industry. The South African / African environments are somewhat different and unique in their own right from European and American climates and operational conditions, and there lies opportunities for innovations and / or customisation. Some of the benefits in the safe operation of plant equipment will be:

- ✓ Scientifically proven cost-cutting measures in the long term. For example, the critical crack size may be stated as x in a code / standard / specification, while this may be adjusted to x+1 or x-1 in current operating condition.
- ✓ Corrosion cracking differences are well documented in equipment located along the coastal wet and humid areas as compared to dry inland areas.

The widely held and promoted reasoning that the diploma qualified students are future level 3 technicians, is also a very narrow perspective and fails to appreciate other roles possible and most probable, not yet defined within industry.

These can only be realised if industry embraces a tertiary qualification and indeed further higher education in Non-Destructive Testing. Together with industry a dialogue must emerge that will define these roles.

There is therefore a need for a 'pool' of researcher in Non-Destructive Testing. This will increase the knowledge of how best to conduct inspections of structures operating in Africa as opposed to Europe and Americas.

The 'knowledge gap' for current technicians is therefore a primary concern that a tertiary qualification must address.

In the long-run, safe operation of our industrial plants with less down-time will contribute to a growing economy, which is what South Africa and the rest of Africa requires to create more employment.

5. CONCLUDING REMARKS

- A tertiary qualification should not be viewed as a replacement of Level Certification, nor must it be meant to replace Level Certification. It must be primarily to enhance the knowledge, skills and abilities of practitioners in industry.
- Industry support for the tertiary qualification must not be a 'lip-service' exercise. It has to be backed by substantive engagement so as to demystify and continuously clarify its purpose.
- Relevant research projects that can be applied in industry or better still, are generated by industry seeking solutions to existing / recurring problems must be projects for research by students in part fulfilment of their qualification requirements. There must be constant reviews and improvement of the qualification, informed by industry feedback.
- Optimisation of the tertiary institutions capacities as catalysts in overcoming what is missing or 'the gap'. This will fast-track understanding of the current state of affairs and the envisaged state of affairs in the future (what is happening and what needs to happen).
- Engagements in accreditation and harmonization of Non-Destructive Testing education and training, should not be a contestation, but rather a healthy debate in pursuance of its advancement.
- It is now a fact that the VUT diploma has highlighted the need for transformation in the South African Non-Destructive Testing community. The increased access into Non-Destructive Testing by Blacks in the past 10 years is testimony of its awareness impact. These developments must be embraced and encouraged as inevitable, for an inclusive economy.

ACKNOWLEDGMENT

I would like to thank staff and students, past and present, who constantly engage me in impromptu discussions – in the corridors of VUT - on the state of Non-Destructive Testing in South Africa. I dare say, Non-Destructive Testing is our chosen / accidental career; therefore let's positively contribute to its advancement and growth for the benefit of our country, continent and the world.

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