SKILLS DEVELOPMENT FOR GREEN ECONOMY

TN: 81226408; PN: 2016.2215.8
South Africa

REPORT

Topic: **VR AND MIXED REALITY ASSESSMENT FOR PLUMBERS**

Venues(s): **Gauteng Province, Eastern Cape Province**

Date(s): **October 2020; May 2021**

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This report was prepared by independent, external experts and reflects their opinions and evaluations.

For:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
Skills Development for a Green Economy II Programme

Contents

List of abbreviations and acronyms

4IR	Fourth Industrial Revolution
aLMP	Active labour policy programmes
CSI	Corporate social investment
DHET	Department of Higher Education and Training
DSPP	Dual system pilot project
EEC TVET	Ekurhuleni East Technical and vocational education training centre
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
ICT	Information and communication technology
iDPP	Integrated development partnership with the private sector
IOPSA	Institute of Plumbing South Africa
M&E	Monitoring and evaluation
NDP	National Development Plan of South Africa
NPO	Non-profit Organisation
PE TVET	Port Elizabeth Technical and vocational education training centre
SD4GE II	Skills Development for a Green Economy II
TVET	Technical and vocational education training
QLFS	Quarterly Labour Force Survey
VR	virtual reality

0 EXECUTIVE SUMMARY

0.1 Programme's rationale and objective

The National Development Plan of South Africa (NDP) calls for the annual entry of 30 000 qualified artisans into the industry.

The plumbing sector and its ability to create lower skilled jobs is important in South Africa, given that the Quarterly Labour Force Survey (QLFS) by Statistics South Africa of Quarter 1 in 2021 states that the official unemployment rate among youth (15-34 years) was 46,3%. Youth unemployment in South Africa is a national crises.

The development and support for technical and vocational education and training (TVET) sector includes preparing new artisans for the 4IR working world, through the exposure of apprentices to digital and technically advanced learning, assessments and workplace environments.

0.2 Brief description of the objectives of the intervention

The objectives of this assignment included:

a. Exposure to learning digitally within VR and mixed reality environments
b. Assesssing the digital skills of participants
c. Digitising technical content and curricula and
d. Introducing new digital/4IR assessment tools.

Expected outcomes included:

- Improved technical ability that is applied within a digital environment;
- The development of an alternative assessment tool to the current trade test, which will test the ability of the apprentices on a wider range of skills sets, including their digital skills;
- Improved soft skills so that theoretical knowledge can be applied to a fast paced and dynamic work environment incl planning, time management, tenacity and endurance, teamwork and overall self-development.

0.3 Reference to the Terms of Reference

The VR and mixed reality assessment tool is interactive, dynamic and it draws on the skills required of the artisan who operates in the 4th industrial revolution.

The gap analyses that followed the VR assessment allowed for the creation of individual skills development and training plans for each of the participants. A 100% pass rate was achieved for the participants of this pilot project.

0.4 Main observations

The participants were initially unsure about the VR and mixed reality software as they were not previously exposed to AutoCad or any kind of technical software programmes. The lecturers were also unsure about VR and mixed reality technologies, even though they are familiar with computers.

Once the VR and mixed reality technologies orientation were completed, both the participants and the lecturers enjoyed the detail and the functionalities of the technologies because the participants had to interact with the 3D virtual drawings, virtual scenarios, and real-life client orders. The skills gaps identified through the VR assessment formed the basis for the subsequent project-based training.

0.5 Key recommendations, lessons learned, next steps

Standardised mentorship programmes
The mentorship programme should have compulsory areas of work exposure so that all apprentices are exposed to various aspects of their trades, in a standardised and routine manner.

Informal skills exchange between employers within an industry association
Decentralized induction and trade-related workshops should be facilitated by employers and product manufacturers/ traders at colleges, with such workshops wholly financed by the DHET. This will promote a close working relationship and institutionalising of the dual system.

TVET pedagogy and didactics lessons sharing among inter-college lecturers
Regular lesson observations and best practices by lecturers should be shared through national inter-college workshops. This will guarantee that the new approach is understood and implemented, and it might prevent lecturers from falling back into the old patterns of old teacher-oriented learning.

More exposure to technology based technical training and assessment
The students were able to operate the VR technology, immediately after the orientation session. This demonstrates that the technology is user-friendly. The students were also excited to use the new technology and the conditions to implement VR technology is therefore conducive for increased technical learning, teaching and assessment with VR technology and VR should be used to give South African artisans an edge over competitors.

1 INTRODUCTION

1.1 Detailed analysis of the project's background

The primary focus National Development Plan (NDP) of South is to eliminate income poverty and inequality, as well as to increase employment.

The NDP accordingly calls for the annual entry of 30 000 qualified artisans into the industry. The plumbing industry is however characterised by far more informal activity than formal, with the number of formal enterprises declining every year and the number of informal operators increasing.

It is estimated that there are more than 125 000 self-identified plumbers in South Africa. In this dataset that is produced by Statistics South Africa, 10 359 employed one or more people and 12 860 are own-account workers.

An analysis by race of the owners shows that there are increasing numbers of formal black, Indian and coloured plumbers. Most plumbing business, whether formal or informal, are dominated by men. Female business owners are most likely to be operating in the informal sector.

The plumbing sector and its ability to create lower skilled jobs is important in South Africa, given that Quarterly Labour Force Survey (QLFS) by Statistics South Africa of Quarter 1 in 2021 states that the official unemployment rate among youth (15-34 years) was 46,3%. Youth unemployment in South Africa is a national crises.

Image 1: Apprentice completing the virtual trade test

The Department of Higher Education and Training (DHET) has since identified that the current artisan supply system is ineffective and that it does not produce the required results. A decision was therefore taken to pilot a dual apprenticeship system in South Africa with selected public TVET Colleges and participating employers in an attempt to improve on the prevailing system. This pilot commenced in 2013 and the Skills for a Green Economy programme (SD4GE II) that is facilitated by the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), is one of the initiatives that contributes to the overarching aims of skills development in South Africa, through its support for the dual apprenticeship system.

The development and support for technical and vocational education and training (TVET) sector includes preparing new artisans for the 4IR working world, through the exposure of apprentices to digital and technically advanced learning, assessments and workplace environments.

This project is accordingly an initiative by the GIZ in partnership with the Institute of Plumbing South Africa (IOPSA) and the DHET. It seeks to assess the level of the exposure, readiness and capabilities of plumbing apprentices at selected TVET colleges to participate in a digitized working environment as outlined in the National Development Plan of South Africa.

1.2 Problem Statement

The throughput and pass rates at TVET colleges have been very poor for the past few years and currently stands at just over 50% during the period 2011-2018. In addition to this, it should be noted that 4IR technologies are presented as having the potential to propel digitally-ready countries into a new age of unprecedented economic prosperity, 4IR skills are becoming a critical skill in the workplace.

The challenge for South Africa is therefore to increase the entry, throughput and pass rates at TVET Colleges and simultaneously prepare new entrants to the labour market as digitally able. The desired output from TVET Colleges are best described by the DHET's aspiration for Artisans of the 21st century (A21s).

1.3 Composition of the expert's team incl. professional background

Harald Fleischmann

Has more than 20 years' work experience in technical- and technological engineering and vocational training projects. Has more than 10 years' experience in the development of nationwide examination papers for an international education institute. Develops project based practical TVET training for all levels as well as experience in assessment materials development for the South African TVET environment. Is familiar with the CBET system used in TVET in South Africa since 2016. Involved in training of TVET trainers and instructors in South Africa, competency development in elaboration of Learning Support Materials in various trades.

Quilder Non-profit Organisation (NPO)

This project was supported by Quilder NPO. Quilder is made up by young, qualified make and female artisans who participated in the dual system pilot project (DSPP) of the GIZ. These young people are mostly from the rural areas and have since upskilled themselves in digital technologies. They generate an income for themselves by doing actual artisan work in different trades, as well as produce digital learning material that can be used by TVET Colleges.

In this project, Quilder supported the main expert with the actal implementation at the college facilities. They prepared the logistical arrangements for the assessments, testing the functionalities of the digital technologies and guided the participants in the use of virtual technologies and mixed reality technologies. As it was the first time that the participants were exposed to virtual reality and mixed reality technologies, they needed to take instruction on how to orientate for a digital assessment. The assessment participants could easily identify with the young facilitators from Quilder and were able to draw inspiration from them.

1.4 Brief description of methods and approach

a. Approach

In their 2020 report entitled, *"Trends in New Qualifications and Competencies in TVET: Perspectives of the European UNEVOC Network,* The International Centre for Technical and Vocational Education and Training (UNEVOC) found seismic shifts in the European Technical and Vocational Education and Training (TVET) sector. These trends are summarised as "Digital Literacy and the Whole Human Being (Development), Learner-Centred Competence-Based and Project-based Local-Specific Informal Training„.

The approach taken with the virtual reality and mixed assessments were a combination of digital literacy and the whole human being development as well as project-based local-specific training.

The competencies assessed and included for training, can be summarised as follows:

Basic competencies	**Professional, technical, and specialised knowledge and competencies**
▪ Literacy ▪ Numeracy ▪ Digital literacy ▪ Literacies at the level that can adapt to job and societal changes	▪ Technical requirements of the specific occupation ▪ Entrepreneurial competencies
Advanced cognitive competencies	**Social and emotional competencies**
▪ Critical thinking ▪ Complex problem-solving ▪ Creativity ▪ Openness to learning ▪ Self-discipline	▪ Conscientiousness ▪ Time management ▪ Collaboration ▪ Responsibility ▪ Self-efficacy

Table 1: Competencies assessed with the virtual trade test

It is the integration of these four sets of competencies that will create the desired workers (A21s), who can confidently respond to, anticipate and prepare for rapid innovation cycles within their occupations, and in society.

It should be noted that the VR assessment took place during the first phase of this project. The assessment was completed to assess the skills still needed by the apprentices in order to pass their trade tests. This was then followed with the skills development training as the second phase. The skills development training included both technical aspects for the plumbing proficiency, as well as soft skills such as time management, coping with stress, collaboration and more.

b. Assessment tools and instruments

The content for the assessment tools as well as for the subsequent training were developed from reading the global environment and compared this with the local needs.

In line with UNEVOC's recommendation, the VR assessment and training programme identified a set of integrated competencies that included learning, technical, literacy, life, contextual and entrepreneurial competencies. These competencies contribute to the creativity, emotional intelligence, critical thinking, leadership and information literacy of each participant.

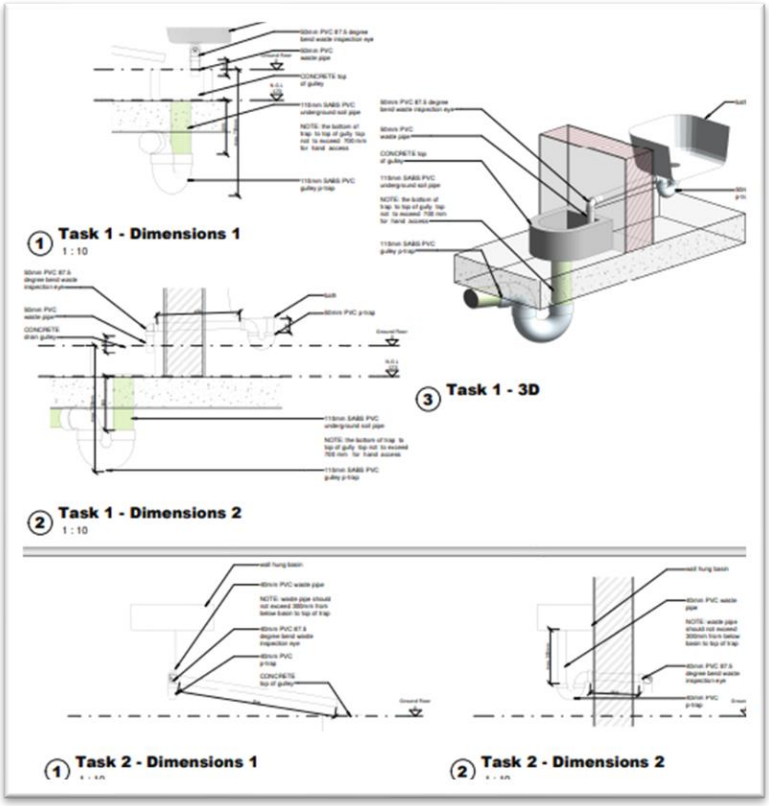
Project-based assessment and teaching are central to the development of new competencies. Project-based assessment and teaching offer real-world problems and expects participants to solve these through enquiry-based techniques.

The participants were exposed to virtual reality and mixed reality construction sites during the **Phase 1** Assessments. Participants had the opportunity to experience a virtual reality (VR) construction site as well as simulations with the aid of a digitized 3-D virtual construction site. The VR house offers a virtual world environment where problems and tasks have to be solved.

In addition to solving interdisciplinary professional and work-related problems, the virtual house forces participants to interact inside of, and with other participants on a digital interface. Common topics, such as hot water preparation, earthing of metal piping and rainwater harvesting, now had to be performed digitally and within this virtual environment.

Phase 2 of the project then identified the areas of development and the training was subsequently focussed on those needs. Apprentices struggled to complete their tasks during the VR assessment. They did not plan their time in relation to their tasks and would spend too much time on the initial tasks. This left very little time for all the tasks. As a result, the apprentices would become stressed, apply poor workmanship and would have little regard for issues such as workplace safety and tidiness.

The training therefore used a project-based approach, whereby the demands from the client for an efficient yet speedy plumbing solution had to be managed in relation to the cost-effectiveness of the job, workplace health and safety demands as well as the overall technical compliance and workmanship needed.



Drawings 1: Flat drawings provided during the follow-up training

The training provided refresher information on taking client instructions and listening, body language, planning, working in a team, coordinating material and other resources such as the allocation of people to different assignments, time management, exposure the concurrent demands and concurrent assignments, client and customer orientation; in addition to the technical competencies.

2 OBJECTIVES

The objectives of this assignment included:

Phase 1

- Exposure to learning digitally within VR and mixed reality environments
- Assesssing the digital skills of participants
- Digitising technical content and curricula and
- Introducing new digital/4IR assessment tools

Phase 2

- Assessing the skills needed to successfully complete a trade test
- Provision of refresher and gap training to successfully complete a trade test.

Expected outcomes

- Improved technical ability that is applied within a digital environment;

- The development of an alternative assessment tool to the current trade test, which will test the ability of the apprentices on a wider range of skills sets, including their digital skills;

- Improved technical and soft skills so that theoretical knowledge can be applied to a fast paced and dynamic work environment incl planning, time management, tenacity and endurance, teamwork and overall self-development.

3 IMPLEMENTATION AND ROLL-OUT

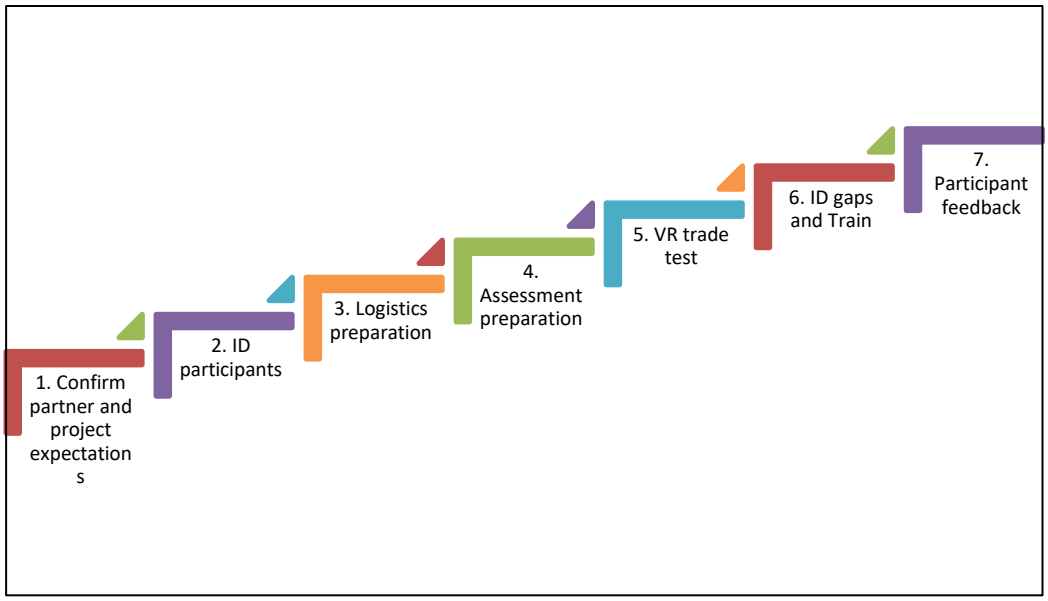


Diagram 1: Project Processes

3.1 Process: Partner and project expectations

The transition from analogue teaching practices to digital teaching practices is changing what teaching and assessment looks like. Increasingly the focus will be on creating the conditions for exploring, fact finding and the application of information, rather than providing ready-made knowledge. This approach towards assessment and teaching had to be confirmed with the project partners.

The technical content and the application thereof in the VR and mixed technology environments, also had to be confirmed by IOPSA.

3.2 Process: Identification of students for assessments and training

IOPSA selected the TVET Colleges for implementation. A conscious decision was taken to include project sites outside of Gauteng in order to achieve a more representative sample of the TVET College population and environment in South Africa. The lack of digital equipment, computers and access to data networks were reviewed in deciding the final sites for the pilot. A limited number of participants were ultimately included given the need to create suitable environments for the roll-out of the digital technologies.

3.3 Process: Logistics preparation

Conducive environments for the interaction with digital technologies had to be created. This included the need to ensure the availability of computers, VR headsets and controllers. It also included created a local data network so that the participants could access the internet for fact-finding during the training component. The data network was not required during the assessment phase.

3.4 Process: Assessment preparation

It was decided to kick-off the pilot with the VR assessments and then follow this up with supplementary training. In this way, an assessment could be made of the ability of the participants to interact with VR and mixed technologies, in a project-based learning and assessment environment.

The content for the digital assessment and training had to be re-created from the traditional analogue medium, to be compatible to VR and mixed reality environments. The technical and curriculum content also had to be updated in order to assess and develop the additional and new competencies, that were listed previously. The VR and mixed reality content was continuously reviewed by IOPSA for relevance and technical accuracy. The VR and mixed reality material were then supplemented with analogue material so that the lecturers could have a practical example of the possibilities for alternative and integrated teaching and assessment, that is in line with the aspirations of A21.

3.5 Process: Implementation of the virtual reality and mixed reality assessment tools

The VR and mixed-reality assessment and training programme focused largely on improving technical skills and soft skills.

The assessment of technical competencies included:

- Health & Safety regulations
- Install, maintain, and test above-ground soil waste, vent systems and sanitaryware appliance
- Install, maintain and test a below-ground drainage system
- Install, maintain and test cold water and hot water systems
- Install, maintain and test a rainwater system.

The training and development on soft skills included:

- Application of digital skills to technical environments
- Discussions on group dynamics and personal responsibilities
- Discussions on the core principles of project management
- Discussions on thinking strategies for dealing with complex tasks
- Discussions on coping with uncertainty
- Discussions on creativity and creative problem solving
- Time management

- *Process activities included*:

    - Group discussions
    - Group tasks
    - Individual tasks
    - Individual presentations

Image 2: The VR component is combined with the physical tasks

3.6 Process: Conducting training on gaps identified

The implementation of the VR and mixed reality assessments allowed for the customising of a training program that meets the local demands of employers and the needs of students/ apprentices.

A project-based approach to the training was implemented. By its naturre, this is a learner-centred approach as student needs are constantly evaluated and the content is action-orientated. Students are encouraged to apply their skills and knowledge to solve problems and face challenges. The informal nature of project-based training offers the benefit of continuous and flexible learning.

Using this approach competencies of the holistic human are being developed and TVET training is able to respond to the fast pace changes and the proliferation of new technologies of the training.

The training was also included the individual learning pathways (ILPs) approach by recognising prior learning and the unique needs and motivation of each participant. IPLs also identify missing technical skills and ensure personal autonomy.

3.7 Process: Participant feedback

Inter-personal interviews were scheduled at regular intervals with the participants to complete the gap analyses. It was also done to assess the transition from analogue to digital assessment and training. The last evaluation was formal in the form of a questionnaire and independent assessors evaluated group participation and technical skills development.

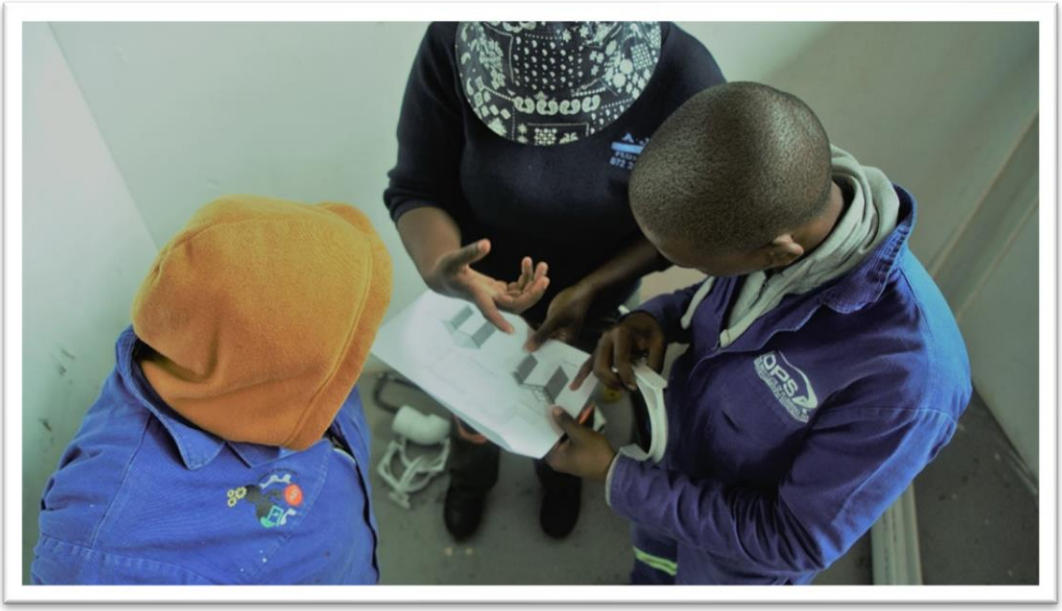


Image 3: Planning and teamwork during the training component

Some of the qualitative feedback from the participants include:

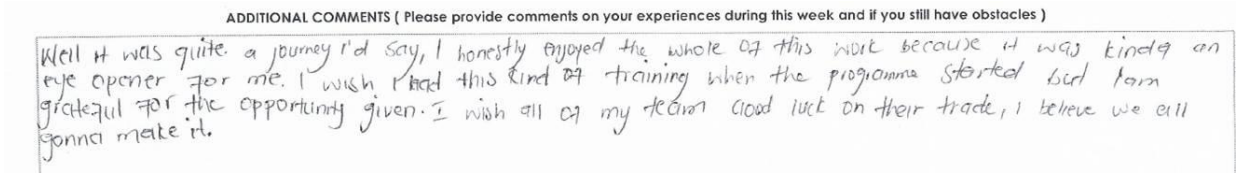
- **Calvin Mostert (PE TVET)**
  - “Firstly, a big thanks to the lecturers training us and going over and above while doing theory and practical. This was helpful in preparing us, for trade test days. Thank you!”

- **Nomfundiso (PE TVET)**
  - “The overall experience was very helpful in boosting my skills, time and stress management. I am happy with the preparation we received”.

- **Phinda Nyokwana (PE TVET)**
  - “It was a good learning experience; I learnt a lot and I will improve more on my obstacles”.

- **Liyabona (PE TVET)**
  - “The experience was exciting and worth it, I got to see my weaknesses and strengths. The training team was friendly which made everything easier and fun to, without any stress or fear. I learnt new things as well.

- **Nelisiwe Mpatlanyane (EEC TVET)**
  - “Well, it was quiet a journey I would say, I honestly enjoyed the whole of this work because it was an eye opener for me. I wish I had this kind of training when the programme started, but I am grateful for the opportunity given. I wish all my team good luck on their trade; I believe we all going to make it”.


ADDITIONAL COMMENTS (Please provide comments on your experiences during this week and if you still have obstacles)

Well it was quiite a journey I'd say, I honestly enjoyed the whole of this work because it was kinda an eye opener for me. I wish I had this kind of training when the programme started but I am grateful for the opportunity given. I wish all of my team good luck on their trade, I believe we all gonna make it.

- **Sharon Phaahla (EEC TVET)**
  - “The training was helpful; it was just that we could not do some tasks due to lack of facilities and some materials”.

- **Mpho Mphela (EEC TVET)**
  - “This training helped me to improve and manage my time well. Thank you! As soon as you have qualified plumbers please add them on board, otherwise I learned a lot through out the presentations and practicals”.

Apprentices found the VR and mixed reality assessment and training process stimulating and exciting. The contextualised nature of the training process and the interaction with fellow apprentices enriched the learning process.

The assessment tasks shifted from a one-dimensional replication of unrelated tasks to a complete, multi-faceted and real-world situation wherein knowledge and skills had to be applied. In many instances, the apprentices understood for the first time how specific facets of previously learning material fitted in, as they now knew the context and the environment within which to apply their technical knowledge.

Considering the immersion of the apprentices into the process, a wider range of competencies of each apprentice could be assessed. Some interesting observations resulted. For example, some of the top scorers (as identified by their colleges) in the traditional trade test performed at an average level, at most, when functioning in this “real world” project-based context where learning had to be applied instead of merely regurgitated. The opposite was also true in many cases.

Apprentices had found the process to have been a good learning experience. Overall comments included:

- Learning the importance of detailed planning
- Learning the importance of doing things right, at the first attempt
- Learning the importance of time management
- Learning the importance of teamwork

All the participants passed their trade tests at the conclusion of the project.

4 FINDINGS AND RESULTS

The initial observations shows that the apprentices are struggling with time management.

The following tasks were performed by the apprentices, in which they could not finish on time:

- Installation of a Geyser (outside, horizontal)
- Installation of a Geyser (outside, vertical)
- Waste pipe installation to the Gully
- Waste pipe installation to the Drain

The participants were unsure about the the VR and mixed reality software as they were not previously exposed to AutoCad or any kind of technical software programmes. The lecturers were also unsure about VR and mixed reality technologies, even though they are familiar with computers.

Once the VR and mixed reality technologies orientation were completed, both the participants and the lecturers enjoyed the detail and the functionalities of the technologies because the participants had to interact with the 3D virtual drawings, virtual scenarios, and real-life client orders.

Image 4: An informal group photo during the lunch break with selected participants at PE TVET

5 RECOMMENDATIONS

Standardised mentorship programmes
The mentorship programme should have compulsory areas of work exposure so that all apprentices are exposed to various aspects of their trades, in a standardised and routine manner. Adherence to industry guidelines will ensure best practices in the workplace and prevent apprentices from only being exposed to predictable, narrowly specified, simple and routine tasks.

Informal skills exchange between employers within an industry association
Decentralized induction and trade-related workshops should be facilitated by employers and product manufacturers/ traders at colleges, with such workshops wholly financed by the DHET. This will promote a close working relationship and institutionalising of the dual system.

Product manufacturers can also provide product demonstrations and information dissemination that could also improve technical ability and equipment handling.

TVET pedagogy and didactics lessons sharing among inter-college lecturers
Regular lesson observations and best practices by lecturers should be shared through national inter-college workshops. This will guarantee that the new approach is understood and implemented, and it might prevent lecturers from falling back into the old patterns of old teacher-oriented learning.

More exposure to technology based technical training and assessment
The students were able to operate the VR technology, immediately after the orientation session. This demonstrates that the technology is user-friendly. The students were also excited to use the new technology and the conditions to implement VR technology is therefore conducive for increased technical learning, teaching and assessment with VR technology and VR should be used to give South African artisans an edge over competitors.

APPENDIX

5.1 Terms of Reference
5.2 Assessment workbook
5.3 Virtual reality assessment tools in printed format
5.4 Photo gallery