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Immersive Learning Research Network

Work-in-Progress—How Virtual Reality Can Support Registered Training Organizations to Design / Conduct Effective Assessments in Accordance with the Principles of Assessment

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Abstract. Registered Training Organizations (RTOs) in Australia are the training providers which deliver nationally recognized training in Australian Vocational Education and Training (VET) systems. RTOs encounter challenges, with quality assurance and compliance being significant. According to Australian Skills Quality Authority (ASQA) which is the national regulator for Australia's VET sector, it is crucial for RTOs to align assessment practices with regulatory standards, as failure to do so may lead to penalties or loss of accreditation, as stated in ASQA Standards for RTOs 2015, emphasizing the implementation of an assessment system in accordance with Principles of Assessment (PoA) that set out guidelines of assessment tools used in all assessment activities. This work-in-progress paper aimed to discuss the capabilities of Virtual Reality (VR) technology in the design and implementation of vocational education assessments, ensuring adherence to the defined principles. The authors begin by exploring how each PoA can be improved with VR, offering examples of designing and conducting VR-enhanced assessments for a specific Unit of Competency (UoC) which specifies the standards of performance required in the workplace. The article concludes by summarizing the advantages of VR across each PoA and suggesting avenues for future research on the implementation of VR technology in vocational assessments.

Keywords: Principle of Assessment (PoA), Registered Training Organizations (RTOs), Virtual Reality (VR), Unit of Competency (UoC).

1 Introduction

The quality of assessment has been at the forefront of Vocational Education and Training (VET) policy debates for governments, commentators and industry stake-holders [1]. Registered Training Organizations (RTOs) are currently encountering various challenges related to these principles in their assessment practices [2]. RTOs need to design assessments that align with the learning outcomes and skills they are meant to assess [3, 4]. These learning objectives and competencies represent the knowledge and skills necessary for performing a job in accordance with industry standards, referred to as a Unit of Competency (UoC). Yet designing and developing fair and unbiased assessments can be difficult for RTOs as factors such as cultural diversity, disabilities and language barriers need to be considered to ensure that assessments are accessible to all learners.

This paper will discuss the potential effects of VR technologies in designing and conducting the VET assessments relating to the four Principles of Assessment (PoA) accordingly, answering the research question "How can VR technology be used to address the four principles of assessment in VET?". For each of the four PoA, it will outline the value VR can provide, using assessment design for UoC-*RIICTC304E (Muck out tunnel earthworks)* as a case study. The final section will then provide a synthesis of these ideas, together with further examples of how VR can be used in practice. This paper provides a novel contribution of VR technologies in quality assurance of VET assessment tools while no other works have done this mapping and through this paper, we look to map a way that VET educators may use VR in their practice, enhancing approaches to vocational education.

2 Background

Vocational Qualifications (by which we mean the study in VET) are very popular in Australia as an approach to offer people the opportunity to learn specific and practical job skills [5]. Attwell et al [6] stated one of the greatest implications for VET lies in the changing tasks and roles within jobs, requiring changes in initial and continuing training, for those in work as well as those seeking employment. The VET sector is central to skilling and upskilling workforce that addresses workforce challenges and skills shortages and ensuring sustainability and quality of the economy. It's essential for VET to integrate advanced technologies in training and assessment to prepare the workforce for the digital future [7].

The Australian Skills Quality Authority (ASQA) Standards for RTOs 2015 outlines Principles of Assessment (PoA) including Fairness, Flexibility, Validity, and Reliability. Fairness considers learners' needs; Flexibility adapts methods to suit learners, including Recognition of Prior Learning (RPL); Validity ensures assessments measure required knowledge and skills from the entire Unit of Competency (UoC); and Reliability requires consistent judgements among assessors. The national registry for VET, Training.gov.au serves as the official guide for RTOs in developing and implementing assessment tools based on these principles.

Meanwhile, Milgram and Kishino [8] had introduced Extended Reality (XR) as a concept, encompasses immersive learning environments and technologies, including six types: Non-immersive VR, Immersive VR, Game-based VR, BIM-enabled VR, Augmented Reality (AR), and Mixed Reality (MR) [9]. VR produces realistic 3D environments using electronic technology for immersive experiences [10]. AR overlays virtual information in physical contexts using sensory technologies like graphics and sounds. MR combines aspects of both AR and VR [9].

This paper will focus on VR due to its wide adoption in the kinds of domains of VET [11, 12]. Lee and Shvetsova [13] described VR as a simulated reality that learners experience objects through sensory perceptions. Therefore, VR provides the vocational learners with a special and important learning and practical experience as the essence of vocational education is to be 'hands on' and to cater for diverse learning groups.

Hence our proposition that VR technologies can play a significant role in enhancing and validating the learning outcomes from aspects of validity, reliability, fairness, and flexibility of the VET assessments from different aspects [10, 12-14]. Although no previous studies have been conducted on this topic and the literature on formal assessment and validation of VR and AR and multimodal systems is still sparse, numerous research has approved that VR technology provides more effective training than traditional methods and promises better performance results of learners, which have shown some encouraging trends of VR-based assessments [15].

3 Methodology

To address our research question, we conducted a sampling review of the literature to identify components that demonstrated VR work in line with the PoA. This review used Google Scholar, ProQuest and NCVER (National Center for Vocational Education Research) Research & Statistics database as our main data sources. This research used “Virtual Reality” or “VR” and “vocational training” or “assessment for competency” or “formative and summative assessment” as keywords and searched for VR studies in VET. We identified 105 papers across these three databases in our initial search. Most articles were journals and conference papers. By reading titles and abstracts, 50 papers were selected for bibliometric analysis. After excluding non-vocational, non-VR, non-competency-based training, we analyzed validation criteria for each PoA and mapped VR features to these criteria, discussing VR's potential in meeting each criterion.

The UoC-*RIICTC304E (Muck out tunnel earthworks)* is the selected sample for mapping. It covers skills for tunnel earthworks in civil construction, including scaling down loose equipment, manual spoil removal, and machine loading. This unit applies to operational roles in civil construction [16].

4 VR with Respect to Principles of Assessment

Whilst there are various components of learning that could be considered in this space, this paper is focusing on VR in assessment rather than training to discuss the benefits of VR technology in the assessment tasks to enable clear judgments on how well learning outcome can be attained [17]. Additionally, in line with the Milgram and Kishino definition, the discussion will be about all types of VR including non-immersive VR and immersive VR.

4.1 VR for Fairness

Fairness in assessment requires clear instructions, inclusivity, and reasonable adjustments to meet learners' needs without compromising workplace skills and knowledge [18]. Some UoCs demand resources that some groups of learners may lack, leading to unfairness. Clayton [3] highlighted the need for alternative assessments that maintain curriculum standards and assessment requirement of UoCs from training.gov.au or the industry competency standards, which raised a request for RTOs and trainers.

VR based assessment can provide RTOs and trainers alternative methods when designing assessment, which offer standardized access to resources, tools, and equipment, regardless of the candidate's physical location or the availability of physical resources. VR technologies can be designed with accessibility features, such as voice commands or visual cues, which can support learners with disabilities and ensure a more equitable assessment experience. In addition, all learners can benefit from the immersive and interactive instructions for an assessment that suit their preferences. VR assessments also can provide immediate feedback in a nonintrusive manner, to allow learners to adjust their approach in real time [12, 19].

For example, in the context of designing assessment for UoC-*RIICTC304E (Muck out tunnel earthwork),* one of assessment requirements is that "the candidates must demonstrate knowledge of: principles and techniques required to muck out tunnel earthworks, including those relating to: 1) soil and rock type characteristics; 2) construction principles; 3) mucking machines and 4) dust controls; 5) muck removal, including by both machine and hand spoil haulage systems, including rail and road conveyor" [16]. Rather than setting up the various assessment circumstances, the utilization of VR simplifies the assessment design, allowing assessors to simulate all requirements with different formats in one virtual circumstance and enabling learners to switch from one format to another.

4.2 VR for Flexibility

Regarding assessment flexibility, RTOs should allow learners to negotiate certain aspects like timing, project focus, and location. Additionally, learners can be assessed through Recognition of Prior Learning (RPL), which evaluates competencies acquired through previous formal, non-formal, and informal learning against training package or VET course requirements.

The NCVER report for 2010-11 shows a low percentage of VET learners granted RPL in selected training packages [1]. There are numerous reasons that some employers are unwilling to employ staff who had gained a qualification based purely on RPL as the people needed to gain an understanding of current practices rather than superseded knowledge [1]. Some RTOs do not have systematic RPL kit to offer RPL options to the candidates. Some candidates fail RPL due to the subjectivity of the assessors' interpretation on their previous experience [3].

VR can support RTOs and employers on this aspect of assessment. VR simulation can be used to assess learners with prior experience who are seeking RPL by replicate current real-world scenarios to allow the candidate to demonstrate their acquired skills in environments that closely resemble the actual workplace nowadays and provide immediate standardized feedback to candidates based on their actions without impact of assessor subjectivity. Furthermore, VR assessment can be updated and adapted to reflect changes in current industry standards and practices quicker than the traditional paper-based assessment kit, because virtual reality tutorials are designed modularly, modifications are easily made as workplace situations change [14]. This is more efficient than the traditional paper-based assessment modification, which will involve improving assessment conditions, upgrading equipment for assessment, and upskilling assessors which may require massive manpower and financial efforts. For example, learners can be updated regularly in VR simulated safety induction program regarding Occupational Health and Safety (OHS) requirements and workplace procedures. VR also can provide dynamic and adaptable assessment methods to enable flexibility of the assessment. The diverse range of assessment methods caters to different learning styles and can be conducted at any time and from anywhere with the necessary VR equipment. Learners have the flexibility to complete assessments according to their own schedules. Delivering VR equipment to learners' locations for assessment purposes may pose a challenge for certain RTOs.

An example from one of the assessment conditions in the UoC-*RIICTC304E (Muck out tunnel earthworks)* is that "assessment must include access to: personal protective equipment; equipment required to muck out tunnel earthworks; be conducted in a safe environment; and be assessed in the context of this sector's work environment; and be assessed in compliance with relevant legislation/regulation and using policies, procedures and processes directly related to the industry sector for which it is being assessed; and confirm consistent performance can be applied in a range of relevant workplace circumstances" [15]. In traditional assessment design, the learners need to demonstrate that the assessment is carried out in the given workplace however using VR, learners can be assessed in simulation and provide them to apply the knowledge in a range of workplace conditions and apply relevant legislations accordingly.

4.3 VR for Validity

In VET assessments, validity ensures assessments reflect skills, knowledge, and competencies that are relevant to the specific job, which include content validity, construct validity, criterion-related validity, and face validity. RTOs must align assessments with learning outcomes and industry requirements, as per ASQA Standards for RTOs 2015 Table 1.8-1. To achieve this, the RTOs should: 1) Map the assessment tasks to UoC, addressing Performance Criteria, Performance and Knowledge Evidence, Assessment conditions, and Foundation skills. 2) Reflect realistic workplace activities and confirm learners' readiness for real-world situations. 3) Seek Industry feedback on currency and relevance of the assessment [20].

Assessment conditions for UoCs often require equipment access, tool utilization, operation cost, maintenance, and safety considerations. These can impose challenges on RTOs. Various scenarios must be integrated to ensure validity of assessment, collect sufficient evidence and gauge learners' responses in diverse situations. Equipment maintenance, audits, safety checks, and industry feedback are crucial for validity. However, industry collaboration in assessment tool development is limited due to time and resource constraints, which threatens assessment consistency and accuracy, as noted by Halliday-Wynes and Misko [1].

VR technology offers benefits in designing valid assessments by reducing equipment costs, enhancing safety controls, providing diverse, realistic scenarios, and fostering industry collaboration. For instance, VR technology can replicate complex scenarios of a tunnel environment in a highly realistic manner through computer-generated 3D graphics. To simulate an underground tunnel environment with all involved materials in a physical place is time-consuming and costly [12], assessments conducted within VR simulations mirror real-world challenges, contributing to the validity of the assessment. Additionally, VR can capture and evaluate complex sequences of actions in certain vocational skills, which might be challenging to assess through traditional means. For example, in healthcare, performing a surgery simulation in VR could closely replicate the real procedure, allowing assessors to evaluate the learner's skills more accurately [19, 21]. Xie, Tudoreanu et al. [14] mentioned that VR allows learners to experience in a safe and controlled environment and to explore the outcomes of their decisions without risk to themselves or equipment; Moreover, VR system can generate different scenarios randomly to reflect various working conditions; VR can also visualize degrees of risk, temperature, air quality, chemical exposure levels, and the effects of these. Ma [22] stated that with the integration of production and education, the seamless connection between school employment and enterprise recruitment can be promoted in the era of AI enhanced technologies such as VR/AR/MR. RTOs then can work with industry on the development of the assessment and judgement of the assessment decision to ensure the quality outcome of the learning. In summary, VR supports assessment validity through cost reduction, safety, scenario diversity, and industry engagement.

Take one of the mandatory conditions for assessment of UoC-*RIICTC304E (Muck out tunnel earthworks)* as an example, "the assessment must be assessed in the context of this sector's work environment, and the candidate must demonstrate the ability to muck out tunnel earthworks on at least two occasions, including at least ten cubic meters by machine to required job specifications."[16]. Ensuring the assessment's validity requires the establishment of a simulated tunnel environment, including a high shelving unit with items mimicking loose rocks in a tunnel opening. This preparation poses a significant challenge for both the RTO and assessors. Additionally, evaluating learners operating machinery to remove ten cubic meters of earth in an actual underground setting presents a substantial challenge for assessors, given the safety and emergency procedures involved. A VR system can contribute by simulating different working conditions in a tunnel environment at a less expense compared to the physical simulation, randomly generating varied situations to assess learners [14]. This aids assessors in observing learners' task performance and reactions to diverse scenarios, enabling valid judgments on competency by comprehensively understanding learners' capabilities.

4.4 VR for Reliability

In the previous discussion, we covered Fairness, Flexibility, Validity, and now address Reliability. Clayton [3] defines reliability as consistency in assessments. Reliable VET assessments produce consistent evidence across different learners, assessors, and contexts [3, 23]. Challenges for RTOs in maintaining reliability of assessment include careful item development, clear and consistent instructions, assessor training, and minimizing source of measurement errors. More assessors' involvement can reduce consistency due to teaching, learning styles, and assessment setting differences [3]. Halliday-Wynes and Misko [1] agreed that consistency in assessment involves the achievement of comparable outcomes. The diverse assessment methods in VET training compromise consistency. Concerns over assessment quality and consistency have been raised by Skills Australia (now the Australian Workforce and Productivity Agency) and the Productivity Commission in many forums and reports.

VR technologies have the potential to maintain the reliability of the assessments by creating standardized and controlled assessment environments, which include standardized assessment scenarios; reducing the impact of assessor subjectivity due to the different interpretation of learner's performance from different assessors, therefore consistent and immediate feedback can be provided to the learner not influenced by an individual assessor's perspective. VR system can collect detailed data about learners' performance within the simulation and these data can be analyzed to identify patterns and trends for enhancing the objectivity and reliability of assessment results [6, 24, 25].

Let's look at two of the mandatory assessment conditions of UoC-*RIICTC304E (Muck out tunnel earthworks)*: "The assessment must be conducted in a safe environment; and confirm consistent performance can be applied in a range of relevant workplace circumstances" [16]. Due to the high-risk nature of tunnelling work, constant safety monitoring is essential in the underground environment. VR assessments offer learners and assessors a secure setting with limited exposure to hazards [12]. Additionally, the controlled VR environment eliminates external factors like temperature, lighting, or equipment availability, ensuring learners can consistently perform in various scenarios under controlled conditions.

5 Summary

Based on our review of the literature, it's clear that VR technology has the potential to significantly enhance the principles of assessment in vocational education environments by offering realistic simulations, diverse scenarios, cost-effective training, immediate feedback, standardized evaluations, industry relevance, and enhanced engagement. The benefits of VR technology enhanced assessment relate to individual principle are summarized in Table 1.

Table 1. Benefits of VR-enhanced assessment in relate to Principle of Assessment.

PoA	Benefits	Examples
Fairness	Equal Access to Resources	Standardized access to resources, tools, and equipment
	Inclusive Learning	Voice commands or visual cues to support learners with disabilities; Visual, auditory, and kinesthetic experiences that suit learner's preferences
	Reduced Bias	External characteristics such as gender, race, or appearance will not affect marking process
	Transparent Assessment Process	Immersive technologies provide learners with a transparent view of how their assessments are being evaluated
	Immediate Feedback	Immediate feedback is provided which allows learners to adjust their approach and improve in real-time
Flexibility	Remote/online platform	Conducted in learners' own environments, which accommodates learners who might face barriers to attending a physical assessment location
	Diverse Assessment Methods	Various assessment scenarios cater to different learning styles and allows learners to demonstrate their skills in ways that suit their strengths
	Flexible Scheduling	Assessments can be conducted at any time and from anywhere with the necessary VR equipment
	Reassessment	Assessments can be repeated without additional resource requirements
	Support for RPL (Recognition of prior learning)	Simulations can be used to assess learners with existing skills and knowledge who are seeking Recognition of Prior Learning (RPL)
Validity	Realistic Simulations	Assessment scenarios that replicate real work environments, tools, equipment, and interactions, which allows learners to

		engage in tasks and activities that closely resemble what they would encounter in actual workplace settings
	Variety of context	A wide range of assessment scenarios, allowing assessors to evaluate learners in different contexts
	Standardized Evaluation	Standardized evaluation criteria and metrics reduce the potential for subjective grading
	Variety of assessment submission	Facilitation of the submission of multimedia content, such as videos, images, and audio recordings
	Customization	Simulations can be customized to meet the specific needs of different vocational courses and industries
	Adaption	Adapting the difficulty of assessment scenarios based on learners' performance
	Correspondence relating to industry changes	Assessments can be updated to reflect changes in industry standards and practices in low cost, which ensures that assessments remain relevant and aligned with current workplace requirements
Reliability	Consistent Assessment Conditions	A controlled environment where consistency minimizes variations caused by factors like room conditions, lighting, and equipment availability
	Automated Marking	Automation of the marking process for objective questions, reducing the potential for human scoring errors and inconsistencies
	Precise Data Collection	Detailed data about learner interactions and performance can be captured within the simulation
	Consistent Data Analytics	Consistent data of learners' skills level for analysis, enabling RTOs to track and compare learner performance over time
	Consistent Feedback	Consistent and immediate feedback to learners based on their interactions within the simulation
	Remote Proctoring and Monitoring	Remote proctoring technologies can help ensure the integrity of assessments by monitoring learners' behavior, detecting unusual activities, and reducing the likelihood of cheating

6 Limitations and Future Research

Whilst it is possible to map VR to VET practice, our review shows that there are some limitations and challenges for implementing VR technology-enhanced assessment in the VET sector. For example, providing haptic feedback to the learner is still not achievable by current VR technology and multiuser VR training in real time is still and open research and engineering challenges [12]. The potential damage to eyes under long-time exposing to VR light; ethical issues related to the technology in education such as bias, transparency and data ownership; expensive initial installation expense and ongoing maintenance fees; the transformation on VET curriculum, development of training methods and practices, assessment of learning outcomes, the role and responsibilities of trainers and assessors in the training and assessment; extra proper training and professional development to for trainers, assessors, administrative staff and learners to exploit the technology [6] will all pose huge challenges to individual, training providers and the related government bodies.

Therefore, it is important to note that effective implementation requires VR technology reliability considerations and careful assessment design [25, 26]. Moreover, assessors need training to effectively evaluate learner performance within VR simulations [27-29]. The initial installation expense and ongoing maintenance fees are additional factors that RTOs need to consider.

For future researchers, it is recommended to conduct both quantitative and qualitative studies to investigate VET practitioners' perspectives on VR-based assessments and the capabilities of virtual simulation technologies in gathering comprehensive evidence for skill and competency assessment.

7 Conclusion

As technology evolves, integrating VR into assessment strategies requires ongoing research, development, and quality assurance efforts to ensure the assessments can accurately measures the intended learning outcomes, produces consistent and stable results, accommodates diverse learners and contexts, and ensures equal opportunities for all participants. Government policymakers, VET curriculum designers and developers, Registered Training Organizations (RTOs), VET trainers, industry stakeholders, and VR experts should collaborate to advance this goal within the vocational sector. In this way, future research has the potential to demonstrate that VR and VET are well established to work together to provide greater competencies for learners.

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