Augmenting Knowledge Management with Immersive Technologies: Exploring Transformative Use Cases for AR and VR

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***Abstract*- By means of interactive three-dimensional simulations, immersive technologies such as virtual reality (VR) and augmented reality (AR) are revolutionizing employee education and information maintenance. Twenty case studies of prominent global organizations utilizing AR/VR solutions to digitize knowledge and improve training in the automotive, aerospace, medical care, power, constructing, sales, higher learning, and business services industries are analyzed in this study. The detailed use cases illustrate the AR/VR implementation life cycle, starting from initially concepts and progressing to large-scale implementations. They tackle various challenges such as maintaining design insights, supporting maintenance, integrating personnel, standardizing security policies, and enhancing innovation education. Significant prospective is illuminated through critical analysis of numerous deployments at Boeing, Komatsu, Volvo, Siemens Energy, Walmart, and others, which yields key insights regarding the factors that drive, challenges, and developing patterns of AR/VR knowledge transfer.**

Keywords-. Augmented reality, Virtual reality, Mixed reality, Knowledge management, Knowledge transfer, Workforce training, Digital skills

I. INTRODUCTION

In the contemporary, highly competitive global economy, the intricacies of knowledge management and ongoing workforce development have solidified the necessity for organizations to priorities these practices in order to ensure their survival and expansion [1-3]. Nevertheless, conventional learning methodologies are facing significant challenges due to the rapid pace of technological advancements, the presence of dispersed teams, and the ongoing requirement for reskilling [4]. By utilizing immersive technologies such as virtual reality (VR) and augmented reality (AR), this field is poised for radical change as a result of simulated learning that is highly experiential [5-6] and propelled by spatially immersive three-dimensional environments and abundant interactivity [7-9]. This study examines enterprise AR/VR adoption for knowledge preservation [10-11], reuse, and applied workforce training as it pertains to transformative global use cases. A compilation of twenty practical case studies is presented, covering industries such as aerospace, automotive, healthcare, construction, energy, and more that have utilized immersive technologies to facilitate induction, support upskilling, exchange specialized design insights, and increase productivity. A thorough analysis of various implementations and deployment life cycles of AR/VR solutions yield concrete insights regarding the factors that drive, impede, and emerge as trends for the technological arsenal required to effectively transmit complex knowledge at scale in the twenty-first century. The analysis provides organizations with feasible strategies for integrating these swiftly developing solutions into resilient knowledge management frameworks, resulting in enormous returns for the business.

II. METHODOLOFY

Twenty case studies of prominent global organizations utilizing AR and VR to digitize information and improve employee education across sectors are analyzed in this study. Through additional studies of business AR/VR usage in the automotive, aerospace, energy, building, medical, military, educational institutions, and business services industries, the detailed scenarios of use have been gathered. The cases illustrate the application of immersive technologies to tackle a variety of knowledge-intensive issues, such as facilitating servicing of machinery, growing up skill development, streamlining induction processes, standardizing security procedures, and enhancing innovation education. From Fortune 500 industry stalwarts to innovative ventures are among the featured businesses. The use cases illustrating the AR/VR usage life cycle from original trials to large-scale implementations have been highlighted for the purpose of organized evaluation and is shown in Figure 1. Collectively, these worldwide instances emphasize the capacity of AR/VR solutions to generate interactive simulations that surpass those of 2D methods in terms of safeguarding tacit knowledge and facilitating practical, experiential learning. Key insights regarding adoption drivers, implementation challenges, and emergent solution trends are derived from the case analyses.

III. CASE STUDIES

A. Boeing uses AR for aircraft design and manufacturing knowledge sharing

By using AR models and immersive 3D visualization, Boeing designers, engineers, and factory workers across locations

can collaborate real-time on aircraft design finalization and visualize assembly processes before production. This enhances knowledge sharing and problem solving [12-13]. Further elaborating on Boeing's augmented reality implementation, it enabled technicians to navigate through numerous instructions prompts by utilizing Google Glass gesture touches, head-tracking interfaces, and voice commands [14].

B. Komatsu boosts equipment repair knowledge with AR assist

Technicians at Komatsu are utilizing an augmented reality (AR) application that superimposes visual instructions, labels, animations, and metadata onto components and equipment while they perform maintenance. This access to repair advice and troubleshooting advice on demand has accelerated technological education. To illustrate, the work in [15] shows Collaborative efforts with TOMOE Corporation integrate digital technologies, including augmented reality (AR), and assembly expertise at manufacturing sites. This integration enables the visualization and superimposition of design drawings (3D CAD data) onto steel frame components that are assembled on-site. The result is an enhanced yield potential and the timely detection of defects.

C. Volvo implements VR training for safety knowledge

Volvo has created a virtual reality (VR) solution with the purpose of educating novice truck drivers about disaster prevention and exposing them to perilous driving situations. This practical safety expertise is resulting in decreased risks and swift behaviour modification. The advancement of advanced manufacturing creates novel opportunities for human-robot collaboration, thereby contributing to the establishment of a more sustainable industrial sector. The objective of this study is to investigate the feasibility of integrating collaborative applications into manual production systems to automate processes, and subsequently assess the resulting economic and ergonomic implications. The de-labelling procedure utilized for timber pallets at the case company Volvo Construction Equipment in Braæs, Sweden, is the subject of the work [16-17].

D. Siemens Energy leverages AR for wind turbine installation

Using AR glasses, Siemens Energy can project holographic blueprints over wind farm construction sites share design knowledge visually with installation teams. AR also assists with sequencing, coordinates, and alignments during placement. As the worldwide reaction to the coronavirus pandemic disrupts economies, transportation systems, and daily existence, it has become imperative that essential infrastructure be readily accessible to fulfil our fundamental requirements.

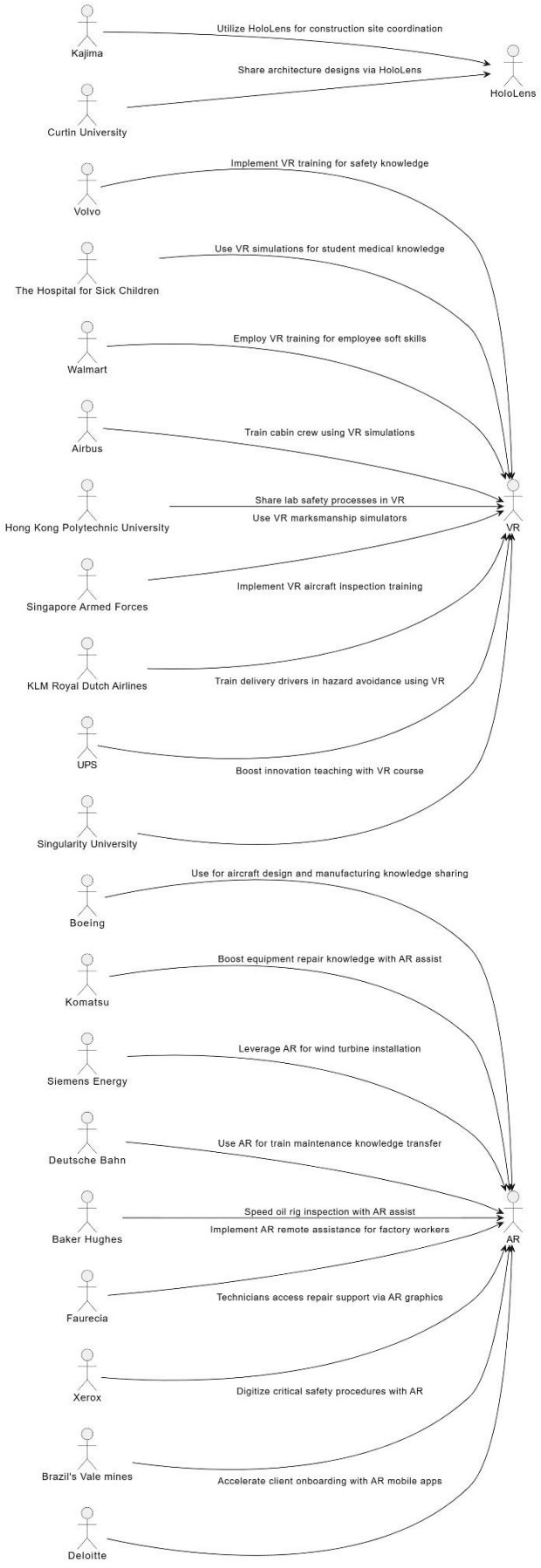

Fig 1. Sequence diagram showing the various cases studied in this work

Siemens, being a prominent service provider in the energy sector, places maintaining power supply as its foremost objective [18].

E. The Hospital for Sick Children uses VR simulations for student medical knowledge

A number of variables to take into account in a requirements evaluation may favor the development of a virtual reality (VR) medical setting over an alternative education method, as illustrated in Figure 2 [19].

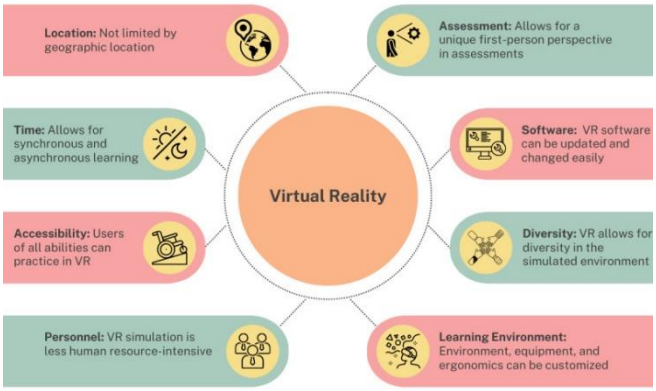

Fig.2. A requirements assessment should incorporate the following elements to encourage the utilization of VR as in [19]. Open access.

The location, a period of time access, employees, programmes, variety, and the educational setting are some of these elements. In contrast to manikin simulation, virtual reality (VR) simulation transcends geographical limitations and facilitates asynchronous learning. Virtual reality environments can be intentionally created to be user-friendly, particularly for those who have limited mobility. Furthermore, they do not necessitate as much utilization of hospital and human resources as manikin simulation. When juxtaposed with alternative pedagogical approaches, the experiential learning and first-person viewpoint inherent in virtual reality facilitate novel modes of assessing and evaluating [20].

F. Walmart employs VR training for employee soft skills

Walmart is enormous. It claims to have more than 2,000,000 employees and more than 11,000 locations in 27 countries, making it the largest retail network in the globe. The organisation strongly holds the belief that its personnel are the foundation of this immense undertaking and places considerable emphasis on staff training. The company guarantees that every member of its staff is adequately trained, assessed, and certified for their respective roles through the provision of diverse learning opportunities. Walmart employs sophisticated technology to a significant degree in their training programmes. Walmart is extremely enthusiastic about incorporating virtual reality (VR) into their training, among other innovations. Andy Trainor, senior director of Walmart Academies, asserts that the experience is genuinely transformative. In fact, employees feel as though they are experiencing it [21].

G. Deutsche Bahn uses AR for train maintenance knowledge transfer

Deutsche Bahn has incorporated virtual and augmented reality into its vocational training and professional development programmes since 2018. Rail industry occupations are becoming more in need of specialized knowledge in the current digital era. As railway facilities and installations continue to evolve, individuals must acquire proficiency in new technologies expeditiously. A variety of engineering experts, including goods car investigators, train conductors, industry power engineers and dispatchers, would benefit from VR training. A current popular topic is the "virtual signal box," that's a model of a mechanical signal box used for dispatcher training in virtual reality. Presently, additional applications are under development. DB trains its personnel using an internal virtual reality application known as Engaging Virtual Education (EVE). In the DB mind box incubator programme, VISCOPIC, a Munich-based startup, has also created virtual training using lifelike holograms of switches [22].

H. Kajima utilizes HoloLens for construction site coordination

Kajima created KT-VISION; a proof-of-concept programme designed for HoloLens. Its purpose is to provide on-site visualization of structure designs and progress on construction. Kajima managers at the site have the ability to observe 3D interactive holograms of the building plans superimposed on the actual building site through the utilization of HoloLens headgear. By conducting comparisons between real-time conditions and the initial designs and schematics, they are able to detect discrepancies and issues at an early stage [23-24].

I. Baker Hughes speeds oil rig inspection with AR assist

Baker Hughes subsidiary and the industry leader in non-destructive testing (NDT) solutions for industry assessment, Waygate Technologies, has introduced Everest Ca-Zoom HD, an innovative pan, tilt, and zoom (PTZ) camera system. Built with a built-in transit case to provide restricted-area checks that are accurate, effective, and safe in numerous sectors, including oil and gas, power, substances, pharmaceuticals and food & beverage [25].

J. Faurecia implements AR remote assistance for factory workers

Faurecia is a French supplier of technologies for emissions oversight, the interiors, reclining, and the outside of automobiles. A number of manufacturing facilities have

adopted smart eyewear equipped with augmented reality (AR) to assist employees in the assembly and inspection of components. AR smart spectacles enable remote specialists to observe the visual output of workers and provide guidance during intricate construction and quality assessments [26].

K. Airbus trains cabin crew using VR simulations

Virtual reality (VR) simulations for training have been developed by Airbus for airline flight attendants and cargo personnel. These simulated events utilise intricate virtual compartments to replicate authentic emergency situations such as depressurization, turbulence, and flames. By donning virtual reality (VR) devices, cabin personnel are able to adequately train for and virtually experience these in-flight scenarios. Airbus asserts that virtual reality (VR) training proves more uniform, constant, and more affordable than other methods [27].

L. Hong Kong Polytechnic University shares lab safety

Hong Kong Polytechnic University (PolyU) is disseminating laboratory safety procedures and policies via virtual reality (VR) technology. A virtual reality (VR) experience that replicates the rigors of a scientific laboratory has been created by PolyU. The simulation addresses critical laboratory safety subjects, including the utilization of fume chambers, the proper application of protective equipment, and the appropriate reactions to potential mishaps such as fires and spillage [28].

M. Xerox technicians access repair support via AR graphics

Xerox has created a visual assistance method that utilizes augmented reality to aid technicians in the maintenance of multipurpose copiers, printers, and other devices. By utilizing augmented reality (AR) spectacles or headgear equipped with integrated cameras, technicians have the capability to observe hologram overlaid illustrations and commands. These overlays furnish technicians with instantaneous guidance regarding investigating, part proof of identity, and repair operations [29].

N. Curtin University shares architecture designs via HoloLens

In order to exhibit architecture designs for buildings, Curtin University is putting Microsoft's HoloLens hologram device to the test. HoloLens enables students and faculty to engage with comprehensive three-dimensional representations of forthcoming campus construction endeavors. The comprehensive virtual reality screens enable users to traverse accurate holograms of the both the inside and outside of buildings. The headset enables users to virtually perceive critical architectural design elements, such as illumination and material characteristics. In integrated virtual surroundings, students are able to discourse and offer input regarding the construction designs in an interactive fashion. Planners can swiftly revise on 3D building models using HoloLens in response to suggestions from stakeholders. Curtin intends to extend the use of HoloLens for interactive 3D visualization and instruction to other fields, including engineering and medicine. The utilization of this extended reality technology is intended to improve educational results, creativity in design, and involvement of stakeholders at the institution of higher learning. [30].

O. Singapore Armed Forces use VR marksmanship simulators

The virtual reality (VR) simulations offer instruction on firearms such as the SAR-21 automatic rifle, excluding the use of live ammunition. Lifelike situations aid in the development of aiming abilities such as correct posture, controlled respiration, steady aim, and trigger manipulation. Trainees receive individualized feedback from VR analytics regarding areas that necessitate enhancement. The system provides access to an extensive library of virtual shot situations and fire grounds. Virtual reality (VR) training offers a safer, more reliable, and configurable alternative to traditional firing range methods [31].

P. KLM Royal Dutch Airlines implements VR aircraft inspection training

A virtual reality training programme has been developed by KLM with the purpose of instructing personnel on the visual inspection of aero plane outside prior to flights. Engineers utilise virtual reality (VR) headgear that replicate the physical inspection and navigation of aircraft. Exposure is provided by incredibly accurate 3D models to highlight aircraft destruction such as rivets, scratches, leakage, etc. VR guidelines direct them to the thirty-plus-point exterior inspection procedure for each type of aircraft in KLM's fleet. Instantaneous VR feedback assists in the acceleration of novice auto mechanics' proficiency in aircraft inspection. Regardless of climate, lighting, or other obstacles, trainees are instructed to meticulously traverse each inspection zone. By acquainting oneself with aero plane color plans, modelling variations, and livery specifics, VR facilitates the detection of deviations. In addition to pre-flight inspections, examples of servicing and fixing will be incorporated into the VR training [32].

Q. Brazil's Vale mines digitize critical safety procedures

Using AR technology, Vale, among the biggest mining enterprises in worldwide, is digitizing crucial mine safety protocols. Augmented reality (AR) devices are utilized by mine workers to superimpose sequential safety protocols and instructions onto their line of sight. This assists personnel in

navigating critical pre-operation inspection protocols pertaining to machinery that is heavy. Augmented reality aids them in precisely and comprehensively validating components such as electrical and braking systems. Arranging for the completion of all milestones and the proper sequencing of tests is how AR attempts to avert equipment malfunctions and shutdowns. AR spectacles monitor adherence to safety regulations, such as the utilization of protective equipment, mittens, and headgear [33].

R. UPS trains delivery drivers in hazard avoidance

For the purpose of recognizing hazards, UPS designed an immersive virtual reality (VR) training programme for its delivery vehicle drivers. Virtual reality devices impute realistic drive situations encompassing prevalent road hazards to the drivers. The virtual reality (VR) simulations accurately depict urban and suburban settings that are fraught with dangers, such as pedestrians trespassing vehicle doors opening, and irresponsible drivers. While maneuvering paths, drivers actively rotate their heads and bodies to view the entire virtual reality environment. More than twenty sections of instruction strengthen safety precautions by assessing drivers' early hazard recognition abilities. Virtual reality monitors drivers' rapid responses as well as offers suggestions for instruction to enhance their risk assessment abilities. UPS reports that the increased danger mentality of drivers trained in virtual reality has decreased the incidence of accidents [34].

S. Deloitte Accelerates Client Onboarding with AR Mobile Apps

Deloitte has created a mobile application utilizing augmented reality technology in order to expedite the orientation process for newly hired customers at its consultancy offices. When onboarding new clients, personnel utilise mobile applications or AR eyewear to display interactive wayfinding, room/area labels, and directions. In expansive office configurations, users are directed to meeting rooms, workstations, services, and connections through the use of visual and auditory markers. Critical induction details, such as organizational schematics, security policies, and Wi-Fi access, is readily available through augmented reality overlays. The augmented reality assistance enables newly hired personnel to quickly acquaint themselves, access, and integrate using their own timetables. Deloitte observes enhanced teamwork and efficiency as a result of clients circumventing conventional hand-holding induction delays [35].

T. Singularity University Boosts Innovation Teaching with VR Course

The VR course titled "An Introduction to Exponential Technologies" was first developed by Singularity University, a think tank based in Silicon Valley. The objective of the VR training is to augment an understanding of concepts of revolutionary technologies such as biotechnology, machinery, and robotics, among others. Students are taken to engaging classrooms associated with every gadget while donning VR headgear. By interacting with 3D representations of technologies, conducting virtual tests, and observing intricate structures in action, students can customize their irregular learn. Augmented evaluations and hyper-visual virtual reality games facilitate grasping of the summary inventiveness concepts. As a result of VR learning, students report greater knowledge retention and a heightened sense of connection to the human implications of technologies [36].

IV. Discussions and future scope

In addition to accelerating digitization, the COVID-19 pandemic has revealed the fragility of numerous traditional business practices, such as managing knowledge. Augmented reality (AR) and virtual reality (VR), as illustrated by the case studies, offer a timely opportunity to update the methods by which personnel obtain, distribute, and implement knowledge. AR/VR's interactive and immersive functionalities can furnish standardized, secure environments in which users can repeatedly simulate challenging situations that are literally unfeasible or prohibitively expensive to imitate. This has significant ramifications for security and efficiency in industries such as medical care, facilities and production, where the acquisition of practical knowledge is limited by physical risks. By providing employees with on-demand comprehensive reference libraries, insights that were previously confined to the minds of researchers or locked cabinets become accessible. Nevertheless, significant obstacles persist with respect to the seamless integration of machinery into legacy operations and limitations on hardware usability. Frontiers include but are not limited to user convenience, connectivity robustness, and the absence of customization flexibility. The expected return on investment in such technologies cannot be ensured in the absence of conscientious change administration and regular monitoring.

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