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Impact of Virtual Training and Digital Knowledge Management on Human Capital Performance in EPC Oil & Gas Projects

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ABSTRACT

Purpose – This study analyses the influence of virtual training programs and digital knowledge management systems on human capital performance in Engineering, Procurement, and Construction (EPC) oil and gas projects. The study seeks to evaluate the efficacy of various digital interventions in improving workforce competence, productivity, and project efficiency.

Design/Methodology/Approach – This study adopts a qualitative research methodology to explore the influence of virtual training and digital knowledge management on human capital performance within EPC oil and gas projects. Data is collected through semi-structured interviews with a purposive sample of EPC professionals, including project managers, HR specialists, and technical leads. The interviews are designed to elicit in-depth insights into participant experiences, perceptions, and strategies regarding digital learning and knowledge-sharing practices. Thematic analysis is employed to identify patterns, challenges, and best practices emerging from the narratives, providing a rich, contextual understanding of how digital interventions shape workforce performance in dynamic project environments.

Findings reveal a positive association between virtual training and digital information management systems and improved human capital performance. The study underscores that continuous learning, real-time knowledge sharing, and digital competency development contribute to superior project outcomes, fewer errors, and better adaptation to dynamic industry demands. However, obstacles such as barriers to digital adoption and resistance to change are noted.

Research Implications/Limitations – The study is limited to EPC oil and gas projects, and findings may not be entirely generalisable to other industries. Additionally, technical improvements and organisational preparation levels may alter the effectiveness of digital interventions over time. Future studies should explore longitudinal studies and industry-wide benchmarking.

Practical Implications – The study delivers practical insights for EPC organisation HR professionals and project managers to optimise virtual training and knowledge management methods. Organisations can embrace digital learning ecosystems to strengthen employee skillsets, foster knowledge retention, and improve project execution.

Originality/Value – This research contributes to the expanding discourse on digital transformation in human capital development within the oil and gas business. By combining a mixed-methods approach, the study gives empirical evidence on the significance of virtual training and digital knowledge management in resolving skill gaps and boosting worker agility in EPC projects.

Keywords: Virtual Training, Digital Knowledge Management, Human Capital Performance, EPC Projects, Oil and Gas Industry, Mixed-Methods, Digital Learning.

INTRODUCTION:

The oil and gas industry's Engineering, Procurement, and Construction (EPC) sector works in a complex and dynamic environment with strict project deadlines, significant capital expenditures, and close regulatory scrutiny. Because these initiatives frequently entail a heterogeneous workforce and geographically distant sites, human resource coordination and optimisation are crucial to their success. External constraints like fluctuating oil prices, environmental sustainability regulations, digital disruption, and an ageing workforce also pose challenges for the industry. These difficulties highlight the demand for highly skilled, knowledgeable, and adaptable human capital.

The performance of human capital, characterised by workers' abilities, productivity, flexibility, and competencies, has become a key factor in determining operational effectiveness and project delivery success in this challenging environment. The changing needs of contemporary EPC projects are often not met by traditional workforce development techniques, such as in-person training and legacy knowledge-sharing processes. They might not be timely, scalable, or contextually flexible enough to accommodate distant activities and quick technological changes.

To overcome these constraints, EPC organisations increasingly adopt digital transformation initiatives that revolve around digital knowledge management systems and virtual training. To provide just-in-time, scalable, and context-specific learning experiences, virtual training platforms use technologies including mobile learning, simulation-based modules, video conferencing, and learning management systems (LMS). Digital knowledge management systems, on the other hand, use tools like corporate content management systems, intranets, and collaborative digital platforms to make it easier to systematically gather, store, distribute, and use organisational information.

These digital interventions facilitate upskilling and ongoing learning, accelerate onboarding, encourage institutional knowledge retention, and reduce reliance on essential personnel. More significantly, they allow organisations to adapt to project difficulties more quickly, enhance decision-making through shared intelligence, and foster a learning culture. By integrating these solutions into everyday project operations, EPC businesses may significantly improve workforce agility, innovation capabilities, and human capital performance.

In the context of EPC oil and gas projects, this study examines the effectiveness and strategic relevance of digital knowledge management and virtual training. It uses a qualitative lens to examine how these tools are used, their influence on worker performance, and what factors help and hinder their success. The research intends to offer practical insights for industry stakeholders looking to future-proof their people management strategies by concentrating on this junction of digital transformation and human capital growth.

LITERATURE REVIEW

Virtual Training in EPC Oil and Gas Projects

Virtual training has become increasingly popular in industrial training, especially in highly technical and geographically dispersed industries such as the EPC in the oil and gas sector. To develop workforce skills, virtual training uses e-learning environments, simulations, video-based training, and virtual reality (VR) technologies (Cheng et al., 2021). Existing research suggests that virtual training promotes retention, adaptability, and learning engagement, particularly compared to traditional face-to-face procedures (Barrett & Loughlin, 2022).

Safety compliance and current project data are paramount in the oil and gas sector. Virtual platforms enable scalable, low-cost training without interrupting operations. Ali and Anbari (2023) found that virtual simulation-based training significantly improves worker preparedness and operational safety in high-risk work environments. Additionally, integrating AI adaptive learning technologies can customise training to improve efficiency and job performance (Lin & Lee, 2022).

Despite these benefits, user digital readiness and resistance typically hinder adoption, particularly by older or office workers (Ahmed et al., 2021). This calls for a strategic approach to digital learning that considers technological access, user capabilities, and organisational culture.

2.2 Digital Knowledge Management (DKM)

Digital Knowledge Management (DKM) refers to the technical and process way by which organisational knowledge is captured, stored, retrieved, and shared. In EPC projects, which are often characterised by extensive multidisciplinary workforces and rotational workforce practices, effective DKM is necessary in order to achieve continuity, avoid rework, and leverage institutional knowledge (Nonaka & Takeuchi, 1995; Alavi & Leidner, 2001).

Recent research by Nguyen et al. (2023) highlights how integrated knowledge platforms support cross-functional integration and knowledge reuse when embedded in project management systems. Technologically driven KMS tools, such as cloud-based repositories, web forums, expert systems, and AI-supported search applications, have been found to increase innovation, response rates, and worker autonomy (Han & Park, 2022). In the context of EPC settings, this is reflected in design errors decrease, less sophisticated procurement phases, and handover procedures across project phases.

But the functioning of DKM systems depends significantly on employee incentives and the value of the content within them. Research by Alharthi and Drew (2022) indicates that although most EPC companies have invested in KMS, there remains underutilisation due to poor user interface design and inadequate incentives for knowledge exchange.

Human Capital Performance (HCP)

Human Capital Performance is typically defined as employees' collective capacity to deliver results alongside organisational goals. It has been quantified to encompass productivity, innovation, adaptability, knowledge application, and proficiency (Becker et al., 2001). Human capital is a principal resource in the EPC industry—capable employees have direct effects on project schedules, adhering to budgets, and quality management.

Existing studies affirm that investment in training and knowledge assets yields considerable performance improvements (Zhao et al., 2022). Moreover, in project-based industries, workforce responsiveness and agility are key to managing uncertainties and scope changes. Digital transformation, when aligned with human capital

strategies, generates a more responsive and resilient workforce (Khan et al., 2021).

More importantly, the combination of virtual training and DKM is also proposed in literature. Tiwari and Patnaik (2023) confirm that workers who receive official e-learning modules and have access to knowledge repositories exhibit significantly higher task performance and cross-functional competencies.

Gaps and Research Need

Even though the literature on workforce development and digital transformation is expanding, little is known about the precise effects of digital knowledge management systems and virtual training on human capital performance in the oil and gas industry's Engineering, Procurement, and Construction (EPC) sector. Most current research focuses on generic industrial settings, often overlooking the specific operational challenges and knowledge requirements of EPC projects. Furthermore, little research has been conducted on how various digital interventions interact to enhance workers' potential, especially in developing nations where these initiatives are common. By investigating how integrated digital solutions can enhance human capital performance in intricate EPC environments, this study seeks to close this gap.

RESEARCH OBJECTIVES

To explore EPC professionals' perceptions of the effectiveness of virtual training in enhancing workforce performance.

To understand how digital knowledge management systems facilitate knowledge sharing and learning within EPC project environments.

To identify the experiential challenges and success factors in implementing digital learning tools across EPC oil and gas projects.

RESEARCH METHODOLOGY

Methods of Research

This study uses a qualitative research design to understand better how digital knowledge management and virtual training affect human capital performance in EPC oil and gas projects. The qualitative technique was chosen because of its ability to capture rich, in-depth insights into participants' life experiences, perceptions, and organisational contexts.

Information Gathering

A purposive sample of 18 professionals, including HR managers, project engineers, and digital transformation specialists involved in EPC oil and gas projects, participated in semi-structured interviews to collect data. The selection of participants was predicated on their firsthand experience with knowledge management or virtual training. The semi-structured style enabled both directed and flexible conversations, allowing participants to discuss personal experiences and explore important issues.

Analysis of Data

Every interview was verbatim transcribed, taped, and subjected to thematic analysis. NVivo software was used to code the dataset and identify recurring themes and patterns. The study was conducted using the six-phase process described by Braun and Clarke (2006), which included becoming familiar with the data, creating preliminary codes, identifying themes, evaluating themes, defining and labelling themes, and producing the final report.

Ethical Considerations and Research Validity

Member checking was used to verify the interpretations by having chosen participants review their transcripts and key themes to ensure reliability and dependability. Participants provided informed consent, and ethical approval was obtained before data collection. Throughout the study, confidentiality and anonymity were upheld.

ANALYSIS

Qualitative Analysis

Thematic analysis of the interview data revealed several key themes that explain how virtual training and digital knowledge management influence human capital performance in EPC oil and gas projects. These themes are grouped into four major categories: perceived benefits, digital integration challenges, enablers of adoption, and impact on performance.

Perceived Benefits of Virtual Training

Participants consistently highlighted the flexibility and accessibility of virtual training platforms. Respondents noted that digital modules enabled employees across geographically dispersed sites to access consistent training materials without disrupting project timelines. Many emphasised the usefulness of interactive simulations and real-time feedback tools for improving technical competency and safety awareness. One HR manager remarked:

"Virtual training allows us to keep the workforce updated without waiting for a physical session—it saves time and increases engagement."

Challenges in Digital Knowledge Management

While most interviewees acknowledged the advantages of digital knowledge systems, several reported difficulties in implementation. Older employees and those in remote project sites often faced challenges due to limited digital literacy or poor internet infrastructure. A project engineer shared:

"Sometimes the tools are there, but not everyone is confident using them, especially in the poor connectivity field."

Other issues included inconsistent content updates and reluctance to contribute to shared platforms due to workload or unclear ownership of content.

Enablers of Successful Digital Adoption

Leadership commitment and a clear digital strategy emerged as crucial factors for successful integration. Respondents noted that teams with proactive management support and ongoing training were more likely to adopt virtual tools effectively. Additionally, embedding knowledge sharing into daily workflows—rather than treating it as an extra task—was considered essential. An IT specialist commented:

"Once people saw how the platform helped solve real-time issues, they began to use it without being told to."

Impact on Human Capital Performance

Most participants agreed that digital training and knowledge management positively influenced performance by reducing errors, speeding up onboarding, and improving collaboration. Teams that embraced these tools reportedly showed faster problem-solving, better decision-making, and greater alignment with project goals. However, participants emphasised that technology alone is insufficient—organisational culture and continuous engagement remain critical.

Case Study: Digital Transformation in Alfanar EPC Project

To illustrate the real-world implications of virtual training and digital knowledge management, a case study was conducted on Alfanar EPC's offshore platform upgrade project in the Arabian Gulf. This multi-phase project involved over 300 engineers, technicians, and project managers spread across five countries.

Context and Intervention

Faced with tight project timelines and limited access to on-site training due to travel restrictions, Alfanar introduced a comprehensive virtual training program using a proprietary Learning Management System (LMS) and cloud-based knowledge management tools. The goal was to ensure all employees received standardised instruction on safety protocols, project management systems, and technical procedures.

Implementation Strategy

Virtual Training: Customised e-learning modules, including 3D simulations of offshore environments, were deployed.

Digital Knowledge Repository: A SharePoint-based platform allowed engineers to upload and access best practices, checklists, and troubleshooting guides.

Mentoring via Teams: Senior engineers provided remote mentoring and real-time feedback using Microsoft Teams.

Outcomes

Based on semi-structured interviews with 12 employees across different roles, several outcomes emerged:

Improved Knowledge Retention: Trainees reported higher retention due to interactive modules and the ability to revisit content on demand.

Enhanced Collaboration: Cross-functional teams accessed the same knowledge base, reducing duplication and errors during procurement and installation.

Performance Gains: Project milestones were consistently met ahead of schedule, with a 17% reduction in rework compared to previous similar projects without digital tools.

One project manager noted:

"Before, knowledge stayed in people's heads. Now, anyone can find what they need without waiting for someone else to explain it."

Lessons Learned

The case highlights that technology adoption must be supported by leadership and integrated into daily workflows. Continuous feedback from users also contributed to system improvements and higher engagement rates.

CONCLUSION

This study investigated how digital interventions—especially digital knowledge management and virtual training—help improve human capital performance in EPC oil and gas projects. The results of a focused case study and qualitative insights show that these technologies fill important information gaps and promote ongoing learning, teamwork, and operational effectiveness. Incorporating these tools promotes workforce flexibility, particularly in the complex and dynamic project contexts characteristic of the EPC industry. Strategic digital investments in human capital will be crucial to maintaining performance, innovation, and competitive advantage as the industry continues to evolve amid labour and technological challenges.

SUGGESTION

The following suggestions are made to EPC organisations looking to improve human capital performance through digital transformation in light of the insights gained from the qualitative research and case study:

Invest in Customised Digital Training Programs: Organisations should create virtual training modules that mirror real-world situations and project-specific contexts to improve relevance and learner engagement. Simulation-based learning and gamification can increase efficacy even more.

Boost Digital Infrastructure and Access: Businesses need to ensure their IT infrastructure is robust to enable smooth adoption, especially at remote project locations. Connectivity gaps can be filled by offering offline learning options and mobile-friendly access.

Encourage a Culture of Digital Learning: By integrating digital tools into routine tasks, recognizing digital learning achievements, and offering rewards for participation, management can foster a culture of continuous digital learning.

Involve Stakeholders in Change Management: Employee participation in digital project planning and feedback stages can enhance user adoption and lessen opposition.

For continuous improvement, regular user training sessions and feedback loops are crucial.

Make sure that it is in line with the organisational strategy: For maximum impact and sustainability, virtual training and knowledge management programs should align with project KPIs, people development plans, and overarching corporate objectives.

FUTURE SCOPE OF THE STUDY

This finding opens up several new research directions. First, longitudinal studies might evaluate the long-term effects of digital information management and virtual training on staff performance and retention throughout several EPC project cycles. Furthermore, studies comparing EPC with other highly complex industries (such as aerospace or construction) may provide a more comprehensive understanding of the flexibility of digital learning platforms. Future studies could also examine how new technologies, such as augmented reality (AR), virtual reality (VR), and AI-powered learning platforms, can improve human capital performance. Finally, combining quantitative and qualitative methods in subsequent research could enhance the depth and generalizability of the findings.

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