Improving Innovative Performance in a Telecommunications Subcontractor through 5g Technology Training

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ABSTRACT

XYZ Sdn Bhd, a telecommunications subcontractor in Malaysia, faces challenges such as limited technical expertise and resource constraints in transitioning from 4G to 5G technology. While this shift presents opportunities for innovation, it is hindered by insufficient 5G skills and organizational readiness. Addressing these gaps is essential to enhance technical competencies and sustain competitiveness in a rapidly evolving sector. Despite the critical importance of the 5G transition in Malaysia, limited research focuses on subcontractor firms and their specific skill enhancement strategies.

This study aims to identify the organization's learning needs, enhance employee competencies in 5G technology, and cultivate a culture of continuous learning and knowledge sharing. It differentiates the theoretical roles of the Technology Acceptance Model (TAM), Learning Organization (LO) Theory, and Action Research (AR). TAM explains how employees perceive and adopt 5G tools; LO fosters organizational mechanisms for continuous learning and knowledge retention; and AR provides a structured, iterative framework to diagnose, implement, and evaluate training interventions before and after implementation.

A qualitative methodology is applied, using semi-structured interviews with engineers and managers, supported by document reviews and observations. A purposive sample of 7 participants (6 engineers and 1 manager) with over ten years of experience ensures sufficient industry expertise. Data are analyzed using Braun and Clarke's (2006) six-phase thematic approach, verified through intercoder reliability (target Cohen's $\kappa \geq 0.8$), triangulation, and member checking to ensure validity and transparency.

The study anticipates measurable outcomes such as a 15% faster 5G KPI troubleshooting rate, a 30% increase in the adoption of 5G features and counters, and improved peer-learning initiatives within teams. These quantitative indicators strengthen the empirical rigor and baseline comparison of innovative performance.

A customized 5G training module is expected to strengthen technical skills, foster creative problem-solving, and enhance organizational adaptability. The findings will guide practical interventions, including targeted training programs and feedback-driven innovation workshops, while reinforcing scholarly understanding of subcontractor innovation through a clearly articulated theory–method–outcome alignment.

Building on the abstract's overview of the research aims, theoretical underpinnings, and anticipated outcomes, the following section introduces the study context and problem background in greater detail.

Keywords: 5G Technology, Subcontractor, Innovative Performance, Learning Organization, Technology Acceptance Model, Action Research, Skills Development, Training.

INTRODUCTION

The rapid evolution of 5G technology presents substantial opportunities and challenges for the telecommunications industry. In this context, subcontractor firms such as XYZ SDN BHD in Malaysia face mounting pressure to enhance workforce capabilities and innovative performance to remain competitive. Despite offering engineering services to major telecom vendors such as Huawei and ZTE, XYZ SDN BHD struggles to align its technical competencies with emerging 5G requirements. With over 90% of its engineers lacking 5G-specific expertise, the company risks losing bids for high-value contracts, thereby weakening its industry position.

This study aims to investigate how structured, competency-based training interventions can bridge the 5G skill gap within XYZ SDN BHD and enhance its innovative performance. The study distinctly operationalizes its theoretical underpinnings. TAM informs the understanding of individual acceptance and behavioural intention toward 5G tools; LO theory emphasizes the development of adaptive and knowledge-sharing cultures; and AR provides an iterative, cyclical process to co-create, implement, and evaluate interventions in real operational contexts.

Through semi-structured interviews, participant feedback, and pre-/post-training assessments, the research examines how these theories interact within each research cycle TAM guiding training acceptance (Cycle 1), LO sustaining knowledge transfer (Cycle 2), and AR linking both through reflective practice.

The significance of this research lies in its dual contributions. Theoretically, it extends innovation literature to subcontractor contexts, an underexplored domain compared to primary telecom operators (Calandra & Chow, 2024; Shani & Coghlan, 2019). Practically, it develops a measurable training framework with clear innovation indicators competency improvement, adoption rate, and process efficiency that subcontractors can replicate to reduce vendor dependency and enhance service quality. Such frameworks are vital to fostering inclusive and sustainable innovation ecosystems.

The primary research questions are: (1) What training module should be developed to address 5G skill gaps at XYZ SDN BHD? (2). How effective is the developed training module in improving employee competency and readiness for 5G technology adoption). The corresponding objectives are to design, implement, and evaluate a contextualized 5G training module, and to measure its impact on technical performance and organizational innovation.

To contextualize the research problem and ground the theoretical framework, the following section literature review examines the current state of innovation challenges in telecom subcontractor firms, with emphasis on training gaps, existing models, and underexplored theoretical linkages.

LITERATURE REVIEW

This study explores the under-researched domain of innovation within telecommunications subcontractor firms, with a focus on XYZ SDN BHD. The literature review identifies key challenges, including limited research, skill gaps, and the absence of tailored training frameworks for subcontractors, despite their vital role in 5G deployment. While innovation literature extensively addresses large telecom operators, subcontractors often lack the financial and infrastructural resources to implement similar strategies. The technological evolution from the telegraph to 5G has transformed the industry (Laker, 2023; Slimani et al., 2023). However, the rapid pace of 5G adoption presents unique hurdles for smaller firms, including insufficient upskilling and training.

Innovation is not solely technological but also organizational, involving new processes, feedback loops, and customer-driven service designs (Kalıpçı, 2023; Shani & Coghlan, 2019). However, generic, vendor-driven training programs remain inadequate for subcontractors, who are individuals or entities offering specialised telecommunications services, such as network maintenance, and are accountable for executing tasks on behalf of a primary contractor (MacKenzie, 2000; Fridkin & Kordova, 2022). This highlights the need for hybrid, competency-based models that integrate microlearning, real-world scenarios, and continuous certification (Farnese et al., 2019; Ahmed et al., 2023). The Technology Acceptance Model (TAM) and Learning Organization (LO) Theory provide insights into adoption behaviour and continuous learning. However, TAM must be extended to account for industry-level constraints, such as limited infrastructure and vendor dependency (Venkatesh et al., 2003; Kalıpçı, 2023).

Moreover, the role of engineers especially RF specialists (Saeed, 2025) is magnified in subcontractor environments where rapid field adaptation is critical. Despite their centrality, the literature lacks attention to their learning environments and upskilling challenges. This study applies Action Research (AR) to develop and evaluate a contextualized 5G training framework in two cycles, allowing iterative adaptation and stakeholder engagement. Empirical rigor is reinforced through a purposive sample of 7 participants, thematic analysis with intercoder reliability (target $\kappa \geq 0.8$), and validation via triangulation and member checking.

This study integrates Learning Organization (LO) Theory, the Technology Acceptance Model (TAM), and Action Research (AR) to build a robust framework for improving innovative performance at XYZ SDN BHD. LO Theory (Senge & Sterman, 1992; Marsick et al., 2004) emphasizes continuous, multilevel learning that aligns individual development with strategic organizational goals. TAM (Davis, 1989) focuses on perceived usefulness and ease of use, helping design user-centered training content. AR (Susman & Evered, 1978) structures the empirical process through planning, acting, observing, and reflecting.

Each theory plays a distinct role within the research cycles with Cycle 1, TAM guides the design of training content and the pre-implementation feedback process. LO informs the development of adaptive learning mechanisms and peer knowledge exchange and AR shapes the diagnostic assessment and pilot testing loop.

In Cycle 2, TAM continues to monitor technology uptake, LO sustains the learning infrastructure, and AR evaluates intervention effectiveness and refinement. The synergy between these models ensures that technology adoption is not isolated but embedded within a culture of organizational learning and continuous feedback. Together, they form a cyclical system where AR supports adaptive execution, TAM drives user-centric design, and LO sustains long-term learning.

This framework informs four key propositions:

P1: Technology acceptance fosters the development of learning organizations.

P2: Technology acceptance enhances innovative performance.

P3: Learning organizations positively influence innovation.

P4: Learning organizations mediate the relationship between technology acceptance and service innovation.

To enhance innovative performance in telecom subcontractor firms like XYZ SDN BHD, this study synthesizes seven interconnected themes derived from TAM, LO Theory, and AR. These themes form a holistic framework that addresses workforce development, technology adoption, and organizational adaptability:

Theme 1: Fostering an Adaptive Learning Culture promotes continuous improvement at all levels through systems thinking and feedback loops (Marsick et al., 2004; Susman & Evered, 1978).

Theme 2: Skills Gap-Oriented Development emphasizes structured training linked to perceived usefulness and strategic learning objectives (Davis, 1989).

Theme 3: Technology Acceptance & Workflow Integration focuses on embedding intuitive, valuable technologies into daily practice, supported by TAM constructs and LO principles.

Theme 4: Pre-Implementation Feedback & Iterative Refinement uses AR’s cyclical model to refine training based on real-time organizational feedback continuously.

Theme 5: Customer-Focused Innovation Application aligns learning and innovation with client expectations to maximize value creation and market relevance.

Theme 6: Collaborative Knowledge Transfer highlights peer learning, stakeholder engagement, and cross-functional teamwork as drivers of innovation (Chaudhuri et al., 2023).

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Theme 7: Organizational Enablement for Learning emphasizes the importance of creating facilitating conditions, allocating resources, and securing leadership commitment to support sustainable learning environments.

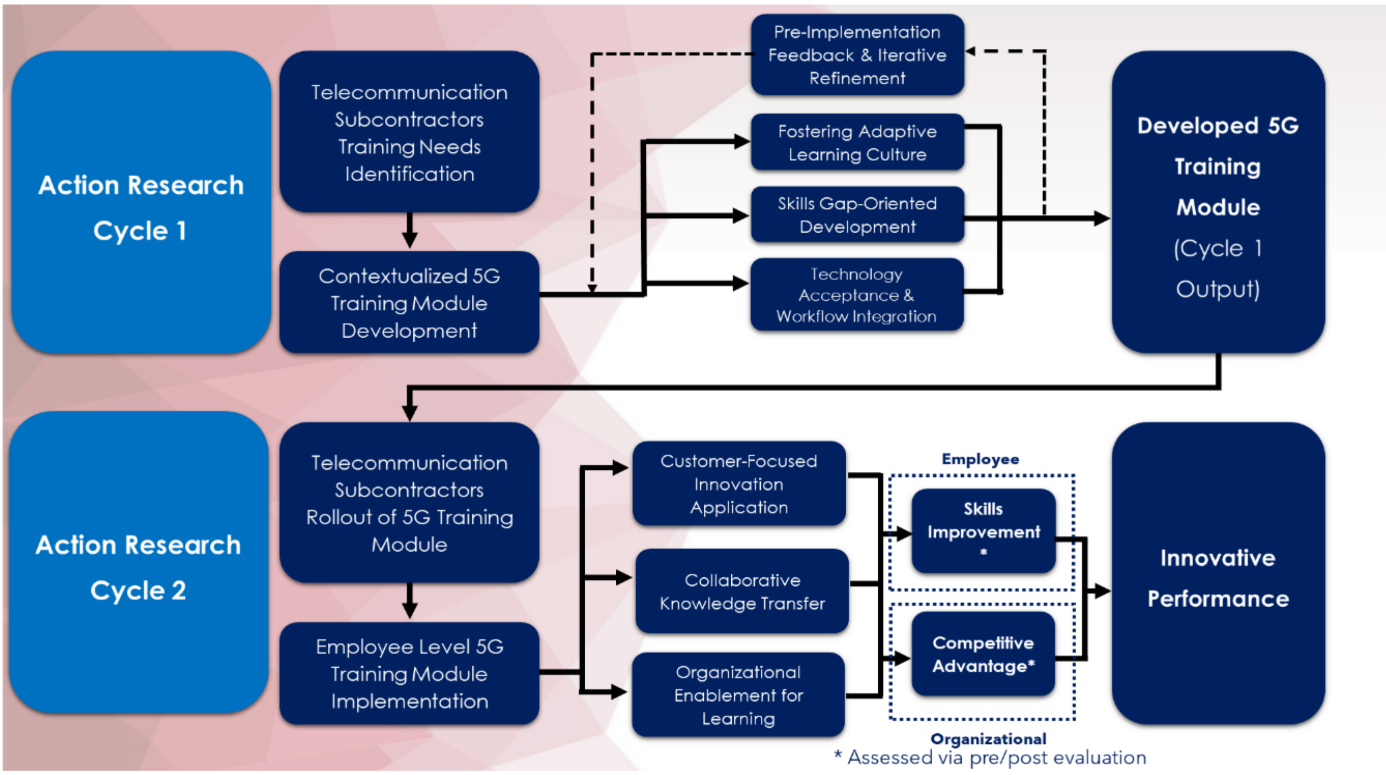
Collectively, these themes bridge theory and execution, guiding the development of adaptive, skill-based, and customer-centric innovation strategies.

Cycle 1 focuses on the development and adaptation of training modules, guided by themes such as Adaptive Learning Culture, Skills Gap-Oriented Development, and Technology Acceptance & Workflow Integration. Needs assessments, employee interviews, and pilot testing ensure that training is relevant, hands-on, and aligned with 5G job functions (Davis, 1989; Marsick et al., 2004; Venkatesh et al., 2003).

Cycle 2 implements and evaluates the training through workshops and simulations, emphasizing Organizational Enablement, Collaborative Knowledge Transfer, and Customer-Focused Innovation Application. Outcomes are measured by Pre versus Post-training assessments that measure improvements in 5G competency, task efficiency, and innovation performance, reinforcing a culture of continuous learning and feedback (Fishbein & Ajzen, 1977; Wilkie & Liefeith, 2020).

This study's conceptual framework integrates the Technology Acceptance Model (TAM) and Learning Organization (LO) Theory, operationalized through a two-cycle Action Research (AR) process. Cycle 1 involves the development and pilot testing of a tailored 5G training module aligned with organizational needs and industry demands. Cycle 2 emphasizes implementation and evaluation, measuring the training's impact on employee competency and organizational innovation. The framework is guided by key research objectives: RO1. To develop and adapt 5G training modules; RO2. To assess their effect on innovative performance assessed by 15% faster troubleshooting, 30% increase in 5G feature usage, and increased peer-led initiatives. . Emerging themes such as Adaptive Learning Culture, Technology Acceptance, Skills Gap-Oriented Development, and Collaborative Knowledge Transfer highlight the multidimensional nature of innovation-building in subcontractor firms. Outcomes are measured through skills enhancement, improved performance, and sustained competitive advantage. This iterative, theory-driven, and evidence-based model ensures that training not only upskills employees but also fosters long-term innovation capacity at XYZ SDN BHD.

Figure 1: Conceptual Framework for 5G Training Implementation and Innovation Outcomes



(Source: Self-Created)

To enhance conceptual clarity and coherence, Table 1 summarizes how the three theoretical pillars, TAM, LO, and AR are applied across the research cycles and linked to the expected innovation outcomes.

Table 1: Visual Link Between Theory, Method, and Outcomes

Theoretical Framework	**Application Within Research Cycle**	**Measurable Innovation Outcomes**
Technology Acceptance Model (TAM)	Used in Cycle 1 to design training modules based on perceived usefulness and ease of use; interview guide structured around TAM constructs.	Increased confidence with 5G tools; 30% rise in 5G feature usage; improved system adoption rate.
Learning Organization (LO) Theory	Guides both Cycle 1 and Cycle 2 to build a feedback-driven, adaptive learning culture across the organization.	Increased knowledge-sharing; 3+ peer mentoring sessions/month; sustained feedback loops.
Action Research (AR)	Structures the two-cycle intervention: diagnosis and pilot in Cycle 1; implementation and evaluation in Cycle 2.	15% faster KPI troubleshooting; enhanced innovation proposals; iterative training refinements.

Informed by the gaps and propositions identified in the literature, the next section outlines the methodological approach used to design, implement, and evaluate the 5G training intervention through an integrated TAM–LO–AR framework.

RESEARCH METHODOLOGY

This study adopts a pragmatic research paradigm to investigate how customized 5G training interventions can enhance innovative performance at XYZ SDN BHD, a Malaysian telecommunications subcontractor. Pragmatism provides flexibility by combining theory and practice to generate actionable insights. The methodology is anchored in Saunders' Research Onion framework (Saunders et al., 2014; Saunders et al., 2023) and guided by an Action Research (AR) approach (Susman & Evered, 1978).

Ontologically, the study aligns with critical realism, recognizing multiple stakeholder realities. Epistemologically, it emphasizes practical knowledge generated through direct engagement with engineers and managers (Creswell & Poth, 2017). Axiologically, it is value-driven, embedding stakeholder needs into intervention design and execution (Patton, 2002).

A descriptive and exploratory research design is employed, enabling documentation of current 5G skill gaps and iterative refinement of training modules. The study consists of two Action Research cycles, each structured around a distinct integration of TAM, LO, and AR:

Cycle 1 (Diagnosis & Design): TAM guides how participants perceive training utility and ease of use; LO informs learning culture development; AR provides the cyclical mechanism to design and pilot training content.

Cycle 2 (Implementation & Evaluation): TAM supports assessment of post-training system adoption; LO sustains peer learning and behavioural changes; AR evaluates and refines interventions based on outcomes and feedback.

Sampling follows a purposive strategy, targeting experienced engineers and managers with exposure to 5G deployment tasks. Seven participants (6 engineers and 1 Manager) with 10 years of experience in RF optimization, KPI monitoring, or 5G rollout activities have been selected. The unit of analysis shifts across cycles: individual skillsets in Cycle 1 (for diagnosing gaps), and team-level interaction in Cycle 2 (for evaluating collaborative outcomes).

Data collection involves, Semi-structured interviews guided by TAM and LO constructs and Observations of training sessions and live simulations. Field notes and document reviews (e.g., pre-existing training reports, SOPs).

The interview protocol is expert-reviewed and pilot-tested to ensure alignment with theoretical constructs and to confirm question clarity.

Data analysis follows Braun and Clarke's (2006) six-phase thematic analysis. To ensure transparency and credibility, Two independent coders perform initial open coding with Intercoder agreement (target Cohen's $\kappa \geq 0.80$) validates coding consistency.

Empirical indicators are built into the evaluation, including Pre/post-training comparisons of technical competency,

Innovation behaviour proxies (e.g., task resolution speed, peer mentoring participation, 5G counter adoption) and Qualitative coding frequencies on innovation-related statements.

Ethical protocols are strictly observed, including informed consent, identity anonymization, confidentiality agreements, and opportunities for participants to provide feedback on findings (Guillemin & Gillam, 2004; Hashimov, 2014).

Overall, this methodology provides a rigorous, stakeholder-driven, and contextually grounded framework. By integrating Action Research for execution, TAM for user-centered design, and Learning Organization Theory for sustainability, the research ensures that training interventions are empirically robust, contextually relevant, and strategically aligned with subcontractor innovation needs.

The following section presents the expected findings based on the conceptual framework and dual-cycle action research process. It outlines projected participant responses, training outcomes, and anticipated indicators of innovative performance across both cycles.

RESULTS

The expected findings of this study are structured according to a thematic analysis aligned with the conceptual framework and the anticipated outcomes of the two Action Research cycles.

In Cycle 1 (Diagnosis and Design), it is expected that TAM will guide the assessment of engineers' perceptions of training usefulness and ease of implementation. LO will support the identification of learning gaps and capacity needs across technical roles, while AR will structure the diagnosis, co-design, and pilot testing of training content. The training module is expected to be contextually tailored to the subcontractor environment, with emphasis on modular, on-demand formats—such as simulation videos and interactive labs—that align with field realities and limited time availability.

Participants are projected to show a preference for competency-focused learning paths, especially on topics such as 5G coverage optimization, DSS configuration, beamforming strategies, and KPI troubleshooting. While initial feedback may highlight only partial alignment with real job demands, the AR cycle will enable iterative refinement, and adjustments are expected to improve relevance and hands-on applicability over time.

In Cycle 2 (Implementation and Evaluation), the focus shifts to evaluating post-training behavioral and organizational change. TAM will measure actual adoption of new tools and workflows, LO will monitor changes in peer knowledge exchange and learning behaviors, and AR will guide the reflection-feedback-adjustment loop. Implementation challenges such as time conflicts, lack of access to live test environments, or supervisory support are anticipated, but overall participation is expected to remain high among key technical staff.

Post-training, engineers are expected to demonstrate increased proposal of customer-aligned, field-adaptive solutions, Engagement in peer mentoring (e.g., "shadow sessions" or informal group chats) and more confident use of 5G counters, Dynamic Spectrum Sharing (DSS) tools, and Physical Resource Block (PRB) based

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troubleshooting methods. Department-level improvements, such as 15% faster KPI diagnosis, and reduction in escalation cases.

These are measurable against baseline data gathered during Cycle 1, such as average issue-resolution time, self-reported confidence levels, and 5G counter usage logs. Additionally, evidence of knowledge diffusion through informal training groups or increased solution co-creation is expected to reflect a shift toward a learning organization culture.

Overall, a moderate but meaningful increase in innovative performance is anticipated, particularly among early adopters and high-performing teams. This performance is expected to manifest as Initiative-taking behavior, Proactive identification of optimization opportunities and increased internal innovation proposals (target ≥ 3/month/team)

These findings are grounded in the differentiated application of the Technology Acceptance Model (Davis, 1989), Learning Organization Theory (Marsick et al., 2004), and Action Research (Susman & Evered, 1978). Each contributes uniquely across the research cycles with TAM explaining how training content is adopted and perceived, LO supports knowledge transfer, feedback culture, and reflective practice while AR enables real-time adjustment and embedded stakeholder participation

The results remain provisional and will be validated through final data triangulation, member checking, and thematic consolidation during post-Cycle 2 analysis.

Synthesizing the insights from the theoretical framework, methodological design, and projected outcomes, the final section draws conclusions regarding the effectiveness of the training intervention, discusses limitations, and proposes directions for future research.

CONCLUSION

In conclusion, this study demonstrates that targeted, context-sensitive training interventions—grounded in the distinct roles of the Technology Acceptance Model (TAM), Learning Organization (LO) Theory, and Action Research (AR) can significantly enhance innovative performance within telecommunications subcontractor environments. TAM informs the user-centered design and adoption of training tools, LO fosters a sustainable learning culture, and AR structures the iterative development, implementation, and evaluation cycles. Through a two-cycle framework, the study addresses critical 5G technical gaps such as 5G KPIs, DSS, and beamforming, while aligning content with user perceptions and organizational realities. Expected outcomes include measurable improvements such as a 15% reduction in KPI troubleshooting time, a 30% increase in 5G feature adoption, and increased peer-led knowledge sharing—validating that innovation is shaped not only by technology but also by structured learning, contextual enablement, and employee readiness. However, limitations remain, including the single-case scope, ongoing data collection, and reliance on existing vendor infrastructure. Future research should validate this framework across diverse subcontractor settings, explore longitudinal impacts, and integrate additional models such as absorptive capacity or organizational support theory to deepen understanding of innovation sustainability. Ultimately, this study contributes both theoretical clarity and practical value by offering a replicable training framework that bridges competency gaps and fosters innovation among telecom subcontractors navigating the 5G transition.

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Ethical Approval

Not applicable.

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Author contributions

Umar Pervaiz conceived the idea, drafted the manuscript, and refined the final version. Obed Rashdi Syed contributed to improving the manuscript through their valuable comments and suggestions throughout the writing process.

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Declarations

Competing interest

The authors declare that they have no conflict of interest.

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