

Improving skills deployment in mega or large complex projects

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Abstract

This study examines how skilled project resources are deployed on mega- and large-scale complex infrastructure projects, with a focus on South African state-owned entities (SOEs). It seeks to assess the contribution of skilled resources to project performance in large, complex infrastructure utility projects. Although existing project management frameworks offer guidance on processes and leadership competencies, they provide limited direction on how skills, competencies, and roles should be configured within temporary project organisations. To address this gap, the study employs a structured content analysis of secondary data, including recent peer-reviewed literature and industry reports, using both deductive and inductive coding techniques. The findings reveal recurring challenges, notably skills misalignment, unclear role definition, and inadequate resource planning. These insights inform the development of a conceptual competency-based framework that links project classification with required capabilities, competencies, roles, and organisational structures. The study contributes to theory by advancing the operationalisation of resource configuration in complex project environments, and to practice by offering a structured approach for aligning skilled resources to improve project performance in South African SOEs.

Keywords: Mega projects, Large Complex projects, Competence, Capabilities, Skills, Project structures.

1. Introduction

There is an extensive body of literature on project management and organisational design in projects. Despite this breadth, many project-oriented organisations tend to adopt similar approaches in practice. In both South Africa and internationally, a significant number of organisations align their methodologies with the Project Management Body of Knowledge (PMBOK), which represents the dominant framework advocated by the Project Management Institute (PMI). This widespread alignment reflects the influence of standardised project management practices. Despite the widespread use of frameworks such as PMBOK, current approaches focus on high-level organisational structures (functional, matrix, projectised) and do not provide sufficient guidance on how to configure project teams in terms of roles, competencies, and skills. When dealing with mega or large complex infrastructure projects, a project manager alone cannot execute them. This raises the question of what support resources a project manager needs to successfully manage and integrate such projects.

Mega projects are typically defined as large-scale, complex projects exceeding US\$1 billion, involving multiple stakeholders and extended timeframes. Large complex infrastructure projects are characterised by scale, interdependencies, and organisational complexity. Project management literature primarily focuses on the project manager's skills and explains when resource planning should occur, but it does not

explain how to determine the optimal configuration of project teams in terms of roles, skills, and competencies.

2. Literature Review

A structured synthesis of the literature reveals four key themes, namely, resource configuration, skills alignment, capability requirements and organisational structure. The literature consistently highlights that while skills and competencies are recognised as critical, there is limited guidance on how they should be structured and deployed within project organisations.

2.1. Theoretical Foundations

- HCT positions knowledge and education as assets that will ensure contribution to project performance but does not specify how skills should be configured into project roles within temporary organisations.
- RBV explains the competitive advantage of skills at organisational level but does not allude to project team structures, which are inherently temporary.
- PMBOK is used internationally for process standards and guidance on good practice in project management but does not provide structured design or competency modelling.
- Systems theory provides a lens for interconnection and complexity but does not support a skill or competency-based staffing model.
- SMT provides detail on labour market inefficiencies and shortages concerned with

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economic supply and demand of skills in a country but does not support any form of organisational design.

Collectively, these theories highlight the importance of skills but do not provide mechanisms for translating competencies into project roles.

2.2. Determine the optimum number and type of resources required to execute a mega or large complex infrastructure projects.

Traditional resource planning methods include expert judgement, bottom-up estimation, and analytical techniques. However, these methods often lack reliability due to the uniqueness and scale of such projects (Watt, 2014). Front-end planning (FEP) is widely recognised as a critical phase where resource decisions must be made. Poor planning during this phase often leads to inadequate skill deployment, resulting in project delays or failure (Babaei, Locatelli & Sainati, 2021). Approximately 39% of project failures are attributable to insufficient or misallocated resources (Bhika, 2017), and only 16% of crisis-managed projects succeed (Morrow, 2024).

Mega projects operate as complex systems that require the integration of multiple stakeholders, disciplines, and contracting arrangements, such as EPC and EPCM models, each of which demands distinct skill sets and resource configurations (Winch, Sergeeva & Lowe, 2023). The inability to plan for these variations results in frequent project disruptions, including suspensions to secure additional resources (Juarez Cornelio, Sainati & Locatelli, 2023). “Projectification” is an approach that has led to many new projects being assigned to teams rather than individuals, and therefore, specific skilled resources are required to support this shift. (Wagner, Huemann & Radujkovic, 2021). Additionally, resource planning is often influenced by organisational and portfolio-level decisions rather than project-specific requirements, leading to suboptimal allocation within individual projects (Stordy, Zerjav & Kanjanabootra, 2021). This highlights a critical gap in the linkage between macro-level resource planning and micro-level project execution needs. Part of the observations was also that skills shortages exacerbate the problem due to a poor educational system in South Africa. State-Owned Enterprises (SOEs) in South Africa are also experiencing brain drain and loss of tacit knowledge, leading to skills shortages and high staff turnover (Bhika, 2017).

2.3. Examine the alignment of specific skills required to execute mega or large complex infrastructure utility projects

The alignment between skills, roles, and project requirements is widely recognised as a key determinant of project success. Mega or large complex projects require a combination of technical, managerial, and behavioural competencies, all of which must be aligned

with specific project roles (Khan, 2018). A clear understanding of the various activities and capabilities that need to be managed is necessary. This should then be supported entirely by a specifically designed organisational structure for the project rather than focused on project complexity, team cooperation and communication (Cristóbal, Fernández & Diaz, 2018). The complexity of these projects necessitates interdisciplinary teams in which technical expertise is integrated with communication, collaboration, and leadership skills (Daniel et al., 2023). However, literature indicates that while competencies are frequently identified, they are rarely mapped to specific roles within project organisations (Moradi, Kähkönen & Aaltonen, 2020). Skills mismatches are particularly prevalent in developing countries, where shortages of critical engineering and management skills result in misaligned project teams and reduced performance (Bhika, 2017). Furthermore, project managers often lack competencies across technical, socio-economic, and adaptive domains, which significantly impacts project outcomes (Damayanti, Hartono & Wijaya, 2021).

Leadership and organisational culture also play a crucial role in aligning skills within project teams. Poor role definition, ineffective communication, and lack of team cohesion are identified as major contributors to project failure (Denicol, Davies & Pryke, 2021). Project-oriented organisations must develop the capability to respond to instability, adapt to change, and realign structures and processes while maintaining effective skill deployment. This is referred to as organisational resilience (Wang, Zhao & Zhang, 2022). The literature also highlights the increasing importance of organisational resilience, where project teams must adapt to dynamic changes while maintaining alignment of skills and capabilities (Wang, Zhao & Zhang, 2022).

Despite strong agreement on the importance of skills alignment, there remains limited guidance on how to operationalise the alignment between skills, roles, and competencies within project structures. Skills development and alignment must be built into the fabric of the project organisation and the project team members (Desjardins, Jean & Bredillet, 2022).

2.4. Examine critical skills and capability requirements for the successful execution of a mega or large complex project.

Mega and large complex projects require a broad range of capabilities that extend beyond traditional project management skills. These include technical expertise in engineering and construction, as well as critical soft skills such as communication, leadership, and stakeholder management (Pieterse et al., 2022). The literature emphasises that competencies should not be limited to project managers but should extend across entire project teams. However, research indicates that most studies focus predominantly on leadership

competencies, neglecting the broader team capabilities required for project execution (Ram, 2023). Organisational capability is defined as the ability to integrate skills, processes, and resources to achieve project objectives. This highlights the importance of viewing skills not in isolation but as part of a broader system of capabilities that enable project performance. Many project organisations still treat project capabilities and skills as secondary considerations and are not concerned with the critical need for the use of a combination of skills and capabilities (Zhang & Leiringer, 2023).

Projects are uncertain, non-linear, interdependent, and often ambiguous; they require extensive experience and knowledge to manage teams within these parameters (Nachbagauer, 2021). A balance is required between expertise and experience in mega projects (Bhika, 2017). There are no dedicated systems for managing mega projects, and historically, they have been executed by traditional project managers using traditional processes and systems. This leads to a lack of skills in many of the capabilities required to execute projects effectively. Examples such as procurement, construction, quality, material management, communication, and stakeholder management are key (Aiyetan & Das, 2022). Leadership qualities are directly related to project success in most industries, and these leaders need to possess interpersonal skills, effective communication, and a governance-oriented approach (Faisal, Al Subaie, Sabir & Sharif, 2022). Emerging trends such as digitalisation, agile methodologies, and hybrid project management approaches are also influencing skill requirements, requiring organisations to continuously adapt and develop new competencies (Cabeças & Marques da Silva, 2021). Furthermore, collaboration across multiple stakeholders, including contractors and external partners, requires strong cross-functional capabilities and integrated team performance (Yin et al., 2023).

2.5. Develop a framework for the alignment of skilled resources to execute mega or large complex infrastructure utility projects.

Projects utilise core teams and key performance indicators from a construction stakeholder perspective, which includes clients, contractors, and consultants. It is suggested that the traditional triangular measure framework, time, cost, and quality, is no longer the only measure that can be used to determine the success of a project. A systematic framework should be implemented in the early stages of mega or large complex projects to address various project requirements and performance measurements (Ashkanani & Franzoi, 2022).

Across all reviewed literature, a consistent gap emerges:

- Skills and competencies are identified but not structured
- Roles are defined but not linked to required skills
- Frameworks exist but remain high-level and non-operational

Most importantly, there is a lack of a systematic approach to configuring project teams based on competencies and roles within mega or large complex projects.

This gap forms the basis for the development of the conceptual framework proposed in this study.

3. Research Methodology

This study employs a qualitative content analysis of secondary data, using a systematic and transparent analytical procedure. The dataset comprises peer-reviewed journal articles, industry reports, and scholarly literature on mega and large complex projects. Sources were identified through structured database searches (e.g., Scopus, Web of Science, and Google Scholar) using predefined keywords related to project complexity, skilled resources, competencies, and infrastructure delivery. Inclusion and exclusion criteria were applied based on relevance, publication quality, and recency.

The analysis followed a multi-stage coding process. First, an initial open coding phase was conducted to extract key concepts related to skills, competencies, and resource deployment. This was followed by axial coding, where codes were grouped into higher-order categories reflecting patterns of convergence and divergence in the literature. Finally, selective coding was used to synthesise these categories into core themes that inform the proposed framework for aligning skilled resources in mega projects.

To enhance analytical depth, both manifest and latent content were examined, allowing not only the identification of explicit concepts but also the interpretation of underlying assumptions and relationships within the literature. The analysis was iterative and comparative, enabling the identification of conceptual gaps and tensions across sources.

Trustworthiness was ensured through established qualitative criteria. Credibility was strengthened through systematic source selection and iterative coding; dependability was supported by maintaining an audit trail of coding decisions; confirmability was enhanced through transparent documentation of analytical procedures; and transferability was addressed by providing thick descriptions of the context and scope of the literature reviewed. This rigorous approach improves the transparency, replicability, and overall methodological robustness of the study.

4. Findings and Discussion

The findings presented in this section are primarily based on thematic content analysis of the existing literature. The analysis reflects established knowledge, dominant debates, and identified gaps within the current body of research on skills and resource planning in mega or large complex projects. A key observation is that, despite a substantial body of literature addressing resource types and availability, there is limited information on how to determine the appropriate number, configuration, and alignment of resources within a mega or large complex project. While organisations may have access to sufficient resources, these are frequently misaligned in terms of competency or incorrectly allocated to project roles (Moradi, Kähkönen & Aaltonen, 2020; Pieterse et al., 2022).

Mega or large complex projects require a combination of technical, behavioural, and managerial capabilities. However, there is no consensus on how these should be combined or structured within project teams. A further key observation is that existing frameworks largely operate at a high level, focusing on competencies, governance structures, or leadership capabilities, without translating these into clearly defined roles and responsibilities within project teams. As a result, there is a disconnect between competency models and their practical application in project environments, leading to inefficiencies in team design and execution (Turner, 2021; Daniel et al., 2023). This gap is also evident in the portfolio management literature, which emphasises allocating resources across multiple projects rather than within a single mega or large complex project (Stordy, Zerjav & Kanjanabootra, 2021). In addition, there is limited research indicating specific links between project scale and complexity and the specific competencies and skills required (Desjardins, Jean & Bredillet, 2022; Zhang & Leiringer, 2023). Collectively, these findings highlight the absence of an integrated approach that connects project characteristics with resources at an operational level.

There is strong agreement amongst authors that successful project delivery depends on the alignment of skills, competencies, and capabilities with clearly defined roles, organisational structures, and project activities (Khan, 2018; Pieterse et al., 2022). Project complexity intensifies this requirement, as a broad

range of technical, managerial, and interpersonal capabilities, along with coordinated and integrated teams, is crucial for project success (Damayanti, Hartono & Wijaya, 2021; Nachbagauer, 2021; Denicol, Davies & Pryke, 2021).

There is no clear consensus on the core competencies required for project managers and project teams (Moradi, Kähkönen & Aaltonen, 2020; Faisal et al., 2022), nor on the most appropriate organisational structures for project execution. While some studies advocate agile, flexible, adaptive structures to manage complexity, others highlight the risks associated with matrix structures, including role conflict between functional and project priorities (Cristóbal, Fernández & Diaz, 2018; George, 2020). Existing theoretical and conceptual frameworks tend to emphasise specific areas of project management, particularly leadership and governance, without sufficiently integrating technical skill requirements into project team design (Faisal et al., 2022; Denicol, Davies & Pryke, 2021). Although these frameworks provide insight into management and control mechanisms, they do not adequately explain how project outcomes are achieved through effective project structures. Organisational design and governance structures are recognised as critical enablers of project execution, with models highlighting the need for integrated roles of owners, sponsors, suppliers, and operational teams in mega or large complex project delivery (Winch, Sergeeva & Lowe, 2023; Galvin, Tywoniak & Sutherland, 2021). There is limited agreement on how project success should be defined and assessed. Traditional metrics based on cost, time, and quality are increasingly challenged by broader evaluation criteria, including sustainability, stakeholder value, and team well-being (Ashkanani & Franzoi, 2022; Lingard & Turner, 2023). In addition, there are also differing opinions regarding the main drivers of project success, with some studies emphasising human competencies and leadership (Ahmed & Philbin, 2022; Irfan et al., 2021), while others prioritise organisational drive during front-end planning and governance structures for execution (Babaei, Locatelli & Sainati, 2021; Merrow, 2024). As the findings are conceptual in nature and serve to synthesise and structure existing knowledge, the proposed framework provides a basis rather than representing empirically tested relationships. These findings collectively inform the development of a conceptual framework (Figure 1) designed to address

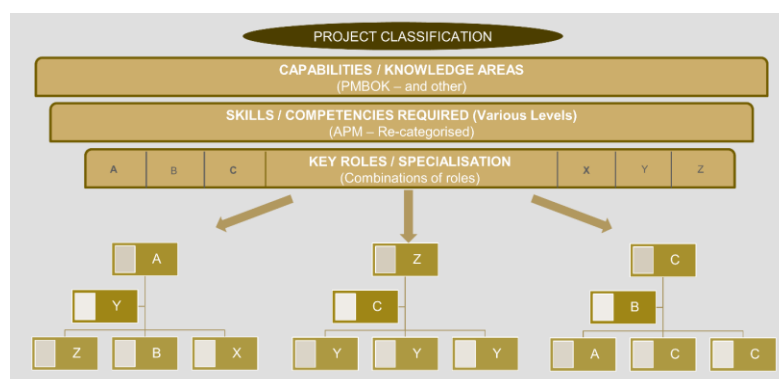


Figure 1: Proposed Conceptual Framework: Mega/Large Complex Project Resource Planning Framework

gaps in translating competencies into structured project team configurations.

The framework addresses the disconnect between high-level competency models and operational team configuration by providing a structured progression from project classification to resource deployment. Project complexity informs the identification of relevant knowledge areas, which define required organisational capabilities. These capabilities are translated into specific competencies and skills, which are then mapped to clearly defined roles and specialised skills. These roles are subsequently presented in a project organisational structure designed to support effective execution. By explicitly linking project capabilities, competencies, skills, roles, and organisational structure, the framework provides a structured approach to resource planning. It therefore addresses the gap identified in the literature and contributes a practical method for aligning skills with project delivery requirements.

5. Conclusion and Further Research

This study highlights a critical gap in the existing project management literature: limited guidance on how to systematically configure project teams in mega and large complex project environments. Although the importance of skills and competencies is well established, their structured integration into project roles and organisational arrangements remains insufficiently conceptualised. This gap has implications

for resource deployment and contributes to ongoing challenges in project performance.

In response, the study proposes a framework for aligning skills, roles, and organisational structures in complex project settings. The framework contributes to theory by advancing a more integrated understanding of resource alignment, and to practice by offering a structured approach to improving resource planning and project execution, particularly within state-owned entities.

However, the study is constrained by its reliance on secondary data and its contextual focus on South African SOEs, which may limit the generalisability of the findings. Accordingly, further research is required to empirically validate the proposed framework through case-based or mixed-method studies. Future research should also examine its applicability across different industries and organisational contexts and refine the framework to accommodate varying institutional and project conditions.

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