AXEL Intelligence: Designing Enterprise API Governance and Knowledge Management Through Lean Startup and Design Science Research

Muhammad Farhan Dirhami*, Ali Murtado Fauzarrohman, Anindita Hapsari

IT Division, PT. Telkom Indonesia (Persero) Tbk, Jakarta 12710, Indonesia
farhan.dirhami@telkom.co.id

Abstract. Application programming interfaces (APIs) are critical to enterprise integration, yet many organizations continue to face challenges in API governance and knowledge management. This study examines how Lean Startup problem validation can be integrated with Design Science Research (DSR) to identify these challenges and guide the development of AXEL Intelligence, an AI-Enabled API Governance and Knowledge Management Platform at PT Telkom Indonesia. Twelve semi-structured interviews identified eight recurring issues: fragmented documentation, manual discovery, slow access approval, knowledge silos, security concerns, limited monitoring visibility, lack of standardization, and limited governance mechanisms. These findings informed a revised Lean Canvas and the design of AXEL Intelligence, which combines an API catalogue, automated workflows, role-based access control, monitoring dashboards, and a retrieval-augmented generation (RAG) assistant. The study contributes empirical evidence on API governance and knowledge management challenges, demonstrates the integration of Lean Startup validation within DSR, and presents AXEL Intelligence as a digital transformation artifact. After being deployed in production for internal use, the platform has attracted 906 registered users and catalogued over 2,000 APIs, demonstrating organizational adoption.

Keywords: API Governance, Design Science Research, Digital Innovation, Digital Transformation, Knowledge Management, Lean Startup

1 Introduction

Digital transformation involves more than the adoption of new technologies. It represents the ongoing reconfiguration of organizational capabilities, processes, and structures through digital means [1, 2]. In this process, the governance of digital assets plays an important role in shaping organizational performance. Application programming interfaces (APIs) are a key enabler of digital transformation. They facilitate system interoperability, support integration across applications, and expose business capabilities within and beyond organizational boundaries. As a result, APIs have evolved from technical infrastructure into strategic organizational assets [3, 4].

However, the rapid growth of APIs also increases the complexity of managing discovery, documentation, security, monitoring, and governance throughout the API lifecycle. These difficulties are compounded when the knowledge needed to use APIs remains informal and concentrated in individuals rather than captured as a shared organizational resource, linking API governance closely to knowledge management. Weak management practices can lead to duplicated effort, delayed delivery, and greater security risks [3]. These challenges are particularly relevant in large telecommunications organizations.

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PT Telkom Indonesia, the country's largest telecommunications provider, operates a diverse portfolio of applications across multiple business units. Prior to the development of AXEL Intelligence, several recurring issues were identified. Documentation was fragmented, service discovery relied heavily on personal contacts, access requests followed email-based processes, security practices varied across teams, monitoring visibility was limited, and critical organizational knowledge remained informal and dependent on individuals. These challenges motivated the problem validation research presented in this study. Similar issues have been reported in the API management literature, including fragmented documentation, manual provisioning, and limited governance mechanisms practices [3, 5]. Despite growing interest in API governance, the integration of Lean Startup problem validation with Design Science Research (DSR) remains underexplored. To address this gap, PT Telkom Indonesia developed AXEL Intelligence, a platform that integrates discovery, documentation, access management, governance, monitoring, and knowledge retrieval through a centralized catalogue, role-based access control (RBAC), workflow automation, monitoring dashboards, and a retrieval-augmented generation (RAG) assistant. This study examines AXEL Intelligence as a digital innovation artifact developed by incorporating Lean Startup customer discovery and problem validation principles [6, 7] into the DSR methodology proposed by [8].

1.1 Research Questions

The study addresses three research questions:

1. What API governance and knowledge management challenges are experienced by enterprise users?
2. How can Lean Startup problem validation inform the design of an AI-enabled API governance and knowledge management platform?
3. How does AXEL Intelligence address the validated organizational challenges?

1.2 Research Contributions

This paper makes three contributions. First, it provides empirical evidence of API governance and knowledge management challenges in a large telecommunications organization. Second, it demonstrates how Lean Startup problem validation can be integrated with Design Science Research to guide digital innovation. Third, it presents the design of an AI-enabled API governance and knowledge management platform that combines API discovery, access management, governance, monitoring, and organizational knowledge sharing within an enterprise environment.

2 Theoretical Background and Related Work

2.1 Digital Transformation and API Governance

Digital transformation (DT) refers to the strategic reshaping of organizational capabilities, processes, and structures through digital technologies [1]. Moving beyond digitization and digitalization, DT embeds digital initiatives into business strategy and organizational identity [2, 9]. Within this context, APIs have become critical assets for interoperability and digital service integration. API management encompasses the design, publication, security, monitoring, and lifecycle operation of APIs [3].

As organizations increasingly treat APIs as reusable products, discoverability, documentation quality, and reuse become essential [5]. Effective governance helps ensure security, consistency, and scalability through appropriate policies, responsibilities, and decision-making structures [4], particularly in microservice environments where interfaces proliferate and evolve rapidly [10].

2.2 Knowledge Management and Enterprise AI

Knowledge management (KM) focuses on the creation, sharing, storage, and reuse of organizational knowledge [11]. When critical knowledge remains concentrated in individuals, organizations face coordination challenges and the risk of expertise loss [12]. To address these issues, organizations increasingly adopt machine learning and generative AI for knowledge capture and retrieval [13, 14]. Their effectiveness depends heavily on data quality and contextual relevance [15]. Retrieval-augmented generation (RAG) addresses this limitation by grounding generated responses in verified organizational knowledge sources [16].

2.3 Design Science Research and Lean Startup

Design Science Research (DSR) focuses on developing and evaluating artifacts that address organizational problems [17]. [8] propose a six-stage process comprising problem identification, objective definition, design and development, demonstration, evaluation, and communication. Lean Startup complements DSR by strengthening problem identification through validated learning and iterative build-measure-learn cycles [7]. Customer discovery interviews help verify the existence and significance of problems before development begins, supporting objective definition and artifact design [6].

2.4 Research Gap

Although these streams are individually well established, their integration remains limited. Existing studies provide relatively little empirical evidence on API governance challenges in large organizations [3], and few demonstrate how Lean Startup problem validation can be combined with DSR to develop AI-enabled API governance and knowledge management solutions. This study addresses that gap by integrating both approaches in the development of an enterprise platform within a large telecommunications organization.

3 Research Methodology

3.1 Research Design

This study adopts a qualitative and design-oriented research approach that integrates Lean Startup problem validation with Design Science Research (DSR) [8]. Lean Startup customer discovery practices are used to strengthen the problem identification and objective definition phases of DSR by ensuring that artifact requirements are derived from validated organizational experiences rather than assumptions made by developers or researchers [6, 7].

The resulting research process combines problem validation, thematic analysis, and Lean Canvas reconstruction within the six DSR activities proposed by [8]. Fig. 1 presents the overall research framework and illustrates how Lean Startup practices support the development of a design artifact grounded in organizational needs.

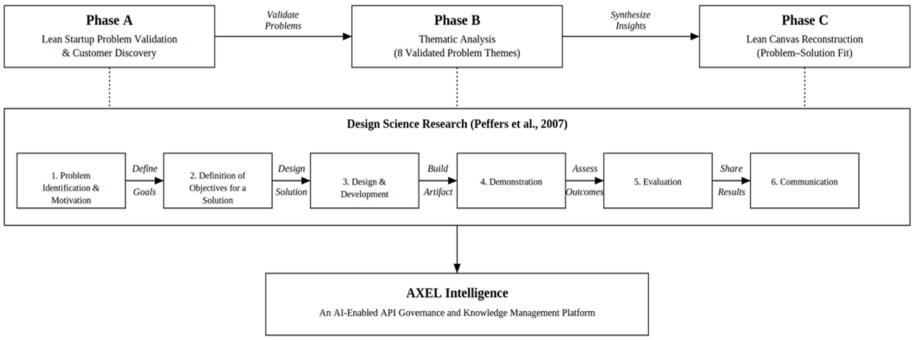

Fig. 1. Research framework integrating Lean Startup problem validation with DSR.

3.2 Data Collection

Data were collected through twelve semi-structured interviews with PT Telkom Indonesia personnel selected purposively to represent key roles across the API lifecycle, including providers, consumers, integration specialists, backend developers, coordinators, and technical experts. This sampling strategy ensured diverse perspectives on API governance and usage. Interviews lasted approximately 30-60 minutes and followed a 22-question protocol covering respondent profiles, API discovery and documentation, access management, security and governance, operational challenges, and problem prioritization. Participants also identified their three most significant challenges and described how they currently addressed them.

3.3 Data Analysis

Interview transcripts were analyzed using thematic analysis [18] with a combined deductive-inductive coding approach informed by [19]. Initial deductive codes were derived from Lean Canvas problem assumptions, while inductive codes emerged from participant responses. The analysis identified additional issues related to monitoring limitations, standardization gaps, and governance weaknesses that were not fully captured in the original assumptions. The coding process produced eight consolidated themes representing the primary API governance and knowledge management challenges.

3.4 Evaluation, Validity, and Ethics

AXEL Intelligence was deployed as a production platform for internal use within PT Telkom Indonesia with 906 cumulative registered users and 2,059 APIs catalogued, indicating substantial organizational adoption. Consistent with a formative Design Science Research evaluation approach [8, 20] evaluation focused on how well the platform addressed the API governance and knowledge management challenges identified during problem validation. These adoption figures evidence real-world deployment and use; they are not a measure of the platform's effect on the validated problems, which remains an explicit target for future quantitative evaluation.

Research credibility was strengthened through triangulation across interview transcripts, thematic coding results, and respondent summaries. Participation was voluntary, and all respondents were anonymized to protect confidentiality. Interview excerpts were lightly paraphrased while preserving their original meaning. The authors were directly involved in the development of AXEL Intelligence. This dual role as researchers and practitioners is acknowledged as a potential source of interpretive bias and a limitation of the study.

4 Results and Discussion

This section addresses RQ 1-3 via problem validation, Lean Canvas reconstruction, system architecture design, and problem-solution mapping & evaluation.

4.1 Problem Validation Findings

Systematic coding of the interview data produced eight themes, summarized in Table 1. Four were reported by all respondents. Manual API discovery relied heavily on personal contacts, team coordination, or service desk requests due to the absence of self-service capabilities. Documentation was fragmented across email, chat platforms, PDF files, and spreadsheets, with no centralized repository. Access approval was handled through email and informal coordination, resulting in delays, limited transparency, and a lack of tracking mechanisms. Respondents also reported limited monitoring visibility, with API performance information often unavailable or dependent on manual log inspection. API security concerns were identified by eleven respondents. Multiple authentication approaches were in use, leading to inconsistent security practices, credential management concerns, and potential data exposure risks. Three additional themes emerged inductively. Knowledge silos were reported by nine respondents, who described API ownership and operational knowledge as concentrated within specific individuals, creating dependency and coordination challenges. Lack of standardization and limited governance mechanisms were each identified by seven respondents, reflecting the absence of shared documentation standards, consistent authentication practices, formal access tracking, and enforced approval workflows.

Table 1. Thematic coding and problem salience across respondents (n = 12)

Code	Theme	Representative Codes	n	Salience
T1	Scattered API Documentation	Fragmented documentation, outdated records, no central repository	12	Very high
T2	Manual API Discovery	Manual search, ask PIC, no self-service	12	Very high
T3	Slow Access Approval	Email requests, approval delays, no tracking	12	Very high
T4	Knowledge Silos	Person-dependent knowledge, unclear ownership	9	Very high
T5	API Security Concerns	Inconsistent authentication, shared credentials, security risks	11	Very high
T6	Limited Monitoring Visibility	Limited observability, manual logs, weak analytics	12	Very high
T7	Lack of Standardization	Nonuniform documentation, inconsistent standards	7	Moderate
T8	Limited Governance Mechanisms	No tracking, no access matrix, no unified workflow	7	Moderate

Across both deductive and inductive themes, respondents consistently regarded existing workarounds as inadequate. None considered current tools and practices effective. Seven respondents rated them as ineffective or low in effectiveness, while the remaining five reported only moderate effectiveness. Accordingly, all twelve respondents expressed the need for a centralized API management platform, highlighting capabilities such as self-service discovery, integrated governance, workflow automation, AI-assisted services, and end-to-end lifecycle management.

4.2 Lean Canvas Reconstruction

The validated findings were synthesized into a reconstructed Lean Canvas that replaced the initial design assumptions with empirically validated evidence from the interviews (Fig. 2). The resulting value proposition was a unified and intelligent API platform that integrates API discovery, documentation, access management, governance, monitoring, and AI-supported knowledge retrieval. This value proposition was informed by all eight validated themes and was further supported by feedback from early adopters within the IT Division. Application owners consistently identified the API catalogue, streamlined approval workflow, and AI assistant as the most valuable platform capabilities. These priorities closely reflected the four themes with the highest salience (T1, T2, T3, and T6), providing qualitative evidence of problem-solution fit before broader organizational deployment (Blank & Dorf, 2012).

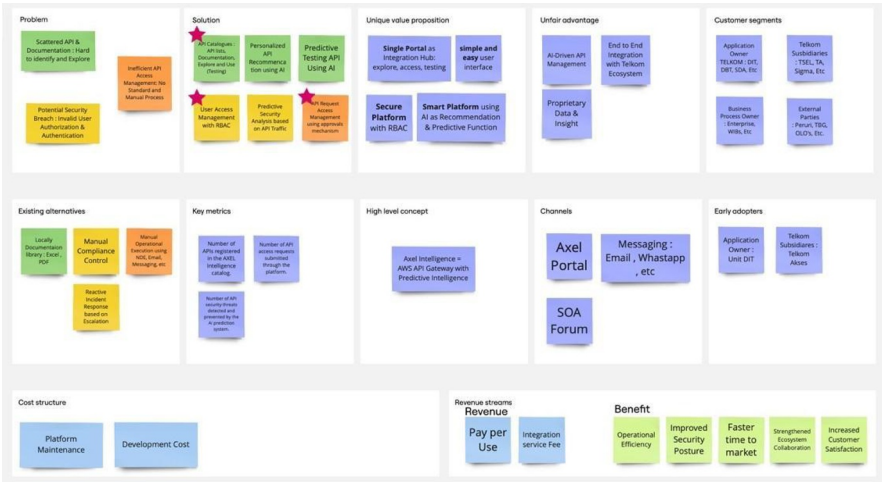

Fig. 2. Lean Canvas for AXEL Intelligence as developed during the initiative.

4.3 System Architecture and Design

AXEL Intelligence adopts a layered architecture to support AI-enabled API discovery and knowledge retrieval (Fig. 3). A ReactJS web client communicates through an Nginx web server with a FastAPI backend that orchestrates document ingestion, retrieval, and response generation. Supporting services include a Qdrant vector database for embedding storage and similarity search, a Redis Stack cache for metadata and frequently accessed results, and an internal large language model service. All components are deployed as Docker containers within the enterprise environment.

When API documentation is uploaded, the FastAPI backend segments the content into passages, converts them into vector embeddings, and indexes them in Qdrant. User queries are embedded using the same process and matched against stored vectors to retrieve the most relevant passages. These passages are assembled into a context window and provided to the internal large language model service (Interface Chatbot Application, ICA) for response generation, while Redis Stack reduces latency by caching metadata and recurring retrieval results.

By grounding responses in retrieved source material before generation, the RAG approach improves contextual relevance, reduces unsupported outputs, and keeps organizational knowledge within boundaries [15, 16, 21]. Together, these components provide natural-language access to API knowledge and transform fragmented, individual-dependent expertise into a structured and searchable organizational asset [11, 22].

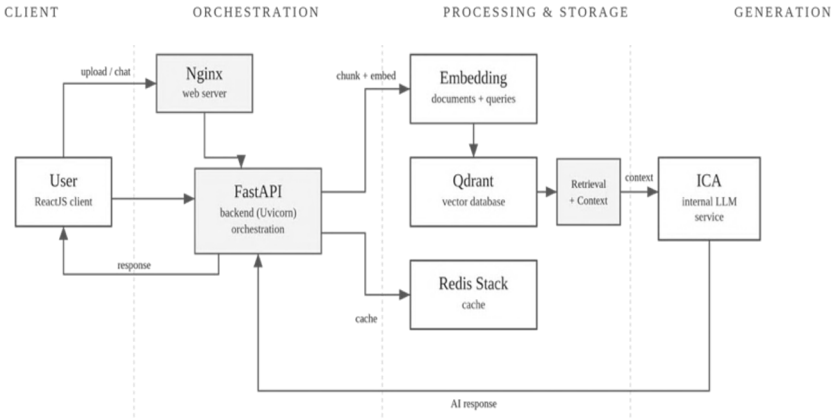

Fig. 3. AXEL Intelligence system architecture and RAG flow.

4.4 Problem-Solution Mapping and Evaluation

Table 2 maps each validated problem to its root cause, the corresponding platform feature, and the expected benefit. Consistent with the formative evaluation approach applied here [8, 20], all stated benefits represent design propositions grounded in the empirical problem evidence; their quantitative effectiveness is an explicit target for future evaluation and is not a measured result of the present study. The platform addresses all eight themes through an integrated combination of governance infrastructure, knowledge management, workflow automation, and AI-supported discovery rather than a set of isolated point solutions.

Table 2. Problem-solution mapping for AXEL Intelligence

Code	Theme	Root Cause	AXEL Feature	Expected Benefit
T1	Scattered API Documentation	Fragmented documentation sources	Centralised Documentation Repository	Improved documentation reuse
T2	Manual API Discovery	No Self-service catalogue	API Catalogue and AI Discovery	Faster API discovery
T3	Slow Access Approval	Manual and untracked routing	Automated Approval Workflow	Faster provisioning
T4	Knowledge Silos	Person-dependent knowledge, unclear ownership	AI Knowledge Retrieval	Reduced knowledge dependency
T5	API Security Concerns	Inconsistent authentication controls	RBAC and Security Controls	Improved security and compliance
T6	Limited Monitoring Visibility	Lack of observability	Monitoring Dashboard	Better operational visibility
T7	Lack of Standardization	No common standards	Templates and Standardised Structure	Greater consistency
T8	Limited Governance Mechanisms	Lack of governance controls	Audit Trails and Unified Governance Portal	Improved accountability

5 Conclusion

This study integrated Lean Startup problem validation with the Design Science Research (DSR) process of [8] to ensure that AXEL Intelligence was grounded in empirically identified organizational needs rather than assumptions.

Regarding enterprise API governance challenges, twelve semi-structured interviews at PT Telkom Indonesia identified eight recurring issues. Manual API discovery, fragmented documentation, slow access approval, and limited monitoring visibility were reported by all respondents, alongside security concerns, knowledge silos, weak standardization, and limited governance mechanisms. These findings demonstrate that API governance challenges are organizational as well as technical.

Regarding problem validation in artifact design, customer discovery interviews were used to test initial assumptions and inform a reconstructed Lean Canvas that established problem-solution fit before development. Consequently, design objectives were derived from verified user needs rather than presumed requirements.

Regarding the platform response, AXEL Intelligence addresses the identified challenges through a centralized documentation repository, AI-assisted API catalogue, approval workflows, RBAC, monitoring and analytics capabilities, and a retrieval-augmented generation assistant grounded in organizational API documentation.

This study is limited to a single organizational context and twelve participants, and its evaluation remains formative. Future research should evaluate performance outcomes quantitatively and examine the transferability of the combined Lean Startup-DSR approach across different organizational settings.

Disclosure of Interests

The authors declare they have no competing interests

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