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Proposed Information System Design to Support Catalog Information in Construction Services at PT XYZ

Bima Pramono Aji
Institut Teknologi Bandung, Indonesia
Email: bima_pramono@sbm-itb.ac.id

ABSTRACT

The construction sector continues to face challenges related to project cost efficiency, especially during the procurement phase. At PT XYZ, this issue stems from the absence of an integrated catalog information system for pricing and contracts. Consequently, budget planning, vendor selection, and procurement assessments lack reliable historical data. Disparate pricing data across departments and insufficient integration with ERP SAP reduce the accuracy of budget formulation and decision-making. This study aims to: (1) ascertain developmental requirements for a catalog information system based on ideal conditions and root cause analysis; and (2) devise a system design to support data-driven procurement decisions. The research employs the System Development Life Cycle (SDLC) methodology, starting with preliminary research to investigate underlying causes, followed by gap analysis, technical information assessment, and system design through Data Flow Diagrams (DFD) and Entity Relationship Diagrams (ERD). The database is structured according to Third Normal Form (3NF) to ensure data efficiency and integrity. The findings show that the proposed catalog system integrates centralized price databases with ERP SAP, incorporates vendor evaluation mechanisms, establishes standardized data templates, and implements price trend analysis features. The resulting system is expected to enhance the accuracy and consistency of procurement decisions by providing historical data access, vendor performance tracking, and automated price simulations. This research contributes to procurement digitization practices in the construction industry by offering a systematic framework for implementing integrated catalog information systems that improve cost efficiency, transparency, and planning quality in construction projects.

KEYWORDS *catalogue information; digitalization; price database; SDLC; system design*

INTRODUCTION

The construction industry accounts for approximately 13% of global GDP but has experienced lackluster productivity growth, averaging merely 1% per year over the last twenty years (Institute, 2017). Non-residential construction, particularly within the industrial and logistical sectors, continues to be a significant economic catalyst (Brown, 2024).

In Indonesia, infrastructure projects such as the Trans-Sumatra and Trans-Java toll roads have enhanced regional connectivity, fostering growth in regions such as Sulawesi, Kalimantan, and Papua. Notwithstanding these advantages, challenges remain in governance, delays, and budget overruns (World Bank, 2020). Digital technologies are widely regarded as crucial for improving accountability and efficiency in project implementation (Wijaya et al., 2022; Zuliarni et al., 2024).

Nevertheless, the majority of construction players in Indonesia are unfamiliar with data-driven decision-making (Izzattisselim & Legowo, 2024; Triyanto & Supriyanto, 2024). Data is dispersed across platforms such as BIM and ERP, hindering real-time insights (Faizi, 2024).

Technologies like IoT and cloud databases are inadequately leveraged, particularly outside Java. Numerous decisions continue to depend on intuition due to cultural aversion to digitalization (Famdale & Widyadana, 2023), while apprehensions over data security further impede adoption.

PT XYZ possesses substantial expertise in executing strategic infrastructure projects throughout Indonesia. Its portfolio encompasses high-rise structures, public infrastructure (roads, bridges, water systems), and EPC-based initiatives.

PT XYZ is implementing a *Digital Transformation Roadmap* to enhance its competitiveness. This effort encompasses fundamental company digitalization via technologies including ERP SAP, E-SCM, CRM, E-QHSSE, performance dashboards, BIM, and digital surveys utilizing LiDAR and UAV drones.

E-SCM, connected with the ERP SAP recording system, supports supply chain management (Hedman & Henningsson, 2016). E-SCM is developed as a centralized procurement management instrument featuring the following essential functionalities: Partner registration, electronic procurement, vendor progress monitoring, payment monitoring, and vendor evaluation (Amini & Li, 2019; Ahmad et al., 2020; Kurniawan et al., 2021; Tarigan et al., 2023).

Construction service firms concentrate on the design, execution, and oversight of infrastructure projects (Febriyani & Samsudin, 2024; Hannesto & Surya, 2017). A pivotal stage in this process is the formulation of the Implementation Plan Budget, wherein Field Operation Costs constitute 80%–85% of total expenses. These encompass costs related to materials, labor, equipment, and subcontractors. Effective control of these expenses is crucial to project success.

Nevertheless, according to COGS data from projects finalized between 2022 and 2024, PT XYZ has not yet realized improvements in production efficiency, as delineated in the subsequent table.

Table 1. Number of efficient projects 2022 – 2024

Year	Number of Completed Projects	Number of Efficient Project	Number of Inefficient Project
2022	20	10	10
2023	18	9	9
2024	20	13	7

To investigate project inefficiencies, this study uses a cause map diagram. The core problem identified is cost overruns, traced to three root causes: budget miscalculations, contractor underperformance, and rework from planning-field mismatches. Miscalculations are primarily due to inaccurate procurement price estimates, stemming from the absence of a centralized price database.

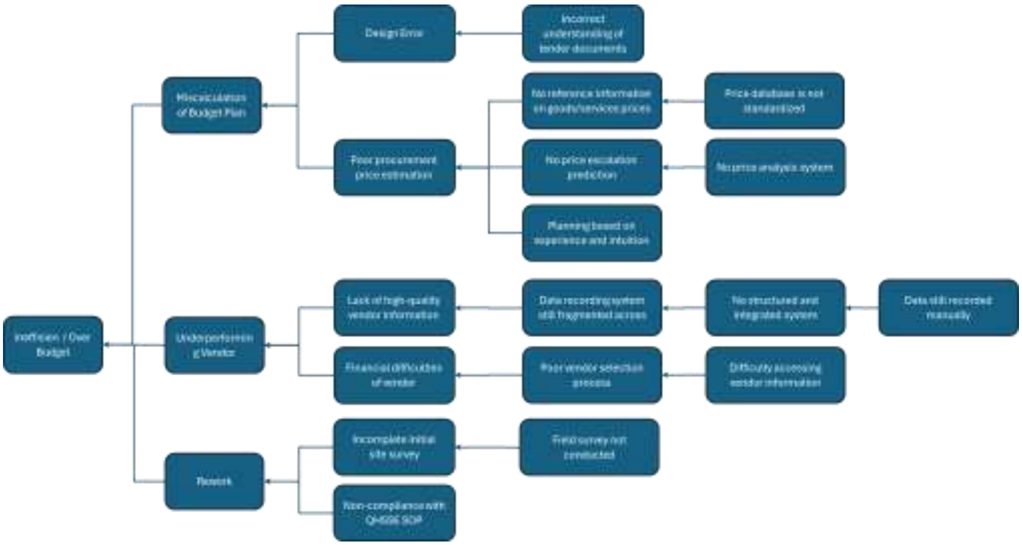

Figure 1. Cause Map Diagram

This research addresses critical gaps in procurement information management within the construction industry by examining the development requirements and technical specifications for an integrated catalog module information system. Specifically, this study aims to: (1) establish developmental requirements for the catalog module information system through comprehensive gap identification, analysis of improvement opportunities, benchmarking of analogous applications, and delineation of development objectives; and (2) design the requisite information system architecture necessary for catalog module development, demonstrated through business process design, functional decomposition, context diagrams, data flow diagrams, and entity relationship diagrams. The practical implications of this research extend to enhanced procurement efficiency through centralized price databases, improved budget accuracy via historical data access, strengthened vendor selection through performance-based evaluation systems, and increased transparency in procurement decision-making processes. Theoretically, this study contributes to the literature on information systems implementation in construction management by providing a systematic SDLC-based framework that bridges the gap between procurement business processes and digital system architecture.

RESEARCH METHOD

This study employs the System Development Life Cycle (SDLC) approach because of its organized and sequential characteristics, which correspond with the project's established objectives from initial research. The Software Development Life Cycle (SDLC) facilitates systematic development via planning, analysis, design, and implementation, rendering it appropriate for fulfilling the Catalogue module requirements in E-Supply Chain Management (E-SCM) based on optimal circumstances and root cause analysis.

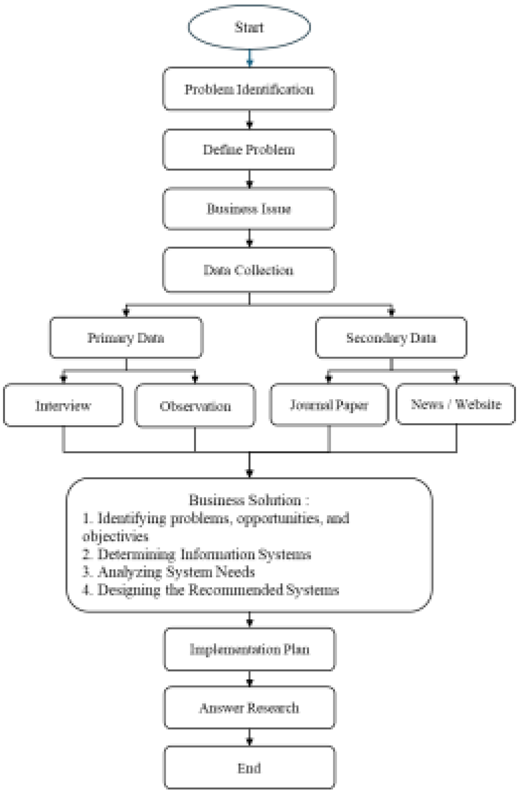

Figure 2. Research Flow

This study handles qualitative data from the initial examination of procurement database requirements. Preliminary study entails engaging procurement managers, succeeded by an SDLC-oriented identification of issues and system objectives. Primary data is gathered via interviews and observations of procurement processes, thereafter analyzed alongside existing literature to develop an E-Price Catalog system. The system is executed by modeling information flow and data integration through Data Flow Diagrams.

This study utilizes both primary and secondary data. Primary data were obtained through interviews with the Construction Services Procurement Team involved in planning, execution, and evaluation. Secondary data were gathered through literature review of relevant papers, journals, and books covering procurement systems, database architecture, and information systems.

The Software Development Life Cycle (SDLC) is a systematic approach used in software development to ensure that the resulting system is of high quality, meets user needs, and is developed within a specified time and budget.(Hasanah & Untari, 2020).

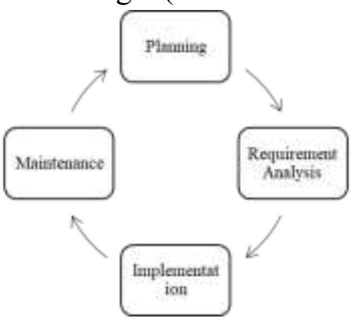

Figure 3. SDLC Flow

Figure 3. showed SDLC staged. In the SDLC Planning stage, business needs are analyzed, project feasibility is assessed, and system processes are defined using modeling tools such as DFD and ERD (Dennis, Wixom, & Roth, 2012).

DFD describes how data flows through the system, including the processes performed and interactions with users and databases. However, DFD only shows the data flow and does not explain how the system will be implemented technically, so it requires additional diagrams such as ERD and UML

Entity Relationship Diagram (ERD) is a high-level conceptual model of a database that describes a system and its boundaries. After the modeling, the system is designed based on the analysis results. At this stage, the system architecture, user interface design, database, and software structure are designed to ensure that the system can run well according to the specifications that have been determined.

RESULT AND DISCUSSION

The discussion commences with the planning phase to assess gaps, opportunities, developmental objectives, necessary developmental items utilizing benchmarks, and offered solutions. The second response delineates the proposed system architecture as the culmination of the analytical process, utilizing flow diagrams, DFD and ERD.

Proposed Solution

Gap Analysis & Opportunity Improvement

In assessing the existing challenges, it is necessary to identify the information management gap in E-SCM compared to the ideal condition required. It showed in table 2.

Table 2. Gap Analysis Existing Condition

Ideal Condition	Gap
Price Database Alignment	No system exists for mapping the price data flow in a centralized and comprehensive manner.
Price Database for Tender & Negotiating with Vendor	No decision support system is available based on actual price data or vendor history.
Design Data System	No cleansing and standardization process for material and service databases.
Design Development Roadmap	No long-term development plan for cross-system integration.
Simulation	No price simulation feature exists that can automatically generate estimates based on historical or trend data.

The existing E-SCM system is deficient in a centralized and systematic method for managing pricing information. Price information is disjointed among divisions, lacking a uniform procedure for item nomenclature, units, or specifications. Decision-making continues to depend on manual records and user intuition, without a decision support system that utilizes past data or vendor performance. Furthermore, there is an absence of a cohesive plan to synchronize the catalog module with the ERP system, hence constraining cross-system data interoperability. The lack of cleansing and standardization processes adversely affects data consistency and usefulness. Users encounter difficulties in obtaining pertinent data for price simulation during bids, as there is no mechanism available to produce estimates based on previous trends. The identified shortcomings impede data-driven procurement decisions, exacerbate cost inefficiencies, and elevate the risks of project delays and budget overruns, as illustrated in Table 3.

Table 3. Analysis Opportunity for Improvement

Gap	Opportunity for Improvement
No system exists for mapping the price data flow in a centralized and comprehensive manner.	No system exists for mapping the price data flow in a centralized and comprehensive manner.
No decision support system is available based on actual price data or vendor history.	Development of Catalog Database / Price Database
No cleansing and standardization process for material and service databases.	Structuring data to support data-driven decision-making
No long-term development plan for cross-system integration.	Development of standardized database formatting
No price simulation feature exists that can automatically generate estimates based on historical or trend data.	No price simulation feature exists that can automatically generate estimates based on historical or trend data.

System Needed

Following the gap analysis and cause map, multiple opportunities for enhancement have been recognized, chiefly the necessity for a centralized and digital catalog system to facilitate organized data and data-driven decision-making. A uniform pricing framework for materials and services is essential to enhance bid evaluation, in conjunction with ERP module connectivity and price analysis capabilities to assure data integrity and facilitate price trend simulations.

The system requirements study seeks to augment access to vendor performance records, refine procurement planning precision, and furnish consistent pricing references. It aims to facilitate seamless information exchange between systems and assist in predicting cost assessments. At present, PT XYZ does not possess a centralized mechanism for mapping the flow of price data. Creating an integrated Price Database with ERP will facilitate the systematic archiving of historical pricing data, hence enhancing future procurement planning.

Furthermore, no decision support system utilizes historical price data or prior vendor performance. Incorporating vendor evaluation within the Corporate Partner module and unifying it within E-SCM will augment objectivity in vendor selection and boost transparency. Standardization and data purification are essential; the existing system lacks a mechanism to harmonize units of measure and standards for materials and services. A uniform data template and structured format are essential for maintaining consistency across projects.

To guarantee system sustainability and cross-platform integration, explicit business process design and documentation (DFD and ERD) are necessary. At now, there is an absence of a long-term development strategy for integrated procurement systems. An established architectural blueprint will enable modular system development and integration between E-SCM and ERP platforms.

Finally, the system requires a pricing analysis module with prediction capabilities derived from past data. At now, automated pricing simulations are unsupported. Creating price trend forecasting algorithms based on historical data would enable planning teams to generate more accurate and adaptive cost predictions in accordance with market trends. A synopsis of the system is presented in Table 4.

Table 4. System Needed Analysis

Gap	System Needed
No system exists for mapping the price data flow in a centralized and comprehensive manner.	Develop a Price Database integrated with ERP. Data Needed : Centralized Price database
No decision support system is available based on actual price data or vendor history.	Vendor evaluation integration with price database. Data needed : Integrated module
No cleansing and standardization process for material and service databases.	Standardization of data recorded in ERP. Data needed : Data template
No long-term development plan for cross-system integration.	Design business process and BRD for ERP system integration with E-Catalogue. Data needed : DFD and ERD
No price simulation feature exists that can automatically generate estimates based on historical or trend data.	Integration of formulas/algorithms to analyze data. Data needed : Historical Database

No price simulation feature exists that can automatically generate estimates based on historical or trend data. Integration of formulas/algorithms to analyze data. Data needed: Historical Database.

Proposed Solution

Following the gap analysis and cause map, numerous critical opportunities for improvement have been discovered to optimize procurement data management at PT XYZ. The primary deficiencies encompass the lack of a centralized pricing database, insufficient decision support utilizing historical data and vendor performance, absence of a data standardization protocol, no long-term cross-system integration strategy, and the absence of price simulation functionalities.

The suggested solutions entail creating a centralized Price Database/E-Catalog linked with ERP, integrating vendor assessment into the Corporate Partner module, instituting standardized data collection procedures with explicit templates, and designing business processes and system architecture (DFD and ERD) to facilitate sustainable system integration. Furthermore, facilities for predictive price analysis will be established to facilitate automated simulations and enhance cost forecasting accuracy.

Benchmarking was performed using four construction services—PT A, PT B, PT C, and PT D—to validate this improvement potential and inform system development. The selection was predicated on the congruence of business processes and industrial context. The benchmarking process concentrated on five prioritized areas for enhancement; each associated with particular data requirements.

The findings indicate that all evaluated organizations have established an integrated Price Catalog module and built a business process plan for ERP integration. This underscores the significance of a systematic and documented methodology for maintaining procurement data, which has been the norm in the state-owned construction industry. Consequently, creating a comparable solution for E-SCM is both pertinent and imperative.

In the realm of data analysis and price forecasting, only PT C and PT D have comprehensively adopted sophisticated analytics functionalities, encompassing unit cost analysis, vendor price trends, purchase order recaps, and strategic price projections. This indicates that although progress has occurred, there remains potential for further enhancement in the use of data-driven decision-making tools throughout the sector.

The benchmarking results underscore the necessity for E-SCM to implement best practices in the integration of a centralized pricing database with ERP, improve data uniformity, and cultivate advanced analytical skills.

Design Implementation

The creation of Data Flow Diagrams (DFD) and Entity Relationship Diagrams (ERD) is essential for system integration and solution design. These graphics depict the relationship between ERP modules and the Price Book Database. This technical paper will provide the foundation for developing systematic, uniform, and scalable system architecture that can be efficiently executed throughout the company's procurement activities.

Prior to the creation of the system's Data Flow Diagram (DFD) and Entity Relationship Diagram (ERD), it is essential to design a business process flowchart to illustrate the whole interaction among stakeholders. The Price Database system is employed from the initial phases of the procurement process to facilitate data-driven planning.

Should a vendor remain unlisted, Procurement Staff will initiate registration through E-SCM. The vendor presents price proposals via the Price Catalog, which are subsequently processed and archived in the Price Database. The e-Procurement module facilitates tendering, whilst the e-Contract submodule documents awarded contracts and automatically updates the database for future reference.

The finalized procurement results are connected to the Construction Monitoring System, enabling construction personnel to monitor implementation through purchase orders and contracts. This data facilitates regular vendor performance assessments, documented in the Corporate Partner module and aligned with the Price Database. Subpar performance may result in reprimands or exclusion from consideration. Payment is initiated upon the completion of milestones through handover paperwork. Construction personnel upload Park and Post Invoice files into the Invoice System, where all payment information is kept and tracked via the Payment Database, facilitating efficient tracking and assessment.

Following the mapping of the Price Database and Catalog workflow, function decomposition is performed to delineate operations into specific functions, then represented in a Data Flow Diagram (DFD). This methodology facilitates an all-encompassing system architecture—from authentication and data administration to integration and reporting—as depicted in Figure 4.

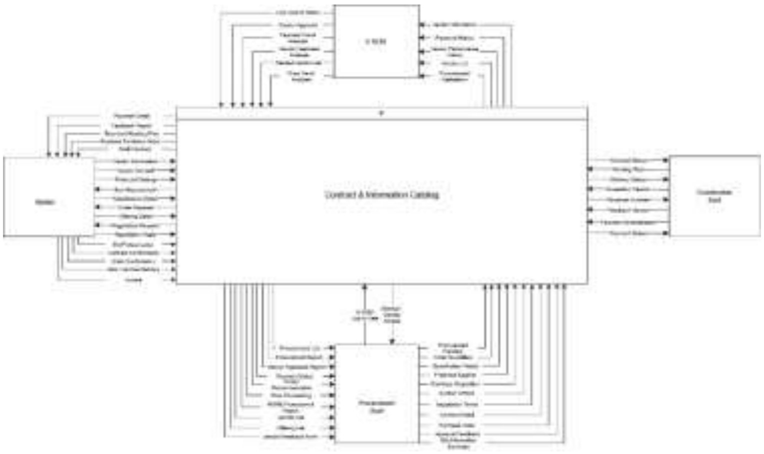

Figure 4. Function Decomposition Diagram

The context diagram offers a detailed representation of the Price Book Database system and its relationships with external organizations, including Procurement Staff, Vendors, Construction Staff, and E-SCM. The context diagram also establishes the basis for the creation of DFD levels 0, 1, and 2, which decompose the processes with increased specificity. The context diagram facilitates the methodical identification of data flows and interacting entities.

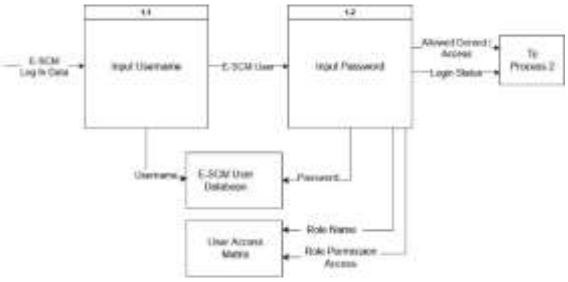

Figure 5. Proposed DFD Process 1: Log In

The initial step demonstrates that E-SCM users are required to input their login credentials via “Input Username” (1.1) and “Input Password” (1.2). The submitted data is then authenticated by the “E-SCM User Database” to confirm the validity of the provided credentials. This information concurrently verifies the user's access privileges using the "User Access Matrix."

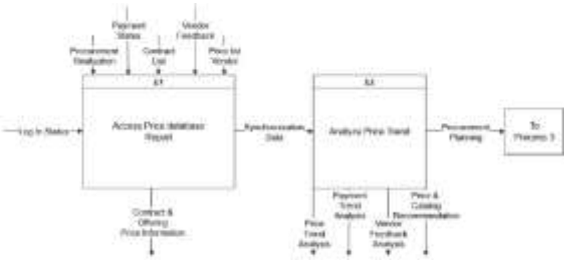

Figure 6. Proposed DFD Process 2: Price Database Report & Analyze Price Trend

This flow depicts the second step in the system, specifically the application and examination of data within the Price Database to facilitate procurement planning. The procurement process commences at the planning phase, where E-SCM users, upon successful login, advance to "Access Price Database" (2.1). The synchronized data is subsequently passed to the "Analyze Price Trend" (2.2) phase, where an analysis of price trends is performed utilizing payment data and vendor input. This study yields pricing and catalog suggestions that serve as the basis for purchase strategy in following stages.

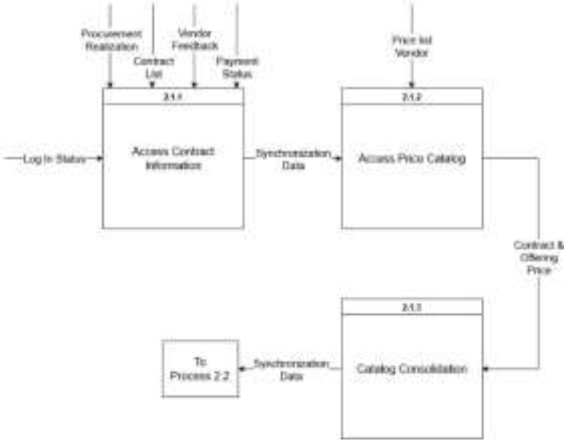

Figure 7. Proposed DFD Process 2.1

This graphic depicts subprocess 2.1 inside the Price Database system, encompassing contract access (2.1.1), vendor catalog access (2.1.2), and catalog consolidation (2.1.3). Users initially access contract data—including realizations, vendor feedback, and payments—which is then synchronized with vendor pricing lists. The data is collected into a consistent dataset utilized as input for price trend analysis in Stage 2.2, guaranteeing precise and current pricing for procurement planning.

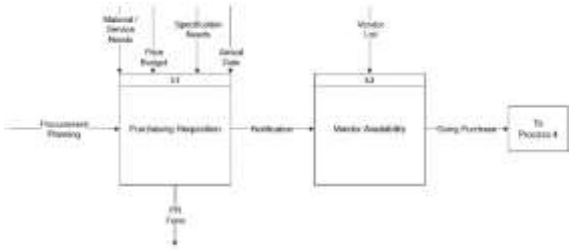

Figure 8. Proposed DFD Process 3 : Purchasing Request

This figure depicts Subprocess 3, encompassing Purchasing Requisition and Vendor Availability. In step 3.1, users provide procurement information including item type, budget, specs, and delivery date. The system thereafter initiates step 3.2 to verify vendor availability against the current list to confirm that the request can be fulfilled by eligible suppliers. If matches are identified, the procedure proceeds.

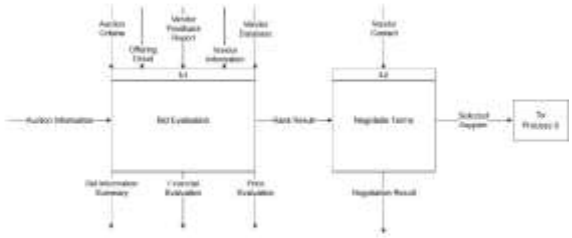

Figure 9. Proposed DFD Process 5.1 & 5.2 : Bid Evaluation & Negotiate Terms

During the "Bid Evaluation" phase (5.1), the system examines inputs including auction criteria, vendor proposals, feedback, and database information to evaluate bids in terms of summary, financial, and pricing dimensions. The result is a prioritized list of vendors (Figure IV.11). The highest-ranked vendor advances to "Negotiate Terms" (5.2), wherein the system enables communication for deliberations on pricing, scheduling, and payment conditions. The outcome of the negotiation serves as the foundation for supplier selection.

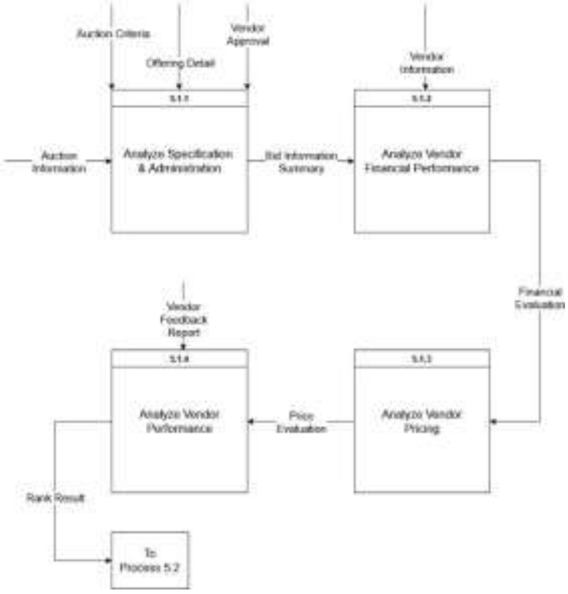

Figure 10. Proposed DFD Detailed Process 5.1

This figure delineates Process 5.1 (Bid Evaluation), which consists of four subprocesses. Subprocess 5.1.1 evaluates technical and administrative compliance through Auction Criteria and Vendor Approval, resulting in a Bid Information Summary. Subprocess 5.1.2 assesses financial sustainability via vendor records, culminating in a Financial Evaluation. Subprocess 5.1.3 evaluates price competitiveness through financial data to provide a Price Evaluation. The concluding subprocess use the Vendor Feedback Report to evaluate historical performance, generating a Rank Result that consolidates all assessment dimensions.

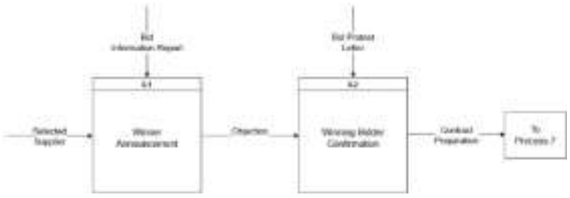

Figure 11. Proposed DFD Process 6.1 & 6.2

During the Winner Announcement procedure (6.1), the chosen supplier is disclosed, and all suppliers are provided with a Bid Information Report that outlines the evaluation outcomes. This guarantees transparency for all participants. Vendors may send a Bid Protest Letter if dissatisfied, which undergoes a clarifying process for review. Upon verification, the system identifies the winner, and the procedure advances to Contract Preparation as the initial phase of contract formulation (Process 7).

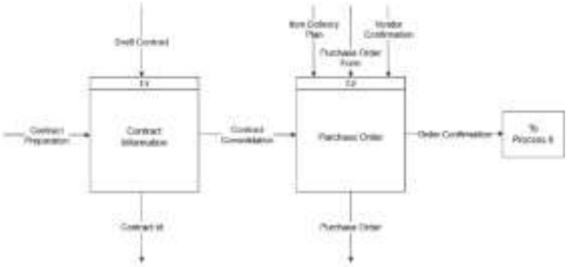

Figure 12. Proposed DFD Process 7.1 & 7.2

The "Contract Information" procedure (7.1) accepts inputs comprising Contract Preparation and a Draft Contract, then processing them to provide a unique Contract ID. The contract information is later employed in the following step, "Purchase Order" (7.2), during the Contract Consolidation phase.

In Process 7.2, the system produces a Purchase Order derived from the Purchase Order Form, Item Delivery Plan, and Vendor Confirmation.

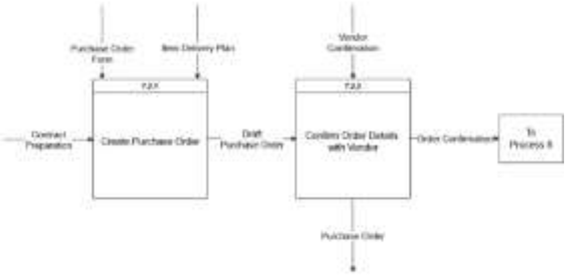

Figure 13. Proposed DFD Process 7.2.1 & 7.2.2

Process 7.2 comprises two subprocesses: Create Purchase Order (7.2.1) and Confirm Order Details with Vendor (7.2.2). In section 7.2.1, the system utilizes the Purchase Order Form, Delivery Plan, and Contract to produce a Draft Purchase Order. In section 7.2.2, the vendor examines and verifies order particulars. Upon verification, the system generates the Final Purchase Order and Order Confirmation, assuring consistency prior to the commencement of delivery.

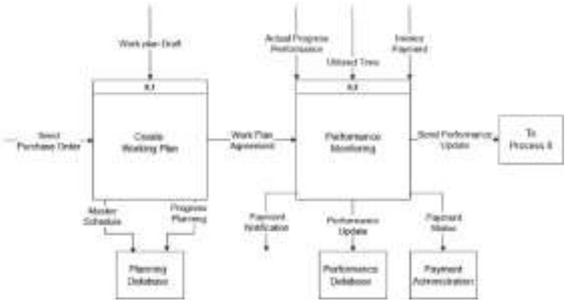

Figure 14. Proposed DFD Process 8.1 & 8.2

Process 8 comprises "Create Working Plan" (8.1) and "Performance Monitoring" (8.2). In version 8.1, the system utilizes the Purchase Order and Work Plan Draft to generate a Work Plan Agreement, which is archived in the Planning Database as the project's execution reference. In section 8.2, actual performance is evaluated against the plan utilizing data like progress, time utilization, and invoice status. Results are archived in the Performance Database and influence payment processing and subsequent assessments.

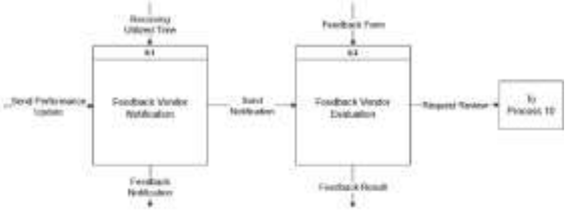

Figure 15. Proposed DFD Process 9.1 & 9.2

Process 9 encompasses Feedback Vendor Notification (9.1) and Feedback Vendor Evaluation (9.2). The system dispatches a feedback request to construction personnel based on performance and temporal data. In section 9.2, submitted evaluations are assessed to produce a Feedback Result, which informs vendor performance enhancement and future procurement choices.

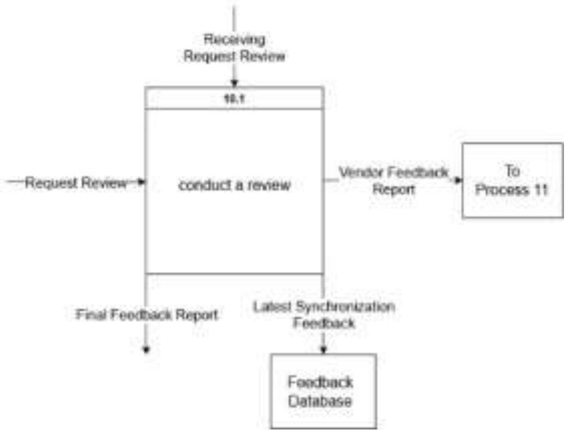

Figure 16. Proposed DFD Process 10.1

Process 10, Conduct a Review (10.1), is commenced by procurement personnel upon receipt of a vendor performance review request. Personnel assess the Vendor Feedback Report to guarantee impartial evaluation. The outcome is a Final Feedback Report containing conclusions and recommendations, archived in the Feedback Database for future reference.

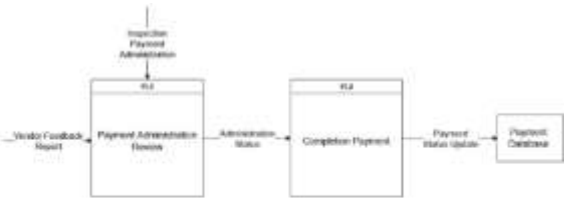

Figure 17. Proposed DFD Process 11.1 & 11.2

The final stage, Payment (Process 11), begins with Payment Administration Review (11.1), where vendor feedback and administrative data are validated. Once approved, the process continues to Completion Payment (11.2), issuing a Payment Status Update recorded in the Payment Database. This ensures payment traceability and transparency. The analysis of all eleven processes in the DFD illustrates a coherent and implementable system flow, integrating all activities from login to final payment.

Integration of the DFD with the Context Diagram , showed in figure 4.15, clarified interactions between external entities and internal processes. This structured approach enables thorough analysis of user information needs, improving the accuracy of the system design.

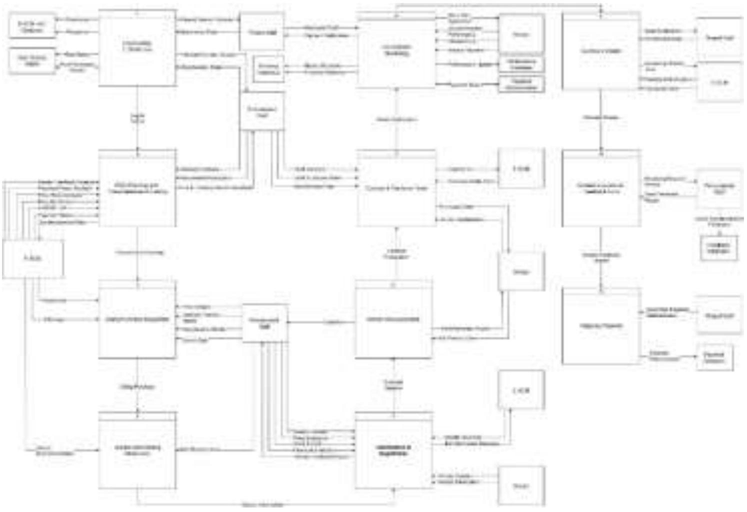

Figure 18. Summary DFD Process

The subsequent phase in the development of the information system is the design of the Entity-Relationship Diagram (ERD). After identifying the entities, the subsequent stage is to ascertain the attributes for each entity, which delineate the types of information that must be stored—such as Company Name, Staff ID, FeedbackID, or PaymentTAID. Figure 19 illustrates an example of the identified key items.

E-SCM User
Staff ID
Role ID
Username
Password
Staff Name
Role Name
Role Permission

Vendor
Vendor ID
ExtSAPID
NPWP
CompanyName
ContactInfo
Qualification

Figure 19. Sampling Entity Identification

Foreign key qualities are established according to the relationships among entities. The VendorID in the Contract Catalog serves as a foreign key connecting it to the Vendor object. The relationship is depicted in Figure 4.17.

	E-SCM User
PK	**Staff ID**
FK	Role ID
	Username
	Password
	Staff Name
	Role Name
	Role Permission

	Vendor
PK	**Vendor ID**
	ExtSAPID
	NPWP
	CompanyName
	ContactInfo
	Qualification

Figure 20. Sampling Primary Key & Foreign Key Identification

The third stage in constructing the ERD is delineating linkages and cardinality among entities. Figure 4.19 below depicts the interrelations among three principal entities: Report on Users, Vendors, and Vendor Feedback.

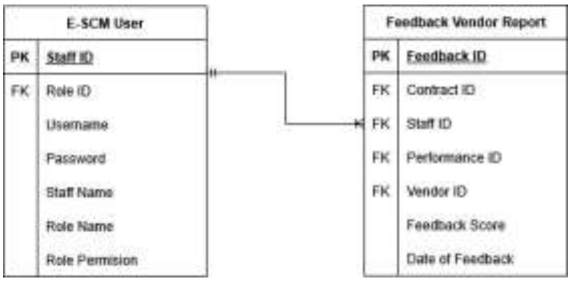

Figure 21. Sampling Entity Relationship

The Feedback Vendor Report entity possesses a many-to-one link with both the User and Vendor entities. A single user may submit many feedback entries, while a single seller might get feedback from numerous users.

Comprehensive ERD has been meticulously crafted to depict the relationships among all entities within the system. Figure 4.20 illustrates the data structure and the relationships among entities, derived from the previously established primary and foreign keys. This diagram functions as the principal reference for constructing a cohesive and uniform database architecture.

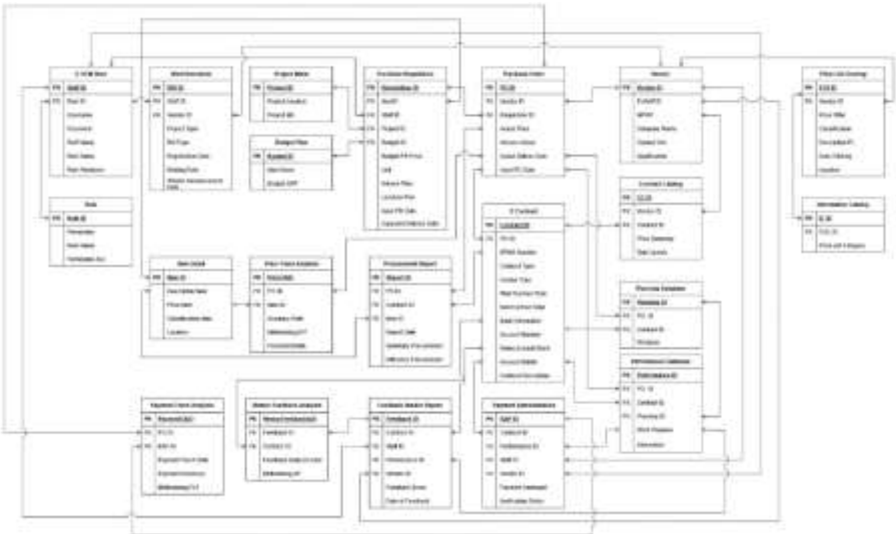

Figure 22. Proposed ERD

The concluding phase in database design is the normalization procedure, which guarantees efficient data storage devoid of redundancy. Normalization has three primary stages: First Normal Form (1NF), Second Normal Form (2NF), and Third Normal Form (3NF).

In first normal form (1NF), all characteristics within a table must possess atomic values, meaning there are no repeating groups, and the domains must be consistent. In Second Normal Form (2NF), all non-key attributes must exhibit full functional dependence on the primary key, indicating the absence of partial dependency on any subset of a composite key. In Third Normal Form (3NF), transitive dependencies are prohibited; non-key characteristics must not rely on other non-key elements.

In the context of the ERD depicted in Figure 4.21, the entities User, Vendor, and Feedback Vendor Report adhere to all three regular forms. In 1NF, each object comprises non-redundant, atomic properties, including Username, NPWP, and Feedback Score. In 2NF, all properties such as Role Name, Company Name, and Date of Feedback are entirely dependent on their corresponding main keys (Staff ID, Vendor ID, and Feedback ID). In Third Normal Form (3NF), transitive dependencies are absent; for example, Role Permission is contingent upon Staff ID rather than Role Name. By satisfying the criteria of 1NF, 2NF, and 3NF, this data structure is deemed stable, efficient, and prepared for deployment within the database management system.

	E-SCM User	1 NF	2 NF	3 NF
PK	**Staff ID**			
FK	Role ID			
	Username			
	Password	V	V	V
	Staff Name			
	Role Name			
	Role Permission			

	Vendor	1 NF	2 NF	3 NF
PK	**Vendor ID**			
	ExtSAPID			
	NPWP			
	CompanyName	V	V	V
	ContactInfo			
	Qualification			

Figure 23. Database Normalization

CONCLUSION

The investigation reveals that E-SCM procurement management in construction can be enhanced by addressing data fragmentation, manual entry, and lack of predictive features through SDLC methodology, implementing a unified pricing database, automated e-procurement data entry, and vendor evaluation integration. This design meets procurement planning, execution, and assessment needs via data flows outlined in context diagrams, DFDs (levels 0–2), and ERDs, with Third Normal Form normalization ensuring database integrity and performance. Integrated modules for price catalogs, vendor feedback, contracts, and invoicing enable a streamlined, data-driven process. For future research, exploring AI-driven predictive analytics and blockchain for real-time supplier performance tracking and contract transparency could further optimize construction supply chains, building on these foundational improvements.

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