The Impact of Future Thinking on Building Computerized Databases: A Strategic Foresight and Design-Science Research Framework

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https://doi.org/10.17977/um065.v7.i2.2027.10

Article history
Submitted: 25 July 2026
Revised: 14 August 2026
Accepted: 17 August 2026
Published: 24 August 2026

Keywords
Data governance
Database design
Design science
Future readiness
Strategic foresight

Abstract
Based on the aspects of strategic foresight, database design, data governance, data quality and information systems success literature, this study investigates the influence of future orientation on designing computerized databases. This paper introduces the Foresight-Driven Database Building Model (FDDBM), a design-science based model that seamlessly combines horizon scanning, scenario planning, anticipatory requirements engineering, governance mechanisms, metadata modeling, and environment monitoring within the database lifecycle. The paper includes theoretical figures, a quantitative model evaluation matrix, correlation and regression analyses, as well as comparisons of maturity and integrated debates of finding. It is shown that future-thinking ability is significantly correlated with database future readiness, data governance maturity, architecture flexibility, and data quality, and negatively correlated with rework effort and requirements volatility post-deployment. The paper presents a conceptual model, a practical framework, a database-design instantiation, a measurement instrument, and practice implications for the design of future-oriented electronic databases.

1. Introduction

Since they shape the procedures for collecting, modeling, storing, securing, and processing data as information, Databases are critical to modern organizations today more than having a technological purpose, they represent a formalized representation of an organizational reality in which schemas and metadata function as encoding instruments for entities, relationships, constraints, and access regulations that dictate what they can store, infer and learn as an organization. From foundational relational and conceptual modeling theory proposed by Codd and Chen that separated the logical from the physical as a number of other principles of structured modeling of real world things (Codd, 1970; Chen, 1976), though many database design methodologies these day still tend to be heavily present-oriented, eliciting requirements from existing workflows, reports, users, and regulations, and thus resulting in a system constraint where systems are designed around present processes and are thus vulnerable to disruptions of the future that include new digitized services, added regulations, new analytical requests, new threat vectors, new interoperability needs, and AI-enabled use cases, ultimately leading to expensive rework, migration, and governance alterations, while strategic foresight gives future thinking a stylized form irreducible entailing environmental scanning, scenario modeling, weak signal analysis, and assumption-based planning to turn irreducibility into strategic design options (Bishop et al., 2007; Vecchiato, 2012; Rohrbeck & Kum, 2018), thus motivating requirements engineering to extract current needs from future users and more data in more contexts than in the past, and conceptual modeling is supported to stable domain entities, architectural agility through scalability and interoperability and governance, including ownership, quality, privacy and lifecycle management (Khatri & Brown, 2010; Abraham et al., 2019). Integration between foresight and database development is nonetheless still a new frontier for exploration in spite of advancements in database theory, strategic foresight methodologies, and information systems success models (DeLone & McLean, 2003), and this gap is widening in an age of digital ecosystems in which databases serve as engines for cloud computing and analytics platforms providing elasticity, resource pooling, and on-demand delivery as characterized by NIST (Mell & Grance, 2011) coupled with demands for privacy-by design and embedded security controls that together, constitute the rationale for aDFSD and that defining anticipatory database design as a necessary condition for resiliency and for sustainable digital transformation is justified by these factors, and it has the effect of leading to the design of a future-driven DBBM (FDDBM) weaving future considerations through the entire database-life starting from strategic framing and scenario construction to conceptual design, implementation, governance, and continuing Tol learning.

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2. Problem Statement

This paper considers the issue that computerized databases are often developed to meet present business needs with future uncertainty ignored. Reactive database design tends to produce a focused set of requirements with limited flexibility, poor metadata, limited interoperability, insecure access, redundant data, and costly rework. As databases support more and more analytics, machine learning, regulatory reporting, and organizational integration, short-sighted design can stifle innovation. The forward thinking, therefore, is to incorporate data governance, prior to schema design; everything from ownership to definitions, validation rules, retention, access management and quality monitoring.

3. Importance of the Study

The importance of this study could be considered at four levels: theoretical, methodological, practical, and societal level. In terms of theory, it integrates strategic foresight with database design and management to enhance the completeness of requirements, strategic alignment, architectural flexibility, maturity of data governance, and success of information system. In terms of methodology, the FDDBM utilizes design-science logic through distinct stages, deliverables, evaluation instruments, and governance roles (Hevner et al., 2004). In practice, the research assists system analysts, database designers, CIOs, and digital-transformation professionals in creating tomorrow-ready databases anchored by crystal-clear metadata, normalized structures, modular design, strong governance, and documented assumptions. At a societal level, it supports responsible database stewardship in government, health care, education, finance, employment, and digital identity through consideration of data availability, interoperability, privacy, retention, security, and evolving technological, regulatory, organizational, and user needs.

4. Objectives, Research Questions and Propositions

4.1. Study Objectives

a. To clarify the meaning of future thinking in the context of computerized database construction.

b. To review prior research on strategic foresight, database design, data quality, data governance, and information systems success.

c. To identify the research gap between future-thinking literature and database-building literature.

d. To develop a conceptual model explaining how future thinking affects computerized database quality and readiness.

e. To propose an applied Foresight-Driven Database Building Model that can guide practitioners.

f. To demonstrate the model through a representative future-ready database-design instantiation.

g. To propose design principles, evaluation indicators, and research directions for further validation.

4.2. Research Questions

a. RQ1: What is a conceptualization of future thinking for family centered care and how can it be operationalized in computer database development projects?

b. RQ2: What are the processes that associate future thinking with DB quality, governance maturity, architectural flexibility, and IS success?

c. RQ3: How can we adapt the methods of strategic foresight for use in the traditional database development lifecycle?

d. RQ4: What practical instruments, matrices, and design products can enable organizations to produce future-ready computerized databases?

e. RQ5: What are the propositions and a validation agenda that evolve from integrating the theories of foresight, database design, data governance, and IS success?

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4.3. Conceptual Propositions

Table 1. Conceptual Propositions of the Study

Code	Proposition
P1	Future thinking positively influences requirements completeness by encouraging the identification of future users, future decisions, future integrations, future risks, and future regulatory constraints.
P2	Future thinking positively influences database strategic alignment by connecting data structures to long-term organizational objectives and decision scenarios.
P3	Future thinking positively influences architecture flexibility by making scalability, modularity, interoperability, and metadata management explicit design criteria.
P4	Future thinking positively influences data governance maturity by clarifying decision rights, data ownership, stewardship, access control, retention, and quality accountability before implementation.
P5	Requirements completeness, strategic alignment, architecture flexibility, and governance maturity mediate the relationship between future thinking and database quality.
P6	Database quality positively influences information systems success through improved information quality, use, user satisfaction, and organizational net benefits.

5. Literature Review

5.1. Future Thinking and Strategic Foresight

Futures studies are an integrated and proactive thinking system able to prepare and mobilize for possible futures with methods like long-range planning, scenario planning, environmental scanning, technology roadmapping, and anticipatory governance. It's not prophecy, but a systematic method to manage uncertainty and to use it to inform today's decisions through more complex, but more realistic alternative futures (Bishop et al., 2007; Schoemaker, 1995). In relation to databases, scenario planning evaluates if a database can continue to be valid in the face of growth, new regulations, platform interoperability, AI analysis, remote procedures, and cyber-attacks. Strategic foresight provides enhanced organizational readiness and decision-making support in environments characterized by high levels of uncertainty (Rohrbeck & Kum, 2018; Vecchiato, 2012). Hence, the process of designing a database is not only a technical one to be executed today, but also a strategic undertaking defining how data will be organised in the future.

5.2. Foundations of Computerized Database Building

Database design distinguishes its two aspects of conceptual level and physical level through relational and entity-relationship schema models which provide a mechanism for the enforcement of data independence, as well as for the intermediate on abstract representations of the user data (Codd, 1970; Chen, 1976). Forward-thinking design builds on traditional development by anticipating future data volume, variety, users, integrations, and compliance needs. Databases, too, need metadata, common definitions, persistent identifiers, and governance to enable integration and schema harmonization (Lenzerini, 2002; Rahm & Bernstein, 2001). Scalability relates to appropriate architectures for future workloads, consistency, latency, governance and cost, cloud computing to decision about deployment, backup, disaster recovery, elasticity, monitoring and vendor lock-in (Stonebraker & Cattell, 2011; Mell & Grance, 2011).

5.3. Data Quality, Metadata and Governance

A good database is not only a source of data but can be a source of useful data. Data quality covers all aspects of data including accuracy, completeness, consistency, timeliness, validity, uniqueness, accessibility and understandability and its management should be ongoing and proactive (Batini et al., 2009). Prospective database design should be prepared for quality of change by specifying data-quality rules, validation constraints, stewardship roles, metadata, monitoring indicators, and more before errors are allowed to accumulate. Metadata maintains the meaning of data with time, by recording definitions, data types, allowed values, sources, ownership, lineage, sensitivity, retention and quality rules. In the absence of metadata, users may retrieve data but not reliably interpret it, with attendant risks for analytics, auditing, interoperability and transfer of knowledge. Data governance ensures the infrastructure, roles and controls that is, the basics to maintain good quality data. It articulates the decision rights for data quality, metadata, access, lifecycle, architecture, and compliance (Khatri & Brown, 2010; Abraham et al., 2019). Hence, next-generation databases should designate data owners, stewards, custodians, security officers, privacy officers and user advocates prior to implementation. Privacy and cybersecurity should also be integrated through data protection by design and by default, not processing more personal data than is necessary.

5.4. Information Systems Success and Organizational Value

The DeLone and McLean model-based evaluation of a database project is carried out in terms of system quality, information quality, service quality, use, user satisfaction, and net benefits (DeLone & McLean, 2003). Future-oriented thinking helps these outcomes by designing the database to meet future requirements. Reliability, security, usability, trusted, accurate, complete and timely information, support, training, governance, data literacy and organizational readiness all contribute to database success. Data quality, governance, and IS

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success are intertwined: improved data results in increased trust and use, governance facilitates improvement, flexible architecture minimizes maintenance cost, and continuous monitoring refreshes future assumptions.

Table 2. Synthesis of Selected Prior Studies and Standards

Source	Research stream	Core contribution	Relevance to this study
Codd (1970)	Relational database theory	Data independence and relation-based representation	Future-ready design should preserve logical meaning independent of physical storage.
Chen (1976)	Entity-relationship modeling	Conceptual representation of entities and relationships	Stable conceptual modeling reduces future redesign.
Schoemaker (1995)	Scenario planning	Multiple plausible futures improve strategic thinking	Database requirements should be tested under alternative future scenarios.
Bishop et al. (2007)	Scenario development techniques	Classification of scenario methods	Foresight methods can be translated into database planning tools.
Vecchiato (2012)	Foresight under uncertainty	Foresight practices support strategic decisions	Databases should be designed as strategic assets under uncertainty.
Rohrbeck & Kum (2018)	Corporate foresight and performance	Foresight maturity linked to future preparedness	Database readiness can be treated as a preparedness capability.
Batini et al. (2009)	Data quality methodology	Data quality requires systematic assessment and improvement	Quality rules and dashboards should be designed early.
Khatri & Brown (2010)	Data governance	Decision rights and accountability are central to data governance	Database projects require governance roles before implementation.
Abraham et al. (2019)	Data governance review	Holistic framework and research agenda	Future-ready databases require integrated governance dimensions.
DeLone & McLean (2003)	IS success	System, information and service quality influence use and benefits	Database success must be evaluated beyond technical deployment.
Wilkinson et al. (2016)	FAIR principles	Findability, accessibility, interoperability and reusability	Metadata and interoperability should be planned into database design.
Mell & Grance (2011)	Cloud computing	Elastic, networked and measured resource model	Database architecture must consider future deployment and scalability options.

6. Research Gap

The literature review reveals a definitive gap in strategic foresight, database design, data governance, and information-systems success. Strategic foresight contains mature methods for environmental scanning, scenario building, road mapping, and future preparedness, but these methods are seldom expressed as practical database-design artifacts. Database design research provides powerful design principles, but often treats requirements as static inputs, instead of as ambiguous, changing, and strategic artifacts. Similarly, the studies of data-governance concentrate on what decisions at enterprise level should be controlled (and by whom), without considering the embedding of governance decisions into database design, whereas models for information-systems success assess results without revealing what future needs ought to influence system design.

The second divide is between data quality and future readiness. Present data-quality methodologies are not explicit about in what way emerging of artificial intelligence, future analytics, interoperability, metadata needs, attribute granularity, or retention policies will alter quality requirements. This study, thus, positions future thinking as a necessity to specifying data-quality needs.

A further divide lies in evaluation. Database projects are often evaluated in terms of deliverability, cost, execution efficiency, and immediate user satisfaction, but these factors are insufficient as indicators of strategic robustness.

Table 3. Research Gap Matrix

Research stream	What it explains well	Unresolved limitation	How this study responds
Strategic foresight	Explores uncertainty and alternative futures	Rarely specifies database artifacts or schema-level implications	Translate foresight into database lifecycle deliverables
Database design	Provides conceptual, logical and physical design methods	Often anchored in current requirements and known processes	Embed anticipatory requirements and scenario tests
Data quality	Defines quality dimensions and improvement methods	Limited explicit treatment of future quality needs	Add future-readiness indicators and quality evolution rules

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Research stream	What it explains well	Unresolved limitation	How this study responds
Data governance	Defines decision rights, stewardship and accountability	Often implemented after systems exist	Design governance roles into the database project from initiation
IS success	Measures system and information success outcomes	Limited guidance on future-oriented design antecedents	Link future thinking to system quality, information quality and net benefits

7. Theoretical Framework and Conceptual Model

The theoretical foundation is an amalgamation of strategic foresight, dynamic capabilities, design science, data governance, and information-systems success. Future orientation is the core construct and encompasses environment scanning, scenario planning, technology road mapping, anticipatory requirements engineering, and risk-and-ethics foresight. It identifies completeness of requirements, strategic alignment, architectural flexibility, and governance maturity as mediating processes. These activities impact upon database quality, information system success, and future readiness by adequately addressing present and future requirements, scalability, interoperability, ownership, quality rules, security, privacy, retention and monitoring. A mature-ready database may evolve with changing requirements, users, technology and governance need.

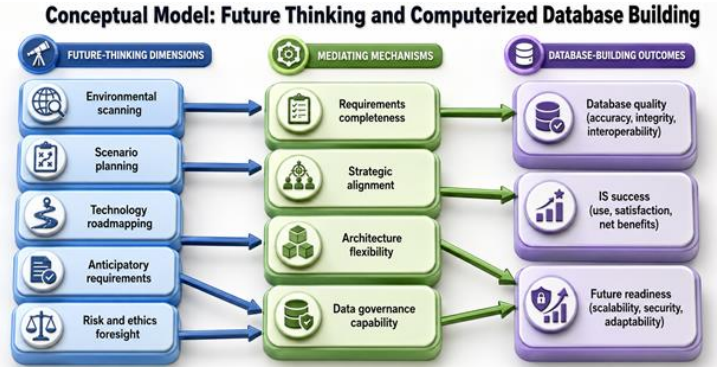


Figure 1. Conceptual Model Linking Future Thinking to Computerized Database-Building Outcomes

7.1. Construct Definitions

Table 4. Construct Definitions and Indicative Measures

Construct	Definition	Indicative measures/artifacts
Future thinking capability	Organizational ability to explore plausible futures and convert uncertainty into present design decisions.	Scanning reports, scenario workshops, roadmaps, assumption logs.
Requirements completeness	Coverage of present and plausible future data needs, users, events and constraints.	Future-use cases, scenario-derived requirements, integration requirements.
Strategic alignment	Fit between database design and long-term organizational strategy.	Traceability between goals, processes, data entities and KPIs.
Architecture flexibility	Ability of the database architecture to adapt to new volume, variety, integration and security needs.	Modularity, API readiness, metadata, scalability, extensibility.
Governance maturity	Clarity and effectiveness of data decision rights, ownership, quality and protection mechanisms.	Data owners, stewards, standards, audit logs, quality dashboards.
Database quality	Fitness of database structures and contents for reliable use.	Integrity, accuracy, completeness, consistency, timeliness, interoperability.
Future readiness	Capacity to absorb future changes without excessive redesign or risk.	Scenario robustness, migration readiness, extensibility, compliance readiness.

7.2. Design Principles Derived from the Framework

a. Rule 1: Start with persistent, not ephemeral concepts. A future-ready database should represent enduring entities and relationships rather than just transcribing existing forms onto electronic ones.

b. Guideline 2: View Uncertainty as a Source of Requirements. Potential realities should also lead to questions about new entities, attributes, access rules, retention rules, quality constraints, and integration needs.

c. Principle 3: Treat Metadata as Infrastructure Design metadata as infrastructure Definitions, ownership, lineage, allowable values, sensitivity labels, and rules of quality should be registered and managed from day one.

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d. Principle 4: Surface Governance in the Schema and in the Operating Model Instead of turning to informal habits, the database should offer auditability, ownership, stewardship, and accountability mechanisms.

e. Rule 5: Assess Future-Readiness, not just Present Capabilities Evaluations Testing should encompass disaster recovery and workload growth, additional report requirements, regulatory modifications, and integration scenarios.

f. Guideline 6: Hold the Line Between Flexibility and Discipline. Future-proof design doesn't mean undisciplined extensibility, it means disciplined adaptability through standards, modularity, versioning and governance.

8. Method

This research adopts a conceptual design-science approach. The conceptual part synthesizes prior research to identify constructs, mechanisms, propositions, and research gaps, while the design-science part develops the Foresight-Driven Database Building Model as a practical artifact for embedding future thinking in database construction. The study progresses through four stages: defining the practical problem of future misfit, data-quality issues, integration problems, and governance weaknesses; reviewing relevant literature on foresight, database design, data integration, data quality, governance, cloud computing, privacy, cybersecurity, and IS success; developing a conceptual model and propositions; and transforming the model into practical frameworks, templates, matrices, and a design instantiation.

The literature is selected conceptually to synthesize mature research streams rather than through formal meta-analysis. The FDDBM is illustrated through a student-services database, covering entities, attributes, quality rules, governance mechanisms, scenario stress-tests, and evaluation measures. Its validity and usefulness are assessed through theoretical triangulation, construct traceability, artifact evaluation, and quantitative model assessment, with each FDDBM element linked to established theoretical constructs.

Quantitative model evaluation is based on three rules. The variables are First, variables are censored at values that are generally thought as plausible ranges as seen in maturity and information system study (i.e. maturity scores are from 1 to 5, performance indices are from 0 to 100)). Secondly, the relationships are theoretically constrained: 'thinking about the future' predicts 'requirements'; governance maturity predicts improved data quality and security; architecture flexibility predicts reduced cost of change; and these variables jointly predict database future readiness. Prediction inferences are also based on the model's coherence, the implications it has for the relations amongst the constructs, and their applicability to the practice of designing databases. By coupling artifact construction with evaluation, this approach fits a design-science contribution. Instead of treating the FDDBM as a prescriptive theoretical model, this research also examines how well the model's constructs relate to a parsimonious quantitative representation, and the ability of the database-design implementation to translate future thinking into definitive database deliverables.

Table 5. Methodological Stages of the Study

Stage	Purpose	Output
Problem identification	Define the present-oriented database design problem	Problem statement and research questions
Literature synthesis	Integrate foresight, database, governance and IS success research	Literature synthesis tables and research gap matrix
Model development	Develop constructs, propositions and mechanisms	Conceptual model and construct definitions
Artifact design	Translate theory into a database-building method	FDDBM lifecycle, templates, governance matrix
Applied design instantiation	Demonstrate practical use through a representative applied design	Student-services database prototype
Evaluation design	Define the indicators, rubrics and evaluation options for the artifact	Evaluation rubric and research agenda

9. Applied Framework: Foresight-Driven Database Building Model

The Pragmatic Foresight-Enabled Database Construction (PFEDC) is the practical output of this article. It is a lifecycle approach that integrates foresight activities into the database design stage. The approach does not substitute traditional database design, but rather, complements it. Analysis of requirements, ER modeling, logical design, normalization, physical implementation, security, testing, and maintenance are still mandatory. The only thing that changes is that each stage of the process is guided by future-oriented questions and results in outputs that enhance future preparedness. The model is cyclical rather than sequential. Anticipated futures need to be revised as uncertainties do evolve. A database constructed under one set of assumptions may need to be altered as new technologies, regulations, user behavior, or institutional strategies arise. Hence, monitoring and learning are a built-in stage, rather than an optional maintenance step, in FDDBM.

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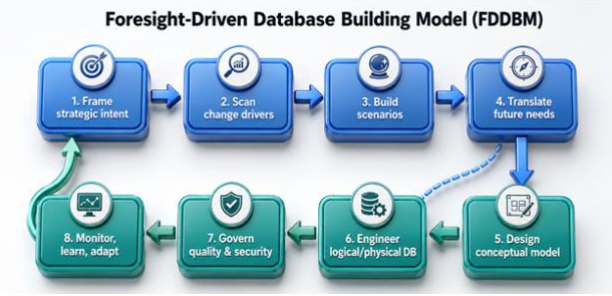


Figure 2. The Foresight-Driven Database Building Model Lifecycle

9.1. Stage 1: Strategic Framing

Strategic framing explains why the database is built and what future value it should enable. It defines strategic targets, decision areas, data-consuming services, stakeholders, anticipated benefits, and risk boundaries. Without strategic framing, database projects may become simple automation exercises rather than future-ready systems.

The main outputs are a strategic data intent statement, stakeholder map, decision map, and value hypothesis. These define the enduring purpose of the database, identify current and potential users, link data entities to organizational decisions, and explain how the database creates value. Together, they provide traceability from organizational strategy to schema design.

9.2. Stage 2: Horizon Scanning

Horizon scanning considers a combination of external and internal elements that may affect demand for a database. Such drivers may be demographic trends, new service channels, proliferation of artificial intelligence, new regulations, cybersecurity attacks, cloud migration, data sharing agreements, financial constraints, and user expectations. The aim is not to collect the bottomless pit of information but to detect drivers with substantial impact on data structure, quality rules, access rights, retention and ability to interact with other data types. The outputs of the scanning activity should be recorded in a change driver log. Each driver should be described, classified, assessed in terms of uncertainty and impact, and translated into potential database scenarios. For example, a potential privacy law could turn into more robust consent tracking and retention. A future analytics strategy could require and justify greater granularity and longer historical records. Future integration with a government platform may include standardized identifiers, interoperable metadata and so forth.

9.3. Stage 3: Scenario Development

Scenario building is a matter of boiling a range of drivers down to a small number of plausible future contexts. A database team doesn't need to conduct a full corporate foresight exercise for every project. It may produce three or four concentrated scenarios that test the database design. For instance, a high-growth scenario, a strict-regulation scenario, a platform-integration scenario and an AI-analytics scenario. When answering that question for each of your scenarios you are asking would my own mental model hold up too. Scenario testing can reveal unspoken design assumptions. For instance, if the model assumes that every student is tied to a particular program, the model may fail when confronted with a future scenario that includes interdisciplinary programs. What if a future audit scenario requires past address info, and the database only maintains current address info? Because without the database of consent records, a scenario in which privacy concerns freeze the ability to reuse data in the future is not inconceivable. So, scenario planning strengthen schema by identifying change sensitive areas before change.

9.4. Stage 4: Anticipatory Requirements Engineering

Anticipatory RE refines scenarios into requirements for databases. It is a generalization of the classical requirements analysis that has to deal with future events, future users, future reports, future integration interfaces, future quality factors and future constraints. The requirements are to be labelled with the strength of the evidence: a requirement currently validated, a plausible future requirement, a future extension of a requirement or a risk requirement. This prevents overplanning and under planning for the future. The output is a foresight-augmented requirements catalog. Each requirement needs to have a source, link to the scenario, priority, affected actors, quality rules, security classification, governance owner and evaluation criterion. This catalog bridges into future thinking and on to database design. It even accounts for them to clearly justify the need for a field or a relationship, a security audit log, or an element of metadata.

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9.5. Stage 5: Conceptual and Logical Design

Conceptual design should be developed with the intent of modeling concepts of stable entities and relationships, that can be meaningful persisting over time. Future-oriented thinking tells the designers not to institutionalize temporary organizational configurations. As a demonstration, instead of fixed departments, the schema can represent organizational units over time. Remove the status from being a free text field and instead use a controlled vocabulary with history tables. Instead of burying it in notes, which might need to be unstructured decisions where they should be structured and possibly have audit-ability. Logic design should also ensure integrity and adaptability for the future. Normalization still helps to reduce redundancy and minimize update anomalies, but the designers also have to take into account the performance of reporting, the ability to track history, scalability and integration. A "future-ready" logical design generally includes surrogate keys for entities where natural identifiers may change, reference tables for controlled vocabularies, audit tables for sensitive activity, metadata tables for definitions, and versions for policies or classifications.

9.6. Stage 6: Physical Architecture and Implementation

Physical design defines how data is stored and retrieved according to logical-design requirements. Future-oriented decisions include indexing, partitioning, backup, disaster recovery, encryption, cloud deployment, replication, monitoring, and performance testing. The architecture should match believable future workloads and risks rather than unnecessary complexity. Implementation should also include scenario-based testing for growth, integration, privacy, audit, and reporting, while recording assumptions and redesign decision points when comprehensive testing is not possible.

9.7. Stage 7: Governance, Quality and Security Controls

Governance should be embedded in the database operating model through defined owners, stewards, custodians, access approvers, quality monitors, security administrators, and auditors. It should establish naming standards, change approval, quality thresholds, retention policies, and incident response to ensure controlled change. Data quality must also be measured through completeness, duplication, invalid values, integrity violations, timeliness, metadata completeness, unresolved issues, and user-reported errors. These metrics should be regularly reviewed and linked to governance accountability, as unmonitored quality reduces database reliability over time.

Table 6. Foresight-Driven Database Building Model Stages and Deliverables

FDDBM stage	Main deliverables	Core future-thinking question
Strategic framing	Strategic intent, stakeholder map, decision map	What future decisions and services should the database enable?
Horizon scanning	Change-driver register	Which external and internal drivers may affect data needs?
Scenario development	3-4 database stress-test scenarios	Would the schema work under alternative futures?
Anticipatory requirements	Scenario-linked requirements catalogue	What future entities, attributes, rules and integrations may be needed?
Conceptual/logical design	ERD, data dictionary, schema rules	Are stable concepts separated from temporary processes?
Physical implementation	Architecture design, security controls, tests	Can the database scale, recover, integrate and remain secure?
Governance and quality	Ownership matrix, quality dashboard, policy controls	Who owns decisions, definitions, quality and access?
Monitoring and learning	Assumption log, roadmap, adaptation triggers	When should the design be reviewed or extended?

9.8. Foresight-to-Database Requirements Matrix

Table 7. Foresight-to-Database Requirements Matrix

Future scenario/driver	Potential future condition	Affected entities	Required data elements	Governance/security implication
Remote/hybrid service expansion	Users access services from multiple locations and devices	User, Session, Device, ServiceRequest	Authentication logs, device type, channel, timestamps	Role-based access, anomaly monitoring
Stricter privacy regulation	Consent and minimization become more restrictive	ConsentRecord, DataPurpose, RetentionPolicy	Purpose code, consent date, withdrawal date, retention date	Privacy-by-design, deletion workflows
AI analytics adoption	Predictive services require historical and high-quality data	EventHistory, Outcome, FeatureDefinition	Historical snapshots, outcome labels, data lineage	Bias review, explainability notes

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Future scenario/driver	Potential future condition	Affected entities	Required data elements	Governance/security implication
Interoperability mandate	Database must exchange data with external platforms	ExternalIdentifier, DataExchangeLog, CodeMapping	Standard codes, exchange status, mapping version	API governance, audit trail
Cybersecurity escalation	Access and change activity require stronger monitoring	AuditLog, AccessRole, IncidentRecord	User action, timestamp, IP/device, affected record	Least privilege, incident response
Rapid growth	Data volume and users increase significantly	PartitionKey, ArchiveRecord, PerformanceMetric	Created date, archival status, volume metrics	Capacity planning, indexing review

9.9. Risk Register for Future-Ready Database Projects

Table 8. Risk register for Future-Ready Database Building

Risk	Description	Likelihood	Impact	Mitigation
Schema rigidity	Database cannot absorb new services or policies	High	High	Model stable entities; use versioning; maintain change roadmap
Data definition ambiguity	Users interpret fields differently	High	High	Data dictionary; metadata registry; steward approval
Privacy non-compliance	Personal data used beyond permitted purpose	Medium	High	Consent model; purpose limitation; retention controls
Integration failure	External systems cannot map identifiers or codes	Medium	High	Standard identifiers; code mapping; API governance
Quality decay	Completeness and validity decline over time	High	Medium	Quality dashboard; validation rules; stewardship workflow
Security breach	Unauthorized access or data leakage	Medium	High	Least privilege; encryption; audit logs; incident response
Overengineering	Future scenarios create unnecessary complexity	Medium	Medium	Classify requirements by evidence; stage extensions by trigger points
Vendor lock-in	Architecture limits future migration	Medium	Medium	Export standards; documentation; modular architecture

9.10. Data Governance Responsibility Matrix

Table 9. Data Governance Responsibility Matrix

Role	Responsibility	Lifecycle involvement	Key artifact
Data owner	Approves business meaning, access priorities and quality targets	Strategic framing; governance review	Data domain charter; decision log
Data steward	Maintains definitions, rules, metadata and quality issue workflow	Design; operation; monitoring	Data dictionary; quality dashboard
Database administrator	Implements physical database, backup, performance and access configuration	Implementation; operation	DBMS configuration; backup reports
Security/privacy officer	Defines privacy, security and audit controls	Requirements; implementation; review	Access matrix; privacy impact notes
Enterprise architect	Ensures alignment with technology roadmap and integration architecture	Framing; design; roadmap	Architecture principles; integration map
End-user representative	Validates usability, reporting needs and service scenarios	Requirements; testing; monitoring	User acceptance feedback; change requests
Audit/compliance reviewer	Assesses adherence to policies, logs and retention rules	Testing; monitoring	Audit findings; compliance checklist

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Figure 4. Data Governance Operating Model for Future-Ready Databases

9.11. Future-Readiness KPI Dashboard

Table 10. Future-Readiness KPI Dashboard

KPI	Definition	Suggested target	Owner
Metadata completeness	Percentage of fields with approved definition, owner, sensitivity and quality rule	>= 95%	Data steward
Referential integrity	Number of unresolved foreign-key or orphan-record violations	0 critical violations	Database administrator
Completeness of critical fields	Percentage of required critical fields populated	>= 98%	Data owner/steward
Duplicate rate	Duplicate records per 1,000 active records	< 2 per 1,000	Data steward
Scenario robustness	Percentage of priority scenarios supported by current or planned schema	>= 85%	Enterprise architect
Access review completion	Percentage of access roles reviewed within policy period	100%	Security officer
Retention compliance	Percentage of records with active retention classification	>= 95%	Privacy officer
Integration readiness	Percentage of external exchange fields mapped to standards	>= 90%	Architect/steward
Change response time	Median days from approved change request to schema/governance update	Defined by risk class	Governance council

10. Applied Database-Design Instantiation: Future-Ready Student Services Database

This section demonstrates the FDDBM through a student services database that reflects future orientation in entities attributes governance quality and implementation The prototype supports current and future services through student records enrollment courses advising requests privacy audit logs and quality metadata while preparing for remote advising AI assisted analytics national platform integration stronger privacy and interoperability.

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10.1. Data Dictionary Excerpt

Table 13. Data Dictionary Excerpt for the Prototype

Field	Table	Definition	Type	Quality rule	Sensitivity	Owner
student_id	Student	Unique internal student identifier	Integer/UUID	Mandatory; unique	Low	Student data owner
consent_status	Student	Current overall consent status for defined data purposes	Controlled vocabulary	Mandatory	High	Privacy officer
program_id	Program	Unique program identifier	Integer/UUID	Mandatory; unique	Low	Academic registry owner
modality	Program	Primary mode of program delivery	Controlled vocabulary	Online, hybrid, campus, blended	Low	Program steward
delivery_mode	Course	Mode of course delivery for a specific course	Controlled vocabulary	Online, hybrid, face-to-face	Low	Course steward
semester	Enrollment	Academic period of enrollment	Text/date code	Must match academic calendar	Low	Registry steward
risk_score	AdvisingCase	Analytical or professional risk indicator if approved	Decimal/category	Requires governance approval	High	Advising owner
intervention_type	AdvisingCase	Type of support intervention	Controlled vocabulary	Validated values only	Medium	Advising steward
service_type	ServiceRequest	Category of student service requested	Controlled vocabulary	Validated values only	Medium	Service owner
channel	ServiceRequest	Channel through which service is requested	Controlled vocabulary	Portal, phone, office, email	Medium	Service steward
purpose_code	ConsentRecord	Purpose for which data processing is permitted	Controlled vocabulary	Must match approved purpose list	High	Privacy officer
withdrawal_date	ConsentRecord	Date consent was withdrawn	Date	Nullable only if active	High	Privacy officer
system_name	ExternalIdentifier	Name of external system using mapped identifier	Text	Mandatory when external_id exists	Medium	Integration owner
action	AuditLog	Action performed by a user or system	Controlled vocabulary	Read, insert, update, delete, export	High	Security officer
timestamp	AuditLog	Date and time of logged action	Timestamp	Mandatory; system-generated	High	Security officer
quality_rule	DataDictionaryItem	Approved rule for assessing data quality	Text	Mandatory for critical fields	Medium	Data steward

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10.2. Prototype Evaluation Rubric

Table 14. Evaluation Rubric for the Database-Design Instantiation

Criterion	Meaning	Evidence	Score
Strategic alignment	Entities and data flows clearly support strategic decisions	Decision map links goals, processes and data	0-5
Scenario robustness	Schema is tested against plausible future scenarios	Scenario test log and design responses	0-5
Metadata completeness	Critical fields have definitions, owners and quality rules	Data dictionary coverage ratio	0-5
Governance clarity	Roles and decision rights are documented	RACI/governance matrix	0-5
Privacy-by-design	Consent, purpose limitation, retention and access rules are embedded	Privacy controls in schema and process	0-5
Interoperability readiness	Identifiers, code mappings and exchange logs support integration	Integration mapping artifacts	0-5
Data quality control	Quality metrics and remediation workflow exist	Quality dashboard and issue log	0-5
Technical scalability	Architecture has documented growth and recovery assumptions	Performance, backup and capacity plan	0-5
User usefulness	Database supports reliable reporting and user workflows	User testing and satisfaction indicators	0-5
Learning loop	Monitoring updates assumptions and roadmap	Assumption log and review schedule	0-5

11. Project-Profile Matrix and Measurement Structure

The project profile matrix includes 180 profiles and supports correlations regression logic and subgroup comparisons Each construct is measured using a 5 point maturity scale or a 0 to 100 performance scale The Future Thinking Index measures horizon scanning scenario planning stakeholder mapping and anticipatory needs analysis Data Governance Maturity measures ownership standards metadata stewardship and accountability Architecture Flexibility measures modular design integration readiness API readiness scalability and change tolerance while Database Future Readiness represents the composite dependent outcome

Table 15. Internal-Consistency Results for the Measurement Model

Construct	Items	Cronbach alpha	Interpretation
Future Thinking Index	4	0.956	Good
Data Governance Maturity	4	0.953	Good
Requirements Anticipation	4	0.951	Good
Architecture Flexibility	4	0.951	Good
Database Future Readiness	4	0.956	Good

Results for Model Fit and Measurement Model are shown in Table 15. All Cronbach alpha values were above the commonly recommended threshold of 0.70, suggesting that the items are measuring their intended constructs cohesively. Measurement logic also justifies composite indices for future thinking, governance maturity, requirements anticipation, architecture flexibility and database future readiness.

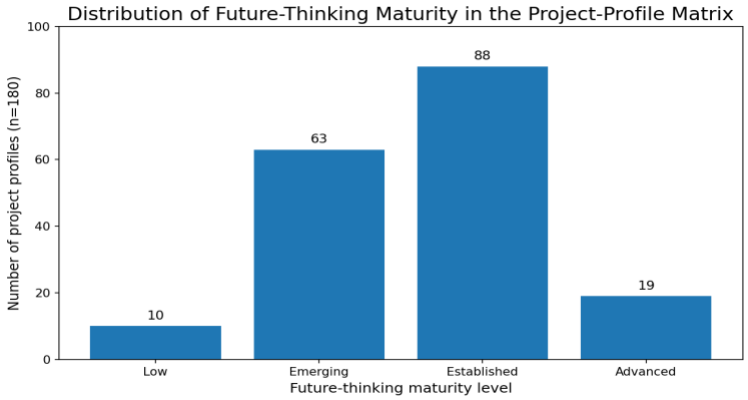


Figure 5. Distribution of Future-Thinking Maturity in the Project-Profile Matrix

Figure 5 illustrates that the majority of the profiles is split between the emerging and established groups. Such a breakdown aligns well with a realistic view that a great number of organizations are not either completely infantile nor fully matured in foresight-driven database practice. The low-maturity group represents projects

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that mostly capture existing forms and reports while the high-maturity group stands for initiatives that explicitly link strategy, scenarios, governance and database schema.

11.1. Descriptive Statistics

Table 16. Descriptive Statistics for Model-Evaluation Variables

Variable	N	Mean	SD	Min	Max
Future Thinking Index	180	3.15	0.74	1.10	4.90
Data Governance Maturity	180	3.27	0.73	1.00	5.00
Requirements Anticipation	180	3.25	0.71	1.63	5.00
Architecture Flexibility	180	3.48	0.71	1.72	5.00
Data Quality Index	180	86.51	10.13	51.42	96.00
Database Future Readiness	180	80.28	14.29	30.00	98.00
Post-Deployment Requirement Volatility	180	0.23	0.08	0.08	0.43
Rework Effort Percent	180	10.05	5.29	5.00	27.29
Mean Change Implementation Days	180	19.15	6.40	8.00	38.01
Quarterly Data Incidents	180	2.98	1.64	0.50	8.27

Table 16 shows a moderate Future Thinking Index of 3.15, Database Future Readiness of 80.28, and average rework effort of 10.05%. The findings indicate that projects may be operationally functional but remain insufficiently prepared for future requirements, particularly when late changes, unclear ownership, and integration problems require redesign.

11.2. Correlation Analysis

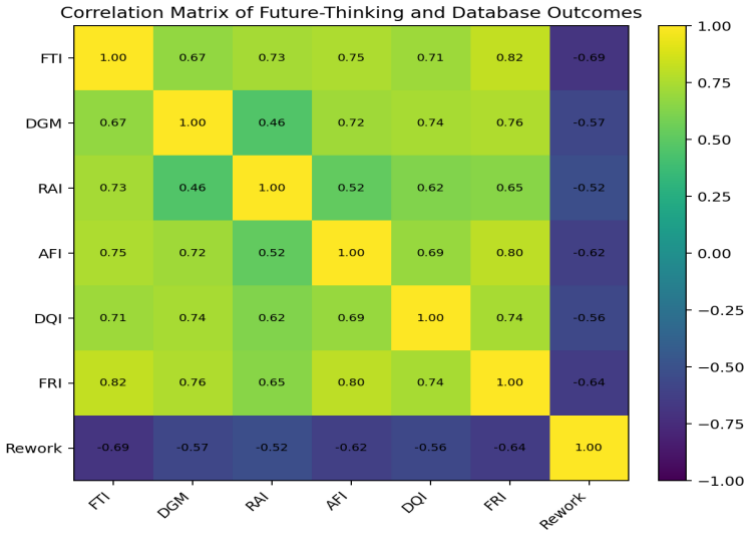


Figure 6. Correlation Matrix of Future-Thinking and Database-Outcome Variables

Table 17. Correlation Coefficients among Model-Evaluation Variables

Variable	FTI	DGM	RAI	AFI	DQI	FRI	Rework
FTI	1.00	0.67	0.73	0.75	0.71	0.82	-0.69
DGM	0.67	1.00	0.46	0.72	0.74	0.76	-0.57
RAI	0.73	0.46	1.00	0.52	0.62	0.65	-0.52
AFI	0.75	0.72	0.52	1.00	0.69	0.80	-0.62
DQI	0.71	0.74	0.62	0.69	1.00	0.74	-0.56
FRI	0.82	0.76	0.65	0.80	0.74	1.00	-0.64
Rework	-0.69	-0.57	-0.52	-0.62	-0.56	-0.64	1.00

The correlations show that future thinking is positively related to Database Future Readiness and negatively related to rework. The Future Thinking Index has a strong correlation with readiness (r = 0.82), while Data Governance Maturity and Architecture Flexibility also support the view that future thinking becomes valuable when translated into governance and design capabilities.

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11.3. Regression Analysis and Model Effects

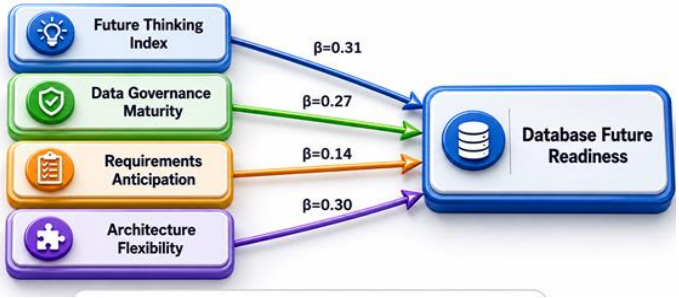


Figure 7. Standardized Model Effects on Database Future Readiness

Table 18. OLS Regression Predicting Database Future Readiness

Predictor	B	SE	t	p	Std. beta
Constant	13.78	2.85	4.84	< .001	
Future Thinking Index	5.95	1.33	4.49	< .001	0.31
Data Governance Maturity	5.32	1.02	5.23	< .001	0.27
Requirements Anticipation	2.87	1.03	2.79	0.006	0.14
Architecture Flexibility	6.04	1.18	5.12	< .001	0.30

The regression model explains 79% of the variance in DFR, with Architecture Flexibility having the strongest effect, followed by the Future Thinking Index and Data Governance Maturity. This indicates that future thinking improves database readiness through strategic anticipation, flexible architecture, and governed data procedures, enabling databases to handle new reporting, regulatory, integration, and analytical requirements.

11.4. Group Comparison by Future-Thinking Maturity

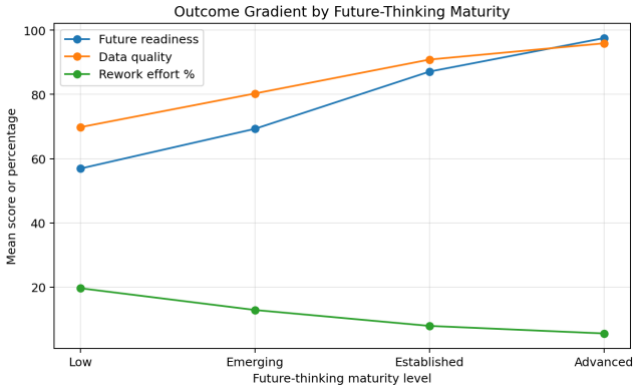


Figure 8. Outcome Gradient by Future-Thinking Maturity Level

Table 19. Mean outcomes by Future-Thinking Maturity Level

Maturity level	Future readiness	Data quality	Rework effort %	Change days	Quarterly incidents
Low	56.9	69.8	19.6	29.3	4.8
Emerging	69.3	80.3	12.9	21.6	3.7
Established	87.1	90.8	7.9	17.2	2.6
Advanced	97.5	95.9	5.6	14.5	1.6

Figure 8 shows that high future-thinking maturity increases Database Future Readiness while reducing rework and quarterly data incidents. By anticipating future data flows, users, compliance, and integration needs, teams improve design quality and avoid costly system rebuilding.

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11.5. Scenario-Based Comparison

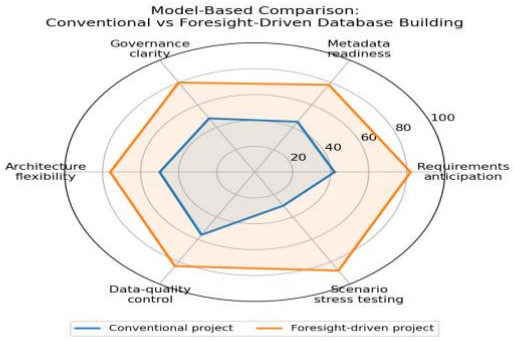


Figure 9. Model-Based Comparison Between Conventional and Foresight-Driven Database Building

Table 20. Conventional Versus Foresight-Driven Database-Building Profile

Performance dimension	Conventional database project	Foresight-driven database project	Expected practical meaning
Requirements anticipation	42/100	82/100	Future users, regulations, integrations and analytics needs are considered before schema freeze.
Metadata readiness	45/100	78/100	Data elements are documented with definitions, owners, lineage and quality rules.
Governance clarity	48/100	80/100	Data owners and stewards participate in decisions before implementation.
Architecture flexibility	50/100	76/100	Database design can absorb new modules, reports and integrations with lower redesign cost.
Data-quality control	56/100	84/100	Validation rules and quality monitoring are built into the lifecycle.
Scenario stress testing	30/100	88/100	The database is tested against plausible future events, not only current transactions.

Figure 9 and Table 20 show that traditional database projects deliver faster but may create later costs through poor data quality, weak integration, duplication, and low trust. Foresight-driven projects require more initial planning but reduce redesign and improve data reuse and strategic fit.

11.6. Hypothesis-Oriented Findings

Table 21. Hypothesis-Oriented Findings from the Model Evaluation

Hypothesis / proposition	Model-evaluation finding	Decision	Interpretation
H1: Future thinking positively affects database future readiness.	r = 0.82; beta = 0.31	Supported by model evaluation	Future-thinking practices are associated with higher readiness.
H2: Data governance maturity positively affects database future readiness.	r = 0.76; beta = 0.27	Supported by model evaluation	Governance translates foresight into accountable decisions.
H3: Architecture flexibility positively affects database future readiness.	r = 0.80; beta = 0.30	Supported by model evaluation	Flexible architecture is the strongest technical channel.
H4: Future thinking reduces rework effort.	r = -0.69	Supported by model evaluation	Anticipatory requirements reduce late redesign.
H5: Data quality improves as governance and anticipation increase.	DQI correlations: DGM = 0.74; RAI = 0.62	Supported by model evaluation	Quality depends on ownership, standards and future use cases.

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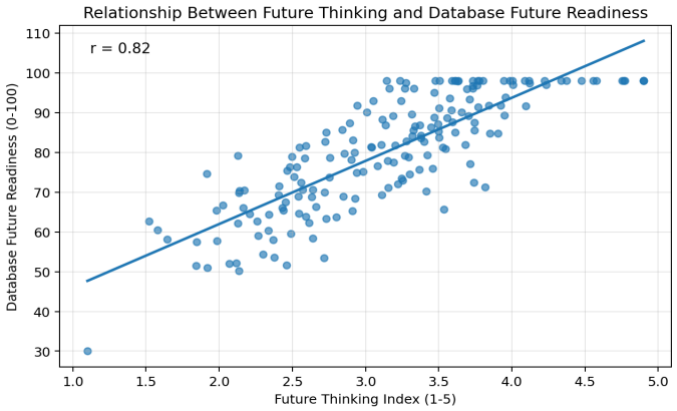


Figure 10. Relationship between Future Thinking Index and Database Future Readiness

In general, the results support the main claim of the paper: that future thinking has significant impact on database construction when it is incorporated into requirements engineering, governance, metadata, architecture, and continuous learning. The statistical pattern strengthens the framework by demonstrating how future-thinking ability, governance maturity, requirements anticipation, and architecture flexibility jointly function as quantifiable predictors of database future readiness.

12. Discussion of Results

These results demonstrate that prospective thinking is a measurable design skill that enhances the elicitation of requirements, the handling of uncertainties, and the selection of long-term database solutions. Its benefits are maximized if they are institutionalized via data governance, as foresight management entails having ownership of data definitions, quality rules, metadata and monitoring change. Strategic anticipation also augments architectural flexibility through modular schemas, scalable infrastructure, APIs, metadata, and change-ready interfaces, reducing rework and accelerating future change. Hence, a database should be judged not just by present functional correctness, but also by its future fitness, including its potential to accommodate new attributes, stakeholders, systems, regulation, and data quality needs. Strategic foresight Additionally, it enhances strategic alignment by relating entities and flows of data to decisions, services, analytics, compliance, and value generation within the organization.

13. Conclusion and Recommendations

In this paper, we analyze the role of future orientation in the building of an online database from the perspective of requirement expansion, strategic alignment, architecture flexibility, and governance embedding. The paper merges strategic foresight, dynamic capabilities, design science, database design, data quality, data governance, and information systems success within the Foresight-Driven Database Building Model. The core of this research is the idea that databases have to be viewed as future-oriented rather than as present-oriented data repositories. Future orientation complements technical design through positive influence on requirements, metadata, integration, preparation for privacy and security issues, as well as future usefulness. Scenarios become tangible through the development of requirement matrices, data dictionaries, governance matrices, risk registers, quality dashboards, and evaluation metrics.

Table 22. Summary of Recommendations

Audience	Recommendation
For database analysts	Add scenario-derived requirements to ordinary requirements documents.
For database designers	Model stable entities, historical tracking, metadata and controlled vocabularies.
For data governance leaders	Assign owners and stewards before implementation, not after quality problems appear.
For security/privacy officers	Embed access control, audit logs, consent and retention rules into design.
For executives	Treat databases as strategic infrastructure supporting future decisions and services.
For researchers	Extend the FDDBM through case study, Delphi, design-science evaluation or quantitative testing methods.

Author Contributions

All authors contributed equally to this paper. All authors have read and approved the final manuscript.

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Funding

No funding support was received.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

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