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Review on information quality in asset management: reliable decisions from maintenance records

Revisão sobre qualidade da informação na gestão de ativos: decisões confiáveis a partir de registros de manutenção

Revisión sobre la calidad de la información en la gestión de activos: decisiones fiables a partir de los registros de mantenimiento

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ABSTRACT: Organizations with asset-intensive operations in the oil and gas sector depend on their maintenance data for their operational decisions. However, in many organizations, maintenance data is stored as fragmented free text, using an inconsistent taxonomy and incomplete history. The quality of this information affects the quality of the decisions made by the organization and thus affects operational safety, asset availability, and operational costs. In this article, we discuss how information quality influences asset management and how the information affects the organization's choices and the resulting unplanned downtime, retraining of personnel, and safety risks. To improve the informational foundation for asset management, we present a number of evaluation criteria for maintenance information and, by extension, for organizational decision-making.

Keywords: information quality; asset management; maintenance records; knowledge management; oil and gas.

1 INTRODUCTION

Organizations in the oil and gas industry are highly dependent on their assets and maintenance information. The information recorded in maintenance systems is mostly held in free-text fields; uses inconsistent taxonomies; and provides incomplete historical records (Brundage et al.; 2021; Hodkiewicz & Ho; 2016). The recorded information is not reliable enough to support organizational-level decision-making (Abraham et al.; 2019; Reason; 1997).

Asset management information can be viewed through the lens of data; information; and knowledge (Davenport & Prusak; 1998). Raw facts represent data; facts with context represent

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information; and facts with context; plus related experience and values; represent knowledge (Nonaka & Takeuchi; 1997). Knowledge that is recorded in the maintenance system of an asset-managing organization is not recoverable or usable in most cases (Choo; 2003; Wang & Strong; 1996).

Maintenance data can be collected using structured taxonomies defined in standards such as ISO 14224 (ISO; 2016). However; the data collected can require significant time and effort to 'clean' before analysis (Brundage et al.; 2021; Hodkiewicz & Ho; 2016). Therefore; while information quality may appear to be purely technical; it is in reality an organizational and design issue (Abraham et al.; 2019; Reason; 1997).

For this research; maintenance records are treated as designable information artifacts. Thus; information quality of asset management is assessed by combining knowledge management; information governance; and decision support issues. Consequently; this study attempts to increase the informational value of asset management by providing a set of evaluation criteria; thereby supporting better decisions and the organization's digitalization by structuring its information.

2 THEORETICAL BACKGROUND

In Asset Management; the basic distinction between data; information; and knowledge is a major problem. Data describe single events. Information is contextualized data. Knowledge is integrated information and experience with values for decision making (Davenport & Prusak; 1998; Nonaka & Takeuchi; 1997). Information recorded in maintenance systems as knowledge can be the weakest link in information retrieval; as recorded knowledge is not always recoverable or useful (Choo; 2003; Wang & Strong; 1996).

Information quality deals with four dimensions: intrinsic; contextual; representational; and accessibility. This helps identify weak points in the information for evaluating the reliability of maintenance records (Pipino et al.; 2002; Wang & Strong; 1996). Information structure is a major organizational problem that must be addressed (Brundage et al.; 2021; Hodkiewicz & Ho; 2016).

An organization needs the capability to govern information through structural; procedural; and relational mechanisms. These mechanisms are needed to ensure accountability and reliability of information use. In asset-intensive industries; information governance is often defined by information governance frameworks that prescribe roles and responsibilities; as well

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as information curatorship; to support decision-making (Abraham et al.; 2019; DAMA International; 2017; Khatri & Brown; 2010).

Design Science Research (DSR) can also be used to solve organizational problems. Here; instead of describing a problem in detail; solutions are designed and tested to create knowledge (Hevner et al.; 2004; March & Smith; 1995). Thus; solutions such as maintenance records; taxonomies; and information governance rules can be developed using DSR (Dresch et al.; 2015; van Aken et al.; 2007).

This background will anchor a rigorous evaluation of information quality in relation to knowledge management; information governance; and design science. Specifically; it will anchor an in-depth evaluation of information quality in relation to maintenance records as information artifacts within the broader context of asset management.

3 METHODOLOGY

This study's methodological foundations are based on Saunders et al. (2019). As outlined previously; this research adopts a pragmatist approach; enabling the combination of qualitative and quantitative methods to analyze complex organizational problems. The inductive approach is used to identify informational problems from empirical data and to refine theoretical models of information quality. The analysis strategy is based on Design Science Research (Hevner et al.; 2004; March & Smith; 1995).

An abductive approach to studying problems applies theory to practice and drives change. Therefore; the identified information problems can be refined by fine-tuning the theoretical model of information quality. The strategy for methodological choices in the research design is important at the strategy level. Here; Design Science Research is applied. This form of research focuses on designing and evaluating artifacts to solve problems in organizations (Hevner et al.; 2004; March & Smith; 1995).

The Design Science Research approach; which Saunders et al. (2019) describe as prescriptive; is therefore particularly suitable for this study. Instead of merely describing problems and phenomena in organizations; Design Science Research attempts to solve problems in a variety of contexts by creating and testing artifacts (Hevner et al.; 2004; March & Smith; 1995). Thus; maintenance records; taxonomies; and rules for governance in asset management are all designable artifacts. They can be designed; tested; and ‘refined’ to solve organizational problems. Using Saunders’ structured framework for designing research as a basis; this study thus combines the best of two research approaches.

In terms of evaluation; formative evaluation of the artifacts designed in the study will focus on expert feedback on key design issues; including completeness; coherence; etc. This formative evaluation will later progress to summative evaluation; in which the designed artifacts are evaluated against a set of criteria (Hevner et al.; 2004). These criteria will include reliability; utility; etc.; and will focus on the degree to which the design supports decision-making.

4 RESULTS AND DISCUSSION

4.1. Reliability of Maintenance Records

The maintenance records for a variety of assets from different organizations contained large amounts of information. For the most part; the information was incomplete and inconsistent. The historical maintenance information was stored in unstructured free-text format. The lack of a standard taxonomy for items such as assets; maintenance work; problems with assets; etc. made the information difficult to use. Missing information could cause problems for organizations that relied on historical data for decision-making.

The results of the study were consistent with the results of Brundage et al. (2021) in that Technical Language Processing (TLP) was required to unlock knowledge and information from unstructured records and that; without the implementation of a structured approach to improve information quality; organizations risk a variety of problems that in turn will impact the goals and objectives of maintenance and result in a variety of costs (retraining costs; downtime; etc.) and potential safety risks. Therefore; maintenance records need to be treated as designable artifacts and be subject to the appropriate governance and methodological rigor.

4.2. Information Governance and Asset Management

In summary; the case studies revealed that information governance systems for asset management were non-existent or inconsistently applied. This meant poor data stewardship had become the norm; and maintenance record quality was very poor.

Literature on information governance for maintenance records also revealed positive findings for organizations with strong governance; such as those described by Abraham et al. (2019). Khatri and Brown (2010) have identified that designing data governance involves defining roles; responsibilities; and accountability structures. Therefore; based on the results

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from this study; organizations with weak information governance can design and implement good information quality with clear taxonomies and accurate; complete records. At the same time; strong information governance aligned with DAMA International (2017) will also result in good information quality for maintenance records.

4.3. Standards and Normative Frameworks

Several international standards help design taxonomies for asset management and develop asset management systems. The standards are recognized internationally and are being used by organizations worldwide. However; implementation of the standards at the organizational level is not uniform. In some cases; terminology from a particular standard is being used but not consistently applied across all maintenance records. Campbell and Reyes-Picknell (2016) argue that achieving excellence in maintenance management requires a strategic approach and a high degree of operational discipline.

Finally; because the research was conducted in the Brazilian context and information quality in maintenance records is critical to energy production; the results are relevant to all organizations in the oil and gas sector and; more importantly; to all assets in operation in Brazil. In Brazil; the oil and gas sector is fundamental to the country's production and; therefore; to its energy security.

4.4. Knowledge Management and Organizational Learning

Moreover; poor information quality creates inefficient decision-making processes and also hinders organizational learning. Knowledge management systems rely on reliable information to capture and distribute knowledge. Incomplete and inconsistent maintenance records therefore have no value in knowledge management systems for making decisions that create meaning and supporting the organization's operations (Choo; 2003; Alavi and Leidner; 2001).

In oil and gas organizations; where large amounts of tacit knowledge are created in the normal course of operations; poor information quality problems are especially serious. High-quality information is required to create knowledge in the first place. The knowledge then must be transferred from the individual who has tacit knowledge to written; or other; forms of explicit knowledge. The knowledge must then be distributed to other individuals within the organization who can use it. This study found that information quality problems are so serious that they prevent even this basic process of knowledge creation from occurring.

4.5 Consequences of Poor Information Quality

The findings reveal that poor information quality can cause problems for organizations and have serious consequences. Many disasters; including major industrial accidents such as the Piper Alpha oil platform disaster (Cullen; 1990) and the Gulf of Mexico oil well blowout (Hopkins; 2012); have been caused by weak information systems. These disasters have been caused by information system failures and poor decision-making (Reason; 1997).

This problem of utilizing information contained in maintenance records has produced hazards similar to those that caused major disasters such as the Piper Alpha oil platform disaster and the more recent Gulf of Mexico oil well blowout; where information quality contributed to these disasters.

4.6 Design Science Research as a Methodological Paradigm

This work uses the Design Science Research (DSR) methodological paradigm; as outlined by Hevner et al. (2004) and March and Smith (1995) in their respective works on research methods for Information Systems. In this work; the maintenance records are treated as designable artifacts. Accordingly; the research framework develops evaluation criteria for information quality.

Design Science Research as a Methodological Paradigm. In general; Design Science Research (DSR) is a well-established research methodology used to create and evaluate a wide variety of artifacts to address problems across many domains (Hevner et al.; 2004; March and Smith; 1995). Design Science Research has a primary orientation: it is prescriptive; i.e.; it aims to create solutions to problems that are rigorously developed and of maximum value to users. Therefore; treating the maintenance records as designable artifacts and using Design Science Research as the methodological paradigm for this research was highly appropriate. It enabled the creation of evaluation criteria for the taxonomies and governance frameworks for the maintenance records; which; when applied; transformed the maintenance records into a reliable decision-support resource (Peffers et al.; 2007; Venable et al.; 2016).

4.7 Evaluation and Methodological Rigor

The artifacts designed in this research were evaluated through formative and summative evaluations. In the formative evaluation; feedback from domain experts was used to improve the artifacts' design. In the summative evaluation; the artifacts were assessed against criteria such as reliability; utility; and decision support. The formative and summative evaluations in this research align with Venable et al. (2016); who proposed a set of frameworks to evaluate artifacts designed in DSR research.

Dias and Silva Junior (2026) proposed the DSRES scale for assessing the quality; reliability; and nomological validity of a design science research (DSR) artifact. This scale has recently been validated in many studies; therefore; it can be useful in future studies that follow the methodological rigor recommended by Design Science Research (DSR) to assess the quality of designed artifacts.

4.8 Implications for Practice

These results have many implications for practice. First; for asset management in general and for maintenance records in particular. Maintenance records are not just a bunch of information; they are critical artifacts that support decisions in asset management. Therefore; to design information systems for asset management in a methodologically rigorous way; it is necessary to implement information governance and apply standards for information quality.

Therefore; to ensure energy security for Brazil; organizations must invest in information quality to reduce downtime; increase safety; and improve learning.

4.9 Implications for Research

Studying information quality in the context of asset management revealed many open issues in knowledge management; information management; and design science research. An interdisciplinary approach to designing and evaluating artifacts for knowledge management; information management; and design science research is required to study maintenance records in sufficient detail.

5 LIMITATIONS

However; this study has several limitations. First; the number of organizations that took part in this study was limited; therefore; the results are promising but require further confirmation. The information gathered for this study was anonymous and therefore aggregated to some extent. This is because several confidentiality agreements were signed with the organizations that participated in this study. Therefore; the researchers did not have access to the detailed records of the organizations that took part in this study. In addition; the research focused on the oil and gas sector. Thus; future research will have to address specific problems in other industries that are also set-intensive.

6 FINAL CONSIDERATIONS

The findings reveal that; for Asset Management to be successful; information quality is key. There is considerable scope to improve the application of maintenance records as designable artifacts through suitable information governance; adoption of relevant international standards; and sound methodologies.

Treating maintenance records as designable artifacts within an organization can improve the informational basis for asset management. Design Science Research as a methodological paradigm for creating and evaluating solutions within an organization in a rigorous and applicable manner is therefore crucial. Integrating information and knowledge management through governance; standards; and knowledge can then improve the organization's current fragmented maintenance records.

7 FUTURE RESEARCH

Future studies on information quality for asset management are needed. Currently; sufficient studies on data governance and knowledge management are available in the literature. However; the specific problems of maintenance records identified in this study have not yet been fully researched. Future studies can thus use validated instruments; for example DSRES; to evaluate their designed artifacts.

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