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Optimizing Business Efficiency: The Strategic Potential of Low-Code Tools in Developing Information Management Systems and Their Benefits for Companies

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Abstract The quest for business efficiency encourages organizations to adopt innovative strategies for optimizing their internal processes. One of the biggest challenges faced by the companies is to manage high quantity of information efficiently for strategic decision-making. This article discusses the development of information management systems by using low-code tools, as an approach to improve efficiency in data management at internal process for the chosen company, without the need of high-level expert developers. The paper is carried out as action research, which is constructed in three stages: process mapping, data collection and results' analysis, considering the use of current low-code tools by non-developers in this area, creating a robust and adaptable system, showing advantages and impact on operational performance with post-implementation comparison by system users. During the mapping, the main activity was to understand the process and workflows from the company's task which is under analysis. Data collection occurred through observation and structured questionnaire. At the end, data analysis was carried out through descriptive statistical analysis. The research presents in its results the development of a new information management system, web-based, where the main advantages identified were on accuracy, data collection, dissemination and the increase in operational efficiency due to the use of the new system.

Keywords: Management System, Low-Code Tools, Business Process Management, Continuous Improvement, Process Optimization, Information Systems

1 Introduction

Currently, the constant search for business efficiency drives organizations to explore innovative approaches to optimize their processes. One of the main challenges faced by companies in various sectors is the efficient management of information, which is essential for strategic and operational decision-making. The literature emphasizes that obsolete systems and manual processes can restrict organizations ability to adapt to rapid market changes, in addition to increasing operational costs and reducing competitiveness [Tian *et al.*, 2023]. In fact, the implementation of more agile technologies, such as low-code tools, has gained prominence for their ability to simplify the development of solutions, allowing companies to overcome these challenges.

The problem addressed in this study is based on the gap that exists between the growing need for efficiency and the persistence of outdated procedures, which could be optimized through robust systems developed with low-code tools. According to [Silva *et al.*, 2023], the use of low-code platforms allows teams that are not specialized in development to reduce the time and cost of implementing management systems, contributing to greater flexibility and operational efficiency. This is aligned with the need to modernize business practices, allowing the integration of processes and data more effectively.

Daily challenges related to information management, such as lengthy manual processes, lack of integration between systems and data inconsistencies, compromise the operational efficiency of companies. These challenges are widely discussed in the literature as an obstacle to innovation and business competitiveness, especially in dynamic markets [Tian *et al.*, 2023]. To mitigate these adversities, it is crucial to explore innovative technological solutions that allow the development of agile, efficient and adaptable information management systems.

In this context, low-code tools emerge as a promising alternative. Low-code platforms offer an efficient way to develop applications with less technical complexity, allowing developers without experience in web development to create effective solutions [Fernandes *et al.*, 2020]. In this article, the objective is to demonstrate the increase in efficiency through the use of low-code tools in the development of information management systems. Therefore, we present a comparative analysis of efficiency before using traditional development tools and then using low-code tools, seeking to demonstrate the direct impact of the management system developed on the operational performance of teams.

Finally, it's important to highlight that this study concerns a system in constant evolution, where subsequent stages of the research will involve the integration of a limited generative AI, based on the company's internal data, to further increase the capacity for analysis and automation of processes.

2 Theoretical Background

2.1 Low-Code Tools

Low-code tools are software development platforms that allow the creation of applications and systems with minimal manual coding. They are designed to simplify the development process by providing visual interfaces and pre-built components that can be just "drag and drop" elements to create complex functionalities [Rokis and Kirikova, 2023]. Its benefits include: faster development, simplicity for users, cost reduction, simplified collaboration and business agility [Alamin *et al.*, 2021]. However, there are limitations that can be cited, such as: limited customization, security concerns, scalability limitations and vendor dependence [Frank *et al.*, 2021].

In general, it can be said that low-code tools are becoming increasingly prevalent in the creation of management systems, covering a wide range of applications, such as Customer Relationship Management (CRM) systems, Enterprise Resource Planning (ERP), project management and business process management [Frank *et al.*, 2021]. Through these platforms, organizations can quickly develop customized solutions to meet their specific management needs, such as lead tracking, process automation, inventory management and analytical report generation [Rokis and Kirikova, 2023]. The adoption of low-code tools in these contexts has been driven by the tangible benefits they offer, including faster implementations, cost reduction and greater adaptability to changing business requirements.

Low-code development offers clear advantages in terms of speed and accessibility, but challenges related to customization, vendor lock-in and security concerns show that there are still significant barriers to overcome [Luo *et al.*, 2021]. Professionals in the field need to evaluate carefully whether low-code is the right solution for their projects, especially when there are complex requirements, so its use must be weighed against the limitations that these tools may have [Rokis, 2022].

2.1.1 Pentaho

Pentaho is an open-source software suite focused on business analytics and data management. It offers a variety of tools to assist organizations in Extracting, Transforming and Loading (ETL) data, as well as providing features for analysis, reporting, data mining and visualization. Developed by Pentaho Corporation, Pentaho is widely used by companies in various industries to aid in informed decision-making and optimization of business processes. One of the main advantages of Pentaho is its open-source nature, which provides flexibility and cost-effectiveness for organizations [Setyawan *et al.*, 2020].

The open-source nature allows companies to customize and adapt the suite to their specific needs without relying exclusively on proprietary vendors, which can result in reduced costs over time [Mussa *et al.*, 2018]. Another advantage of Pentaho is the possibility to integrate with various data sources, including relational databases, spreadsheets, CSV files and ERP systems. This integration capability facilitates access and consolidation of scattered data, allowing comprehensive and holistic analysis of enterprise information [Mussa *et al.*, 2018].

2.1.2 Scriptcase

Scriptcase is a rapid web application development tool that enables developers to create agile and complex solutions in a short amount of time, using only a web browser. With Scriptcase, it is possible to create complete web applications, from content management systems to CRM and ERP systems [Ceron *et al.*, 2024].

The main advantage of Scriptcase is its simplicity of use. It has an intuitive and friendly interface that allows developers to create and customize apps without the need for advanced programming knowledge. Additionally, Scriptcase offers a wide range of pre-configured features and functionalities, such as grids, forms, charts and reports, which simplifies the development of complex applications. Another advantage of Scriptcase is its ability to integrate with different databases and systems. It supports a variety of popular databases such as MySQL, PostgreSQL, SQL Server and Oracle and allows developers to integrate their apps with external systems through APIs and web services [Ceron *et al.*, 2024].

2.2 Management System

The management system is a collection of processes and tools used by an organization to coordinate and control their activities and resources, aimed at achieving predetermined objectives and goals. Management systems are crucial for ensuring the efficiency and effectiveness of a companry's operations, providing a clear and well-defined organizational structure [Rigby, 2001]. These systems can cover areas such as quality management, environmental management, health and safety at work, among others.

One of the main advantages of implementing a management system is to improve operational efficiency. By establishing standardized processes and defining clear responsibilities, organizations can optimize their operations, reduce costs and increase productivity. Quality management systems, for instance, may assist on identify and fixig flaws in processes, increasing customer satisfaction and the company's competitiveness [Abdolshah and Jahan, 2006].

Furthermore, management systems promote a more systematic approach to compliance with laws and regulations. With the growing complexity of legislation in different sectors, companies adopting management systems have a competitive advantage by ensuring compliance with legal and regulatory requirements. This can help on avoiding fines and sanctions, as well as contribute to a more positive corporate image among customers and investors [Lewandowski and Cirella, 2023].

When considering the disadvantages, one of the main challenges is the cost of implementation and maintenance of these systems. Organizations often need to invest in staff training, technology and specialized consulting to successfully implement a management system, which can represent a significant financial burden [Cheng *et al.*, 2007]. Furthermore, the rigidity of the processes established by management systems can limit the adaptability of organizations following changes in their business environment, so an excessively bureaucratic management system can hinder innovation and agile response to new threats. [Cheng *et al.*, 2007].

In summary, management systems offer several advantages, such as improved efficiency, legal compliance and competitiveness. However, it's also important to consider the disadvantages, such as high implementation costs and process rigidity, before deciding to adopt these systems

2.2.1 Strategic Information Planning and Resource Management

Strategic information planning and resource management are crucial elements for the success of any organization in the information age. In this point, strategic information planning is a process that aims to align informational resources with long-term organizational objectives [Criado *et al.*, 2010]. This involves identifying the organization's information needs, analyzing available resources and developing strategies to optimize the use of information in support of strategic objectives. One of the advantages of strategic information planning is improved decision-making. By aligning informational resources with the organization's strategic objectives, decisions can be based on more accurate and relevant data, resulting in more assertive and effective choices [Wahyoedi *et al.*, 2023].

Strategic information planning requires detailed analysis, which can require a significant investment of time and money on the part of the organization. On the other hand, resource management is a critical part of the strategic information planning process. Effective management of informational resources, such as information systems, databases and communication networks, is essential to ensure that the organization can make the most of its information capabilities. This includes appropriate allocation of resources, performance monitoring and adaptation to changes in the organizational and technological environment [Sinnaiah *et al.*, 2023].

Resource management is the optimization of the use of available resources effectively, which can result in reduced waste and redundancies, thereby increasing operational efficiency and minimizing unnecessary costs. Additionally, resource management contributes to information security, ensuring that sensitive data is protected against both internal and external threats [Muehlen and Michael, 2004].

2.3 Related Work

The use of low-code tools has drawn increasing academic and industrial interest, primarily due to their potential to enhance business efficiency when strategically applied. However, there is a significant gap in the literature specifically addressing the integration of these tools into information management systems to optimize business operations, which is the focus of this study. Related works provide complementary perspectives, forming a foundation for understanding this complex subject.

Low-code and no-code platforms have been highlighted for their capacity to drive operational efficiency by facilitating the adoption of digital technologies [Razak *et al.*, 2024]. This view is complemented by the emphasis on the economic benefits and operational efficiency of these platforms in business process automation [Slotvitskaya *et al.*, 2024]. However, these studies do not explore the direct impact of such tools on customized information management systems.

Practical applications of low-code platforms in the energy sector have demonstrated how non-technical users can rapidly enhance operational efficiency [Wang *et al.*, 2023]. Similarly, the automation of business processes in the manufacturing sector has shown that these tools can be adapted to various industries to accelerate solution development and reduce associated costs [Waszkowski, 2019].

In the field of collaboration and innovation, low-code platforms have been shown to improve collaborative efficiency between UX/UI designers and developers, fostering more agile development cycles [Pacheco *et al.*, 2021]. Methods for automatic page publishing based on low-code platforms have further highlighted these tools' ability to simplify technically complex tasks [Bian *et al.*, 2023].

A comprehensive literature reviews consolidated evidence of the positive impact of low-code platforms on software development, emphasizing their accessibility and effectiveness in lowering barriers to technological innovation [Rokis and Kirikova, 2023]. However, these studies still lack an in-depth analysis of the strategic impact of such platforms on information management systems and their direct contribution to business efficiency.

The analyzed studies demonstrate that low-code platforms have significant potential to enhance efficiency and accessibility across various applications. Essential foundations and operational insights are provided by [Razak *et al.*, 2024] and [Slotvitskaya *et al.*, 2024], while practical cases illustrating productivity gains are presented by [Wang *et al.*, 2023] and [Waszkowski, 2019]. Complementing these perspectives, the contributions of low-code tools to collaboration and technological innovation are expanded upon by [Pacheco *et al.*, 2021] and and [Bian *et al.*, 2023], underscoring the need for future research on their strategic impact on information management systems.

Given these insights, the related works emphasize the necessity of additional research to deepen the understanding of how low-code platforms can optimize business efficiency. While various aspects and applications are addressed in the reviewed studies, this research distinguishes itself by adapting the use of these tools for the development of managerial information systems. With a focus on efficiency in developing these systems through low-code tools, the present study details the implementation and results obtained, as presented in section 4.

3 Methodological Procedures

The methodological procedure can be described as an action research. This type of research assumes that practitioners themselves are often the best people to conduct research on their own practices. It recognizes that professionals possess deep understanding and expertise in their respective fields, allowing them to provide valuable insights into their own practices and experiences [Bradbury-Huang, 2010].

The action research is a method that combines investigation with practical action to address complex problems in real-world contexts [Kassem *et al*., 2023]. The method involves close collaboration between researchers and participants from the studied organization, aiming not only to understand the problems but also to implement effective solutions and promote meaningful changes [Erro-Garces and Alfaro-Tanco, 2020].

The research approaches adopted for data collection are divided into qualitative approaches, using structured direct non-participant observation as a method and quantitative approaches, using structured questionnaires with closed-ended questions as a method. Direct non-participant observation is a systematic data collection method that involves direct and organized observation of participants' behavior [Hyldegaard *et al*., 2015]. In this sense, the researcher has the opportunity to approach the research field, maintaining the position of guest, collecting data through questionnaires, forms or measures of participants' opinions. This approach simplifies the collection of narratives about a group or organization, simplifying access to restricted knowledge [Ciesielska *et al*., 2018].

The structured questionnaire with closed questions is based on the Likert psychometric scale. The Likert scale was created to measure preferences for behaving or reacting in a specific circumstance around an object, transforming qualitative variables into quantitative variables [Joshi *et al*., 2015].

Regarding the characterization of the sample, this research was conducted at a Science and Technology institute that operates in the development of technological solutions for the local and global market, with customers from all Latin America with a wide variety of software projects. The research adopts non-probabilistic convenience sampling, since this study focuses only in a product management team composed by 11 employees responsible for product requirements management who have agreed to join in the research and test the systems investigated and developed by publishing their results.

Convenience sampling is a non-probabilistic technique frequently used in quantitative and qualitative research. Its popularity among researchers is due to its low cost and reduced time investment. This technique consists of selecting an accessible and available sample for the study, without the need to follow strict statistical criteria [Golzar *et al*., 2022]. However, convenience sampling has disadvantages, such as the unfeasibility generalizing the results beyond the sample used and the lack of representativeness of the population as a whole [Weigold and Weigold, 2022].

3.1 Research phases

It was necessary to divide the research process into three phases, **First phase:** Process mapping, the main benefit obtained by mapping the processes is the emergence of a vision and a shared understanding of a process by all involved [Greasley, 2006].

In this first phase, we sought to map the process and understand in detail the current reality of the team's activities, routines and workflows. Thus, the development activities of the information management systems by the developers were mapped, as well as the existing reporting system and its use by the sector's employees in two stages. First, with the system developed with traditional tools and, second, with the new system, developed with low-code tools. Data collection, measurement and analysis were carried out in both stages.

Second phase: Data Collection, this phase is divided into two stages.

The first stage involves data collection through structured observation. For this stage, a questionnaire with open-ended questions was used, focusing on the process of building the previous system (using traditional tools) and new system (using low-code tools).

The second stage of data collection took place through a structured questionnaire based on the psychometric Likert scale to evaluate employees' perception regarding the efficiency of the systems developed (previous and new), providing a deeper understanding of development activities, application, understanding and refining the analysis process.

For the structured observation, it was analyzed the variables related to the execution time of development activities by developers, respecting the following observations: (I) Development time system - which is the time spent to develop the report system (II) time taken by the developer to perform his activities using the tool, without the assistance of a specialist co-worker, (III) Data report preparation system - measured time of execution and preparation for data collection task.

Regarding the structured questionnaire, we seek to analyze the efficiency of the systems developed with traditional tools (previous) and with Low-Code tools (new) based on the perception of the end user. The questionnaire applied had seven questions in its design, which were equally applied to both models, where we seek to analyze the following variables. this information can be seen in **Table 1**.

Third phase: Measurement and Analysis of Results were performed based on descriptive statistical analysis. Descriptive statistics is a numerical analysis that seeks to describe a measure of central tendency or dispersion of a sample [Fisher and Marshall, 2009]. The results of this step were obtained through the mean and standard deviation for structured observation two collaborators and statistical mode for the structured questionnaire with Likert scale of eleven collaborators.

3.2 Data collection procedure

For the data collection procedure, two Action Research cycles were analyzed, involving the development process using traditional tools and the use of Low-code tools, in addition to the process of analyzing the efficiency of the data management system developed with these tools.

3.2.1 First Cycle: Development and analysis of the previous system

In the first cycle of action research, the focus was on developing a data management system using traditional tools such as Power Query M, JQL and CSV files in Excel. This cycle followed the steps of problem identification, action planning, data collection, analysis of results and finally, reflection and replanning.

- **Problem identification:** The problem identified in the first cycle was the high time and complexity of the data management system development process using traditional tools, such as Power Query M, JQL and the CSV format.
- **Action planning:** To investigate the effects of this approach, the cycle was planned based on the following parameters: (I) Development time: assess the time required to build the system; (II) Complexity: analyze the difficulty of implementing each stage of the process and (III) User perception regarding the efficiency of the developed system: collect feedback from users about the usability and efficiency of the final system.
- **Data collection:** Data collection was performed by monitoring the development process, observing developers in the process of writing and reviewing scripts manually and processing data at each stage, as well as seeking integration between tools.
  After the development and implementation of the tool, users were subjected to tests with the system and data on efficiency of use were collected. For these two collection phases, structured observation and structured questionnaires with a Likert scale were applied.
- **Analysis of the results:** can be seen in section 4 results and discussions.
- **Reflection and replanning:** Reflection on this cycle indicated the need to explore methods that would reduce development complexity and provide a better experience for end users. The long development time and the difficulty in performing updates stood out as critical points. Based on this, the second cycle of action research was planned, seeking development with a focus on Low-Code tools.

3.2.2 Second Cycle: Development and analysis of the new system

The second cycle aimed to analyze the development of a new data management system, this time using low-code tools such as Pentaho, Scriptcase and Power BI. This cycle followed the same steps as the first, but with a different approach regarding the tools used.

- **Problem Identification:** The objective of this cycle was to verify whether the adoption of low-code tools could reduce development time and improve system usability, while maintaining or even improving data management efficiency.
- **Action Planning:** The same metrics were used to plan this cycle: (I) Development time: evaluate the reduction in time compared to the first cycle. (II) Complexity: analyze whether low-code tools simplify the process. (III) User perception of efficiency: collect feedback on the interface and functionality of the new system, now developed with Pentaho, Scriptcase and Power BI.
- **Data Collection:** Data collection followed the same pattern as the first cycle, using observation and questionnaires to investigate user experience. Therefore, data collection was carried out by monitoring the development process, observing developers in the same way as previously done.
  After implementation, the same users from the first cycle were invited to test the new system. The same observations and questionnaires were carried out to capture perceptions in terms of development efficiency, usability and task execution time.
- **Analysis of the Results:** can be seen in section 4 results and discussions.
- **Reflection and Replanning:** Based on the results obtained, it was noted that, in highly specific and complex tasks, the low-code system presented some limitations. With this reflection, new research cycles can be planned to investigate combinations of Low-Code with traditional methods, seeking to further optimize the process of developing and maintaining data management systems.

4 Results and discussions

4.1 Development and application of the previous information management system.

The information management system developed for this research basically consists of a system that collects data from products that went to homologation and are approved.

These products should be documented, stating all technical specifications and respective requirements that were applied to each model for each customer, this work is carried out weekly by the product management team previously described in section 3.

The system initially developed, from now on referred to as the previous system, is an information system designed for weekly data collection (**Figure 1**) and is based on a script developed in Power Query M, which corresponds to an ETL (Extract, Transform and Load) data query language limited to the use of Microsoft Power BI and Excel [Makchan and Pornphol, 2019].

Table 1. Variables and questionnaire questions

Variables	Questions
(I) The new System compared to the previous system has a more friendly interface.	Does the system under analysis have a user interface friendly?
(II) The new system in relation to the previous system facilitates the obtaining and understanding of data without the need for support from a specialist.	Does the system under analysis simplify obtaining and understanding data without the need for specialist support?
(III) The previous system provides greater speed in the interpretation and analysis of information when compared to the new system.	Does the system under analysis provide you with agility in interpreting information?
(IV) The new system in relation to the previous system allows us to transmit the data in a practical way.	Does the system under analysis allow you to transmit data in a practical way?
(V) Both systems allow us to perform data collection activity but in the previous system this activity is performed more easily.	Does the analysis system allow you to collect data in a practical and easy way?
(VI) The new system performs data collection activity more easily than the previous system.	Is using this system easier than any other system that offers this support?
(VII) In the new system when data is loaded do not need to be validated with origin.	In the system under analysis, when used, is it not necessary to validate the data with the source?

As a flexible data transformation language, Power Query M is highly scalable, allowing users to import, transform and model data from various sources. The tool was developed by Microsoft and its main feature and purpose is to connect to different types of data sources, whether databases or text files and then load the information, enabling its modification without having to type a line of code [Kajáti *et al.*, 2017].

The process starts with a script used to collect data that will serve as a basis for applying it to Power Query M is presented. Initially the script collects data when executed, loading a CSV file, which was originated from a query in Jira, the task management system used by the corporation called JIRA.

JIRA is a project management system that uses the high-level JQL (Jira Query Language) language written in a simple way, where the server interprets it and converts it into SQL or HQL (Hibernate Query Language) queries depending on the type of database implemented [Bunmapob and Limpiyakorn, 2022].

After reading the CSV file, Power Query M performs an analysis where each piece of data is collected and compared with results obtained in a previous list, eliminating repeated information and keeping only new information related to the current week.

The **Figure 2** shows an example of a data fragment in the background after using the script in Power Query. Some of the image data was deliberately censored as it contained confidential company's information. However, it is possible to notice the rudimentary way of collecting data and information with little or almost no optimization in the process.

The data collection generated by the script is a slow process and directly affects the team's productivity, as the runtime varies between an average of 1 hour and up to 1 hour and a half, depending on the number of projects and information to be collected during the week.

One of the disadvantages of this system is the possibility of consulting data from previous weeks, there is a dependency on already collected data since the automation itself needs to make a comparison between spreadsheets in Excel to present the result. In case of automation failures, the system that centralizes the data needs to be consulted directly, leaving no other alternative than manually filling out the report. **Figure 3** presents the result after using the script generating an Excel table with a set of data for management and analysis of information coming from models approved by each customer (some data has been deliberately blurred).

This whole process presents limitations mainly regard to maintenance of the script. Since it is a specific programming language, an employes without knowledge of the language or basic program background present difficulties in case of needing adjustments to the automation. A simple adjustment to the filter used by the tool can become a complex activity for such a profile of employee, requiring additional time for training and implementation. Another limitation of the system is related to the filling of data, which consists of using the previously downloaded data giving the possibility of handling and manual insertion of these data. This is because the filter used via script does not have conditional structures that allow automatically filling certain data which may lead to inconsistency in data losing the truthfulness of the information.

4.2 Development and implementation of the new information management system using low-code tools.

The development of the new information management system to report requirements and products has aimed to create standardization, improving data security and quality, as well as automate processes to reduce errors and perform constant checks to ensure consistency for the approval results. To start the system development, it was necessary to divide the process activities into three main parts: separation and listing of information, creation of status rules and preparation of a report showing the effectiveness and control of approvals.

As a starting point for the development of the system,

```
today=`date +%Y.%m.%d_%H_%M_%S`
SW1_FileName="SW1_$today.csv"
SW2_FileName="SW2_$today.csv"

###Generates the Excel file, with current date interted in its title
mv -v "D:/[illegible]/Database/LastWeek/"* "D:/2020/SW_List/Database/Old"
mv -v "D:/[illegible]/SW_List/Database/CurrentWeek/"* "D:/[illegible]/SW_List/Database/LastWeek/"

###The script runs a routine that moves the files to different directories.
###Database file from last week is moved to old database directory.
###Database file from current week is moved to last week directory.
cd "D:/[illegible]/SW_List/Database/CurrentWeek/"
curl -u user:password -X GET "[JIRA filter link]" > $SW1_FileName

###Routine makes login and access JIRA filter, consulting current week data and generates
###a new file on current week directory that is renamed by "SW1_FileName" parameter value
### STEP 2: Consult data source and format data in Excel table
###This routine generates a table that contains all data collected until the previous week:

let
    Source = Folder.Files("D:\[illegible] FOTA [illegible]\Database\LastWeek"),
    #"Filtered Rows" = Table.SelectRows(Source, each [Extension] = ".csv"),
    #"Sorted Rows" = Table.Sort(#"Filtered Rows",{{"Date modified", Order.Descending}}),
    #"Split Column by Delimiter" = Table.SplitColumn(#"Sorted Rows", "Name", Splitter.SplitTextByDelimiter("[illegible]", QuoteStyle.Csv), {"Name.1", "Name.2"})
    #"Removed Duplicates" = Table.Distinct(#"Split Column by Delimiter", {"Name.1"}),
    #"Filtered Hidden Files2" = Table.SelectRows(#"Removed Duplicates", each [Attributes]?[Hidden]? <> true),
    #"Invoke Custom Function2" = Table.AddColumn(#"Filtered Hidden Files2", "Transform File from LastWeek", each #"Transform File from LastWeek"([Content])),
    #"Removed Other Columns2" = Table.SelectColumns(#"Invoke Custom Function2", {"Transform File from LastWeek"}),
    #"Expanded Table Column2" = Table.ExpandTableColumn(#"Removed Other Columns2", "Transform File from LastWeek", Table.ColumnNames(#"Transform File from L
    #"Changed Type1" = Table.TransformColumnTypes(#"Expanded Table Column2",{{"Issue key", type text}, {"Issue id", Int64.Type}, {"Created", type date},
    #"Renamed Columns" = Table.RenameColumns(#"Changed Type1",{{"Custom field (Model Category)", "Model Category"}, {"Custom field ([illegible] Type)", "[illegible] Type"},
in
    #"Renamed Columns"


###This routine generates a table that contains only new data from current week:
```

Figure 1. Part of the script used in collecting the data that generates the report.

Jira Query Language (JQL), Pentaho and Scriptcase tools were used. Initially, there were some difficulties occured, such as customization time of the filters, knowledge of the requirements and bureaucracy for IT access permissions. To overcome these barriers, it was decided to divide the implementation and development of the system into two phases: the first phase was dedicated to data collection and the second phase to data visualization.

In the first phase, Pentaho was used as an ETL (Extract, Transform and Load) tool to integrate data, allowing connection to the JIRA system through the API and sending the collected information to a central database. In the second phase, the need for a Low Code tool that would allow creating a robust web system, accessible on any platform and meeting the institution's security requirements, was identified.

After researching, Scriptcase was chosen, a web system development tool in the On-Premises format. Therefore, it was possible to create a system with login, ticket creation and especially, create applications to control and generate reports, meeting the needs of the proposed new information management system to report requirements and products.

During the development process, the information flow was adopted, which consisted firstly in organizing and classifying the relevant customer data in the sector's database. This organization and classification were based on the products registered in the JIRA system and predefined business rules to filter the products along with the records. The entire operation of the system and the flows of the process can be viewed in **Figure 4** which describes the dataflow.

The usage flow of information is divided into four stages. The first stage is to make a JQL (Jira Query Language) query with the standard listing of all data. The second step is to use the Low Code Pentaho tool to create a loading structure that executes the JQL query through API. This query returns a result in JSON format, which is interpreted by the Low Code tool and transforms the data into a table format compatible with the database. In this step, the Jira data table is created. The third step is to again use the Low Code Pentaho tool to read the Jira data table and create the customer listing based on the business rules established by those involved in the process. In this phase, extra fields are added for necessary controlling and automations. The fourth and final step is to use the table with the customer listing to generate several control reports and applications such as BI and Scriptcase. The development steps and the flow of creating lists and automations for the new data management system can be seen in **Figure 5**.

The Process flow and customer automation was completely developed using SQL (Structured Query Language) and the Low Code Pentaho tool, following the next steps: First one, create the Client Load corresponding to the creation of a listing from the Jira data table based on various approval status rules and the existence of versions. Second step, develop an automation to fetch the product version status leaving them pending. Third step, carry out an automation aimed at inserting a priority status based on a customer branch in the list. Fourth step, define the priority of items on the list based on the execution week according to the delivery date. Fifth step, run an automation set the priority for those products that are not part of the execution week. Sixth step, address a responsible person for the list item. Last step checks the classification of empty fields within the database.

Figure 6 presents the new information management system, i.e., the result of this entire development process where a screen example from the page of the new system can be viewed where forms of quick or specific filtering, column and record sorting buttons, as well as options for export, mass filling and editing of registration per record can

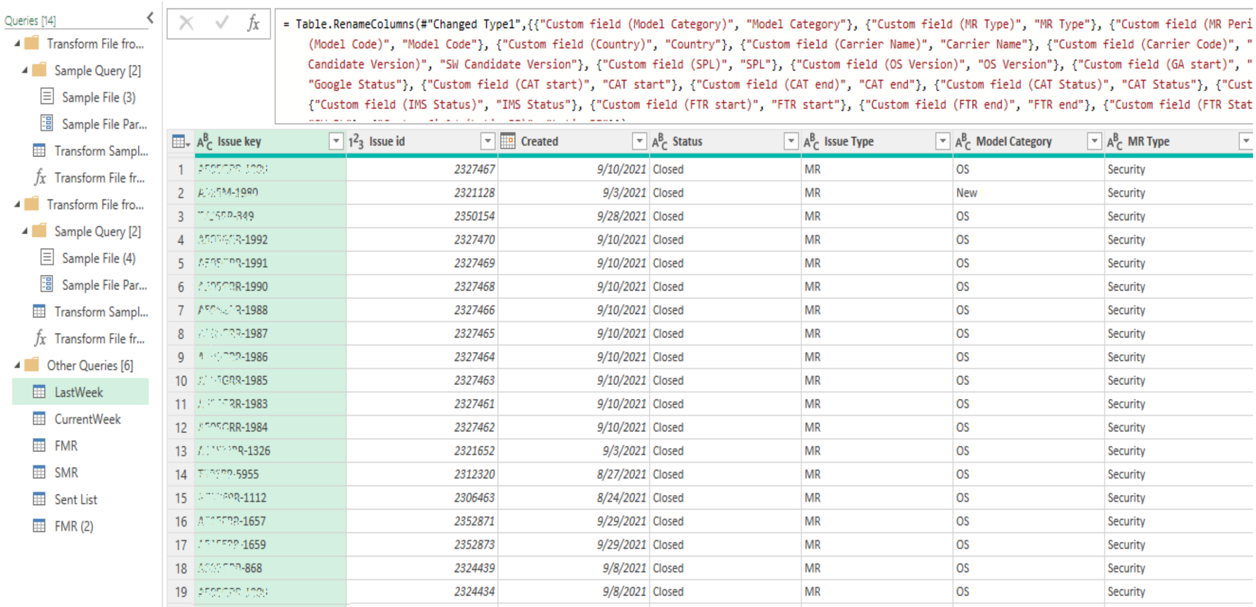

Figure 2. Processed data presented in Power Query script editor after using the Script that brings the data for information management.

be observed. Some data has been deliberately blurred since it contains company's sensitive information.

The results obtained after the development of the new web-based information management system are considered successful regarding to the requirements established for the system. The developed system has an interface that aims for simplicity of use while offering robustness in terms of data filtering and manipulation, allowing the user to collect updated data that can be easily processed from a variety of filter options developed based on the business rule of the process, which enables objective analysis by employees.

The new system makes available to the employee a range of large-scale data, considering that its collection period reaches data from the previous years' Jira system, thus, the tool allows the availability of accessing age-old records.

Regarding management, the main business rule filters are present, so that the employee can make the necessary combinations for weekly activities, identifying the products, customers and projects that will be worked on during a given period, among other information. In this case, the employee can assign the person in charge and status of each project with respect to its respective documentation, identifying, for example, the pending items, or the cases that are already in progress or whether the task is finished.

Regarding the development process of the new system, initially, it can be said that it took longer than the previous system because two resources with different levels of technology expertise were used and along with that, the fact that there were no experts in web systems development in this team was considered. However, this corroborates the argument that the simplicity of using the low-code tool with Pentaho allows structuring a database even without an extremely specialized development team. In addition, integration with automations and web systems (developed in Scriptcase) for data insertion is found. Together with SQL (Structured Query Language), the system was improved to the point that the end user monitors, analyzes the problem and with just a few clicks, can generate the reports and information necessary to meet customer demands.

4.3 Results of structured observation

The data presented below refer to the results obtained through structured observation with the support of descriptive statistical analysis applied to the analysis variables: (I) development time of the requirements management system; (II) moment when the developer realizes that he can perform development activities without the help of a specialist; and (III) execution and preparation time for the data collection task. These results can be viewed in **Table 2**, which presents the comparison between both systems.

For the first analysis variable, development time, the criteria used was the observation of the management systems delivery process since the concept until the conclusion of the functional system. In this context, the completion and delivery time indicates that the previous system presented superior performance, since its implementation was completed approximately one week before the new system, being concluded in just three weeks. This shows that the development of the previous system was more agile.

To assess the second variable, the learning curve, the developers changed their development tools and underwent brief training. In this way, developer A, who had mastered traditional tools, began working with low-code tools, while developer B began using traditional tools. Both were asked to develop the same system they had previously created, but with the new tools.

When comparing the learning curve between the developers, it was observed that developer B took six weeks to fully master the traditional tools, while developer A needed only 1.5 weeks to become familiar with the low-code tools, demonstrating that the low-code tool seems to be less complex and easier to learn.

Model Name	Country	Carrier Code	SW Version	SPL	OS Version	SW Fix2	SW PL	Issue key	CAT Status
Model 01	Paraguay	Code 01	SW Version 01XX01	November/23	Android 12	November/23	XX-XX	YY-YY	Approval
Model 02	Argentina	Code 02	SW Version 01XX02	November/23	Android 12	November/23	XX-XX	YY-YY	Approval
Model 03	Uruguay	Code 03	SW Version 01XX03	November/23	Android 12	November/23	XX-XX	YY-YY	Approval
Model 04	Costa Rica	Code 04	SW Version 01XX04	November/23	Android 12	November/23	XX-XX	YY-YY	Approval
Model 05	Ecuador	Code 05	SW Version 01XX05	November/23	Android 12	November/23	XX-XX	YY-YY	Approval
Model 06	Argentina	Code 06	SW Version 01XX06	November/23	Android 12	November/23	XX-XX	YY-YY	Approval
Model 07	Paraguay	Code 07	SW Version 01XX07	November/23	Android 12	November/23	XX-XX	YY-YY	Approval
Model 08	Uruguay	Code 08	SW Version 01XX08	November/23	Android 12	November/23	XX-XX	YY-YY	Approval
Model 09	Chile	Code 09	SW Version 01XX09	November/23	Android 12	November/23	XX-XX	YY-YY	Approval
Model 10	Ecuador	Code 10	SW Version 01XX10	November/23	Android 13	November/23	XX-XX	YY-YY	Approval
Model 11	Colombia	Code 11	SW Version 01XX11	November/23	Android 14	November/23	XX-XX	YY-YY	Approval
Model 12	Uruguay	Code 12	SW Version 01XX12	November/23	Android 15	November/23	XX-XX	YY-YY	Approval
Model 13	Panama	Code 13	SW Version 01XX13	November/23	Android 16	November/23	XX-XX	YY-YY	Approval
Model 14	Ecuador	Code 14	SW Version 01XX14	November/23	Android 17	November/23	XX-XX	YY-YY	Approval
Model 15	Argentina	Code 15	SW Version 01XX15	November/23	Android 18	November/23	XX-XX	YY-YY	Approval
Model 16	Costa Rica	Code 16	SW Version 01XX16	November/23	Android 19	November/23	XX-XX	YY-YY	Approval

Figure 3. Data collected and made available in Excel after applying the script.

Table 2. Development process comparison

Var	Description of variables	Min	Max	Mean	Std. Dev	CV
Time	Development time (previous system)	n/a	3 weeks	-	-	-
	Learning curve time (previous system)	4 weeks	8 weeks	6 weeks	2.828	47.1%
	Data report preparation (previous system)	60 minutes	90 minutes	75 minutes	21.213	28.3%
	Development time (new system)	n/a	4 weeks	-	-	
	Learning curve time (new system)	1 week	2 weeks	1,5 weeks	0,707	47,1%
	Data report preparation (new system)	2 minutes	5 minutes	3,5 minutes	2,121	60,6%

Applying statistical analysis to the data collected for this variable, it was observed that the previous system has a standard deviation of 2.828 and a coefficient of variation of 47.1%, indicating a significant variation in learning times, representing approximately 47.1% of the six-week average. This suggests that learning times in the previous system are not homogeneous. For the new system, the standard deviation was 0.707, which indicates a smaller variation in learning times compared to the previous system. Although the coefficient of variation is the same (47.1%), the smaller standard deviation of the new system suggests greater consistency in learning times.

Regarding the third variable, data collection and report preparation time, the average time for this task in the previous system was 75 minutes, while in the new system this time was drastically reduced to just 3.5 minutes. This represents a significant saving of time and resources for the organization. The statistical analysis for these results shows significant results.

For the previous system, the standard deviation was 21.213, with a coefficient of variation of 28.3%, resulting in a range from 53.7 to 96.2 minutes. For the new system, the standard deviation was 2.121, with a coefficient of variation of 60.6%, indicating a proportionally greater variation between the times collected. However, despite of the relatively high variation, the total execution time of the new system is much lower than the previous system, then this variation does not significantly interfere with the overall efficiency of the system.

4.4 Results of structured questionnaire

The data collected from the structured questionnaire and presented in **Table 3**, demonstrates that the usability of the previous and new systems have an evident relation with the improvement in efficiency in requirements management activities. This presents that there is an upgrade in the performance of the team in their tasks, based in the enhancement of user experience between the systems.

PS = Previous System, NS = New System, SD = Strongly Disagree, D = Disagree, NAD = Neither Agree or Disagree, A= Agree, SA = Strongly Agree

Var. I - Usability in developed systems is a crucial factor for efficiency in requirements management, as it directly influences the time employees take to generate and analyze reports. The evaluation of variable I showed that most employees Strongly Agree that the new system has a more user-friendly interface compared to the previous system, with a result of Strongly Disagree. This improvement in the

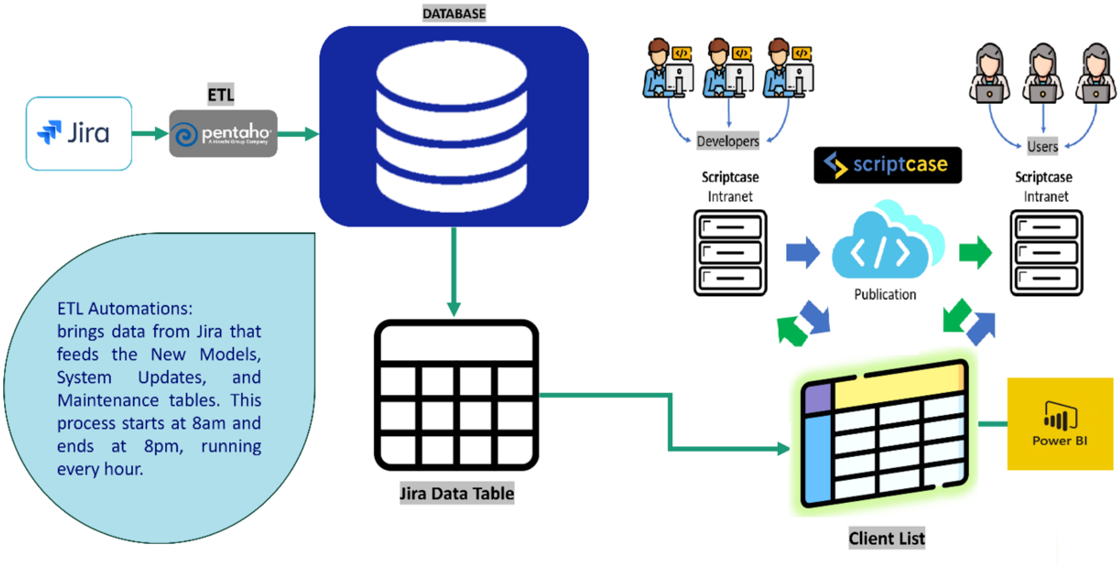

Figure 4. System data flow.

interface makes it easier to use, reducing the time needed to train users, allowing them to adapt to the system more quickly. This reduced time spent learning how to use the system translates into a gain of efficiency, as employees can focus more on requirements management activities and less on understanding how to operate the system.

Var. II - The new system also stood out for its ease of obtaining and understanding data, without the need for specialized support. The Strongly Agree trend for the new system indicates that employees perceive a significant improvement in their ability to access and interpret information independently, while the trend for the previous system was Strongly Disagree. This increase in user independence implies a reduction in the time spent on technical support queries, resulting in more agile requirements management. The ability to obtain information easily is essential for analyzing and reviewing requirements in iterative cycles, contributing to better planning and process control.

Var. III -The analysis of this variable reveals that the new system with the Strongly Agree mode presents a substantial improvement in the agility to interpret and analyze information compared to the previous system that presented the Strongly Disagree mode. The ability to analyze data more quickly and efficiently has a direct impact on the requirements management process, as it allows for a more agile interpretation of data, reduces delays in response and improves the speed of analysis, as it releases more time for employees to other strategic activities, contributing to an overall increase in productivity.

Therefore, the comparison between the previous and new systems demonstrates that the new system is significantly more efficient in analyzing information, providing agility in the requirements management process.

Var. IV - Practicality in data transmission is another factor that directly impacts efficiency in requirements management. Although the new system presented a trend of Neither Agree nor Disagree, indicating a neutral perception, there was still an improvement in relation to the previous system, which had a Disagree. Practicality in data transmission facilitates communication between stakeholders and ensures that requirements and updates are quickly made available to everyone involved in the process. This contributes to more coordinated and efficient management, with fewer delays in the dissemination of information.

Var. V - The ease of performing data collection activities and the previous system obtained a Disagree mode, indicating that employees do not consider data collection as easy as in the new system, whose mode was Strongly Agree. This improvement in data collection suggests that the new system reduces the complexity and effort required to gather information, increasing agility and accuracy in defining requirements.

Var. VI - For this variable, the results show that the mode for the new system was Strongly Agree, while for the previous system it was Strongly Disagree. This indicates that the new system offers a more autonomous experience for users, allowing them to perform collection activities independently, thus eliminating the dependence on experts to access and understand information. This feature is essential to increase efficiency, as it reduces the workload for support resources and allows users to focus on other critical requirements management tasks.

Var VII - Reveals that both systems had the Disagree trend, indicating that employees disagree that validation of the uploaded data is unnecessary. This result suggests that users still feel the need to validate the data with the source, which may indicate a lack of trust in the automated process of the new system and also in the traditional process of the previous system. Data validation is essential to ensure the accuracy and consistency of the information used and a lack of trust in this aspect may lead to a greater reliance on manual validations, reducing the efficiency of the system.

It can be seen from the data obtained that both systems

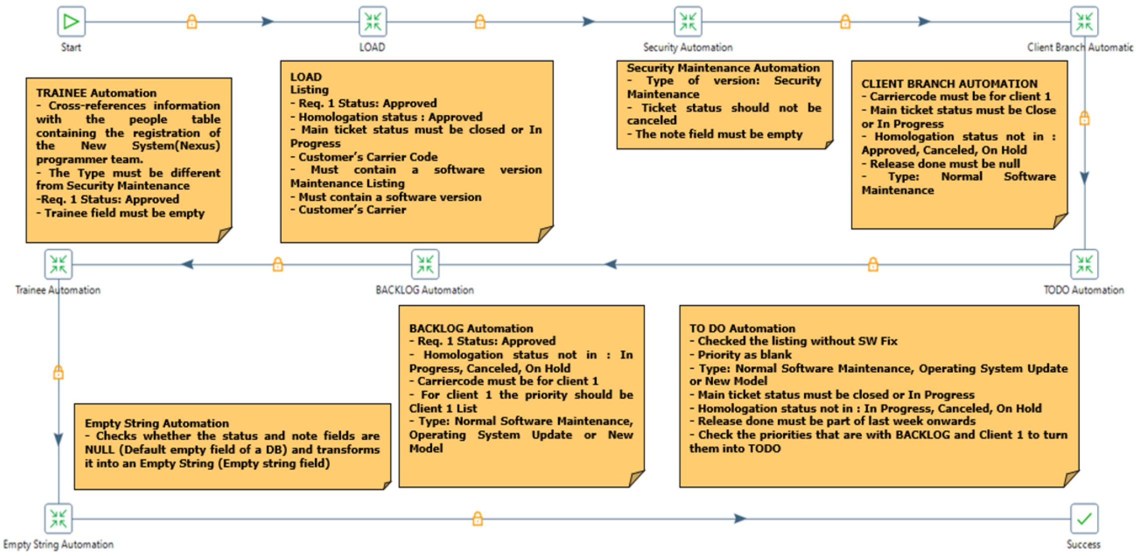

Figure 5. Process flow and customer automation.

have particularities, but the new system presents significant improvements in terms of usability, which is directly reflected in the gain of efficiency in the requirements management process. The reduction of the learning curve, greater autonomy of users in obtaining and understanding data and the simplification of information collection are factors that contribute to more agile and effective management of requirements. Despite the points that still need improvement, such as agility in data analysis and reliability in the validation process, the gains achieved so far suggest that the new system represents a significant advance in relation to the previous one.

These improvements enable the organization to deal more efficiently and productively with requirements management, minimizing redundant efforts and maximizing focus on value-added activities such as analysis and planning. In this way, the new system has the potential to improve not only employee productivity, but also agility in responding to changes, essential factors in a competitive and constantly evolving environment.

5 Threats to validity and research limitations

5.1 Threats to Validity

Following according to the taxonomy of [Wohlin *et al.*, 2012] it is possible to evaluate some limitations and threats to the validity of our results.

Internal Validity: Variability in Team Expertise: The development team had different levels of technology experience, which may have introduced inconsistencies in the development process. This variability may have directly influenced the implementation time and the results obtained, making it difficult to generalize the impact of the tools covered in this study. Absence of Web Development Experts: The lack of web systems experts may have limited the solutions adopted and influenced the efficiency of the development, which leads to the question of whether a more experienced team could have obtained different results.

External Validity: The research was conducted in a controlled and specific environment, adopting particular tools and processes. The findings may be limited or distinct when applied to other companies and industries that utilize different information management systems with different workflow patterns. Relying on specific Low-Code tools like Pentaho and Scriptcase utilized within the investigated company's context might not yield similar outcomes concerning other information management settings across different organizations. The selected sample and restrictions imposed by the information management team during the research conduct directly influence the results, rendering them non-generalizable to other companies and contexts.

Constructive Validity: Measuring Efficiency: Efficiency was measured based on development time, usability and speed of data collection, but other factors such as code quality, maintainability and system security were not directly addressed. These gaps may compromise a complete assessment of the new system's effectiveness. Subjectivity in User Assessments: Employee perceptions were collected using a Likert scale, which may involve subjectivity in responses, especially with regard to the user-friendly interface.

Conclusion Validity: Although the development of the new system has brought clear benefits, such as reducing data collection time and simplifying the interface, threats to validity highlight limitations that need to be addressed so that the results are more generalizable and consistent.

5.2 Research process limitations

The research presents certain limitations that must be considered when interpreting the results. Firstly, the

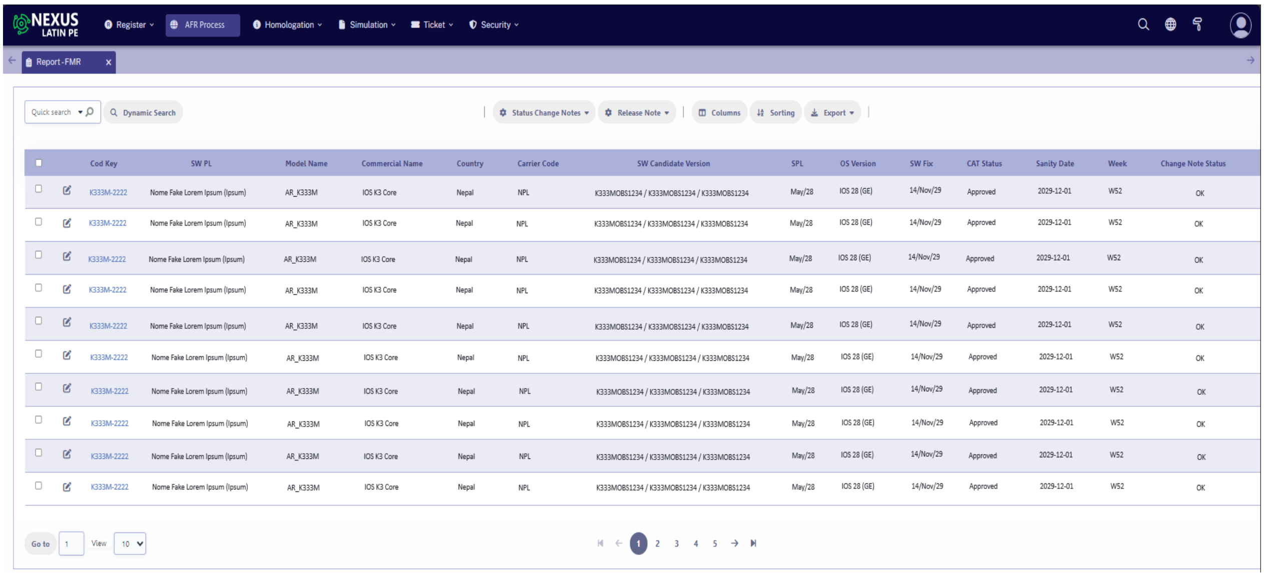

Figure 6. New information management system.

study used a convenience sample consisting of a team of employees responsible for the product approval process who volunteered to test the developed applications, which limits the representativeness of the results. These employees belong to a single sector of the organization and are directly involved in using the created systems. Therefore, the findings reflect the specific characteristics of this organization and may not apply to other companies or sectors with different structures and needs.

It is also important to mention that the limited time available for implementing and testing the developed solutions-imposed restrictions on the results. The systems were evaluated based on development time, intuitive interface, usability, and data collection efficiency. However, it was not possible to assess long-term impacts, such as the continuous maintenance of the systems or their adaptation to changing company needs. Thus, the applicability and efficiency of Low-code solutions compared to traditional systems still require further investigation.

Another limitation to consider is the scope of the tested tools. As this is a research and technology institute that develops solutions for third parties, its information security policy restricts the acquisition and use of tools that access the external network, limiting the variety of available platforms. Low-code tools such as Pentaho and Scriptcase were selected for their specific characteristics, but the positive results observed may not extend to other Low-code platforms with different functionalities and limitations.

Additionally, data collection was conducted in a single round for each action research cycle, which may have impacted the accuracy of the findings. A single application of questionnaires may limit the understanding of evolving perceptions over time and hinder a more in-depth analysis of the impact of the implemented solutions. To address this limitation, it would be advisable to conduct multiple data collection rounds at different points within each cycle, allowing for a more comprehensive evaluation. Moreover, refining some questionnaire items with stricter criteria could help minimize ambiguous interpretations and enhance the reliability of the collected data.

Given these limitations, future studies could explore larger samples, involving a greater number of employees and applying the solutions in different sectors. Additionally, analyzing other Low-code platforms and investigating the long-term impacts of the implemented tools may provide a more comprehensive understanding of their effectiveness and applicability in the business context.

6 Conclusion

This study evaluated the effectiveness of low-code tools, Pentaho and Scriptcase, in the development of data management systems at a technology institute, comparing them with the traditional tools previously used, such as Power Query M. The findings indicate that, although the traditional system was functional, it presented limitations in terms of usability. Users reported difficulties in the data extraction and manipulation process, with long development times and the need for considerable effort for maintenance and updates. Additionally, the learning curve was a barrier for new users, who struggled to use the system efficiently. These challenges highlight the complexity and time required in the use and maintenance of traditional systems.

The system based on Power Query M, designed for weekly data collection, required an average report preparation time of approximately 75 minutes, with significant variations. Its reliance on manual comparisons between spreadsheets affected the team's productivity and required technical knowledge for adjustments, making maintenance a complicated and time-consuming process. In contrast, the new system developed with low-code tools showed substantial improvements in efficiency and usability. The data indicated that the low-code system was perceived as more efficient, especially in task execution time and ease of use. Users highlighted the more intuitive interface

Table 3. User perception results between previous and new information system developed

Var	Analysis questions	Model	SD	D	NAD	A	SA	Mode
Usability	Does the system under analysis have a user interface friendly?	PS	8	2	1	0	0	SD
		NS	0	0	0	1	10	SA
	Does the system under analysis simplify obtaining and understanding data without the need for specialist support?	PS	11	0	0	0	0	SD
		NS	0	0	0	4	7	SA
	Does the system under analysis provide you with agility in interpreting information?	PS	8	1	2	0	0	SD
		NS	0	0	1	1	9	SA
	Does the system under analysis allow you to transmit data in a practical way?	PV	0	1	6	4	0	NAD
		NS	0	0	0	0	11	SA
	Does the analysis system allow you to collect data in a practical and easy way?	PV	5	6	0	0	0	D
		NS	7	3	0	0	1	SD
	Is using this system easier than any other system that offers this support?	PV	2	5	4	0	0	D
		NS	0	0	0	0	11	SA
	In the system under analysis, when used, is it not necessary to validate the data with the source?	PS	4	7	0	0	0	D
		NS	1	7	2	0	1	D

and increased agility in data manipulation. The report preparation time was drastically reduced to just 3.5 minutes, representing significant savings in time and resources.

The research reinforces that the simplicity in using the provided information is due to the friendly and intuitive interface of a web platform, which proved to be responsive to the employees. According to the results, the learning time was reduced by 75%, which is a positive feature for the company in implementing improvements related to operational efficiency. The ease of data interpretation, visualization and system intuitiveness were evidenced by the employees' opinions, as observed in the Likert scale. Thus, the results show that employees had almost no questions when using the current system, which improved the flow of management and process execution. One point to be improved in both systems (old and new) is the need for data validation by comparing the obtained information with its source. However, this aspect can be refined over time by applying new data processing rules in the automated system code, including the use of artificial intelligence to refine the entire process. It is recognized that there area opportunities for improvement, especially regarding data validation.

It can be said that the use of action research allowed for deep involvement of participants and a practical evaluation of the systems. The method facilitated the identification of problems and the implementation of solutions, with a collaborative approach that directly involved the product management team. Although the sample consisted of only 11 employees, this approach provided valuable insights into user experiences and system functionalities.

The study's limitations are significant, mainly due to the use of a convenience sample. The selection was made up of employees from a single department, which may not reflect the diversity of experiences and needs across the organization. This limits the generalization of the results to other areas or companies in different contexts. To fully understand the potential of low-code tools, further studies with larger and more diversified samples, as well as longer evaluation periods, are needed.

We believe that for new researches, with the inclusion of a greater number of participants and application in other areas and business sectors, can strengthen the understanding of the use of low-code tools in corporate environments by improving efficiency in the development process and creation of management information systems.

Declarations

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Authors' Contributions

All authors contributed to the design of this research at every stage from writing, reviewing, and editing as well as data curation, formal analysis, investigation, methodology, and writing of the original draft and final manuscript.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The datasets generated and analysed during the current study are available by e-mail with authors.

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