




Business intelligence dashboard as a technological innovation for analysis on digital transformation in higher education

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Abstract– *The aim of this work is to present the dashboard as an interactive tool to analyze and visualize the results of the literature review on digital transformation in education, including the used architecture and software used to make it. The study collected 4149 articles from Scopus, Taylor and Francis, ScienceDirect, Redalyc y Sage and were selected 126 articles after applying quality criteria. The research used a mixed approach, both qualitative and quantitative, by one side, the literature review and the other side, extraction data analysis (EDA) was carried out. The study was conducted in four phases: Search and Acquisition, Cleansing and Organization, Analysis, and Design. PowerBI Desktop was the tool used to design and deploy the interactive dashboard. The main result was to visualize the most important information about digital transformation in higher education, such as the demographic distribution of the authors, their affiliations, the most prolific authors in the topic, and the trending topics. This innovative approach contributes to a more informed and data-driven understanding of digital transformation in higher education.*

Keywords-- *Dashboard, Digital Transformation, Interactive visualization, Technological innovation, PowerBI.*

I. INTRODUCTION

Digital transformation in higher education is a topic of growing interest in academic research and educational practice, where educational organizations can transform data into useful information, enabling them to improve their performance and gain a competitive advantage. This shift toward integrating technology into education has been driven by a number of factors, including emerging technological advances and changing labor market demands [1].

In the academic research field, there are many results from DT in education. However, the main challenge is how to analyze it. One way to understand the growth of this area and the key factors is through visualization techniques.

The educational landscape undergoes a dynamic transformation fueled by the relentless advancement of digital technologies. Immersive learning experiences, personalized pathways, and innovative pedagogies are reshaping how knowledge is imparted and absorbed.

While traditional scientometric analyses offer valuable insights into publication trends, author profiles, and geographical distribution, they often present static data visualizations that require considerable time and effort to create and interpret. This paper proposes a novel approach – an interactive business

intelligence (BI) dashboard – to visualize the landscape of DT in education research. The dashboard uses a set of prepared data, so that the researcher can focus on extracting the conclusions from the resulting graphs from the dashboard, and not spend time on the visualization style. The point is unveiling their potential as a powerful tool for analyzing digital transformation in education.

Thus, the research questions are: RQ1: How to effectively analyze and interpret visually the body of knowledge of DT in higher education?, and RQ2: What insights can be gleaned from the interactive visualizations generated by the dashboard about the key trends, themes, and pioneers in DT in higher education? The goal of this study is to show the dashboard as an interactive tool to visualize and analyze the results from the literature review on digital transformation in higher education, including the used architecture and software to make it.

The main contribution is to show visual information about a literature review in DT in an innovative and interactive way, for a more informed and data-driven understanding. Also, researchers of this field could extract relevant information according to their questions of interest through BI dashboard interaction.

This paper is structured with four sections, first background wherein we expose definitions and state-of-the-art about business intelligence, technological innovation and digital transformation in education. Second, methodology and methods, there we describe methods in detail about systematic literature review, cleaning data, and the dashboard design. Third results, in this section we explain the dashboard design, architecture, mockup, colors, data model, and layouts. Finally, the conclusions and references are presented.

II. BACKGROUND

A. Business Intelligence

Business Intelligence (BI) encompasses a set of technologies, processes, and practices that organizations use to collect, analyze, and process data to generate valuable information that supports both strategic and operational decision making. From its origins in the 1980s as information systems, BI has evolved to include advanced analytical tools and multi-disciplinary reporting capabilities [2].

As such, the BI is a set of tools and strategies focused on the collection and processing of information for subsequent

organizational analysis [3]. This tool is used by enterprises of different sizes, including the Small and Medium-sized Enterprise (SMEs). BI can save time, cost, and effort, compared to using transactional systems [4]. Despite the initial cost that it generates for an organization to implement BI, the main benefit is to have a clear overview of information management.

Through BI, organizations can transform data into useful information, enabling them to improve their performance and gain competitive advantage [2]. Therefore, understanding Business Intelligence is essential for improving the decision-making process of institutions [6].

B. Technological innovation

Technological innovation highlights a fundamental role in economic and business development, enhancing the competitiveness and growth of nations. Technological innovation, involving changes in products and processes through the adoption of new technologies and practices, is key to improving productivity and generating competitive advantage [5]. The level of development of a country is influenced by the competitiveness that their institutions can achieve in terms of innovation in their processes, achieving sustainable development in them [5]. What's more, technological innovation not only affects the economy, but also affects working conditions, education and the quality of life [6]. In an organization, technological innovation is one key aspect for progress and development. Therefore, it is necessary to understand the influence of buyers and suppliers [7], the capabilities of its leaders, and the flexibility of the organizational configuration [8].

A dashboard is a flexible data visualization tool that allows to connect and display information from multiple sources, files, services, APIs. The typical visualizations are tables, graphs and other visual representations. In the context of technological innovation, dashboards are considered an innovation in themselves, transforming the way organizations manage and visualize data. Their application spans multiple work areas, including accounting, customer satisfaction, sales, user experience, data analytics, and digital marketing [9]. In the field of higher education, information is necessary to adapt to the changing market and knowing how other educational institutions have made the transformation in the era of digitalization allows them to build on what has been built, develop their capabilities, competences, and contribute to the growth of nations.

The study by Dolganova [10] shows the usefulness of the dashboard to present the results of the assessment of the readiness to implement digital transformation in a university and the results of the maturity model.

C. Digital Transformation in Education

Digital Transformation (DT) is a process of change that involves all aspects of an organization [1]. DT in higher education is driven by technological, human, organizational and pedagogical factors. The aim is to prepare students for the

challenges of the Fourth Industrial Revolution and global demands, including cognitive, social, technical, and interpersonal skills [11].

DT consists of technological enablers, some of these technologies are: machine learning, mobile devices, blockchain technology, artificial intelligence, digital twins, and the Internet of Things. "The digital transformation model focuses on the five forces that are reorganizing business strategies: customers, competition, data, innovation, and value. These five forces are redefining the strategy with which companies must operate in order to succeed" [1].

The concept of "digital transformation" in higher education is the adoption of processes, practices and, in some cases, new management models to provide value to society. For that is required the development of a groundbreaking university information system, offering users a unified platform with comprehensive data on students, staff, faculty, and researchers. This data will encompass individual profiles, publications, patents, taught courses, and ongoing research projects, all of which are driven by technological advancement and innovation [1] [12].

The COVID-19 health crisis has created various challenges and opportunities for higher education. In the academic and pedagogical sphere, it has prompted a reconsideration of traditional educational practices and teaching methodologies in order to adapt to a blended reality utilizing technology [13] [14]. However, for official educational institutions, much remains to be implemented in terms of DT [13] [15]. These shortcomings are due, on the one hand, to the gap that exists between the different countries in terms of technological development [16], and on the other hand, to the level of internal infrastructure of each institution, in the preparation of teachers, and in the implementation of institutional policies oriented to technological change [17].

III. METHODOLOGY AND METHODS

This study has a mixed approach, both qualitative and quantitative. On one hand, it is qualitative because the data extraction was manual after deep reading of selected papers; on the other hand, it is quantitative for the descriptive analysis and visualizations chosen. The chosen methodology was adapted from the SALSA (Search, Appraisal, Synthesis, and Analysis) framework [18] adjusted from Codina [19], which is used to address research on digital transformation in higher education institutions. In order to visualize the results we proposed using the dashboard as an innovative way to show the data.

The SALSA methodology that we adopt for our research is divided into four main phases: Search and Acquisition, Cleansing and Organization, Analysis, and Design. Tools used to perform the research and design the dashboard were: Parsifal, Mendeley, Microsoft Excel, Python, Power BI.

The Parsifal tool is disponible online and was used to perform Systematic Literature Review (SLR), optimizing the time needed to obtain and select information [20]. Parsifal uses the PICOC method, which consists of five components: Population,

Intervention, Comparison, Outcomes and Context [21]. Parsifal with its PICOC method allowed us to build search equations from the parameters we specify in each of its components, and export the data in .xlsx files.

The Mendeley tool was used as a repository of full-text articles for deep reading. Microsoft Excel and Python were used to organize, pre-process, and transform the data. Finally, Power BI was used to design, process, and deploy the dashboard.

A. Search and Acquisition

Research questions that were shown above, are:

RQ1: How to effectively analyze and interpret visually the body of knowledge of DT in higher education?

RQ2: What insights can be gleaned from the interactive visualizations generated by the dashboard about the key trends, themes, and pioneers in DT in higher education?

Repositories relevant to the research were identified and selected, such as Sage, ScienceDirect, Scopus, Taylor & Francis Group and Redalyc, which were chosen based on a criterion of relevance, trust and accessibility. Table 1 shows the PICOC method used.

TABLE I
PICOC METHOD

P	Higher Education, University, Tertiary Education, Educational Organization.
I	Digital Transformation.
C	Model, Methodology, Strategy, Readiness, Framework.
O	Enabler, Determinant, Facilitator, Characteristic, Factor, Feature, Criteria, KPI, Indicator.
C	>2016

Additionally, with the help of the Parsifal tool, specific search equations were generated for each selected repository.

The general search equation with the study variables was: “(“College” OR “Educational Organization” OR “Higher Education” OR “HEI” OR “Higher Education Institution” OR “Tertiary Education” OR “University”) AND (“Digital Transformation”) AND (“Framework” OR “Good practices” OR “Methodology” OR “Model” OR “Readiness” OR “Strategy”) AND (“Characteristic” OR “Criteria” OR “Critical Success Factor” OR “Determinant” OR “Driver” OR “Enabler” OR “Facilitator” OR “Factor” OR “Feature” OR “Indicator” OR “KPI” OR “success determinant factor” OR “variables”)”

Subsequently, 4.149 articles related to DT in HEIs were collected.

B. Cleansing and Organization

After collecting articles, we begin performing an Exploratory Data Analysis (EDA) from data collected. We proceeded to clean, organize and extract relevant data. Selection and exclusion criteria were established to validate the quality of the studies and duplicate or irrelevant articles were eliminated, leaving 348 articles.

Selection and exclusion criteria:

1) *Exclusion criteria:* To rule out studies, the following criteria were applied:

- Articles related to elementary schools or high schools.
- Research focused on companies or corporations.
- Publications prior to 2016.

2) *Inclusion criteria:* To include articles in the review, the following criteria were considered:

- Studies addressing higher education or digital transformation in education.
- Research dealing with digital strategy.
- Articles analyzing key factors or enablers in digital transformation.
- Research focused on higher education institutions (HEIs) or universities.

Parsifal facilitated the formulation of quality assessment questions and the creation of a data extraction form for subsequent analysis, through its two protocols: Quality Assessment Checklist and the Data Extraction Form. After applying the quality assessment checklist, a total of 126 articles were available for review.

C. Analysis

In this phase, a comprehensive analysis of the selected studies was carried out. The quality of these studies was verified using the questions formulated in the previous stage. Once the verification was completed and the studies that met the quality criteria were filtered, the contents were extracted using the forms designed in Parsifal. In addition, the journal indicators were obtained from the SJR website.

Parsifal allowed the export of information from the studies, as well as the information extracted from the forms. A database was then created with six different tables: Articles, Authors, Content, Indicators, Type of Indicators and Journals. During this process, it was necessary to use the technique of data analytics to organize, correct and complete the information provided, since duplicate data, writing errors and missing information were found.

D. Design

Once the database was complete, the most appropriate graphs and tables were selected to represent the information collected. Careful consideration was given to the choice of each visual element, as these would facilitate the understanding of the information by a diverse audience. In addition, an interactive dashboard was designed and created to allow users to explore the data in a more depth.

The design of the dashboard was conceived to allow users to interact with it, which is achieved through the implementation of various filters. These filters will facilitate a thorough exploration of the results, allowing users to focus on specific areas of interest and gain a more complete understanding of the information presented.

IV. RESULTS

A. Dashboard design

In order to answer the first question (RQ1) related to effectively analyzing and visual interpretation, Fig. 1 shows the architecture layout of the general process to build the dashboard.

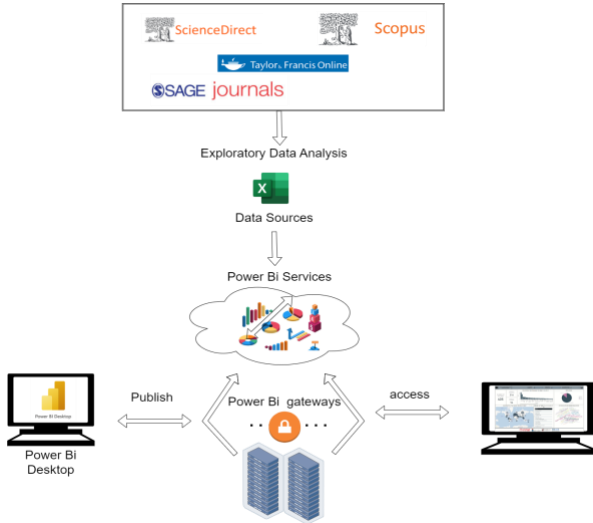


Fig. 1 General architecture of dashboard design.

The architecture includes the data source which contains structured and preprocessed data, and gateway between power BI desktop and online deployment with the dashboard designed. Fig. 2 contains the distribution of the panel, including a menu to move between pages, and filters on top. The canvas shows summarized indicators and graphics, and on the bottom includes the logotype of the university and research group.

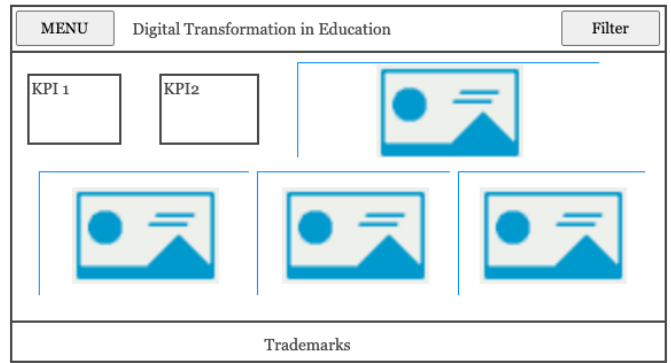


Fig. 2 Mockup of the Dashboard.

Four layouts with information about the landscape of digital transformation in education in Power BI were designed, including publications, journals, authors, and content analysis. Fig. 3 shows the initial dashboard layout, which visualizes the results of the literature review from 126 publications. We selected a waterfall chart to show the increase in publications per year, a pie chart to show the source of the publications, a bar chart to detail how to select papers, a cloud chart to show the main words and factors of the digital transformation.

B. Insights from the digital transformation in education

In order to answer the second question (RQ2) related to analysis and insights gleaned from the interactive visualizations generated by the dashboard, Fig. 4 offers us a very important overview as part of the research results. After processing the information available, we find a total of 54 countries, 405 authors from 216 affiliated entities who have published on DT since 2017. The most common selection criterion for approving articles was digital transformation, followed by higher education and universities, which is consistent with the research

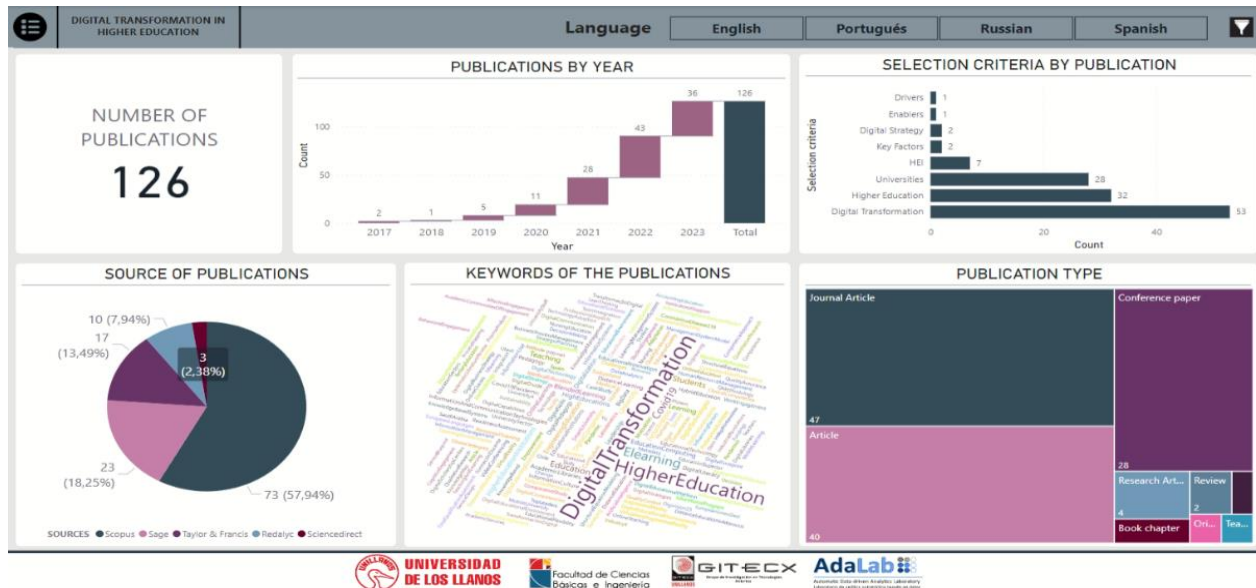


Fig. 3 Dashboard on the digital transformation in education designed on Power BI [22].

topic (detail in Fig. 3). Additionally, the largest number of publications is concentrated in the pandemic and post-pandemic period. The source with the largest contribution of literature was Scopus with 73 approved articles, representing 57.94% of the total.



Fig. 4 Key Performance Indicators (KPI) of authors, countries, and institutions.

Fig. 5 and Fig. 6 show the distribution of countries of origin of authors. Russia stands out with 58 affiliated authors and Spain with 42. However, it is notable that the topic of DT in education is of global interest due to the presence of publications on all continents.

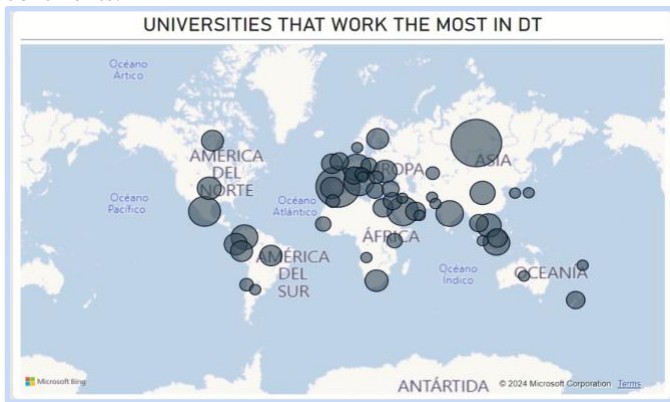


Fig. 5 Geographical distribution of countries and institutions with publications on the digital transformation in education.

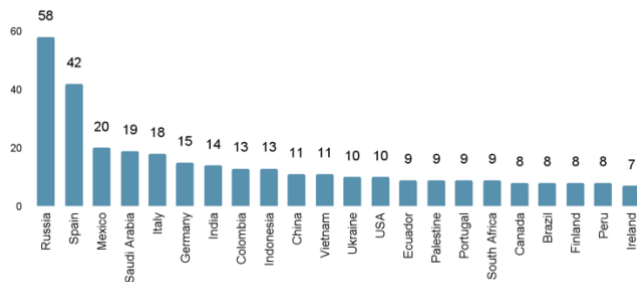


Fig. 6 Countries with publications on the digital transformation in education.

Table III shows a summary of the main countries and the number of authors affiliated with their institutions and who made publications associated with the DT.

TABLE III
TOP COUNTRIES BY AUTHORS NUMBER ON DIGITAL TRANSFORMATION IN EDUCATION

Country	Authors number
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Russia	58
Spain	42
Mexico	20
Saudi Arabia	19
Italy	18
Germany	15
India	14
Colombia	13
Indonesia	13
China	11
Vietnam	11

In Table IV, Francesc Marc Esteve Mon stands out for having the most publications in this field, and other important authors and the number of articles they have published are also observed.

TABLE IV
MAIN AUTHORS

Author	Publications number
Francesc Marc Esteve Mon	3
Faten Hamad	2
Hussam Fakhouri	2
Kobylin Oleg	2
Kuzminska Olena	2
Martinez Perez Sandra	2
Mazorchuk Mariia	2
Morze Nataliia	2
Ramirez Montoya Maria Soledad	2
Rodriguez Abitia Guillermo	2
Viñoles Cosentino Virginia	2

Fig. 7 shows different methodological approaches of studies on digital transformation in education, deductive approach had the highest count with 39.6% of studies, followed by inductive with 27%, empirical with 27%, and no-information with 6%. Deductive approach had the highest count among approach methods meaning studies are literature-based and then be compared with their reality.

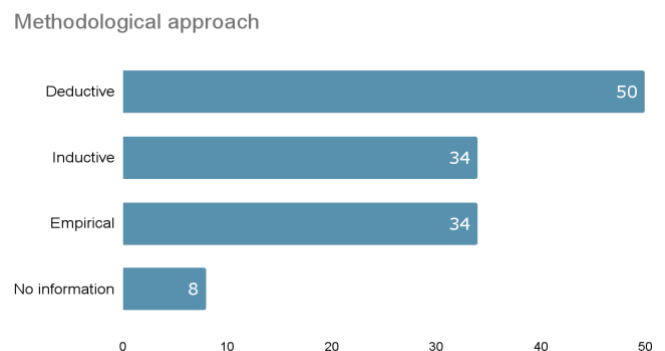


Fig. 7 Methodological approach of studies on digital transformation in education.

Using the dashboard visualizations and analyzing the selected articles, a list of themes and trends in digital transformation in education that are considered important based on their frequency of occurrence were extracted. These trending themes are displayed in Fig. 8 as a word cloud, where the size of the word represents the importance, and in Table V presents the top themes. Digitalization is considered the trending topic, followed by infrastructure, leadership, big data, and digital literacy.



Fig. 8 Word cloud of themes and trends on digital transformation in education.

TABLE V
TRENDING THEMES ON DIGITAL TRANSFORMATION IN EDUCATION

Trending themes	Frequency
Digitalization	13
Infrastructure	13
Leadership	9
Big Data	7
Digital technologies	7
Digital literacy	6
E-learning	6
MOOC	5
Organizational flexibility	4
Artificial intelligence	4
Virtual reality	4

V. DISCUSSION

Building dashboards as an innovative tool of BI allows to perform queries and to display the analysis results on the collected data in an interactive way. These solutions have demonstrated their usefulness in various ways, for instance, in 2017 [23] the dashboard, developed with open source software, was used for decision support for a mining company. In the year 2020, Everts [24] proposed a dashboard of the pandemic wherein the information and speed were necessary. The dashboard showed information about the health crisis such as "the most severe outbreaks occurring in very local places such as hospitals and care homes". Also, the dashboards were used to show relevant information, presented in a way that allows you to track what is happening at a moment in time. For other hand, Cordova *et al.* [23] in 2021 shared a methodology of five phases for dashboard design. Dashboard effectiveness is based on their ability to distill large amounts of data into clear and

accessible visuals, allowing researchers to extract relevant information efficiently and effectively [23].

However, the process of extracting information for dashboard construction is a critical step in ensuring the integrity and relevance of the presented data. Data and its processing is a step mandatory of any design of the dashboard, in this sense, in [9] shows many issues related to data quality, for that, the importance of treating it.

A clean, processed dataset is essential to ensure the integrity and relevance of the data presented. Therefore, it is necessary to perform a data cleansing process before creating the dashboard [9] [23]. In this work, the process included the following steps:

- 1) *Removal of extra spaces:* The data was rigorously reviewed to eliminate any unnecessary white space.
- 2) *Correction of misspelled words:* The data in which there were writing errors such as additional hyphens, capital letters, accents, etc. were corrected.
- 3) *Language verification:* Some data were translated into English.
- 4) *Elimination of repeated data:* Repeated data were eliminated, since duplicate information was presented due to typographical errors.
- 5) *Column separation:* Columns are separated by category for better visualization
- 6) *Correction of delimiters:* Different delimiters were found, so it was necessary to unify them
- 7) *Data completeness:* Missing information in each of the tables was completed.
- 8) *Data format change:* Data formats were changed to make them easier to control.

This cleaning and purification process ensured that the data was accurate and consistent, which was essential for subsequent analysis and dashboard creation. By carefully selecting and organizing the information gathered during the literature review, we can ensure that the dashboard accurately reflects current trends in TD in HEIs. This approach minimizes the risk of presenting irrelevant information in the final report, which could potentially affect the dashboard's quality and reliability [25].

Finally, the dashboard is an interactive tool for visualizing and analyzing the results of the literature review, facilitating the identification of trends, key themes and outstanding contributions in the field of study. The purpose of this work was to illustrate the power of BI dashboards for all types of literature reviews. Innovation plays a fundamental role in the construction of the dashboard, as it is characterized by concepts such as creativity and invention [6]. Tejada Estrada *et al.* [5] mention that technological innovation is one of the most important given the economic changes it implies, understanding changes in products and processes.

VI. CONCLUSIONS

This study raised the questions (RQ1, RQ2) to be answered according to the stated objectives. In this way, in relation to the first question, it can be concluded that dashboards are especially important for presenting literature review results because they can condense large amounts of data into clear and accessible visual representations that facilitate understanding and analysis of information collected during the literature review. Instead of presenting static data in complex tables or graphs, the dashboard provides an interactive experience that allows users to explore the data and extract relevant information based on their specific needs.

The dashboard was designed as an interactive tool to visualize and analyze the results of the literature review on digital transformation in higher education. This process involved selecting and organizing the relevant data obtained during the research, using data analysis tools and techniques to transform the findings into clear and accessible visualizations; this allowed the collected information to be clearly presented in a way that is easy to understand by the people who will interact with it.

On the other hand, regarding the second question, it can be concluded that digital transformation in education is a field of extensive study, and that the methodological approaches with which the studies are approached are diverse. The DT is addressed on all continents, with special emphasis on Europe and Asia, mainly through publications by authors from Russian universities. In Latin America, it is Mexico and Colombia that lead research with the greatest number of researchers studying strategies for the digital transformation of education.

Business intelligence delivers the results that prove it improves tasks, interactivity, and allows examining real-world case studies that demonstrate the successful implementation of BI dashboards in research settings with academic orientation.

Finally, the innovation of using a dashboard to present results from literature reviews lies in its ability to combine the academic rigor of the literature review with the accessibility and ease of use of data visualization tools. By providing a dynamic visual representation of research findings, the dashboard goes beyond the limitations of traditional static reports and provides researchers and practitioners with a more intuitive way to interact with data and gain valuable insights.

As a future work, the dashboard will be evaluated by a panel of experts in engineering and data visualization to ensure its accuracy, usability, and effectiveness in conveying insights. Based on their feedback, we will refine and finalize the dashboard.

Considering the power of BI dashboards for all types of literature reviews, it is proposed to test it with other cutting-edge topics. In addition, it will be possible to link and update the database in real time.

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