ORIGINAL ARTICLE

IJAMB JOURNALAMB.COM
INTERNATIONAL JOURNAL OF ADVANCES IN MEDICAL BIOTECHNOLOGY

Managing Knowledge for pharma and biotech innovation

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Received: 01 March 2024; May 15 April 2024.

Abstract: Knowledge Management (KM) involves a deliberate and systematic organization of people, processes, structure, and technology with the main objective of creating value for innovation from the reuse of data and information. Although there are several models for KM in various types of organizations, there is nothing concrete to integrate the knowledge generated in collaborative University-Industry projects in the pharmaceutical and biotechnology areas. This work aimed to gather elements for the creation of a sustainable model of effective articulation in this scenario. It is a strategic action that can bring benefits of intellectual, economic, and social impact. This research used different instruments: systematic mapping, questionnaires, and experience reports. The mapping highlighted the need to consider the following aspects for the development of KM models: collaborative/competitive arrangements, tacit/explicit knowledge managers and change screening. The questionnaire and report demonstrated that the challenges go beyond aspects such as data organization. They must prioritize the social aspect of knowledge sharing, using safe coordination to prevent misconduct.

Keywords: Innovation. University-Industry Interaction. Data Management. Information Management. Information Technology.

Introduction

Innovation is not clearly defined but it is mainly understood as the involvement of new ideas to generate new techniques, products, and processes. Herein, it is important to emphasize that innovation is not limited to creating something completely new, but rather seeks to facilitate everyday life, reduce costs, and make things more accessible. In Brazil, scientific innovation is understood as the last link in the chain of Science-Technology-Innovation (ST&I), and it is crucial to translate the intellectual and economic impacts of research made in universities to society. Using this linear relationship, innovative products and services are thought to be the outcome of scientific advances, but the reality is always like this? Further, can innovative actions stimulate discoveries in basic science? These intriguing questions are pressing in the current situation in Brazil, where it is possible to observe a certain polarization between basic and applied research.

The influence of pure science in advancing innovation was criticized by Matt Ridley during his provocative point called "The Myth of Basic Science", which stimulated thoughtful responses on social media about the role and benefits of science and technology. The divergences about the role of basic science and technology in innovation raised pointed to bidirectional influences[1]. However, the current understanding of innovation points to a context-dependent factor with great influences on local or regional vocation and development. Herein, the partnership between the University-Government-Industry was also another influential point, thus giving rise to the Triple Helix Theory. However, changes in the global scenario have expanded the form of relationships between these actors. This traditional triad has been strengthened with new models of collaboration for knowledge generation, including society (Quadruple Helix) and the environment (Quintuple Helix) with important helices in the dynamics of innovation" [2].

The University-Pharmaceutical or Biotech Industry interface is a specific example of the quintuple helix operation and plays a fundamental role in meeting the demands of innovation in the health area through scientific entrepreneurship. In this context, the contribution of private capital to universities through public-private partnerships has the potential to create favorable conditions for the better functioning of the whole gear. This scenario may seem like the solution

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doi https://doi.org/10.52466/ijamb.v6i1.121

to the problems being faced by the country, however, it could generate even greater discrepancies when we consider that Industry and Academia have essentially different objectives. Because they have different focuses, Industry and Academia walk at different paces. While the industrial sector aligns its efforts towards the agile development of products and obtaining profit in the short term, the academic environment is concerned with the generation of publications that guide knowledge as well as the training and qualification of personnel, which usually occurs in the long term [3].

Qualitative research carried out focusing on the University-Pharmaceutical Industry interface in Brazil showed that many challenges need to be overcome so that the knowledge generated in universities can be effectively transformed into solutions for the population. Among the various points raised by the respondents and interviewees, the processes that involve Knowledge Management (KM) were highlighted. Despite the existence of Technological Innovation Centers, issues related to sharing information with the agility and organization necessary to support decision-making in emergencies such as the one we are experiencing during the COVID-19 pandemic are still far from expected. Some processes that involve KM that were mentioned are: streamlining the flow of information, increasing the efficiency of continuous training of employees, and improving data analysis and management[4].

KM involves a deliberate and systematic organization of people, processes, and technology as well as the organizational structure itself with the main objective of creating value for innovation from the reuse of data and information. This coordination is achieved through the creation, sharing, and application of lessons learned and best practices in the "organization memory"[5]. KM also involves data and information management flows in two main dimensions: tacit and explicit [6]. The implementation of systematic KM practices generates several benefits, such as improving the financial performance of global startups, executing external knowledge search strategies complemented by internal innovation management, and facilitating digital collaborations[7-9].

Although there are several models to manage knowledge within various types of organizations, there is nothing concrete to integrate the fundamental knowledge generated in universities with those that are more applied and of a more technological nature, commonly generated and used by Industry. In this way, the main objective of this work was to identify some of the main elements that should be considered for the creation of a sustainable KM model for collaborative projects. The establishment of this articulation is a strategic action to catalyze scientific entrepreneurship in the context of the Quintuple Helix. Because innovation is a long-term, complex, and risky endeavor, a sustainable KM model would be a valuable contributor to Brazilian initiatives in closing some important gaps in collaborative projects.

Material and methods

In this work, an exploratory study was carried out with a view to a future creation of a model for KM of scientific and technological innovation projects, preferably those situated within University-Industry collaborations in the context of the quintuple helix. The research was conducted using three different instruments to meet the breadth and complexity of this topic: i. Systematic mapping of the Scientific Knowledge Management topic following two generically defined guiding questions: (Q1) What are the main elements that involve Knowledge Management? and (Q2) What ICT-based tools currently exist to support the Knowledge Management process? ii. The questionnaire aimed at parties involved in scientific entrepreneurship that takes place at the University-Pharmaceutical Industry interface. The questionnaire was disseminated via social networks. The questionnaire was created based on two models of KM: the North American model (Davenport & Prusak) and the Japanese model (Nonaka & Takeuchi).; iii. Field Diary containing the researchers' perceptions and experience report around the theme. The data from the systematic mapping, questionnaire, and field diary were analyzed using qualitative analysis software (ATLAS.ti, following content analysis processes as recommended by Bardin[10]. The Excel software was also used in the process of generating the graphs.

Shane (2005) states that technology is "the incorporation of knowledge in different ways, making it possible to create new products, explore new markets, use new ways of organizing, incorporate new raw materials or use new processes to meet customer needs"11. In this context, entrepreneurs are the driving force that catalyzes the process of transforming knowledge into inventions and innovations with potential economic and social impacts. Commonly, all this dynamic is dictated by technological entrepreneurship, that is, one that directly seeks the practical utility of the invention without worrying too much about understanding the scientific aspects that underlie its applicability[12]. However, the crisis triggered by COVID-19 has exposed the need for technological solutions, especially those that focus on human health (e.g., the production of medicines and vaccines), which must necessarily include aspects related to fundamental knowledge so that well-informed decisions are made. In this context, scientific entrepreneurship emerges as a necessary development of the articulation between Science and Technological Innovation, aiming at minimizing risks and maximizing gains with the creation of new products and/or services. The results presented in this work highlight some of the main elements that should be considered in the creation of KM models for scientific entrepreneurship.

Systematic Mapping - Identifying Knowledge Management Model Elements

The initial total of 50 articles was refined according to the research questions, closing in 19 articles from primary studies and 9 secondary studies. The results of the systematic mapping allowed a better structuring of the research topic around different topics related to KM of innovative projects, preferably those that happen collaboratively between the University and Industry. The survey on the main topics used by the authors considered not only the keywords explicitly defined in the articles but also the text codes. Such codes allowed a panoramic mapping of the main elements that involve KM practices. The emerging themes were then listed based on the codes defined and allocated within the two guiding questions (Table I).

The KM process is complex and dynamic and involves different actors in the collaborative interface. Despite multiple approaches and some prominent models (e.g., the SECI model of Nonaka-Takeuchi and the model of Davenport-Prusak), some main elements could be identified and can be scaled both within the human and technological dimensions. The use of information and communication technologies as digital platforms is considered necessary, but not sufficient to deal with all the dynamics of KM practices. In addition, many of these technologies perform simple system analysis operations such as structuring and archiving data and information but lack some of the key elements shown to be important in all KM practices (e.g., disambiguation, data analysis, knowledge reliability).

Some of the main elements related to KM that go beyond the domain of Information and Communication Technologies (ICTs) refer to the human element or "social character" of knowledge. Although digital social networks are common, currently they do not seem to satisfy the practical needs of KM in terms of traceability and definition of information impact in contexts of interest to a project or organization. It is worth mentioning that this social element is one of the basic engines of the Nonaka-Takeuchi model, especially when talking about exchanges of tacit knowledge[13]. Some emerging themes refer to the possibility of uniting people around the shared construction of academic and business experiences. This type of functionality within platforms is in line with the results obtained via the questionnaire – open questions, which were evaluated in the second stage of this work.

The need to transpose concepts linked to social theories to digital platforms should be considered when planning the types of functionalities that should be created. In this context, the so-called "crowdsolving" platforms stood out among the results, in which individuals are brought together to provide collective solutions to problems previously defined by an organization and/or community. In addition to typical data and information processing operations, such types of platforms can encompass different types of typologies in how human relationships are managed. For example, the possibility of creating competitive and collaborative arrangements is something that should be considered depending on the urgency of solving the challenge.

Table I - Main emerging themes defined in the systematic mapping.

Articles (Author/Date)	Keywords defined by the author	(Q1) What are the main elements that involve Knowledge Management?	(Q2) What ICT-based tools currently exist to support the Knowledge Management process?
(Angelidou; Mount; Pandza, 2022)[8]	Collaboration, complementarity, search for external knowledge, managerial innovation	•Significant learning Tacit knowledge manager •Explicit Knowledge Manager (Technical) •Knowledge reliability •Disambiguation resolution •Agility •Academic experience •Business Experience •Communications Manager •Change screening •Data Manager •Metrics Manager •Competitive arrangements •Collaborative arrangements	•Crowdsolving Platforms •Platforms for digital documentation
(Battisti *et al.*, 2022)[9]	KM practices, financial performance, global startups		
(Bozic; Bachkirov; Cerne, 2021)[14]	Science-practice gap, rigor-relevance debate, knowledge creation, collaborative challenges, grounded theory		
(Chen *et al.*, 2022)[15]	knowledge management, data-driven decisions, dynamic capabilities, hidden knowledge		
(Marijan; Gotlieb, 2021)[16]	Software engineering, collaborative research, knowledge co-creation, collaborative model, technology transfer, knowledge transfer, research-based innovation		
(Spanellis; Macbryde; Dorfler, 2021)[17]	Knowledge-based systems, causal mapping, knowledge sharing		
(Zhao; Oberoi, 2022)[18]	Crowdsolving, crowdsourcing, SECI model		
(Zhong *et al.*, 2022)[19]	knowledge mapping,		
(Naprawski, 2021)[20]	Agile knowledge management, online reorganization		
(Wohlin; Runeson, 2021)[21]	Technology transfer model, university -Industry collaborative model		
(Abbas *et al.*, 2022)[7]	Lessons learned, collaborative platform, integration		
(Albats; Alexander; Cunningham, 2022)[22]	Academic entrepreneurship, digital platform		
(Myneni *et al.*, 2016)[23]	Cognition, information management		
(Nakayama; Hustad; Sutcliffe, 2021)[24]	Documentation system, tacit knowledge, explicit knowledge, knowledge sharing		
(Alsulami; Hashim; Abduljabbar, 2022)[25]	knowledge sharing		
(Pudjiarti; Lisdiyono; Werdiningsih, 2022)[26]	Regulatory implementation, innovation performance		
(Saunders; Radicic, 2022)[27]	Open innovation, cooperation for innovation		
(Muscio; Shibayama; Ramaciotti, 2022)[28]	Student entrepreneurship, entrepreneurial universe, academic training		
(Chopra *et al.*, 2021)[29]	Sustainability		
(Edwards, 2022)[30]	Information management		
(Gomez-Marin *et al.*, 2022)[31]	Sustainable indicators, collaborative mapping, organizational memory		
(Hadi; Liu; Li, 2022)[32]	knowledge brokers		
(Stemberkova *et al.*, 2021)[33]	Transferência de tecnologia		
(Di Vaio *et al.*, 2021)[34]	Digital transformation, sustainable performance		
(Benitez-Hidalgo *et al.*, 2021)[35]	Knowledge extraction, semantics		
(Allen *et al.*, 2021)[[36]	data visualization		
(Ketikidis; Solomon, 2018)[37]	entrepreneurial education		
(Schaefer; Makatsaria, 2021)[38]	Market intelligence, data analysis		

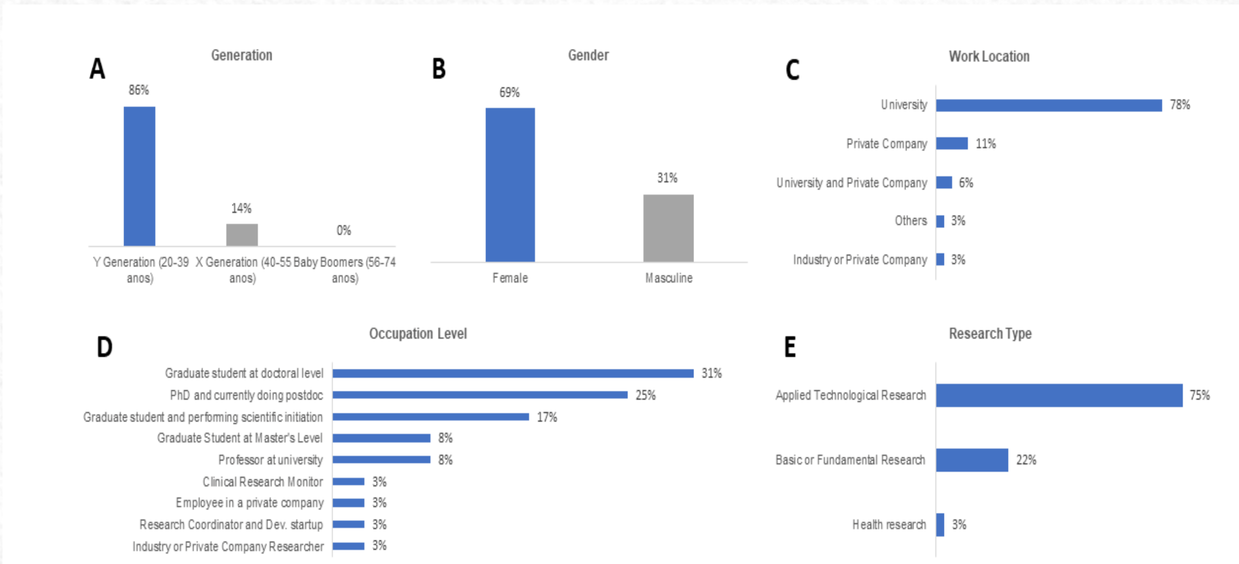
Source: Original search results.

Questionnaire - Characterization of the respondent population

The socio-demographic characterization of the respondents aimed to identify some possible elements (e.g., sex, age) that may influence perceptions about the KM processes of science-based projects. The characterization of the personal profile of the respondents, shown in Figure 1A-B, showed most female participants (69%), while male respondents totaled 31%. Regarding age group, most respondents belong to Generation Y (20-39 years old, 86%) and a minority belong to Generation X (40-55 years old, 14%). No respondents belonging to Generation Z (under 20 years old) or Baby Boomers (56-74 years old) were counted. This classification based on a generational approach is an important aspect to be considered as it interferes both with the perception of the values associated with KM processes and the difficulties, especially with processes that involve the application of ICT-based tools[39] .

The characterization of the professional profile is shown in Figure 1C-E. It was identified that 78% of the respondents are inserted only in the University, 11% are inserted in a private company and 6% are part of both the University and a private company. A minority (3%) is inserted elsewhere. Regarding the level of training, most respondents are doctoral students (31%), post-doctoral students (25%), and scientific initiation (17%). A minority is composed of master's students (8%), professors (8%), coordinators in a private company (3%), startup coordinators (3%), and researchers from Industry or private companies (3%). Regarding the type of research they develop, 75% work with technological research, 22% with fundamental research, and 3% with research in Health. This last result is particularly interesting because it may constitute evidence that in Brazil, we have not yet managed to create the culture of an entrepreneurial Science, that is, one that seeks to align the fundamental knowledge with technological innovation.

Figure 1 - Characterization of the personal and professional profile of the respondents.



Source: Original search results.

Questionnaire - Assessment of the perception of the parties involved about the workflows in the KM of science-based projects

KM workflows permeate dimensions related to organizational culture and learning, social capital, and technological tools. More specifically, the American model of KM focuses mainly on applications of ICT resources to facilitate the flow of data and information within the organization. A series of questions were formulated to understand some operational aspects to assess how respondents interact with such flows. The results are shown in Figures 2 and 3 and focus on understanding how the Collect → Transfer → Storage → Processing of data and information dynamics takes place. Most respondents work with quantitative data (92%) and a minority work with qualitative data (8%). Regarding data transfer processes, 44% use flash drives and external hard drives immediately after data collection, and 31% also use flash drives, but do so periodically. Another 14% leave the data stored on the computer connected to the equipment. Minorities use cloud storage (3%), physical storage + cloud (3%), and notebook notes (3%).

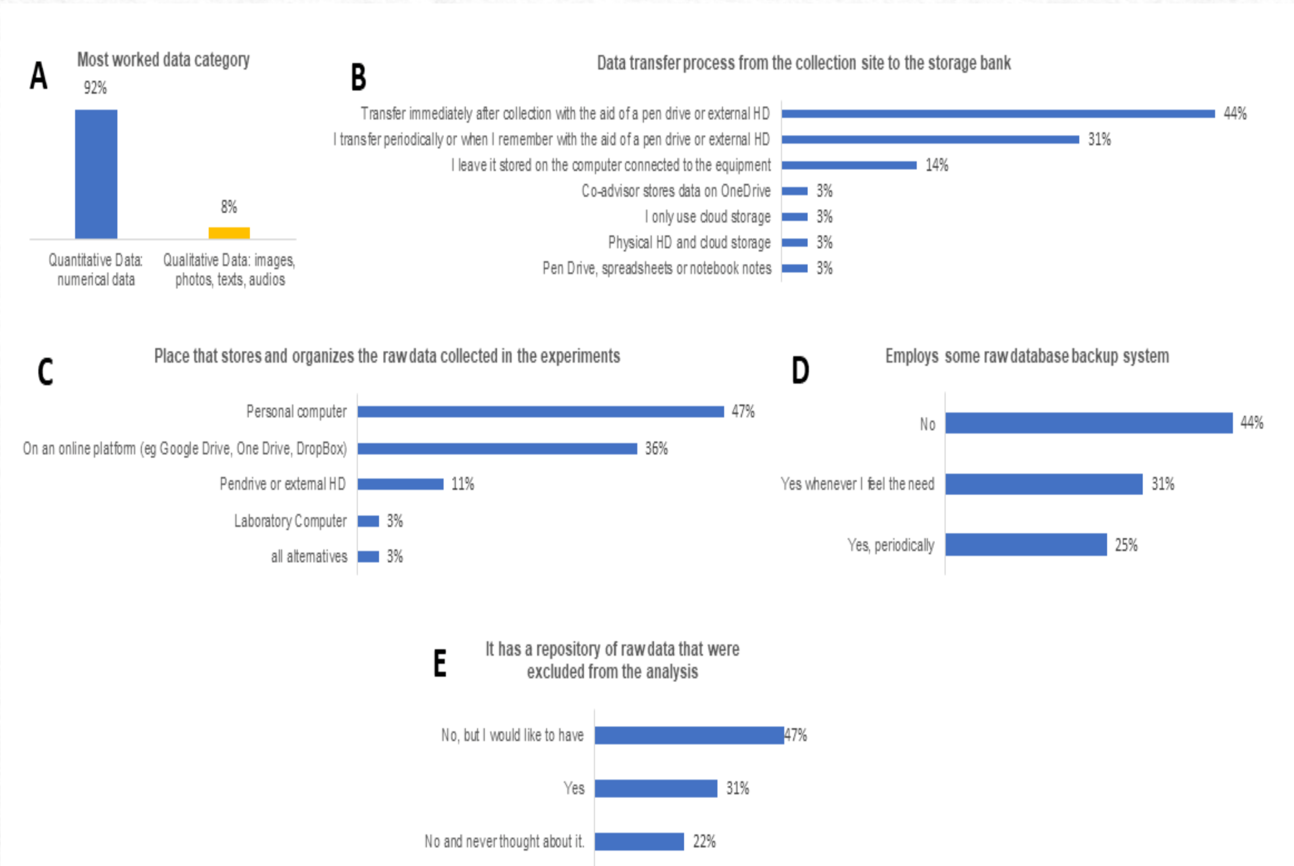
The storage of data/information from the projects is a highly relevant element in interactive University-Industry contexts as it is directly related to aspects related to security and their sharing.

Regarding the storage location of the raw data collected: 47% use a personal computer, 36% use some online platform such as Google Drive, One Drive and Dropbox, and PenDrive/external HD (11%). A minority storage on the laboratory computer (3%) or use all alternatives (3%). Most respondents do not use any backup system for the data collected (44%), and others use backup whenever they feel the need (31%). The minority (25%) said they use backup. About a repository of raw data that was excluded from analysis: most do not have it but would like to (47%), 31% have the repository and 22% do not have it and had never thought about it.

Still considering data and information management processes, Figure 3 presents the results related to metadata storage management and analysis processes. Regarding the repository for metadata, 42% of respondents said they have and organize the metadata manually, another 42% do not have it but would like to have it, and 14% do not have it and had never thought about it. Regarding the processes that involve Information Management: 53% said that some data is analyzed manually and others are analyzed automatically; 38% perform data analysis only manually following a previously established protocol. Only 8% do a fully automated analysis; About the process of generating meaning from the data: 36% compare the results with support material, 31% generate multiple graphs to be able to better visualize the information, 8% compare the results with the support material (reference values and articles of the area).

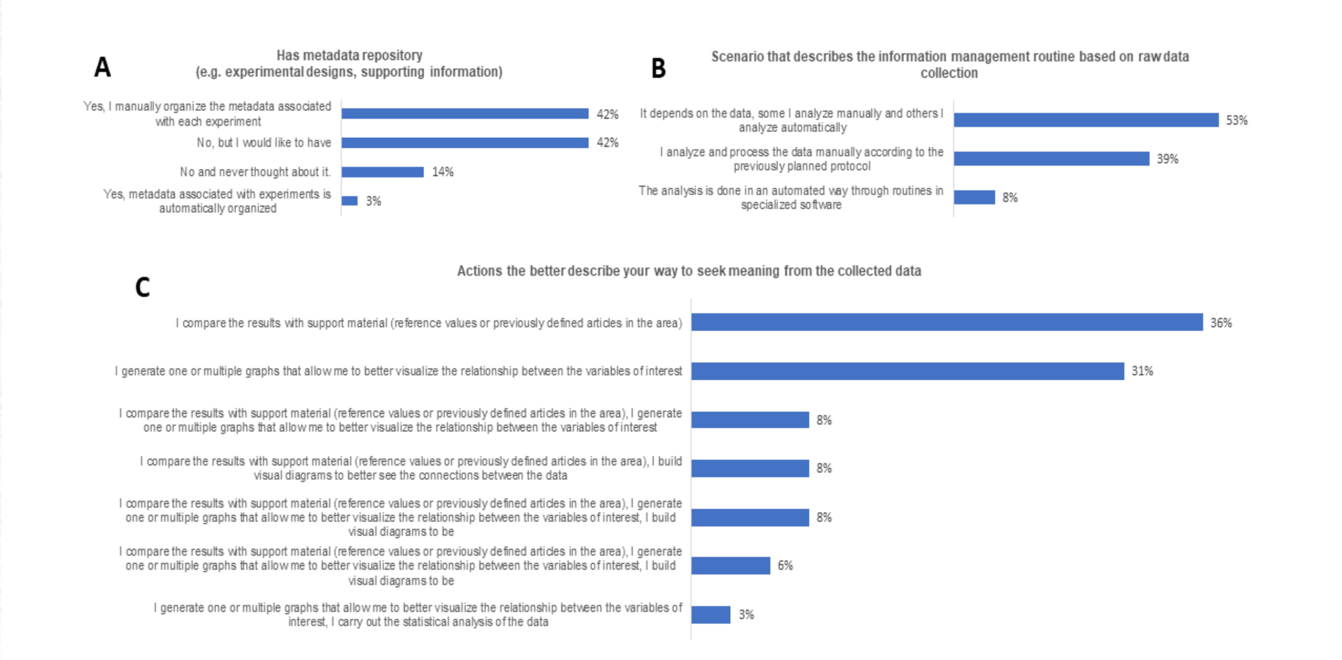
When analyzing together the results shown in Figures 2 and 3, it is evident that several respondents still use manual and unsafe means to manage data/information from science-based projects. Some important aspects related to the use of backup systems and metadata management are still far from best practices and may incur KM problems. Such problems can range from the lack of systematization of databases, which impairs analysis and decision-making processes, to the leakage of sensitive and/or confidential information. It is also worth mentioning that these results are in line with the main parameters considered within the context of knowledge/information management established by some authors, such as people, processes, culture, technology, and structure[30].

Figure 2 - Knowledge Management processes and routines - aspects involving data and information management (Part 1).



Source: Original search results.

Figure 3 - Knowledge Management processes and routines - aspects involving data and information management (Part 2).



Source: Original search results.

Questionnaire - Assessment of potential challenges and elements of value in processes involving the KM of science-based projects

The challenges and perceived value of some KM elements were also evaluated (Figure 4). More specifically, we sought to understand the perception of value that some respondents have on the processes of socialization, externalization, internalization, and combination, which are established in Nonaka and Takeuchi's KM model (Figure 4 A-D). It was observed that all these model processes have a lot of value to respondents for acquiring knowledge. Most of the respondents (81%) attributed a lot of value (grade 5) to the "externalization" process, defined in terms of writing, recording, drawing, and making the information visual (Figure 5-B). A total of 72% of respondents also gave a high value (grade 5) to the "internalization" process, defined as studying, reading, listening, and watching. While the first refers to the articulation of tacit knowledge into explicit, the second uses explicit knowledge, that is, rationalized, into something tacitly internalized by the individual.

The components "socialization" and "combination" were considered valuable (grade 5) by 67% and 56% of the respondents, respectively. Socialization was defined in terms of interacting with people, hands-on observation, and group discussions. It is an extremely important process in sharing experiences, creating tacit knowledge in multiple ways (e.g., mental models and technical skills)[13]. In turn, the combination component seeks to systematize different sets of explicit knowledge using schemas, records, etc. Despite not opposing the common sense that socialization is an important component in knowledge-sharing processes, the results presented emphasize the importance of internalization and externalization processes. This may not necessarily be related to the sharing of information, but to actions that aim to deepen the understanding of knowledge on a given topic.

The other questions regarding the value of KM processes focused on topics related to University-Industry collaborative projects (Figure 4 E-L). The results showed that 92% of respondents are interested in this type of project, with 72% and 78% of respondents giving high value (grade 5) to the following interaction products: obtaining financial resources for research (e.g., equipment and various materials) and the possibility of having the collaboration well evaluated by the platform for future collaborations, respectively (Figure 4 – H and I). In comparison, fewer respondents, 50 and 56%, think that the receipt of salaries and the dissemination of research in scientific journals is valuable (Figure 4 – F and G).

Questionnaire - Answers to open questions

The open questions at the end of the online questionnaire aimed to raise the main topics and more subjective elements related to the KM processes of research projects with innovative potential. A series of codes emerged from the thematic analysis of the responses and were based on hypotheses for the construction of digital platforms for KM (Table II).

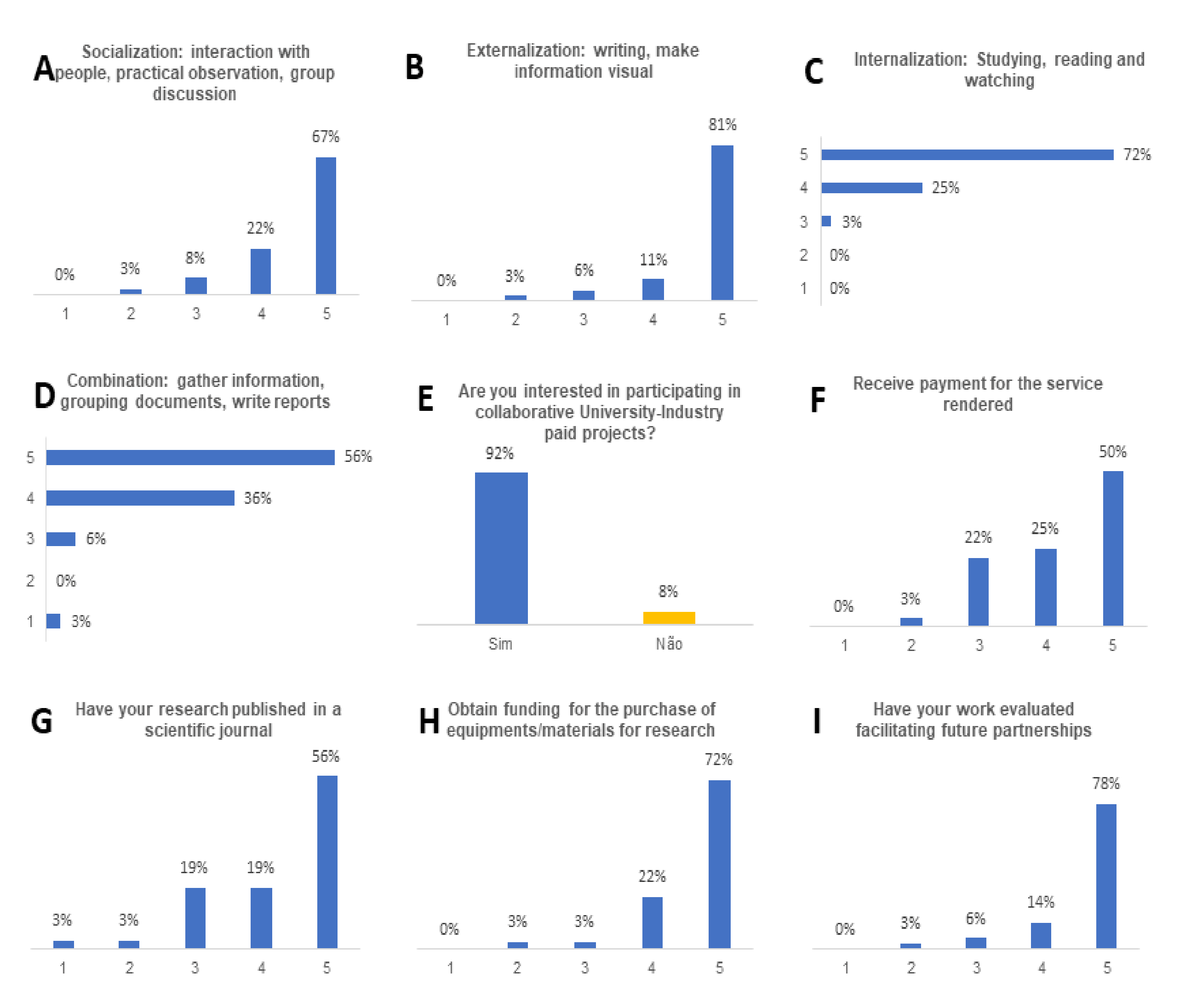
Tacit knowledge management is the most

challenging form of management due to the influence of adjacent subjectivity in interactions. The perception is that currently there are no efficient ways to manage this type of knowledge, but there are hypotheses of interesting solutions that could be investigated. Here, respondents cited the creation of study groups, information records, and means of sharing experiences as effective ways to build KM for tacit knowledge.

The KM of University-Industry collaborative projects is something that needs to be guided by members who make up both sides of the coin. In this work, we mainly explore the academic side, but according to the respondents, different views can be integrated, aiming at a management that favors both the development of new products and the generation of more knowledge around themes of mutual interest. In this case, academics can provide basic (and even frontier) knowledge to be assimilated by members of the industry in the development of innovation projects.

Another aspect that became clear is that the generation of scientific publications should not be the only indicator to guide University-Industry interactions. The fruits of these interactions go far beyond that and can even bring a return to society as it promotes the generation of new innovative products and services. Thus, depending on how KM is practiced, the benefits of the interface can effectively benefit the triple helix parties: government, university, industry. Establishing the main conditions of success for each of these parts is research that needs to be addressed in future works.

Figure 4 - Challenges and value elements of the main processes involved in Knowledge Management. The statements were rated on a five-point scale: (1) Not valuable – (5) Very valuable.



Source: Original search results.

Table II - Coding of emerging themes in the open questions of the online questionnaire on Knowledge Management in University-Industry collaborative projects.

Questions	Parts	Thematic Codes	Hypotheses
It is known that tacit knowledge (that inherent to the person and from experiences) is difficult to share. What is the importance of this type of knowledge in innovative projects? Do you believe that there are currently efficient ways to manage this type of knowledge?	"... tacit knowledge is what differentiates people and is fundamental for collaborative projects, as it is what makes it possible to generate empathy and real applicability of techniques and theories. My suggestion is to analyze it in a systematic and even psychoanalytic way, try to understand the scenario, the problem, possible solutions. This ends up making the situation more translucent and measurable." "... of great importance and currently I don't see efficient ways of sharing this knowledge. Years of work are often lost with the departure of the person who owns this knowledge..." "Collaborations are essential so that tacit knowledge is disseminated to other groups, reducing steps and accelerating the process of research and development of new products. There are a few ways to manage this knowledge on researcher platforms, such as Research Gate and/or discussion forums. But still nothing very efficient. "	Study group Keep Information Records share experiences	Currently, there are no efficient ways to manage tacit knowledge, but this can be done through the creation of study groups and spaces for sharing experiences.
Do you believe that a Knowledge Management of innovative projects that take place in collaboration between the University-Industry can bring a competitive advantage to the Industry? And for the University? Because?	"Yes, because the vision of the academic environment is limited. The industry has a different vision and applicability than academia, and one can benefit from the other. " "I believe so, since the knowledge of academia combined with technology and industrial speed can generate great results. Since the academic scientist may have a different view from the person who works only in the industry."	Integration of different views Provides fundamental knowledge Acquire industrial vision	The KM of collaborative projects can add to both the University and the Industry, that is, the integration of the two mental models is possible and can be used to achieve greater goals and with social impact.
What is for you a successful scenario of the Knowledge Management process in University-Industry collaborative projects?	"It is an idea that is created and developed together, with a specific purpose and goals that both fields (academic and industrial) benefit and progress with the development of a product/idea." "Transfer of knowledge and technology, training, alignment of interests of both parties."	Product generation Generating more knowledge (publications)	The success of collaborative scenarios occurs when they are able to produce both products and more knowledge for the population.
Are you interested in participating in UNpaid University-Industry collaborative projects? If yes, what would encourage you to participate? What would you consider viable to receive in return besides financial gratification?	"Yes, the experience of professional practice, proof for services and time spent." "Yes, the recognition and confidence in my work, as well as the possibility of expanding my knowledge in different areas.	Recognition	The differential of unpaid collaborative projects goes beyond financial gratification. It can unfold into recognition for the participants.

Source: Original search results.

Experience Report

The consolidation of science-based entrepreneurship still represents a challenge for the country since fundamental research is far from technological research. This becomes even more complex when it comes to research for innovation, that is, research in close connection with the economic market. Articulating these three types of research represents an action for the consolidation of science-based entrepreneurship and, therefore, must contemplate the specificities of each one of them. Experiences from both academia and industry clearly show that researchers have different mental models and focus of action. Thus, the creation of a sustainable KM model that can promote this articulation will possibly require a strong investment in leadership training capable of understanding the different interests of the parties involved.

One of the most likely consequences of the increase in private investment and decrease in public investment is that the University is forced to fully conform to the molds of the business world. In a period of crisis and pressure like the one we are experiencing; this could possibly be reflected in the polarization between basic and applied research. As applied research manages to produce tangible results in a shorter period, it is quite possible that it would receive greater investment from the private sector, thus standing out from basic research. However, this dichotomy between basic research and applied research does not exist. The two types of approach are not mutually exclusive. On the contrary, they are closely intertwined, and one catalyzes the development of the other. In this way, the current Brazilian scenario requires the parties involved take these points into account for the creation of solutions focused on KM model of scientific entrepreneurship. A good guide for this problem is the Stokes diagram, which proposes a research classification system so that scientists can guide their activities according to the need to produce results to expand the knowledge and have practical utility [40].

Ethical issues regarding data and information security, especially information of a confidential nature, must also be considered. Most universities still do not have an adequate structure to deal with these issues. It will certainly be necessary to implement information security mechanisms that are not yet in the public domain. Another point also refers to misconduct actions such as plagiarism, predatory competition, improper manipulation of data, etc. These issues need to be thought through and regulatory mechanisms need to be created so that people within the model can feel safe and motivated in relation to knowledge sharing.

Final considerations

This work showed that the KM of University-Industry collaborative projects aimed at fostering science-based entrepreneurship is complex and composed of several elements related not only to operational issues of digital technologies, but also to social aspects that encompass human relations in the knowledge construction process. This aspect was evident both by the systematic mapping of articles in the area and by the questionnaires disseminated over the internet. Among the results of the closed questions, it is worth mentioning the lack of automated processes for organizing backups and metadata as well as processes related to data sharing security. Open questions highlighted the difficulties in managing tacit knowledge as well as the importance of integrating industry and university mental models in innovation processes. The hypotheses built from the answers to open questions provide a direction for future research and can be assimilated in future initiatives of developing digital solutions for KM in collaborative projects.

Something that should be considered in KM, in addition to the way of obtaining and collecting data, is the discussion of these data and their interpretation by the research and development team, to establish an understanding of its meaning and then produce an applicable knowledge. This process, perhaps, represents a more time-consuming step, as it depends on the elaboration of logical thinking about the data obtained, which can make the management model more time-consuming and the development of a product/technology slower, thus being a limiting step. Coordinating this discussion of data with the fast pace of production in an industry, for example, is challenging, given the constant demand for creation and innovation in this sector.

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