The Evolution of Hackathons as an Innovation Tool: A Systematic Analysis

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***Abstract*—Hackathons have established themselves as dynamic open innovation spaces that promote interdisciplinary collaboration and creative problem-solving. This systematic review, which follows the PRISMA methodology, synthesizes the findings of 73 articles from Scopus, Web of Science, and IEEE Xplore, with the aim of analyzing the evolution, impacts, and knowledge gaps surrounding hackathons as an innovation tool. The study identifies a growing trend in their global implementation, with a particular emphasis on skill development, driving innovation, and strengthening entrepreneurial competencies. However, limitations are evident, such as the scarcity of longitudinal studies, the poor assessment of their long-term sustainability, and the geographical concentration of research in technologically advanced countries. Future research should focus on comparing organizational models, measuring long-term results, and including diverse contexts. Our findings underscore the potential of hackathons to boost creativity and entrepreneurship, as well as foster sustainable and collaborative innovation processes.**

***Keywords*—Hackathon; evolution; tool; innovation; review**

I. Introduction

Over the past two decades, hackathons have established themselves as a global phenomenon and one of the most representative methodologies of open innovation [1]. These activities, distinguished by their dynamism and intensive teamwork over short periods of time, have been implemented by universities, governments, technology companies, and social organizations to promote creativity and the rapid solution of complex problems [2]. The literature recognizes hackathons as innovation laboratories that favor knowledge transfer and the creation of interdisciplinary networks, which explains their growing relevance in innovation systems worldwide [3].

Despite their growing popularity, the central problem is that traditional hackathon approaches, based on rapid prototyping and intensive teamwork, often face limitations. Many of the solutions generated fail to transcend beyond the event due to difficulties in scalability, project sustainability, and a lack of integration with productive ecosystems. Although strategies such as intensive mentoring and the provision of technical resources have been implemented [4], [5], these actions do not ensure the continuity of the innovation cycle after the hackathons.

In this context, new perspectives are emerging that propose reconfiguring hackathons by integrating open innovation approaches, whether tools to support prototype development, facilitate data analysis, or generate new participation dynamics. These methods seek to optimize technical processes and expand the impact of hackathons as spaces for interdisciplinary collaboration with sustainable and practical value.

These new approaches are supported by current literature, which demonstrates how hackathons can contribute to diverse fields: in education, as experiential learning environments [6]; in healthcare, for the creation of telemedicine solutions or biomedical data analysis [7]; in the business sector, as mechanisms for innovation and talent recruitment [8]; and in the social sphere, as spaces to address community issues [9]. These studies show that hackathons have a positive impact on creativity, the generation of functional prototypes, and the construction of collaborative networks, which reinforces their role as promoters of innovation.

However, research remains lacking. Most studies focus on describing individual cases of hackathons or analyzing their usefulness in specific areas or countries [10]. A lack of systematic research was found that integrates the available evidence and allows for the identification of trends, patterns, and limitations in the development and evolution of these practices globally. This lack of information justifies the need for a systematic review that provides a comprehensive view of how hackathons have evolved and their true impact on innovation.

Unlike previous reviews that have limited themselves to analyzing hackathons in particular contexts or using descriptive approaches, this study offers an original contribution by comparatively synthesizing the global evolution of hackathons as a tool for innovation, integrating multiple aspects, such as academic, social, business, and technological aspects, into a single comprehensive study. This review seeks to identify thematic and geographical gaps, as well as provide a new interpretative perspective that classifies studies according to their lines of impact and level of innovation maturity. It also adds methodological value by using a thematic approach that allows emerging patterns and trends not addressed by previous research to be recognized. Consequently, this study broadens the theoretical understanding of hackathons as places of open innovation and offers practical guidance for their design, implementation, and evaluation in different institutional and geographical contexts.

Based on this problem, the research questions that guide this study are: How have hackathons evolved in their role as global innovation tools? What impacts have they generated in the different contexts analyzed? And what are the main knowledge gaps emerging in the scientific literature?

Finally, this study is organized as follows: the background section defines related theoretical aspects for a better

understanding of the topic; the methodology section describes the process followed for the systematic review. Subsequently, the results section presents the findings on the evolution of hackathons as innovation tools; a discussion exploring the implications analyzed is also presented. Conclusions summarize the main contributions of the study. Finally, the gaps identified in the literature and future lines of research for consideration are presented.

II. Background and Related Applications

A hackathon is a short event in which multidisciplinary teams collaborate intensively to develop technological prototypes to solve specific problems [11]. Its origin dates back to programming communities, but in recent years it has expanded to diverse contexts such as education, healthcare, the business sector, and social innovation [12]. These dynamics are considered innovation tools, as they bring together diverse talent, foster collective creativity, and accelerate ideation processes that in conventional environments often take months.

Innovation is understood as the ability to generate and apply novel ideas with added value [13]. In this sense, hackathons provide an agile and collaborative mechanism for its development. In this vein, hackathons are not limited to programming competitions; they function as experimental laboratories where experiments, experiences, and novel ideas are discovered. Because of this, they have become an important tool for universities, governments, and companies seeking to promote projects, generate scalable prototypes, and collectively solve social problems [14], [15].

In parallel, technological development has made available various innovative tools that enhance the results of hackathons. These include collaborative software platforms (GitHub or GitLab), programming environments that include machine learning libraries (TensorFlow, PyTorch, Scikit-learn), and cloud services that offer data processing and analysis resources (AWS, Google Cloud, Microsoft Azure), which facilitate the processing of large volumes of data and the construction of real-time solutions.

The applications of these tools are diverse: in healthcare, they are used to develop adaptive learning platforms [7]; in the financial sector, to generate predictive risk models [8]; and in the creative industry, to design interactive experiences or produce digital content [2]. Thus, hackathons are positioned as interdisciplinary spaces that integrate methodologies, technologies, and collaborative dynamics, with an impact on both the social and academic and business spheres.

III. Materials and Methods

The scientific literature on the evolution of hackathons as an innovation tool remains limited and dispersed, making it difficult to obtain a comprehensive view of their impact and development in different contexts. Although there is research that considers hackathons as experiential learning spaces and open innovation platforms, most of it presents case studies or specific descriptions without a systematic synthesis of available knowledge. This scarcity of structured reviews justifies the need for a rigorous analysis that consolidates scientific evidence, identifies patterns of evolution, and uncovers thematic gaps to guide future research.

To address these research gaps, a review based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol was chosen. This protocol is a reference framework widely used in academic research for its ability to guarantee a rigorous and traceable process [16]. In contrast, other methodologies, such as narrative or integrative reviews, tend to be more flexible; on the contrary, PRISMA provides clarity in the inclusion and exclusion criteria and in the representation of the document selection flow. Furthermore, the analyzed studies validate that, in contexts of innovation and technology, this framework supports its relevance for synthesizing dispersed evidence and building solid conceptual frameworks.

A. Review Approach

The information gathering strategy focused on the use of high-impact academic databases such as Scopus, Web of Science (WoS), and IEEE Xplore, all three used to ensure a diverse literature in technological aspects and focused on the topic. In addition, bibliometric analysis tools such as VOSviewer and Bibliometrix were used, which allowed the visualization of co-authorship networks, thematic trends, and keyword co-occurrence analysis. The choice of these strategies is justified by the need to ensure broad and specialized coverage. Databases such as Scopus and WoS offer a global vision of scientific production [17], while IEEE Xplore is essential for capturing specific research in engineering and computer science. On the other hand, the use of bibliometric tools, such as VOSviewer and Bibliometrix [18], [19], facilitates the organization and synthesis of information, in addition to the identification of hidden patterns in the literature, which increases the interpretive value of the analysis.

B. Search Strategy

Custom Boolean search algorithms were developed for each database, checking for matches on keywords, abstract, and title.

The keyword group used for Scopus: (TITLE (hackath*) OR TITLE-ABS-KEY (hackfest*) OR TITLE (codefest*) AND TITLE-ABS-KEY (innov*))

The keyword group used for WoS: hackathon* (Title) OR hackfest* (Title) OR codefest* (Title) AND innov* (Title)

The keyword group used for IEEE Xplore: ("Document Title":hackath*) OR ("Document Title":hackfest) OR ("Document Title":codefest*) AND ("Document Title":innov*)

C. Selection and Analysis Process

Fig. 1 shows a flowchart describing the different stages of the information selection process. The initial search yielded 269 Scopus publications, 265 of WoS, and 106 of IEEE Xplore. In addition, filtering by thematic area favored the inclusion of studies related to the analyzed topic. The search criteria were then limited to journal articles, international conferences, and systematic reviews. This is because journal articles are peer-reviewed and have greater support than other types of research. Likewise, the inclusion of systematic reviews in this analysis corresponds to the importance of their scope and information provided. Therefore, other types of documents such as book chapters or patents, editorial notes, letters, and surveys, were discarded, as they contribute very little to the results in the

direction of this topic. The selected articles do not have a time specification. After filtering the search based on predefined inclusion and exclusion criteria, the number of relevant documents was 142 Scopus publications, 121 of WoS, and 55 of IEEE Xplore. Subsequently, the titles and abstracts of each document obtained were examined to determine their relevance to the scope of this study. Ultimately, with a distribution of 29 from Scopus, 25 from WoS, and 30 from IEEE Xplore, the screening of titles and abstracts of these studies resulted in a total of 84 documents.

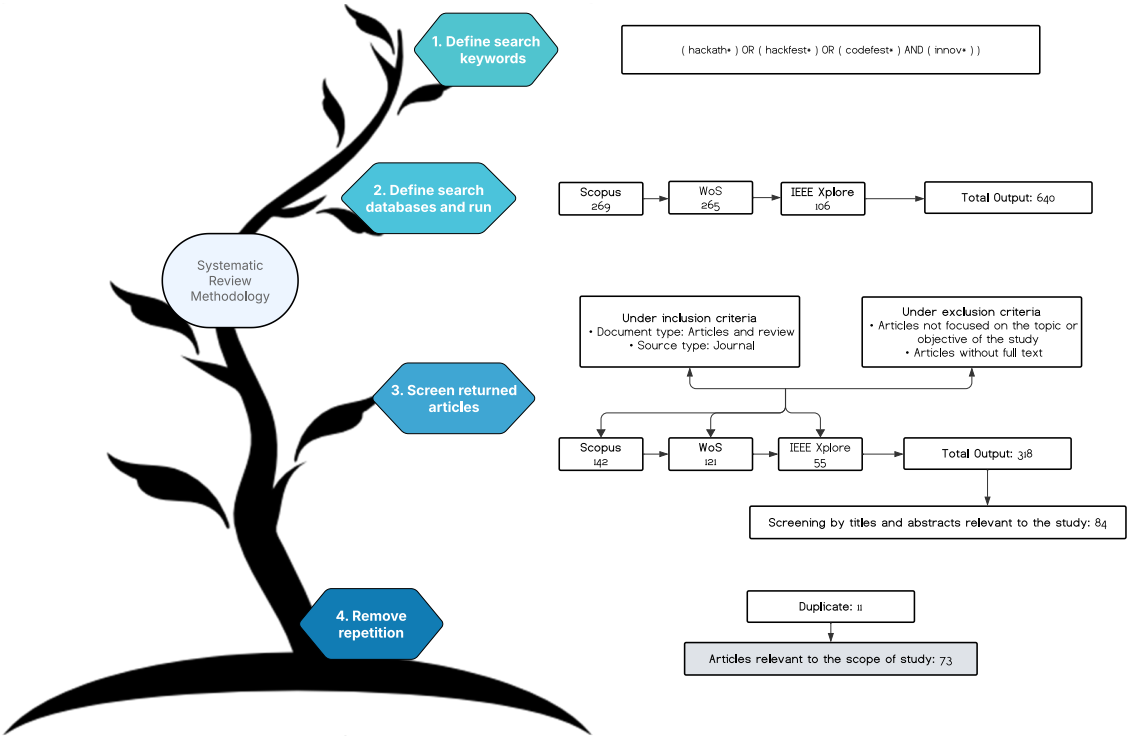

Fig. 1. Flowchart based on PRISMA.

The inclusion criteria considered studies that addressed hackathons with a focus on innovation or technological development, presented theoretical frameworks or specific application models, and were also available in full access. Studies that only described events without evidence of results, were not directly related to the development of technological skills, or were texts without full access were excluded. The process of eliminating duplicates consisted of using the Mendeley manager, comparing matches between title, DOI, and authors. Although 84 studies were identified after screening, a total of 11 duplicates were detected after cross-checking between databases, which is possible due to the low overlap between conferences and journals indexed in IEEE and WoS compared to Scopus. In this case, the version with the most complete and best-indexed metadata was retained.

For data extraction, a structured matrix of records was developed on authors, year, country, objective, methodology, scope of application, and main results. The quality assessment of the studies was carried out considering methodological clarity, thematic relevance to the research questions, and the level of evidence found. Only studies that met at least two of these criteria were included in the final analysis. Finally, after applying all the filters, 73 documents relevant to the in-depth review were retained.

The relevance of this research lies in its systematic nature, which not only brings together and synthesizes the literature on AI in hackathons but also ensures transparency and scientific rigor. This makes it a useful resource for both researchers and practitioners seeking to understand how AI is changing the dynamics of open innovation globally.

D. Analysis

The data analyzed show sustained growth in scientific production on hackathons as an innovation tool, especially regarding innovation and technological development. The most important countries in terms of production are Germany, Brazil, and the United States, demonstrating the consolidation of innovation and the link between industry and the public sector. Research in Germany focuses on digitalization, while Brazil stands out for its efforts in inclusion and technological education. The United States, for its part, focuses on research related to social and technological solutions. The fact that publications are mostly distributed in journals on applied social sciences, innovation management, and engineering education demonstrates the interdisciplinary nature of hackathons.

The review identified five key approaches: educational hackathons, which focus on active learning and skills development; inclusive hackathons, which foster diversity and equitable participation. [20]; healthcare hackathons, which seek medical solutions and telecare [7]; collaborative hackathons, as inter-institutional co-creation spaces [6], and innovation hackathons, where prototypes and business models are generated [21]. Although descriptive and case analyses are the

most common, there has been a recent growth in systematic reviews and bibliometric evaluations. Even so, the literature presents significant gaps, especially in the lack of longitudinal, comparative and socioeconomic impact studies. This study contributes to the field by offering an integrative view that summarizes global trends and emerging opportunities to strengthen hackathons as strategic innovation tools.

IV. Results

The bibliometric analysis of records obtained from Scopus, WoS, and IEEE Xplore revealed relevant patterns in the evolution of research on innovation-oriented hackathons. Variations in scientific output were observed over time, along with a marked concentration in countries with established innovation systems, such as the United States, Brazil, and Germany. The results show a steady growth in the number of publications, especially in recent years, which coincides with the global expansion of open innovation methodologies and interdisciplinary collaboration. Furthermore, the analysis of co-authorship networks and keywords allowed us to identify emerging topics such as technology education, collaborative entrepreneurship, and digital inclusion, in addition to revealing theoretical gaps in measuring the impact and sustainability of these events.

The value of this analysis lies in the fact that it not only exposes the sustained increase in academic interest in hackathons but also links these trends to recent social and technological transformations, such as the digitalization of educational processes and the expansion of innovation labs. This approach allows us to visualize the dynamics of growth, collaboration, and thematic specialization within the field, providing a solid foundation for guiding future research and strengthening our understanding of hackathons as strategic drivers of development and innovation.

A. Bibliometric Analysis

Bibliometric analysis, used as part of the systematic review process, allowed us to examine the evolution and distribution of scientific literature on hackathons in the context of innovation, through the counting, classification, and visualization of publications, citations, and academic collaboration networks. For this purpose, we used the tools VOSviewer and Bibliometrix, widely recognized in scientific research for their ability to analyze large volumes of information. VOSviewer allowed us to generate keyword co-occurrence maps, co-authorship networks, and international collaborations, revealing the conceptual structure and relationships between the main thematic focuses of the field [18]. For its part, Bibliometrix, implemented in the R environment, facilitated descriptive analyses, annual production graphs, identification of influential journals, and detection of emerging trends in hackathon research [19]. The integration of both tools was essential to identify thematic clusters and research patterns, allowing us to accurately visualize the interconnections between authors, countries, and institutions. This approach contributed to a deeper understanding of the dynamics of the field, highlighting how hackathons have established themselves as key spaces for co-creation, experimentation, and knowledge transfer within innovation.

1) Keyword co-occurrence map: A keyword co-occurrence map makes it easier to visualize the connections between terms that appear together in scientific publications, enabling the discovery of emerging and significant topics [22]. The databases used for this analysis were Scopus, WoS, and IEEE Xplore, in order to unify their terms and verify the data each database offers.

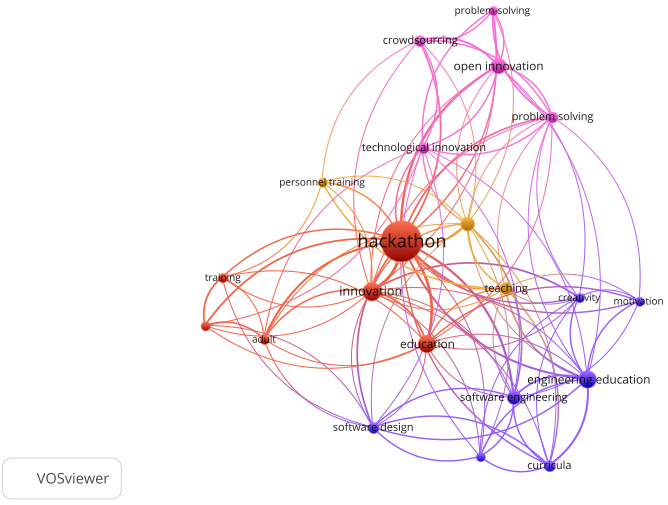

Fig. 2. Keyword co-occurrence map in VOSviewer

Using VOSviewer and with a minimum of four keyword co-occurrences, 679 keywords co-occurred, and four significant clusters were identified. Fig. 2 shows a network visualization map of the four co-occurring keyword groups with 21 elements, 112 links, and a total link strength of 206. Keywords with the highest number of links are understood to be the most impactful and notable. Keywords with nodes that are clearly larger than the rest are "hackathon", "innovation", and "education". The size of a keyword indicates how frequently it appears in research documents. Keywords that are closest to it show their

co-occurrence in those same works. The colors are representative of the clusters and indicate the most frequent keywords. Since this information ensures more efficient indexing and retrieval of research, it can help researchers select the appropriate keywords for their work.

This bibliometric analysis demonstrates that the study focuses on the development and application of hackathons as a strategic innovation tool. The results obtained demonstrate that this type of analysis is highly useful for identifying established and emerging research areas, as well as for mapping the dynamics of collaboration between institutions and countries. The connection and size of the nodes in the relationship maps reflect a strong interdependence between the themes of open innovation, technology education, and collaborative entrepreneurship, highlighting the importance of approaching hackathons from a comprehensive perspective that combines learning, technology, and social impact.

2) International co-authorship map: The co-authorship map is a fundamental tool for visualizing collaborations between researchers, allowing for the identification of active networks and influential academic communities within the field of study. This type of analysis facilitates understanding how research groups are configured, their thematic links, and how they share knowledge about hackathons and innovation.

The minimum number of documents identified in VOSviewer per author was set to 2 to filter the maximum range of co-authorship and, in turn, analyze possible improvements in this regard. This generated 286 authors, including the lead author and their co-authors. These connected elements generated 1 cluster and 15 links. The visualization co-authorship network in Fig. 3 shows the researchers Balzer F., Braune K., and Hofferbert J. as the most frequent collaborators.

The resulting co-authorship network reflects a progressive strengthening of collaborative capacities at the international level, demonstrating the consolidation of scientific communities that approach hackathons from interdisciplinary perspectives. This result represents a significant advance in the coordination of global efforts aimed at understanding and promoting hackathons as spaces for innovation, learning, and technological development.

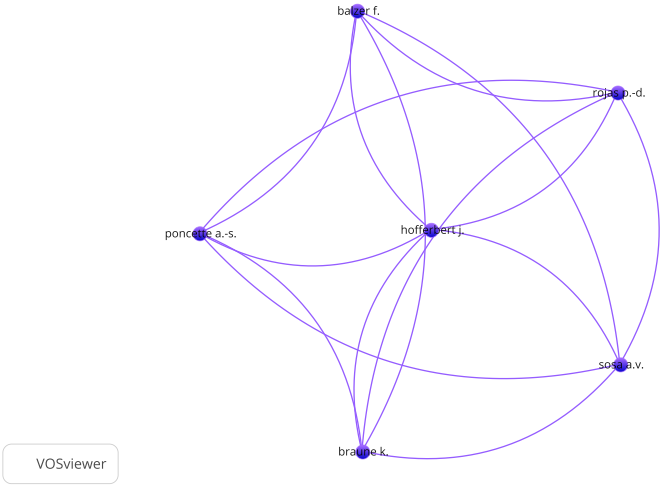

Fig. 3. Co-authorship map in VOSviewer

3) Collaboration map by country: The country-by-country collaboration map allows us to visualize international connections in scientific production, revealing how knowledge is generated and shared within the realm of hackathons and innovation. These collaborative networks are essential for understanding the formation of academic communities and the transfer of knowledge.

Using the VOSviewer tool, a country analysis was conducted for further sustained identification. The number of countries detected by the VOSviewer software was 40, of which 16 met the established criteria of a minimum relationship of three. Fig. 4 shows the countries active in research on hackathons as an innovation tool. These connected elements resulted in 5 clusters, 37 links, and a total link strength of 40. As can be seen, the largest nodes represent the United States, Brazil, and Germany. This indicates that researchers from these countries have contributed the most to studies on hackathons as an innovation tool.

The results of this analysis are consistent with previous studies that show a geographic concentration of scientific production in countries with established innovation tools [23]. In particular, the United States, Brazil, and Germany stand out as the main research centers, demonstrating a strong interconnection in topics related to technology education and open innovation methodologies.

The low participation of developing countries highlights the need to promote more balanced and diverse scientific collaboration [24], fostering research networks that integrate different socioeconomic and cultural realities. Expanding global participation would enrich perspectives on the impact of hackathons in different contexts, favoring the development of more inclusive and sustainable strategies [25]. In short, the concentration of research power in a few countries underscores the importance of fostering international alliances and collaborative projects that strengthen the circulation of knowledge and promote a more global understanding of hackathons as a tool for innovation.

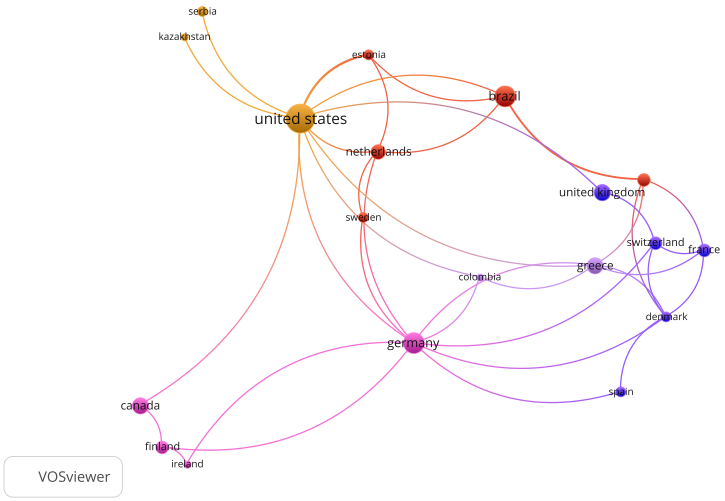

Fig. 4. Country co-occurrence map in VOSviewer

4) Distribution of publications by year: The temporal analysis of publications is essential to identify trends of growth, consolidation, or stagnation in scientific production on hackathons as an innovation tool. Fig. 5 presents the annual evolution of the collected studies, showing a general upward trend over the last decade. Between 2016 and 2019, production was moderate, with values ranging from 2 to 4 publications per year, reflecting an exploratory stage of the topic. Starting in 2020, sustained growth is observed, with a notable increase in 2021 (13 publications) and a new upswing in 2024 (14 publications). This pattern evidences a growing interest in hackathons in contexts of innovation, education, and interdisciplinary collaboration [26].

The significant increase in recent years can be explained by several factors: the expansion of open innovation ecosystems, the digitalization of training processes, and the boost to virtual collaboration following the COVID-19 pandemic [27], which favored the organization of hackathons in hybrid and global environments. Although a slight decrease was recorded in 2025 (11 publications), this variation is likely due to the recent indexing of articles. Overall, the results suggest that the field has moved from an exploratory phase to a stage of scientific consolidation, supported by the increase in empirical studies, reviews, and bibliometric analyses. This trend indicates that hackathons are consolidating as a strategic mechanism for collaborative innovation, the continuity of which will depend on the strengthening of academic networks and institutional support for projects that integrate technology, creativity, and social development.

5) Distribution of publications by journals: Analyzing the distribution of publications by journal allows us to identify the predominant disciplines and approaches in research on hackathons as an innovation tool. Fig. 6 presents the journals with the highest number of articles published on this topic, demonstrating a concentration of studies in a small group of specialized publications, suggesting a focused interest in the intersection of education, technology, and innovation.

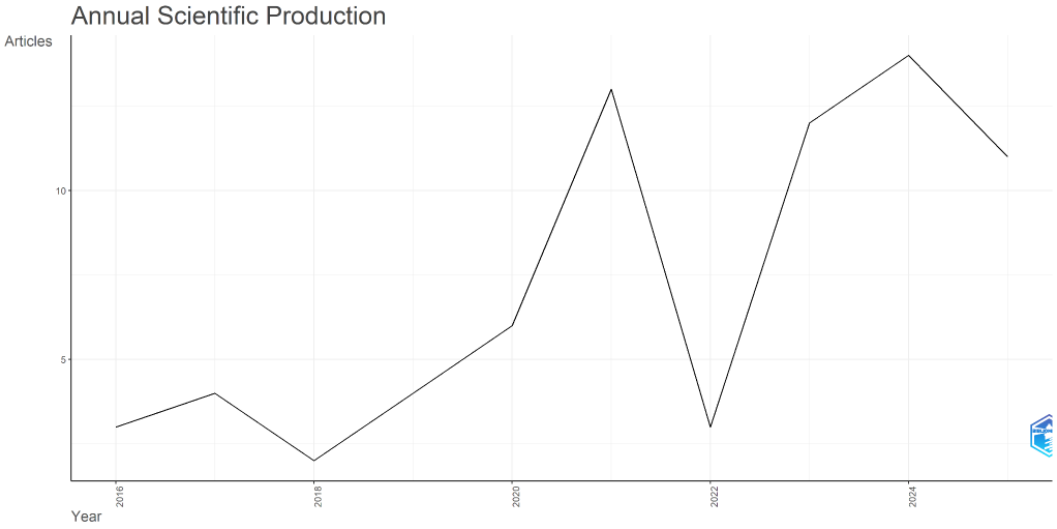

Fig. 5. Distribution of publications by year.

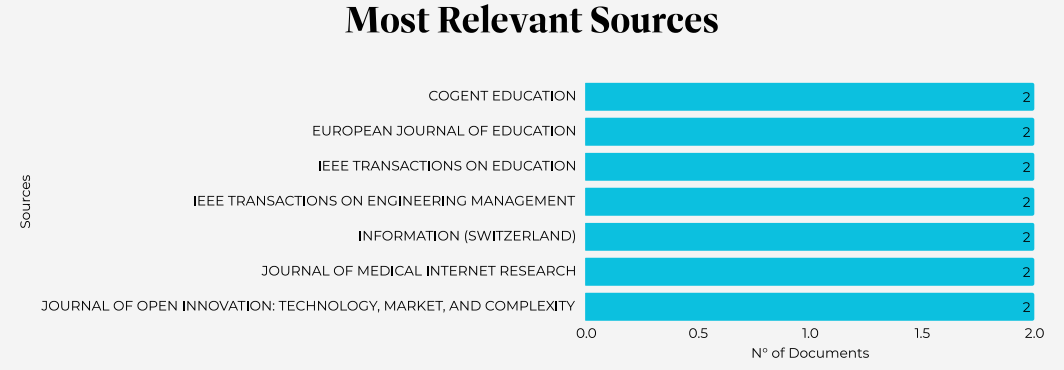

Fig. 6. Distribution of articles published by journal titles.

The results show that journals such as Cogent Education, the European Journal of Education, and IEEE Transactions on Education stand out for their contribution to the study of hackathons from an educational perspective, reflecting the growing interest in their use as a strategy for active learning and the development of digital skills. Meanwhile, IEEE Transactions on Engineering Management and Information (Switzerland) address the topic from the perspectives of innovation management and technological adoption. Likewise, the Journal of Medical Internet Research and the Journal of Open Innovation: Technology, Market, and Complexity present approaches focused on open innovation, technology transfer, and interdisciplinary collaboration.

This diversity of publications confirms the interdisciplinary and transversal nature of hackathons, covering areas ranging from education and engineering to organizational management and social innovation [28], [29], [30]. The concentration in certain specialized journals suggests that the field is in a phase of consolidation, with some academic media acting as reference nodes for the dissemination of emerging research. This pattern reinforces the need to strengthen collaboration across disciplines and scientific communities in order to broaden the understanding and practical application of hackathons in different innovation contexts.

B. Content Review

The final analysis included a total of 73 documents selected using the PRISMA methodology, which addressed the role of hackathons as innovation tools in different technological, educational, and social contexts. The final selection was obtained after applying rigorous inclusion and exclusion criteria, prioritizing studies that directly explore the relationship between Artificial Intelligence (AI), open innovation, and collaborative methodologies. This delimitation allowed the analysis to focus on the most representative approaches in the field, ensuring that the synthesis accurately reflects the trends, impacts, and research gaps surrounding the use of hackathons as mechanisms for digital transformation and interdisciplinary innovation. The analyzed sample demonstrates a balance between geographic diversity, application areas, and methodological approaches, avoiding a dispersion toward studies that, although related to innovation, do not delve into the use of hackathons as innovation environments. This approach allowed the review to be structured based on three central questions that guided the process:

- Q1: How have hackathons evolved in their role as global innovation tools?
- Q2: What impacts have been generated in the different contexts analyzed?
- Q3: What are the main knowledge gaps emerging in the scientific literature?

This type of analysis, represented in Fig. 7, provides the basis for a systematic and comparative review of the selected studies, allowing us to identify the most established lines of development, emerging areas of application, and opportunities for future research. Together, the results offer a comprehensive and up-to-date view of the evolution of hackathons as drivers of innovation supported by AI, interdisciplinary collaboration, and technological experimentation.

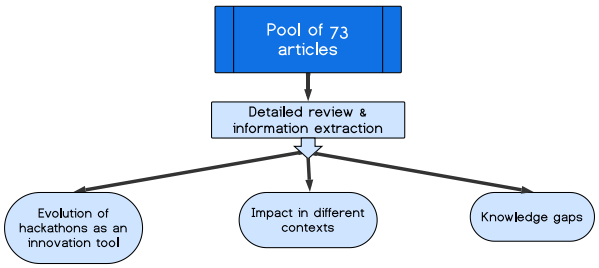

Fig. 7. Structure of the systematic content review.

1) Evolution of hackathons as innovation tools: In relation to the first research question: How have hackathons evolved in their role as global innovation tools?, the findings reveal a growing interest in the scientific literature to understand the transformation of these events, since they have gone from being light programming moments to becoming strategic platforms for open innovation and interdisciplinary collaboration. The studies analyzed show a diversification in their approaches and objectives, ranging from international corporate collaboration to the development of technological solutions with social and environmental impact. In this sense, [31], [5] highlight the role of hackathons in the creation of global innovation networks, which can overcome geographical and organizational boundaries to generate joint solutions in digital environments.

Likewise, there has been an increase in research that includes AI tools in the design and execution of hackathons,

suggesting a transition toward hybrid AI-assisted co-creation models [32]. These experiences optimize prototyping and enhance the analytical and predictive capacity of participating teams, accelerating the ideation and validation processes. In parallel, other emerging lines of research are oriented toward the use of hackathons as spaces for measuring environmental change and sustainable innovation [33], [34], integrating participatory methodologies to address ecological challenges through the use of open data.

The analysis reveals a consolidation in research on digital innovation, which is evidenced by it being the category with the most publications, as seen in Fig. 8. These contributions emphasize the role of hackathons as a promoter of organizational digital transformation [4], [12]. In contrast, studies on social hackathons [35], [9] show a smaller number, although with a growing relevance due to their ability to promote inclusion, citizen participation, and community development. Overall, this evolution shows that hackathons have ceased to be light programming moments, to become dynamic ecosystems of collaborative innovation, in which technology, creativity, and social commitment are intertwined.

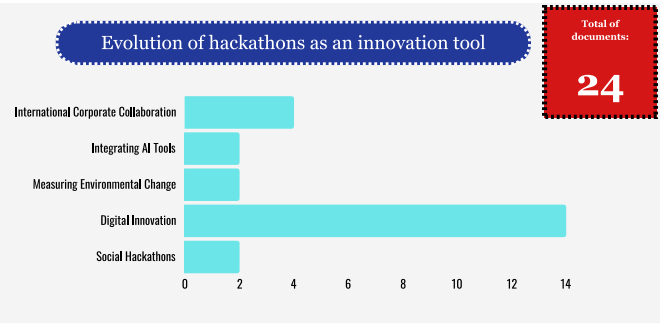

Fig. 8. Distribution of articles by hackathon evolution.

2) Impacts generated in the different contexts analyzed: Regarding the second research question: What impacts have been generated in the different contexts analyzed? The results show that hackathons have had a transversal influence in multiple application areas, particularly in engineering training, medical and healthcare improvements, general educational training, social innovation, and the integration of women in technological environments. In the field of engineering, the reviewed studies emphasize that these events promote the acquisition of practical skills, creativity, and interdisciplinary collaboration, integrating experiential learning methodologies and immersive simulation [36]. In addition to training experiences that combine emergency management and engineering [37], [38], these findings consolidate the perception of hackathons as applied learning environments that complement formal education and promote technological innovation in higher education.

In the healthcare and medical sectors, hackathons have emerged as co-creation spaces for clinical innovation and digital health, where multidisciplinary professionals collaborate to develop solutions for data management, medical record interoperability, and responding to public health crises. Hackathons focused on digital health have demonstrated improvements in clinical communication and the efficiency of healthcare procedures, according to the studies analyzed [7], [39]. Furthermore, the effects on general education and social innovation highlight the value of these events for project-based learning and community engagement, as they promote collaborative work among students, social organizations, and institutions [40], [41]. Finally, female integration stands out as a field in progress [20], where the participation of women is promoted in traditionally male-dominated environments, which contributes to increasing diversity and equity in innovation spaces. Taken together, these results demonstrate that hackathons generate significant impacts on both technical training and social inclusion and transformation, consolidating themselves as dynamic tools for connecting education, technology, and sustainable development (see Fig. 9).

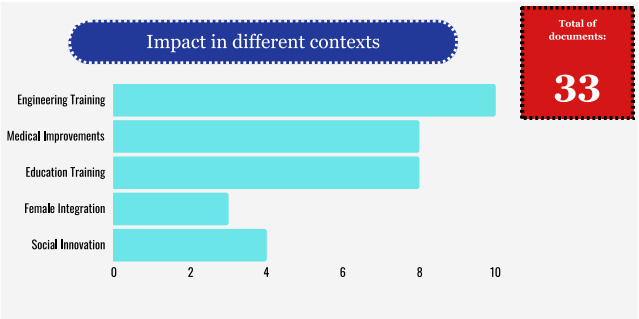

Fig. 9. Distribution of articles by impact in areas.

3) Main knowledge gaps: Regarding the third research question: What are the main knowledge gaps emerging in the scientific literature? A review of the selected studies reveals significant gaps in understanding the long-term impacts and systematization of the hackathon model as an innovation tool. The main gaps are grouped into four areas: entrepreneurial competence, sustained innovation drive, comprehensive skills development, and long-term sustainability. Although studies demonstrate the potential of hackathons to foster entrepreneurial skills and experimentation with emerging technologies [42], [43], the literature still lacks longitudinal studies that assess how these skills are sustained or translated into real business projects. This gap restricts understanding of the real impact of hackathons, both organizationally and economically, beyond their immediate educational context.

Likewise, although the role of hackathons in driving global innovation is highlighted [44], especially in sectors such as digital health and sustainability, there is a lack of established theoretical frameworks that explain how these collaborative dynamics are integrated into public policies or long-term innovation ecosystems [45]. Regarding skills development, although hackathons improve communication, teamwork, and creativity [46], [47], [48], there is still little evidence about whether these skills are effectively transferred to the academic or professional environment. Finally, regarding long-term sustainability, the studies analyzed agree that hackathons struggle to maintain the continuity of the projects created and to institutionalize their results in organizations or communities [49], [50]. These gaps suggest the need for a more structured methodological approach, aimed at measuring the lasting

impact, the scalability of solutions, and the integration of hackathons as part of sustainable educational, social, and business innovation strategies (see Fig. 10).

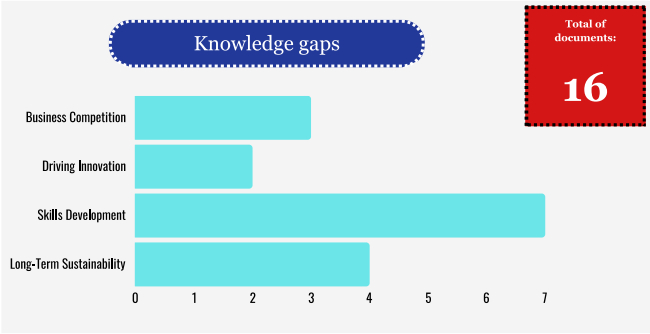

Fig. 10. Distribution of articles by main knowledge gaps.

C. Discovery

The final analysis included a total of 73 selected documents, which allowed for the identification of key trends and approaches shaping the development of hackathons as innovation tools. To organize the findings, a thematic coding process was used to align each article with one of the three research questions (R1, R2, R3). Table I shows a summary of most of the selected studies, including data such as authors, year of publication, article title, and the research question it addresses. This mapping allows for an examination of the thematic breadth and distribution of studies within the established categories, lending greater relevance and transparency to the review process.

1) Hackathons as tools for innovation: Hackathons have evolved from experimental events focused on rapid software development to established open innovation systems. This shift is evident in the diversification of their focuses, spanning social, corporate, academic, and technological areas, reflecting their role in digital transformation and collaborative creation on a global level.

2) Impact in different contexts: The identified impacts manifest themselves in different contexts, such as the social sphere, where hackathons promote citizen participation and the co-creation of community solutions; in the business sphere, where they promote organizational agility and innovation; and in the academic sphere, they strengthen digital skills and interdisciplinary learning. These effects demonstrate their potential to promote collaborative and sustainable innovation.

3) Gaps in the literature: The gaps identified are primarily related to the lack of longitudinal studies, the absence of standardized metrics to assess the real impact of hackathons, and the underrepresentation of countries with low technology and limited scientific budgets. There is also a persistent need to integrate more robust theoretical approaches that explain the learning and knowledge transfer mechanisms that occur during these events.

4) The evolution of hackathons: It has become clear that they have ceased to be experimental spaces and have become strategic platforms for open innovation, bringing together participants from diverse fields through intensive collaborative dynamics. Their consolidation as a global practice demonstrates a transition toward more inclusive, interdisciplinary, and sustainable models, where innovation is built collectively and oriented towards social and technological impact.

TABLE I. SELECTED STUDIES

No.	*Authors*	*Year*	*Title of article*	*Associated research question*
[33]	AlQallaf, N., Elnagar, D.W., Aly, S.G., Elkhodary, KI, & Ghannam, R.	2024	Empathy, Education, and Awareness: A VR Hackathon's Approach to Tackling Climate Change	R1
[2]	Attalah, I., Nylund, P.A., & Brem, A.	2023	Who captures value from hackathons? Innovation contests with collective intelligence tools bridging creativity and coupled open innovation	
[31]	Barana, A., Chatzea, VE, Henao, K., Hildebrandt, AM, Logothetis, I., Marchisio Conte, M., Papadakis, A., Rueda, A., Samoilovich, D., & Triantafyllidis, G.	2025	Driving International Collaboration Beyond Boundaries Through Hackathons: A Comparative Analysis of Four Hackathon Setups	
[5]	Beretta, M., Obwegeser, N., & Bauer, S.	2024	An Exploration of Hackathons as Time Intense and Collaborative Forms of Crowdsourcing	
[47]	Charvát, K., Obot, A., Kalyesubula, S., Zampati, F., Löytty, T., Kubičková, H., Uhlíř, P., & Zadrazil, F.	2021	INSPIRE Hackathons and SmartAfriHub - Roadmap for Addressing the Agriculture Data Challenges in Africa	
[9]	Dabral, A., Bajwa, S., Shioyama, S., Chatterjee, R., & Shaw, R.	2021	Social Innovation Hackathon for Driving Innovation in Disaster Risk Reduction (DRR)	
[51]	Endrissat, N., & Islam, G.	2022	Hackathons as Affective Circuits: Technology, organizationality and affect	
[35]	Faludi, J.	2023	Hack for impact – sociomateriality and the emerging structuration of social hackathons	
[11]	Flus, M., & Hurst, A.	2021	Design at hackathons: new opportunities for design research	
[21]	Franco, S., Presenza, A., & Messeni Petruzzelli, A.M.	2021	Boosting innovative business ideas through hackathons. The "Hack for Travel" case study	
[27]	Gama, K.	2021	Successful Models of Hackathons and Innovation Contests to Crowdsource Rapid Responses to COVID-19	
[12]	Heller, B., Amir, A., Waxman, R., & Maaravi, Y.	2023	Hack your organizational innovation: literature review and integrative model for running hackathons	
[52]	Jaribion, A., Khajavi, S.H., Järvihaavisto, U., Nurmi, I., Gustafsson, R., & Holmström, J.	2023	Crowdsourcing Properties and Mechanisms of Mega Hackathons: The Case of Junction	

No.	Authors	Year	Title of article	Associated research question
[53]	Kamariotou, M., & Kitsios, F.	2022	Hackathons for Driving Service Innovation Strategies: The Evolution of a Digital Platform-Based Ecosystem	
[54]	Kitsios, F., & Kamariotou, M.	2019	Beyond open data hackathons: Exploring digital innovation success	
[8]	Kitsios, F., & Kamariotou, M.	2023	Digital innovation and entrepreneurship through open data -based platforms: Critical success factors for hackathons	
[55]	Leemet, A., Milani, F., & Nolte, A.	2021	Utilizing Hackathons to Foster Sustainable Product Innovation - The Case of a Corporate Hackathon Series	
[56]	Lobbe, J., Bazzaro, F., & Sagot, J.C.	2021	Innovation in collaborative design: an exploratory study in hackathon	
[57]	Pe-Than, E.P.P., Nolte, A., Filippova, A., Bird, C., Scallen, S., & Herbsleb, J.D.	2019	Designing Corporate Hackathons With a Purpose: The Future of Software Development	
[34]	Rasmussen, S.B., Bosker, T., Ramanand, G.G., & Vijver, M.G.	2024	Participatory hackathon to determine ecological relevant endpoints for a neurotoxin to aquatic and benthic invertebrates	
[58]	Richterich, A.	2019	Hacking events: Project development practices and technology use at hackathons	
[32]	Sajja, R., Erazo Ramirez, CE, Li, Z., Demiray, BZ, Sermet, Y., & Demir, I.	2024	Integrating Generative AI in Hackathons: Opportunities, Challenges, and Educational Implications	
[10]	Temiz, S.	2021	Open innovation via crowdsourcing: A digital only hackathon case study from Sweden	
[59]	Terrazas, G., Hawkridge, G., McNally, M., McFarlane, D., Ling, ZY, & Lau, J.	2023	Hackathons to Accelerate the Development of Low-Cost Digital Solutions	
[38]	Araújo, AA, Kalinowski, M., & Baldassarre, MT	2024	Can participation in a hackathon impact the motivation of software engineering students? A preliminary case study analysis	R2
[60]	Araújo, AA, Kalinowski, M., & Baldassarre, MT	2025	Embracing Experiential Learning: Hackathons as an Educational Strategy for Shaping Soft Skills in Software Engineering	
[61]	Braune, K., Rojas, PD, Hofferbert, J., Sosa, A. v, Lebedev, A., Balzer, F., Thun, S., Lieber, S., Kirchberger, V., & Poncette, AS	2021	Interdisciplinary Online Hackathons as an Approach to Combat the COVID-19 Pandemic: Case Study	
[62]	Browning, J.W., McKeever, S., Ferrario, M.A., O'Neill, I., & Stewart, D.	2025	Creating Sustainable Solutions: An Inclusive Hackathon Leveraging GenAI in a Local Context	
[63]	Byrne, JR, O'Sullivan, K., & Sullivan, K.	2017	An IoT and Wearable Technology Hackathon for Promoting Careers in Computer Science	
[64]	Cardwell, F.S., Elliott, S.J., & Clarke, A.E.	2021	The value of hackathons in integrated knowledge translation (iKT) research: Waterlupus	
[65]	Čović, Z., & Manojlović, H.	2019	Developing Key Competencies through Hackathon Based Learning	
[36]	Fernández, SZ, Miron, DL, Couce-Casanova, AC, & Diaz, FF	2025	Dual Hackathon Based on Immersive Simulation: A Multidisciplinary Approach for Engineering Training and Emergency Management	
[41]	Gama, K., Valença, G., Laurendon, CEM, Marques, Á. N., Ramos, LE, Amaral, R., Barros, CMDL, & Xavier, G.	2023	Hackathons as Inclusive Spaces for Prototyping Software in Open Social Innovation with NGOs	
[66]	Guerrero, C., Leza, M. del M., González, Y., & Jaume-i-Capó, A.	2016	Analysis of the results of a hackathon in the context of service-learning involving students and professionals	
[67]	Haque, R., Salmani, A., Raessinejad, N., & Moshirpour, M.	2022	Effectiveness of Hackathons in Software Engineering Education	
[68]	Hurst, W., Spyrou, O., & Krampe, C.	2024	The Data Factory: Findings from an Extended Reality-based Hackathon for Data Science Education	
[69]	Kienzler, H., & Fontanesi, C.	2017	Learning through inquiry: a Global Health Hackathon	
[70]	Kumalakov, B., Kim, A., Mukhtarova, S., Shukurova, A., & Khon, N.	2018	Hackathon as a Project Based Teaching Tool: Employing Programming Challenge in the Class	
[71]	Mhlongo, S., Oyetade, KE, & Zuva, T.	2020	The Effectiveness of Collaboration Using the Hackathon to Promote Computer Programming Skills	
[72]	Milutinović, V., Cincović, J., Jocović, V., & Drašković, D.	2025	Applied AI, Teamwork, and Learning in Student Hackathons: Case Study from Serbia	
[73]	Moshirpour, M., Shoura, T.A., Duffett-Leger, L., & Moshirpour, M.	2023	Multidisciplinary Hackathons: Towards Developing Practical Software Engineering Skills	
[20]	Paganini, L., Ferraz, C., Gama, K., & Alves, C.	2021	Promoting Game Jams and Hackathons as more Women-Inclusive Environments for Informal Learning	
[74]	Paganini, L., & Gama, K.	2020	Female Participation in Hackathons: A Case Study About Gender Issues in Application Development Marathons	
[75]	Paganini, L., Gama, K., Nolte, A., & Serebrenik, A.	2023	Opportunities and constraints of women-focused online hackathons	
[76]	Pathanasethpong, A., Soomlek, C., Morley, K., Morley, M., Polpinit, P., Dagan, A., Weis, J.W., & Celi, L.A.	2017	Tackling Regional Public Health Issues Using Mobile Health Technology: Event Report of an mHealth Hackathon in Thailand	

No.	Authors	Year	Title of article	Associated research question
[39]	Poncette, AS, Rojas, PD, Hofferbert, J., Sosa, A. v, Balzer, F., & Braune, K.	2020	Hackathons as Stepping Stones in Health Care Innovation: Case Study With Systematic Recommendations	
[77]	Porras, J., Khakurel, J., Ikonen, J., Happonen, A., Knutas, A., Herala, A., & Drögehorn, O.	2018	Hackathons in Software Engineering Education - Lessons Learned from a Decade of Events	
[40]	Remshagen, A., & Huett, K.C.	2023	Youth Hackathons in Computing for the Community: A Design Case	
[37]	Rennick, C., Litster, G., Hulls, C.C.W., & Hurst, A.	2023	Curricular Hackathons for Engineering Design Learning: The Case of Engineering Design Days	
[7]	Rigas, E.S., Kostomanolakis, S., Kyriakoulakos, N., Kounalakis, D., Petrakis, I., Berler, A., Boumpaki, A., Karanikas, H., Kelepouris, A., Bamidis, P.D., & Katehakis, DG	2023	A hackathon as a tool to enhance research and practice on electronic health record systems' interoperability for chronic disease management and prevention	
[78]	Rocha, T., Davila, N., Vaccari, R., Menezes, N., Mota, M., Monteiro, E., Souza, CRB de, & Pinto, G.	2025	Affirmative Hackathon for Software Developers with Disabilities: An Industry Initiative	
[79]	Ryś, M.	2024	Unraveling Participation Motivations in Pandemic-Related Hackathons: A COVID-19 Study	
[80]	Silver, J.K., Binder, D.S., Zubcevik, N., & Zafonte, R.D.	2016	Healthcare Hackathons Provide Educational and Innovation Opportunities: A Case Study and Best Practice Recommendations	
[81]	Synekop, O.	2023	Hackathon in Differentiated English for Specific Purposes Instruction of Information Technology Students	
[82]	Wyngaard, J., Lynch, H., Nabrzyski, J., Pope, A., & Jha, S.	2017	Hacking at the Divide Between Polar Science and HPC: Using Hackathons as Training Tools	
[6]	Yuen, KKF, & Wong, AOM	2021	Designing an Effective Hackathon via University-Industry Collaboration for Data Science Education	
[46]	Adinda, D., Gettliffe, N., & Mohib, N.	2025	Educational hackathon: preparing students for collaborative competition	R3
[44]	Angelidis, P., Berman, L., Casas Pérez, MDLL, Celi, LA, Dafoulas, GE, Dagan, A., Escobar, B., López, DM, Noguez Monroy, J., & Osorio-Valencia, JS	2016	The hackathon model to spur innovation around global mHealth	
[49]	Chen, C.W., Yeh, Y.S., Chan, T.C., & Wu, Y.S.	2025	Public-private partnership in pipeline science of acute care ecosystem: Insights from Taiwan's Presidential Hackathon	
[83]	Flores, M., Golob, M., Maklin, D., Tucci, C.L., West, S., & Stoll, O.	2020	DARE2HACK: Crowdsourcing ideas through hackathons to codesign new human-centric services	
[45]	Förschler, A., & Decuypere, M.	2024	Where are we heading? Hackathons as a new, relational form of policymaking	
[42]	Jussila, J., Suominen, A.H., & Rainio, T.	2020	Entrepreneurship Competence Using Educational Hackathons in Finland	
[84]	Kube, D., Gombert, S., Suter, B., Weidlich, J., Kreijns, K., & Drachsler, H.	2024	Hacking gender in computer-supported collaborative learning: The experience of being in mixed-gender teams at a computer science hackathon	
[43]	Miličević, A., Despotovic-Zrakic, M., Stojanović, D., Suvajžić, M., & Labus, A.	2024	Academic performance indicators for the hackathon learning approach – The case of the blockchain hackathon	
[28]	Oyetade, K., Zuva, T., & Harmse, A.	2024	Evaluation of the impact of hackathons in education	
[85]	Rooholamini, A., & Salajegheh, M.	2024	Health profession education hackathons: a scoping review of current trends and best practices	
[86]	Rys, M.	2025	Youth Hackathons: Empowering the Next Generation of Innovators	
[3]	Schulten, C., & Chounta, I.A.	2024	How do we learn in and from Hackathons? A systematic literature review	
[87]	Serek, A., Zhaparov, M., Yoo, S.M., Talasbek, A., Kim, Y.K., & Jin, M.W.	2020	Best Practices in Running IT Hackathons Based on Paragon University Dataset	
[48]	Sotaquirá-Gutiérrez, R., Beltran, LM, & Ruiz, JPG	2025	Hackathons as experiential learning platforms for engineering design skills	
[50]	Vanhée, L., Danielsson, K., Enqvist, L., Grill, K., & Borit, M.	2024	Hack it with EDUCHIC! educational hackathons and interdisciplinary challenges-Definitions, principles, and pedagogical guidelines	

V. Discussion

First, regarding the evolution of hackathons as innovation tools, the results of the review confirm that they have evolved from being short technological events to becoming consolidated as strategic spaces for interdisciplinary collaboration. Their use has expanded to sectors such as education [6], healthcare [7], sustainability [33], and digital transformation, where they function as promoters of open innovation and global co-creation. The analysis shows that hackathons have become environments for experiential learning and technological experimentation, integrating both academic institutions and corporate organizations. This development, strengthened by the empirical and theoretical trends analyzed, validates this study by showing a sustained and varied evolution of hackathons.

Regarding the impacts generated in different contexts, the reviewed evidence confirms that hackathons have had

significant effects on vocational, medical, and social training, promoting the acquisition of technical skills, the integration of underrepresented groups, and the development of community-impact solutions [9]. In the educational field, they are consolidated as effective environments for strengthening interdisciplinary practice and critical thinking [6]; in the medical field, they promote clinical innovation and emergency management [7]; and in the social field, they stimulate citizen inclusion and collaboration. These results validate the perspective of this review by demonstrating that hackathons are tools for educational and social change, as well as technological innovation methodologies, which entail quantifiable advantages in diverse contexts.

Finally, regarding the knowledge gaps identified, the analysis argues that, although significant progress has been made, challenges persist in the longitudinal evaluation of impact, project sustainability, and institutionalization of results. The lack of unified theoretical frameworks or long-term comparative research restricts a comprehensive understanding of the phenomenon. However, this analysis provides an important contribution by systematizing emerging trends and delimiting fields of study that should be prioritized for future research. In this sense, the study validates its relevance by providing a structured and critical overview of the state-of-the-art, highlighting the need to approach hackathons from a more analytical, sustainable, and impact-oriented perspective.

VI. Conclusion

This study conducted a comprehensive analysis of the evolution, impact, and knowledge gaps surrounding hackathons as innovation tools globally, combining a bibliometric approach with a detailed review of 73 scientific papers. The results show sustained growth in academic output starting in 2020, with a notable increase between 2021 and 2024. This trend confirms the growing interest of the scientific and professional community in hackathons as strategic environments for open innovation, experiential learning, and collaborative problem-solving, especially in technological, educational, and social contexts.

The analysis shows that the most developed sectors are digital innovation, engineering training, education, and healthcare, reflecting a stronger focus on inclusion and sustainability. Geographically, scientific production is concentrated in countries such as the United States, Brazil, and Germany. However, it is less prevalent in countries with less technological impact, reflecting an unequal distribution of knowledge. Furthermore, the most frequent keywords, such as hackathon, innovation, and education, reveal a multidisciplinary approach focused on the creation of social and technological value. Networks of co-authorship and institutional collaboration suggest consolidated, albeit dispersed, academic communities, opening up opportunities to strengthen international ties and foster the practical transfer of results.

In summary, the results confirm that hackathons have established themselves as dynamic innovation spaces capable of integrating creativity, technology, and collective learning. However, challenges remain related to long-term impact assessment, project sustainability, and the lack of integrative theoretical frameworks.

The main contribution of this review lies in offering a comprehensive and comparative overview of how hackathons have evolved from their beginnings as technological events to open and sustainable places of innovation. Unlike previous studies, this work does not limit itself to describing isolated cases, but rather synthesizes global patterns of application, identifies structural gaps in research, and proposes an implicit classification that links the educational, social, and business dimensions of hackathons. This integrative approach provides a new analytical perspective that allows us to understand hackathons as permanent mechanisms for learning, technology transfer, and co-creation.

From a theoretical perspective, the review broadens our understanding of the relationship between open innovation and collective learning, establishing that hackathons function as places of distributed innovation. On a practical level, hackathons offer guidance for designing post-event monitoring and evaluation mechanisms that measure the real impact of the solutions generated. Finally, in terms of innovation policies, the results invite the integration of hackathons into national strategies for technological development, entrepreneurial education, and citizen participation. In conclusion, this review systematizes the existing evidence and provides an interpretive framework that redefines the role of hackathons as evolutionary tools for global innovation.

VII. Gaps in the Literature

Despite the notable growth in research on hackathons as environments for innovation and collaborative learning, the scientific literature presents significant limitations that should be considered to guide future lines of work. One of the main gaps identified is the scarcity of longitudinal studies that analyze the sustained impact of hackathons on project development, venture creation, or the consolidation of innovation tools. Most studies focus on immediate outcomes, such as the learning experience or idea generation [2], without analyzing the continuity or the degree of actual implementation of the proposed solutions.

Likewise, a thematic fragmentation is evident in the approaches addressed. While studies on business competition and skills development have gained visibility [12], research on the long-term sustainability of hackathons and their capacity to be integrated into organizational or public policy strategies remains limited. Similarly, studies on innovation drive tend to focus on high-tech or educational contexts, leaving aside community, social, or country settings with less innovation infrastructure, which restricts a comprehensive understanding of the phenomenon.

Ultimately, there is a marked geographic concentration in scientific production, led by the United States, Brazil, and Germany, with limited representation in countries in Latin America, Africa, and Asia. This uneven distribution suggests that the opportunities, management models, and collaborative dynamics of hackathons may be influenced by economic and structural factors [23], rather than by the nature of the event itself. In this sense, it is necessary to promote interdisciplinary

and comparative research that analyzes hackathons in diverse contexts, with special emphasis on their social impact, organizational sustainability, and results measurement. Further examining these gaps will help to develop a more robust theoretical framework and guide the design of hackathons as sustainable tools for innovation and collective change.

VIII. Recommendations for Future Studies

- Analyzing the long-term sustainability of hackathons.
- Compare different hackathon models.
- Investigate the evolution of business and innovation skills.
- Evaluate the factors that favor or limit organizational sustainability.
- Explore the social and cultural dimensions of hackathons.
- Deepen ethical and equity approaches to participation.
- Develop longitudinal comparative studies.

References

[1] J. Falk et al., "The Future of Hackathon Research and Practice," IEEE Access, vol. 12, pp. 133406–133425, 2024, doi: 10.1109/ACCESS.2024.3455092.

[2] I. Attalah, P. A. Nylund, and A. Brem, "Who captures value from hackathons? Innovation contests with collective intelligence tools bridging creativity and coupled open innovation," Creativity and Innovation Management, vol. 32, no. 2, pp. 266–280, Jun. 2023, doi: 10.1111/CAIM.12552.

[3] C. Schulten and I. A. Chounta, "How do we learn in and from Hackathons? A systematic literature review," Educ. Inf. Technol., vol. 29, no. 15, pp. 20103–20134, Oct. 2024, doi: 10.1007/S10639-024-12668-1.

[4] F. Kitsios and M. Kamariotou, "Digital innovation and entrepreneurship transformation through open data hackathons: Design strategies for successful start-up settings," Int J Inf Manage, vol. 69, Apr. 2023, doi: 10.1016/J.IJINFOMGT.2022.102472.

[5] M. Beretta, N. Obwegeser, and S. Bauer, "An Exploration of Hackathons as Time Intense and Collaborative Forms of Crowdsourcing," IEEE Trans Eng Manag, vol. PP, pp. 1–15, 2024, doi: 10.1109/TEM.2022.3174712.

[6] K. K. F. Yuen and A. O. M. Wong, "Designing an Effective Hackathon via University-Industry Collaboration for Data Science Education," TALE 2021 - IEEE International Conference on Engineering, Technology and Education, Proceedings, pp. 723–728, 2021, doi: 10.1109/TALE52509.2021.9678826.

[7] E. S. Rigas et al., "A hackathon as a tool to enhance research and practice on electronic health record systems' interoperability for chronic disease management and prevention," Front Digit Health, vol. 5, 2023, doi: 10.3389/FDGTH.2023.1275711.

[8] F. Kitsios and M. Kamariotou, "Digital innovation and entrepreneurship through open data-based platforms: Critical success factors for hackathons," Heliyon, vol. 9, no. 4, p. e14868, Apr. 2023, doi: 10.1016/J.HELIYON.2023.E14868.

[9] A. Dabral, S. Bajwa, S. Shioyama, R. Chatterjee, and R. Shaw, "Social Innovation Hackathon for Driving Innovation in Disaster Risk Reduction (DRR)," Journal of Integrated Disaster Risk Management, vol. 11, no. 1, pp. 64–82, 2021, doi: 10.5595/001C.28876.

[10] S. Temiz, "Open Innovation via Crowdsourcing: A Digital Only Hackathon Case Study from Sweden," Journal of Open Innovation: Technology, Market, and Complexity, vol. 7, no. 1, p. 39, Mar. 2021, doi: 10.3390/JOITMC7010039.

[11] M. Flus and A. Hurst, "Design at hackathons: new opportunities for design research," Design Science, vol. 7, Feb. 2021, doi: 10.1017/DSJ.2021.1.

[12] B. Heller, A. Amir, R. Waxman, and Y. Maaravi, "Hack your organizational innovation: literature review and integrative model for running hackathons," J Innov Entrep, vol. 12, no. 1, Dec. 2023, doi: 10.1186/S13731-023-00269-0.

[13] D. M. Kochetkov, "Innovation: A State-of-the-Art Review and Typology," International Journal of Innovation Studies, vol. 7, no. 4, pp. 263–272, Dec. 2023, doi: 10.1016/J.IJIS.2023.05.004.

[14] K. Green and K. Torres, "Creating Innovative Educational Hackathons as a Means for International Institutions to Collaborate While Also Assisting NGOs," WorldCALL Official Conference Proceedings, pp. 1–6, Jan. 2024, doi: 10.22492/ISSN.2759-1182.2024.1.

[15] A. Happonen, A. Nolte, N. Bystriakova, U. Santti, and K. Kärhä, "Study on Hackathons for New Innovation Seed and Business Model Development Needs in Digitalization Driven Sustainability, Circularity and Environmentally Friendly Solutions Demanding Digitalizing Societies," New Innovations in Economics, Business and Management Vol. 4, pp. 1–29, Jan. 2022, doi: 10.9734/BPI/NIEBM/V4/14443D.

[16] M. L. Rethlefsen et al., "PRISMA-S: an extension to the PRISMA statement for reporting literature searches in systematic reviews," J Med Libr Assoc, vol. 109, no. 2, pp. 174–200, Apr. 2021, doi: 10.5195/JMLA.2021.962.

[17] R. Pranckutė, "Web of Science (WoS) and Scopus: The Titans of Bibliographic Information in Today's Academic World," Publications 2021, Vol. 9, Page 12, vol. 9, no. 1, p. 12, Mar. 2021, doi: 10.3390/PUBLICATIONS9010012.

[18] A. Kirby, "Exploratory Bibliometrics: Using VOSviewer as a Preliminary Research Tool," Publications 2023, Vol. 11, Page 10, vol. 11, no. 1, p. 10, Feb. 2023, doi: 10.3390/PUBLICATIONS11010010.

[19] S. Büyükkidik, "A Bibliometric Analysis: A Tutorial for the Bibliometrix Package in R Using IRT Literature," Journal of Measurement and Evaluation in Education and Psychology, vol. 13, no. 3, pp. 164–193, Sep. 2022, doi: 10.21031/EPOD.1069307.

[20] L. Paganini, C. Ferraz, K. Gama, and C. Alves, "Promoting Game Jams and Hackathons as more Women-Inclusive Environments for Informal Learning," Proceedings - Frontiers in Education Conference, FIE, vol. 2021-October, 2021, doi: 10.1109/FIE49875.2021.9637301.

[21] S. Franco, A. Presenza, and A. M. Petruzzelli, "Boosting innovative business ideas through hackathons. The 'Hack for Travel' case study," European Journal of Innovation Management, vol. 25, no. 6, pp. 413–431, Dec. 2021, doi: 10.1108/EJIM-06-2021-0300/FULL/PDF.

[22] C. Liu and S. Prajapati, "Insight from keywords co-occurrence in SEG annual meetings: a bibliometric study," SEG Technical Program Expanded Abstracts, vol. 2022-August, pp. 1810–1814, Aug. 2022, doi: 10.1190/IMAGE2022-3726975.1.

[23] L. Hou, Y. Pan, and J. J. H. Zhu, "Impact of scientific, economic, geopolitical, and cultural factors on international research collaboration," J Informetr, vol. 15, no. 3, Aug. 2021, doi: 10.1016/j.joi.2021.101194.

[24] U. Cantner, T. Grebel, and X. Zhang, "The architecture of global knowledge production – do low-income countries get more involved?," Industrial and Corporate Change, vol. 33, no. 5, pp. 1298–1329, Aug. 2024, doi: 10.1093/ICC/DTAD042.

[25] A. Haley, S. K. Alemu, Z. Zerihun, and L. Uusimäki, "Internationalisation through research collaboration," Educ Rev (Birm), vol. 76, no. 4, pp. 675–690, Jun. 2024, doi: 10.1080/00131911.2022.2054958.

[26] S. Ribault et al., "To other new educational ways for interdisciplinary cooperation and innovation: about a student-driven hackathon," MedEdPublish, vol. 12, p. 20, Feb. 2024, doi: 10.12688/MEP.18991.2.

[27] K. Gama, "Successful Models of Hackathons and Innovation Contests to Crowdsource Rapid Responses to COVID-19," Digital Government: Research and Practice, vol. 2, no. 2, Dec. 2020, doi: 10.1145/3431806.

[28] K. Oyetade, T. Zuva, and A. Harmse, "Evaluation of the impact of hackathons in education," Cogent Education, vol. 11, no. 1, 2024, doi: 10.1080/2331186X.2024.2392420.

[29] S. S. Razak et al., "Fostering Global Neurosurgical Innovation and Collaboration Through Virtual Hackathons," Neurosurgery, vol. 71, no. Supplement_1, pp. 199–199, Apr. 2025, doi: 10.1227/NEU.0000000000003360_1248.

[30] E. Romeo-Arroyo et al., "Open Innovation With Sensory and Consumer Science: Hackathon as a Tool for Academic Industry-Cooperation," J Sens Stud, vol. 40, no. 1, Feb. 2025, doi: 10.1111/JOSS.70025.

[31] A. Barana et al., "Driving International Collaboration Beyond Boundaries Through Hackathons: A Comparative Analysis of Four Hackathon Setups," Information 2025, Vol. 16, Page 488, vol. 16, no. 6, p. 488, Jun. 2025, doi: 10.3390/INFO16060488.

[32] R. Sajja, C. E. Ramirez, Z. Li, B. Z. Demiray, Y. Sermet, and I. Demir, "Integrating Generative AI in Hackathons: Opportunities, Challenges, and Educational Implications," Big Data and Cognitive Computing 2024, Vol. 8, Page 188, vol. 8, no. 12, p. 188, Dec. 2024, doi: 10.3390/BDCC8120188.

[33] N. AlQallaf, D. W. Elnagar, S. G. Aly, K. I. Elkhodary, and R. Ghannam, "Empathy, Education, and Awareness: A VR Hackathon's Approach to Tackling Climate Change," Sustainability 2024, Vol. 16, Page 2461, vol. 16, no. 6, p. 2461, Mar. 2024, doi: 10.3390/SU16062461.

[34] S. B. Rasmussen, T. Bosker, G. G. Ramanand, and M. G. Vijver, "Participatory hackathon to determine ecological relevant endpoints for a neurotoxin to aquatic and benthic invertebrates," Environmental Science and Pollution Research, vol. 31, no. 15, pp. 22885–22899, Mar. 2024, doi: 10.1007/S11356-024-32566-W/FIGURES/4.

[35] J. Faludi, "Hack for impact – sociomateriality and the emergent structuration of social hackathons," Journal of Organizational Ethnography, vol. 12, no. 2, pp. 223–241, Jul. 2023, doi: 10.1108/JOE-12-2022-0036/FULL/PDF.

[36] S. Z. Fernandez, D. L. Miron, A. C. Casanova, and F. F. Diaz, "Dual Hackathon Based on Immersive Simulation: A Multidisciplinary Approach for Engineering Training and Emergency Management," IEEE Access, vol. 13, pp. 61958–61971, 2025, doi: 10.1109/ACCESS.2025.3556815.

[37] C. Rennick, G. Litster, C. C. W. Hulls, and A. Hurst, "Curricular Hackathons for Engineering Design Learning: The Case of Engineering Design Days," IEEE Transactions on Education, vol. 66, no. 6, pp. 654–664, Dec. 2023, doi: 10.1109/TE.2023.3295754.

[38] A. A. Araújo, M. Kalinowski, and M. T. Baldassarre, "Can participation in a hackathon impact the motivation of software engineering students? A preliminary case study analysis," Feb. 2024, doi: 10.1145/3641822.3641876.

[39] A. S. Poncette, P. D. Rojas, J. Hofferbert, A. V. Sosa, F. Balzer, and K. Braune, "Hackathons as Stepping Stones in Health Care Innovation: Case Study With Systematic Recommendations," J Med Internet Res, vol. 22, no. 3, Mar. 2020, doi: 10.2196/17004.

[40] A. Remshagen and K. C. Huett, "Youth Hackathons in Computing for the Community: A Design Case," TechTrends, vol. 67, no. 3, pp. 508–520, May 2023, doi: 10.1007/S11528-023-00852-Y/METRICS.

[41] K. Gama et al., "Hackathons as Inclusive Spaces for Prototyping Software in Open Social Innovation with NGOs," Proceedings - International Conference on Software Engineering, vol. 2023-May, pp. 58–70, Sep. 2023, doi: 10.1109/ICSE-SEIS58686.2023.00012.

[42] J. Jussila, A. H. Suominen, and T. Rainio, "Entrepreneurship Competence Using Educational Hackathons in Finland," Journal of Finnish Studies, vol. 23, no. 2, pp. 32–73, Dec. 2020, doi: 10.5406/28315081.23.2.05.

[43] A. Miličević, M. Despotović-Zrakić, D. Stojanović, M. Suvajžić, and A. Labus, "Academic performance indicators for the hackathon learning approach – The case of the blockchain hackathon," Journal of Innovation & Knowledge, vol. 9, no. 3, p. 100501, Jul. 2024, doi: 10.1016/J.JIK.2024.100501.

[44] P. Angelidis et al., "The hackathon model to spur innovation around global mHealth," J Med Eng Technol, vol. 40, no. 7–8, p. 392, Nov. 2016, doi: 10.1080/03091902.2016.1213903.

[45] A. Förschler and M. Decuypere, "Where are we heading? Hackathons as a new, relational form of policymaking," Journal of Education Policy, vol. 39, no. 4, pp. 519–540, Jul. 2024, doi: 10.1080/02680939.2024.2313199.

[46] D. Adinda, N. Gettliffe, and N. Mohib, "Educational hackathon: preparing students for collaborative competency," Educ Stud, Sep. 2025, doi: 10.1080/03055698.2024.2369868.

[47] K. Charvát et al., "INSPIRE Hackathons and SmartAfriHub – Roadmap for Addressing the Agriculture Data Challenges in Africa," Agris on-line Papers in Economics and Informatics, vol. 4, no. December, pp. 33–48, 2021, doi: 10.7160/AOL.2021.130404.

[48] R. Sotaquirá-Gutiérrez, L. M. Beltran, and J. P. Garzon Ruiz, "Hackathons as experiential learning platforms for engineering design skills," Cogent Education, vol. 12, no. 1, Dec. 2025, doi: 10.1080/2331186X.2024.2442187.

[49] C. W. Chen, Y. S. Yeh, T. C. Chan, and Y. S. Wu, "Public–private partnership in pipelining science of acute care ecosystem: Insights from Taiwan's Presidential Hackathon," Learn Health Syst, vol. 9, no. 3, p. e10474, Jul. 2025, doi: 10.1002/LRH2.10474.

[50] L. Vanhée, K. Danielsson, L. Enqvist, K. Grill, and M. Borit, "Hack it with EDUCHIC! Educational hackathons and interdisciplinary challenges—Definitions, principles, and pedagogical guidelines," Eur J Educ, vol. 59, no. 3, p. e12658, Sep. 2024, doi: 10.1111/EJED.12658.

[51] N. Endrissat and G. Islam, "Hackathons as Affective Circuits: Technology, organizationality and affect," Organization Studies, vol. 43, no. 7, pp. 1019–1047, Jul. 2022, doi: 10.1177/01708406211053206.

[52] A. Jaribion, S. H. Khajavi, U. Jarvihaavisto, I. Nurmi, R. Gustafsson, and J. Holmstrom, "Crowdsourcing Properties and Mechanisms of Mega Hackathons: The Case of Junction," IEEE Trans Eng Manag, vol. 70, no. 9, pp. 3021–3035, Sep. 2023, doi: 10.1109/TEM.2021.3079107.

[53] M. Kamariotou and F. Kitsios, "Hackathons for Driving Service Innovation Strategies: The Evolution of a Digital Platform-Based Ecosystem," Journal of Open Innovation: Technology, Market, and Complexity, vol. 8, no. 3, p. 111, Sep. 2022, doi: 10.3390/joitmc8030111.

[54] F. Kitsios and M. Kamariotou, "Beyond Open Data Hackathons: Exploring Digital Innovation Success," Information 2019, Vol. 10, Page 235, vol. 10, no. 7, p. 235, Jul. 2019, doi: 10.3390/INFO10070235.

[55] A. Leemet, F. Milani, and A. Nolte, "Utilizing Hackathons to Foster Sustainable Product Innovation-The Case of a Corporate Hackathon Series," Proceedings - 2021 IEEE/ACM 13th International Workshop on Cooperative and Human Aspects of Software Engineering, CHASE 2021, pp. 51–60, May 2021, doi: 10.1109/CHASE52884.2021.00014.

[56] J. Lobbe, F. Bazzaro, and J. C. Sagot, "Innovation in collaborative design: an exploratory study in hackathon," International Journal of Design Creativity and Innovation, vol. 9, no. 2, pp. 119–137, Apr. 2021, doi: 10.1080/21650349.2021.1894989.

[57] E. P. P. Pe-Than, A. Nolte, A. Filippova, C. Bird, S. Scallen, and J. D. Herbsleb, "Designing Corporate Hackathons With a Purpose: The Future of Software Development," IEEE Softw, vol. 36, no. 01, pp. 15–22, Jan. 2019, doi: 10.1109/MS.2018.290110547.

[58] A. Richterich, "Hacking events: Project development practices and technology use at hackathons," Convergence, vol. 25, no. 5–6, pp. 1000–1026, Dec. 2019, doi: 10.1177/1354856517709405.

[59] G. Terrazas, G. Hawkridge, M. McNally, D. McFarlane, Z. Ling, and J. Lau, "Hackathons to Accelerate the Development of Low-Cost Digital Solutions," Journal of Computer Information Systems, vol. 63, no. 5, pp. 1124–1138, Sep. 2023, doi: 10.1080/08874417.2022.2128935.

[60] A. A. Araujo, M. Kalinowski, and M. T. Baldassarre, "Embracing Experiential Learning: Hackathons as an Educational Strategy for Shaping Soft Skills in Software Engineering," Software Engineering Education Conference, Proceedings, pp. 319–324, Feb. 2025, doi: 10.1109/CSEET66350.2025.00040.

[61] K. Braune et al., "Interdisciplinary Online Hackathons as an Approach to Combat the COVID-19 Pandemic: Case Study," J Med Internet Res, vol. 23, no. 2, Feb. 2021, doi: 10.2196/25283.

[62] J. W. Browning, S. McKeever, M. A. Ferrario, I. O'Neill, and D. Stewart, "Creating sustainable solutions: An inclusive hackathon leveraging genAI in a local context," IEEE Global Engineering Education Conference, EDUCON, Jun. 2025, doi: 10.1109/EDUCON62633.2025.11016553.

[63] J. R. Byrne, K. O'Sullivan, and K. Sullivan, "An IoT and Wearable Technology Hackathon for Promoting Careers in Computer Science," IEEE Transactions on Education, vol. 60, no. 1, pp. 50–58, Feb. 2017, doi: 10.1109/TE.2016.2626252.

[64] F. S. Cardwell, S. J. Elliott, and A. E. Clarke, "The value of hackathons in integrated knowledge translation (iKT) research: Waterlupus," Health Res Policy Syst, vol. 19, no. 1, pp. 1–16, Dec. 2021, doi: 10.1186/S12961-021-00785-Z/TABLES/5.

[65] Z. Covic and H. Manojlovic, "Developing key competencies through hackathon based learning," SISY 2019 - IEEE 17th International Symposium on Intelligent Systems and Informatics, Proceedings, pp. 167–172, Sep. 2019, doi: 10.1109/SISY47553.2019.9111513.

[66] C. Guerrero, M. Del Mar Leza, Y. González, and A. Jaume-I-Capó, "Analysis of the results of a hackathon in the context of service-learning involving students and professionals," 2016 International Symposium on Computers in Education, SIIE 2016: Learning Analytics Technologies, Nov. 2016, doi: 10.1109/SIIE.2016.7751857.

[67] R. Haque, A. Salmani, N. Raessinejad, and M. Moshirpour, "Effectiveness of Hackathons in Software Engineering Education," Proceedings - Frontiers in Education Conference, FIE, vol. 2022-October, 2022, doi: 10.1109/FIE56618.2022.9962527.

[68] W. Hurst, O. Spyrou, and C. Krampe, "The Data Factory: Findings from an Extended Reality-based Hackathon for Data Science Education," 2024 10th International Conference on Virtual Reality, ICVR 2024, pp. 85–90, 2024, doi: 10.1109/ICVR62393.2024.10867973.

[69] H. Kienzler and C. Fontanesi, "Learning through inquiry: a Global Health Hackathon," Teaching in Higher Education, vol. 22, no. 2, pp. 129–142, Feb. 2017, doi: 10.1080/13562517.2016.1221805.

[70] B. Kumalakov, A. Kim, S. Mukhtarova, A. Shukurova, and N. Khon, "Hackathon as a Project Based Teaching Tool: Employing Programming Challenge in the Class," IEEE 12th International Conference on Application of Information and Communication Technologies, AICT 2018 - Proceedings, Oct. 2018, doi: 10.1109/ICAICT.2018.8747149.

[71] S. Mhlongo, K. E. Oyetade, and T. Zuva, "The Effectiveness of Collaboration Using the Hackathon to Promote Computer Programming Skills," 2020 2nd International Multidisciplinary Information Technology and Engineering Conference, IMITEC 2020, Nov. 2020, doi: 10.1109/IMITEC50163.2020.9334089.

[72] V. Milutinović, J. Cincović, V. Jocović, and D. Drašković, "Applied AI, Teamwork, and Learning in Student Hackathons: Case Study from Serbia," Proceedings - 12th International Conference on Electrical, Electronic and Computing Engineering, IcETRAN 2025, 2025, doi: 10.1109/ICETRAN66854.2025.11114198.

[73] M. Moshirpour, T. Al Shoura, L. Duffett-Leger, and M. Moshirpour, "Multidisciplinary Hackathons: Towards Developing Practical Software Engineering Skills," Proceedings - Frontiers in Education Conference, FIE, 2023, doi: 10.1109/FIE58773.2023.10343214.

[74] L. Paganini and K. Gama, "Female Participation in Hackathons: A Case Study about Gender Issues in Application Development Marathons," Revista Iberoamericana de Tecnologias del Aprendizaje, vol. 15, no. 4, pp. 326–335, Nov. 2020, doi: 10.1109/RITA.2020.3033209.

[75] L. Paganini, K. Gama, A. Nolte, and A. Serebrenik, "Opportunities and constraints of women-focused online hackathons," Proceedings - 2023 IEEE/ACM 4th Workshop on Gender Equity, Diversity, and Inclusion in Software Engineering, GEICSE 2023, pp. 33–40, 2023, doi: 10.1109/GEICSE59319.2023.00009.

[76] A. Pathanasethpong et al., "Tackling Regional Public Health Issues Using Mobile Health Technology: Event Report of an mHealth Hackathon in Thailand," JMIR Mhealth Uhealth, vol. 5, no. 10, Oct. 2017, doi: 10.2196/MHEALTH.8259.

[77] J. Porras et al., "Hackathons in Software Engineering Education - Lessons Learned from a Decade of Events," 2018 IEEE/ACM International Workshop on Software Engineering Education for Millennials (SEEM), 2018, Accessed: Oct. 12, 2025. [Online]. Available: https://ieeexplore.ieee.org/document/8442127/authors#authors

[78] T. Rocha et al., "Affirmative Hackathon for Software Developers with Disabilities: An Industry Initiative," Proceedings - 2025 IEEE/ACM 18th International Conference on Cooperative and Human Aspects of Software Engineering, CHASE 2025, pp. 39–50, Jan. 2025, doi: 10.1109/CHASE66643.2025.00013.

[79] M. Ryś, "Unraveling Participation Motivations in Pandemic-Related Hackathons: A COVID-19 Study," Computer (Long Beach Calif), vol. 57, no. 10, pp. 56–65, 2024, doi: 10.1109/MC.2024.3414194.

[80] J. K. Silver, D. S. Binder, N. Zubcevik, and R. D. Zafonte, "Healthcare Hackathons Provide Educational and Innovation Opportunities: A Case Study and Best Practice Recommendations," J Med Syst, vol. 40, no. 7, Jul. 2016, doi: 10.1007/S10916-016-0532-3.

[81] O. Synekop, "Hackathon in Differentiated English for Specific Purposes Instruction of Information Technology Students," Multidisciplinary Journal for Education, Social and Technological Sciences, vol. 10, no. 2, pp. 77–93, Oct. 2023, doi: 10.4995/MUSE.2023.19966.

[82] J. Wyngaard, H. Lynch, J. Nabrzyski, A. Pope, and S. Jha, "Hacking at the divide between polar science and HPC: Using hackathons as training tools," Proceedings - 2017 IEEE 31st International Parallel and Distributed Processing Symposium Workshops, IPDPSW 2017, pp. 352–359, Jun. 2017, doi: 10.1109/IPDPSW.2017.177.

[83] M. Flores, M. Golob, D. Maklin, C. L. Tucci, S. West, and O. Stoll, "DARE2HACK: Crowdsourcing ideas through hackathons to codesign new human-centric services," Proceedings - 2020 7th Swiss Conference on Data Science, SDS 2020, pp. 5–10, Jun. 2020, doi: 10.1109/SDS49233.2020.00009.

[84] D. Kube, S. Gombert, B. Suter, J. Weidlich, K. Kreijns, and H. Drachsler, "Hacking gender in computer-supported collaborative learning: The experience of being in mixed-gender teams at a computer science hackathon," J Comput Assist Learn, vol. 40, no. 6, pp. 2513–2527, Dec. 2024, doi: 10.1111/JCAL.12905.

[85] A. Rooholamini and M. Salajegheh, "Health profession education hackathons: a scoping review of current trends and best practices," BMC Med Educ, vol. 24, no. 1, Dec. 2024, doi: 10.1186/S12909-024-05519-7.

[86] M. Rys, "Youth Hackathons: Empowering the Next Generation of Innovators," Eur J Educ, vol. 60, no. 3, p. e70176, Sep. 2025, doi: 10.1111/EJED.70176.

[87] A. Serek, M. Zhaparov, S. M. Yoo, A. Talasbek, Y. K. Kim, and M. W. Jin, "Best Practices in Running IT Hackathons Based on Paragon University Dataset," International Journal of Emerging Technologies in Learning (iJET), vol. 15, no. 19, pp. 231–238, Oct. 2020, doi: 10.3991/IJET.V15I19.15523