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New Software Product Development: Bibliometric Analysis

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Abstract
The aim of this article is to conduct a comprehensive bibliometric analysis of the existing literature in the domain of new software product development. The research methodology is based on bibliometrics, cluster analysis and meta-analysis of key indicators of knowledge dissemination and publications about the new software product in the Scopus scientometric database for 2003–2022.Through bibliometric analysis, this study provides valuable information on the trends, patterns and impact of research and publications in the field of new software product development. Based on the literature reviewed, known research areas, influential authors and new directions are identified, thus providing a comprehensive overview of the current state of knowledge in the field of new software product development. The number of publications dedicated to new software products has steadily increased over the past two decades, indicating a growing interest in this field among researchers and scholars. The United States, China, and Germany emerged as the leading countries in terms of the number of publications, highlighting their strong presence in software development and technological advancements. Meta-analysis demonstrates the significant impact of Engineering, Mathematics, and Social Sciences on the publication count of the new software product. Overall, the findings highlight the widespread interest and interdisciplinary nature of software product development, with particular emphasis on the role of Computer Science and Engineering in driving advancements in this domain. The conducted bibliometric analysis can serve as a basis for further research and help researchers and practitioners to identify knowledge gaps and directions for future research.

Keywords Software Product · Innovation Management · Technology · Development · Engineering · Effectiveness

Extended author information available on the last page of the article

Introduction

In today's fast-paced and interconnected world, software has become an integral part of our daily lives, enabling us to accomplish tasks efficiently, connect with others effortlessly, and access information instantaneously. As technology continues to advance at an unprecedented rate, the demand for innovative software products has surged, leading to a highly competitive landscape in the software development industry. Developing new software products is a complex endeavour. Apart from the necessity of technical expertise, creative thinking and understanding of the market (Appio et al., 2021) it also requires a systematic approach. The process is comprised of ideation, planning, design, development, testing, and deployment. The goal is to deliver a solution that meets users' evolving needs (Cooper & Sommer, 2018).

In this study, we delve into the fascinating world of new software product development and explore the key aspects that drive innovation in the digital age. We will examine the challenges faced by software development teams, highlight best practices and methodologies employed throughout the process, and shed light on the transformative impact of emerging technologies in shaping the future of software product development. One of the fundamental challenges in new software product development lies in identifying and understanding the needs and desires of the target audience (Melegati et al., 2019). Effective market research and user-centric design methodologies play a crucial role in ensuring that the software product meets the expectations of its intended users. It's helpful for the developers to gain insight into the preferences, pain points, and behaviours of the users. That way they can create solutions that offer meaningful and delightful experiences (Jansen et al., 2020).

The rapid advancement of technology presents both opportunities and hurdles for software development teams. The advent of artificial intelligence, machine learning, cloud computing, and the Internet of Things has opened up new avenues for innovation, enabling the creation of intelligent, scalable, and interconnected software products (Gill et al., 2019). However, with technological progress comes the need for continuous learning, adaptation, and keeping pace with the ever-changing landscape.

New software product development is a dynamic and exhilarating journey that requires a harmonious blend of technical expertise, innovation, and market understanding (Parthasarathy, 2022). As the digital landscape continues to evolve, software development teams must embrace emerging technologies, adapt to changing user expectations, and foster a culture of continuous learning and improvement (Marion & Fixson, 2021). By doing so, they can unlock the full potential of their creativity and bring to life software products that redefine the way we live, work, and interact in the digital age. The aim of this article is to conduct a comprehensive bibliometric analysis of the existing literature in the domain of new software product development. The study conducted a comprehensive bibliometric analysis to understand the trends, patterns, and impacts of research and publications in this field. The main tasks solved during the study are:

1. Through the analysis of publication patterns, citation networks, and co-authorship collaborations, the study identified the key research trends that have emerged in the field of new software product development. This involved examining the frequency and distribution of research publications over time to uncover the evolution of topics, methodologies, and technologies employed in this area.
2. By mapping the citation network and analyzing co-citation patterns, the study aimed to identify seminal works and influential factors that have shaped the landscape of new software product development. This analysis provided insights into the most referenced studies, influential authors, institutions, and countries, thereby highlighting the key contributors to the knowledge base in this field.
3. The study examined the distribution of research across different subtopics to identify potential gaps in the existing literature. This analysis will help researchers and practitioners identify areas that have received less attention or require further exploration, providing valuable directions for future research and development efforts in new software product development.

Through this comprehensive bibliometric analysis, we strive to offer a holistic view of the research landscape in new software product development. By uncovering research trends, influential factors, and potential gaps, this analysis will provide researchers, practitioners, and decision-makers with valuable insights to shape future strategies, foster collaboration, and advance the field of software product development in an informed and impactful manner.

State-of-the-art

Mapping the Landscape of Software Development Publication data

In recent years, the field of software product development has witnessed rapid advancements and transformations, driven by technological innovations, evolving user needs, and changing market dynamics. This literature review explores the key themes that have emerged in the context of new software product development. In the study, a bibliometric analysis methodology was applied, using cluster analysis and meta-analysis of key indicators of knowledge dissemination and publications on the development of new software products. The analysis was based on data from the Scopus scientometric database for the period from 2003 to 2022, covering 22,116 publications (Table 1).

The dataset comprises an impressive collection of 22,116 documents sourced from 8,475 journals, books, and other scholarly outlets. This diversity of sources indicates a broad interest and cross-disciplinary engagement in software product development. The annual growth rate of publications stands at 4.09%, pointing to a steady increase in research output. This growth rate, though modest, is significant given the dataset's starting volume. The average age of the documents is 9.75 years, which suggests that while the field continues to evolve, it also has a substantial body of established knowledge. With an average of 14.37 citations

Table 1 Main information about studied publication

Description	Results
Main information about data:	
Timespan	2003:2022
Sources (journals, books, etc.)	8475
Documents	22,116
Annual growth rate %	4.09
Document average age	9.75
Average citations per doc	14.37
Document contents:	
Keywords plus (ID)	79,973
Author's keywords (DE)	39,947
Authors:	
Authors	51,843
Authors of single-authored docs	2812
Authors collaboration:	
Single-authored documents	3958
Co-authors per document	3.52
International co-authorships %	17.11
Document types:	
Article	12,633
Book chapter	718
Book chapter conference paper	5
Book conference paper	1
Conference paper	8759

Source: formed by the author

per document, the research on new software product development demonstrates impactful contributions to the field, indicating that the works are widely recognized and referenced within the academic community.

The analysis reveals a rich lexicon of 79,973 "Keywords plus (ID)" and 39,947 "Author's keywords (DE)". These figures not only underscore the extensive thematic diversity and specialized focus areas within the field but also highlight the evolving nature of software product development discourse.

The human capital involved in this academic endeavor is significant, with 51,843 authors contributing to the corpus. However, only 2812 of these have published single-authored documents, suggesting a strong tendency towards collaborative research in the field. This tendency is further supported by the fact that there are 3958 single-authored documents compared to a higher average of 3.52 co-authors per document. The percentage of international co-authorships stands at 17.11%, indicating a healthy level of global collaboration, although there is still room for improvement in terms of international cooperation.

The breakdown of document types reveals a dominant preference for articles, which constitute 12,633 of the total documents, underscoring the academic

community's inclination towards traditional scholarly communication. Conference papers also make up a substantial portion with 8759 entries, reflecting the field's dynamic nature and the importance of conferences as venues for sharing cutting-edge research.

For the cluster analysis, we used VosViewer and Biblioshiny tools in the R environment. These tools helped identify connections between research areas and distinct concepts. Furthermore, it aided the determination of thematic patterns and interconnections in new software product research. These tools contributed to the identification of important domains and directions in the research literature, highlighting the interdisciplinary nature of software product development and the particular focus on the role of computer science and engineering in advancing this field.

Thematic Insights into new Software Product Development

The cluster analysis of publications was carried out using the concept "new software product" in keywords for 2003–2022. Using the VOSviewer software environment, we identified the relationships between studies in this area and distinct concepts (Fig. 1). The cluster analysis aimed to uncover the thematic patterns and interconnections within the research landscape concerning new software products. By analyzing the co-occurrence of keywords in the publications, VOSviewer identified clusters of studies that shared similar concepts or themes. These clusters provided insights into the various aspects and subtopics related to new software products. Researchers and practitioners could examine the identified clusters to gain a better understanding of the research trends, emerging topics, and potential collaborations in this area. Moreover, the analysis facilitated the identification of key concepts that were frequently associated with new software products, thereby highlighting the important domains and areas of focus within the research literature.

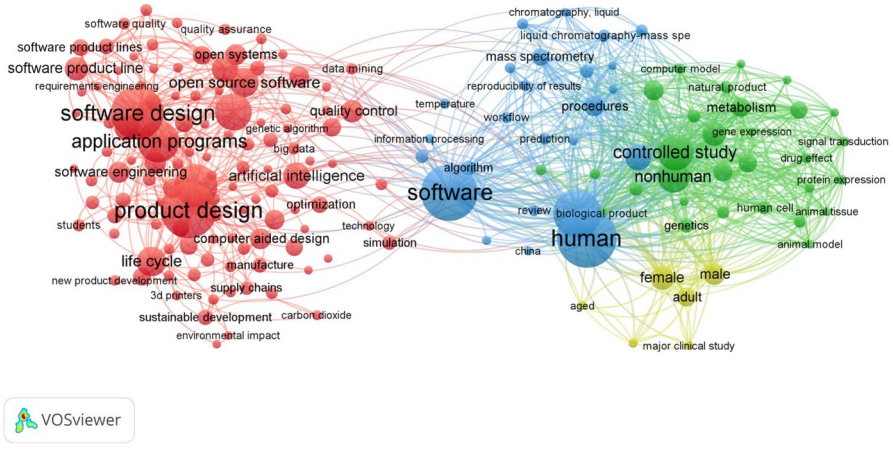

Fig. 1 Cluster analysis of "new software product" publications in the Scopus database from 2003 to 2022. Source: formed by the author

Throughout the analyzed period, the largest (red) cluster can be identified, which demonstrates the interconnection of research on a new software product in the context of its development, application creation, artificial intelligence, and ensuring the necessary characteristics for its advancement. The remaining clusters mainly reveal the development direction of medical and biotechnological research for the new software product, which integrates engineering and human science. The cluster analysis conducted using VOSviewer helped reveal the relationships and connections between studies focused on new software products and other relevant concepts, thereby enhancing our understanding of the research landscape in this domain.

Agile and lean development methodologies have gained significant attention in the software industry, emphasizing iterative and incremental development, customer collaboration, and rapid delivery. The literature highlights the benefits of these approaches in enabling flexibility, responsiveness, and adaptive product development, thereby reducing time-to-market and enhancing customer satisfaction. The key themes within agile and lean development include continuous integration, continuous delivery, cross-functional teams, and the adoption of agile practices such as Scrum and Kanban (Zayat & Senvar, 2020). User-centered design (UCD) focuses on understanding and addressing user needs, preferences, and behaviors throughout the product development lifecycle (Zorzetti et al., 2022). The literature reveals the importance of involving end-users in the design process through techniques like personas, user interviews, usability testing, and prototyping (Herumurti et al., 2023). The key themes within UCD encompass user research, usability engineering, interaction design, and the integration of user feedback to create intuitive and user-friendly software products (Dopp et al., 2020; Park et al., 2022).

DevOps practices emphasize collaboration, automation, and continuous integration and deployment (CI/CD) to bridge the gap between development and operations teams. The literature highlights the role of DevOps in streamlining software development, enhancing product quality, and improving deployment processes. Key themes within DevOps include infrastructure automation, version control, automated testing, monitoring, and the use of cloud computing platforms for scalable and reliable deployments. Effective software product management is crucial for successful new product development (Shameem, 2022). Literature sheds light on product managers' roles. They define the product's vision, strategy, and roadmaps. They also prioritize features according to market demands and customer feedback. Key themes within software product management include requirements engineering, product planning, product lifecycle management, and product analytics for data-driven decision-making (Mishra & Otaiwi, 2020; Wiedemann et al., 2019a; Lwakatare et al., 2019).

The literature highlights the impact of emerging technologies, such as artificial intelligence (AI), machine learning, Internet of Things (IoT), and blockchain, on software product development. These technologies offer new opportunities and challenges, including intelligent automation, predictive analytics, enhanced user experiences, and secure and decentralized applications (Gerke et al., 2020; Merenda et al., 2020). Key themes within emerging technologies include the integration of AI algorithms, IoT connectivity, blockchain-based solutions, and the ethical implications of deploying these technologies in software products (Mugarza et al., 2020; Nica & Stehel, 2021).

Software product development is increasingly influenced by the emergence of software ecosystems and open-source communities. The literature explores the benefits and challenges of leveraging open-source software components, libraries, and frameworks in new product development. Key themes within software ecosystems and open source include collaborative development models, licensing considerations, community engagement, and the role of open-source platforms in fostering innovation (Coetzee et al., 2020). One of the major challenges in new software product development is the rapidly changing technology landscape. The software industry is characterized by constant advancements and evolving trends. Developers must keep up with the latest technologies, programming languages, frameworks, and tools to build cutting-edge software products (Colón-Ramos et al., 2019; Salvato & Laplume, 2020). Failure to adapt to these changes may result in outdated and less competitive products. Additionally, the integration of new technologies into existing software ecosystems can present compatibility and interoperability challenges. Developing a successful software product requires a deep understanding of market dynamics and customer needs (Marion & Fixson, 2021). The market for software products is highly volatile and unpredictable. Identifying the right target audience, determining their needs, and creating a product that resonates with their expectations is a challenging task. Additionally, customer needs and preferences change quickly. Developers need to constantly collect feedback from customers and adjust their products to remain relevant. Failure to do so may result in a product that fails to meet market demand (Bianchi et al., 2020).

New software product development often faces resource constraints, including budgetary limitations, time constraints, and limited availability of skilled personnel. Adequate funding is crucial for conducting research, acquiring necessary tools and technologies, and marketing the product effectively (Chiang & Lin, 2020; Beecham et al., 2021). Software development projects often face tight deadlines, putting pressure on developers to deliver high-quality products within limited timeframes. The shortage of skilled developers and technical expertise can also hamper the development process, leading to delays or compromised quality (Berg et al., 2020).

Modern software products are increasingly complex and require integration with various hardware and software components. Developing software products that seamlessly integrate with existing systems while ensuring performance, security, and scalability is a significant challenge. The scale and complexity of software systems can lead to issues such as system crashes, performance bottlenecks, and security vulnerabilities. Ensuring robustness, maintainability, and scalability while managing dependencies and interconnections is crucial but demanding (Thota et al., 2020). Ensuring the quality of software products is a critical challenge in new software product development. Inadequate testing and quality assurance processes can result in software products with functional defects, poor user experience, and security vulnerabilities (Saputri & Lee, 2021). It's essential to develop comprehensive testing strategies and automate the testing process. Conducting thorough quality checks throughout the development lifecycle is also crucial. However, these activities require additional time, effort, and resources, which can be challenging to allocate in fast-paced development environments (Issa Mattos et al., 2023). New software product development plays a vital role in driving innovation and competitiveness in

the rapidly evolving digital landscape. As organizations strive to create cutting-edge software products, it is essential to adopt best practices that can enhance the efficiency and effectiveness of the development process (Cooper, 2019).

Agile methodologies have become more popular in recent years as they help increase flexibility and adaptability in software fevelopment. This approach focuses on iterative development, teamwork, and customer feedback, allowing teams to adapt to changes and deliver quality software products (Aldave et al., 2019; Najihi et al., 2022). By involving users throughout the development process, software teams can ensure that the product meets user expectations and delivers a superior user experience. The concept of a minimum viable product (MVP) involves releasing a product with the minimum set of features necessary to meet user needs and gather feedback. Adopting an MVP approach allows teams to validate assumptions and gather early feedback. This allows the creation of informed decisions about the product's direction (Tripathi et al., 2019; Dennehy et al., 2019). This iterative process allows for faster time-to-market and reduces the risk of developing features that users may not find valuable. DevOps practices emphasize collaboration, automation, and continuous improvement between development and operations teams. Adopting a DevOps mindset and using CI/CD pipelines helps automate building, testing, and deployment. This speeds up and improves the reliability of software releases (Almeida et al., 2022; Wiedemann et al., 2019a). This approach ensures that software products are regularly updated, and any issues are addressed promptly.

Efficient project management practices are crucial for successful software product development. Techniques such as scrum, Kanban, and lean project management can help teams streamline development processes, manage resources effectively, and deliver software products on time and within budget. Clear communication, proper task allocation, and regular progress tracking are essential aspects of effective project management. Quality assurance and testing are integral to software product development to ensure that the final product meets the desired quality standards (Zonnenshain & Kenett, 2020). Best practices in this area include test-driven development (TDD), continuous testing, and the use of automated testing frameworks. Rigorous testing throughout the development lifecycle helps identify and address bugs and performance issues early, resulting in a more reliable and stable software product (Iqbal & Suzianti, 2021).

With the rapid advancement of technology, the creation of new software products is increasingly influenced by the rise of emerging technologies. However, the literature has not sufficiently tackled the specific challenges and strategies inherent in the development of software products within these new domains. Traditional studies have often centered on conventional software development methodologies, failing to grasp the complexity and specific nuances associated with cutting-edge technological advancements. There's a noticeable gap in literature regarding practical insights, frameworks, and approaches designed expressly for software product development in these burgeoning fields. Bridging this gap requires a detailed examination and synthesis of research that delves into the challenges faced by software development teams as they navigate emerging technologies. Furthermore, it necessitates the identification of effective strategies, methodologies, and frameworks that can serve as a guide for the development of software products within these areas. By

addressing this gap, researchers and practitioners can gain a deeper understanding of the unique challenges and opportunities in developing new software products for emerging technology sectors. This understanding will promote informed decision-making. Consequently, it may lead to the creation of successful software products within these innovative areas.

The Common Research Trends

Over the past two decades, the number of publications dedicated to the development of new software products has been steadily increasing. In 2003, only 762 publications were found, but by 2022, the number had reached 1558, which is twice as much. This indicates a growing interest in the field of creating new software products and their development. Figure 2 illustrates the growth of publications with the keyword "new software product" in the Scopus database from 2003 to 2022. The growth rate of publications featuring "new software product" keywords is not constant. While there is an overall upward trend, the rate of growth varies from year to year. Some years show significant increases, while others show smaller or even negative growth. The number of publications experienced some fluctuations between 2007 and 2015. Despite the dynamic growth in the volume of publications in the subject areas of "Computer Science" and "Mathematics," most other subject areas did not exhibit a consistent growth trend. However, starting from 2016, the volume of publications related to new software products has been steadily increasing for over 5 years. This indicates a growing scientific interest in the field of new software products and the effectiveness of project management in this sphere. Figure 2 illustrates the growth of publications with the keywords "new software product" in the Scopus database from 2003 to 2022.

There is a general upward trend in the number of publications over the years, indicating an increasing interest in new software products among researchers and

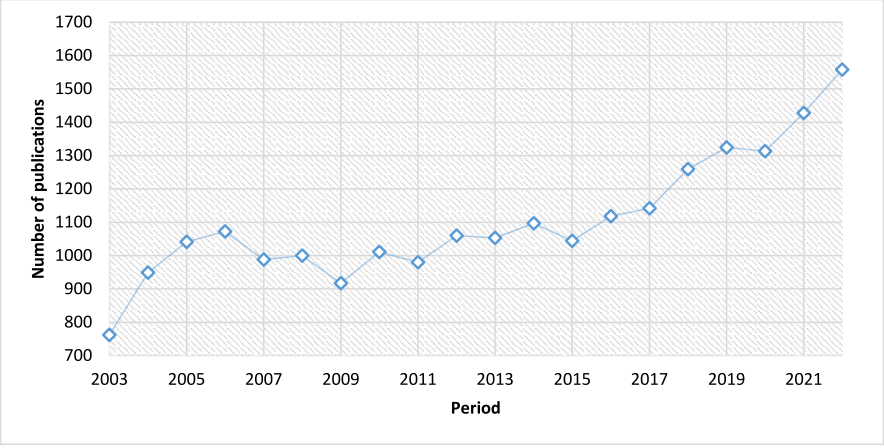

Fig. 2 Increase in the quantity of publications featuring "new software product" keywords in the Scopus database from 2003 to 2022. Source: formed by the author

scholars. From 2003 to 2009, there was a relatively stable period with the number of publications ranging between 762 and 1011. However, from 2010 onwards, there was an increase in the number of publications, with occasional dips in certain years. The steepest increase in the quantity of publications occurred with a significant rise from 1097 in 2014 to 1324 in 2019.

The quantity of publications has shown a gradual increase with some fluctuations. There are fluctuations in the number of publications from year to year, with some years showing higher numbers than others. Notable peaks can be observed in 2018, 2019, 2021, and 2022, where the number of publications reached its highest points. In recent years, from 2019 to 2022, there has been a continuous growth in the number of publications featuring "new software product" keywords, indicating a sustained interest in this area of research. Several factors may explain the rise in publications. Namely, advancements in software development methods, the growing role of software across domains, the rise of open-source software, the spread of software-driven technologies, and more recognition of software as a research area.

Figure 3 presents a map illustrating the geographical representation of publications on the new software product in the Scopus database from 2003 to 2022. The map showcases the distribution of these publications according to their country of origin.

The analysis indicates that the United States has the highest number of publications (4615) related to new software products, followed by China (2412) and Germany (1935). These countries have a significant presence in the software development field and are known for their technological advancements (Fig. 4). In addition to the United States, China, and Germany, other notable countries with

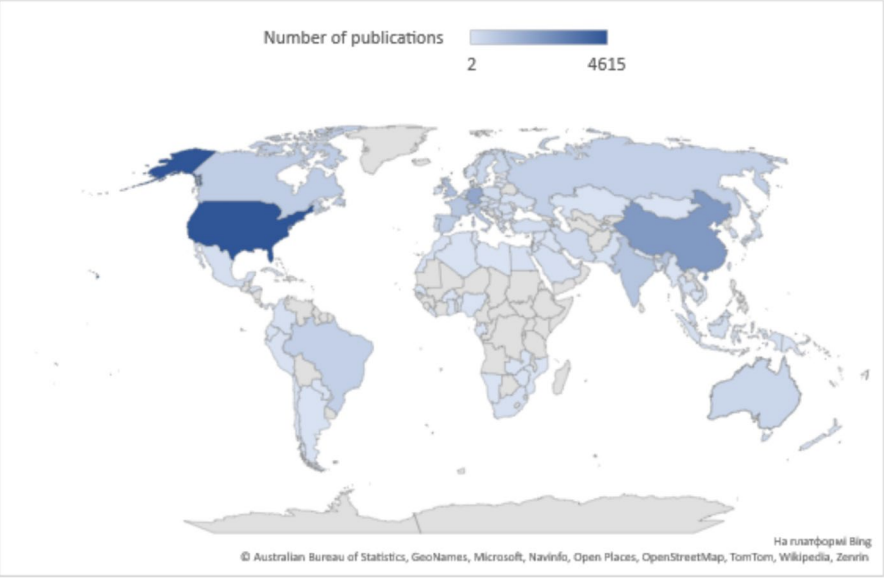

Fig. 3 Mapping publication sources in the Scopus database from 2003–2022 with the keywords "new software product". Source: compiled by the author

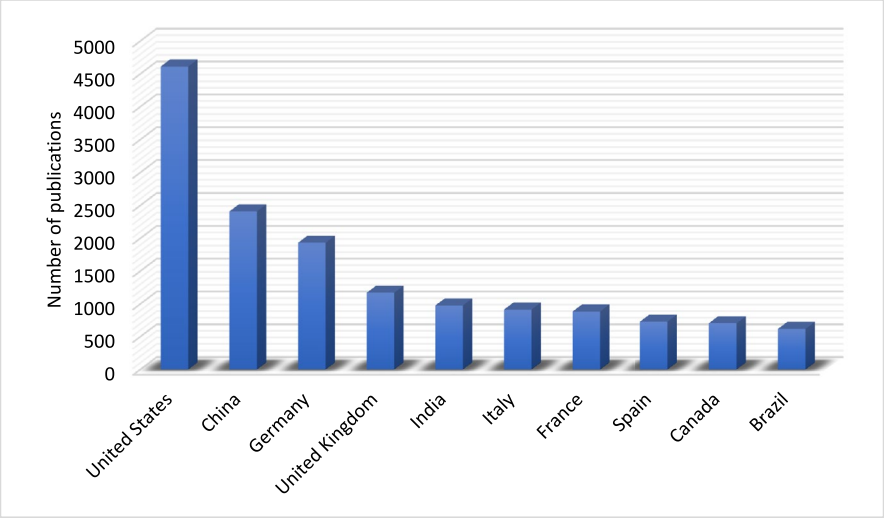

Fig. 4 Leading countries in research publications within the specified field during 2003–2022. Source: formed by the author

a considerable number of publications include the United Kingdom (1173), India (979), and Italy (916). This suggests that software development and new software products are of interest and importance in these regions.

Europe shows a strong presence in terms of the number of publications. This highlights Europe's active involvement in researching and publishing on new software products. In addition to China and India, other countries from the Asia-Pacific region with significant publication numbers include Japan, South Korea, Malaysia, Taiwan, Iran, Singapore, Indonesia, New Zealand, Pakistan, Thailand, and Australia. This indicates a widespread interest and contribution to research on new software products from this region. Brazil and Mexico represent Latin America, while South Africa and Nigeria are the only African countries mentioned. These numbers suggest that more research and publication on new software products are needed from these regions to match the levels seen in other parts of the world. Countries from the Middle East and North Africa include Saudi Arabia, Israel, Egypt, Tunisia, Algeria, and Morocco. While the numbers are relatively lower compared to other regions, it still indicates some level of research activity related to new software products.

United States: The United States stands out as the leading country with a significant number of publications, with 4615 publications during the studied period. The US has traditionally been a powerhouse in scientific research and development, with numerous world-renowned universities, research institutions, and funding opportunities. China follows closely behind the United States. Over the years, China has made significant investments in research and development, leading to substantial growth in scientific output. The country has been focusing on bolstering its research infrastructure, attracting talented researchers, and promoting innovation. Germany ranks third. Known for its strong research culture, Germany has a robust academic

system with a focus on scientific excellence. The country boasts renowned universities, research institutes, and industrial collaborations, contributing to its high publication output. The United Kingdom holds the fourth position. The UK has a rich scientific heritage and is home to prestigious universities and research institutions. Despite its smaller size compared to some other countries on the list, the UK maintains a strong research presence and fosters a collaborative research environment. India demonstrates its research potential by securing the fifth spot with 979 publications. India has been steadily increasing its investment in research and development, particularly in fields such as technology, medicine, and space science. The country's large population and diverse academic institutions contribute to its growing scientific output. Italy appears sixth on the list. Italy has a long history of scientific contributions, particularly in fields such as engineering, physics, and art. The country is renowned for its universities and research centers, attracting scientists from around the world. France occupies the seventh position. France has a strong tradition of scientific research, and its universities and research organizations have made significant contributions to various disciplines. The country promotes scientific collaboration and innovation through funding programs and research grants. Spain ranks eighth. Spain has been making notable progress in scientific research, focusing on areas such as renewable energy, biomedicine, and materials science. The country's universities and research institutions have been actively engaged in research collaborations with international partners. Canada secures the ninth spot. Despite its smaller population, Canada has a strong research ecosystem and invests heavily in scientific research and development. The country's universities and research institutions excel in fields such as natural sciences, engineering, and health sciences. Brazil rounds up the top 10 list. Brazil has been making significant efforts to boost its scientific research output, particularly in areas such as environmental sciences, agriculture, and bioengineering. The country's universities and research institutions have been actively collaborating with international partners to advance knowledge and innovation.

Figure 5 depicts the breakdown of publications containing the keywords "new software product" in the Scopus database from 2003 to 2022, categorized by field of study.

The top two fields with the highest number of publications are Computer Science (9339) and Engineering (9222). This indicates the significant interest and research in the development of new software products within these fields. Along with Computer Science and Engineering, several other STEM (Science, Technology, Engineering, and Mathematics) fields also show considerable publication numbers. These include Mathematics, Materials Science, Physics and Astronomy, Chemical Engineering, Energy, and Chemistry. This suggests that the development of new software products is relevant and impactful across various STEM disciplines. Business and Management: The field of Business, Management, and Accounting demonstrates a significant interest in new software products, likely indicating the growing importance of software applications in business operations and management. Some fields, such as Decision Sciences, Social Sciences, Medicine, Environmental Science, Economics, Econometrics, and Finance, and Earth and Planetary Sciences, show notable publication numbers. This suggests the interdisciplinary nature of software product

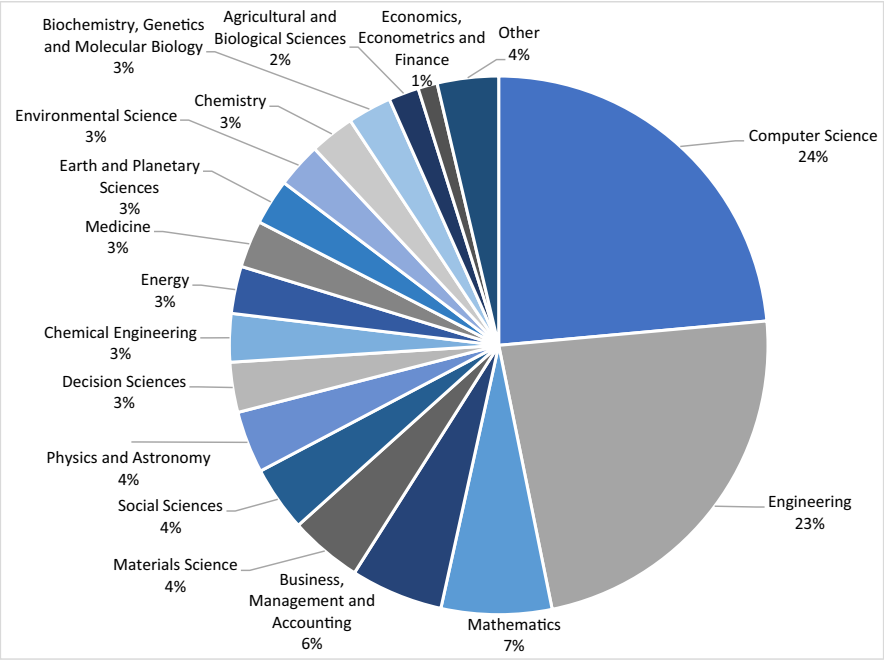

Fig. 5 Distribution of knowledge domains in Scopus publications with the keywords "new software product" from 2003 to 2022. Source: formed by the author

development, with implications in various domains, including healthcare, environmental science, and decision-making processes. The analysis demonstrates that the development of new software products is a widespread research interest across multiple fields of study. The prominence of Computer Science and Engineering indicates their central role in this domain, while other fields also contribute significantly, reflecting the interdisciplinary nature of software product development.

The bibliometric analysis of new software product development highlights a complex network of themes and connections across various keywords, representing the state and evolution of research in this area. The thematic map is organized into clusters, with "quality control" and "computer software" as the dominant clusters (Fig. 6).

The "quality control" cluster focuses on aspects such as computer simulation, automation, algorithms, and artificial intelligence, pointing towards a strong emphasis on ensuring the quality and reliability of software through sophisticated methods. Risk assessment, technology, data handling, and simulation are notable for their high betweenness centrality, indicating their role as pivotal topics that bridge various research areas within this cluster. The high pagerank centrality of keywords like "computer simulation" and "algorithms" underscores their influence and the frequent engagement by the academic community.

The "computer software" cluster dives into the more technical and applied aspects of software development, including software design, engineering, testing,

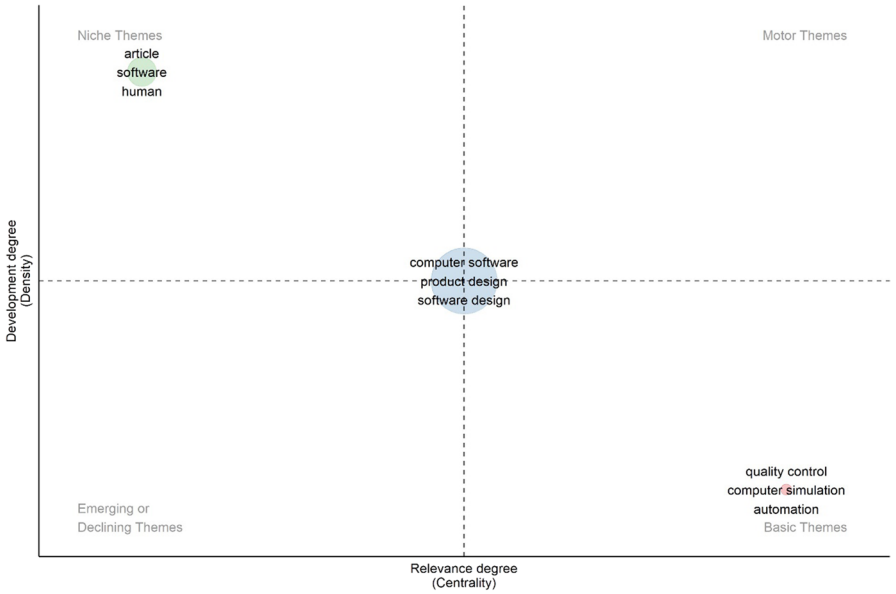

Fig. 6 Thematic map. Source: formed by the author

and the lifecycle of software products. It covers a wide array of subjects from "computer aided design" to "software architecture" and "embedded systems", reflecting the breadth of research and development activities in the software industry. "Product design" and "software engineering" emerge as central themes, highlighted by their pagerank centrality, suggesting a strong focus on these areas within the community. Keywords like "software", "human", and "humans" suggest a focus on the human aspect in software development, emphasizing user-centric design and human-computer interaction. The presence of "priority journal", "computer program", and "controlled study" indicates a strong emphasis on publishing high-quality research and the use of controlled methodologies to validate findings. Across all clusters, the analysis reveals a landscape marked by a focus on quality control, the application of computer science principles in software development, and the importance of considering the human element. The centrality measures highlight the key topics and terms that serve as connectors or significant points of focus within the network, suggesting areas that are currently of high interest or emerging as important fields of study within new software product development.

Meta-analysis on new Software Product Research

A meta-analysis was performed using the publication count in various scientific research fields from 2003 to 2022, and this allowed for the calculation of the penetration index for a new software product focused on microalgae-based processes and products. Figure 7 illustrates the findings from this analysis.

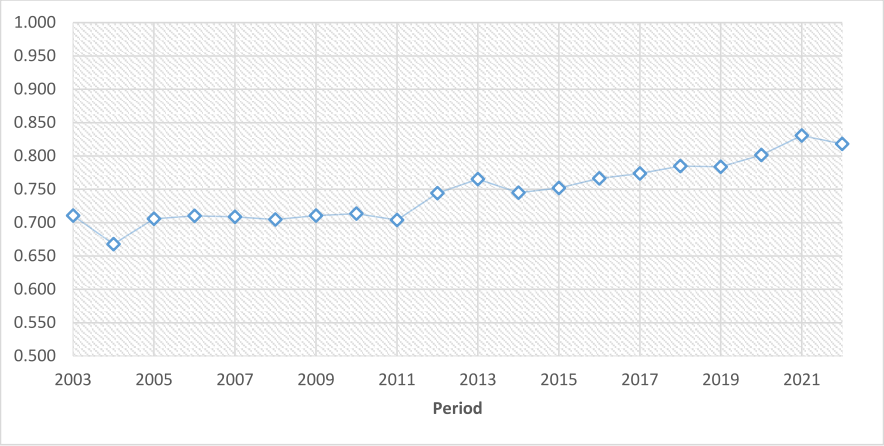

Fig. 7 Penetration index of publications on the new software product across subject areas of scientific research. Source: formed by the author

The penetration index has been generally increasing over the years, indicating a growing presence and influence of the new software product across subject areas of scientific research. From 2003 to 2010, the penetration index shows a relatively stable growth, ranging from 0.710 to 0.714. This suggests a consistent level of adoption and interest in the software product during this period. Starting from 2011, there is a noticeable increase in the penetration index. From 2011 to 2016, the index shows a significant jump from 0.704 to 0.766, indicating a period of accelerated adoption and usage across subject areas. From 2016 to 2021, the penetration index continues to rise steadily, with some minor fluctuations. This period reflects a sustained and increasing presence of the software product in scientific research, with the index reaching 0.831 in 2021. In 2022, there is a slight decrease in the penetration index to 0.818, breaking the trend of continuous growth. This dip may indicate a temporary decrease in publication activity or a shift in research focus, but it's important to consider other factors that may have influenced this change. The analysis suggests a positive trend in the adoption and penetration of the new software product across subject areas of scientific research. The steady growth followed by a period of accelerated adoption indicates the software's increasing importance and utilization in the scientific community. The fluctuations in the index should be further examined to understand any underlying factors contributing to the observed changes.

In order to ascertain the connections between the five most densely populated regions, a correlation analysis was performed, considering the quantity of publications. The findings are displayed as a correlation matrix (Fig. 8).

The highest correlation is observed between Computer Science and Mathematics (0.907), indicating a strong relationship between these two subject areas in terms of publication volumes within the scope of the new software product. The strongest correlation within a subject area is found between Engineering and Materials Science (0.869), suggesting a significant relationship between these two disciplines in terms of publication volumes. For most of the studied subject areas, there is a

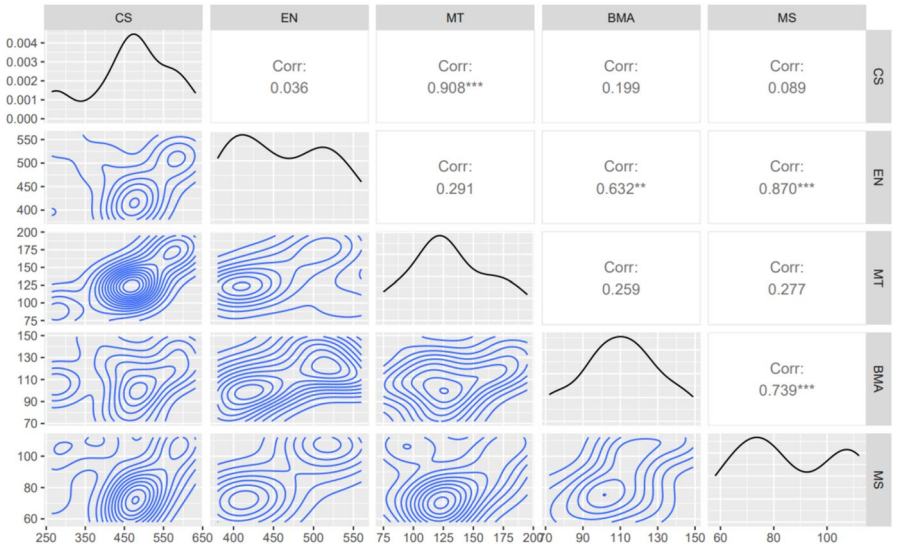

Fig. 8 Correlation matrix of subject areas in relation to publication volumes within the scope of a newl software product. Note: CS - "Computer Science", EN - "Engineering", MT - "Mathematics", BMA - "Business, Management and Accounting", MS - "Materials Science". Source: formed by the author

sufficient correlation level above 0.5, indicating a positive relationship between them in terms of publication volumes. These subject areas include Computer Science, Engineering, Mathematics, and Business, Management, and Accounting. The weakest correlation is observed between Computer Science and Engineering (0.035), indicating a relatively weaker relationship in terms of publication volumes within the scope of the new software product. In order to assess the influence of the growing number of publications in specific subject areas on the adoption rate of a novel software product in scientific research, an analysis was performed. The key metrics of this analysis are outlined in Table 2.

Table 2 Regression analysis metrics for the quantity of publications related to the new software product categorized by subject areas from 2003 to 2022

Subject Area	Coefficients	Standard Error	t Stat	*P*-value	Lower 95%	Upper 95%
Intercept	-190.0528	253.9833	-0.7483	0.4667	-734.7928	354.6872
Engineering	0.8859	0.6169	1.4361	0.1729	-0.4372	2.2089
Mathematics	6.5607	2.0206	3.2469	0.0058	2.2270	10.8944
Business, Management and Accounting	3.6653	1.8292	2.0038	0.0648	-0.2579	7.5884
Social Sciences	5.3498	1.6181	3.3062	0.0052	1.8792	8.8203
Economics, Econometrics and Finance	3.1854	5.0091	0.6359	0.5351	-7.5581	13.9290

Source: formed by the author

Based on the available data, it is not possible to construct an adequate regression model, as the p-values for the "Engineering" and "Business, Management and Accounting" subject areas exceed the permissible value of 0.05, with values of 0.6102 and 0.4678 respectively. This indicates the inadequacy of the obtained model and suggests the need to exclude the identified subject areas from the model. The results obtained after excluding the data for these subject areas are presented in Table 3.

The p-values for all the coefficients are below 0.05, indicating that the coefficients are statistically significant. The coefficient of determination (R-squared) is 0.93. Based on the results of the regression analysis, the following model can be formulated to understand the relationship between subject areas and the publication count in the context of a new software product:

$$VP = 1.76 \cdot \ EN + 7.43 \cdot MT + 5.57 \cdot SS$$

The t-tests indicate that the developed model is applicable, as the t-statistics for all coefficients are greater than the critical t-value ($t_{obs} > t_{crit}$). The Fisher criterion confirms the adequacy of the model, as the F-statistic is greater than the critical F-value ($F_{tabl} < F$). It is worth noting that the coefficient values indicate the strength and direction of the relationship between each subject area and the publication count. The subject areas "Engineering" (EN), "Mathematics" (MT), and "Social Sciences" (SS) all have positive coefficients, suggesting a positive relationship with the publication count. Among them, "Mathematics" has the highest coefficient, indicating the strongest positive influence on the publication count. The intercept term represents the expected publication count when all subject areas have zero influence. The regression analysis suggests that the subject areas of Engineering, Mathematics, and Social Sciences have a significant impact on the publication count in the context of the new software product.

Potential gaps in the Studied Literature

The literature offers a strong foundation. However, it appears there's a need for more in-depth exploration of the changing user expectations and market demands.

Table 3 Outcomes of regression analysis on publication count within different subject areas for 2003–2022 in relation to a new software product

Subject Area	Coefficients	Standard Error	t Stat	*P*-value	Lower 95%	Upper 95%
Intercept	-249.1636	253.4961	-0.9829	0.3403	-786.5513	288.2241
Engineering (EN)	1.7629	0.5531	3.1875	0.0057	0.5904	2.9353
Mathematics (MT)	7.4288	1.5955	4.6560	0.0003	4.0464	10.8112
Social Sciences (SS)	5.5677	1.7973	3.0978	0.0069	1.7576	9.3778

Source: formed by the author

These are quickly influenced by technological progress and societal shifts. New technologies are developed and adopted quickly in the software industry,

challenging research to stay current. This suggests there might be a gap in studies focused on how these technologies affect product development, team dynamics, and product-market fit (Table 4).

The main potential gap identified is the integration of interdisciplinary approaches to software product development. While some publications mention the interdisciplinary nature of the field, incorporating insights from areas such as psychology, sociology, and business could enhance understanding of how software products are developed, adopted, and utilized within various societal and cultural contexts. This could also include exploring the ethical, legal, and social implications of software products, particularly those utilizing artificial intelligence, machine learning, and big data analytics.

The analysis also points to a geographical concentration of research output, with the United States, China, and Germany being the most prolific countries in software product development research. This indicates potential gaps in literature from regions that are underrepresented in research outputs, such as Latin America, Africa, and parts of Asia. Studies from these regions could provide unique perspectives on local market needs, cultural influences on product development, and innovative practices that emerge from different constraints and opportunities. While agile methodologies, user-centered design, and DevOps practices are well-covered in the literature, there is a lack of comprehensive studies that examine the long-term impacts of these practices on product success, team well-being, and organizational culture. Exploring these areas could provide valuable insights into the sustainability of current software development practices and their adaptability to future challenges. While the existing literature on new software product development is extensive and covers a wide range of topics, there are potential gaps that future research could address. These include the integration of emerging technologies, interdisciplinary approaches, geographical diversity in research outputs, long-term impacts of prevalent development practices, and the synthesis of existing research to distill key insights and directions for future studies.

Conclusions

Through bibliometric analysis, this study provides valuable information on the trends, patterns, and impact of research and publications in the field of new software product development. Using the reviewed literature as a basis, it's possible to identify known research areas, influential authors, and new directions. This provides a comprehensive overview of the current state of knowledge in the field of new software product development. The conducted bibliometric analysis can serve as a basis for further research and help researchers and practitioners to identify knowledge gaps and directions for future research.

The paper emphasises the importance of theoretical foundations in the development of new software products. By building on established theories and models such as user-centred design, agile methodologies and DevOps practices, developers and project teams can benefit from a solid foundation of knowledge and best practices. Theoretical input provides a conceptual framework that guides decision making,

Table 4 Exploring gaps in literature on new software product development

Area of focus	Key findings	Identified gaps	Future research directions
Trends in software product development	Steady increase in publications from 2003–2022, highlighting growing interest. The United States, China, and Germany lead in research output.	- Rapid technological advancements outpacing current research, indicating a potential gap in examining the implications of new technologies on development processes and team dynamics. - Limited geographical diversity in research outputs, pointing to underrepresentation of regions such as Latin America, Africa, and parts of Asia.	- Investigate the impact of emerging technologies (AI, ML, IoT) on software product development processes. - Expand research efforts to include more diverse geographical regions to understand local market needs and innovative practices.
Agile and lean methodologies	Agile and lean development methodologies are emphasized for their benefits in flexibility and customer satisfaction.	- Lack of comprehensive studies on the long-term impacts of agile and lean practices on product success, team well-being, and organizational culture.	- Conduct longitudinal studies to examine the sustainability and adaptability of agile and lean practices over time.
User-centered design and DevOps practices	Importance of user involvement and DevOps practices for quality assurance and rapid deployment highlighted.	- Insufficient integration of interdisciplinary approaches in software product development, despite acknowledgments of its interdisciplinary nature.	- Explore interdisciplinary approaches combining psychology, sociology, and business insights with technical development practices. - Examine ethical, legal, and social implications of software products, especially those utilizing AI and ML.
Impact of emerging technologies	Emerging technologies like AI, ML, and IoT offer new opportunities but also pose challenges for software development teams.	- Existing literature may not adequately address the unique challenges and strategies associated with developing software products using emerging technologies.	- Synthesize research specifically examining the challenges and effective strategies for software development in emerging technology domains.

Table 4 (continued)

Area of focus	Key findings	Identified gaps	Future research directions
Software ecosystems and open source	Exploration of the benefits and challenges of leveraging open-source components in software product development.	- The rapidly changing technology landscape and the need for developers to keep pace with the latest technologies, programming languages, and tools.	- Investigate the compatibility and interoperability challenges of integrating new technologies into existing software ecosystems. - Study the dynamics of software ecosystems and the role of open-source communities in fostering innovation.
Software Product Complexity	The complexity of modern software products requires integration with various hardware and software components, posing significant challenges in development.	- The existing literature focuses on traditional software development processes, which may not fully capture the complexities and nuances of working with advanced and complex software systems.	- Conduct studies to explore best practices, frameworks, and approaches for managing complexity in software product development, particularly in high-tech and interconnected domains.
Quality assurance and testing	Quality assurance and testing are critical for ensuring the software product meets quality standards, with best practices including TDD and automated testing frameworks.	- Inadequate testing and quality assurance processes leading to software products with defects and poor user experience. - The need for comprehensive testing strategies and the challenges of allocating sufficient resources in fast-paced development environments.	- Develop and evaluate innovative testing methodologies and tools to improve quality assurance in software product development. - Explore strategies for efficient resource allocation and management in testing and quality assurance activities.

Source: formed by the author

problem solving and the realisation of innovative ideas. It enables software teams to make informed choices and develop software products that meet user needs and market requirements.

The study emphasises the importance of hands-on implementation, iterative processes, and collaboration within cross-functional teams. It also highlights the value of agile methodologies, rapid prototyping, and continuous feedback. These approaches ensure the timely delivery of high-quality software products. By incorporating practical input, software teams can translate theoretical knowledge into tangible results, test assumptions, and improve their solutions based on real-world feedback.

The number of publications dedicated to new software products has steadily increased over the past two decades. This indicates a growing interest in this field among researchers and scholars. The growth rate of these publications has varied. Some years have experienced significant increases, while other year have shown smaller or negative growth. The United States, China, and Germany emerged as the leading countries in terms of the number of publications, highlighting their strong presence in software development and technological advancements. Europe, Asia-Pacific, and select countries from other regions also contributed significantly to the research and publication on new software products. However, there is room for increased research and publication from Latin America, Africa, and the Middle East. The rising number of publications reflects the increasing importance of software development and the recognition of software as a significant research topic.

The meta-analysis conducted across various scientific research fields reveals significant interest in developing new software products, being computer Science and Engineering the most prominent fields. However, other STEM disciplines, such as Mathematics, Materials Science, Physics and Astronomy, Chemical Engineering, Energy, and Chemistry, also contribute significantly to software product development. The interdisciplinary nature of software product development is evident, with implications in domains such as business, decision sciences, social sciences, medicine, environmental science, economics, and earth and planetary sciences. The penetration index of the new software product shows a growing presence and influence across subject areas, with a sustained increase in adoption and usage. The correlation analysis reveals strong relationships between subject areas such as Computer Science and Mathematics, and Engineering and Materials Science. Regression analysis demonstrates the significant impact of Engineering, Mathematics, and Social Sciences on the publication count of the new software product. Overall, the findings highlight the widespread interest and interdisciplinary nature of software product development, with particular emphasis on the role of Computer Science and Engineering in driving advancements in this domain.

The research conducted on the development of new software products provides a comprehensive overview of the subject through bibliometric analysis, theoretical contributions and practical ideas. It emphasises the importance of research and analysis in understanding the current situation in software product development. It emphasises the importance of theoretical frameworks in managing the development process and outlines practical strategies and methodologies to stimulate innovation and create successful software products. By combining theoretical and practical

aspects, software development teams can optimise their processes, create user-centric solutions and remain at the forefront of the rapidly evolving digital age.

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Declarations

Conflict of Interest The authors declare no competing interests.

References

Aldave, A., Vara, J. M., Granada, D., & Marcos, E. (2019). Leveraging creativity in requirements elicitation within agile software development: A systematic literature review. *Journal of Systems and Software*, *157*, 110396.

Almeida, F., Simões, J., & Lopes, S. (2022). Exploring the benefits of combining devops and agile. *Future Internet*, *14*(2), 63.

Appio, F. P., Frattini, F., Petruzzelli, A. M., & Neirotti, P. (2021). Digital transformation and innovation management: A synthesis of existing research and an agenda for future studies. *Journal of Product Innovation Management*, *38*(1), 4–20.

Beecham, S., Clear, T., Lal, R., & Noll, J. (2021). Do scaling agile frameworks address global software development risks? An empirical study. *Journal of Systems and Software*, *171*, 110823.

Berg, V., Birkeland, J., Nguyen-Duc, A., Pappas, I. O., & Jaccheri, L. (2020). Achieving agility and quality in product development-an empirical study of hardware startups. *Journal of Systems and Software*, *167*, 110599.

Bianchi, M., Marzi, G., & Guerini, M. (2020). Agile, stage-gate and their combination: Exploring how they relate to performance in software development. *Journal of Business Research*, *110*, 538–553.

Chiang, H. Y., & Lin, B. M. (2020). A decision model for human resource allocation in project management of software development. *Ieee Access : Practical Innovations, Open Solutions*, *8*, 38073–38081.

Coetzee, S., Ivánová, I., Mitasova, H., & Brovelli, M. A. (2020). Open geospatial software and data: A review of the current state and a perspective into the future. *ISPRS International Journal of Geo-Information*, *9*(2), 90.

Colón-Ramos, D. A., La Riviere, P., Shroff, H., & Oldenbourg, R. (2019). Transforming the development and dissemination of cutting-edge microscopy and computation. *Nature Methods*, *16*(8), 667–669.

Cooper, R. G. (2019). The drivers of success in new-product development. *Industrial Marketing Management*, *76*, 36–47.

Cooper, R. G., & Sommer, A. F. (2018). Agile–stage-gate for manufacturers: Changing the Way New products are developed integrating agile project management methods into a Stage-gate system offers both opportunities and challenges. *Research-Technology Management*, *61*(2), 17–26.

Dennehy, D., Kasraian, L., O'Raghallaigh, P., Conboy, K., Sammon, D., & Lynch, P. (2019). A lean start-up approach for developing minimum viable products in an established company. *Journal of Decision Systems*, *28*(3), 224–232.

Dopp, A. R., Parisi, K. E., Munson, S. A., & Lyon, A. R. (2020). Aligning implementation and user-centered design strategies to enhance the impact of health services: Results from a concept mapping study. *Implementation Science Communications*, *1*(1), 1–13.

Gerke, S., Babic, B., Evgeniou, T., & Cohen, I. G. (2020). The need for a system view to regulate artificial intelligence/machine learning-based software as medical device. *NPJ Digital Medicine*, *3*(1), 53.

Gill, S. S., Tuli, S., Xu, M., Singh, I., Singh, K. V., Lindsay, D., & Garraghan, P. (2019). Transformative effects of IoT, Blockchain and Artificial Intelligence on cloud computing: Evolution, vision, trends and open challenges. *Internet of Things*, *8*, 100118.

Herumurti, D., Bimantara, I. M. S., & Supriana, I. W. (2023). User-centered design-based Approach in Scheduling Management Application Design and Development. *IPTEK The Journal for Technology and Science*, *34*(1), 26–43.

Iqbal, M., & Suzianti, A. (2021). New product development process design for small and medium enterprises: A systematic literature review from the perspective of open innovation. *Journal of Open Innovation: Technology Market and Complexity*, *7*(2), 153.

Issa Mattos, D., Dakkak, A., Bosch, J., & Olsson, H. H. (2023). The HURRIER process for experimentation in business-to-business mission-critical systems. *Journal of Software: Evolution and Process*, 35(5), e2390.

Jansen, B. J., Salminen, J. O., & Jung, S. G. (2020). Data-driven personas for enhanced user understanding: Combining empathy with rationality for better insights to analytics. *Data and Information Management*, *4*(1), 1–17.

Lwakatare, L. E., Kilamo, T., Karvonen, T., Sauvola, T., Heikkilä, V., Itkonen, J., & Lassenius, C. (2019). DevOps in practice: A multiple case study of five companies. *Information and Software Technology*, *114*, 217–230.

Marion, T. J., & Fixson, S. K. (2021). The transformation of the innovation process: How digital tools are changing work, collaboration, and organizations in new product development. *Journal of Product Innovation Management*, *38*(1), 192–215.

Melegati, J., Goldman, A., Kon, F., & Wang, X. (2019). A model of requirements engineering in software startups. *Information and Software Technology*, *109*, 92–107.

Merenda, M., Porcaro, C., & Iero, D. (2020). Edge machine learning for Ai-enabled iot devices: A review. *Sensors (Basel, Switzerland)*, *20*(9), 2533.

Mishra, A., & Otaiwi, Z. (2020). DevOps and software quality: A systematic mapping. *Computer Science Review*, *38*, 100308.

Mugarza, I., Flores, J. L., & Montero, J. L. (2020). Security issues and software updates management in the industrial internet of things (iiot) era. *Sensors (Basel, Switzerland)*, *20*(24), 7160.

Najihi, S., Elhadi, S., Abdelouahid, R. A., & Marzak, A. (2022). Software Testing from an agile and traditional view. *Procedia Computer Science*, *203*, 775–782.

Nica, E., & Stehel, V. (2021). Internet of things sensing networks, artificial intelligence-based decision-making algorithms, and real-time process monitoring in sustainable industry 4.0. *Journal of Self-Governance and Management Economics*, *9*(3), 35–47.

Park, D. Y., Choi, J., Ryu, S., & Kim, M. J. (2022). A user-centered Approach to the application of BIM in Smart Working environments. *Sensors (Basel, Switzerland)*, *22*(8), 2871.

Parthasarathy, S. (2022). A decision framework for software startups to succeed in COVID-19 environment. *Decision Analytics Journal*, *3*, 100037.

Salvato, J. J., & Laplume, A. O. (2020). Agile stage-gate management (ASGM) for physical products. *R&d Management*, *50*(5), 631–647.

Saputri, T. R. D., & Lee, S. W. (2021). Integrated framework for incorporating sustainability design in software engineering life-cycle: An empirical study. *Information and Software Technology*, *129*, 106407.

Shameem, M. (2022). A systematic literature review of challenges factors for implementing DevOps practices in software development organizations: A development and operation teams perspective. *Evolving Software Processes: Trends and Future Directions*, 187–199.

Thota, M. K., Shajin, F. H., & Rajesh, P. (2020). Survey on software defect prediction techniques. *International Journal of Applied Science and Engineering*, *17*(4), 331–344.

Tripathi, N., Oivo, M., Liukkunen, K., & Markkula, J. (2019). Startup ecosystem effect on minimum viable product development in software startups. *Information and Software Technology*, *114*, 77–91.

Wiedemann, A., Forsgren, N., Wiesche, M., Gewald, H., & Krcmar, H. (2019). The DevOps Phenomenon. *ACM Queue*, *17*(2), 40.

Wiedemann, A., Forsgren, N., Wiesche, M., Gewald, H., & Krcmar, H. (2019a). Research for practice: The DevOps phenomenon. *Communications of the ACM*, *62*(8), 44–49.
Zayat, W., & Senvar, O. (2020). Framework study for agile software development via scrum and Kanban. *International Journal of Innovation and Technology Management*, *17*(04), 2030002.
Zonnenshain, A., & Kenett, R. S. (2020). Quality 4.0—the challenging future of quality engineering. *Quality Engineering*, *32*(4), 614–626.
Zorzetti, M., Signoretti, I., Salerno, L., Marczak, S., & Bastos, R. (2022). Improving agile software development using user-centered design and lean startup. *Information and Software Technology*, *141*, 106718.

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