A bibliometric analysis on entrepreneurial digital competencies

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ABSTRACT

In today's fast-paced digital economy, digital competencies are crucial for entrepreneurial success. This study delves into the impact of digital skills on entrepreneurial intentions, emphasizing their integration into business strategies. Through a bibliometric and systematic literature review of over 5,000 Scopus-indexed publications from 2003 to 2023, we examine trends in digital entrepreneurship across different industries. Our findings reveal a strong correlation between digital competencies and entrepreneurial performance, particularly in areas like digital literacy, information management, and social media use. The research highlights the need to strengthen digital skills in education and training programs to boost entrepreneurial potential in SMEs and startups. Using tools such as VOSviewer, this study offers a detailed look at global trends, key contributors, and emerging patterns at the intersection of entrepreneurship and digital technology. These insights are valuable for policymakers, educators, and entrepreneurs aiming to succeed in the digital age.

1. Introduction

Digital competencies for entrepreneurs have become an essential focus in the modern corporate environment, especially since the digital economy evolves swiftly. Digital competences involve a spectrum of abilities and knowledge that empower individuals to proficiently employ digital technologies in their business endeavours.

These competencies not limited to, digital literacy, information management, online marketing, and the ability to leverage social media for business purposes. As the digital landscape becomes increasingly complex, the importance of these competencies cannot be overstated. They serve not only as a foundation for entrepreneurial success but also as a means of fostering innovation and adaptability in a competitive market. The disruptive impact of digital technology on business operations and consumer interactions highlights the importance of digital competences for entrepreneurs. Entrepreneurs must navigate the variety

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of digital tools and channels in today's market in order to reach their target audiences, run their businesses, and stimulate growth.

Research indicates that the integration of digital technologies into entrepreneurial practices is a key determinant of success, as it enables entrepreneur to streamline processes, enhance customer engagement, and ultimately improve their competitive positioning in the market (Kang, 2024; Mulyanto, 2024; Santos et al., 2023). Furthermore, the ability to adapt to digital advancements is increasingly seen as a prerequisite for sustaining business viability in an era marked by rapid technological change (Kholifah et al., 2022; Nikou et al., 2020; Firmansyah et al., 2023). The theoretical frameworks that underpin the study of digital competencies in entrepreneurhip are diverse and multifaceted. One prominent theory is the Theory of Planned Behavior (TPB), which posits that individual intentions to engage in entrepreneurial activities are influenced by attitudes, subjective norms, and perceived behavioral control (Zhou, 2024; Duong et. al, 2024). This theory has been applied to understand how digital competencies shape entrepreneurial intentions, suggesting that individuals with higher levels of digital literacy are more likely to perceive themselves as capable of starting and managing a business in the digital realm (Yanto et al., 2022; Aloulou et al., 2023).

The study of digital competences in entrepreneurship is grounded in several kinds of detailed theoretical frameworks. The Theory of Planned Behaviour (TPB) is a well-known theory that contends that attitudes, personal norms, and perceived behavioural control all have an impact on people's intentions to engage in entrepreneurial activities (Zhou, 2024; Duong et al., 2024). According to this theory, which has been used to analyse how digital competencies influence entrepreneurial intentions, people who are more proficient in technology are more likely to believe they are capable of creating and running digital companies (Yanto et al., 2022; Aloulou et al., 2023). Furthermore, the concept of entrepreneurial self-efficacy, indicating an individual's conviction in their capacity to achieve success in entrepreneurial endeavours, has been associated with digital competencies. This suggests that improved digital proficiencies may boost entrepreneurs' confidence and eagerness to undertake innovative initiatives (Kholifah et al., 2022; Haryanto, 2024).

Moreover, the role of digital competencies in fostering an entrepreneurial mindset is increasingly recognized. Educational institutions and policymakers are emphasizing the need for curricula that integrate digital literacy and entrepreneurhip education, aiming to equip future entrepreneur with the necessary skills to thrive in a digital economy (Patrício, 2023; Farani et al., 2017; Mir et al., 2022). This alignment of educational objectives with industry demands is crucial for preparing individuals to navigate the complexities of digital entrepreneurhip effectively. As such, fostering digital competencies is not merely an individual endeavor but a collective responsibility that involves educational institutions, businesses, and government entities working together to create supportive ecosystems for aspiring entrepreneur (Rohmah, 2023; Cao & Liu, 2023).

In conclusion, digital competencies are essential for entrepreneur seeking to succeed in the modern business environment. The interplay between digital skills, entrepreneurial intentions, and self-efficacy highlights the importance of integrating digital literacy into entrepreneurial education and training programs. As the digital landscape continues to evolve, the ability to harness digital technologies will remain a critical factor in determining entrepreneurial success and innovation.

2.   Literature review

Digital competencies for entrepreneurs are increasingly recognized as essential for navigating the complexities of the modern business landscape. These competencies encompass a broad range of skills, including digital literacy, data management, online marketing, and social media utilization, all of which are crucial for entrepreneurs to successfully integrate digital technologies into their operations (Triyono et al., 2023). The rise of the digital economy has underscored the need for entrepreneurs to develop these competencies to reach target audiences, manage operations efficiently, and sustain growth in competitive

markets (Yaroshenko et al., 2020). The proliferation of digital platforms, the shift to e-commerce, and the importance of big data analytics have transformed entrepreneurial practices, making digital skills a key determinant of success (Fritz et al., 2024). Despite this understanding, gaps remain in the literature regarding how these competencies specifically contribute to entrepreneurial success across various sectors and regions. The study of digital competencies for entrepreneurs is often anchored in several theoretical frameworks, with the Theory of Planned Behavior (TPB) being one of the most prominent. TPB posits that an individual's intention to engage in entrepreneurial activities is influenced by attitudes, subjective norms, and perceived behavioral control (Zainal et al., 2023). In this context, digital competencies align closely with perceived behavioral control, suggesting that entrepreneurs with higher digital competencies are more likely to engage in entrepreneurial activities due to their confidence in managing digital tools (Ajzen, 1991).

Another relevant framework is the Resource-Based View (RBV), which argues that unique resources, including digital skills, provide a competitive advantage by being valuable, rare, and difficult to imitate (Barney, 1991). The Technology-Organization-Environment (TOE) framework further emphasizes the importance of external factors, such as technological advancements and organizational structures, in fostering the adoption of digital tools by entrepreneurs (Tornatzky & Fleischer, 1990). These frameworks collectively highlight the role of digital competencies as both a psychological driver and a strategic resource. The evolution of digital competencies in entrepreneurship has been driven by significant technological advancements, from the early days of internet presence to the current emphasis on e-commerce and data analytics (Andrés et al., 2016). As digital technologies have advanced, so too has the understanding of what constitutes essential digital skills for entrepreneurs. While early studies focused on basic digital literacy, recent research has expanded the definition to include more complex competencies such as online branding, big data analytics, and digital innovation (Cabero & Almenara, 2021). This thematic shift reflects a growing recognition of the importance of digital entrepreneurship as a distinct field, requiring not just technical know-how but also the ability to innovate and adapt to changing technological landscapes (Vakaliuk, 2022). Moreover, entrepreneurial self-efficacy has emerged as a critical concept in this context, with enhanced digital competencies shown to bolster entrepreneurs' confidence in their ability to succeed in digital environments (Satalkina & Steiner, 2020). The intersection of digital skills, self-efficacy, and entrepreneurship has led to a deeper exploration of how these competencies can drive innovation, operational efficiency, and market competitiveness (Sanchez-García et al., 2017).

Despite the growing body of literature on digital competencies for entrepreneurs, several significant gaps remain. One notable gap is the lack of longitudinal studies examining how digital competencies evolve over time and their sustained impact on entrepreneurial success (Briones, 2023). Current research primarily focuses on cross-sectional analyses, leaving unanswered questions about the long-term benefits of digital competencies and how they influence entrepreneurs' ability to adapt to new technologies and market changes. Additionally, much of the existing research is generalized, lacking in-depth exploration of how different types of entrepreneurial ventures—such as those in emerging industries—require specific digital competencies (Vaquero et al., 2020). The role of environmental factors, such as access to digital infrastructure and supportive policies, is also underexplored, particularly in developing regions where digital entrepreneurship faces unique challenges (Melnychuk & Boiarynova, 2023). Furthermore, while the intersection of digital competencies with entrepreneurial self-efficacy has been discussed, there is limited research on how these two constructs interact with other important factors like emotional intelligence and leadership skills (Yu et al., 2023).

Future research should address these gaps by conducting longitudinal studies that track the development of digital competencies over time and their impact on entrepreneurial success across different industries and regions. Exploring how entrepreneurs adapt their digital skills to emerging technologies, such as artificial intelligence and blockchain, will provide valuable insights into the evolving nature of digital entrepreneurship. Additionally, more research is needed to understand the specific digital competencies required for success in sectors such as fintech, e-commerce, and social media-driven ventures. Investigating the intersection of digital competencies with emotional intelligence, leadership, and other soft skills will also contribute to a more comprehensive understanding of what it takes to succeed in today's digital

economy. Finally, educational institutions and policymakers must focus on creating curricula and training programs that not only teach basic digital literacy but also foster innovation, adaptability, and strategic thinking, equipping future entrepreneurs with the tools to thrive in a rapidly changing digital landscape (Guillén-Gámez et al., 2023).

Table 1. Theories related to entrepreneurial digital competencies

Author(s)	Title	Theory	Key Ideas
Amit & Zott (2012)	Creating value through business model innovation	Business Model Innovation Theory	Business model innovation is a key driver of value creation and competitive advantage.
Bandura (1997)	Self-efficacy: The exercise of control	Self-Efficacy Theory	Self-efficacy influences goal setting, effort, perseverance, and resilience, which are crucial for entrepreneurial behavior.
Barney (1991)	Firm resources and sustained competitive advantage	Resource-Based View (RBV)	Valuable, rare, inimitable, and non-substitutable resources lead to sustained competitive advantage.
Brennen & Kreiss (2016)	Digitalization	Digitalization Theory	Digitalization impacts communication, organizational behavior, and the way businesses interact with technology.
Carayannis & Campbell (2012)	Mode 3 knowledge production in quadruple helix innovation systems	Quadruple Helix Innovation System	Collaboration between academia, industry, government, and civil society fosters innovation and knowledge production.
Chesbrough (2010)	Business model innovation: Opportunities and barriers	Business Model Innovation Theory	Business model innovation leverages new technologies to create competitive advantage.
Eisenhardt & Martin (2000)	Dynamic capabilities: What are they?	Dynamic Capabilities Theory	Dynamic capabilities enable firms to reconfigure competencies in response to rapidly changing environments.
Isenberg (2011)	The entrepreneurship ecosystem strategy as a new paradigm for economic policy	Entrepreneurial Ecosystem Theory	Entrepreneurial ecosystems require policies, networks, and cultural factors that support entrepreneurial growth.
Krueger et al. (2000)	Competing models of entrepreneurial intentions	Theory of Planned Behavior (TPB)	TPB-based models effectively predict entrepreneurial intentions and highlight the role of self-efficacy in shaping entrepreneurial behavior.

Author(s)	Title	Theory	Key Ideas
Kraus et al. (2021)	Digital entrepreneurship: A research agenda on new business models for the twenty-first century	Digital Entrepreneurship Theory	Digital entrepreneurship requires new business models that leverage digital technologies for innovation and scalability.
Liñán & Chen (2009)	Development and cross-cultural application of a specific instrument to measure entrepreneurial intentions	Theory of Planned Behavior (TPB)	TPB-based instruments reliably measure entrepreneurial intentions across cultures, supporting the cross-cultural application of entrepreneurial intent.
Markman & Baron (2003)	Person–entrepreneurship fit: Why some people are more successful as entrepreneurs than others	Person–Entrepreneurship Fit Theory	A strong fit between individual traits and entrepreneurial roles enhances success in entrepreneurial ventures.
Mikalef et al. (2020)	Investigating the effects of big data analytics capabilities on firm performance	Dynamic Capabilities & Big Data Analytics	Big data analytics capabilities positively impact firm performance, mediated by dynamic capabilities, enhancing innovation and decision-making.
Nambisan et al. (2019)	The digital transformation of innovation and entrepreneurship	Digital Transformation in Entrepreneurship	Digital transformation reshapes innovation processes and entrepreneurial strategies, offering new opportunities for competitive advantage.

3.   Methods

The study methodology included two main analyses: a statistical assessment of datasets obtained from the Scopus database and a network analysis performed with VOSviewer 1.6.19. This integrated method facilitated an extensive examination of the research domain of digital capabilities in entrepreneurs. We used Scopus, a prominent and extensive database, for the statistical analysis of the study corpus. These encompassed materials categorised by source, year, subject matter, kind, nation, author, affiliation, and funding sponsors.

Furthermore, VOSviewer, a dedicated software, was utilised to do network analysis on the obtained datasets. This instrument facilitated the analysis of co-citations and co-occurrences within the study data. Utilising VOSviewer, we illustrated the relationships and interactions among publications, authors, and research institutions, discerning clusters of connected studies, prominent research trends, and principal contributors in the domain of digital competences for entrepreneurs. This methodology provided significant insights into the knowledge framework and developing trends in the literature.

The combination of statistical analysis from Scopus and network analysis from VOSviewer yielded a thorough and nuanced comprehension of the prevailing research landscape regarding digital competences among entrepreneurs. This methodology provided a precise insight into the progress of the field, research partnerships, and growing areas of interest, facilitating the extraction of significant conclusions and implications from the examined data.

Scopus bibliometric tools and Microsoft Excel were employed for fundamental statistical analysis and the presentation of bibliometric data. VOSviewer was utilised to create and examine networks of diverse entities (e.g., documents, authors, sources, and references) linked by citation, co-citation, co-authorship, or co-occurrence links. The software enabled the construction, visualisation, and exploration of bibliographic maps (van Eck & Waltman, 2010). A science mapping analysis concentrating on digital skills was performed utilising the search strategy flow diagram developed by Zakaria et al. (2020), as illustrated in Figure 1. The principal source of research publications in this study was the Scopus database.

3.1 Primary database

We utilized Scopus, a widely used global database known for its extensive array of scholarly publication encompassing various subjects. Scopus stood out as the most comprehensive database compared to Google Scholar and Web of Science, making it the optimal selection for our analysis.

3.2 Keywords and search criteria

The success of any bibliometric survey depends on selecting the right keywords to find relevant publications. For our study on digital competencies among entrepreneur, we carefully chose fundamental keywords like "digital" and "competencies" combined with "entrepreneur" to identify pertinent literature. We refined our search by considering publication year and stage, focusing on works published between 2003 and 2023 to capture recent, peer-reviewed contributions. Applying these keywords and search criteria resulted in 126 publications on digital competencies among entrepreneur from the Scopus database. With no restrictions on country or language, the publications provide diverse and global perspectives on the subject matter

Table 2. Fundamental keywords and limits

Fundamental Keywords	Publication Year	Publication Stage
Digital AND competencies AND entrepreneur	2003-2024	Final

Source of Table 2: Author's own work using Ms Excel

Thus, the search query utilized for the analysis is as follows:
`TITLE-ABS-KEY (digital AND competencies AND entrepreneur) AND PUBYEAR > 2003 AND PUBYEAR < 2023 AND (LIMIT-TO (PUBSTAGE, "final"))`

3.3 Initial search outcomes

Upon searching the Scopus database using relevant keywords, we found a significant number of publications. These publications were then analyzed based on their languages, providing valuable insights into the distribution of scholarly work across different linguistic domains.

The analysis showed that the majority of publications on digital competencies among entrepreneur are predominantly in the English language, totaling 124 publications. English emerged as the primary medium for disseminating research findings on this topic.
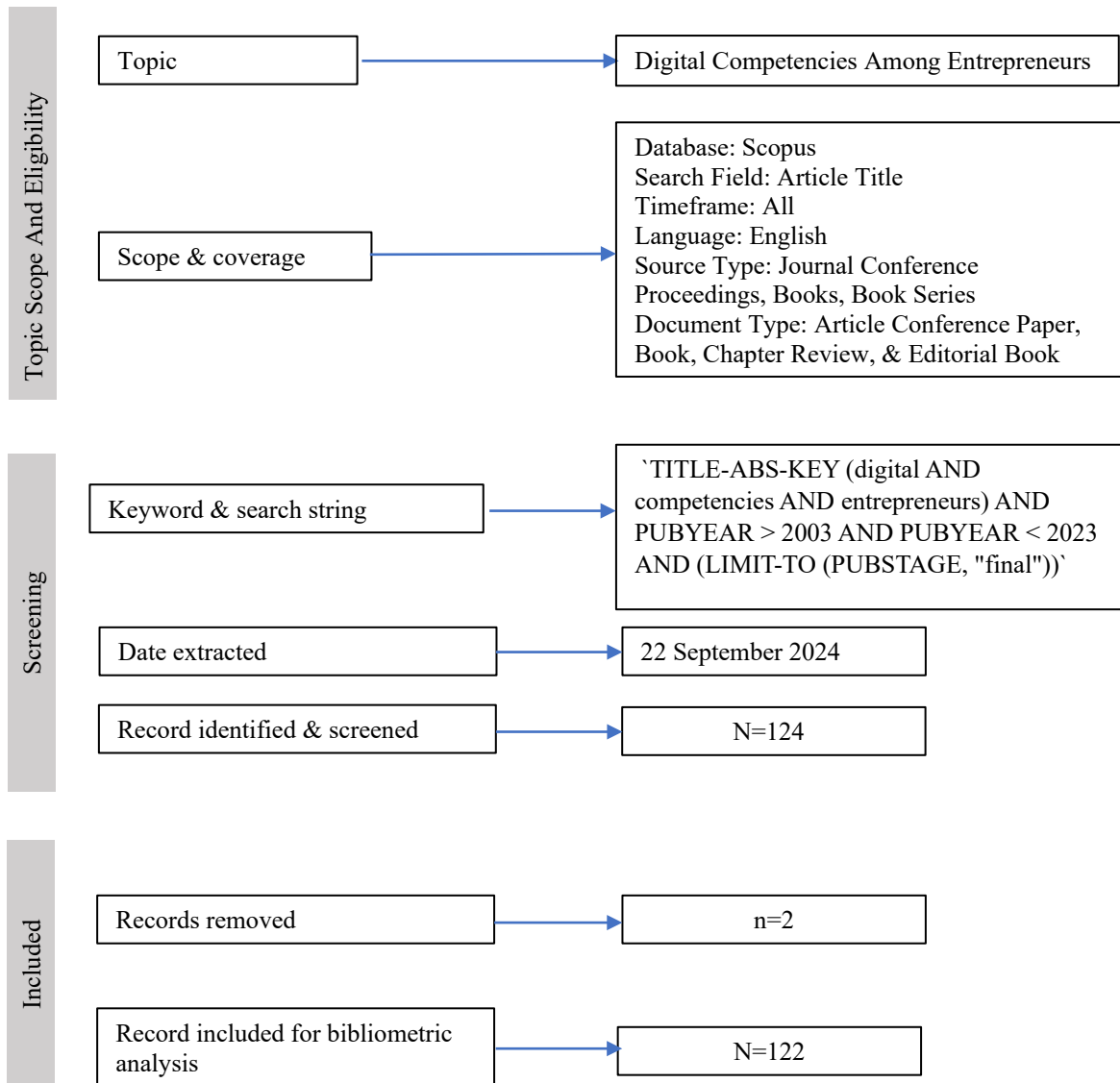
Topic Scope And Eligibility

| Topic | → | Digital Competencies Among Entrepreneurs |

| Scope & coverage | → | Database: Scopus
Search Field: Article Title
Timeframe: All
Language: English
Source Type: Journal Conference Proceedings, Books, Book Series
Document Type: Article Conference Paper, Book, Chapter Review, & Editorial Book |

Screening

| Keyword & search string | → | `TITLE-ABS-KEY (digital AND competencies AND entrepreneurs) AND PUBYEAR > 2003 AND PUBYEAR < 2023 AND (LIMIT-TO (PUBSTAGE, "final"))` |

| Date extracted | → | 22 September 2024 |

| Record identified & screened | → | N=124 |

Included

| Records removed | → | n=2 |

| Record included for bibliometric analysis | → | N=122 |

Fig. 1. Flow Diagram of Search Strategy

Table 3. Top five languages of publication

Language of publication	Publication count
English	117
Spanish	3

According to Table 3, English is by far the dominant language for publications on digital competencies among entrepreneur, with 117 publications. Spanish follows with 3 publications, while Polish, Russian, and Turkish each have 1 publication. This methodology provided an insightful overview of research trends and international collaborations in the field of digital competencies among entrepreneur.

4. Results

The data for this study was derived from a comprehensive search of the Scopus database. After an initial cross-validation and exclusion of non-English publications, the final dataset was analyzed to provide insights into various aspects of entrepreneurial intention research.

4.1 Document and source types

Table 4 shows that 132 publications, representing 51.76% of the total distribution, have been classified as articles. Articles are usually thought of as comprehensive study publications that present unique discoveries, methodologies, and analyses. The availability of articles shows a strong concentration on empirical research and intellectual contributions in understanding the evolution of digital competence among entrepreneurs.

Table 4. Document type

Document Type	Total Publication	Percentages
Article	66	54.1
Conference Paper	36	29.51
Book Chapter	11	9.01
Conference Review	5	4.10
Review	2	1.64
Book	2	1.64

Conference papers, comprising 36 publications (29.51%) are concise, targeted presentations at academic conferences, showcasing the active engagement of scholars in sharing and discussing research findings. Book chapters account for 11 (9.01%) of publications, giving in-depth studies on specialised issues for professionals to analyse SME entrepreneurs' digital competencies in larger context. Reviews represent two publications, or 2.75% of the total. Reviews offer evaluative summaries of existing scholarly works on specific topics. The presence of review articles underscores the need to consolidate and summarize current research in this field, providing a valuable resource for readers to stay up to date with the latest literature (Ketcham & Crawford, 2007).

Book is included on two publications, resulting in 1.64% of the total. Editorials are often opinion pieces written by specialists or editors that provide insights or viewpoints on the current state of research in their field. The low quantity of editorials indicates that opinion-based contributions are less common in this field.Book is included on two publications, resulting in 1.64% of the total. Editorials are often opinion

pieces written by specialists or editors that provide insights or viewpoints on the current state of research in their field. The low quantity of editorials indicates that opinion-based contributions are less common in this field.. Finally, books contribute one publication, or 0.39% of the total. Books, often written by subject matter specialists, provide a comprehensive examination of entrepreneurs' digital competencies from a holistic perspective.

Table 5. Source type

Source Type	Total Publication	Percentages (%)
Journals	67	54.9
Conference Proceedings	27	22.13
Books	19	15.57
Book Series	8	6.56

Source of Table 5: Author's own work using Ms Excel

The data in the table 5 highlights the distribution of publication types in the field of digital competencies among SME entrepreneurs. Journals account for the majority of the publications, with 67 entries, making up 54.9% of the total. This indicates that most of the research is published in peer-reviewed academic journals, reflecting the rigorous nature of the research in this area. Conference proceedings follow with 27 publications, or 22.13% of the total, demonstrating the importance of academic conferences as platforms for scholars to present and discuss their findings. Conferences allow for timely dissemination of research outcomes, which is critical in the rapidly evolving field of digital competencies.

Books represent 19 publications, or 15.57%, indicating that substantial, in-depth analyses of the topic are being explored and documented in book form. This also suggests that scholars are interested in providing comprehensive coverage of digital competencies through long-form writing. Lastly, book series account for 8 publications, or 6.56%, further demonstrating that extended research projects or collaborations spanning multiple volumes are contributing to the scholarly discourse in this area. Overall, the variety of publication types illustrates a well-rounded academic engagement with the topic, with a strong emphasis on journal articles and conference proceedings but also recognizing the value of books and book series for more in-depth and expansive treatments of the subject.

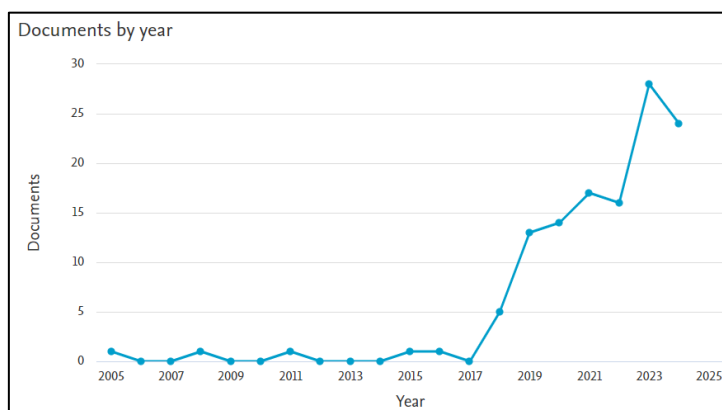### 4.2 Year of publications/evolution of published studies

Fig. 2. Publication trend by years

The distribution of publications over the years reveals significant trends in research on digital competencies among SME entrepreneurs. The data shows a marked increase in publications in recent years, with 2023 leading with 28 publications (22.95%), followed by 2024 with 24 publications (19.67%). This growth underscores the increasing relevance of digital competencies in SMEs as a contemporary research topic. The cumulative percentage further highlights that over 69.66% of the total publications were produced within the last five years (2020–2024). This surge reflects a growing academic and practical interest in how SMEs are adopting digital technologies, likely spurred by the rapid pace of digital transformation and economic shifts. Earlier years, particularly between 2017 and 2014, show limited activity, with no publications in some years, and a gradual resurgence in 2018. This revival signals an increasing focus on the role of digital tools and competencies for SMEs, possibly as digital solutions became more accessible and critical to business success. These patterns suggest a growing interest in understanding how digital transformation impacts SME entrepreneurs, with the majority of this research emerging in recent times.

Table 6. Year of publications

Year	Publications (n)	Percentage (%)
2024	24	19.67
2023	28	22.95
2022	16	13.11
2021	17	13.93
2020	14	11.48
2019	13	10.66
2018	5	4.10
2017	0	0
2016	1	4.5
2015	1	4.5
2014	0	0
2013	0	0
2012	0	0
2011	1	4.5
2010	0	0
2009	0	0
2008	1	4.5
2007	0	0
2006	0	0
2005	1	4.5

4.3 Subject area

Table 7. Subject area

Subject Area	Total Documents	Percentage (%)
Computer Science	49	19.4
Business Management & Accounting	48	19.00
Social Sciences	42	17.4
Engineering	32	12.8
Economics Econometrics Finance	26	10.5
Energy	10	4.3
Environmental Science	10	4.3
Decision Science	6	2.7
Mathematics	6	2.7
Pyschology	5	2.3
Others	12	4.7

According to the data presented Table 7 categorized the research by subject area, revealing the interdisciplinary nature of publications on digital entrepreneurship, education, and transformation. The Computer Science field led with 49 documents (19.4%), reflecting the central role of technology in shaping digital transformation and entrepreneurship. Closely following was Business Management & Accounting, which contributed 48 documents (19.0%), emphasizing the importance of business strategies and management in understanding entrepreneurial development. Social Sciences contributed 42 documents (17.4%), underscoring the exploration of the societal impact of digital transformation and entrepreneurial activities. Engineering was another key field, with 32 documents (12.8%), focusing on the technological aspects of Industry 4.0 and digital innovation in entrepreneurship. Other notable subject areas include Economics, Econometrics, and Finance with 26 documents (10.5%), which highlights the role of financial modeling and economic analysis in entrepreneurship. Both Energy and Environmental Science contributed 10 documents each (4.3%), reflecting a growing interest in the intersection of sustainability and entrepreneurship. Smaller contributions came from Decision Science and Mathematics, each with 6 documents (2.7%), and Psychology with 5 documents (2.3%), suggesting an emerging interest in the cognitive and decision-making processes of entrepreneurs. The remaining 12 documents (4.7%) were categorized as "Other," demonstrating the broad range of disciplines contributing to the study of digital transformation and entrepreneurship. This distribution across various subject areas highlights the multidisciplinary approach required to address the complexities of digital transformation, entrepreneurship, and education in the modern era.

4.4 Most active source titles

Table 8. Most active source titles

Sources Title	Total Publications	Percentage (%)
Lecture Notes In Networks And Systems	8	6.56
Sustainability Switzerland	4	3.28
Technological Forecasting And Social Change	2	1.64

Sources Title	Total Publications	Percentage (%)
Social Enterprise Journal	2	1.64
Reshaping Entrepreneurial Education Within An Industry 4 0 Context	2	1.64
Proceedings Of The European Conference On Innovation And Entrepreneurship	2	1.64
Proceedings Of The European Conference On E Learning	2	1.64
Journal Of Small Business And Enterprise Development	2	1.64
Journal Of Distribution Science	2	1.64
Journal Of Business Research	2	1.64
Iop Conference Series Materials Science And Engineering	2	1.64
International Journal Of Information And Education Technology	2	1.64
International Journal Of Engineering Pedagogy	2	1.64
International Joint Conference On Knowledge Discovery Knowledge Engineering And Knowledge Management Ic3k Proceedings	2	1.64

The data in Table 8 highlights a diverse range of sources for research on digital competencies among SME entrepreneurs, including conference proceedings, journals, and other publications. This variety underscores the interdisciplinary nature of research in this field, with contributions coming from both academic and industry-focused platforms. Lecture Notes in Networks and Systems emerged as the leading source, with 8 publications (6.56%), emphasizing the significant role of conference proceedings in advancing research related to technology, networks, and systems. Sustainability (Switzerland) followed with 4 publications (3.28%), highlighting the increasing focus on sustainability in the context of digital entrepreneurship.

Several other journals and conference proceedings, including Technological Forecasting and Social Change, Social Enterprise Journal, Reshaping Entrepreneurial Education Within an Industry 4.0 Context, Proceedings of the European Conference on Innovation and Entrepreneurship, Proceedings of the European Conference on E-Learning (ECEL), Journal of Small Business and Enterprise Development, Journal of Distribution Science, Journal of Business Research, Iop Conference Series: Materials Science and Engineering, International Journal of Information and Education Technology, International Journal of Engineering Pedagogy, and International Joint Conference on Knowledge Discovery, Knowledge Engineering, and Knowledge Management (IC3K Proceedings), each contributed 2 publications (1.64%). The research explores the multidisciplinary nature of digital transformation's impact on entrepreneurship and education, encompassing technological forecasting, social enterprises, and Industry 4.0 through various journals and conference proceedings.

4.5 Keywords analysis

Table 9. Keywords analysis

Author keyword	Total publication	Percentage (%)
Entrepreneurship	15	12.30
E-learning	14	11.48
Students	13	10.66
Digital Transformation	13	10.66
Entrepreneur	12	9.84
Digital Entrepeneur	11	9.07
Innovation	8	6.56
Digital Economy	8	6.56
Industry 4.0	7	5.74
Education Computing	7	5.74
Education	7	5.74
Competiton	7	5.74
Competencies	7	5.74
Entrepreneurship Education	6	4.92
Digitalization	6	4.92
Digital Technologies	6	4.92
Digital Competencies	6	4.92
Information Use	5	4.10
Higher Education	5	4.10
Digital Literacy	5	4.10

The author keyword visualisation map revealed that the most commonly used author keywords were Digital Transformation, SME Entrepreneurs, Small and Medium Enterprise Information Technology, and SME Entrreneur. Table 9 and Figure 3 show the top keywords in the subject of digital competences among SME entrepreneurs, providing useful information about the research emphasis and areas of interest linked with this topic. The most frequently occurring keyword, "Entrepreneurship," was found in 15 publications, accounting for 12.30% of the total, highlighting its central role in the academic discourse. Closely related keywords include "Entrepreneur" (9.84%) and "Digital Entrepreneur" (9.07%), reflecting an emphasis on both traditional and digital aspects of entrepreneurial activity. The prominence of "Entrepreneurship" demonstrates its importance as a critical topic of study, particularly in the context of digital innovation. "Digital Transformation," present in 10.66% of the publications, underscores the growing scholarly focus on the intersection of entrepreneurship and technology. This is complemented by the keyword "Digitalization" (4.92%), further emphasizing the importance of digital processes in contemporary entrepreneurial research.

Together, these keywords illustrate a clear shift toward understanding how digital tools and practices are reshaping the entrepreneurial landscape. Besides,"E-learning" emerged as a significant area of research, present in 14 publications (11.48%), reflecting a strong interest in the role of technology in education. The keyword "Students" was also prevalent, appearing in 13 publications (10.66%), which suggests that much

of the discourse centers on how students are engaging with entrepreneurship and digital tools. The overlap between these two keywords indicates that a substantial portion of the literature is concerned with educating students in entrepreneurial skills via digital learning platforms. Furthermore, keywords related to competencies and education featured prominently in the analysis. "Competencies," "Education Computing," "Education," and "Entrepreneurship Education" each appeared in 5.74% to 4.92% of the publications, highlighting the significance of education and skills development in both entrepreneurship and digital transformation. The inclusion of "Digital Competencies" (4.92%) and "Digital Literacy" (4.10%) suggests that researchers are increasingly focused on the skills needed to succeed in the digital economy, particularly for entrepreneurs. This aligns with broader discussions on how educational institutions are adapting to prepare individuals for the challenges of a technology-driven business environment. Meanwhile, keywords "Innovation" (6.56%) and "Industry 4.0" (5.74%) demonstrate a focus on the role of technological advancements and innovation in entrepreneurial activities. These themes suggest that the literature is exploring how emerging technologies, including automation and advanced manufacturing processes, are transforming industries and creating new opportunities for entrepreneurs. This trend aligns with the global push toward Industry 4.0, which emphasizes the integration of digital technologies into industrial processes. The "Digital Economy" (6.56%) and "Digital Technologies" (4.92%) also appear frequently in the analysis, indicating that these areas are receiving increasing attention. The digital economy, in particular, is being examined for its impact on entrepreneurship, as technological advancements continue to shape economic landscapes. The frequent mention of "Digital Technologies" suggests an ongoing exploration of how specific tools and platforms are enabling entrepreneurial growth and innovation
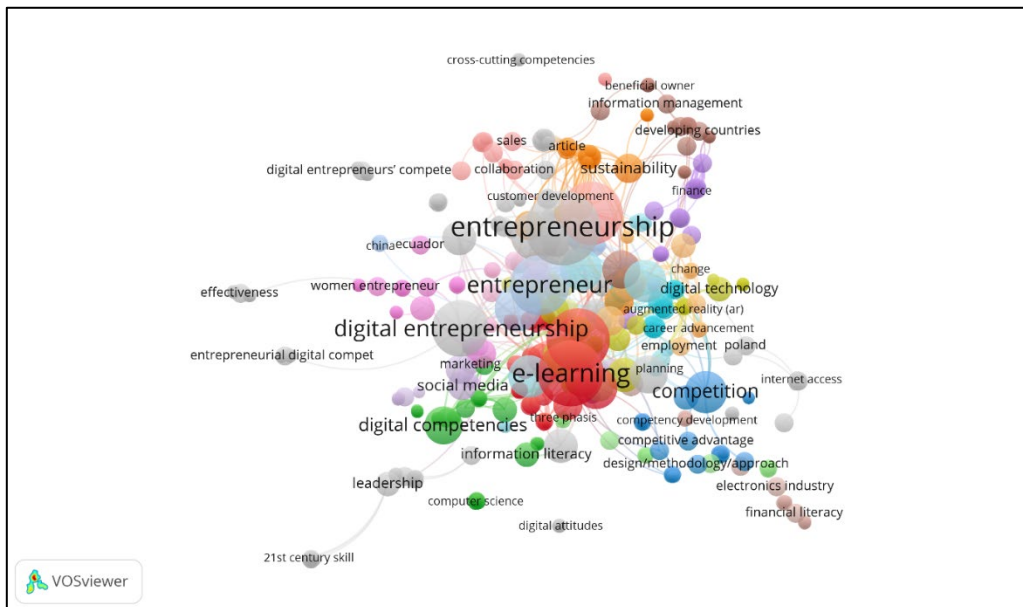

Fig. 3. Keyword analysis.

Overall, the leading keywords reveal a multidisciplinary approach to investigating the digital competencies of SME entrepreneurs, encompassing technology, management, innovation, and economic factors. This list identifies the most significant areas of inquiry and provides directions for future research in this field.

4.6 Geographical distribution of publications - Most influential countries
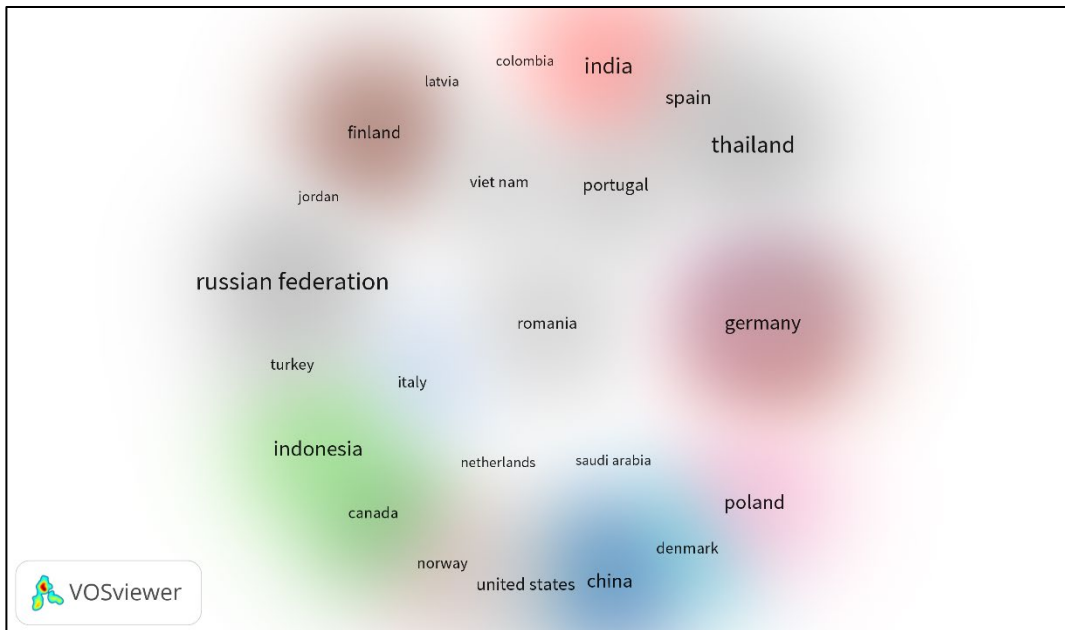

Fig. 4. Geography distribution of publications clustering

Table 10 presents the contribution percentages of the top 14 countries in terms of digital competencies. This data indicates the contributions of various countries to the research on digital competencies. The Russian Federation leads with 11 publications (9.02% of the total), followed by Thailand with 9 publications (7.38%). Indonesia has 8 publications (6.56%). Germany, Malaysia, Poland, and the United Kingdom each have 7 publications (5.74%). China, India, and Spain contribute 6 publications (4.92%), while Finland, Portugal, and the United States each have 5 publications (4.10%). Lastly, Romania has 4 publications (3.28%). Overall, this data provides insight into the geographical distribution of research output in digital competencies, highlighting the leading contributors such as the Russian Federation and Thailand.

Table 10. Top countries contributed to the publications

Country	Total publication	Percentage (%)
Russian Federation	11	9.02
Thailand	9	7.38
Indonesia	8	6.56
Germany	7	5.74
Malaysia	7	5.74
Poland	7	5.74
United Kingdom	7	5.74
China	6	4.92
India	6	4.92
Spain	6	4.92
Finland	5	4.10
Portugal	5	4.10
United States	5	4.10
Romania	4	3.28

4.7 Authorship

Table 11. Authorship list

Author Name	No of Documents	Percentage (%)
Wannapiroon, P.	4	3.28
Duong, C. D.	3	2.46
Thanachawengsakul,N.	3	2.46
Abhari,K.	2	1.64
Do,N.D.	2	1.64
Erdisna	2	1.64
Geisler,S.	2	1.64
Jasiewicz,J.	2	1.64
Kisilowska.M.	2	1.64
Marneros,S.	2	1.64
Mierzecka,A.	2	1.64
Nurhas,I.	2	1.64
Papageorgiou,G.	2	1.64
Pawlokasi,J.	2	1.64
AL-Shboul,M.A	1	0.82
Abaddi,S.	1	0.82

Author Name	No of Documents	Percentage (%)
Abdul Rahman,N.	1	0.82
Abdullah,A.	1	0.82
Ahman,E.	1	0.82
Ahuja,V.	1	0.82
Al-Hassan,F.	1	0.82
Al-Sayed,O.	1	0.82

Table 11 features the 20 most active authors who have published paper in the field of digital competencies. Author productivity refers to the number of papers an author has published within a given period, as defined by Mukherjee (2010). Table 11 illustrates that Wannapiroon, P. is the most prolific author, with four (4) publications, accounting for 3.28% of the total. Following closely are Duong, C. D. and Thanachawengsakul, N., each with three (3) documents, contributing 2.46% each. Other active authors, such as Abhari, K., Do, N.D., and Geisler, S., have published two (2) documents, making up 1.64% each of the total publications.

4.8 Most influential institutions

Table 12: Most influential institutions (minimum 2 publication)

Institution	Total Publication	Percentage (%)
Peter the Great St. Petersburg Polytechnic University	4	3.28
King Mongkut's University of Technology North Bangkok	4	3.28
University of Jyväskylä	4	3.28
National Economics University Hanoi	3	2.46
Chandrakasem Rajabhat University	3	2.46
Universiti Teknologi MARA	2	1.64
NorgesTeknisk-Naturvitenskapelige Universitet	2	1.64
University of Warsaw	2	1.64
San Diego State University	2	1.64
Aalborg University	2	1.64

Table 12 highlights the top institutions associated with publications on digital competencies. These institutions have contributed significantly to the field, with the Peter the Great St. Petersburg Polytechnic University, King Mongkut's University of Technology North Bangkok, and the University of Jyväskylä leading the way, each contributing four (4) publications, representing 3.28% of the total. Following them, National Economics University Hanoi and Chandrakasem Rajabhat University have each contributed three (3) publications, making up 2.46% of the total. Universiti Teknologi MARA, along with several other institutions such as Norges Teknisk-Naturvitenskapelige Universitet, University of Warsaw, San Diego State University, and Aalborg University, have each contributed two (2) publications, representing 1.64% each. Further collaboration across these institutions could enhance the development of comprehensive

research on digital competencies, fostering a deeper understanding of its role in enhancing the capabilities of SME entrepreneurs worldwide.

4.9   Citation analysis

Table 13. Highly cited articles

Authors	Title	Cited by
Núñez-Canal et al. (2022)	New challenges in higher education: A study of the digital competence of educators in Covid times	131
Ngoasong (2017)	Digital entrepreneurship in a resource-scarce context: A focus on entrepreneurial digital competencies	107
Haefner & Sternberg (2020)	Spatial implications of digitization: State of the field and research agenda	63
Zaheer et al. (2019)	Straight from the horse's mouth: Founders' perspectives on achieving 'traction' in digital start-ups	60
García-González & Ramírez-Montoya (2021)	Characterization of the teaching profile within the framework of education 4.0	59
Marković (2008)	Managing the organizational change and culture in the age of globalization	49
Orser & Riding (2018)	The influence of gender on the adoption of technology among entrepreneurs.	41
Xin et al. (2023)	Do international resources configure entrepreneurs sustainable performance in the digital era? Evidence from Pakistan	35
Uzunboylu & Hürsen (2011)	Lifelong learning competence scale (Lllcs): The study of validity and reliability; [Yaşam boyu öğrenme yeterlik ölçeği (yböyö): Geçerlik ve güvenirlik çalişmasi]	33
Bikse et al. (2022)	Consequences and Challenges of the Fourth Industrial Revolution and the Impact on the Development of Employability Skills	19

Table 13 lists the most highly cited publications in the field of digital competencies from 1995 to 2022. The top-cited article, Núñez-Canal et al. (2022), with 131 citations, focuses on the digital competence of educators during the COVID-19 pandemic. Ngoasong (2017) follows with 107 citations, emphasizing digital entrepreneurship in resource-scarce contexts, particularly highlighting the importance of entrepreneurial digital competencies. Other notable works include Haefner and Sternberg (2020) with 63 citations, who explore the spatial implications of digitization, and Zaheer et al. (2019) with 60 citations, offering insights into achieving "traction" in digital start-ups. Furthermore, García-González & Ramírez-Montoya (2021), with 59 citations, delve into the characterization of the teaching profile in the context of Education 4.0, demonstrating the evolving role of educators in the digital age. These highly cited articles provide valuable insights into various facets of digital competencies, ranging from educational challenges during the pandemic to gender influences on technology adoption among SMEs. Such works form the foundation for further research in digital competencies and entrepreneurship.

5. Discussion

In the current digital era, digital competencies among entrepreneurs have become increasingly crucial. The future agenda for digital competencies is increasingly intertwined with the rapid advancements in emerging technologies, particularly artificial intelligence (AI) and blockchain. As these technologies reshape industries and create new entrepreneurial opportunities, it is essential for entrepreneurs to develop a robust set of digital competencies that enable them to leverage these innovations effectively. This discussion explores the implications of AI and blockchain for entrepreneurs, highlighting the necessary digital competencies and the potential impact on various sectors. AI is transforming the entrepreneurial landscape by enabling businesses to automate processes, enhance decision-making, and improve customer engagement.

As noted by Oyeyemi (2024), the integration of AI into business operations requires entrepreneurs to possess a deep understanding of AI technologies and their applications. This includes competencies in data analysis, machine learning, and algorithmic thinking, which are crucial for harnessing AI's potential to drive innovation and efficiency. Furthermore, Polak et al. (2022) emphasize that digital competencies are foundational for AI literacy, suggesting that entrepreneurs must prioritize skill improvement in this area to remain competitive. The ability to interpret AI-generated insights and make data-driven decisions is becoming a critical success factor for startups and established businesses alike. Blockchain technology also presents significant opportunities for entrepreneurs, particularly in enhancing transparency, security, and efficiency in transactions.

Carrasco and Romi (2021) highlight that blockchain can influence market dynamics by providing a decentralized trust system, which is particularly relevant for entrepreneurs operating in contested markets. This necessitates a new set of competencies, including an understanding of blockchain protocols, smart contracts, and decentralized applications. Entrepreneurs must be equipped to navigate the complexities of blockchain technology and its implications for governance and accountability (Allen, 2019). Moreover, as Varriale et al. (2020) suggest, the adoption of blockchain can improve the reputation and profitability of businesses, making it essential for entrepreneurs to integrate blockchain strategies into their business models.

The tourism and hospitality sectors exemplify the pressing need for digital competencies related to AI and blockchain. Carlisle et al. (2023) identify significant digital skills gaps in these industries, particularly concerning AI and robotics. As automation technologies become prevalent, employees will require relevant technical skills to operate and innovate within these frameworks. This highlights the importance of targeted training programs that equip entrepreneurs and their teams with the necessary digital competencies to thrive in a technology-driven environment. Moreover, the intersection of AI and blockchain can create new entrepreneurial avenues. For instance, the combination of AI analytics and blockchain's secure data sharing capabilities can lead to innovative solutions in supply chain management, healthcare, and financial services (Morkunas et al., 2019).

Entrepreneurs who can effectively leverage these technologies will be better positioned to address market needs and capitalize on emerging trends. In conclusion, the future agenda for digital competencies must encompass a comprehensive understanding of AI and blockchain technologies. Entrepreneurs should prioritize the development of skills that enable them to harness these innovations effectively, including data literacy, algorithmic thinking, and knowledge of blockchain applications. As industries continue to evolve, fostering a culture of continuous learning and adaptation will be essential for entrepreneurs seeking to navigate the complexities of the digital landscape and drive sustainable growth.

6.   Conclusion

This bibliometric review provides a comprehensive overview of the evolution of research on entrepreneurial intention over the past century. It highlights key trends, influential works, and emerging themes, offering valuable insights for future research directions.

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Conflict of interest statement

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Authors' contributions

Nor Faiz Azizan conceptualized the central research idea and provided the theoretical framework for the study. He was responsible for data collection, conducting formal analysis, and developing the methodology. In addition, he managed the administration of the entire research project and wrote the original draft of the manuscript. Nor Faiz Azizan also contributed to the review and editing process.

Mohammed Hardy Loh Rahim supervised the research progress, offering guidance throughout the project. He played a crucial role in validating the research findings and conclusions. Furthermore, Mohammed Hardy Loh Rahim reviewed and revised the manuscript, before approving it for submission.