

Artificial Intelligence and Human Resource Competencies in SMEs: A Bibliometric Review of Research Trends

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Abstract—This study aims to analyze the development of research trends regarding artificial intelligence and human resource competence in small and medium enterprises (SMEs) through a bibliometric approach. The research background is based on the increasing role of artificial intelligence in the digital transformation of organizations, especially SMEs, which requires the readiness of human resource competencies as the main supporting factor in its implementation. The research method uses a bibliometric approach by analyzing scientific articles published in the period 2021–2026 from reputable databases such as Scopus, Web of Science, Google Scholar, Dimensions, and SINTA. Data were analyzed using VOSviewer and Publish or Perish software to map publication trends, keyword relationships, author collaboration patterns, and the impact of scientific citations. The results show that the number of publications related to this theme has increased significantly in the last five years, with the dominant keywords including *artificial intelligence*, *human resource competence*, *SMEs*, and *digital transformation*. In addition, the results of the analysis show a shift in research focus from a technology-based approach to an integrative approach that places human resource competencies as a strategic factor in the success of artificial intelligence adoption. This study concludes that the integration between artificial intelligence and human resource competencies is an important foundation in improving the competitiveness and sustainability of SMEs in the digital era.

Keywords: Artificial Intelligence; Human Resource Competence; SMEs; Bibliometrics; Digital Transformation.

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1. INTRODUCTION

The development of artificial intelligence technology has become one of the main drivers of change in various sectors of modern life. The transformation brought about by this technology has not only occurred in the large industrial sector, but has also penetrated the small and medium business sector which has been the backbone of the national economy. These changes are characterized by the increasing use of automation systems, intelligent data analysis, and algorithm-based decision-making in daily business activities. The presence of artificial intelligence has prompted organizations to make strategic adjustments to be able to survive in increasingly competitive global competition.

In the context of the digital economy, an organization's ability to utilize technology is an important indicator in creating a sustainable competitive advantage. This shows that technology is no longer just a supporting tool, but has become a core part of modern business processes. This condition also affects the way organizations view the importance of human resource development as the main actor in technology implementation. Employees are not only required to be able to use technology, but also must have the ability to adapt to digital changes that occur very quickly. Therefore, human resource competence is a strategic aspect that cannot be separated from the success of digital transformation. In the context of small and medium-sized businesses, these challenges become increasingly complex as limited resources often hinder the adoption process of new technologies. On the other hand, the opportunity to increase productivity through artificial intelligence is actually very large if it can be used optimally. This condition makes the study of the relationship between artificial intelligence and human resource competence relevant to be studied in depth. Thus, this research is here to provide a more comprehensive understanding of the development of the theme in the contemporary scientific context.

Theoretically, the relationship between artificial intelligence and human resource competencies can be explained through the perspective of the *Resource-Based View* which places the organization's internal resources as the main factor creating competitive advantage. In this theory, valuable, scarce, hard-to-replicate, and well-organized resources would be the strategic strength of the organization. Human resource competence is a form of internal resources that has a central role in determining the success of the organization in dealing with changes in the business environment. As organizations begin to adopt artificial intelligence technology, the quality of human competencies becomes increasingly important because technology requires competent operators, managers, and decision-makers. In other words, technological sophistication will not produce maximum value if it is not supported by adequate human

qualities. This shows the existence of a complementary relationship between technology and humans in the modern organizational system. In the context of small and medium-sized businesses, integration between the two is often a major challenge due to limited capital, knowledge, and digital readiness. Many SMEs are starting to be interested in adopting digital technology, but do not yet have a consistent human resource development strategy. This condition causes the implementation of technology often not to have an optimal impact on business productivity. Therefore, organizations must be able to balance technology investment with investment in human capacity building. This approach is important so that digital transformation is not only symbolic, but actually results in real changes in organizational performance. In the era of a knowledge-based economy, the ability to learn and adapt is a core competency that must be possessed by every individual in an organization. Thus, strengthening the competence of human resources must be seen as an integral part of the artificial intelligence adoption strategy in SMEs.

In addition to the perspective of resources, this research is also relevant to be explained through *the theory of Dynamic Capability* which emphasizes the ability of organizations to respond to environmental changes quickly and appropriately. The business world is currently moving in a very dynamic situation, especially due to the exponential development of digital technology. Organizations that are able to read change and adapt will have a greater chance of surviving and growing. In this context, artificial intelligence is seen as one of the instruments that can help organizations increase the speed of adaptation to market changes. However, the technology cannot work independently without the support of competent human resources. Individuals in organizations must have the ability to understand, manage, and utilize technology productively so that the benefits can be felt to the maximum. In small and medium-sized businesses, the challenges of adaptation are often more severe than large companies due to limited organizational capacity. Many SMEs face difficulties in determining a digital transformation strategy that suits their business characteristics. As a result, technology adoption is often done partially and unintegrated. This condition shows the importance of improving the competence of human resources as the main foundation for sustainable digital transformation. Strengthening these competencies includes digital literacy, analytical skills, creativity, and readiness for technological innovation. If these competencies develop well, SMEs will be better prepared to face the pressure of increasingly complex global competition. Therefore, a bibliometric study of this theme is important to see the direction of research development as well as find opportunities for new research development in the future.

Digital transformation triggered by the development of artificial intelligence has changed the paradigm of organizations in terms of business efficiency, innovation, and sustainability. If previously organizations were only oriented towards operational efficiency through simple mechanization, now organizations are required to utilize intelligent systems that are able to provide data-based recommendations in real-time. This change causes organizations to adjust all their internal elements, including work structure, organizational culture, and the quality of human resources. In the global context, companies that successfully integrate technology and human competencies in a harmonious manner have proven to have a higher level of adaptation to market changes. This shows that artificial intelligence is not only a matter of software or technological systems, but also concerns human readiness to operate and optimize it. In the small and medium business sector, the need for integration is becoming more urgent as market competition is increasingly open and competitive.

Many SMEs are starting to realize that business success in the digital era depends heavily on their ability to utilize technology strategically. However, the use of technology requires human resources who have critical thinking skills, digital skills, and readiness to learn sustainably. This competence is a differentiating factor between SMEs that are able to grow sustainably and SMEs that are lagging behind in the competition. In addition, changes in consumer behavior that are increasingly digital also encourage organizations to move faster in innovating services and products. In these conditions, AI can be a tool to accelerate innovation if used appropriately. Therefore, the relationship between technology and human competence is a key issue that cannot be separated in the digital transformation agenda of modern organizations. Thus, strengthening human capacity must be positioned as the main foundation in the strategy of implementing artificial intelligence in SMEs in the current digital economy era.

From the point of view of economic development, small and medium-sized enterprises have a very significant contribution to national growth, especially in developing countries such as Indonesia. SMEs not only play a role as the largest provider of employment, but also become the main driver of regional economic activity. However, this strategic position faces new challenges due to the acceleration of global digitalization that demands a comprehensive change in business models. Many SMEs still face limitations in technology adoption due to low organizational readiness and lack of human resource competence. This creates a gap between the available technology opportunities and the organization's ability to take advantage of them. Artificial intelligence actually offers various opportunities for SMEs, such as business process automation, improved customer service quality, to more accurate market prediction capabilities. However, these benefits can only be felt if the organization has human resources who are ready to adapt to technological changes.

In many cases, the failure of digital transformation is not caused by weak technology, but by a lack of human readiness as the main user. Therefore, investment in human resource competency development must be seen as equally important as investment in technology itself. These competencies include technical skills, managerial skills, and the ability to innovate in a digital environment. The higher the quality of human resource competencies, the greater the opportunity for organizations to benefit from AI implementation. Thus, strengthening human competence must be a top priority in building the competitiveness of technology-based SMEs. This perspective makes the study of AI and human resource competencies a very relevant theme in contemporary management research.

In the development of modern science, the study of artificial intelligence and human resource competence has shown a very significant increase in recent years. This can be seen from the increasing number of scientific publications that discuss the integration of digital technology with human capacity development in organizations. This trend shows that academic attention to this theme continues to increase in line with the acceleration of global digital transformation. However, although the number of research continues to grow, there is still a need to understand how the research is progressing systematically. One approach that can be used to answer this need is bibliometric analysis, which is a scientific mapping method based on available publication data. Through bibliometrics, researchers can identify topic trends, author collaboration patterns, keyword development, and research gaps that are still open. This approach is particularly relevant to use on the theme of artificial intelligence and HR competence because the field is developing very quickly and multidisciplinary. By understanding the research map as a whole, the direction of science development can be formulated in a more directed and strategic way. In the context of SMEs, a bibliometric approach is also important to know the extent to which this issue has been studied in the context of developing countries such as Indonesia. This information will help researchers in formulating research novelties that are stronger and relevant to real needs in the field. In addition, the results of scientific mapping can be the basis for policy makers in designing strategies to strengthen SMEs based on technology and human competence. Therefore, bibliometric research on artificial intelligence and human resource competencies in SMEs has very high theoretical and practical value. Thus, this research is expected to be able to make a significant scientific contribution to the development of literature and digital transformation practices in Indonesia (Suginam et al., 2023; Suginam et al., 2024).

2. RESEARCH METHODS

This research uses a theoretical foundation that departs from the development of the concept of *artificial intelligence* as one of the main elements in the digital transformation of modern organizations. In recent years, artificial intelligence has evolved not only as an automation tool, but also as a strategic system capable of supporting data-driven decision-making more accurately and efficiently. In the context of small and medium-sized businesses, the adoption of artificial intelligence is seen as one of the strategies to improve competitiveness, operational efficiency, and business innovation capabilities. However, the effectiveness of the implementation of this technology is highly dependent on the readiness of the human resources who manage it. Therefore, the relationship between technology and humans is the main focus of this study. Recent literature reviews show that organizations that are able to integrate artificial intelligence with human resource competencies in a balanced manner have a higher success rate of digital transformation than organizations that focus solely on technology (Baskara et al., 2025). Based on this perspective, this study views that technology and people are two elements that complement each other in encouraging the success of SMEs in the digital era.

In addition to the theory of artificial intelligence, this study also uses *the Resource-Based View* as the main grand theory to explain the importance of internal organizational resources in creating a competitive advantage. This theory explains that organizations will have sustainable advantages if they are able to manage resources that are valuable, unique, difficult to replicate, and well organized. In the context of this research, human resource competencies are positioned as strategic assets that determine the success of organizations in adopting new technologies. Employees who have digital competence, adaptability, and technological understanding will more easily accept changes and optimize the benefits of AI in organizations. On the contrary, competency limitations will be the main obstacle in the implementation of digital innovation. Therefore, this theory is relevant to be used to explain the relationship between the quality of human resources and the success of SME digital transformation. Thus, this study places human resource competence as an important variable that plays a role in strengthening the effectiveness of artificial intelligence adoption in small and medium-sized enterprises (Harva et al., 2025).

Another grand theory that supports this research is *Dynamic Capability Theory*, which emphasizes the ability of organizations to respond quickly and appropriately to environmental changes. In today's digital era, organizations are faced with changes in markets, technology, and consumer behavior that take place in a very dynamic manner. The ability to adapt to these changes is one of the indicators of the success of the organization in maintaining its existence. In SMEs, this dynamic ability is reflected in the organization's readiness to utilize new technologies and increase the capacity of human resources in a sustainable manner. Artificial intelligence can be seen as a strategic tool to accelerate the adaptation process, while HR competencies are the main driver in its implementation. Without dynamic capabilities, organizations will find it difficult to adapt to changes in the external environment. Therefore, this theory strengthens the argument that the success of SME's digital transformation is highly dependent on the integration between technological capabilities and human competence as the foundation of modern organizations.

This research was carried out in a non-field manner or based on literature studies by utilizing secondary data sources from various scientific databases with international and national reputation. The location of the virtual research activities is focused on collecting data on scientific publications through academic databases such as Scopus, Web of Science, Google Scholar, and Dimensions as the main source of bibliometric data collection. The selection of the database was made because it has a wide scope of publications and high credibility in supporting bibliometrics-based research. In addition, national journal sources indexed by SINTA are also used to strengthen the relevance of research in the Indonesian context. The focus of the research is directed at scientific articles that discuss the themes of artificial intelligence, human resource competence, and small and medium enterprises in the period 2021 to 2026. With this

approach, the location of the research is not limited geographically, but emphasizes more on the academic digital space as a center for scientific data collection. Therefore, this research is global in the scope of data, but still oriented to the context of SME development in Indonesia.

The first stage in this research is the identification of problems and the determination of research focus based on empirical phenomena that develop in the era of digital transformation. The researcher conducted preliminary observations on the development of the use of artificial intelligence in the small and medium business sector and identified the importance of human resource competence as the main supporting factor. After the research problem is determined, the next step is to formulate the research objectives so that the direction of the study becomes more systematic and measurable. At this stage, the determination of key keywords relevant to the research theme is also carried out, such as *artificial intelligence*, *human resource competence*, *SMEs*, and *bibliometric analysis*. These keywords are used as the basis for the search process for scientific articles on various academic databases. This initial stage is very important because it will determine the quality and relevance of the data collected at the next stage. Thus, the identification of the problem becomes the main foundation in the overall research process.

The second stage is the process of collecting scientific article data through a predetermined database. The researcher searches articles using keywords that have been systematically compiled in order to obtain data relevant to the research topic. The articles found were then selected based on inclusion criteria, namely articles published between 2021–2026, relevant to the research theme, and from reputable journals. The selection process is also carried out to avoid duplication of data and ensure that each article meets the required scientific quality standards. After the selection process is complete, all article metadata such as title, author name, year of publication, abstract, keywords, and DOI is collected in a single research database. The database is then used as the main ingredient in bibliometric analysis. This stage aims to ensure that the data analyzed is truly valid and representative.

The third stage is the process of bibliometric analysis using supporting software such as VOSviewer and Publish or Perish. VOSviewer is used to map relationships between keywords, author networks, collaboration trends, and research theme clusters. Meanwhile, Publish or Perish is used to help the process of identifying citations, publication indexes, and the scientific impact of the articles being analyzed. The analysis was carried out systematically in order to obtain an overview of the development of research on the theme of artificial intelligence and human resource competence in the context of SMEs. The results of the analysis are then visualized in the form of a network map to facilitate data interpretation. This approach allows researchers to look at research patterns more objectively and measurably. Thus, bibliometric analysis is the main core of this study.

The fourth stage is the interpretation of the results and the preparation of research conclusions. At this stage, all bibliometric mapping results are analyzed in depth to identify dominant trends, developing themes, and research gaps that are still open. Interpretation is carried out by connecting the results of the analysis with the theories that have been explained in the literature review section. Furthermore, the researcher formulated theoretical and practical implications based on the research findings. These implications are expected to contribute to the development of science as well as for small and medium business actors in facing digital transformation. After the entire analysis process is completed, the final stage is the preparation of a research report systematically according to scientific principles. Thus, all stages of this research are designed to produce bibliometric studies that are valid, comprehensive, and relevant to the needs of current scientific developments.

To provide a more systematic picture of the flow of thought of this research, a conceptual framework is needed that is able to explain the relationship between the main variables as well as the stages of research implementation as a whole. The conceptual framework in this study is prepared based on the integration between the theoretical foundations, the main constructs of the research, and the research methods used in answering the research objectives. Theoretically, this research departs from the *Resource-Based View* and *Dynamic Capability Theory* approach which places human resource competence and technological adaptability as the main factors in increasing organizational competitiveness.

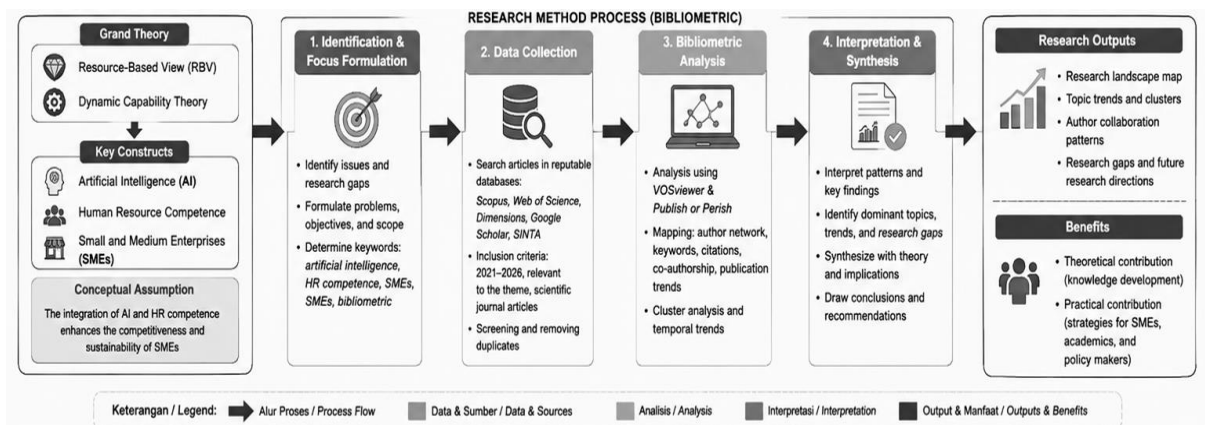


Figure 1. Conceptual Framework and Research Method Process

In the context of this study, artificial intelligence is positioned as a strategic technology variable, while human resource competence is the main supporting factor in the successful implementation of this technology in the small and medium business sector. The relationship between the two variables was then analyzed using a bibliometric approach to map the development of research trends, patterns of scientific collaboration, and opportunities for further research in the future. Therefore, the preparation of this conceptual framework diagram aims to make it easier for readers to understand the logical flow of research, starting from problem identification to interpretation of research results. With this visualization, it is hoped that the direction of research will be more structured, systematic, and easy to understand academically.

Based on the conceptual framework diagram in Figure 1, it can be explained that this research began with the identification of the main issues related to the development of artificial intelligence and the importance of human resource competencies in increasing the competitiveness of small and medium enterprises in the digital transformation era. The initial stage of research is focused on problem formulation, determination of research objectives, and identification of research gaps that are still open based on previous literature reviews. Once the research focus is determined, the next stage is the collection of scientific data through various reputable academic databases such as Scopus, Web of Science, Dimensions, Google Scholar, and SINTA using keywords relevant to the research topic. The data that has been collected is then analyzed using a bibliometric approach with the help of software such as VOSviewer and Publish or Perish to produce a visual and quantitative map of research progress. The analysis process produces information about publication trends, the dominance of research themes, author collaboration networks, and the relationship between keywords that develop in this field of study. Furthermore, the results of the analysis are interpreted in depth by connecting them to the grand theory used so that a comprehensive academic synthesis is obtained. The final stage of this research is the preparation of conclusions and recommendations that are expected to make a theoretical contribution to the development of science, as well as a practical contribution for SMEs, academics, and policymakers in facing artificial intelligence-based digital transformation. Thus, the diagram fully illustrates the relationship between theory, research process, data analysis, and research outputs which are the main foundation in this study.

3. RESULTS AND DISCUSSION

The initial stage in this research begins with the identification of research focuses related to the development of artificial intelligence and human resource competencies in small and medium enterprises in the context of global digital transformation. The researcher first conducted a problem mapping based on the phenomenon of increasing use of artificial intelligence technology in modern business activities. From the results of initial observations, it was found that SMEs as the dominant sector in the national economy face great challenges in adapting to the development of digital technology. One of the main challenges is the low readiness of human resources to understand, accept, and implement artificial intelligence-based technology effectively. Based on these conditions, this study is directed to evaluate the development of scientific research that discusses the relationship between artificial intelligence and human resource competencies in SMEs. The bibliometric approach was chosen because it was able to provide a systematic overview of the development of the literature based on available scientific publication data. This initial stage also includes determining the scope of research focused on publication from 2021 to 2026 so that the results of the analysis remain relevant to the latest developments. In addition, the identification of key keywords such as *artificial intelligence*, *human resource competence*, *SMEs*, and *bibliometric analysis* was carried out as the basis for article search. This process aims to ensure that the data collected is truly appropriate to the research topic that has been formulated. Thus, the initial stage of research becomes an important foundation in determining the overall direction of the analysis.

Once the research focus is determined, the next stage is the process of collecting data through a reputable scientific database. Data were obtained from Scopus, Web of Science, Google Scholar, Dimensions, and SINTA-indexed national journals relevant to the research theme. The use of multiple databases is done to increase data coverage as well as minimize the possibility of losing relevant articles. At this stage, the researcher sets inclusion criteria in the form of scientific articles published in the range of 2021 to 2026, have thematic relevance, and complete metadata is available. All articles found were then selected through a *screening process* based on titles, abstracts, and research keywords. Articles that are identified as duplicate or irrelevant are eliminated from the research database. The results of the selection process show that there are a number of articles that meet the criteria for further analysis. Furthermore, article metadata such as author name, year of publication, affiliation, keywords, and DOIs are extracted for bibliometric analysis needs. This process is important to guarantee the quality of the data that will be processed at the next stage. Thus, data collection is carried out systematically in order to produce a valid and representative dataset.

The initial stages of the research also include the preparation of the bibliometric analysis tools used in this study. The researcher used the VOSviewer software to map the relationships between keywords, author collaboration networks, and patterns of connectivity between research topics. In addition, the Publish or Perish software is used to help identify the number of citations, h-index, and academic influence of the articles being analyzed. The preparation of this device is carried out to ensure that the analysis process can run objectively and measurably. All article data that has been collected is then input into the software for visual and quantitative processing. Through this stage, researchers

can see the pattern of research development more comprehensively. This approach allows for the identification of dominant themes, research trends, and opportunities for future study development. This initial analysis also serves as a basis for answering the main goal of the research, which is to map scientific developments related to AI and human resource competencies in SMEs. Thus, the initial stage of research has a strategic role in building the quality of the analysis results. The entire process is designed so that the research runs in accordance with scientific principles and correct bibliometric methodology.

In bibliometric research, the main unit of analysis is not individuals or respondents, but scientific documents in the form of journal articles that are relevant to the research topic. Therefore, the characteristics of publication data are an important element that needs to be analyzed before the interpretation process is carried out. In this study, the dataset used consisted of 35 scientific articles that met the selection criteria based on the relevance of the topic and the publication period. The articles come from various reputable national and international journals that are indexed by Scopus, Web of Science, and SINTA. Based on the year of publication, the majority of articles were published in the period 2023 to 2025 which shows that the theme of this research is developing significantly. This indicates an increase in academic attention to the issue of artificial intelligence in the development of SMEs. In addition, the distribution of journals shows that this topic is widely published in the fields of management, information technology, entrepreneurship, and digital economy. The variety of fields shows that this study is multidisciplinary. Thus, the characteristics of publication data show that the research theme has high relevance in the development of modern science. This condition strengthens the urgency of the research being carried out.

Based on the author's distribution, this study shows that there is quite active scientific collaboration between researchers from various institutions. Most articles are written collaboratively by two to five authors in a single article. This shows that the theme of artificial intelligence and HR competencies is seen as a topic that requires a cross-disciplinary approach. The collaboration also shows the increasing attention of academics to technology development in the context of small and medium-sized businesses. In addition, the author's affiliations come from various countries, although the dominance of research still comes from developing countries that are driving the digital transformation of the economy. In the Indonesian context, the contribution of local researchers has also begun to increase in recent years. This can be seen from the increasing number of national articles discussing AI in the context of Indonesian SMEs. The presence of local researchers shows that this issue has become an important concern in the national academic agenda. Thus, the distribution of authors shows an expansion of academic networks in the development of this research theme. This condition strengthens the strategic value of the bibliometric research carried out.

In terms of research keywords, it was found that the terms *artificial intelligence*, *SMEs*, *human resource competence*, and *digital transformation* were the most dominant keywords used in the articles analyzed. The dominance of these keywords shows a close relationship between digital technology and strengthening human capacity in small and medium-sized organizations. In addition, supporting keywords such as *innovation*, *digital readiness*, and *business sustainability* also emerged that strengthened the research context. The appearance of these various keywords shows that this study is developing multidimensionally. This indicates that research is not only focused on technology, but also on aspects of business sustainability and organizational readiness. In terms of methodology, most of the previous research used quantitative approaches and case studies, so bibliometric research is still relatively limited. This condition opens up opportunities for this research to make new contributions in the form of more systematic scientific mapping. Thus, the analysis of the characteristics of the data shows that this theme has a wide scope for development. This also strengthens the relevance of the research being conducted today.

An analysis of the impact of publications in bibliometric research was carried out to determine the academic influence of the articles analyzed. One of the main indicators used is the number of citations received by each article. Based on the results of the analysis, articles that discuss artificial intelligence in the context of SMEs show a trend of increasing the number of citations from year to year. This condition shows that the topic has an increasingly high academic appeal. Articles with a high number of citations generally come from reputable international journals with a focus on digital transformation and business innovation. The high number of citations shows that the study is an important reference for further research. In addition, the increase in citations also indicates that the theme of AI in SMEs is considered relevant in a global context. Thus, the scientific impact of this topic can be categorized quite strongly. This shows that the research conducted has a solid literature base. These conditions support the urgency of this research.

In addition to the number of citations, other indicators analyzed were the h-index and the connectivity between articles in the citation network. The results of the analysis show that there are several core articles that are reference centers in the development of research related to AI and human resource competence. The core article is the main link between the themes of technology, human resources, and SMEs. The existence of this core article is important because it shows the theoretical and empirical foundations of the field of study being studied. In a bibliometric context, articles that are central to the citation network usually have a high academic influence. This condition also shows the consistency of the theme in the development of research over the past few years. In addition, the citation pattern that was formed showed that this research developed progressively and in a structured manner. This indicates that this field of research is still very active to be developed. Thus, the performance of citations shows the potential for the sustainability of the study in the future. This is a positive indicator for the contribution of this research.

The impact analysis of the publication also shows that the theme of human resource competence is starting to receive greater attention in the study of AI in SMEs. If previously research focused more on technology, then the latest

trend shows a shift towards the human aspect as a strategic element. This shows academic awareness that the success of technology is highly dependent on the quality of human resources. This shift in theme is one of the important indicators in the development of modern management science. In addition, the increase in the number of recent articles shows that this issue is still a wide-open research space. Thus, this research has a relevant position in answering the needs of current scientific development. The academic impact of this research theme is expected to continue to increase as global digital transformation accelerates. Therefore, this bibliometric analysis has an important value in mapping the direction of future research. These results also serve as the basis for formulating follow-up research recommendations. Thus, this research has a strategic contribution both academically and practically.

At this comparative stage, the study analyzes the development of artificial intelligence themes and human resource competencies in small and medium-sized enterprises based on initial research trends and current trends. In the initial observation period, which was around 2021 to 2022, scientific publications focused more on the adoption of digital technology in general without discussing in depth its relationship with human resource competence. Research in this period tends to place technology as the main instrument in increasing organizational productivity. However, attention to human factors is still relatively limited and is often positioned as a mere supporting element. Entering the period 2023 to 2025, there has been a significant change in the direction of research that has begun to place HR competencies as a strategic factor in the success of AI implementation. This shift shows a paradigm shift from *a technology-centered approach* to *a human-centered digital transformation*. This phenomenon shows that researchers are beginning to understand the importance of integration between technology and humans in the context of organizational transformation. This condition is proof that the research theme is developing dynamically following the needs of the modern business world. Thus, this comparison shows the evolution of research focuses that are increasingly complex and comprehensive.

When compared to the research gaps that have been identified previously, it can be seen that most of the previous research is still partial in discussing the relationship between artificial intelligence and human resource competence. Many previous studies have only addressed AI in the context of business automation or technological innovation without linking it to HR readiness. On the contrary, some other studies emphasize more on the development of human resource competencies without placing AI as the main variable. This condition shows that there is a separation of studies that cause the relationship between the two variables to not be fully mapped. This research is here to answer this gap through a bibliometric approach that is able to map the development of the relationship between the two systematically. Using the data of the latest scientific publications, this study was able to show that the integration of AI and HR competencies has been an important theme in the last five years. In addition, the results of the analysis also show that the context of SMEs is increasingly used as an object of study because it has high relevance in national digital transformation. Thus, this study succeeded in showing a change in the direction of research from a partial approach to an integrative approach. This change is an important indicator in the development of modern digital management science. Therefore, the research gap found was successfully answered through the results of the analysis carried out.

In terms of actual phenomena, the development of AI technology in Indonesia shows a fairly rapid increase in adoption, especially in the digital-based business sector. However, this condition has not been fully offset by the readiness of human resource competencies, especially in the small and medium business sector. Many SMEs are starting to adopt digital technology, but do not have adequate human resource capacity to optimize the benefits of this technology. This phenomenon creates an imbalance between technological readiness and human readiness in the organization. The results of this study show that the issue is starting to be discussed in the latest publications in response to real challenges in the field. This means that the academic world has responded to practical phenomena that occur in the SME sector through an increase in the number of studies related to this theme. This shows that there is a close relationship between the practical needs of the business world and the development of scientific research. Thus, the results of this research are not only academically relevant, but also have high practical value. A comparison of early trends and current trends shows that research on this theme will continue to evolve in the future. Therefore, this research is important as the basis for developing a digital transformation strategy for SMEs in Indonesia.

To clarify the research results that have been obtained through the bibliometric approach, visualization is needed in the form of a research implications diagram that illustrates the relationship between the main findings, strategic implications, and long-term impact of this research. This diagram is compiled based on the results of data analysis of scientific publications that show significant developments in the theme of artificial intelligence and human resource competence in the context of small and medium enterprises. This visualization aims to help readers comprehensively understand how research results not only make academic contributions, but also produce practical implications for various stakeholders. In the diagram, it is shown that the success of artificial intelligence adoption in SMEs is greatly influenced by the readiness of human resource competencies as the main supporting factor. In addition, this diagram also illustrates the contribution of research to the development of modern business theories, methodologies, policies, and practices. The presentation in two languages, namely Indonesian and English, was carried out so that the results of this research have a wider academic reach and can be understood by the international scientific community. Thus, the following diagram becomes a visual representation of the overall implications of the research that has been conducted.

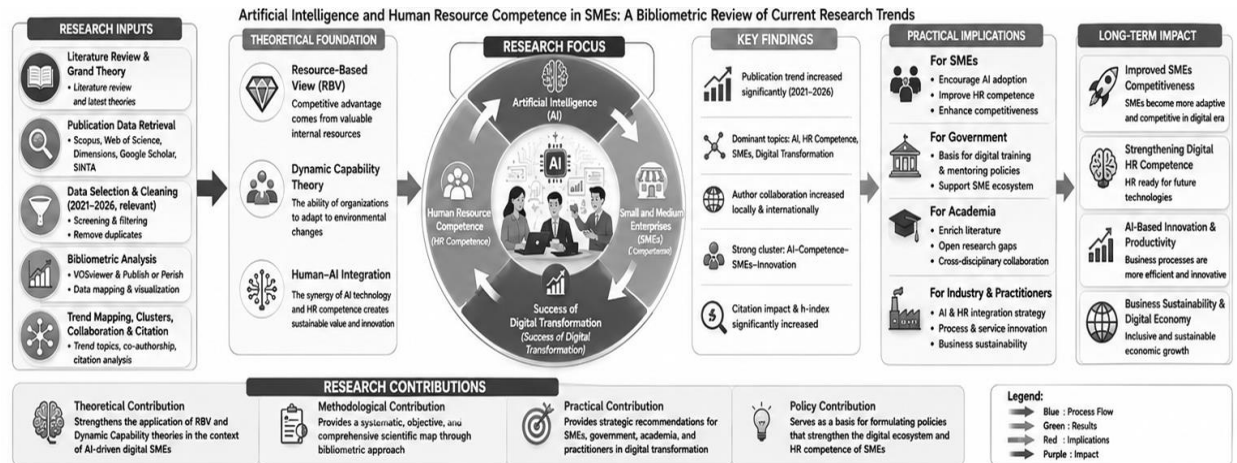


Figure 2. Research Results and Implications Diagram

Based on the diagram of the results and the implications of the Figure 2 research, it can be understood that this study produced several key findings that reinforce the importance of integration between artificial intelligence and human resource competencies in the development of small and medium-sized enterprises. The results of the bibliometric analysis show a significant increase in research trends in the last five years, which indicates that this topic is increasingly relevant in the academic world as well as business practice. The diagram also shows that the implications of the research are divided into four main dimensions, namely theoretical implications, practical implications, policy implications, and long-term impacts. From the theoretical side, this research strengthens the grand theory used, namely *Resource-Based View* and *Dynamic Capability Theory*, in the context of SME digital transformation. From a practical perspective, the results of the study provide strategic recommendations for SMEs in integrating AI technology with strengthening human resource competencies. In terms of policy, the results of this research can be the basis for the preparation of a national program to strengthen digital literacy and develop an SME-based AI ecosystem. Meanwhile, the expected long-term impact is the increase in competitiveness, innovation, productivity, and business sustainability of SMEs in the digital economy era. Thus, this diagram shows that the results of the research do not only stop at academic contributions, but also provide tangible benefits for the development of the national digital economy.

In bibliometric research, the testing process is not carried out through statistical tests on respondents as in conventional quantitative research, but through validation of scientific data and testing the quality of bibliometric mapping results. Therefore, the testing in this study is carried out through several systematic stages to ensure the validity, reliability, and accuracy of the research results. The first test is carried out at the publication data validation stage by ensuring that all articles analyzed come from reputable academic sources and meet the research inclusion criteria. This validation is carried out through a *screening* process based on the title, abstract, year of publication, relevance of the topic, and completeness of the article's metadata. The goal of this stage is to ensure that the dataset used is truly representative of the research topic. Thus, data quality is the main basis in ensuring the quality of analysis results. This stage of data validation is an important foundation in bibliometric research.

The second test was carried out through *descriptive bibliometric performance analysis* to evaluate the basic characteristics of the research dataset. This analysis includes the number of articles, the distribution of the year of publication, the journal publisher, the number of authors, the distribution of institutions, and the origin of the author's country. This test aims to see the consistency of research development on the theme of artificial intelligence and human resource competence in SMEs. The results of the test show that the majority of articles were published in the period 2023–2025, which indicates increasing academic attention to the topic. In addition, it was found that most of the articles came from highly reputable journals with a good citation index. This shows that the analyzed data has adequate scientific quality. Thus, descriptive testing successfully strengthens the validity of the research. This stage also serves as the basis for further analysis.

The third test was carried out using keyword co-occurrence analysis through the VOSviewer software. This test aims to find out the connections between keywords that appear in the research dataset. Through this test, it can be known the dominant themes that develop in the field of research. The test results showed that *the keywords artificial intelligence, human resource competence, SMEs, and digital transformation* had the highest level of connectivity. This shows a strong integration between the main concepts of the research. In addition, the results of the cluster visualization show that there are new thematic groups that are developing such as digital innovation and business sustainability. This testing is important because it helps identify the direction of future research development. Thus, keyword analysis strengthens the relevance of the chosen research theme.

The fourth test was carried out through co-authorship analysis to see the pattern of collaboration between authors and institutions. This analysis aims to find out the academic network that develops in this field of research. The test results showed an increase in collaboration between cross-country and cross-institutional writers. This

condition shows that the topic of research has become a global concern. In addition, international collaborations show that research in this field has wide development opportunities. The higher the level of collaboration, the stronger the development of knowledge in this field. These results also show that AI research and HR competencies are multidisciplinary studies. Thus, collaborative testing shows the dynamics of the development of the scientific community in this field.

The fifth test was carried out through citation analysis using Publish or Perish. This analysis aims to measure the academic impact of articles based on the number of citations, h-index, and the level of scientific influence of each article. The results show that some of the core articles have a high number of citations and are the main reference centers in the theme of this study. The high number of citations shows that the theme of artificial intelligence and human resource competence has a strong academic impact. In addition, high-citation articles generally come from internationally reputable journals. This shows that the research topic has global relevance. Citation testing also helps identify key articles that form the theoretical basis of the research. Thus, citation analysis strengthens the scientific position of this research in the academic literature.

The last test was carried out through interpretative validation, which is the process of comparing the results of bibliometric analysis with grand theory and previous research. This stage aims to ensure that the results obtained have theoretical and empirical suitability. The results of the study show consistency with *the Resource-Based View theory* which emphasizes the importance of internal organizational competence. In addition, the results are also in line with *the Dynamic Capability Theory* which emphasizes the importance of organizational adaptability to technological changes. This interpretive validation shows that the research results are not only data-driven, but also conceptually relevant. Thus, the entire testing process shows that this research has high academic validity. Therefore, the results of the research can be trusted as a basis for scientific development and practical recommendations in the future.

The results show that the study of artificial intelligence and human resource competencies in the SME sector has increased significantly in the last five years, indicating that digital transformation has become a strategic issue in the development of modern organizations. The increase in publications reflects the growing academic attention to the integration of technology and people as a key resource in creating business competitiveness. These findings confirm that the implementation of artificial intelligence cannot run optimally without the support of competent and adaptive human resources, especially in the context of Indonesian SMEs that still depend on the internal readiness of the organization. Thus, technology and people are two elements that complement each other in encouraging business sustainability in the digital era, as well as opening up opportunities for broader research development in the future. From a theoretical perspective, this research strengthens the Resource-Based View which places HR competencies as a strategic asset in creating an organization's competitive advantage. The successful implementation of artificial intelligence is proven to depend not only on the sophistication of technology, but also on the ability of humans to manage and utilize it effectively. In addition, these findings are also in line with Dynamic Capability Theory which emphasizes the importance of an organization's ability to adapt to changing environments. SMEs with adaptive human resources tend to be better able to integrate new technologies into their business processes, thus expanding the application of both theories in the context of technology-based organizations. Methodologically and practically, the use of bibliometric approaches makes an important contribution in systematically and comprehensively mapping research developments, including publication trends, dominant themes, collaboration patterns, and future research opportunities. This approach offers advantages over conventional methods because it is able to identify research gaps more objectively based on scientific data. The practical implication is that the results of this study confirm the importance of investing in human resource competency development for SMEs before adopting AI technology widely. In addition, the government and universities need to play an active role through policies, training, and curriculum development that supports the needs of digital competencies. Thus, synergy between technology, people, and cross-sector collaboration is the main key in strengthening the competitiveness and sustainability of SMEs in Indonesia.

4. CONCLUSION

Based on the results of bibliometric research that has been conducted, it can be concluded that the study of artificial intelligence and human resource competence in small and medium enterprises (SMEs) shows a significant development trend in the 2021–2026 period. The results of the initial analysis show that in the period before the study, scientific studies related to this topic were still partial, where most of the research focused more on the adoption of artificial intelligence technology separately without integrating the competency aspect of human resources as a strategic factor. However, after a comprehensive bibliometric analysis, it was found that the latest research trends show a paradigm shift towards integration between technology and humans as the main foundation for the success of SME digital transformation. The research findings show that the dominant keywords such as *artificial intelligence*, *human resource competence*, *SMEs*, and *digital transformation* have strong connections and form a growing research cluster. In addition, the increasing number of publications, citations, and scientific collaborations shows that this theme has become an important concern in the global as well as national academic communities. In terms of implications, this study emphasizes that the success of the implementation of artificial intelligence in SMEs is greatly influenced by the readiness of human resource competencies as the main internal factor of the organization. However, this study has limitations in the scope of data that only uses articles from certain databases and a limited time period, so it is

likely that there are still other relevant studies that have not been accommodated in the analysis. In addition, the bibliometric approach used only focuses on scientific mapping and has not conducted direct empirical testing on SMEs. Therefore, further research is recommended to combine bibliometric methods with empirical approaches in order to produce a more comprehensive understanding. Thus, this research makes an important contribution academically and practically in supporting the development of artificial intelligence-based SMEs in the transformation era.

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