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From Traditional to Modern: A Bibliometric Analysis of Vocational Education, Collaboration as the Key to Transformation and Quality

[a,b,1] **Hamdan Anwari,** [a,2] **Dwi Sulisworo*,** [a,3] **Bambang Widi Pratolo**

[a] Universitas Ahmad Dahlan, Indonesia
[b] Sekolah Tinggi Pariwisata AMPTA Yogyakarta, Indonesia

Email: [1] 2437082001@ webmail.uad.ac.id, [2] dwi.sulisworo@uad.ac.id*, [3] bambang.pratolo@pbi.uad.ac.id
* Correspondence author

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ABSTRACT

This study aims to analyze the transformation of vocational education from the traditional approach to the modern model through a bibliometric approach. This study maps the development of research related to vocational education in the one past decade, focusing on publication trends, collaboration between authors, and their relevance to the Sustainable Development Goals (SDGs), especially SDG 4 (Quality Education). Data was obtained from 749 studies analyzed using the PRISMA 2020 method and data visualization such as co-authorship, network, overlay, and density. The results show that digital transformation, technology integration, and collaboration between educational institutions, industry, and the government are the main factors in improving the quality of vocational education. The increase in the number of publications and citations reflects the global attention to curriculum innovation and technology-based learning. This research confirms that multidisciplinary collaboration and adaptation to the needs of the job market are essential to produce a highly qualified workforce. The policy implications of these findings show the need to restructure the vocational curriculum to be in line with the challenges of Industry 4.0 and Society 5.0.

Introduction

Vocational education must be transformed with technology so that graduates are ready to face global changes in the economy and job market, in line with technological developments, industrial needs, and the demands of globalization (Li & Fu, 2024). Digital transformation can support the innovation and advancement of higher vocational education by offering more flexible and diverse

learning models and methods, which not only provide information to students as learners but also help them develop deeply as individuals, thereby encouraging the realization of an overall improvement in the quality of education (Nichols et al., 2020; Xu, 2023). From traditional approaches that focus on technical skills to modern systems that integrate digitalization, curriculum innovation, and technology-based learning, vocational education continues to evolve to ensure its relevance in the era of industry 4.0 and society 5.0. Through solid synergy between educational institutions, industry, and the government, school-company cooperation not only optimizes the performance of higher vocational institutions and enriches learning methods, but also creates an educational ecosystem that is adaptive, innovative, and in line with the dynamics of job market needs (Civics, 2024). In addition, the application of digital technology in vocational education has become a key factor in increasing the competitiveness of students' work, where creative and reflective methods can open up space for transformational learning in collaborative settings between schools and companies, while addressing deep-rooted educational and socio-cultural routines, so this collaboration is very important to encourage the effectiveness of the optimal use of digital technology (Wang, 2024; Weijzen et al., 2024a).

In the context of the Sustainable Development Goals (SDGs), especially in the fourth point which emphasizes the importance of quality education for all, the modernization of vocational education is a must. Quality education is recognized as one of the Sustainable Development Goals (SDGs), which, along with other behaviors and attitudes, can impact the development of society in other areas such as health and well-being (Carvalho et al., 2024). Reform of the vocational education curriculum in terms of vocational quality and career development is the key to improving the vocational quality of students. Through clear teaching objectives, diverse teaching strategies, effective implementation, and proper evaluation, the integration of skills and quality can be achieved in order to produce high-quality personnel (Wu et al., 2023). These changes aim to address skills gaps, improve accessibility, and ensure that graduates have competencies relevant to industry developments as well as global workforce needs. According to (V. I. Kovalchuk et al., 2022) In vocational education, digital transformation includes the procurement of modern technology devices and the improvement of the digital capabilities of teachers, so that the training provided can produce a highly qualified workforce efficiently. Therefore, understanding the path of vocational education transformation from a traditional approach to a more modern model is crucial to support the improvement of the overall quality of education.

Vocational education is a form of education that aims to produce a skilled workforce that is ready

to enter the industrial world. Vocational education needs to prioritize improving educator qualifications, developing professional expertise, and strengthening technical materials and facilities, while adapting to the dynamics of the modern job market and encouraging continuous professional learning (V. Kovalchuk et al., 2022) According to (Hollander & Mar, 2009) Vocational education needs to improve knowledge and skills for the world of work, as well as encourage the exchange of experiences and best practices between countries. In the context of globalization and the industrial revolution 4.0, vocational education must be able to adapt to technological changes and the needs of the dynamic job market. With the help of modern technology, vocational education can train students efficiently in terms of cost (Chatterjee et al., 2021). Integrating traditional and digital technologies in vocational education improves the quality of education by complementing each other's abilities and increasing didactic productivity (Vetitnev et al., 2020).

The transformation of vocational education from the traditional model to a modern approach is inseparable from the influence of several main factors that drive significant changes in the learning system. First, technological developments are the main trigger for this transformation. In the era of the Industrial Revolution 4.0 and towards Society 5.0, the integration of technology such as artificial intelligence (AI), Internet of Things (IoT), and big data is a must in the vocational learning process. According to the World Economic Forum (2020), the jobs of the future will depend heavily on digital literacy as well as the ability of individuals to adapt to new technologies. Therefore, vocational education must adopt a curriculum that is relevant to technological developments so that its graduates are ready to face the challenges of the increasingly dynamic world of work.

Second, globalization and the needs of the job market also affect the direction of vocational education transformation. The increasingly complex needs of the global workforce demand vocational education to bridge the skills gap between graduates and industry demands. (Xiong & Chang, 2022) argues that vocational education has a strategic role in increasing a country's economic competitiveness through the provision of a competent, adaptive, and innovative workforce. Thus, vocational education must be designed to produce graduates who are not only technically skilled but also capable of critical, creative, and collaborative thinking.

Third, tripartite partnerships between educational institutions, industry, and the government are an important foundation in creating a vocational education ecosystem that is responsive to changing job market needs. (Itohan Oviawe, 2017) emphasized that this collaboration can ensure synchronization between the educational curriculum and real needs in the world of work. Through these partnerships, apprenticeship programs, industry-based training, and competency

certification can be strengthened so that vocational education graduates have globally recognized qualifications. With a holistic approach that integrates technology, job market needs, and multi-stakeholder collaboration, the transformation of vocational education can create a generation that is ready to face future challenges and contribute to sustainable economic development.

This study uses a bibliometric approach to map the development of studies or research (Zupic & Čater, 2015). In this case, it is about vocational education, its transformation path, and its relevance to quality education. By analyzing thousands of publications in the past decade, the study identifies key research trends, collaborations between authors, as well as the dynamics of academic networks that are developing in this field. Data visualization in the form of co-authorship, network, overlay, and density provides a comprehensive picture of how vocational education has evolved in a global context. For this reason, this research was conducted to review, collaboration patterns, and implications for vocational education policies, as well as their relevance to the achievement of the Sustainable Development Goals (SDGs), especially SDG 4 (Quality Education).

Method

This study adopts the PRISMA 2020 framework not for a systematic review in the conventional sense, but as a methodological guide to enhance the transparency, reproducibility, and rigor of the bibliometric data selection process. Although PRISMA is primarily designed for systematic reviews and meta-analyses (Page et al., 2021), its structured and sequential approach to identifying, screening, and selecting relevant literature offers significant advantages for bibliometric analysis particularly in ensuring that the dataset is comprehensive, traceable, and replicable.

To support this process, the study utilized the Dimensions AI database as the primary source of bibliometric data. The selection of Dimensions AI over more traditional databases such as Scopus or Web of Science was based on several methodological considerations. First, Dimensions AI offers a broader coverage of scholarly outputs, including peer-reviewed articles, policy documents, preprints, and research funded by various international agencies, making it highly suitable for tracking cross-sectoral themes such as vocational education and its links to Sustainable Development Goals (SDGs). Second, its integration of AI-powered search capabilities enables more nuanced keyword exploration and semantic filtering, which is essential for complex topics like collaboration and quality education. Third, Dimensions AI provides open access to data export features, which facilitates transparency and reproducibility in the bibliometric workflow an important principle aligned with PRISMA's emphasis on accountability in evidence selection.

As shown in Figure 1, the study identification process began with a search in the Dimensions AI database using selected keywords related to "Vocational Education," "Collaboration," and "Quality Education" (SDG 4). The initial search yielded 1,124 records. Prior to the formal screening phase, 119 records were removed because they fell outside the designated publication window (2014–2023), thereby focusing the analysis on the most recent decade of scholarly discourse. This left 1,005 records for further evaluation.

In the screening stage, titles and abstracts were reviewed, resulting in the exclusion of 246 records that did not meet the criteria for peer-reviewed scholarly articles (e.g., book chapters, non-indexed sources, or non-English publications). The remaining 759 records were then subjected to a full-text eligibility assessment. During this phase, an additional 10 records were excluded due to insufficient alignment with SDG-related themes—particularly SDG 4: Quality Education—based on keyword presence and thematic focus. Ultimately, 749 publications met all inclusion criteria and were retained for further bibliometric analysis, including co-authorship network mapping, publication trends, and thematic clustering.

The application of the PRISMA protocol in this context provides a robust methodological foundation for bibliometric review, enhancing both the rigor of document selection and the credibility of analytical outcomes. The transparent filtering process visualized in the PRISMA flow diagram (Figure 1) below serves to document each stage of inclusion and exclusion clearly, thereby reinforcing the integrity of the dataset used for the subsequent visualizations and trend analyses:

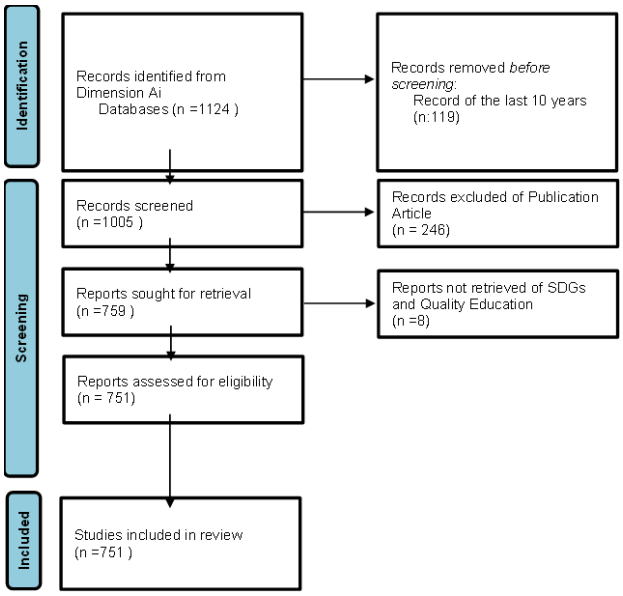

Fig 1: PRISMA 2020 Flow Diagram (Page et al., 2021)

Results and Discussion

Number of Article Publications in Vocational Education in the Field of Quality Education

A search from 2016 to 2025 resulted in 749 scientific article publications. Furthermore, the number of publications on Project Based Learning in the field of quality education per year is presented in Fig 2.

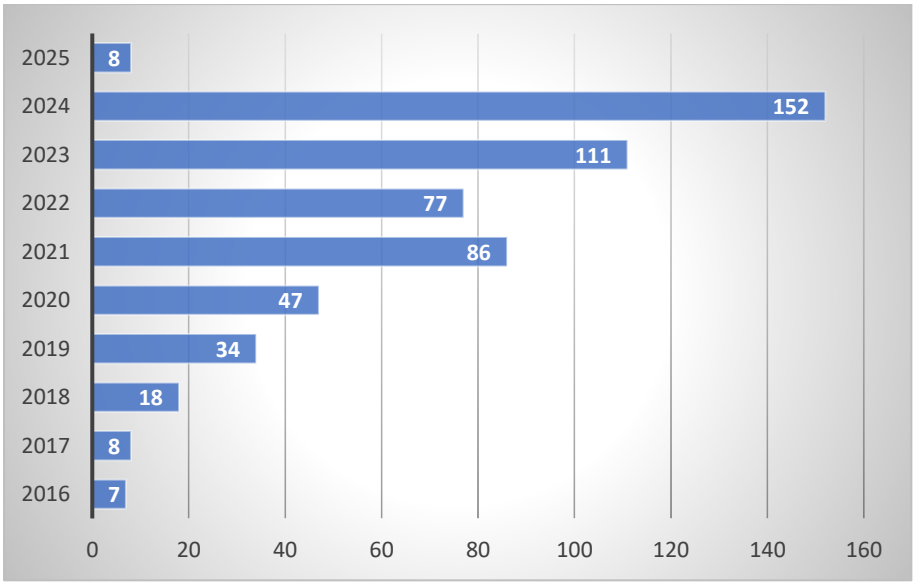

Fig 2: The Trend of Publication in Vocational Education In The Context of Quality Education

The figure 2 shows a significant upward trend in the number of publications related to vocational education from 2016 to 2025. The peak of publications occurred in 2024 with 152 publications, followed by 2023 with 111 publications. This surge indicates increasing attention to the transformation of vocational education, especially in the transition from traditional methods to modern approaches. According to (Pekk et al., 2023) that many studies focusing on the use of technology are conducted to evaluate the management of such institutions. Research and academic attention to collaboration skills have experienced significant growth over the past two decades, showing that this topic is increasingly relevant and receiving a lot of attention from researchers until it reaches its highest point in 2023. The increase in the number of publications in recent years reflects the growing collaboration between educational institutions, industry, and the government in an effort to update the vocational education system. This supports the idea that cross-sector cooperation plays an important role in encouraging innovation and improving the quality of vocational education. The statement explained that the development of vocational education can produce high-quality professional and technical personnel, which ultimately contributes to social

progress and economic growth. In addition, school-enterprise cooperation can develop more innovative workforce training models, thereby improving the skills of professionals and technicians in accordance with industry needs (Sun, 2024). In addition, the increasing number of publications can be interpreted as a sign of increasing awareness of academics and practitioners on the importance of innovation in vocational education. However, the number of publications in 2025 is declining, with only eight publications to date. This may be due to ongoing research or a shift in focus to the implementation of previous research results. Overall, the data shown in the graph reinforces the argument that collaboration is a key factor in the transformation of vocational education. According to (Weijzen et al., 2024) Accepting and understanding the challenges of collaborative learning can be key to creating change and continuous learning. The shift from traditional approaches to more modern methods appears to be supported by the increasing involvement of various parties in research and development in this area.

Trend of the Number of Article Citations in Vocational Education in the Field of Quality Education

The number of citations for the topic of vocational education in the field of quality education from 2016 to 2025 is 1125. Furthermore, the number of citations per year is presented in Fig 3.

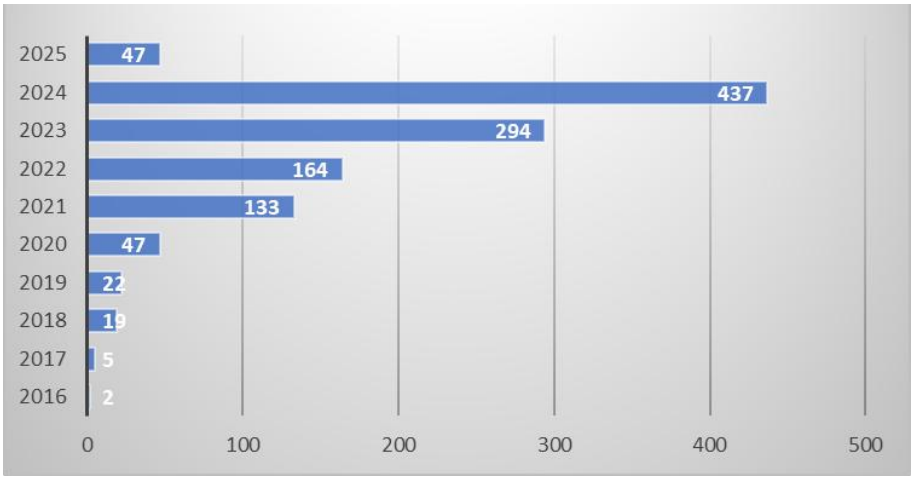

Fig 3: The Trend of Citation in Vocational Education Research In The Context of Quality Education

The graph shows the trend in the number of citations in research related to vocational education from 2016 to 2025. This data reflects the level of influence and relevance of research in the field. The year 2024 recorded the highest number of citations, namely 437 citations, followed by 2023 with 294 citations. This trend shows that research in recent years has been increasingly referenced, signaling an increase in the interest of academics and practitioners in the transformation of

vocational education. According to (Thamizhiniyan et al., 2022) that vocational education research is a distinctive field of education and is related to how the transition process from school to the world of work is formed or directed so that vocational education research is quite in high demand. In addition, a review of publications and research fields on vocational education can be found that research in higher vocational education has a wide scope, including social sciences, computer science, and engineering (Abdullah, 2021). The increase in the number of citations in recent years can also be interpreted as the impact of the increasingly strong collaboration in the development of vocational education (Weijzen et al., 2024b). As publications increase, more and more research is being referenced in subsequent studies, reinforcing the idea that cooperation between academia, industry, and government is a key factor in the shift from traditional systems to more modern methods. However, the number of citations in 2025 is still relatively low, at 47 citations, which is likely due to the time that is still too short for new studies to have a significant impact. On the other hand, the low citation trend in the years before 2021 shows that research related to the transformation of vocational education is still not a major concern in that period. Overall, this graph supports the argument that the transition of vocational education from traditional to modern approaches is increasingly recognized and strengthened through academic references. The increase in citations reflects the increasing influence of research in this field, which can be the basis for the development of more innovative and quality vocational education policies and practices.

Field of Quality Education

Based on the field of research, publications on the topic of vocational education in quality education can be grouped. Furthermore, the number of publications based on the field of quality education (751) is presented in Fig 4.

Fig 4: The Number of Publications on The Topic of Vocational Education in 1 Decade Reviewed From the Field of Sustainable Development Goals Source: (https://app.dimensions.ai/)

The figure 4 sourced from the Dimensions.ai database illustrates the distribution of publications across Sustainable Development Goals (SDGs) categories in the field of "vocational education" and "transformation" from 2016 to 2025. The analysis reveals that SDG 4: Quality Education overwhelmingly dominates the research focus, with 751 publications, indicating that the paradigm shift in modern vocational education remains firmly rooted in efforts to enhance educational quality. This aligns with the urgent need to align vocational education with global quality standards in response to the challenges posed by Industry 4.0 and Society 5.0.

The bibliometric visualization in figure 5 illustrates the co-authorship network among researchers in the field of vocational education, particularly in relation to Sustainable Development Goal (SDG) 4: Quality Education. This map, generated using VOSviewer, groups researchers into clusters based on thematic proximity and collaborative linkages. Each color represents a distinct cluster, and to avoid speculative interpretation, the following analysis is grounded in a critical examination of the thematic focus and publication history of the key researchers within each group. The red cluster is primarily composed of researchers such as Probst, Andreas; Pachatz, Wolfgang; and Bernsteiner, Reinhard C, who have extensively explored competence-based approaches in vocational education systems. Their work centers on curriculum development responsive to labor market needs, validation of work-based learning, and formal and informal skill certification mechanisms. Much of this research draws from the Central European context, particularly Austria and Germany, where dual vocational training systems are widely implemented. The blue cluster is thematically oriented toward technological innovation and digital learning within vocational education. Researchers like Loukatos, Dimitrios and Kondoyanni, Maria focus on project-based learning models supported by digital platforms, online delivery systems, and flexible instructional design aimed at addressing the demands of Industry 4.0. Their studies reflect a growing trend in leveraging ICT to enhance vocational training methodologies. The green cluster highlights the importance of collaboration between vocational education institutions and industry stakeholders. Central figures such as Ozer, Mahmut and Filandysheva, Larisa Borisovna emphasize the integration of industry input into curriculum planning and delivery. Research in this group focuses on strategic partnerships, internship programs, and experiential learning environments designed to align educational outcomes with labor market expectations. The yellow cluster, led by scholars such as Cattaneo, Alberto Alfredo Paol and Marhuenda-Fluixá, Fernando, emphasizes contextual and reflective learning approaches. Their publications frequently address the effectiveness of work-based learning (WBL), knowledge transfer, and the development of reflective pedagogies that

support the formation of sustainable cognitive and social competencies within vocational education settings. Meanwhile, the purple cluster, which includes researchers such as Sánchez-Prieto, Jesús and Pleshakova, Anastasia, is concerned with multilingual education and intercultural communication in vocational contexts. This body of work explores the integration of foreign language instruction particularly English for Specific Purposes (ESP) into vocational curricula across fields such as hospitality, healthcare, and engineering, in response to the demands of an increasingly globalized labor market.

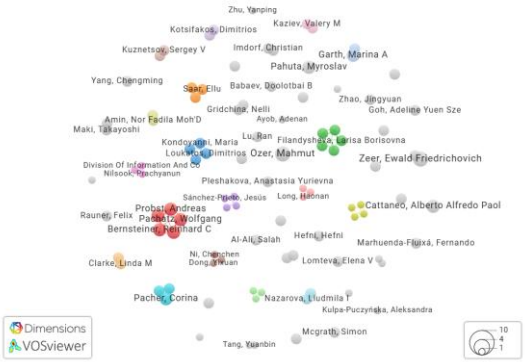

Fig 5: Researcher visualization of vocational education in the field of quality education

Co-authorship Visualization

VOSviewer shows network visualization for co-authorship. Next, the network visualization for co-authorship is presented in Fig 6.

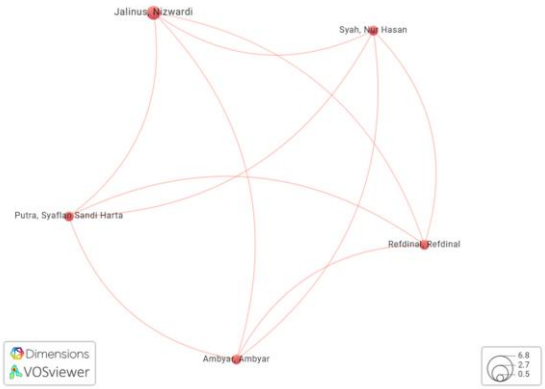

Fig 6: Co-authorship visualization of vocational education in the field of quality education

The image of Co-authorship Visualization shows a network of collaboration between researchers in the field of vocational education. In this visualization, it can be seen that Jalinus Nizwardi has a broader relationship compared to other researchers, showing a central role in research collaboration. Syah Nur Hasan, Reffinal Reffinal, Ambyar Ambyar, and Putra Syaflan Sandi

Harta also have a connection, albeit with a lower intensity. The relationship with SDGs and Quality Education in Vocational Education is the importance of collaboration in the development of vocational education. SDG 4 (Quality Education) emphasizes the importance of research and innovation in education. According to (Olubiyi, 2024) emphasized that quality education in SGDs is based on innovation so that vocational education does not stop at efforts that are still carried out traditionally. Furthermore, with collaboration between researchers, vocational education can develop through the exchange of ideas and the dissemination of best practices.

This collaboration also opens up opportunities for a multidisciplinary approach in vocational education, such as the integration of digital technology, education policy, and relationships with industry. High quality of vocational education requires collaboration between various disciplines or sectors so that it has benefits such as expanding the type of cooperation, clarifying authority and responsibilities and improving the integration of education coordination (Zheng, 2024). With this collaborative mapping, vocational education policies can be based on more evidence-based research. Vocational education institutions can use this data to encourage more collaboration between academics, industry practitioners, and policymakers to improve the relevance of curricula to the needs of a more relevant and integrated job market (Ubihatun et al., 2024). Overall, this visualization shows the importance of cooperation in building a quality and sustainable vocational education system. To support SDG 4, there needs to be a strategy to strengthen academic collaboration that involves more actors in the field of vocational education.

Network Visualization

VOSviewer provides network visualization maps. Next, the network visualization for co-occurrence is presented in Fig 7.

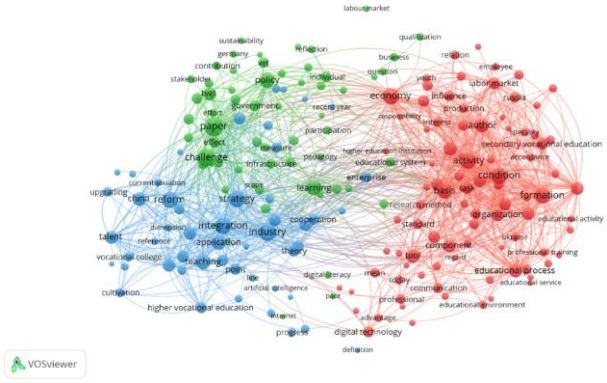

Fig 7: Network Visualization in The Topic of Vocational Education In SDGs
Source: VOSviewer

The network visualization produced using VOSviewer illustrates the interconnection of various concepts in vocational education research. This visual is divided into several main clusters that reflect the big theme in the development of vocational education. The blue cluster highlights the role of modernization and technology in vocational education. Keywords such as teaching, integration, application, industry, artificial intelligence, and digital literacy show that technology integration is a key element in improving the quality of vocational learning. One way that is considered effective to deal with it is to implement technology-based training in vocational education (Chatterjee et al., 2021). The use of artificial intelligence and digital literacy plays an important role in ensuring that vocational education remains relevant to the needs of industry 4.0 and society 5.0. With the optimal application of technology, vocational education graduates can have skills that are more in line with the demands of the modern world of work. Meanwhile, the green cluster highlights policy aspects and challenges in vocational education. Keywords such as policy, challenge, government, strategy, and sustainability show that the development of vocational education does not only depend on technological innovation, but also requires appropriate policy support. Vocational education reform must involve partnerships between the government, industry, and educational institutions in order to create an adaptive learning ecosystem that is responsive to changing workforce needs (Sun, 2024). The red cluster, on the other hand, illustrates the close linkages between vocational education, the economy, and the labor market. Keywords such as activity, organization, educational process, formation, economy, and labor market show that vocational education cannot be separated from economic dynamics. Vocational education must be able to bridge the needs of the industrial world with graduate competencies, so that it can increase the level of labor absorption and reduce the skills gap (Itohan Oviawe, 2017).

In the context of the Sustainable Development Goals (SDGs), especially SDG 4 on quality education, this visualization shows that vocational education does not only focus on learning technical skills, but also involves policy, economic, and technological integration aspects. Vocational education reform based on industrial needs and the use of technology can help create an education system that is inclusive, quality, and relevant to the times (Hossain et al., 2023). Thus, modern vocational education not only improves individual competence, but also contributes to sustainable economic growth and the achievement of global development goals.

Overlay Visualization

In addition, VOSviewer provides overlay visualization maps. Next, the network visualization for co-occurrence is presented in Fig 8.

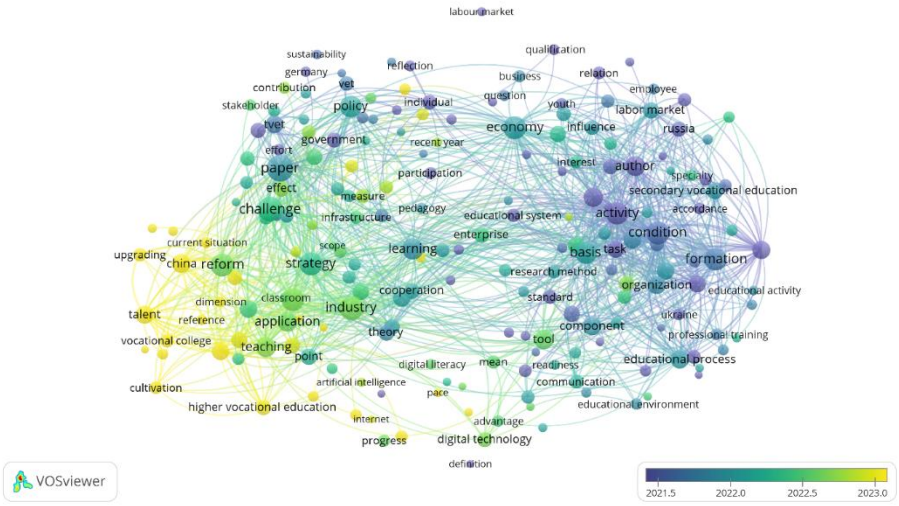

Fig 8: Overlay Visualization In The Topic of Vocational Education In SDGs
Source: VOSviewer

This Overlay Visualization image illustrates the development of research trends in vocational education based on a period of time. The color indicates the chronology of the emergence of key terms, where purple indicates the topic that came up first (2021), green as a transition (2022), and yellow marks the latest research (2023). In general, concepts in vocational education evolved from an initial focus on policy, economics, and labor markets (marked in purple and blue), to the integration of industry and learning (green), as well as to technological innovation and educational reform (yellow).

On the left side of the graph, yellow shows increased attention to China's reform, talent, teaching, application, and higher vocational education, which shows that in recent years, research has increasingly highlighted skills-oriented learning strategies, especially in China as one of the centers of vocational education innovation. This reform aims to improve the quality of the workforce by integrating technology and industry-based learning. Meanwhile, the green middle section marks the shift to the topics of strategy, industry, learning, and digital technology. Reform and innovation of the vocational curriculum in higher education is important to improve the quality of students and meet the needs of skilled workers, both theoretically and practically. (Wu et al., 2023). This indicates that in the 2022 era, research focuses more on strategies to strengthen the relationship between vocational education and industry. This is in line with SDG 4 (Quality Education), which emphasizes the importance of education that is relevant to the job market and skill development according to the challenges of Industry 4.0. These trends in automation and data exchange in manufacturing technology are changing employee qualification requirements, making vocational education even

more important (Spöttl & Windelband, 2021). On the right side of the graph, purple still dominates in terms such as activity, formation, condition, and organization, suggesting that previous research has focused more on fundamental aspects of vocational education, including institutional structure, labor market conditions, and traditional learning methodologies.

The implications of this visualization on vocational education show that the research trend is increasingly shifting from a policy and economic approach to industry-based learning strategies and the adoption of digital technology. In this context, smart technologies, such as adaptive learning pathways and emotion-based learning, play an important role in transforming vocational education by increasing its effectiveness and meeting the demands of the modern economy (H. Zhang & Leong, 2024). This emphasizes that vocational education must be more responsive to technological developments in order to create a learning system that is more innovative, inclusive, and in accordance with global demands. Sustainable reform in vocational education can contribute directly to the achievement of the SDGs, especially in improving access to and quality of education oriented towards future skills (Nazar et al., 2018).

Density Visualization

Likewise, VOSviewer provides density visualization maps. Next, the network visualization for co-occurrence is presented in Fig 9.

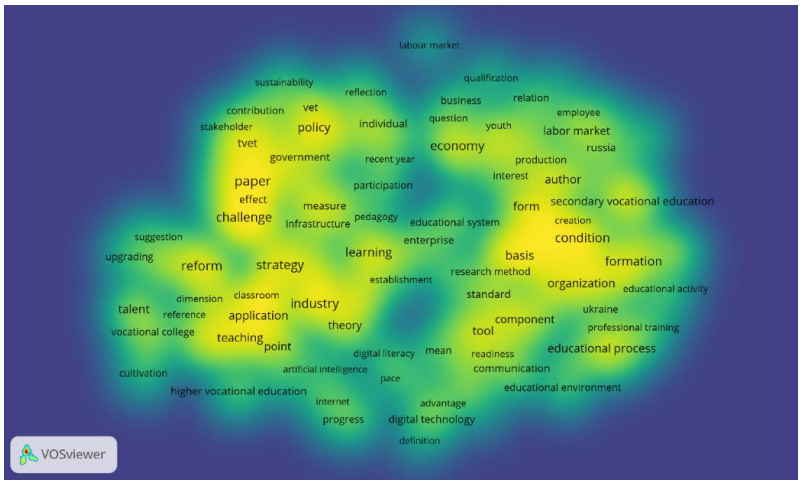

Fig 9: Density Visualization In The Topic of Vocational Education In SDGs.
Source: VOSviewer

The Density Visualization image shows the density of terms that often appear in research related to vocational education. Yellow indicates a topic with high research intensity, while green to blue indicates a lower frequency.

From this figure, it can be seen that high-density topics include policy, challenge, paper, reform, strategy, teaching, application, industry, learning, condition, and formation. Research in vocational education focuses on policies, challenges faced, reform strategies, and the implementation of learning in an industrial context. It indicates that the core focus of vocational education research lies in structural reforms and strategic implementation aligned with industry demands. The increase in the density of terms such as digital technology, artificial intelligence, communication, readiness, and educational process shows that vocational education is increasingly adapting to the development of digital technology. It highlights the growing urgency for vocational institutions to embed technological literacy and innovation into their pedagogical frameworks (Setiyawami et al., 2019). Therefore, the curriculum of higher-level vocational education needs to be restructured to align with future industry advancements, by integrating content updates, practical teaching components, and interdisciplinary courses. This is in line with the goals of SDG 4 (Quality Education), which emphasizes access to quality education with methods relevant to future needs.

The implications of these findings for vocational education emphasize the importance of a more comprehensive strategy in linking education policies to industry needs (Hu, 2024). Thus, policy-driven curriculum reforms serve as a critical pathway toward aligning vocational training with contemporary workforce requirements. Therefore, this study proposes strategies and policy recommendations to optimize the setting of vocational education curriculum to be more in line with the demands of the new economy and able to adapt to emerging industries. Vocational education reform must accommodate digitalization and technology integration in order to produce a workforce that is ready to face global challenges, while ensuring that the information technology curriculum not only focuses on technical skills, but also integrates relevant ideological and political values (Zhou, 2024). Integrating digital competencies with socio-political awareness ensures that vocational graduates are not only technically proficient but also contextually aware and adaptable.

In addition, the importance of communication and readiness in vocational education emphasizes that the curriculum must be more adaptive to changes in the labor market. Thus, vocational education not only focuses on technical skills but also on strengthening policies that support a more flexible and technology-based learning system (Y. Zhang & Wang, 2023). In sum, these evolving priorities underscore the need for a future-proof vocational education system that serves both individual learner success and broader societal transformation in line with SDG 4. This supports the achievement of the Sustainable Development Goals (SDGs) in creating inclusive, quality, and future-oriented education.

Conclusion

The transformation of vocational education is driven by technological developments such as artificial intelligence (AI), Internet of Things (IoT), and big data, which increase learning flexibility and the relevance of graduates to the needs of the job market in the era of Industry 4.0 and Society 5.0. Cross-sector collaboration between educational institutions, industry, and the government is the key to success in creating an adaptive education ecosystem that is able to bridge the skills gap. This modernization supports the achievement of the Sustainable Development Goals (SDGs), especially SDG 4 on quality education, through curriculum reforms that integrate digital technology, practical competence, and ideological-political values. The increase in the number of publications and citations shows a global interest in innovation in vocational education, while data visualization reveals patterns of researcher collaboration and key themes such as policy, challenges, and technology integration. These findings emphasize the need for restructuring the curriculum based on industry needs and a multidisciplinary approach to produce a workforce ready to face global challenges.

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