INTEGRATING ARTIFICIAL INTELLIGENCE (AI) INTO TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING (TVET): A PRISMA-BASED SYSTEMATIC REVIEW

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In today's world, characterized by the dominance of digital technologies, vocational education plays a pivotal role in driving economic growth and development. Nevertheless, it faces significant challenges in adapting to the rapidly evolving demands of modern industries. This study explores the role of Artificial Intelligence (AI) in reshaping vocational education curricula. A total of 73 articles were initially identified from the Web of Science database using specific queries related to AI, vocational education, and curriculum design. After applying inclusion and exclusion criteria, 27 articles published between 2020 and 2024 were selected for in-depth analysis. The systematic review employs the PRISMA methodology to analyze 73 articles, ultimately focusing on 27 relevant studies published between 2020 and 2024. The systematic review in the study follows the PRISMA methodology, ensuring a rigorous and transparent process. Key themes include the integration of AI tools for data-driven insights, personalized learning environments, curriculum design emphasizing AI and digital skills. The study underscores the importance of AI in enhancing teaching practices, promoting inclusiveness, and preparing students for AI-focused careers. It also emphasizes the necessity of AI training for educators, equitable access to technology, and the development of ethical frameworks to guide AI integration in education. The findings emphasize that personalized learning supported by AI enhances students' skill acquisition and aligns educational outcomes with workforce demands. Legal and ethical dimensions of AI, particularly in vocational education, need to be addressed to ensure responsible usage and equitable implementation.

Keywords: *Artificial Intelligence (AI); Technical and Vocational Education and Training (TVET); PRISMA; curriculum design; technical programs.*

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INTRODUCTION

Artificial Intelligence (AI) literacy gained importance with the increasing integration of AI across various sectors. However, vocational school students cannot sufficiently develop the AI-based skills demanded by the industry and business world. One of the primary reasons for this shortfall is the inefficiency and outdated nature of vocational education curricula (Kandlhofer *et al*., 2016; Laupichler *et al*., 2022). Creating an artificial intelligence-supported curriculum for the skills needed by the industry and labor market can provide great advantages to the vocational education process. However, inadequacy of trainers, educational inequalities, ethical concerns and deficiencies, data privacy, prejudices and resistance to change appear as obstacles to the implementation of AI into vocational education curricula (Ejjami 2024; Suparyati *et al*., 2023). These existing challenges prevent students from engaging with innovative technologies and approaches, further exacerbating inequalities in access and limiting their ability to compete effectively (Alla-Mensah, Henderson and McGrath 2021). Creating plans and structures that will encourage equal access to digital technologies for vocational education students will improve the ability of vocational education students to use the workforce and the market efficiently with digital skills and tools (Saddam and Hassan 2024; Yanli and Danni 2021).

In today's world where digital technologies are dominant, vocational education is of critical importance for economic growth and development. However, vocational education is faced with serious problems and issues in meeting rapidly developing demands (Wei and Nga 2024). A major issue is the lack of skills such as AI, data mining, machine learning, and robotics in vocational training curricula (Ali, Triyono and Koehler 2020; Ayofe, Ajetola and Oyewole 2009; Oviawe, Uwameiye and Uddin 2017; Somantri and Pramudita 2024; Özer 2024). This wide gap between vocational education curricula and the skills needed by industries highlights the need for school-workplace collaboration, updated curriculum design, and practical training opportunities to better prepare Technical and Vocational Education students for the demands of the 21st century workforce (Ayofe, Ajetola and Oyewole 2009). To address these challenges, vocational education curricula must align with current and future labor market needs. Priority should be given to structures that enhance students' skills in AI tools and technologies (Ejjami 2024). Achieving this requires a more flexible and responsive educational framework, updated curricula, and stronger connections between secondary and higher education systems (Özer 2024).

LITERATURE REVIEW

Researching the integration of artificial intelligence in technical and vocational education and determining the gaps, areas of study and needs in literature by performing a systematic analysis offers the opportunity for a holistic evaluation

process. Unlike previous studies, this study will provide important information to policy makers, educators and education administrators by examining in detail the obstacles encountered in the integration of artificial intelligence literacy into the curriculum and suggesting applicable strategies. In addition, it is aimed to present concrete policy and curriculum development suggestions for the use of artificial intelligence tools in vocational education and to present innovative solutions for sectoral expectations.

The European Union's "Digital Education Action Plan (2021-2027)" highlights the need for digital transformation in vocational education. This transformation is essential to adapt to changing social, economic, and cultural structures, as well as labor market demands (Vasileiadou 2023; Yanli and Danni 2021). This plan also aims to create an ecosystem that will provide infrastructure to integrate digital tools and skills in technical and vocational education and to empower all members of the education community in order to direct the digital transformation in education (Rodero 2023). New and rapid technological developments are reshaping education systems. They increase access to information, enable personalized learning, and enhance collaboration among stakeholders (Hussain, Qureshi and Malik 2024). Technology integration in teaching has brought structural changes. It has made learning environments more accessible and effective (Ghory and Ghafory 2021; Zhang 2014). Online learning platforms, e-learning, distance education and digital resources have widened access to education. They have promoted equity and fostered global collaborations (Al Jbour, Ghuneim and Anqour 2024). Despite these advances, challenges such as ethics, digital divide, data privacy and data security concerns continue to be significant barriers to technological integration in education (Hussain, Qureshi and Malik 2024). However, innovative technologies can reduce socioeconomic inequalities and promote inclusiveness (Al Jbour, Ghuneim and Anqour 2024). In order to integrate new technology and technological approaches into vocational education curricula, tools such as AI must be inclusive, accessible and adapted to the needs of the sector, so that all students can use them.

AI is a crucial skill for not only computer science but also all sectors and individuals. AI offers many advantages in educational environments, including personalized learning, content creation, performance monitoring, and teaching tools. Studies in literature highlight the impact of AI and related technologies on student success and academic performance (Dahri *et al*., 2024). Research also explores the use of AI in tracking and enhancing student performance in personalized learning environments (Holmes, Bialik and Fadel 2019; Nguyen, Gardner and Sheridan 2020).

The use of AI-supported tools in education provides skills to improve students' problem-solving abilities. These tools offer personalized learning environments tailored to individual learning levels (Kandlhofer *et al.*, 2016). In this way, AI can be use an important tool to solve problems caused by personalized learning environments and student differences in traditional educational environments. In

learning environments created with AI tools, instructors can analyze student needs individually, develop different learning and assessment plans for each student, and provide rapid feedback; thus, the benefits of the student-centered approach can be utilized more (Barua *et al.*, 2022; Chen, Chen and Lin 2020; Olaide *et al.*, 2024). The integration of AI and related technologies into education offers powerful tools to improve teaching practices, but educators need training, support and development to adapt these technologies to existing curricula and solve the problems they encounter (Rehan 2023). For example, with an artificial intelligence-supported tool that analyzes students' repetitive errors on a subject and suggests resources, the deficiencies of students and teaching can be quickly identified and solutions can be produced (Nguyen, Gardner and Sheridan 2020). Increasing students' motivation and improving their academic success by providing a personalized learning environment and creating instant feedback mechanisms will help them participate more intensively in classes and use materials more effectively (Barua *et al.*, 2022). AI tools that use gamification techniques to provide interactive and more entertaining learning experiences can also increase students' interest and motivation in vocational education (Dahalan, Alias and Shaharom 2024). The use of AI in vocational education is gaining importance in such areas as gamification, increasing motivation, providing personalized learning experiences, performance monitoring, and increasing learning efficiency (Suparyati *et al.*, 2023; Yahya, Wahyudi and Hidayat 2023). It is important to increase AI literacy in order for vocational education students to fully benefit from artificial intelligence-supported technologies. The benefits of AI in daily life and its impact on daily life increase the importance of AI literacy in the future careers of students in technical and vocational education (Kandlhofer *et al.*, 2016; Laupichler *et al.*, 2022).

AI literacy is defined as the competence of individuals to understand AI technologies, to be aware of these technologies in their development and careers, to evaluate the potential effects of these technologies, and to use AI technologies within ethical boundaries (Konishi 2015). Another definition describes AI literacy as the ability to critically assess AI technologies, communicate effectively with them, and use them within ethical boundaries (Long and Magerko 2020). There are many studies in the literature that emphasize the critical importance of AI literacy in the digital age, beyond the concepts of information and digital literacy that have proven effective today (Bawden 2001). Determining AI literacy can facilitate its integration into educational environments and help create more sustainable goals. Increasing and diversifying experimental studies on AI literacy will provide more comprehensive information about the advantages of AI literacy and using AI (Çetindamar *et al*., 2022). Creating a solid foundation for AI skills and AI literacy, which have become an important need for the future, is especially important for technical and vocational education environments. This need applies not only to experts who produce AI, such as computer scientists and the IT sector, but also to all individuals (Laupichler *et al*., 2022).

The skilled workforce that vocational education produces is very important in meeting the changing and diversifying demands of today's labor market (World Bank 2012). In order to equip students with critical skills to meet the demands of the labor market, vocational education programs aim to provide students with skills such as practical training, vocational education, personal development and digital literacy in an interdisciplinary structure. In order to improve vocational education programs at the desired level, future research should investigate in detail how organizational design and job requirements affect students' skill development, as well as the development of general and job-specific competencies such as problem solving, systematic analysis, and multidisciplinary thinking (Finegold and Notabartolo 2010). The skills and qualifications that students and vocational training programs are expected to gain are gaining more value as they provide advantages to changing employment structures in parallel with technological developments in industry and society. In addition, aiming to modernize vocational training systems, such as developing the infrastructure of educational institutions and improving teacher qualifications, will contribute more to the needs of the sector and labor capital (Kovalchuk *et al*., 2022). The increasing importance of AI literacy, the use of AI tools, and digital skills are critical to the workforce readiness of the market and economy in a rapidly evolving technological environment. As industrial and business environments tend to use more AI and AI automation in their processes, they expect their employees to catch up with this trend in their work processes. Providing AI literacy in the vocational education process and integrating it into educational curricula enables students to adapt to innovative approaches, to train self-learning individuals, and to create a workforce that can use AI, which increases performance and provides competitiveness, such as creativity, problem solving, production, efficiency and creativity (Thelma *et al*., 2024). To overcome the obstacles related to the integration of AI in Technical and Vocational Education and Training (TVET), it is necessary to overcome the challenges such as inadequate infrastructure, lack of digital competence of educators, ethical problems, resistance and insufficient policy support. In order to overcome these problems, increasing digital literacy in AI, encouraging collaborations with the sector, creating awareness and allocating sufficient resources and infrastructure for the effective use of digital tools are important solutions. In order to meet the demands of Industry 4.0 and to align Technical and Vocational Education with Industry 4.0, it is very important to create policies and structures that prioritize digital competencies (Rokeman *et al*., 2024). The formation of digital gaps in Technical and Vocational Education creates sociological and economic unequal opportunities and situations by limiting access to basic digital skills and resources. These young people who are in the disadvantaged group and have received vocational education cannot meet the demands of today's workforce and Industry 4.0. One of the main consequences of this situation is the inequality in employability, which worsens and widens socio-economic disparities in society. More systematic and targeted interventions and

policies are needed to close the digital divide (Alla-Mensah, Henderson and McGrath 2021).

PROBLEM STATEMENT AND APPROACH

The rapid advancements in artificial intelligence have necessitated a transformation in vocational education to equip students with the necessary AI literacy and technical competencies. As industries increasingly adopt AI-driven solutions, vocational education must adapt to ensure students are adequately prepared for emerging job roles. However, the integration of AI into vocational education faces multiple barriers, including outdated curricula, resistance to change, and lack of adequate infrastructure. Additionally, insufficient teacher training and limited access to modern AI tools further hinder the seamless adoption of AI-based learning methodologies in vocational training programs.

Especially in interdisciplinary studies that intersect the fields of technical and vocational education, AI and curriculum development, systematic literature reviews in synthesizing research evidence are an effective method to reveal and analyze the basic components of a multivariate structure. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology can be used to conduct systematic reviews on a field, ensure transparency in the research process, guarantee reproducibility, and make a valid and reliable standardized (Johnson and Hennessy 2019; Kelly, Moher and Clifford 2016; Rethlefsen *et al*., 2021). PRISMA's ability to minimize bias by using a structured identification, screening and selection process, thus increasing the reliability and validity of the findings, makes this method widely preferred (Kelly, Moher and Clifford 2016; Moher *et al*., 2009). In Technical and Vocational Education, where the integration of AI literacy and AI tools is becoming increasingly important, the PRISMA method can provide analyses and results that will enable researchers to systematically identify and analyze gaps in existing curricula, uncover best practices, and develop evidence-based strategies for curriculum redesign. In addition, the PRISMA-based systematic approach provides significant support for aligning Technical and Vocational Education programs to meet the demands and needs of the evolving industry and business world (Suparyati *et al.*, 2023). This study aims to contribute to a scientific, systematic and comprehensive understanding of AI literacy and its transformative potential in vocational education by using PRISMA's systematic approach.

The aim of this study is to systematically analyze and evaluate the current status of AI literacy in Technical and Vocational Education using the PRISMA methodology, identify barriers such as resistance, ethics, and the digital divide, and propose applicable strategies, policies, and ideas for integrating AI tools, infrastructure, and competencies into the curriculum to better prepare students for an AI-focused career.

METHODS

In this study, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was employed to conduct a systematic literature review. PRISMA is an internationally recognized standard designed to ensure the transparent, reproducible, and comprehensive reporting of systematic reviews and meta-analyses. This approach enhances the methodological rigor and transparency of the study. This study adopts the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol to conduct a systematic review of articles published between 2019 and 2024. The detailed steps of the methodology are as follows:

Search Strategy

This systematic literature review was conducted in accordance with the PRISMA 2020 guidelines to ensure a rigorous and transparent methodology. The inclusion criteria comprised peer-reviewed journal articles published in English between 2019 and 2024, covering the period from the emergence of AI in vocational education. The Web of Science database was utilized for the literature search, employing specific queries that included keywords such as “vocational education”, “artificial intelligence”, and “curriculum”. An initial pool of 73 articles was identified and subsequently screened for relevance and methodological quality.

- ***Search Query:*** TS ((“vocational education” OR “technical education” OR “vocational training” OR “technical training” OR “workforce education” OR “career education” OR “skills training” OR “professional education”) AND (“artificial intelligence" OR “AI" OR “machine learning” OR “deep learning” OR “intelligent systems” OR “automated systems” OR “AI-based systems”) AND (“curriculum” OR “curricula" OR “education programs” OR “training programs” OR “learning framework” OR “teaching materials” OR “educational content”))
- ***Publication Years:*** 2019−2024.
- ***Document Type:*** Articles only.
- ***Language:*** English**.**

Inclusion and Exclusion Criteria

The criteria were meticulously established to ensure that the selected articles aligned with the overarching scope of the review, thereby minimizing potential bias. To guarantee the relevance and quality of the selected studies, the following inclusion and exclusion criteria were applied:

Inclusion Criteria:

- Articles addressing vocational or technical education in relation to AI integration.

- Studies discussing curriculum redesign, educational frameworks, or learning materials.
- Peer-reviewed articles published between 2019 and 2024**.**

Exclusion Criteria:

- Proceeding Paper, Review Article, Editorial Material, Retracted Publication, Early Access or other non-article document types.
- Articles not directly related to curriculum or AI integration in vocational education.
- Papers lacking relevant keywords in the title, abstract, or keywords.

Data Collection and Screening Process

Article Retrieval:

The query was executed on the WOS database, identifying 73 articles.

Screening Stages:

- Stage 1 (Title and Abstract Screening):
  − Titles and abstracts were screened for relevance to the study objectives.
- Stage 2 (Full-Text Review):
  − Full-text articles were assessed for alignment with inclusion criteria.

Data Extraction and Organization

Relevant data were extracted and systematized, including:

- Authors and Publication Year.
- Journal Name and Impact Factor.
- Study Objectives and Methods.
- Research Instruments and Data Analysis Techniques.
- Key Findings and Recommendations.

Data Analysis

- Content analysis was employed to examine the selected articles.
- Studies were categorized under key themes such as AI integration in vocational education, curriculum redesign, and addressing the digital divide.
- Core themes, sub-themes, and exemplary practices were identified.

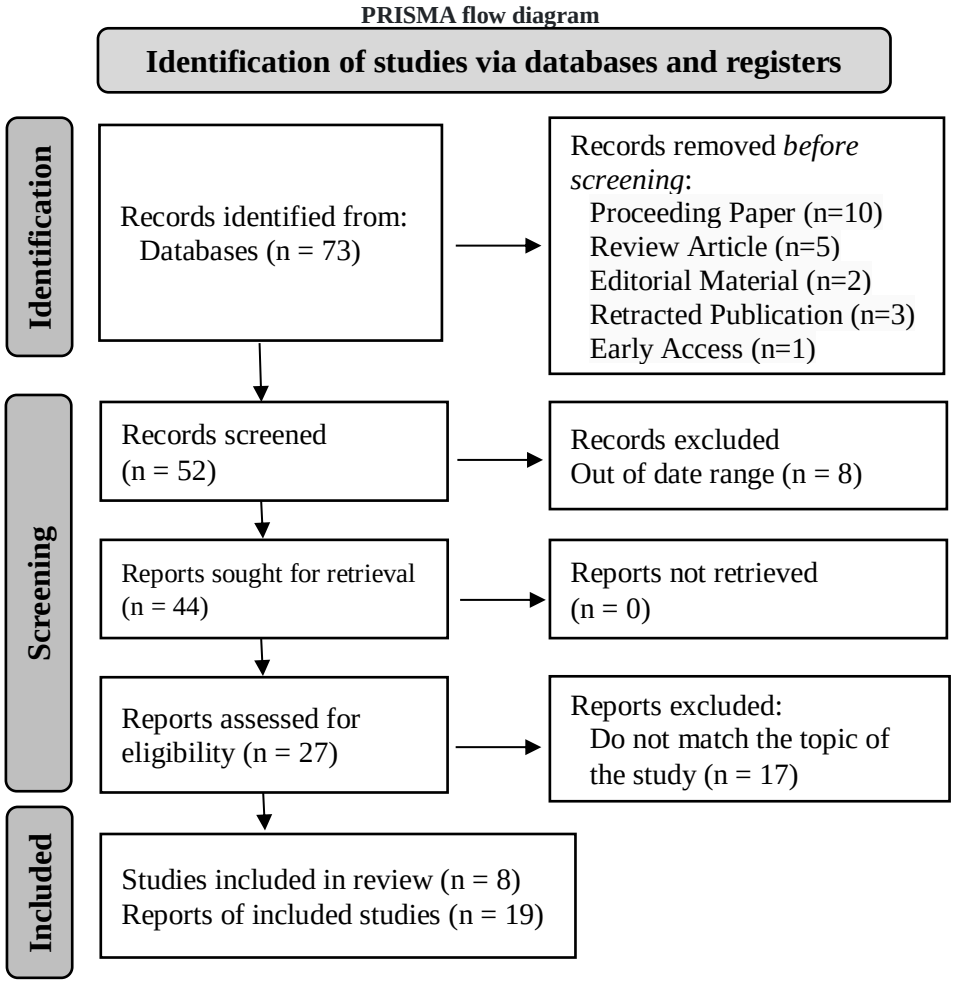
PRISMA Flow Diagram

The stages of the review process were visualized using a PRISMA flow diagram. The detailed procedures for each step of the methodology, conducted within the framework of the PRISMA methodology, are as follows:

- Identification: 73 articles were initially retrieved.
- Screening: Articles not meeting the inclusion criteria were excluded.

- Inclusion: The final number of included articles was determined.

Figure 1



Source: Elaborated by authors.

Reporting Results

In the final stage of the study, a total of 27 articles that had been identified through the systematic review process were subjected to an in-depth qualitative analysis. This analysis was conducted independently by three researchers to ensure rigor, reliability, and multiple perspectives in the interpretation of the data. Through

this process, codes were first identified, followed by the grouping of these codes into broader categories. Subsequently, overarching themes were developed to capture the essence of the findings. The qualitative analysis revealed seven key themes that highlight critical aspects of the research focus: AI Tools for Data-Driven Insights, AI Training for Educators and Professionals, Curriculum Design and Implementation, Equity and Accessibility with AI, Legal and Ethical Dimensions of AI, Perceived Value of AI Training, and Personalized Learning with AI.

Findings will be reported under key themes, including:

- AI literacy in vocational education.
- Strategies for redesigning vocational curricula to incorporate AI skills.
- Efforts to mitigate the digital divide in vocational education systems.

RESULTS

In this section, the data obtained as a result of the PRISMA analysis on the integration of artificial intelligence (AI) in technical and vocational education are presented comprehensively through figures and tables. The figures visualize data such as the distribution of research articles by year, citation counts, contributions of countries, use of research methods and article categories, and analyze academic trends and regional contributions in the field. The tables include themes, subcategories and explanations related to the effects of AI's intersection with technical and vocational education and curriculum development. The themes in the table are explained with explanations and categories in a wide framework ranging from AI's data-driven perspectives to curriculum design, equity and access to personalized learning experiences.

Table no. 1

Distribution of Articles and Citation Counts by Year

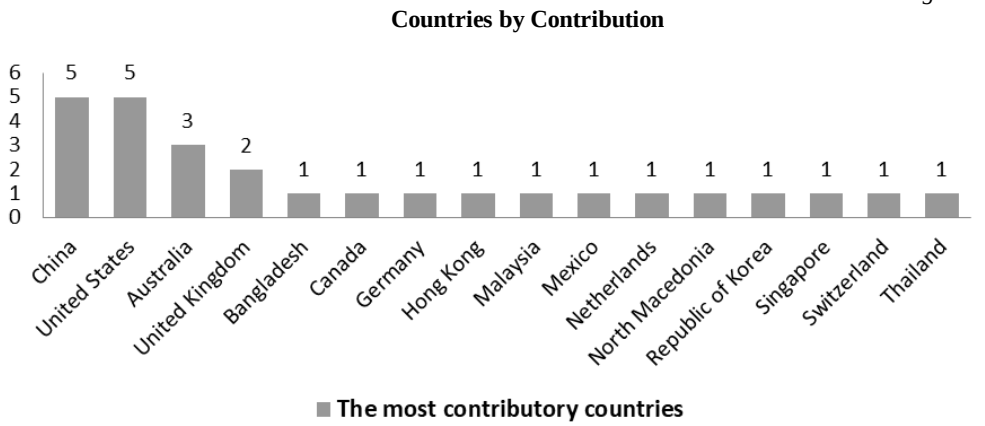
	2020	**2021**	**2022**	**2023**	**2024**	**Total**
Distribution of Articles	2	7	3	6	9	27
Number of Citations to Studies	36	109	6	19	6	176

Table no. 1 shows the number of articles used in the study, classified according to the publication years. When the data is examined, the highest number of publications is observed in 2024 with 9 articles and the lowest number of articles is observed in 2022 with 3 articles. The reason for the decrease in the number of articles may be the effect of the COVID-19 pandemic, which disrupted research activities and productivity globally during this period. In general, when the publication trend of articles is examined by year, it is observed that there are fluctuations in the number of publications, a significant increase in 2024, and a development in the effect of

increasing productivity and returning research activities to their previous levels after the pandemic.

Table no. 1 also shows the total number of citations of the articles used in the study according to their publication years. The data shows that 2021 was the year with the most citations with 109 citations. The reason for the decrease in the number of citations observed in recent years is that not enough time has passed for new publications to be cited. This situation should not be interpreted as the loss of influence of this field academically, as temporal limitations may have caused this situation.

Figure 2



Source: Elaborated by authors based on the reviewed articles.

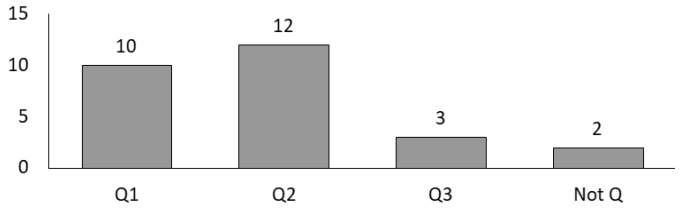
The data obtained from the study show that China and the United States are the leading countries in terms of publications with 5 publication contributions. Australia has 3 and the United Kingdom has 2. The remaining countries have 1 publication contribution. This situation shows the diverse international participation in the subject area. The prominence of China and the United States emphasizes the significant, active and pioneering roles of these two countries in the field of research. The diverse contributions from other countries indicate that there is a need for broad global interest in the field.

The higher publication rates in countries such as China, the United States, Australia and the United Kingdom may be an indication of their significant investments and developments in vocational education and training (VET) along with innovative technologies. For example, the Organisation for Economic Co-operation and Development (OECD) states that VET is a core component of the education systems in OECD countries, with approximately one third of 25−34 year olds receiving technical and vocational education as their highest level of education (OECD 2023).

In addition, it is stated that international comparative research in technical and vocational is gaining importance and this trend is more evident in countries such as China and America that actively participate in comparative studies (Chen *et al.* 2021). The significant contributions of these countries to the field may be related to their active roles in advancing technical and vocational education, their needs and their compatibility with vocational education research.

Figure 3

Distribution of Articles by Journal Quartile



Source: Elaborated by authors based on the reviewed articles.

In this study, 10 articles were published in Q1 journals and 12 articles were published in Q2 journals, and the fact that the published journals were the most prestigious and most cited journals related to their fields shows the importance and quality of the studies. This situation shows the need for research on technologies such as vocational technical education and AI and the value of the research at a high level.

Table no. 2

Articles According to Research Method

Method	Literature Review	Survey	Mixed Methods	Curriculum Design	Big Data Analytics	Case Study	Cohort Study	Delphi Method	Development Study	Scale Development	Pre-Post Test	Model Recommendation	Teaching Model Development
Count	8	5	3	2	1	1	1	1	1	1	1	1	1

Source: Elaborated by authors based on the reviewed articles.

When the articles used in the study are examined, the most commonly used research method is “Literature Review” with 8 articles. This situation shows the need

for researchers to synthesize the current situation and for synthesis studies in this field. The second most common research method is "Survey" method with 5 articles. It was used to collect data on the subject from larger communities and groups and to analyze trends, needs, and the current situation.

"Mixed method", where both quantitative and qualitative approaches are used together, was used in 3 articles and the opportunity to obtain more in-depth results was achieved in these studies (Guetterman, Creswell and Kuckartz 2015). Other methods such as "Curriculum Design", "Case Study" and "Big Data Analytics" were used less and the different methods used in the research show that research on VET, curriculum development and innovative technologies is conducted within a broad research methodology perspective.

Table no. 3

Articles by Research Area

Research area	Education & Educational Research	Computer Science	Engineering	Medical Informatics	General & Internal Medicine	Telecommunications	Health Care Sciences & Services	Chemistry	Respiratory System	Neurosciences & Neurology	Surgery	Nutrition & Dietetics	Obstetrics & Gynecology	Physiology	Sociology	Social Sciences (Other Topics)
Count	11	5	2	2	2	1	1	1	1	1	1	1	1	1	1	1

Source: Elaborated by authors based on the reviewed articles.

The majority of the articles (11) are included under the heading "Education and Educational Research". The main reason for this is that articles were selected with a focus on technical and vocational education, technology and curriculum development. There is increasing interest in educational research aimed at improving teaching methodologies, learning outcomes and educational policies. For example, the Royal Society (2023) states that the importance of educational research in informing policy and practice is increasing, and policy makers and decision makers make decisions based on the results of educational research. "Computer Science" is second with 5 articles, and "General and Internal Medicine" is third with 2 articles. The remaining research areas are different and emphasize different needs in the field of vocational education.

Figure 4

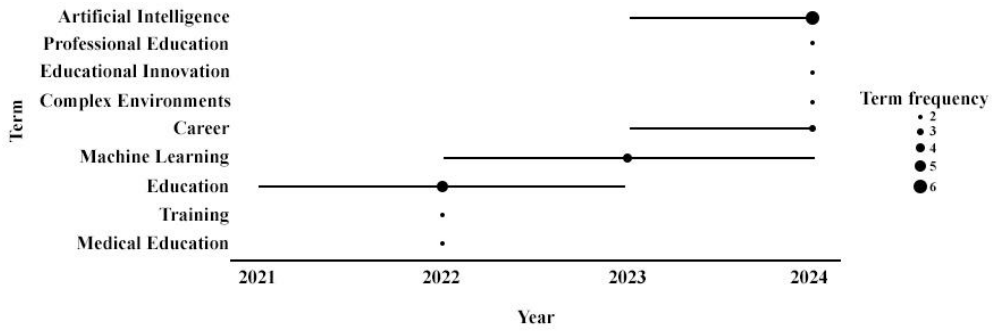
Word Cloud of Keywords

Source: Elaborated by authors using the keywords in the reviewed articles.

The word cloud is produced from the keywords of the publications used in the study. The most striking and prominent terms in this word cloud are AI and Professional Education. This situation shows that there are working trends in terms of AI and professionalization of education. Other important terms such as Machine Learning (ML), Medical Education, Educational Technology, eHealth and Robotics show the need and tendency to use technology more in education. In addition, we can say that concepts such as Industry 4.0 and Inclusive Digital Pedagogy show future trends and work areas.

Figure 5

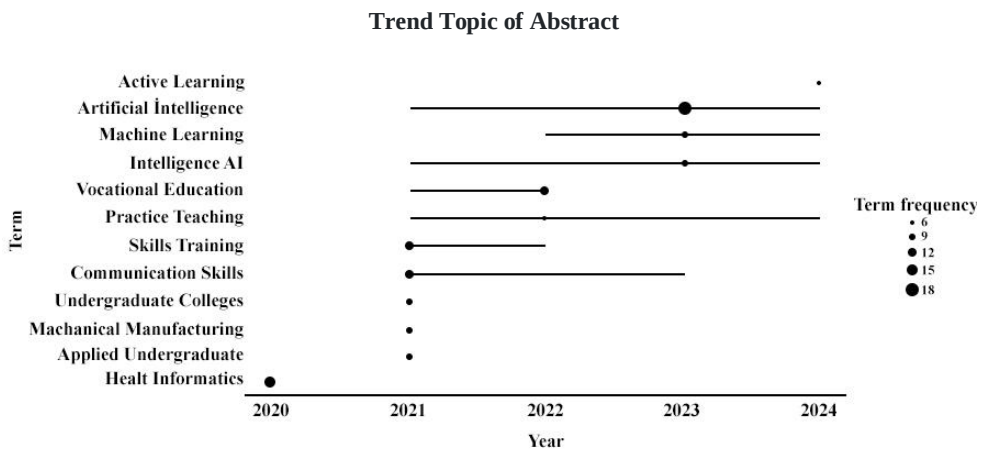
Trend Topic of Keywords



Source: Elaborated by authors based on the reviewed articles using with "R".

In the analysis of the keywords used in the reviewed articles between 2020 and 2024, it was observed that the terms “education” were frequently used from 2021 to 2023, “machine learning” from 2022 to 2024, and “career” and “artificial intelligence” from 2023 to 2024. In 2024, the keywords “professional education”, “educational innovations”, and “complex environments” emerged as prominent terms. When keyword trends are examined, they suggest that the field of education is increasingly intertwined with technological advances, particularly AI and machine learning. This transition may highlight the need for continuous adaptation of educational strategies to prepare students for future challenges. Similarly, the trend topic analysis of the terms used in the abstract section is presented in *Figure 6*.

Figure 6



Source: Elaborated by authors based on the reviewed articles using with “R”.

According to the trend topic analysis of the keywords used in the abstract section, the term “health informatics” was frequently used in 2020. Between 2021 and 2022, the keywords “vocational education” and “skills training” emerged as prominent terms. From 2021 to 2023, “communication skills” gained attention, while from 2021 to 2024, the terms “practice teaching”, and “artificial intelligence” were commonly used. Additionally, between 2022 and 2024, “machine learning” became increasingly prevalent.

Table no. 4

Themes and Categories of Themes

Theme	Category
AI Tools for Data-Driven Insights	Integrating Digital Data Management in Curricula
	Learning Analytics for Student Performance
	Leveraging AI and Big Data for Effective Solutions
AI Training for Educators and Professionals	AI in Training and Professional Development
	AI Training for Educators and Professionals
	Comprehensive AI Training Programs
Curriculum Design and Implementation	Adaptive Curriculum with Big Data
	AI Curriculum Development and Continuing Vocational Education
	Bridging Curriculum Gaps in Emerging AI Technologies
	Curriculum Design for Data Science and Machine Learning
	Curriculum Frameworks for Data and Digital Literacy
	Deep Learning-Oriented Curriculum Design
	Implementing AI in Educational Curricula
	Integrating AI into medical education
Equity and Accessibility with AI	AI in Workload Reduction and Equal Opportunities
	Equity and Accessibility in AI
	Equity and Personalization in AI Applications
Legal and Ethical Dimensions of AI	AI Ethics in Medicine Education
	Comprehensive AI Training Programs and Ethics
	Legal and Regulatory Frameworks for AI
Perceived value of AI training	AI Impact Awareness through Education
	Awareness and Perception of AI
	Perceived value of AI training
Personalized Learning with AI	AI in Simulation-Based Surgical Education
	AI in Work-Integrated Learning
	AI-Driven Personalized Education
	AI-Powered Self-Learning Strategies
	Enhancing Learning Experiences with AI
	Generative AI in Communication Skills Education
	Individualized growth with AI
	Lifelong Learning with AI
	Training platforms with AI

Table no. 4 presents themes and subcategories focusing on the integration and intersection of AI technologies in technical and vocational education. This table includes a guide on how AI technologies can be used in a wide range of contexts, from validated to personalized learning experiences. These themes, which are shaped around keywords such as vocational education, AI, data science curriculum, data science and personalized learning, provide a framework for approaches to student development and curriculum development in vocational education.

One of the important themes, "AI Tools for Data-Driven Insights", emphasizes the potential of students to learn through the use of data management and learning analytics in vocational education of AI. The effective use of big data in education, a summary of digital data management tools for curricula and solutions for sectoral needs are discussed under this theme. "AI Training for Educators and Professionals" includes details on how to increase the AI competencies of trainers in vocational education and how to integrate AI tools and technologies with vocational education curricula.

"Curriculum Design and Implementation", the theme looks at AI-based curriculum development from a broad perspective. In particular, the integration of compatible courses for sectoral needs in areas such as data science, machine development, and deep learning into existing curricula is prioritized. In addition, the theme "Equality and Accessibility with AI" focuses on bridging the digital divide in vocational education and providing equal access to AI tools, developing students holistically in vocational education, and offering them career opportunities where they can compete. The theme "Personalized Learning with AI" focuses on the effect of AI on student-controlled learning, and how to support the individual development of students in technical and vocational education institutions with applications such as lifelong education and workplace-integrated learning. *Table no. 4* is an important guide and reference for educators, educational administrators, curriculum developers and policy makers on the integration of AI and innovative technologies into technical and vocational education curriculum.

Table no. 5

Themes, Explanation and Source

Theme	Explanation	Source
AI Tools for Data-Driven Insights	AI and big data are transforming education by enabling smarter data-driven decisions. Through advanced tools, we can manage digital data seamlessly, analyze performance effectively, and design impactful solutions.	Houwink *et al.* (2020) Brass *et al.* (2023) Chen *et al.* (2024)
AI Training for Educators and Professionals	AI trainings for trainers and experts aim to provide the skills of the future while supporting professional development. These trainings transform educational processes by increasing the competencies to use and apply AI effectively and strengthen professional success with innovative solutions.	Chen *et al.* (2024) Petridou and Lao (2024) Vázquez-Parra *et al.* (2024)
Curriculum Design and Implementation	Curriculum development in education is evolving in parallel with technological advancements. Especially in areas like AI, data science, and deep learning, curriculum designs aimed at equipping students with up-to-date skills are gaining importance. These	Zhou, Zeng and Wang (2022) Petridou and Lao (2024) Azadi *et al*. (2021) Nadzinski *et al.* (2023) Samarasekera *et al.* (2024)

	curricula are being shaped to help students adapt to rapidly changing technology and support their success in future careers.	LeClair *et al.* (2023) Liu *et al.* (2021) Cheng and Wei (2021) Sundar *et al.* (2024) Banerjee *et al.* (2021) Ossa *et al.* (2023)
Equity and Accessibility with AI	AI has significant potential to reduce workloads and ensure equal opportunities. By providing equal access to all, it facilitates the creation of personalized experiences tailored to individual preferences.	Banerjee *et al.* (2021) Hong and Kim (2024) Jamil *et al.* (2024)
Legal and Ethical Dimensions of AI	As AI applications advance, ethical and legal dimensions have become significant points of discussion. Education in this field promotes the responsible use of AI, while regulatory frameworks aim to manage these technologies in a safe and equitable manner. Ethical principles and legal frameworks are necessary to ensure that technology contributes to society without harming it.	Ossa *et al.* (2023) Vázquez-Parra *et al.* (2024) Hu (2022)
Perceived value of AI training	The integration of AI in education has significantly contributed to an increasing awareness of its potential implications for teaching and learning practices. A thorough comprehension of the effectiveness and value of AI is vital for both educators and students to fully capitalize on its potential and ensure its proper utilization within educational settings.	Callahan *et al.* (2021) Vázquez-Parra *et al.* (2024) Sapci and Sapci (2020) Vázquez-Parra *et al.* (2024)
Personalized Learning with AI	The integration of AI into education has precipitated significant advancements across various domains. AI enables personalized and self-directed learning, promoting individualized development through adaptive systems. Furthermore, AI enhances work-integrated learning, supports the development of communication skills, and facilitates lifelong learning through educational platforms that deliver intelligent, tailored content.	Fazlollahi *et al.* (2023) O'Connor (2023) Meng and Sumettikoon (2022) Hasan, Mallik and Tsou (2021) Qi (2024) Barker, Moore and Cook (2024) Jamil *et al.* (2024) Azadi *et al.* (2021)

Table no. 5 presents the main themes related to the integration and impact of AI in technical and vocational education, along with their explanations. The table briefly and concisely defines each theme and provides information on how AI has transformed technical and vocational education, as well as the content and scope of the themes. The table also provides a comprehensive source of information for researchers, educators, curriculum developers, education administrators, and policy makers who need systematic data on the subject, by citing academic studies conducted on these themes. This structure provides a systematic and comprehensive

framework for those investigating how AI and innovative technologies can be integrated into technical and vocational education environments and curricula.

DISCUSSION AND CONCLUSIONS

Artificial intelligence (AI), AI skills and AI literacy in Technical and Vocational Education are widely discussed and considered important today. However, the current curricula of technical and vocational education institutions do not sufficiently support AI, AI tools and AI literacy as a skill at the desired level (Okanya 2023). In this study, a systematic review was conducted in the perspective of technical and vocational education, AI and curriculum development using the PRISMA method. The systematic process and structure created by the PRISMA approach ensured that the current literature was comprehensively scanned and that the studies considered were meticulously evaluated according to the eligibility criteria and that the studies suitable for systematic analysis were transferred (Sarkis-Onofre *et al.* 2021). The fact that most of the articles examined were published in high-quartile journals and in important journals in the field demonstrates the real-life importance of the subject and the awareness of this importance by the academic community.

The diversity of countries where the studies analyzed in the study were conducted shows that vocational education, AI and innovative curricula are considered important by many countries. However, the fact that more studies are conducted in countries with high industrial production such as China, the USA and Australia reveals the needs of the workforce in these countries. Developed countries that conduct Research & Development activities and use technical and vocational education graduates more in production-development processes use artificial intelligence and artificial intelligence tools more intensively in their educational curricula (Rigley *et al*, 2024).

The themes obtained as a result of the analysis; AI Tools for Data-Driven Insights, AI Training for Educators and Professionals, Curriculum Design and Implementation, provide important ideas for determining the desired characteristics in technical and vocational education graduates and for the actions that higher education institutions should take. Enriching the curricula with AI tools, providing sufficient education level for trainer managers and stakeholders for AI-based training and updating the existing curricula accordingly are the prominent approaches (Pedro *et al.* 2019; Yadav and Shrawankar 2025).

Another prominent theme in technical and vocational education is "Personalized Learning with AI". Personalized learning environments with AI offer many opportunities, especially in vocational education. Educational materials that will be created according to student performance in a field are of critical importance for training intermediate staff with the qualifications demanded by the workforce. Simulations and educational materials that will be developed especially for the

acquisition of professional skills in technical and vocational education will increase the skills and experiences of the students (Yanjin *et al.* 2023).

Another important theme from the study, Perceived value of AI training, shows the importance of awareness of the importance and advantages of artificial intelligence-supported curricula in both the sector and the academic community. Collaboration between the academy and the sector, supporting each other as stakeholders in the integration of AI into the curricula, will help develop more up-to-date and technical and vocational education curricula that can meet the needs (Munir *et al.* 2022).

The use of AI in educational environments and the tendency to integrate it into educational curricula have opened up new discussions in areas such as equity, digital divide and ethics (Bulathwela *et al.*, 2024; Eden, Chisom and Adeniyi 2024; Khan *et al.*, 2025; Shalevska 2024). Similarly, two other important themes obtained in this study are "Equity and Accessibility with AI" and "Legal and Ethical Dimensions of AI". In the process of integrating AI into curricula, everyone should use these tools with the same level of opportunities, create adequate infrastructures, and not create a new digital divide, especially at the level of gender and disability. Higher education institutions, authorized administrators and institutions should take the necessary precautions at this point (Khan *et al.*, 2025). Legal and ethical issues related to the use of AI are frequently discussed in technical and vocational education as in every field, and the necessity of conducting sufficient research and examination to solve the problems experienced is another result presented to us by this study.

This study provides a broad perspective on the integration of artificial intelligence into the curriculum of technical and vocational education and includes recommendations that are formed as a result of systematic analyses and deep investigations. The systematic review conducted with the PRISMA method has meticulously evaluated existing research and revealed important trends, perspectives, developments and gaps in the field. In the process of developing artificial intelligence-supported education curricula, differences between countries, sectoral needs, planning and policies to be made in terms of education and ethical issues should be taken into consideration and planned carefully.

In addition, this study provides analyses and suggestions in a broad perspective regarding the integration of AI into curricula in technical and vocational education. The steps to be taken, the points to focus on, the collaborations to be made, the opportunities and threats to be presented in order to equip technical and vocational education students with the skills and competencies required by todays and the business world and society.

LIMITATIONS

One of the key limitations of this study arises from its reliance on the Web of Science (WOS) database as the sole source for article retrieval, which may have led

to the exclusion of relevant studies indexed in other academic databases. Another limitation of this study is to focus on peer-reviewed journal articles published between 2019 and 2024. These limitations should be considered when interpreting the findings and their broader applicability.

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În lumea de astăzi, caracterizată de dominanța tehnologiilor digitale, educația profesională joacă un rol esențial în stimularea creșterii și dezvoltării economice. Cu toate acestea, ea se confruntă cu provocări semnificative în adaptarea la cerințele în schimbare rapidă ale industriilor moderne. Acest studiu explorează rolul Inteligenței Artificiale (IA) în reconfigurarea curriculelor educației profesionale. Inițial, au fost identificate 73 de articole din baza de date Web of Science folosind interogări specifice legate de IA, educație profesională și proiectarea curriculei. După aplicarea criteriilor de includere și excludere, au fost selectate pentru analiză aprofundată 27 de articole publicate între 2020 și 2024. Revizuirea sistematică a utilizat metodologia PRISMA pentru a analiza 73 de articole, concentrându-se în final pe 27 de studii relevante publicate între 2020 și 2024. Revizuirea sistematică din studiu urmează metodologia PRISMA, asigurând un proces riguros și transparent. Tematicile cheie includ integrarea instrumentelor IA pentru analize bazate pe date, medii de învățare

personalizate, proiectarea curriculei cu accent pe IA și competențe digitale. Studiul subliniază importanța IA în îmbunătățirea practicilor de predare, promovarea incluziunii și pregătirea studenților pentru cariere axate pe IA. Acesta evidențiază, de asemenea, necesitatea pregătirii educatorilor în domeniul IA, accesul echitabil la tehnologie și dezvoltarea unor cadre etice pentru a ghida integrarea IA în educație. Rezultatele subliniază că învățământul personalizat susținut de IA îmbunătățește achiziția de competențe a studenților și aliniază rezultatele educaționale cu cerințele forței de muncă. Dimensiunile juridice și etice ale IA, în special în educația profesională, trebuie abordate pentru a asigura utilizarea responsabilă și implementarea echitabilă.

Cuvinte cheie: *Inteligență Artificială (IA); Educație Tehnică și Profesională (ETP); PRISMA; proiectarea curriculei; programe tehnice.*