EXPLORING THE CHALLENGES AND OPPORTUNITIES OF INTEGRATING ICT IN TVET

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The labor market is constantly affected by global events and technological advancements, leading to a need for the workforce to continuously acquire new skills. Technical and Vocational Education and Training (TVET) can provide such opportunities, with Information and Communication Technology (ICT) playing a crucial role in facilitating the process. However, the full potential of ICT in TVET has not been fully realized, and there is a gap in the knowledge regarding its role. To contribute to the body of knowledge, this study has conducted a systematic literature review using Natural Language Processing (NLP) tools, including Word Cloud and Topic modeling. The findings have shown common themes addressing the role of ICT in creating and distributing educational material, creating collaborative and interactive learning environments, and providing personalized learning experiences. This study has revealed challenges related to ICT infrastructure, availability of ICT skills, and technical challenges including cyber-security and technical support. Furthermore, the study has identified a knowledge gap in understanding the role of ICT in the learning value-creation process. As a practical implication, this study highlights the need for future research in the field, to address the knowledge gap related to the role of Artificial Intelligence (AI) technologies in facilitating the value creation process in TVET. The findings have social implications for the development of TVET programs and the development of sustainable workforce, thus contributing to the achievement of the United Nations' Sustainable Development Goals.

Keywords: TVET, text analysis, word cloud, topic modelling, ICT tools, collaborative learning.

1. Introduction

Recent global events, including the COVID-19 pandemic, inflation resulting from Russia's invasion of Ukraine [1], and emerging AI technologies, have had a significant impact on the labor market [2], leading to an increase in unemployment rates in recent years. To adapt to these changes, the workforce is increasingly required to acquire new skills through upskilling and lifelong learning opportunities, such as those provided by technical and vocational

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education and training (TVET) programs. TVET, as a form of education, encompasses skills development for a wide range of beneficiaries and is focused on technologies and sciences, as well as the acquisition of skills, knowledge, attitudes, and the ability to implement these skills in their life [3]. The combination of "*knowing, wanting, and implementing*" is at the core of TVET. As a result of its importance, TVET has been included in the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Sustainable Development Goals (SDGs, 3 and 4) [4]. The UNESCO strategy has placed a focus on youth employment, entrepreneurship, and lifelong learning, recognizing the critical role that TVET plays in addressing these key issues [5].

Information and Communication Technologies (ICT) have a critical role in facilitating education, including TVET. ICT provides a means for sharing educational resources [6], aids in the creation, dissemination, and processing of knowledge [7], and facilitates collaborative learning activities [8, 9]. Despite the significant impact that ICT has in the value-creation process in education, previous research [10, 11, 12] has identified a gap in its role in supporting TVET. These studies highlight the need for further investigation into the role of ICT in enhancing the effectiveness of TVET.

Our previous research [13, 8, 9, 14] recognized a gap in the knowledge regarding the role of ICT in skills building for TVET learners. In order to verify this hypothesis and gain a deeper understanding of the ICT enabled value creation process within TVET, a systematic literature review was performed using a proposed methodology that utilizes NLP tools such as Word Cloud and Topic Modeling. Through this process, the literature on TVET education has been reviewed, with a focus on the role of ICT in facilitating the learning process in TVET. This process identified the key trends and topics of interest to the scientific community in the field of TVET ICT enabled education.

The paper is structured as follows: Section 2 presents the methodology used to conduct the study, the results are presented in Section 3, and a discussion and conclusion that clarifies the answers to the main research questions and concludes the paper by emphasizing the significance of the contributions and providing guidelines for future research are presented in Section 4.

2. Methodology

The proposed methodology consists of three main phases: I) **Articles collection**: the relevant articles for the review are identified and collected; II) **Text preparation**: the collected articles are prepared for analysis, including the text preprocessing to remove any irrelevant or redundant date, and formatting the data in a way that is suitable for analysis; III) **Text modeling and analysis**: the prepared text is analyzed using the LDA method, icluding the identification of the key topics and themes present in the text, and quantifying the relationships between these topics.

Overall, this methodology provides a systematic and transparent approach for conducting a smart literature review using the LDA method, which can help researchers to efficiently and effectively synthesize the existing body of knowledge in a particular field. The results of the analysis can then be used to draw conclusions about the state of the field and identify areas for further research opportunities.

2.1. **Articles collection**

The purpose of this study is to examine the role of ICT in TVET. The keywords "ICT+TVET" and "Online+TVET" were used to search several databases including IEEE, Springer Link, Nature, Science Direct, Scopus, and Web of Science. The search was limited to articles published between 2013 and 2022. A total of 210 articles were found, and after eliminating duplicates and irrelevant articles, the final number of articles used in the study was 178.

We included scientific artifacts that were published in the English language in various sources such as journals, conferences, symposiums, or book chapters as part of our inclusion criteria. This broad range of literature sources allowed us to cover a wide range of literature related to TVET and provided the necessary material to create the dataset for modeling in the subsequent stages.

The steps that have been applied in the articles selection process are the following:

- Screening: During this phase, the articles have been screened to ensure that they were relevant to the aim of the study. They have been also checked for redundancy and only one copy of articles that appeared in multiple searches has been kept.
- Assessment: During this phase, the quality of the articles as scientific artifacts has been evaluated.
- Selection: The relevant articles were chosen and organized into folders based on the source database (e.g. all articles from IEEE were placed in the same folder labeled "IEEE").
- Coding: A four-digit coding scheme was used to label the articles. The first digit represented the database (e.g. articles from IEEE were labeled with a 1 as the first digit), the second digit represented the search keyword, and the last two digits were a sequential number. For example, the article labeled 1001 was the first article found in IEEE using the search keyword "ICT+TVET".

2.2. **Text preparation**

After collecting the relevant articles, we proceeded to extract the text. We have used the PyPDF2 Python library to extract the text from the first three pages of each article. These pages were selected because they typically include the abstract, introduction, and part of the state of the art or method.

Our screening process showed that selecting three pages is sufficient to identify the topic of the articles. The output of this process is a CSV file with three columns: a serial number, the file label, and the extracted text. It's worth noting that, while the research team gained some understanding of the topics of the articles during both the articles' selection and text extraction processes, this information was not encoded in any of the outputs of either process. To ensure impartiality in the study results, the articles are referred to using codes rather than their titles or topics.

To ensure the integrity and quality of the data, the next step after extracting the text was to clean it. The text cleaning process used in this study followed the techniques outlined by [15] and [16]. To clean the text, the following steps were taken:

- All words were converted to lowercase.
- Punctuation, digits, special characters, and extra whitespaces were removed.
- Emails and URLs were removed.
- Stop words were removed using The Python Natural Language Toolkit NLTK library [17], as these words do not provide significant meaning for the topic modeling process and could potentially mislead it.
- The remaining words were lemmatized and stemmed to ensure that each word was properly formatted. To process the text and return it to its root form (stemming) and dictionary format (lemmatization) [18], we used the Python NLTK library.

Through these steps, the data become effectively cleaned and prepared for analysis.

2.3. Text analysis and topic modeling

The data analysis process was divided into the following phases:

2.**3**.1. *Word cloud:* A word cloud is a visual representation that shows the most common words in the articles' text. The size of the word reflects its frequency of appearance in the text, with larger words appearing more frequently [19]. The Word Cloud was created through an iterative process. Through this process, we performed text cleaning to remove any words that did not contribute significant meaning to the analysis, such as "two", "three", "number", "type", "first", "may", "paper", etc. After completing the cleaning process, Python's WordCloud and matplotlib libraries were used to generate the Word Cloud graph.

2.**3**.2. *Topic modeling:* In the topic modeling process, each block of text extracted from each article has been transformed into a list of words. These lists have been used further to create a dictionary using Gensim's Dictionary function [20]. The dictionary included a total of 33977 words. This dictionary has been used to create a matrix showing each word's frequency in the block.

Cluster No.	0	1	2	3	4	5	6	7
Probability	0.068	0.0003	0.0003	0.0938	0.0752	0.5836	0.0306	0.1483

TABLE 1. An example of a block's classification probabilities

A Latent Dirichlet allocation Model (LdaModel) [21] has been created using Gensim with 8 topics, generated through a trial and error process, as there is no set method for determining the correct number of topics. This model has created a matrix with 8 clusters and listed the probability of each block being classified under each cluster.

For example, consider the probabilities listed in Table 1. In this example, the probability that the block belongs to cluster 0 is 0.068, the probability that it belongs to cluster 1 is 0.0003, and so on. The first number in the table refers to the cluster, and the second number represents the probability that the block of text is classified in that cluster.

After creating this matrix for all blocks, we have set a threshold to guide the classification of the blocks into clusters. We may accept the classification with a probability value greater than a threshold [22].

The threshold is usually set as the mean of the probabilities [22] or a percentile threshold [23], within the scope of this article, we have adjusted the percentile threshold to improve the accuracy of classification, as presented in Equation 1, where X is a matrix that contains all the probabilities, sorted in **descending** order, n is the total number of probabilities, and c is a variable that determines the value of the threshold.

$$Threshold = \frac{X_{\lfloor \frac{n}{c} \rfloor} + X_{\lfloor \frac{n}{c} \rfloor + 1}}{2} \tag{1}$$

This formula, which determines the threshold value, takes into account the value of the variable c, calculated using Equation 2, where n is computed as the product between the number of articles and the number of topics.

$$Threshold > (1 - \frac{1}{c}) * 100\% \tag{2}$$

When c is set to 10, the threshold is greater than 90% of the classification probabilities of all blocks in all clusters, which is 1424 (number of articles * number of topics). On the other hand, when c is set to 2, the threshold is greater than 50% of the probabilities. Various values of c have been used for computation, ranging from 10 to 2, and it has been found that the best value for our case was 8. At this value, the threshold is equal to 0.42, which is greater than 87.5% of the probabilities. For example, in Table 1, the block has been classified into cluster 5 because the probability of the block belonging to cluster 5 is 0.5836 which is greater than the threshold of 0.42.

Computing this threshold as presented before, to accurately and consistently assign blocks to their respective clusters, resulted in only 4 blocks being

classified into more than one cluster and 3 were not classified at all. This was the best result that could be achieved. The method for determining the threshold is generally applicable, while the value of c depends on the data set used in the specific use case.

3. Results

This section presents the findings of this study. The study approached the findings with a critical eye to ensure their accuracy and allow a better understanding of the current trends in the literature.

3.1. The word cloud

The Word Cloud analysis shows that some of the most frequent words are "learning", "skill", "student", and "development," each of which occurs more than 999 times, as depicted in Figure 1 and Table 2. This is understandable, as the main role of TVET is to develop students' skills.

Another frequently occurring word is "social," which appeared 603 times. This term was often used in conjunction with "media" to highlight the role of social media in online learning and collaboration, such as in [10]. It was also used to indicate the use of social media as a source of data collection, such as in [24].

In many instances, the term "social network" has been used as a synonym for "social media", while in other cases it has been used to refer to networks of actors that serve as resource facilitators for TVET education, such as in [25]. The word "social" was also used as part of the definition of TVET education to highlight the role of TVET in improving social life [26]. In other instances, it was used in the context of social problems, such as "social inequality" or "social exclusion".

The analysis of the literature found that ICT was mentioned 531 times, with the majority of these references focusing on the use of specific ICT tools such as Learning Management Systems (LMS) [6] and Massive Open Online Courses (MOOCs) [27]. There is also a general trend in this literature toward examining the challenges and opportunities of integrating ICT into TVET. Such articles address the digital divide by highlighting the importance of developing necessary ICT skills [28]. Finally, some articles take a more broad approach and discuss the role of ICT in facilitating TVET education more generally, without focusing on any specific aspect, such as [10].

3.2. Topic modeling results

After conducting a word cloud analysis, we identified that certain words appeared with high frequency in a majority of the articles. These words were causing interference in the clustering process, as their high frequency was disrupting the formation of clusters. As a result, we removed the words that occurred with a frequency greater than 799 times, in order to improve the

FIGURE 1. The word cloud

No.	Words	Frequency
1	['education', 'learning', 'tvet', 'skill', 'student', 'development']	More than 999 times
2	['training', 'study']	800-999
3	['vocational', 'knowledge', 'technology', 'technical', 'teaching', 'social']	600-799
4	['system', 'information', 'ict', 'educational', 'teachers', 'process', 'use', 'malaysia', 'data', 'online', 'countries', 'work']	400-599
5	['higher', 'institutions', 'curriculum', 'international', 'world', 'model', 'access', 'economic', 'quality', 'design', 'employment']	300-399
6	['analysis', 'policy', 'school', 'media', 'literature', 'university', 'communication', 'africa', 'video', 'youth', 'support', 'human', 'activities', 'innovation', 'challenges', 'content', 'result', 'environment', 'performance', 'professional', 'management', 'effective']	200-299
7	['context', 'future', 'framework', 'opportunities', 'current', 'government', 'motivation', 'computer', 'labour', 'practices', 'lecturers', 'resources', 'graduates', 'lifelong', 'integration', 'vet', 'outcomes', 'business', 'community', 'unesco', 'elearning', 'covid', 'rural', 'strategy', 'course', 'society', 'entrepreneurship', 'pedagogical', 'cooperation', 'asia', 'capital', 'service', 'game', 'network']	100-199

TABLE 2. Words Frequency

accuracy of the clustering process, see Table 2. Table 3 presents the resulting clusters, the number of articles in each cluster, and the keywords that guided the classification.

Within the scope of this article, we use the term "cluster" to refer to the aggregation of text blocks. These clusters are transformed into topics by assigning themes to each cluster. It is important to note that the numbering system for clusters and topics differs, with clusters being numbered starting from 0 and topics being numbered starting from 1. However, the terms "cluster" and "topic" may be used interchangeably, with cluster 0 corresponding to topic 1, and so on.

Cluster No.	Number of Articles	Keywords
0	21	["higher", "lifelong", "adult", "social", "international", "country", "unesco", "literacy"].
1	19	["skill", "student", "knowledge", "country", "work", "employment", "policy", "vocational", "system"]
2	37	["teaching", "teacher", "student", "literacy", "technical", "skill", "technology", "vocational", "research", "competence"]
3	16	["youth", "program", "intervention", "study", "market", "employment", "country", "skill", "review", "evidence"
4	8	["ict", "vet", "state", "college", "vocational", "knowledge", "technology", "technical", "integration", "icts"
5	13	["teacher", "technology", "student", "research", "video", "ict", "teaching", "use", "online", "vocational"
6	39	["student", "skill", "knowledge", "Malaysia", "technical", "system", "technology", "process", "educational", "game"
7	26	["system", "curriculum", "school", "student", "vocational", "use", "medium", "technology", "country"

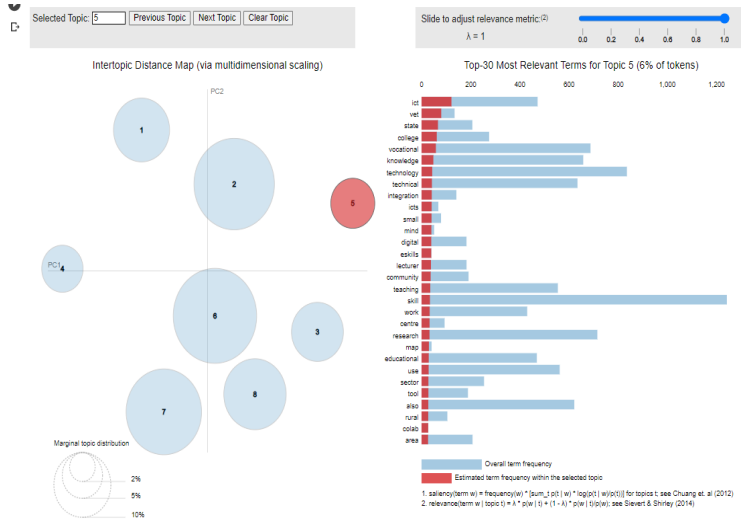
TABLE 3. Clusters - Number of articles - Keywords

The pyLDAvis Python library has been used to visualize the topics in our study. Figure 2 presents the two topics with the most and least number of articles. The size of the bubbles on the left side of the figure represents the number of keywords belonging to each topic [21].

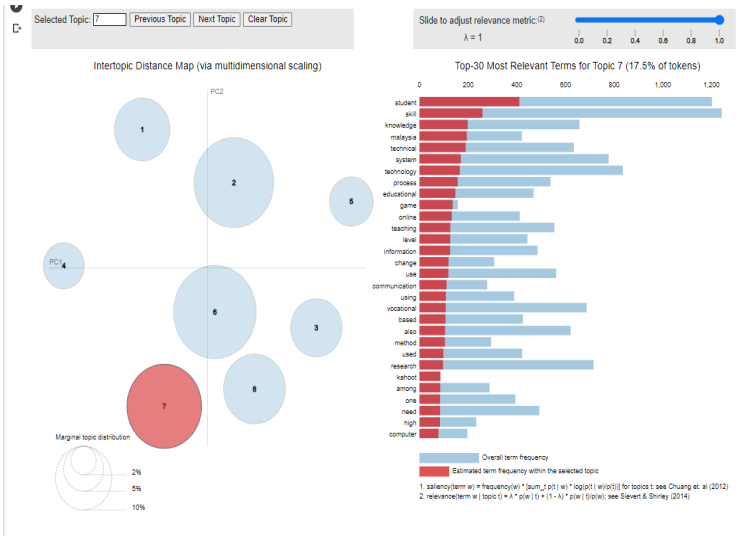
Table 3 presents the most frequently occurring keywords, rather than the full vocabulary of each topic. The right side of each figure displays the vocabulary of the corresponding topic. Each keyword is represented in Figure 2 by two bars: the blue bar represents the frequency of the keyword across all topics, and the red bar represents the frequency of the keyword within the specific topic [21]. As can be seen, cluster 6 (topic 7) has a larger number of common vocabulary items compared to cluster 4 (topic 5).

In the topic analysis process, the keywords listed in Table 3 for each cluster are examined, and they are analyzed in association with the corresponding articles to contextualize the usage of these keywords. In this way, the themes associated with each topic may be understood. In the following, we present the themes associated with each identified topic (Table 3).

- Topic 1 (cluster 0): The analysis of this topic reveals a high frequency of words such as "higher", "lifelong", "adult", "social", "international", "country", "unesco", and "literacy". In this topic, several themes were identified: i) The first theme concerns the utilization of various ICT tools, such as Simulation and Visualization tools [29], Mobile Learning [30], and Social Networks [24], and their potential impact on TVET pedagogy. ii) The second theme addresses the potential role of TVET in attaining the Sustainable Development Goals (SDGs), e.g. [7]. iii) The third theme



(a) Topic 5



(b) Topic 7

FIGURE 2. Clusters-Topics Visualization.

highlights the geographical focus of previous research on TVET, with a notable trend toward studies conducted in Malaysia, Indonesia, Sri Lanka, and Sub-Saharan Africa.

- Topic 2 (cluster 1): The topic analysis reveals a prevalent usage of words such as "skill", "student", "knowledge", "employment", "policy", and "system". This topic exhibits several themes pertaining to the utilization of ICT within the realm of TVET. i) One theme addresses the crucial role of ICT in promoting sustainable and inclusive human development

[7], specifically through the use of AI applications in providing personalized education [31] and the use of education game platforms in enhancing student motivation and engagement [32]. ii) Another theme highlights the importance of ICT skills in achieving the goals of TVET education and addresses the challenge of effectively utilizing these technologies for educational advancement, e.g.[33].

- Topic 3 (cluster 2): The analysis of this topic reveals a high frequency of words such as "teaching", "teacher", "student", "literacy", "skill", "research", and "competence". i) The first theme centers around the use of ICT in facilitating TVET learning processes through various means such as *gamification* to improve students' motivation and engagement in blended learning [34], utilization of *ICT for assessment* [35], and the role of *ICT in knowledge sharing* [36]. Furthermore, the theme emphasizes the significance of *curriculum development* that incorporates *digital materials* [37], and the importance of a *digital environment for social participation in TVET* [38]. ii) Another theme analyzes the importance of ICT skills for lifelong learning [39]. iii) Lastly, the topic also addresses the challenges related to ICT infrastructure, for example, cloud cyber-security [40], and the availability of digital equipment [41].
- Topic 4 (cluster 3): The topic analysis indicates a prevalent usage of words such as "youth", "program", "intervention", "study", "market", "employment", "skill", and "evidence". The scope of this topic does not primarily focus on the role of ICT in TVET education. However, a limited number of articles do touch upon: the factors that influence the use of ICT in education such as ICT literacy and skills, ICT readiness [42].
- Topic 5 (cluster 4): The topic analysis indicates a prevalent usage of words such as "ict", "vet", "college", "knowledge", "technology", and "integration". Despite the small sample size, consisting of only 8 articles, the topic demonstrated a significant emphasis on the utilization of ICT in the context of lifelong education. This was evidenced by the recurring themes that address: i) the utilization of ICT to promote knowledge and skills acquisition and provide access to learning materials [43], and ii) the potential of ICT to create interactive educational experiences through the use of online learning tools [44].
- Topic 6 (cluster 5): The analysis of this topic reveals a high frequency of words such as "teacher", "technology", "student", "research", "video", "ict", "teaching", and "online". The analysis revealed three distinct themes within the topic. i) The first theme related to challenges related to access to ICT including issues such as inadequate infrastructure, limited availability of digital equipment [45], lack of technical support, and low levels of digital literacy among students [46]. ii) The second theme focused on the use of interactive learning tools, including interactive whiteboards [47], gamified interactive digital classrooms [48], interactive media [49].

iii) The final theme pertained to technology integration in education and addressing factors that contribute to a positive online learning experience [50].

- Topic 7 (cluster 6): The analysis of this topic reveals a high frequency of words such as "student", "skill", "knowledge", "system", "technology", "process", "educational", and "game". The themes addressed within this topic were found to be consistent with those identified in prior topics, including: i) challenges associated with integrating ICT in TVET, such as digital literacy and infrastructure [51]; ii) the use of digital teaching aids [10]; iii) the use of social networking (social media) in education [52]; iv) and the use of frameworks such as the Technology Acceptance Model (TAM) [53] and other frameworks to investigate technology acceptance and integration in education [54, 55]. However, an additional theme was identified that pertains to the role of TVET in preparing the youth for future ICT-related jobs [56].
- Topic 8 (cluster 7): The analysis of this topic reveals a high frequency of words such as "system", "curriculum", "school", "student", "medium", "technology", and "country". Most of the themes addressed in this topic were consistent with those identified in prior analyses, including: i) the challenges associated with integrating ICT in education, specifically in regards to "Cybergogy" readiness (the availability of digital literacy among students) [57]. ii) The examination of various digital teaching and learning tools such as education game platforms [32], digital pedagogical tools [58], and online exams [59]. The utilization of project/problem-based learning approaches facilitated by ICT tools [60]. iii) The role of ICT in achieving the United Nations' Sustainable Development Goals (SDGs) [61]. iv) Additionally, a new theme emerged within this topic, oriented toward the role of ICT in facilitating knowledge creation, dissemination, and processing [7].

The analysis has revealed several recurring themes across multiple clusters. Further refinement and interpretation of these findings would benefit from additional human-mediated analysis to identify common themes and summarize the results, and this discussion is presented in the following section.

4. **Discussion and conclusions**

The most commonly *noted challenges*, regarding the integration of ICT in TVET that have been identified in the targeted literature, include the following themes: a) the *availability of ICT skills* among students and educators, and b) the *availability of ICT infrastructure*, particularly internet connectivity and digital equipment.

These themes have been prevalent in literature prior to 2020 and have particularly appeared in studies in developing countries, particularly in rural

regions. However, in recent years, the widespread availability of digital technologies, such as smartphones, has mitigated these challenges to some extent. Contemporary literature has instead highlighted technical challenges related to cyber-security, especially in cloud computing technologies, as well as the availability of technical support. The majority of the studies on the use of ICT in TVET have investigated its role in facilitating education, which is mainly manifested in providing means for:

- Sharing educational materials such as learning management systems, video lectures, and simulation and visualization tools;
- Interactive learning through the use of educational game platforms, interactive whiteboards, virtual classrooms, etc.;
- Collaborative learning, which mainly focuses on the use of social networks (social media) in education and project-problem-based learning;
- Personalized learning through the utilization of AI technologies to provide a personalized learning experience tailored to the student's needs.

Although this subject has rich literature, a research gap remains on the role of ICT in the value creation process of TVET. The majority of the existing literature focuses on assessing the usability and accessibility of specific ICT tools as enablers of educational resources. Moreover, the literature on the contribution of ICT to collaborative learning via social networks follows the same trend. Additionally, the literature on the impact of artificial intelligence (AI) on personalized learning necessitates a thorough examination of this topic.

The *original contributions* of this paper reflect the application of advanced data analysis techniques to extract major topics of research in innovating in the TVET service ecosystem using ICT tools.

Our *original findings* reveal that the majority of literature reflects common challenges related to the availability of ICT skills, ICT infrastructure, and equipment in TVET, as well as more recent technical challenges related to cyber-security and technical support. Additionally, most studies have investigated the role of ICT in facilitating TVET by providing means for sharing educational materials, interactive and collaborative learning, and personalized learning.

Specifically, our study has identified a gap in the knowledge related to the process of value creation in TVET, the role of collaborative project/problem-based education in filling this gap, and the use of AI to facilitate this process in TVET. In addition, this study contributes to the body of existing knowledge by presenting a comprehensive framework for conducting a systematic literature review using natural language processing (NLP). Although the study is limited to its context, this study highlights the need for future work that is value-oriented and utilizes AI technologies to create collaborative and project/problem-based learning experiences in TVET.

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