Best Teaching Practices for Enhancing Teacher Competence in Electrical and Electronic: A Recent Systematic Review

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ABSTRACT

This systematic literature review investigates optimal pedagogical practices for improving teacher proficiency in electrical and electronic education, addressing the growing demand for innovative teaching methods that correspond with technological progress and professional development. The rapid expansion of Industry 4.0 and digitalization in education necessitates that electrical and electronic teachers exhibit not only technical skills but also digital literacy, pedagogical adaptability and socio-emotional awareness. However, present research remains fragmented, with no coherent synthesis linking technology-enhanced learning, digital competence and professional development. Guided by the PRISMA protocol, this review systematically analyzed literature retrieved from two major academic databases Web of Science and Scopus using the keywords "best teaching practices," "teacher competence," "electrical and electronic education," and "teaching strategies." The review concentrated on journal articles released in 2025, yielding 27 primary studies that fulfilled the inclusion criteria. Thematic synthesis revealed three principal themes: (1) Technology-Enhanced Pedagogical Innovations and Learning Tools**,** emphasizing simulation-based, AI-driven, and interactive teaching environments; (2) Digital Literacy, Information Literacy, and Online Learning Environments**,** highlighting the role of digital competence and virtual learning ecosystems in improving instructional quality; and (3) Teacher Professional Development, Curriculum Reform, and Socio-Cultural Dimensions, focusing on reflective practice, gender responsiveness and cultural adaptability in technical education. The results show that there is a strong global push to combine digital and socio-constructivist methods to improve teacher competence, even though there are still some methodological and contextual issues. This review concludes that developing teacher competence in electrical and electronic education requires a holistic framework that bridges technology, pedagogy, and cultural context. The synthesized evidence contributes to advancing policy, curriculum innovation, and teacher education programs, offering a comprehensive foundation for future research and practice in Technical and Vocational Education and Training (TVET).

Keywords: Best Teaching Practices; Teacher Competence; Electrical and Electronic Education; Teaching Strategies.

INTRODUCTION

As technology changes quickly and electrical and electronic systems become more complicated, the need for highly skilled teachers in technical education has grown. As industries move toward digital transformation, teachers in electrical and electronic fields have become crucial not only for teaching basic concepts but also for giving students the skills they need to thrive in the digital age. This context underscores the necessity for continuous professional development and the adoption of innovative teaching practices that align with technological advancements and industry expectations. Recent studies emphasize that teacher competence in these domains is a fluid construct, influenced by technological proficiency and pedagogical flexibility. As a result, finding and sharing the best ways to teach is a top priority for schools and policymakers (Adăscăliței et al., 2021; Appiah-Okyere et al., 2023).

Even though teacher competence is widely acknowledged as crucial, educators in electrical and electronic education continue to encounter enduring challenges. The speed at which technology changes is often faster than what traditional teacher training programs can keep up with. The result leads to gaps in digital literacy, new ways of teaching, and the effective use of new tools in the classroom. Teachers have to deal with the challenges of

using digital tools, managing different types of classrooms, and meeting the changing needs of their students. Furthermore, the necessity for updated pedagogical skills is compounded by contextual factors such as resource limitations, varying levels of institutional support, and the need for culturally responsive teaching strategies (Avci & Pedersen, 2023; Munje & Jita, 2020; Nurhidayat et al., 2024).

This report aims to consolidate the most recent research on optimal teaching practices to improve teacher proficiency in electrical and electronic education, emphasizing empirical evidence and novel methodologies. This review looks at recent studies, proven frameworks, and new trends in a critical way to give teacher educators, curriculum designers, and policymakers useful information. The scope encompasses both pre-service and in-service teacher development, with particular attention to the integration of digital tools, the impact of personal and contextual factors, and the identification of research gaps that warrant further exploration (Cui et al., 2024; Tanak, 2020).

In summary, the changing world of electrical and electronic education needs a deeper understanding of what makes a good teacher one that connects theory with practice and is able to deal with the problems that come with new technology. This report aims to enhance this understanding by providing a thorough review of recent research, emphasizing both the advancements achieved and the domains requiring additional innovation and inquiry.

LITERATURE REVIEW

Recent literature concerning teacher competence in electrical and electronic education is based on the application and adaptation of integrated digital competence frameworks. DigCompEdu, TPACK, and SAMR are popular models because they can help teachers improve their digital and technical skills by defining, measuring, and helping them do so. These frameworks emphasize core dimensions, including technological proficiency, pedagogical adaptability, and professional engagement, and have been operationalized through validated instruments such as the DigCompEdu Check-In and Mini-21. Nonetheless, everyone agrees that the best way to improve competence is to take a holistic approach that includes knowledge, skills, and attitudes, along with ongoing, practice-based training (Gao et al., 2024; González-Medina et al., 2025; Gümüş & Kukul, 2023; Skantz-Åberg et al., 2022; Vuorikari et al., 2025).

The influence of personal and contextual factors on teacher competence development is a recurring theme in recent studies. Although age and gender are not consistently significant predictors, attitudes towards technology, vocational specialization, and self-efficacy exert a more pronounced influence. For example, men pre-service educators frequently exhibit greater technical self-efficacy, whilst older female educators may necessitate specific assistance to bolster their confidence in ICT utilization. Contextual variables, including instructional experience, availability to digital technologies, and institutional support, further influence competence development. These results show that we need different ways to help professionals grow that deal with both individual and systemic barriers, especially in places with limited resources or a lot of different cultures (Agonas et al., 2024; Hidayat et al., 2024; Mulyanti et al., 2024; Šabić et al., 2022).

There is a lot of evidence that shows a variety of effective teaching methods that can help teachers become better at teaching electrical and electronic subjects. Research has shown that blended learning models, which integrate face-to-face instruction with online laboratories, simulation tools, and collaborative projects, enhance both teacher and student outcomes. Gamification and the use of 3D-printed models, when integrated with constructivist learning theory, foster greater engagement, motivation, and knowledge construction. According to several studies (Adăscăliței et al., 2021; Kalenskyi et al., 2025; Lapisa et al., 2025; Listiani et al., 2023; López et al., 2024; Lu & Li, 2025; Samantray et al., 2024; Zaker et al., 2024), project-based, problem-based, and inquiry-based learning approaches are especially effective in connecting theory and practice. Additionally, ICT-integrated pedagogy helps produce high-quality teachers who can handle complex technical content.

Recent study shows that using modern technology like augmented reality (AR), virtual reality (VR), and digital media in teacher training programs is a big trend. Research indicates that focused professional development in AR/VR not only augments teachers' technological competencies but also bolsters their confidence and pedagogical approaches. Self-directed learning strategies, bolstered by digital media, have demonstrated efficacy in enhancing pedagogical abilities and satisfaction among pre-service educators. However, for technology to

work well, it needs a lot of support, such as access to resources, support from the institution, and continual training that is suited to the needs of the people and the situation (Ikram et al., 2021; Jelovica et al., 2023; Liu, 2025; Marques & Pombo, 2021; Salmaini et al., 2025; Surpare et al., 2024; Tanak, 2020).

Even with these improvements, there are still big gaps in the literature. There is an urgent necessity for enhanced qualitative and contextually relevant research that tackles specific issues, including deficiencies in ICT infrastructure and cultural obstacles. Current digital competency frameworks, albeit beneficial, may unintentionally limit teacher autonomy by encouraging standardized, technology-focused methodologies. Subsequent research ought to concentrate on formulating adaptable models that enable educators to tailor best practices to their specific circumstances, incorporate emerging technology, and promote professional participation. To make sure that teachers' knowledge of electrical and electronic education stays up to date with the needs of a technology landscape that is evolving quickly, these gaps must be filled (Alptekin & Taneri, 2025; Dijju et al., 2025; Horváth et al., 2025; McGarr, 2024; Nurhidayat et al., 2024).

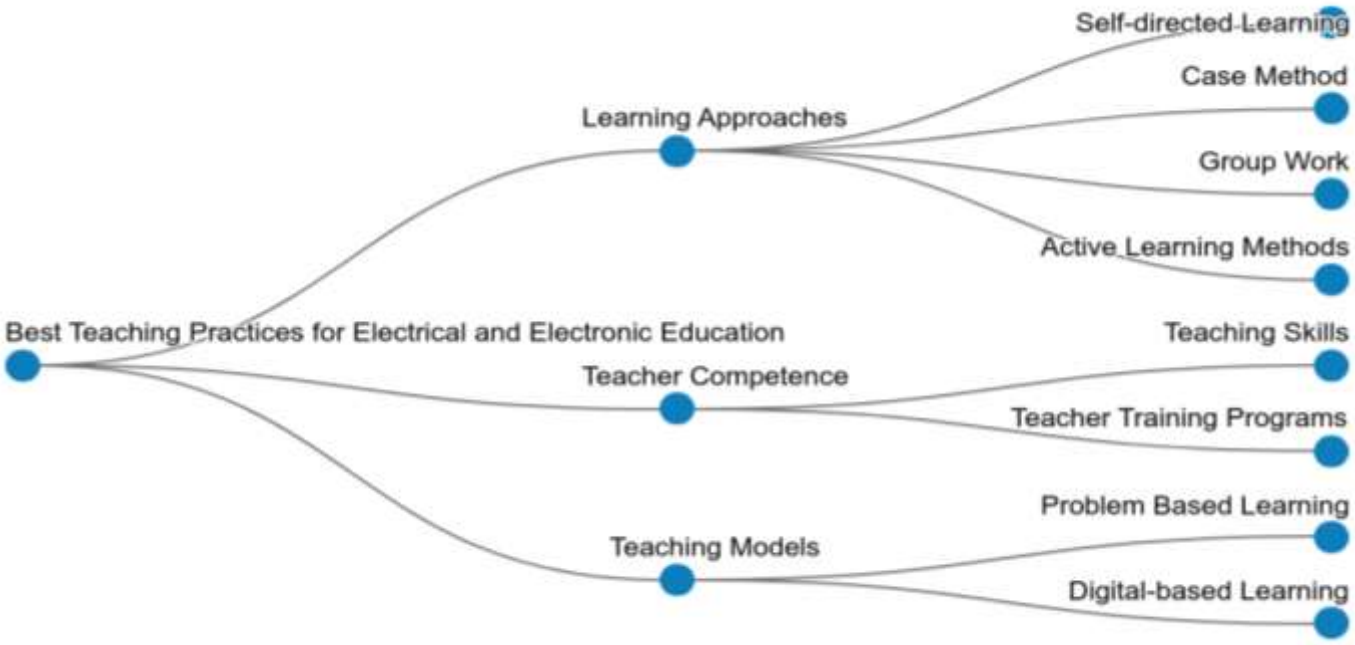

Figure 1: A Conceptual Map of Literature on Best Teaching Practices for Enhancing Teacher Competence in Electrical and Electronic Education.

Figure 1 is a concept map that shows how the parts of Best Teaching Practices for Enhancing Teacher Competence in Electrical and Electronic Education fit together. It focuses on three main areas: learning approaches, teacher competence, and teaching models. These are the building blocks for improving vocational education. The Learning Approaches domain stresses a number of active, student-centered methods, such as self-directed learning, the case method, group work, and active learning strategies. All of these methods encourage student participation, critical thinking, and working together. These methods teach students how to take charge of their learning, which helps them learn how to work with others and solve problems, both of which are important in technical and engineering settings. The goal of the teacher competence domain is to improve teachers and enhance teacher training programs. This area makes sure that teachers have the right technical skills, pedagogical knowledge, and reflective practices to give their students meaningful learning experiences. This professional development not only improves teaching, but it also helps teachers get used to new technology in the classroom and changes in the job market. The Teaching Models domain, on the other hand, is all about digital-based learning and problem-based learning (PBL). This aspect shows how experiential and technology-based teaching methods can work together to prepare students for real-life situations. By giving kids real-world problems to solve, PBL helps them think creatively and analytically. Digital-based learning, on the other hand, uses technology to make learning easier and more fun. The concept map shows that the best ways to teach electrical and electronic subjects need a mix of new ways to learn, ongoing training for teachers, and flexible teaching models. Putting these things together creates a dynamic learning environment that helps students become more creative, technically skilled, and ready for the needs of today's industries. It also makes teachers

better at their jobs. This paradigm ultimately endorses the notion that vocational education can transform lives by equipping individuals to become proficient educators and learners.

Figure 1 presents a concept map illustrating the interconnected components of Best Teaching Practices for Enhancing Teacher Competence in Electrical and Electronic Education, focusing on three main areas: Learning Approaches, Teacher Competence, and Teaching Models, as the basis for making vocational education better. The Learning Approaches domain emphasizes diverse active and student-centered methodologies, including self-directed learning, the case method, group work, and active learning techniques, all of which foster learner engagement, critical thinking, and collaboration. These methods help students learn to take charge of their own learning, which is important for developing problem-solving and teamwork skills that are important in technical and engineering settings. The Teacher Competence domain is all about making teachers better at their jobs and making sure that teacher training programs work. This means that teachers need to have the right pedagogical knowledge, technical skills, and reflective practices to give students meaningful learning experiences. This professional growth not only makes lessons better, but it also helps teachers adapt to new technologies and changes in the job market. The Teaching Models domain, on the other hand, focuses on problem-based learning (PBL) and digital-based learning. This shows how experiential and technology-driven teaching methods can work together to get students ready for real-world situations. PBL fosters analytical and creative thinking through real-world problem scenarios, whereas digital-based learning utilizes technology to improve interactivity and accessibility. The concept map shows that the best ways to teach electrical and electronic subjects are to use a mix of new learning methods, ongoing teacher training, and flexible teaching models. Putting these things together makes a dynamic learning environment that not only makes teachers better at their jobs, but also helps students become more creative, more technically skilled, and more ready for the demands of modern industry. In the end, this framework supports the idea that vocational education can change the world by training teachers and students who are ready for the future.

Research Question

Research questions are very important for a systematic literature review (SLR) because they set the stage and point the review process in the right direction. They set the boundaries and focus, deciding which studies should be included or left out so that the review stays accurate and on topic. Defined research questions enable a thorough and methodical literature review that includes all relevant studies related to essential components of the research domain, thereby reducing bias and ensuring a comprehensive grasp of the existing evidence. They also give you a way to organize, sort, and combine data from the chosen studies, which makes it easier to draw meaningful conclusions. Defined research questions improve focus and coherence, eliminating ambiguity and keeping the review focused on specific, actionable issues. They also clarify and simplify things so other researchers can repeat the review process or build on it in related fields. In the end, research questions make sure that the review meets its main goals, which could be to identify research gaps, see how well interventions work, or look at new trends that are the basis of a strong and trustworthy systematic literature review.

Defining research questions (RQs) is the most important part of planning an SLR because it sets the tone for the whole review process (Kitchenham, 2007). The main goal of the SLR in this study is to find and look at the current state of research in the chosen field. The PICo framework, a mnemonic method developed by Lockwood et al. (2015) and frequently employed in qualitative research, was utilized to systematically formulate research questions. PICo stands for three important parts:

1. Population (P): The target group or participants under investigation, such as a specific demographic or community.

2. Interest (I): The central phenomenon or aspect being explored, which may include experiences, behaviors, or interventions.

3. Context (Co): The environment or setting in which the study occurs, encompassing geographical, cultural, or institutional conditions.

By applying the PICo framework, research questions are structured systematically, ensuring clarity, focus, and precision. This structured approach enables comprehensive literature searching and supports the development of

well-defined, focused questions that underpin the SLR process. Based on this framework, the present study formulated the following research questions:

RQ1: How do teachers in Electrical and Electronic Education implement technology enhanced pedagogical innovations and learning tools to enhance their teaching competence in delivering Electrical and Electronic subjects?

RQ2: What is the relationship between teachers' levels of digital literacy and information literacy and their use of online learning environments with their teaching competence in Electrical and Electronic Education?

RQ3: In what ways do teacher professional development, involvement in curriculum reform, and socio-culturally responsive teaching practices influence the teaching competence of teachers in Electrical and Electronic Education?

MATERIAL AND METHODS

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, created by Page et al. (Page et al., 2021), is a globally accepted standard for doing a systematic literature review. It makes sure that the review process is clear, complete, and consistent in terms of methodology. Following the PRISMA guidelines makes research synthesis more accurate and thorough by giving researchers a structured way to find, screen, and choose studies that are relevant. The framework stresses the need for randomized studies to reduce bias and make the evidence base stronger. This study employed two prominent and reputable databases, Web of Science and Scopus, owing to their extensive coverage and academic integrity.

The PRISMA process has four steps that are done in a set order: identification, screening, eligibility, and data abstraction. During the identification stage, pertinent studies are extracted from designated databases. The screening stage uses pre-set rules to find research that isn't useful or isn't good enough. During the eligibility stage, the remaining studies are carefully examined to make sure they meet the requirements for inclusion. Finally, the data abstraction stage is all about getting useful data from the chosen studies, putting it in order, and combining it to draw useful conclusions. This structured and open method makes sure that the review is done with academic rigor, which leads to trustworthy results that can help with future research and professional practice.

Identification

Based on the PRISMA framework, the *identification* stage represents a critical foundation for ensuring comprehensiveness and credibility in the Systematic Literature Review (SLR) process. In this study, two authoritative academic databases Scopus and Web of Science were strategically selected due to their extensive indexing of high-impact, peer-reviewed journals across disciplines relevant to education and technical-vocational research. Using well-defined keywords such as "Best Teaching Practices," "Teacher Competence," "Electrical and Electronic Education," and "Teaching Strategies," a meticulous search strategy was implemented. The Scopus search yielded 4881 records, while the Web of Science database identified 2463 records. This disparity is common, as Scopus tends to have broader coverage of conference papers and regional publications, whereas Web of Science maintains a more selective index of high impact journals. Collectively, these results reflect the robustness of the search process and reinforce the validity of the review's foundation.

Beyond the numerical data, the large volume of identified records indicates the growing scholarly interest in effective teaching strategies and competency enhancement within the context of technical and vocational education. This aligns with global trends emphasizing evidence-based teaching and the professionalization of vocational educators, particularly in fields like electrical and electronic education where pedagogical innovation is essential for technological adaptation. The use of two complementary databases minimizes publication bias and ensures inclusivity of diverse educational perspectives. This identification phase not only guarantees methodological rigor but also enhances the review's representativeness, enabling subsequent screening and synthesis stages to be anchored in a thorough and reliable evidence base that embodies both theoretical progress and practical pedagogical implementations.

Table 1: Search strings from the Scopus and WOS database.

Scopus	TITLE-ABS-KEY ((Teach* OR Practice* OR "Best Practice") AND (Teacher OR Lecturer OR Tutor OR Educator) AND (Competence OR Knowledge OR Skill OR Attitude) AND (Electrical OR Electronic OR "Electrical and Electronic")) AND (LIMIT-TO (PUBYEAR , 2025)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English")) **Date of Access: November 2025**
WoS	(Teach* OR Practice* OR "Best Practice") AND (Teacher OR Lecturer OR Tutor OR Educator) AND (Competence OR Knowledge OR Skill OR Attitude) AND (Electrical OR Electronic OR "Electrical and Electronic") (Topic) and 2025 (Publication Years) and Article (Document Types) and English (Languages) **Date of Access: November 2025**

Screening

The *screening phase* represents the second and most crucial step in the PRISMA framework, aimed at refining the pool of studies to ensure only the most relevant, high-quality research is included in the systematic review. Following the initial identification of 7344 records from Scopus and Web of Science, a rigorous screening process was implemented based on predefined inclusion and exclusion criteria. Records were carefully evaluated to exclude non-English publications, studies published before 2025, and materials categorized as conference papers, book chapters, review articles, or in-press manuscripts, resulting in the removal of 7105 records. Additionally, 39 duplicate records were identified and excluded to prevent data redundancy. After this meticulous process, 239 eligible records remained comprising 141 from Scopus and 98 from Web of Science which represent a focused and credible subset of the literature for in-depth analysis. This stringent filtering ensures that the review is grounded in scholarly works with verified peer-review standards, high methodological quality, and direct relevance to the research objectives.

Beyond the numerical reduction, this phase underscores the importance of methodological transparency and academic rigor in maintaining the integrity of the review. Excluding non-English and non-journal sources, though seemingly restrictive, is justified to maintain consistency in language interpretation, terminological accuracy, and citation reliability, as English remains the dominant medium in global academic communication. Similarly, filtering out older and non-peer-reviewed materials ensures that the dataset reflects current trends, pedagogical innovations, and empirical findings aligned with 21st-century TVET and educational practices. The careful balance between inclusivity and selectivity achieved in this screening stage enhances the credibility and replicability of the review, providing a strong foundation for subsequent eligibility and synthesis processes that will yield a comprehensive understanding of best teaching practices in electrical and electronic education.

Table 2: The selection criterion for searching.

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2025	< 2025
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press
Subject	Social Science, Engineering	Besides Social Science, Engineering

Eligibility

The eligibility phase represents a pivotal stage in the PRISMA process, where the initially screened studies undergo a more rigorous assessment to confirm their relevance and suitability for inclusion in the qualitative synthesis. From the 239 screened records, 200 full text articles were accessed for eligibility evaluation. During this process, 173 articles were excluded for several reasons, including being outside the research field, having titles that lacked alignment with the study's focus, abstracts that were not related to the research objectives, or limited accessibility to the full text. Such exclusions are justified as they uphold the methodological integrity of the review, ensuring that only studies with direct relevance, conceptual alignment, and accessible data are considered. This meticulous filtering phase enhances the coherence of the review and safeguards against

potential distortions arising from irrelevant or incomplete studies, thereby strengthening the validity and credibility of the synthesized findings.

Beyond the statistical outcomes, the eligibility process underscores the importance of conceptual precision and contextual relevance in systematic reviews, especially within the educational domain. Excluding studies that fall outside the scope or lack substantive contributions to the theme of best teaching practices and teacher competence to ensures that the final dataset comprising 27 high-quality studies represents the most empirically robust and contextually pertinent evidence. This step also reflects an intentional focus on studies that not only discuss teaching strategies in general but specifically address the dynamics of instructional excellence within electrical and electronic education. By applying such stringent criteria, this review positions itself to generate findings that are both academically rigorous and practically meaningful, contributing to the advancement of knowledge and the development of effective pedagogical models within the TVET context.

Data Abstraction and Analysis

An integrative analysis approach was employed in this study as a key analytical strategy to examine and synthesise a diverse range of qualitative research designs. The primary objective was to identify central themes and subthemes that emerged across studies related to best teaching practices and teacher competence. The analytical process began with data collection, marking the initial stage of theme development. As illustrated in Figure 2, the authors conducted an in-depth review of 27 selected publications, extracting statements, evidence, and conceptual insights that aligned with the focus of the current study. Each study's methodology and key findings were critically examined to assess their contribution and relevance to the overarching research objectives. To ensure methodological integrity, the authors worked collaboratively to establish themes grounded in empirical evidence, ensuring alignment between the data and theoretical underpinnings of the review.

Throughout the analytical process, an audit trail or logbook was maintained to document reflections, analytical decisions, and interpretive insights, which enhanced the study's transparency and replicability. This reflexive documentation allowed the researchers to track emerging ideas, address ambiguities, and ensure consistency during data interpretation. Collaborative validation among co-authors was conducted to mitigate bias, ensuring that theme generation was both systematic and evidence-driven. Any discrepancies in conceptual interpretation were discussed and resolved through consensus, reinforcing the reliability and coherence of the thematic structure. This iterative and reflective process underscores the academic rigor of the integrative analysis, ensuring that the resulting synthesis provides a comprehensive, credible, and contextually relevant understanding of pedagogical excellence and teacher competence within vocational education

Table 3: Number and details of primary studies database.

PS	Authors	Title	Year	Source title	Scopus	WoS
1	Tselegkaridis, S. et al. (Tselegkaridis et al., 2025)	Educators' intention to use tangible and graphical experimentation with Arduino and Micro:bit	2025	Discover Education	/	
2	Rodriguez-Gomez, A. et al. (Rodriguez-Gomez et al., 2025)	How to teach frequency response easily to chemical engineers using spreadsheets	2025	Education for Chemical Engineers	/	/
3	Kuang, Y., & Duan, B. (Kuang & Duan, 2025)	Evidence-Based Curriculum Reform: A Data-Driven Framework for Educational Planning and Governance in China	2025	Journal of Chinese Political Science	/	/
4	Aitymova, A. et al. (Aitymova et al., 2025)	Designing An Intelligent System For Personalized Development Of Graphomotor Skills In Preschool Children Based On Analysis Of Deviations From The Standard	2025	Eastern-European Journal of Enterprise Technologies	/	
5	Endryansyah, E. et al. (Endryansyah et al., 2025)	Utilization of Automation Studio Software to Improve the Creative Thinking Abilities of Electrical Engineering Students in Designing Electropneumatic Circuits	2025	Journal of Engineering Education Transformations	/	

6	Leshabane, E. T. et al. (Leshabane et al., 2025)	Teachers' Perspectives on the Implementation of E-Learning in Secondary Schools of Gauteng Province, South Africa	2025	International Journal of Learning, Teaching and Educational Research	/	
7	Ntetha, Z., & Taole, M. J (Ntetha & Taole, 2025)	Factors Influencing Workforce Development of TVET Graduates: A Case Study of Electrical Engineering Students in a TVET College in South Africa	2025	Journal of Technical Education and Training	/	/
8	Olarinde, A. J., & Garcio-Quismondo, M. A. M. (Olarinde & Garcio-Quismondo, 2025)	Information Literacy in the Context of Electronic Learning in India: A Phenomenographic Study	2025	International Journal of Media and Information Literacy	/	
9	Tian, D. et al. (Tian et al., 2025)	"A multi-pronged teaching" approach: Effects of the "IMAGE" teaching mode on the learning of evidence-based practice by nursing postgraduates	2025	Nurse Education Today	/	
10	Yu, L. et al. (Yu et al., 2025)	Factors affecting middle school students' information literacy in the internet plus education environment	2025	Journal of Computers in Education	/	
11	Mat, H. et al. (Mat et al., 2025)	Need analysis: development of a teaching module for enhancing higher-order thinking skills of primary school students	2025	International Journal of Evaluation and Research in Education	/	
12	Erdawati, E. et al. (Suryoputro & Hikmat, 2025)	Impact of The Integration of Generative AI-Automatic Corrective Feedback on Academic Writing Skills	2025	International Journal of Learning, Teaching and Educational Research	/	
13	Alqahtani, R. N., & Almassaad, A. Z. (Alqahtani & Almassaad, 2025)	The Effect of a training program based on the (TAWOCK) model for teaching computational thinking skills on teaching self- efficacy among female computer teachers	2025	Education and Information Technologies	/	
14	Tomar, A. S. et al. (Tomar et al., 2025)	Learning face super-resolution through identity features and distilling facial prior knowledge	2025	Expert Systems with Applications	/	
15	Ellederová, E., & Denysenko, V. (Ellederová & Denysenko, 2025)	Students' and Teachers' Attitudes Towards CLIL in the Interdisciplinary Study Program English in Electrical Engineering and Informatics	2025	TESL-EJ	/	
16	ElSayary, A., & Mohebi, L. (ElSayary & Mohebi, 2025)	Fostering preservice teachers socio-emotional, technological, and metacognitive knowledge (STM-K) using e-portfolios	2025	Education and Information Technologies	/	
17	Canet, M. et al. (Canet et al., 2025)	Helping First-Year University Students to Overcome the Threshold Concept of Ohm's Law	2025	IEEE Transactions on Education	/	
18	Saraç, S. et al. (Saraç et al., 2025)	Learning to support self-regulation: empowering preschool teachers through understanding by design and blended learning	2025	Teacher Development	/	
19	Zhang, A. (Zhang, 2025)	Human Computer Interaction System for Teacher-Student Interaction Model Using Machine Learning	2025	International Journal of Human-Computer Interaction	/	
20	Tomášková, T. et al. (Tomášková et al., 2025)	Innovative Approach to Teaching Sustainable Development at Teacher Training College Through Project for Secondary Use of Recycled Electrical Materials †	2025	Engineering Proceedings	/	

21	Widiawati, H. et al.(Widiawati et al., 2025)	The Effectiveness of Electronic Use of Moodle-Assisted Modules in Student Numeracy Literacy Learning	2025	International Journal of Information and Education Technology	/	
22	Nurbekova, G. et al. (Nurbekova et al., 2025)	The Use of Information Technology in Preparation for International Educational Research	2025	International Journal of Information and Education Technology	/	
23	Balogun, M. et al. (Balogun et al., 2025)	Acceptability, facilitators and barriers to video-based learning at a community health officers' training school in Nigeria	2025	Health Professions Education	/	
24	Chaouqui, M. et al. (Chaouqui et al., 2025)	The level of cognitive and behavioral representation gender consideration among trainee teachers in Morocco	2025	Frontiers in Education	/	/
25	Abenir, M. A. D. et al. (Abenir et al., 2025)	Elevating Community Voices to Reexamine Student Cultural Sensitivity and Adaptability in Electronic Service-Learning (e-SL)	2025	Journal of Higher Education Outreach and Engagement	/	
26	Al-Barakat, A. A. et al. (Al-Barakat et al., 2025)	Evaluating the Effectiveness of Electronic Games-Based Learning in Enhancing Children's Multiplication Skills and Cognitive Achievement	2025	International Journal of Information and Education Technology	/	
27	Marwan, A., & Wahyudi, W. (Marwan & Wahyudi, 2025)	Examining Users' Voices of Cambridge Online Learning as A Medium for English Language Learning	2025	Educational Process: International Journal	/	

Quality Of Appraisal

According to the guidelines proposed by Kitchenham and Charters , after identifying and selecting the primary studies that is, original research articles directly included in the systematic review as the main sources of evidence it is essential to evaluate their quality and perform a quantitative comparison. In this study, the quality assessment framework developed by Anas Abouzahra et al. (Abouzahra et al., 2020) was adopted, which comprises six quality assessment criteria (QA1–QA6) specifically designed for systematic literature reviews. Each criterion was rated using a three-level scoring system: "Yes" (Y) with a score of 1 when the criterion is fully satisfied, "Partly" (P) with a score of 0.5 when the requirement is partially met but presents some limitations, and "No" (N) with a score of 0 when the criterion is not addressed. This structured evaluation ensures consistency, transparency, and objectivity in assessing the methodological rigor of the selected studies.

QA1. Is the purpose of the study clearly stated?

QA2. Is the interest and the usefulness of the work clearly presented?

QA3. Is the study methodology clearly established?

QA4. Are the concepts of the approach clearly defined?

QA5. Is the work compared and measured with other similar work?

QA6. Are the limitations of the work clearly mentioned?

Table 4 presents the quality assessment (QA) process utilized to evaluate each study based on a set of predefined criteria. Three independent experts reviewed and rated the studies using these criteria, assigning scores of "Yes" (Y), "Partly" (P), or "No" (N) to indicate the extent to which each criterion was met. The individual assessments were then aggregated to obtain a total score representing the overall quality of each study. To qualify for inclusion in the subsequent stage of analysis, a study needed to achieve a total score greater than 3.0, which serves as the minimum quality threshold. This benchmark ensures that only studies demonstrating sufficient methodological rigor and clarity proceed to the next phase of the systematic review process.

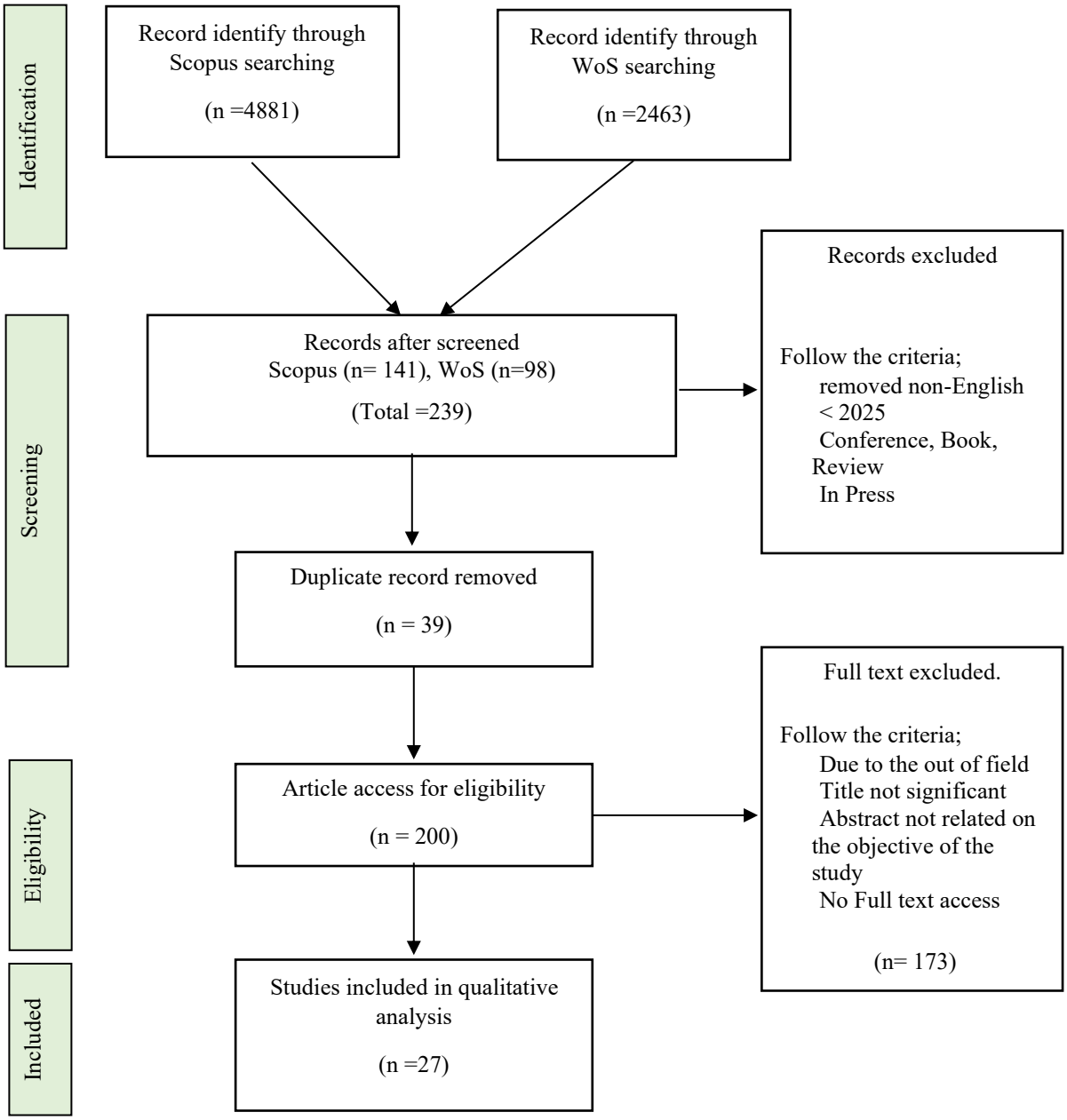

Figure 2: Flow diagram of the proposed searching study (Moher D, Liberati A, Tetzlaff J, 2009)

RESULT AND DISCUSSION

Based on the results presented in Table 4, the overall quality of the 27 reviewed studies indicates a moderate to high level of methodological soundness**.** Most papers clearly stated their research purpose (QA1) and demonstrated relevance and usefulness (QA2), reflecting well-defined objectives and contributions to the educational field. However, fewer studies provided comprehensive methodological descriptions (QA3) or explicitly defined theoretical and conceptual frameworks (QA4). Only a limited number of studies, particularly PS14 and PS17, demonstrated stronger rigor by including comparative analyses or benchmarking against existing research (QA5), achieving the highest overall scores of 75%.

Despite this, a consistent limitation across most papers was the absence of clearly stated research limitations (QA6), which affects the transparency and reproducibility of findings. The majority of articles scored between 58.3% and 66.7%, suggesting that while the studies contribute valuable insights, they often lack depth in methodological explanation and critical reflection. Overall, the dataset reflects promising scholarly engagement in teaching and learning research, yet highlights the need for stronger methodological articulation, comparative validation, and explicit acknowledgment of study limitations in future publications. Here is the quality assessment table for the selected papers, assessed based on the QA1–QA6 criteria and the scoring rubric (Yes = 1, Partly = 0.5, No = 0):

Table 4: Quality Assessment of Selected Studies in the Systematic Literature Review (QA1–QA6)

Paper ID	QA1	QA2	QA3	QA4	QA5	QA6	Total Score	Percentage (%)
PS1	Y	Y	Y	P	N	N	3.5	58.3
PS2	Y	Y	P	P	P	N	3.5	58.3
PS3	Y	Y	Y	P	P	N	4.0	66.7
PS4	Y	Y	P	P	P	N	3.5	58.3
PS5	Y	Y	Y	P	N	N	3.5	58.3
PS6	Y	Y	Y	Y	N	N	4.0	66.7
PS7	Y	Y	Y	P	N	N	3.5	58.3
PS8	Y	Y	Y	P	N	N	3.5	58.3
PS9	Y	Y	Y	P	N	N	3.5	58.3
PS10	Y	Y	Y	P	N	N	3.5	58.3
PS11	Y	Y	Y	P	N	N	3.5	58.3
PS12	Y	Y	Y	P	N	N	3.5	58.3
PS13	Y	Y	Y	P	N	N	3.5	58.3
PS14	Y	Y	Y	P	Y	N	4.5	75.0
PS15	Y	Y	Y	P	N	N	3.5	58.3
PS16	Y	Y	Y	Y	N	N	4.0	66.7
PS17	Y	Y	Y	Y	P	N	4.5	75.0
PS18	Y	Y	Y	P	N	N	3.5	58.3
PS19	Y	Y	Y	P	N	N	3.5	58.3
PS20	Y	Y	P	P	N	N	3.0	50.0
PS21	Y	Y	Y	P	N	N	3.5	58.3
PS22	Y	Y	Y	P	N	N	3.5	58.3
PS23	Y	Y	Y	P	N	N	3.5	58.3
PS24	Y	Y	Y	P	N	N	3.5	58.3
PS25	Y	Y	Y	P	N	N	3.5	58.3
PS26	Y	Y	Y	P	N	N	3.5	58.3
PS27	Y	Y	Y	P	N	N	3.5	58.3

Technology-Enhanced Pedagogical Innovations and Learning Tools

Across the selected studies, technology-enhanced pedagogical innovations consistently show positive influence on learning performance, engagement, and the development of key competencies. Simulation-based and digital tools support complex learning tasks in ways that conventional methods struggle to provide. For instance, Arduino and Micro:bit experimentation was found to depend strongly on perceived usefulness and attitudes for educators' intention to integrate these tools into classroom practice (Tselegkaridis et al., 2025). Spreadsheet-based simulation in Process Dynamics enabled chemical engineering students to construct and use their own frequency-response simulators, leading to faster and clearer understanding of core concepts than traditional approaches (Rodriguez-Gomez et al., 2025). Similarly, Moodle-assisted e-modules significantly improved numeracy literacy and were perceived as engaging and motivating for primary pupils, indicating that structured digital environments can raise achievement and sustain interest in foundational skills (Widiawati et al., 2025).

Several interventions concentrate specifically on strengthening domain-specific conceptual understanding and overcoming misconceptions. In electrical engineering education, a flipped classroom design focusing on Ohm's law successfully identified 16 common misconceptions and proposed 11 good practices that improved conceptual change and metacognition among first-year university students (Canet et al., 2025). Spreadsheet-based Simulation Case Study-Based Learning similarly supported deeper comprehension of frequency-response behaviour in process systems, enabling students to undertake analyses that are normally time-consuming using traditional methods (Rodriguez-Gomez et al., 2025). Electronic games-based learning also enhanced children's multiplication skills and cognitive performance, with game environments making abstract mathematical ideas more concrete and enjoyable (Al-Barakat et al., 2025). Together, these results suggest that interactive tools can address conceptual thresholds and persistent misconceptions in both mathematics and engineering-related domains (Canet et al., 2025); (Rodriguez-Gomez et al., 2025); (Al-Barakat et al., 2025).

A second cluster of studies highlights the role of technology in developing higher-order thinking, creativity, and advanced professional competences. Automation Studio simulations in electropneumatic circuit design produced substantial gains in electrical engineering students' creative thinking and design skills, with marked increases in both achievement and performance indicators (Endryansyah et al., 2025). A need analysis on electrical topics in primary science found that teachers face serious difficulties in teaching higher-order thinking skills and recommended the development of targeted modules to nurture critical and problem-solving skills (Mat et al., 2025). In postgraduate nursing education, the IMAGE multi-pronged teaching mode significantly elevated academic performance, evidence-based practice competence, critical thinking, cooperative ability, and course satisfaction compared to traditional teaching (Tian et al., 2025). In a related way, generative AI based automatic corrective feedback improved multiple dimensions of academic writing quality, including cohesion, coherence, grammatical accuracy, and lexical range, indicating that well-designed AI feedback can support cognitive, behavioural and affective aspects of skill development (Suryoputro & Hikmat, 2025). These findings collectively position technology as a catalyst for higher-level cognitive and professional capabilities in different disciplines (Endryansyah et al., 2025); (Mat et al., 2025); (Tian et al., 2025); (Suryoputro & Hikmat, 2025).

Personalized and context-specific technological systems also emerge as an important strand in the literature. An intelligent application named "Dexterous Fingers" used real-time mathematical modelling of handwriting trajectories to diagnose deviations from reference samples and to provide individualized tasks, resulting in an increased proportion of preschool children with high graphomotor skill levels and a reduction in low performers (Aitymova et al., 2025). In another specialized context, a teacher–student deep learning framework for face super-resolution successfully preserved facial structure information and outperformed existing methods on benchmark datasets, showing how advanced algorithms can improve the quality of visual data used in human–technology interaction (Tomar et al., 2025). At teacher training college level, project-based work using recycled electronic components to build clocks gave students practical experience of sustainable development and highlighted the potential for integrating environmental responsibility with technical education (Tomášková et al., 2025). These examples show how personalization, intelligent diagnostics, and authentic projects can be embedded into technology-enhanced pedagogy to address very specific learning outcomes (Aitymova et al., 2025); (Tomar et al., 2025); (Tomášková et al., 2025).

Another important dimension concerns user acceptance, contextual constraints, and equity of access. Behavioural intention to use Arduino and Micro:bit depended strongly on perceived usefulness and favourable attitudes, and there was a notable preference for simulated Arduino circuits over physical boards, indicating that ease of use and low entry barriers are crucial for adoption among educators without prior electronics experience (Tselegkaridis et al., 2025). Video-based learning in a community health officers' training school achieved high overall acceptability and was valued for convenience, recall, and reusability, but implementation was constrained by unstable electricity, device shortages, and limited internet connectivity (Balogun et al., 2025). Longitudinal work with Moodle-assisted e-modules similarly reported strong student motivation and sustained numeracy gains, reinforcing the idea that digital platforms can support engagement when adequate infrastructure and support are available (Widiawati et al., 2025). Electronic games-based learning in mathematics also demonstrated positive effects on motivation and conceptual understanding, but required teacher training and locally relevant content to reach full potential (Al-Barakat et al., 2025). Overall, technology-enhanced innovations show consistent benefits for learning and competence, but effectiveness is closely tied to acceptance, training, and material conditions in the educational environment (Tselegkaridis et al., 2025); (Balogun et al., 2025); (Widiawati et al., 2025); (Al-Barakat et al., 2025).

Digital Literacy, Information Literacy and Online Learning Environments

Research on digital literacy, information literacy and online learning environments shows that successful implementation depends strongly on human as well as technological factors. In secondary schools in South Africa, perceived ease of use and computer experience emerged as the strongest predictors of e-learning uptake, with ease of use exerting more influence on acceptance than perceived usefulness, based on a Technology Acceptance Model analysis (Leshabane et al., 2025). A phenomenographic investigation in India showed that information literacy in e-learning is not a single skill, but a complex configuration of critical thinking, technological facility, independent learning, ethical information use and instructional practices, with critical thinking positioned as the central dimension (Olarinde & Garcio-Quismondo, 2025). At the same time, work with ePIRLS electronic assessments in Kazakhstan reported that low digital literacy and limited experience with

electronic resources directly undermined learners' ability to navigate interfaces, execute technical operations and interpret digital texts, leading to frequent errors and weaker outcomes (Nurbekova et al., 2025). Longitudinal research in China further indicated that information literacy is shaped less by teacher demographics and more by students' collaborative skills, problem-solving ability and patterns of technology use in an Internet Plus education environment (Yu et al., 2025). Taken together, these studies stress that conceptual models of information literacy, basic computer proficiency and everyday digital practices are closely intertwined in technology-mediated education (Leshabane et al., 2025); (Olarinde & Garcio-Quismondo, 2025); (Yu et al., 2025); (Nurbekova et al., 2025).

Student-related variables and learning analytics approaches receive considerable attention in several investigations. A two-year follow-up study in western China showed that collaborative skills, problem-solving competence and daily online time had significant positive effects on middle school students' information literacy, while teacher gender, experience and management style showed no positive association, and class size only exerted indirect influence through student behaviour and device use (Yu et al., 2025). In a different context, lack of prior experience with digital tools in Kazakhstan produced substantial difficulties during electronic reading literacy assessments; students struggled to understand test interfaces, to navigate digital texts, and to carry out required computer operations, with these weaknesses clearly linked to lower performance (Nurbekova et al., 2025). Complementing these survey type studies, a machine learning based human computer interaction system for a digital electronics learning environment used neural networks, k-nearest neighbours, binary significance and support vector machines to model student behaviour data, and achieved improved academic success and more accurate identification of support needs when compared with previous datasets (Zhang, 2025). The improved dataset that incorporated a case study method yielded higher repeatability and F1 scores and reduced data loss, suggesting that rich behavioural data in online settings can be exploited to refine teacher-student interaction models and to support intervention design (Zhang, 2025). When these findings are viewed together, a picture appears in which information literacy development is closely associated with patterns of digital engagement, and in which advanced analytics can help diagnose risks arising from limited digital competence (Yu et al., 2025); (Nurbekova et al., 2025); (Zhang, 2025).

The literature also underlines that online platforms can support sustained learning and professional growth, but such benefits depend on user perceptions, design features and local conditions. In South African secondary schools, e-learning adoption was strongly influenced by perceived ease of use and computer proficiency, which indicates that even when infrastructure exists, complex or intimidating systems may remain under-utilised (Leshabane et al., 2025). A qualitative study of Cambridge English online learning with Indonesian vocational university students in electrical and informatics engineering found that the platform was regarded as a powerful tool; learners at different proficiency levels could access varied skill materials and extend English learning beyond limited classroom exposure, while teachers gained additional resources for updating pedagogical skills (Marwan & Wahyudi, 2025). In another national context, practitioners in Indian virtual learning environments described information literacy in terms of critical thinking, independent learning and ethical information handling, pointing towards a need for digital courses that intentionally scaffold these competencies rather than only providing content (Olarinde & Garcio-Quismondo, 2025). Experiences with ePIRLS in Kazakhstan further demonstrated that without systematic preparation in digital navigation and interface understanding, electronic assessments can disadvantage learners and depress achievement (Nurbekova et al., 2025). These converging results suggest that online environments for content learning, language development and assessment are most effective when aligned with users' digital literacy levels, supported by explicit training, and organised to reduce technical barriers (Leshabane et al., 2025); (Olarinde & Garcio-Quismondo, 2025); (Marwan & Wahyudi, 2025); (Nurbekova et al., 2025).

Teacher Professional Development, Curriculum Reform and Socio-Cultural Dimensions

Across the reviewed studies, teacher professional development and curriculum reform in technical and vocational contexts appear closely linked to broader national and institutional goals. In China, a factor-analysis-based framework was used to realign the relationship between courses and graduate attributes, producing a refined support matrix that provides more objective guidance for course design and accreditation in engineering programmes, including Digital Electronic Technology (Kuang & Duan, 2025). In South Africa, a qualitative

case study of a TVET college highlighted serious gaps between the electrical engineering curriculum and labour-market demands, including insufficient practical components and a course duration that is too short to complete outcomes effectively, leading to concerns about workforce readiness and local economic impact (Ntetha & Taole, 2025). In a European interdisciplinary programme that combines English with electrical engineering and informatics, investigation of CLIL practice showed that students and teachers recognise the value of English as a lingua franca for scientific and technical collaboration, but also emphasise the need for flexible instructional strategies and sustained support to handle language demands (Ellederová & Denysenko, 2025). Taken together, these findings suggest that curriculum reform, language policy and practical training structures must be planned as integrated elements of teacher competence and system-level planning (Kuang & Duan, 2025); (Ntetha & Taole, 2025); (Ellederová & Denysenko, 2025).

A strong strand in the literature concerns structured professional development programmes designed to enhance specific dimensions of teacher competence. A quasi-experimental study in Education and Information Technologies reported that an electronic training programme based on the TAWOCK model significantly raised teaching self-efficacy for computational thinking among female computer teachers, with large effect sizes for the total self-efficacy scale (Alqahtani & Almassaad, 2025). In the United Arab Emirates, an exploratory sequential mixed-method design showed that systematic use of e-portfolios, guided by Gibbs' reflective model and supported by initial technology training, fostered socio-emotional, technological and metacognitive knowledge among preservice early childhood teachers; the intervention incorporated opportunities for video-based, automated and visual feedback to scaffold reflection (ElSayary & Mohebi, 2025). A professional development programme for preschool teachers in Turkey, structured around the Understanding by Design framework and delivered through blended learning, resulted in marked improvements in knowledge and classroom practices related to self-regulation, including metacognition, emotion regulation and motivation regulation (Saraç et al., 2025). These interventions indicate that carefully designed training, often technology-supported, can produce measurable gains in teachers' self-efficacy and in classroom-relevant higher-order competences (Alqahtani & Almassaad, 2025); (ElSayary & Mohebi, 2025); (Saraç et al., 2025).

Socio-cultural and equity-related dimensions of teacher competence are also prominent. In Morocco, descriptive-analytical survey research on trainee teachers revealed only an average level of conceptual understanding of gender, with substantial divergence in cognitive perceptions, but at the same time a strong consensus around the importance of gender-responsive practices and classroom behaviours that promote equity (Chaouqui et al., 2025). Community-based inquiry in the Philippines into electronic service-learning practices suggested that students are generally viewed as culturally sensitive, yet community members highlight complex influences on this perception, including the institutional reputation of the university, the limitations of digital platforms compared to face-to-face contact, and the need for nuanced communication skills in online environments (Abenir et al., 2025). Work on CLIL in an engineering-focused English programme similarly identified language barriers for both students and teachers, pointing to the need for more tailored support to ensure that subject learning and language development can proceed together in linguistically diverse cohorts (Ellederová & Denysenko, 2025). These studies collectively stress that professional development in technical and vocational fields must address not only subject and pedagogical knowledge, but also gender awareness, cultural sensitivity and advanced communication competencies that function within specific social contexts (Chaouqui et al., 2025); (Abenir et al., 2025); (Ellederová & Denysenko, 2025).

The reviewed evidence further highlights the role of digital and blended modalities as enabling conditions for contemporary professional development and socio-cultural competence building. In the UAE study, e-portfolios supported continuous reflection, remote collaboration and feedback loops that helped preservice teachers integrate emotional, technological and metacognitive aspects of practice, especially in periods of educational disruption (ElSayary & Mohebi, 2025). The self-regulation programme in Turkey relied on a blended structure, combining synchronous and asynchronous components to address time and location constraints for in-service teachers, and produced durable changes in beliefs about children's capacity for control and in the use of self-regulation strategies (Saraç et al., 2025). In the Philippines, electronic platforms for service-learning enabled continued engagement between students and communities, yet the study also underlined that digital tools cannot fully replace face-to-face interaction and must be balanced with sensitivity to local cultural expectations (Abenir et al., 2025). When considered alongside evidence-based, data-driven curriculum design in China and continuous curriculum revision calls in South African TVET colleges, these cases point towards a model of teacher competence that is deeply connected to digital infrastructures, reflective tools and multi-stakeholder governance

arrangements (Kuang & Duan, 2025); (Ntetha & Taole, 2025); (ElSayary & Mohebi, 2025); (Saraç et al., 2025); (Abenir et al., 2025).

CONCLUSION

This systematic literature review set out to synthesize the most recent research on Best Teaching Practices for Enhancing Teacher Competence in Electrical and Electronic Education through an evidence-based and PRISMA-guided process. The study examined 27 peer-reviewed journal articles published in 2025 from Scopus and Web of Science databases, focusing on three central research questions framed by the PICo model: the integration of technology-enhanced pedagogical innovations, the relationship between digital literacy and teaching competence, and the influence of professional development and socio-cultural dimensions. The inclusion criteria centered on English-language journal articles within the fields of education and engineering, ensuring both methodological consistency and relevance to the evolving landscape of technical and vocational education. The main aim was to identify emerging patterns, frameworks, and best practices that collectively define the contemporary standards for effective teaching in electrical and electronic education while addressing the persistent challenges of digital transformation and pedagogical renewal.

The review revealed three dominant and interrelated themes: Technology-Enhanced Pedagogical Innovations and Learning Tools, Digital and Information Literacy within Online Learning Environments, and Teacher Professional Development, Curriculum Reform, and Socio-Cultural Dimensions. Collectively, the findings highlight a pedagogical shift toward the integration of interactive technologies such as simulation tools, augmented and virtual reality, and artificial intelligence-driven feedback systems that promote active engagement, critical thinking, and creativity. Frameworks such as TPACK and DigCompEdu continue to provide structure for assessing and enhancing teachers' digital competence, yet the review found persistent gaps in methodological rigor and the contextual adaptation of these models. Studies also emphasized the growing importance of digital and information literacy as core components of teacher competence, with online platforms serving as both learning and professional development spaces. Furthermore, evidence from international contexts demonstrated that teacher training programs grounded in reflective, technology-supported, and culturally responsive approaches lead to measurable improvements in self-efficacy, socio-emotional intelligence, and metacognitive capacity. Together, these insights underscore that teacher competence in electrical and electronic education is no longer confined to technical mastery but must integrate digital fluency, pedagogical adaptability, and socio-cultural awareness.

From a broader perspective, this review contributes a synthesized framework that bridges previously fragmented findings and provides a comprehensive model for advancing teacher competence in technical and vocational education. It offers a structured understanding of how technology-enhanced practices, literacy integration, and professional development interact to shape pedagogical excellence. The review also exposes critical research gaps, particularly the scarcity of qualitative, context-sensitive studies addressing local resource constraints, gender perspectives, and cultural dynamics within the teaching profession. Practical implications include guiding policymakers, curriculum designers, and institutional leaders in developing evidence-based teacher training programs that emphasize experiential learning, blended and reflective modalities, and sustained digital competence development. Limitations of this review include the exclusive reliance on English-language sources, a focus on journal articles from 2025, and potential publication bias due to database constraints. Future research should expand the temporal range, incorporate mixed-method meta-syntheses, and explore longitudinal data to track the sustainability of competence development initiatives. Ultimately, conducting systematic reviews of this nature remains vital in shaping an evidence-driven, globally relevant foundation for improving teacher competence in vocational and technical disciplines, ensuring that educators remain adaptive, innovative, and aligned with the rapid technological evolution defining the future of education.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest to report regarding the present study.

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