

Teacher Training in Promoting Technological and Inclusive Teaching Practices: A Systematic Review

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Abstract

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Teachers are required to use technology and to use inclusive pedagogical methods to effectively teach the needs of the 21st century's learners. However, limited research has examined how teacher training programs develop these competencies together. The objective of this systematic review is to draw together empirical evidence from 2015 to 2025 that examines how teacher training influences technology integration and inclusive pedagogy. A qualitative synthesis was conducted on 16 studies, following the PRISMA guidelines. Technological and inclusive teaching skills were shown to be closely related, and in the studies, digital technologies were often used to provide more inclusive and accessible learning spaces. Factors that hindered were resource constraints, lack of infrastructure and resistance to change. The findings highlight the need to include contextual and continuous professional development of teachers in the preparation process in order to develop effective pedagogical applications of technology in inclusive education. The findings indicate that the continuous and the context-specific should be integrated in teacher preparation

in order to foster effective pedagogical use of technology in inclusive education. Future studies should delve into the long-term effects of this training on student outcomes and investigate how new technologies such as AI can aid inclusive education.

Keywords: 21st century skills, Inclusive pedagogy, Professional development, Teacher competency, Teacher training, Technology integration

Introduction

The world is changing and so is education in the 21st century, especially due to technology, globalization, and the growing diversity among students. It is the duty of the teacher to play several roles in today's world rather than just a transmitter of knowledge, such as a facilitator, mentor and guide

to help students develop critical skills for a dynamic and interconnected world. This includes critical thinking, creativity, collaboration and digital literacy, skills that are now essential for students' success in today's education landscape (Darling-Hammond et al., 2017; OECD, 2022). In response, teacher professional development (TPD) has become a lifelong learning process that enables teachers to gain the skills they need to effectively use technology and implement inclusive pedagogical practices for the diversity of learning needs in today's classrooms (AbdulRab, 2023; Ventista et al., 2023).

Good TPD programs that are context-appropriate in content, engaging, and hands-on with digital experiences have proven to build teachers' confidence and competence in integrating digital technologies to support student learning (Amemasor et al., 2025). These programs can include mentoring, Professional Learning Communities, ongoing feedback, and can be skill development or skill application to actual classroom situations. In addition, Effective TPD emphasises inclusivity, which means that teachers are involved in the implementation of differentiated instruction, Universal Design for Learning (UDL) and project-based teaching where everyone participates equally regardless of their abilities and backgrounds (European Agency for Special Needs and Inclusive Education, 2020; Kubacka & D'Addio, 2021).

The impact of TPD is known, but still, there is some void in teachers' training related to the requirements of 21st century classrooms. Even though teachers are not limited in their access to digital tools, access to digital tools does not necessarily mean that teachers will use them in their pedagogical practices, and existing training focuses on use of digital tools rather than pedagogically appropriate use of digital tools to achieve instructional objectives (Zorlu, 2020). Similarly, teacher preparation programs tend to concentrate on the content area to be covered and not consider how to accommodate the needs of diverse students and differentiated instruction. Teachers may therefore be aware of a skill they'd like to teach, but not how to create an environment that is inclusive and student-centered to meet the needs of diverse learners.

Previous systematic reviews and empirical research are focused on technology integration or inclusive teaching separately as separate fields of education, but not as integrated capacities. For example, existing literature on teacher Digital Competence primarily focuses on the development of technological skills without taking into account inclusive practices (Aldunate & Nussbaum, 2020). Similarly, the research on technology assisted inclusive education looks at the enablers and challenges of inclusive education, yet it does not consider these in a systematic approach in terms of the wider outcomes of technology integration. Findings in the studies that used mixed methods and were centered on equity-informed, technology-enhanced teaching and learning often emphasized equity-informed practices but primarily emphasized technology for equity, and not on skills of teachers in digital and inclusive teaching (Wang & Hannafin, 2022). The literature provides limited evidence of research explicitly examining the impact of integrating technology and inclusive pedagogy on teachers' long-term preparedness or student outcomes, leaving a gap for research.

This is especially true in developing countries where technological infrastructure and opportunities for ongoing professional development can be scarce, exacerbating the challenges for implementing inclusive, technology-rich teaching (Hindle, 2007). To this end, research is needed that addresses the potential of teacher training programs to influence teachers' technological competence as well as their inclusive pedagogical competence.

To address this gap, the current study systematically reviews recent literature to examine how teacher preparation programs prepare teachers to effectively integrate technology and to be effective inclusive educators. The study is focused on finding out what strategies are effective for training and what are the barriers to successful implementation. It specifically focuses on the design, delivery and content of TPD programs that can support digital literacy, pedagogical knowledge and inclusion, as well as the extent to which these assist teachers to be ready to face today's challenges in the educational landscape.

The purposes of this study are twofold: one, to analyze the role of teacher training programs in teacher competencies development for technology integration and inclusive pedagogical practices in 21st Century classrooms; and two, to draw the thematic patterns and methodological approaches of the existing research on teacher training programs focused on teacher competencies development for technology integration and inclusive pedagogical practices in 21st Century classrooms. In keeping with these goals, the main research question is: What is the effectiveness of the teacher training programs in preparing teachers for the integration of technology and the implementation of inclusive teaching in the contemporary classroom? Secondary questions provide a means to reflect the major themes that arise from training programs and the approaches to researching 21st-century teacher preparedness, while keeping the review focused on the main concern of improving teacher competencies for 21st-century education.

This study is significant because it combines the examination of technology use and inclusive pedagogy in one study and within teacher preparation programs. The study presents findings from the systematic review of evidence from a wide range of sources, such as pre-service and in-service teacher preparation programs from various countries, and offers insights for optimizing teacher preparation programs to improve teacher effectiveness and student learning. In addition, it asks questions that are relevant to practice and policy, such as the importance of continuous and contextually relevant professional development and mentoring, opportunities to learn collaboratively, and role support for technology integration and inclusivity. These studies can inform the development of teacher educator (TE) programs that are more responsive, equitable, and effective to the needs of 21st century classrooms for pre- and in-service teachers, policymakers, and curriculum developers.

Review of Literature

As the needs of the 21st century classroom changes and evolve, teachers must be highly knowledgeable of the content and how to integrate technology, and be inclusive in their practice. The enhancement of these skills is widely acknowledged as being linked to teacher professional development (TPD) (Darling-Hammond et al., 2017; OECD, 2022). The literature presents however an incomplete picture of how TPD is able to achieve these outcomes, particularly when combined with the incorporation of technology frameworks, such as TPACK, with inclusive practice frameworks, such as Universal Design for Learning (UDL).

Technology Integration and Teacher Training

The results of the empirical research highlight the need for teacher training in the enhancement of digital literacy and the incorporation of technology. For example, Zorlu (2020) found that the use of AI to generate questions can enhance pre-service science teachers' critical thinking and collaborative

skills, and Nurhidayat et al. (2021) pointed out the need of integrating ICT into English as a Foreign Language (EFL) teachers' competencies development in Indonesia. The findings of both studies are positive, but differ in technological tools used, context of intervention, and length of intervention. The study by Zorlu was based on a controlled pre-service sample with a heavily equipped educational context while in-service educators in a developing country were investigated by Nurhidayat et al., and the impact of infrastructural limitations on the effectiveness of in-service training was pointed out. Combining these results indicates that the best way to integrate technology into education is to tailor the intervention to the context, but the evidence of sustained impact after the training period is limited.

The TPACK framework is used here as a lens for understanding the outcomes by highlighting the interactions between the technological, pedagogical and content knowledge. TPACK encouraged the integration of digital tools with curricular goals and ensured that digital technologies were not used as a means to an end, but were used for pedagogically relevant purposes. However, little research has focused on the long-term use of practices and the extent to which technology integration is sustainable in different classroom settings, meeting the high standards of TPACK. There is, however, a lack of research in general that examines the long-term use of the practices and the sustainability of the integration of technology in a variety of classroom contexts, adhering to the high standards set by TPACK.

Teacher Training for Inclusive Pedagogy

Teacher preparation also emphasizes inclusive practices so that teachers will be able to accommodate the diversity of students in the ability, background and learning style of the class in today's classroom. Dewsbury and Brame (2019) analysed STEM education that incorporates a Freirean framework of equity and social inclusion. However, these methods, groups of interest, and measurements vary significantly. Both Dewsbury and Brame (2019) used qualitative classroom observations, while Martinez used mixed methods (surveys, interviews) suggesting the strength of evidence and generalizability varied. Comparative synthesis shows that both methods are conducive to inclusion, but require infrastructure support and the level of participation of the participants, as well as the length of the program.

Multiple means of engagement, representation, and expression, used often in the literature, is a structured approach to inclusive teaching that is featured in UDL. Research shows that the explicit inclusion of UDL principles in conjunction with technology integration helps teachers to make changes to teach students of varying abilities (Hindle, 2007). The long-term effect of UDL on teacher practice and student learning outcomes, however, has not been extensively examined, nor has it been shown to have an effect in environments with limited resources.

Professional Development Models and Implementation Challenges

Professional development models across the studies reviewed ranged from brief workshops to longer, more practice-based, mentoring and peer collaboration models. Several studies have found that teacher training programmes that are delivered over time and that are contextualised and meaningful are more effective in enhancing teachers' competencies, than those delivered in a single session (Whitty, 2020; Amemasor et al, 2025). However, there are a number of drawbacks. Samples are small, selection of participants is often not random, and extraneous variables like previous exposure

to a technology or institutional constraints are not necessarily controlled in the studies. In addition, various issues remain such as the lack of digital infrastructure, pedagogical resistance to change, and the absence of continuous support, especially in developing countries (Kubacka & D'Addio, 2021; European Agency, 2020). Teacher training can help to improve technology integration and inclusion, but systemic and contextual factors are crucial to program effectiveness.

This is one limitation in the literature, that technology and inclusive approaches have been ignored. The majority of research focuses on the use of technology, UDL or inclusive pedagogy alone, and the potential for synergy when combining the two in TPD programs are not taken into account. Moreover, short-term assessments do not have information on long term effects on teaching or learning. Limited representation of evidence from developing countries, thus limiting the ability to generalize findings. Together, these gaps indicate the need for more research that can assess the longitudinal outcomes, explore the integration of TPACK and UDL, and account for the contextual constraints, especially in the context of limited resources in education.

Overall, literature suggests that teacher training can be a means to make improvements in technology integration and inclusive teaching, but there is not much substantive evidence, and it is mostly context-specific. Well-designed programs feature ongoing engagement, active learning experiences, collaborative work with peers, and integration with educational goals. However, the conclusions drawn are limited by a methodological approach, a short time perspective and an unequal account of the challenges in context. Future studies should overcome these limitations by using longitudinal designs and compare the effectiveness of integrated versus isolated TPD solutions and test results in various educational environments. Such research will create a firmer foundation for the development of teacher training programs which strengthen technological skills and ensure pedagogical practices are inclusive in order to promote quality learning for all.

Methodology

The study employed a systematic review design to examine the impact of teacher professional development programs on technology integration and 21st-century pedagogical practices for inclusive education in the classroom. The approach of systematic review was chosen to base the synthesis of existing empirical evidence which is systematic, transparent, and reproducible in order to find trends, gaps, and effective practices in teacher professional development (TPD). The review was conducted according to the PRISMA 2009 guidelines for identifying, screening, eligibility assessment and inclusion of relevant studies from a methodological perspective. Based on structured and replicable approach, this study aims to determine the character of teacher training interventions, its impact on teacher competencies, and difficulties in implementation in different educational contexts.

The methodological framework aimed at capturing studies that tackled both technological and inclusive pedagogical competencies was designed, given that teacher training in the 21st century should enable teachers to equally and meaningfully use digital tools and to meet the divergent learning needs of their students. The studies were focused on those published from 2015–2025 to relate to the current education environment. Different types of study design were included: pre-service and in-service teachers at secondary and tertiary education in qualitative, quantitative and mixed methods. This introduction provides background information for the subsequent parts of the study that demonstrate the systematic and analytical approach used in the study, which included the search strategy, inclusion

and exclusion criteria, data extraction and quality assessment.

Search Strategy

Literature search was done in four big academic databases which were Google Scholar, ERIC, JSTOR and Scopus. The searches were done between March and April 2025 in order to locate peer-reviewed research articles published in the years 2015–2025 that included a study on teacher professional development programs to enhance the integration of technology and pedagogical practices for inclusion.

The search strings were recorded for each search of the databases, along with the number of records retrieved and the date of the search, to ensure the transparency and replicability of the search. Search strategies were developed in an iterative fashion so unnecessary studies were excluded and duplicate studies were minimized. The process of structuring the review ensured that it included relevant empirical studies on teacher training programs involving technology and inclusiveness and was methodologically sound and precise.

Inclusion Criteria

Those studies that satisfied several criteria were included. Only journal articles were considered after having undergone the peer review process, therefore ensuring the credibility and reliability of the results. Research published in the 21st century (2015–2025) was selected to represent current educational practice in 21st-century classrooms and only research published in English were selected to ensure correct interpretation of methodology and results. Empirical studies based on quantitative, qualitative and mixed methods were eligible such as interventions, surveys, case studies, and observation studies that reported results of teacher training programs. Pre-service and in-service teachers in secondary and tertiary education were included. Studies were required to examine structured teacher training initiatives that focus on improving the teacher's technology integration skills and/or their inclusive pedagogical skills and strategies, such as workshops, online learning opportunities, blended learning, mentoring, or professional learning communities. Studies in any country were included, provided that they focused on teacher training in the development of digital literacy, technology integration or inclusive teaching skills. Finally, studies were limited to those reporting outcomes that were specific to teacher competency, teacher confidence and teacher implementation of inclusive and technology-integrated teaching. The criteria made sure that the research included only methodologically sound studies, those that were relevant to current teacher training and those that were relevant to the two foci of technology.

Exclusion Criteria

There were several reasons why certain studies were not included in the review. Opinion pieces, conceptual articles, narrative reviews, and policy discussions, which did not measure changes in teacher competencies, were excluded. To keep the scope limited, studies that did not relate to teacher professional development or interventions aimed at technological and inclusive teaching competencies were not included. Articles from before 2015 were not included in order to highlight more recent practices that are consistent with 21st century learning needs. Only studies published in the English language were included because other studies were not available in English and/or lacked methodological details. To prevent duplication of analysis, the duplicate records identified

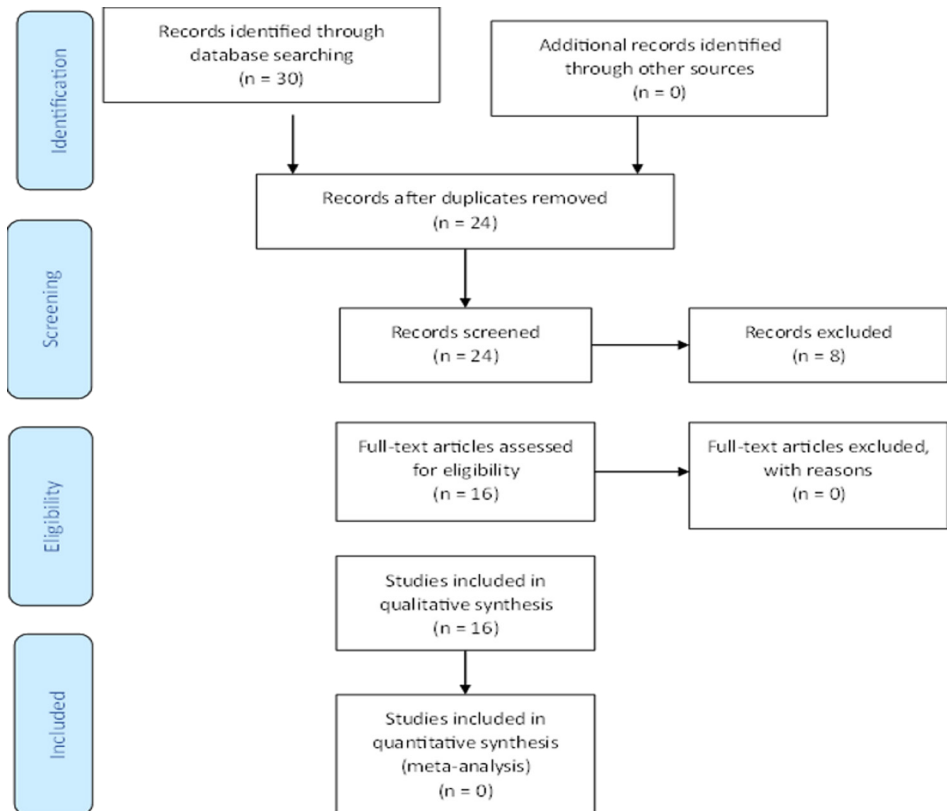
during the database search were removed. In addition, the studies were excluded if methodology was unclear, the intervention or participant descriptions were inadequate, or outcome measures were not clearly defined to further assure methodological rigor. Lastly, articles for which the full text was not available or insufficient information on study design, participants or interventions was found were also excluded.

These exclusion criteria were used during the title/abstract screening and full text assessment process in a systematic way leading to a final dataset of high-quality empirical studies that directly addressed the dual focus of the teacher training programs on technology integration and inclusive pedagogical practices.

PRISMA Framework

The PRISMA (Preferred Reporting Items to Systematic Reviews and Meta-Analyses) guidelines were used in the development of this systematic review to enhance transparency and reproducibility in the selection and reporting of the systematic reviews. The PRISMA model ensures that the research procedure in terms of choosing study pieces is well documented which helps to make the process of replicating the research procedures and review procedure easier.

Figure: 1 PRISMA 2009 Flow Diagram of Study Selection Process



(Moher et al., 2009).

This research is conducted in systematic review design and has a goal to determine the characteristics of the teacher training program that fosters the inclusion of pedagogical practices and the integration of technology so that there are transparency, rigor and repetition in examining

the teacher training program that supports pedagogical practices and the inclusion of technology. The aim of review was to locate, analyze and synthesize empirical research on teacher professional development (TPD) conducted during the period of 2015–2025. The selection process was conducted using the PRISMA flowchart, which made sure every step was recorded. In the first step, 30 records were obtained from the four big academic databases namely Google Scholar, ERIC, JSTOR, and Scopus. Structured Boolean operators with keywords were used to search from March to April 2025 and the keywords were narrowed to two thematic categories: (1) technology-related terms, including but not limited to “teacher training,” “digital literacy,” “technology integration,” “TPACK” and (2) inclusion-related terms, including but not limited to “inclusive teaching,” “Universal Design for Learning,” “differentiated instruction,” and “equity in education.” These terms were combined using the AND/OR operators in order to be relevant to exactly search the strings (e.g., “teacher training AND technology integration AND inclusive teaching”).

Of these 24, 8 were eliminated due to title and abstract screening for studies not focused on teacher development, non-empirical, or lacking of a clear intervention ($n = 6$). Complete text analysis of the remaining 16 studies resulted in the exclusion of 2 additional studies that lacked methodological detail and were unclear about their population context, and 14 studies were used in the final synthesis. Only peer-reviewed, English-language publications since 2015 were included and non-empirical papers and commentaries were excluded, as were studies lacking an intervention that focused on teacher competencies in technology or inclusion, to ensure the quality and relevance of the findings. However, grounds for language and temporal restrictions were considered to be based on the accessibility of evidence and the contemporary relevance.

The included studies were from a variety of study design categories, such as quantitative ($n = 6$), qualitative ($n = 5$), and mixed methods ($n = 3$). The participants spanned pre-service teachers, in-service teachers, across secondary schools, language classes and university teacher preparation programs. Interventions that were identified as “teacher training programs” were workshops, online teaching programs, blended learning programs, mentoring programs, and professional learning communities specifically targeting technological competency and/or pedagogical skills for teaching students with disabilities. Contextual boundaries were mentioned and studies were carried out in the United States, Turkey, Indonesia, Malaysia, and some European countries (Appendix A).

The reviewed studies all highlight the importance of teacher training to strengthen 21st century skills by making use of technology and pedagogical approaches. A plethora of studies have concentrated on the integration of ICT and AI, highlighting teachers' pre-service and in-service training to enable them to acquire new skill sets including critical thinking, problem-solving, and social intelligence (Zorlu, 2025; Chiu et al, 2023; Abdu, 2023). The TPACK framework is used often and is seen as a necessary and sufficient combination of technological knowledge, pedagogical knowledge, and content knowledge for teaching in today's classrooms (Chiu et al., 2023). Moreover, Project-Based Learning (PBL) has shown positive effects on teachers' knowledge, confidence and perceptions of their ability to integrate 21st century skills (Page et al., 2021).

In addition, several studies highlight the importance of inclusive teaching practices and social equity which focuses on the strategies that address diversity in race, ethnicity and gender, and in the classroom needs (Dewsbury & Brame, 2019). The connections between teacher training and

professionalism and student outcomes are also examined, with school-based training and teacher autonomy having a positive impact on teacher quality (Whitty, 2014; Harris & Sass, 2011). The studies, conducted in a variety of settings from Indonesia, Malaysia, Turkey, to the U.S., countries in the Organization for Economic Co-operation and Development and England, show how effective teacher development programs integrate technological competence, pedagogical knowledge and inclusive practice in order to equip teachers for the changing needs of 21st century classrooms.

Data Extraction

The data was centered on a few standardized variables: training strategies (teachers' workshops, AI-based assistance, peer coaching), outcomes (teacher competences in using technology and in inclusive practices), research design and methodology (data collection instruments, data analysis), and challenges in implementation (restriction of resources, reluctance to change, scalability). Study characteristics were systematically organized by means of extraction using the software Microsoft Excel. A deductive coding method was used to classify results based on the research goals; two researchers independently verified the coding results to improve reliability and decrease the possibility of coding bias. Analytic rigor was achieved by discussion and consensus to resolve discrepancies.

Quality Assessment

Quality assessment was carried out to guarantee the use of well-studied methods. The criteria that were used were as follows: rigor of the research design, sample size, representation of the target population, reliability of the results from the different data sources, and publication in peer-reviewed journals. Studies that did not have a clear methodology, data that was insufficient, or were not empirical focused were excluded from analysis. This method guaranteed consistency between the inclusion criteria and the data set, as reported in previous studies, which suffered from methodological inconsistencies.

Finally, synthesized data was analyzed descriptively and thematically to look for recurring patterns, relationships and differences between studies. Study context, intervention type, duration, participant characteristics and outcome measures were compared. This analytical process allowed for a rich analysis of the effectiveness of teacher training programs, not only in terms of what worked but also in terms of the limitations that may exist in the context or system that would impact program outcomes.

Results and Discussion

To examine the effect of teacher training on enhancing the competencies of technology integration and inclusive pedagogy, two of the demands for the 21st century classrooms, was the purpose of this systematic review. Students have a growing need to be digitally literate, adaptable, and inclusive in their learning, which has been identified in the literature on education as a driver for teachers' demand for digital literacy (Darling-Hammond et al., 2017; OECD, 2022). The study also falls under the theoretical frameworks of TPACK (Technological Pedagogical Content Knowledge) and UDL (Universal Design for Learning) which underpin the process of integrating technology and differentiated/inclusive pedagogy. From the methodology point of view, it was a systematic review in accordance with the PRISMA guidelines that analysed 16 empirical studies in the education field published between 2015 and 2025 and with designs of qualitative, quantitative and mixed methods,

which studied pre-service and in-service teacher training programs.

The results indicated that the teacher training in multi-dimensional, context-specific and effective dimensions, emphasizes experiential training, continuous supervision, learning and technology integration with learning goals. In research that weave AI-supported and ICT-based interventions into real classroom activities, like that of Zorlu (2020), the findings indicate that the interventions can significantly boost teacher self-confidence, critical thinking, and collaborative abilities. Similarly, it was determined that pedagogical approaches (e.g. differentiated instruction and project-based learning (PBL)) provided equal and equitable learning opportunities (Dewsbury & Brame, 2019). Teacher outcomes are impacted by contextual and systemic conditions, and training programs in better-resourced contexts have better outcomes than those in less well-resourced ones. Further, the integration of technology and inclusivity did not seem to be mutually exclusive but rather complementary, with technology providing a means to differentiate, to learn together, and to engage more students, as previous research has indicated that these abilities are connected and interdependent.

On a theoretical level, the results support and extend the TPACK and UDL frameworks by showing how the theoretical principles can be practically well integrated in teacher development programs. The research examined overall suggests that professional development works best when it is ongoing, hands-on, and embedded in social contexts, and is not delivered as brief, content-specific, or stand-alone programs. The review helps build theory by identifying the interrelatedness of technological and inclusive competencies as well as providing empirical evidence to support integrated models of teacher professional development.

The findings highlight the need for ongoing professional development on the aspects of technology, pedagogy and inclusion in a contextually appropriate way; and for providing opportunities to discuss and deal with obstacles and opposition to change like availability of resources or resistance to change. The findings have implications for the design of teacher preparation programs and the design of curricula and policy, and they suggest that teacher preparation programs can have a significant impact on student achievement and teacher effectiveness, if they are based on a clear, comprehensive, well-designed program that is connected to the 21st-century education needs.

Technology Integration in Teacher Training

One of the main topics that were visible in the studies was the incorporation of technology in teacher training. Many studies highlighted the need to improve the digital competencies and capacity of the teachers to employ digital tools, online resources and virtual classrooms during teaching. As an example, Zorlu (2020) has discovered that preservice science and EFL teachers were able to acquire the necessary skills of the 21st century, including critical thinking and collaboration, with the help of the training programs involving AI-assisted technologies. The digital platforms and learning management systems (LMS) were promoted through these programs, boosting teachers' confidence in integrating technology into their classrooms.

Similarly, AbdulRab(2020) stressed the importance of digital literacy training in English Language Teaching (ELT) class and showed that the training was useful for the English teacher in developing countries in creating interactive and interesting lessons and collaborative learning using digital tools. The findings of this research underline the need to develop training initiatives that go beyond the mere use of technology, and that involve pedagogical practices that are pedagogically

sound to ensure that the use of digital tools is not vanishing.

Inclusive Teaching Strategies

The second theme of importance was facilitation of inclusive teaching practices. A number of studies were concerned with ways through which teacher training programs equipped the teachers to meet the various learning needs of the students. They highlighted the importance of including “differentiated instruction, Universal Design for Learning (UDL), and other inclusive pedagogical practices”. For instance, Dewsbury and Brame (2019) described how schema-based training programs founded on the pedagogical tenets of Paolo Freire that were used to mainstream inclusion efforts in STEM education, highlighting a focus on cultivating equitable learning spaces that do not exclude based race-, ethnically-, or gendered-related differences. In her article, Cummins (2000) described PBL as an invitation to teachers to create real-world projects that would be both collaborative and inclusive by accommodating multiple forms of learning. The research established that PBL does not only help in developing critical thinking and problem-solving skills, but also assures students having varying background and abilities to have full involvement in the learning process.

Booth et al. (2016) considered how Technological Pedagogical Content Knowledge (TPACK) framework may be used by teachers in the Malaysian classroom, revealing that it assisted educators in implementing technology in a manner that supported learning among students. This strategy enabled the teachers to develop their instructions according to the different needs of the students so that the learning process is inclusive.

Professional Development Models

The findings indicated several professional development models that were used in the teacher preparation programs such as workshops, online training and peer collaboration. These studies consistently demonstrated the ability of these types of models to foster skills for the 21st century. For example, Zorlu (2020) indicated that the AI-supported workshops were so useful to trainees in gaining critical thinking and collaboration skills. “Learning by doing” induction conducted in school with a hand was very good ways of engaging and motivating teachers, according to Whitty (2020).

In a similar vein, Enochsson and Rizza (2021) surveyed ICT-based online teacher courses, and found that teachers were able to use digital tools for teaching in low resource settings. The convenience and flexibility of online courses recommend them as an important option for lifelong learning, particularly in remote or resource-poor contexts.

Teacher Engagement and Motivation

Teacher motivation and enthusiasm were also key features in the success of teacher trainings. Research showed that Hands-on action through Making and Tinkering, peer learning, as well as sustained support helped build greater motivation in teachers to engage with the new teaching methodologies. For example, Harris and Sass (2020) indicated that programs combining peer collaboration and continued mentoring supported facilitators to develop a greater sense of confidence and motivation in the use of technology and inclusive strategies. Programs that provided with the opportunities for communities of practice or collaborative networks were found to be particularly successful in maintaining teachers’ involvement.

Methodological Trends

A wide range of research methods was used in the studies included in the review, with both qualitative, quantitative and mixed methods approaches being used. Studies that used quantitative methods to measure the effects of training on student achievement and teachers' technology integration skills were more prevalent, such as Harris and Sass (2020) that relied on longitudinal data and surveys. In some studies, such as Arksey and O'Malley (2005), interviews and focus groups were used to gain deeper insights into the views of teachers on the in-service training of inclusive education practices. Also, some of the studies were mixed methods, that is, through surveys and classroom observations, as in Kokotsaki et al. (2016) to examine the capacities of teachers and the effect of teacher training on student performance.

The use of these diverse approaches enabled the studies to offer nuanced perspectives on how well teacher training programs work and what it is like for teachers when technology, a new practice (e.g., universal design) in a familiar context, comes into their classrooms.

These findings indicate that the role of teacher education is crucial in developing the teachers' technology and inclusive teaching abilities in the classroom. The results indicated that the education program that emphasizes on active learning, peer practice and continued support is the best program to develop modern teaching skills. However, these systems and their outcomes also point to the obstacles encountered by teachers such as resource constraints and resistance to change which need to be dealt with in order for these programs to be successful.

The current review aimed at investigating the role of teacher training programs in the enhancement of the 21st -century skills and the role they play in the enhancement of not only technological integration but also inclusive pedagogical approaches. When viewed in relation to these aims, the results imply that the current teacher development is becoming more conceptualized as a multidimensional and continuous process as opposed to a singular intervention. Throughout the 16 chosen studies, a similar pattern can be discerned, that is, professional development is most effective when sustained, practice-focused and in line with the realities of diverse classrooms.

One of the most interesting results was related to the implications of training on teachers' digital competence. From the literature analysed it is concluded that the use of technological tools is not beneficial to teachers on its own, but systematic connections to the opportunities for using the reviewed tools in pedagogical concepts. This difference is crucial. While most of the literature on educational technology has assumed the mere availability of technology would lead to change, recent research of this kind (summarized here) suggests that the key to change is pedagogical alignment. To this extent, the results are congruent with the arguments of Darling-Hammond et al. (2017), who note that successful professional development is based on active learning and contextual practice. Moreover, the research findings of Zorlu (2020) indicate that when AI tools and online platforms are applied and integrated in training, teachers' confidence and capability when utilizing the tools and platforms for training are higher when compared with the technical training approach, used separately.

Meanwhile, the review builds on the existing literature by demonstrating the overlap of technological competence and inclusive pedagogy. Instead of considering these as parallel domains, the analyzed studies are progressively placing them as interdependent. Digital tools, when properly utilized, seem to support differentiation instructions, cooperative learning, and wider engagement.

It is in line with AbdulRab (2020), who highlighted that technology can facilitate interactive and student-centered learning experiences, yet it goes a step further by demonstrating that these learning experiences are often inclusive in nature. In this respect, the results can be added to an ongoing discussion in the educational research field: is technological innovation and inclusive education a rival priority or complementary approach? The factual evidence here leans towards the latter argument, implying that the incorporation of digital pedagogy can complement, as opposed to weaken, inclusive acts of pedagogy.

This argument is further supported by the focus on the inclusive teaching strategies in the reviewed studies. Some of the strategies that are commonly raised and could be considered to form part of an essential component of effective teacher training include those of Universal Design of Learning, differentiated instruction and Project Based Learning. These results are aligned with Dewsbury and Brame (2019), who believe in inclusive pedagogy based on equity and social justice, and with Mother et al. (2009), who shows how PBL could develop participatory and flexible learning processes. Nonetheless, the current review proposes a slight change of focus. The concept of inclusion has ceased to be an extra competence or a specialized field of training, but rather it is becoming more integrated as part of the overall process of pedagogy. Such a change might serve to represent the wider global policy agendas, such as those related to inclusive and equitable education, and is indicative of a re-definition of what is represented as a good teaching practice in modern times.

One more important aspect that has been identified in the analysis is related to the design of professional development models. Though a variety of formats were found, such as workshops, online courses, and school-based programs, their efficacy does not seem to be even. The articles all point to the same conclusion that passive or short-term training is limited in its effects, but more significant results are obtained in the case of long-term, collaborative, and practice-based models.

This finding aligns with Amemasor et al. (2025) focus on mentoring and professional learning communities and Whitty (2020) who focuses on the importance of school-based training. It also promotes a wider theoretical approach in teacher training, which considers professional learning to be socially situated and relational, as opposed to individual learning. This way, the success of training could not be related more so to the content but the structure, length, and how the training fits into the professional settings of teachers. Teacher motivation and engagement prove to be equally significant but under-theorized factors in some cases. The studies reviewed indicate that teachers tend to implement new practices more readily when they are encouraged by the help of continuous mentoring, collaborative work, and reflective possibilities. This finding aligns with the works by Harris and Sass (2020), who attribute the rise of teacher quality and student performance to professional development. However, the results also show that motivation is not an individual attitude but it is constructed by the institutional conditions and program design. Resistance to change is more intense where training does not relate to realities in the classroom or where it is not supported. This adds a note of caution to otherwise optimistic descriptions of teacher training, indicating that the implementation issues are here to stay in cross context situations.

The different methods used in the studies reviewed also help the discussion. Through the integration of qualitative, quantitative and mixed-methodology, a more subtle insight into the result of teacher training becomes possible. Qualitative research is likely to emphasise the growth of teachers'

competence or students' achievement that can be quantified while quantitative research would provide the understanding of teachers' experiences, perceptions and situational limitations. Mixed-method designs mediate between these two sides of the case and provide a more detailed explanation of the change processes. However, a more detailed look at this literature base reveals that there is still a lot of evidence that is still assumed to show short-term effects, particularly self-reported confidence and competence. Emphasis on long-term effect (e.g., student learning, systemic change) is less than in other areas. This is the gap, which has been observed in previous studies, and it is one of the areas that are in need of further empirical studies. The review has yielded largely positive results, but there are also several problems that have emerged in the long-term.

Limited resources are one of the main challenges that have always hindered the use of digital infrastructure and access to training in developing countries. The implementation is also complicated by resistance to change which is usually associated with institutional culture or the lack of support. These are the same issues that Kubacka and D'Addio (2021) and the European Agency (2020) point to that highlight the structural aspects of educational reform. In this sense, this means that teacher training in itself would not be able to respond to the challenges of modern education unless it is supported by wider policies, investment in infrastructure, and consideration of contextual inequalities.

In conclusion, this conversation suggests that teacher training is a process that should enable teachers to be prepared for the demands of the 21st century classroom; however, the effectiveness of this process is dependent on the design and implementation of teacher training. Pedagogy-based, technology-driven programs with practices for inclusiveness and continued professional development are most likely to result in significant change. Meanwhile, the systemic barriers that continue to exist do not mean that teacher development is a "solution" in and of itself, but rather a component of a change system in education.

Conclusion and Implications

The findings from the present systematic review suggest that creating well-designed teacher education programs that will improve teachers' technology proficiency and instruction as well as their ability to meet the needs of culturally and linguistically diverse learners is vital. These programs are also beneficial to teachers who need to adjust to the needs of the modern classroom. What is novel about this study is that technology integration, inclusive pedagogy, and language-responsive teaching cannot be separated into three different areas of teacher learning. Instead, they are complementary and can be best developed as a coordinated and integrated set of skills in teacher preparation that is grounded in a continuous professional development process that incorporates digital literacy, pedagogical knowledge, differentiated instruction, Universal Design for Learning, project-based learning, mentoring, and classroom-based practice.

This review builds on previous studies on teacher professional development, and describes the circumstances in which professional development is relevant, sustainable, and meaningful. The results indicate that the benefit for teachers is more from practical learning, rather than short-term or purely technical training, to long-term mentoring, to collaboration with peers, to training sessions that correspond to their needs, and to institutional support. These strategies are used to help teachers become more confident, to apply new skills in the classroom, and to enhance their ability to address the needs of varied learners. In addition, the review revealed that digital technologies can only be used

to support inclusive education if there are learning outcomes, students' needs and classroom realities involved, not just as additional tools.

The study has also significant implications for the instruction of mother-tongue in the community schools of Nepal. It posits that with the support of appropriate teachers, instructional materials, and institutional and community interaction, mother tongue instruction can reinforce learner participation, confidence in the classroom, conceptual understanding, and inclusion. But it is not enough to have policy provisions to guarantee their effectiveness. The need for mother tongue instruction in many community schools can be limited by a lack of resources, teacher preparation, lack of locally developed resources, multi-lingual compositions of classrooms, and perceived dominance of Nepali and English as languages of broader educational and social mobility. Hence, mother tongue instruction should be seen as a component of an inclusive and equity-oriented pedagogical practice and not as a linguistic intervention on its own.

The findings of this study have implications for policy, teacher development, curriculum development, and school practice. Teacher training programs should prepare teachers to learn the concepts and skills of multilingual pedagogy, classroom language management, culturally responsive teaching, inclusive instructional design, and the pedagogical application of ICT. The development of culturally and linguistically relevant curriculum resources must be a priority for curriculum developers and local government. Classroom settings should also be supportive of the valuing of learners' home language, identity and learning needs, supported by school leaders and community.

The review has its limitations, yet it is useful in contributing to. It is based on selected empirical studies, many of which are context-specific and short-term outcomes are reported. There is less evidence of long-term effects, student learning outcomes, and implementation in low-resource contexts which limits the scope for generalization. Further studies should then be performed with a longitudinal and comparative design to explore how the effects of integrated teacher training persist in teachers' classrooms, in student achievement, equity and inclusion, and in the teaching of the language of instruction. There is a need to conduct further study on teachers' classroom strategies, parental perceptions, students' learning experiences, and the role of local governments for sustaining mother-tongue based multilingual education. Future studies also need to investigate the potential of new technology, such as pedagogy assisted by artificial intelligence and adaptive learning environments, to be used in ways that are responsible and positive for inclusive, multilingual, and learner-centered learning.

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Appendix A

Enhancing Teacher Development: The Impact of Training on Technology Integration and Inclusive Practices

S. N	Author(s)	Thematic Concentration	Context
1	Yusuf Zorlu	AI-assisted question generation in education	Focused on preservice science teachers' development of 21st-century skills using AI in a 12-week study.
2	Eka Nurhidayat, Januarius Mujiyanto, Issy Yuliasri, Rudi Hartono	Technology integration and teacher competency in 21st-century learning	Explores the gap between technology integration and teachers' competencies in EFL classrooms in Indonesia.
3	Quinie Ong Kooi Loo, Annamalai Nagaletchimee	ICT integration, TPACK, 21st-century learning skills in pre-service teachers	Investigates how pre-service teachers are empowered by ICT to develop 21st-century skills for teaching in Malaysia.
4	Regiene Chiu, Januarius Mujiyanto, Issy Yuliasri, Rudi Hartono	Technological, Pedagogical, and Content Knowledge (TPACK)	Examines how SHS language teachers incorporate technology into their pedagogical approaches and the challenges faced.
5	Abdu, A. K. (2020)	Technology integration in ELT classrooms	Review of technology integration in English Language Teaching (ELT) and its impact on 21st-century skills development.
6	Ann-Britt Enochsson, Caroline Rizza	ICT in Teacher Training	This paper reviews research on how teacher training institutions prepare future educators for the integration of Information and Communication Technology (ICT) in classrooms across 11 OECD countries.
7	Geoff Whitty	Teacher Education, Professionalism, and School-Based Training	Discusses the effects of increasing school-based teacher education and autonomy on teacher professionalism in England.
8	Douglas N. Harris, Tim R. Sass	Teacher Training, Teacher Quality, Student Achievement	Examines the relationship between teacher training, teacher quality, and student achievement in the U.S., utilizing a rich set of longitudinal data.
9	Corinne Martinez	Project-Based Learning, 21st Century Skills	Focuses on how project-based learning can develop 21st-century skills in teachers and students in U.S. schools.
10	Quinie Ong Kooi Loo, Annamalai Nagaletchimee	TPACK, Teacher Education	Investigates pre-service teachers' development of Technological Pedagogical Content Knowledge (TPACK) in Malaysian teacher education programs.
11	Regiene Chiu	TPACK, Ignatian Pedagogy, Technology Integration	Explores the integration of Ignatian Pedagogical Paradigm (IPP) with TPACK in senior high school language teaching in Jesuit schools.

S. N	Author(s)	Thematic Concentration	Context
12	Zorlu, Yusuf	AI in Education, 21st Century Teaching Competencies	Explores how AI-assisted question generation enhances 21st-century skills, critical thinking, and social intelligence among preservice science teachers.
13	Erdoğan, Eker	Teacher Training, 21st Century Skills	Discusses the significance of 21st-century skills in teacher education programs in Turkey and their integration in pre-service teacher education.
14	Dewsbury, Brame	Inclusive Teaching, Pedagogy	Describes the development of inclusive teaching practices based on Paolo Freire's pedagogical philosophy, focusing on social inclusion across race, ethnicity, and gender in STEM education.
15	Corinne Martinez	21st Century Teaching Skills, Project-Based Learning	This study explored how secondary school teachers learn to teach 21st-century skills through Project-Based Learning (PBL) curriculum in a graduate-level program. It highlights the impact of PBL on teachers' knowledge, confidence, and their perceptions of integrating PBL for college and career readiness.
16	Eka Nurhidayat, Januarius Mujiyanto, Issy Yuliasri, Rudi Hartono	Technology Integration, EFL Classroom, Teachers' Competency	This article focuses on how technology integration enhances teachers' competencies in developing 21st-century learning in the English as a Foreign Language (EFL) classroom. It discusses the challenges and strategies for improving teachers' ICT skills and curriculum design.

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