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Enhancing preservice teacher education: Integrating assistive technology and UDL within the TPACK framework: A systematic literature review

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Abstract: This study aims to explore the integration of assistive technology (AT) and Universal Design for Learning (UDL) within the Technological Pedagogical and Content Knowledge (TPACK) framework to enhance preservice teacher education. The objective is to equip educators with the skills and knowledge necessary to create inclusive learning environments that support diverse learners, particularly students with disabilities. A systematic literature review (SLR) was conducted using the PRISMA framework, with data sourced from reputable databases such as Emerald Insight, Google Scholar, and ScienceDirect. Boolean operators and keywords were employed to identify relevant studies, and five articles met the inclusion criteria after rigorous screening. The study presented an enhanced version of the Technological Pedagogical and Content Knowledge (TPACK) model that integrates assistive technology as a method of building inclusive teaching practice among prospective educators. TPACK stands for technology, pedagogy and content knowledge. This technique has significant potential to improve learning outcomes for children with disabilities and members of other underrepresented groups who get most of their education in classes that are mainstream. This research extends the TPACK paradigm by demonstrating, using specific instances, how instructional technology and assistive technology are distinct but complementary ideas. A strong focus is placed on determining the key digital competencies that preservice teachers need and the practices that boost inclusive educational practices.

Keywords: *Design practices, Scientific inquiry, Teacher training, Teacher-development, Technology-integration belief, TPACK framework.*

1. Introduction

The contemporary educational landscape demands that teachers possess a diverse range of technological competencies to effectively address the needs of an increasingly diverse student population, particularly children with disabilities in mainstream, inclusive schools [1].

As the world transitions from an industrial to an information-based society, the role of educational technology in shaping future educational systems has become more critical than ever [2]. Rigorous reforms toward accountability in this area of governance are driven by many factors, including federally mandated accountability for teachers and students, and advocacy by organizations such as the National Council for Accreditation of Teacher Education (NCATE) and International Society for Technology in Education (ISTE) [3, 4]. Given that these organizations have emphasized embedding technological standards in teacher education programs and have accelerated the adoption of technology in teacher preparation [4, 5] there is significant potential for celebrating the negative effects that the incorporation of tech has had on educational practice. Nevertheless, a large gap exists between what has been achieved in terms of technological integration and what is actually taking place in the classrooms.

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Largely, the explanation for this discrepancy can be found in teacher's lack of training in utilizing technology to help a number of diverse learners including those who are disabled.

The integration of assistive technology with Universal Design for Learning practices within the Technological Pedagogical and Content Knowledge framework has become a major point of focus since recent years. According to Mishra and Koehler [6] TPACK functions as a complete model to explain the effective application of technology within teaching methods (Technological Pedagogical and Content Knowledge). Research based on this extended TPACK framework involving both assistive technology and UDL seeks to resolve the pressing requirement for teaching approaches that support all student needs but particularly students with disabilities. UCLA represents a vital framework that helps educators connect various elements of educational practice for teaching history content to students with disabilities through accessible technological resources. Academic institutions serving more students with disabilities require teachers to change their teaching methods and learning practices [7]. Assistive technology consisting of tools and devices for supporting disabilities shows high promise in expanding educational opportunities for these students [8]. The inclusion of assistive technology and instructional technology allows educational environments to welcome students through comprehensive accommodations that meet their individual requirements. Assistive technology makes historical material available to students with learning challenges by providing non-traditional flexible interfaces [9]. The special need for accessibility emerges in history education because some students with disabilities find it impossible to work with sophisticated historical sources and accounts.

Pre-service teachers seldom develop sufficient attitudes and knowledge along with skills needed to accept and use assistive technology even though such tools provide potential advantages [10]. Teacher training programs face a substantial challenge because they should prepare teaching candidates to integrate technology solutions that benefit students with different learning needs. Corkett and Benevides [11] maintain that pre-service teachers need to start working with assistive technology as soon as possible during their education. The introduction of assistive technology tools in teacher education formation enables future educators to create better instructional choices and assist with Individualized Education Program (IEP) planning and implementation [12]. IEP teams should conduct a complete evaluation of assistive technology solutions before selecting the most suitable tools for students based on their individual needs after baseline data shows assistive technology necessity [13]. Building assistive technology integration with UDL practices within the TPACK framework represents a beneficial solution to tackle teaching challenges [12]. The design principle of UDL creates adaptable learning spaces dedicated to support different learning styles which match the essential elements of inclusive education. The UDL concept incorporated into TPACK training programs allows pre-service teachers to obtain abilities needed for developing sensitive learning spaces that welcome all student types.

The research examines established pre-service teacher education approaches through the combination of TPACK theoretical framework alongside assistive technology along with UDL principles. The combined approach aims to empower educational trainees with effective technological knowledge meant for use in accommodating various learning settings. This study analyzes the relationship between TPACK and assistive technology together with UDL to develop evidence-based practices for inclusive education which result in better teaching strategies for students with disabilities. The research results will expand knowledge related to teaching inclusively and training educator practices. The research highlights that pre-service teachers require dedicated training in both assistive technology and UDL as a basis to establish new curriculum standards for teaching technological proficiency. This pedagogical method enables upcoming educators to develop suitable inclusive teaching environments that serve diverse disability needs which leads to academic progress and lifelong achievement for students. The research will advocate through policy recommendations for establishing mandatory assistive technology and UDL training programs which should include practical experience for pre-service teachers. Educational institutions must give priority to incorporating assistive technology and UDL within teacher training because educational institutions are evolving according to

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technological progress. Educational tools should become core components in teacher training because they establish policy-practice congruence while developing an educated environment suitable for all students regardless of ability level. The implementation of assistive technology brings remarkable value to history education since it allows students with disabilities to study complex historical texts and original sources that traditional teaching methods.

Using UDL principles together with assistive technology integrated into the TPACK framework creates substantial progress in preparing new teachers to handle student diversity in inclusive classrooms. The teaching of technology effectiveness alongside necessary skills becomes key for future educators through education programs which fosters inclusive education while providing high-quality learning opportunities to students with disabilities. The research project works to attain this critical objective through its examination of best implementation practices which unite assistive technology and UDL within the TPACK structure thus generating better educational approaches for students with disabilities.

2. Literature Review

2.1. Implications of Including Assistive Technology in the TPACK Framework

The use of assistive technology in the training of potential teachers may assist in boosting students' academic performance and aid these students in developing transition plans that will help them be successful both in school and in the workforce for the remainder of their lives [14]. One who has completed their education would be better positioned to advocate using text-to-speech software. Once this information has been included in the student's individualized education program (IEP) and a transition plan, all colleges and universities that receive funding from the federal Government must consider it. Due to this, the student may be able to get text-to-speech services from the disability resource center at the institution [15]. Even if the teacher possessed the essential knowledge and skills linked to assistive technology, it is possible that an individual did not realize the potential long-term impact of modifying the content format and reporting the results. The implication of TPACK is hugely concerned with classroom activities as its acceptability indeed tends to enhance usefulness.

Figure 1.
TPACK in Classrooms.

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As illustrated in Figure 1, the classroom TPACK framework highlights the interplay between technology, pedagogy, and content knowledge, emphasizing its role in supporting inclusive education. Figure 1 demonstrates how the integration of AT within the TPACK model enhances accessibility by aligning technological tools with pedagogical approaches to accommodate diverse student needs.

As part of the process of developing an individualized education program (IEP) for a student who has a learning impairment, teachers are required to take into consideration how assistive technology could be beneficial to the student [7]. These tools aim to scaffold students' cognitive processes in a way that makes the most of each learner's processing abilities and achieves the highest possible level of educational success. The challenge of figuring out how to effectively include educational programmers that train instructors about technological advancements is a continuous one [16]. Teachers should make it a priority to include assistive technology in individualized education programmers (IEPs) and transition plans for students with disabilities since it has the potential to have a positive impact on student's academic performance from kindergarten through college.

2.2. Essential Assistive Technology Knowledge and Skills

According to Bausch, et al. [17] a preservice educator needs not only technical know-how but also knowledge in the selection of assistive technology, acceptance of that technology, implementation of that technology, and assessment of that technology. Moreover, de Witte, et al. [18] analyzed that it is essential to record the student's present level of performance before one even thinks about providing them with assistive technology. It is the first step individuals need to take to determine whether assistive technology intervention will be successful and whether or not it will continue to be effective. Smith, et al. [19] stated that students are only given access to assistive technology if there is evidence that it will help them function more effectively in the classroom. A student doing well academically (earning passing grades) is not eligible for assistive technology since they do not need it. To guarantee that this approach of combining knowledge of technology with the use of assistive technology will result in high learning outcomes for preservice teachers, education technology courses must use efficient instructional strategies.

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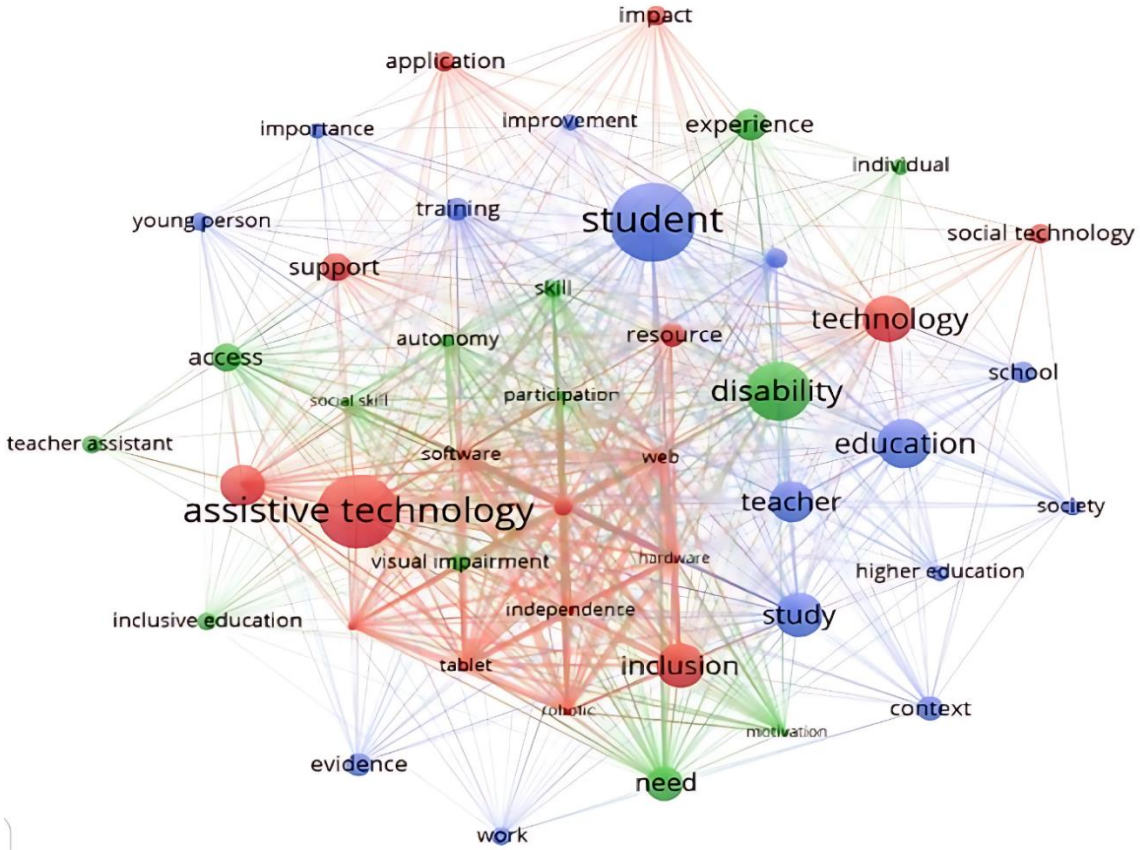

Figure 2.
Assistive Technology for Students.

As shown in Figure 2, assistive technologies are designed to address diverse student needs by providing alternative methods of interaction, engagement, and content accessibility. It elaborates on the role of AT in facilitating adaptive learning experiences, ensuring students with disabilities receive tailored support in achieving educational objectives.

Moreover, Waseela [20] determined that before deciding on a specific piece of assistive technology, teachers should review their curricula to determine what learning goals they hope students will achieve. As part of an Individualized Education Program (IEP), instructors must be able to identify the activities and assessments that students will participate in to demonstrate their level of comprehension of the course's objectives. Furthermore, Chaipidech, et al. [21] highlighted that teachers should also explore how they employ pedagogical tactics in the classroom and how they may use assistive technology to serve students with disabilities better so that these students can fully engage in classroom activities and benefit from them. However, Jones, et al. [22] argued that methodologies and learning theory courses should contain task analyses, baseline performance assessments, and pedagogical strategies specific to the instructor and the subject matter throughout a teacher's preservice education. Effective use of technical resources is not something that can be grafted onto an existing program in any way, shape, or form; instead, advocate for a holistic approach (an upgraded TPACK model) that places a focus on the significance of ensuring the long-term viability of technology as a resource for promoting education that continues throughout a person's life.

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2.3. A Theoretical Framework for the Enhancement of the TPACK Model

The TPACK paradigm is built on active learning approaches. It is inquiry-based, in which students perform research, analyze data, and produce visual representations of their results to communicate what they have learned [23]. Individuals would successfully develop a structure for future educators' education by combining TPACK with pedagogical practice. Educators have started using a framework known as pedagogical praxis, which incorporates theoretical frameworks, reflective practices, and the very concept of education itself to better prepare students for life in a constantly changing society [24]). Considering how technological advances could broaden students' access to learning opportunities is an important part of the pedagogical praxis of an educator.

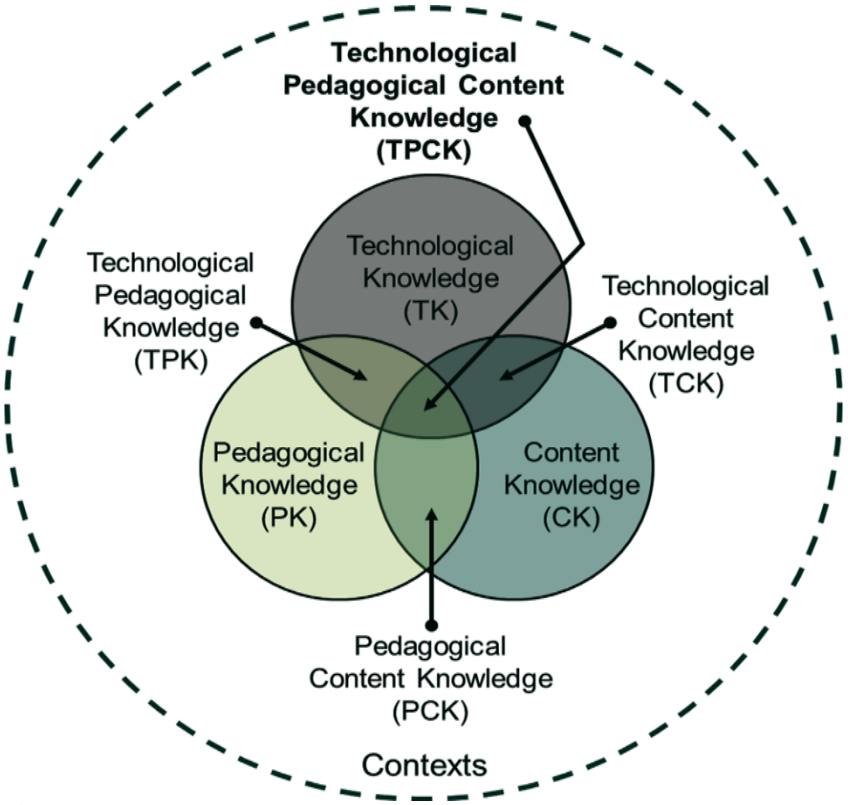

Figure 3.
TPACK Framework.

As depicted in Figure 3, the TPACK framework illustrates the interaction between technological, pedagogical, and content knowledge, providing a foundation for integrating AT into teacher education programs. Figure 3 highlights how educators can leverage the TPACK model to create more inclusive and technologically adaptive learning environments.

This paradigm emphasizes Universal design for learning (UDL) and advocates for using technology to design accessible education from the beginning of the planning process, as opposed to retrofitting or adding technology after learning obstacles have been eliminated. In contrast, the traditional approach is to add or retrofit technology only after those obstacles have been met [25]. Utilizing UDL encourages the development of curricula that can be adapted to meet the needs of a diverse range of students as well as their preferred methods of learning. The degree to which technology is used in a classroom directly relates to the educators' attitudes.

Considering the complications that occur when technology is regarded as a separate body of knowledge, it is essential to acquire an understanding of the TPACK framework to successfully

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integrate technological concepts into both pedagogical practices as well as the content of lesson plans [4, 26]. Even if someone is widely recognized as an expert in their area, this does not ensure they can effectively instruct others. It is the most fundamental principle of the TPACK framework and describes a body of knowledge essential to the teachers' practice [21]. TPACK framework is not generally held by subject matter experts who are also proficient in technology, by technologists who have little grasp of the issue or pedagogy, or by educators who have little technology knowledge [27].

Due to factors such as the specific educator, the exact grade level, the demographics of the class, and many others, each circumstance calls for a unique approach to educational technology.

2.4. Expanding the TPACK Model for Long-Term Educational Success

Dolgopolovas and Dagiene [28] introduce the Technological Pedagogical Content Knowledge (TPACK) framework, which is the intersection of technology, pedagogy, and content knowledge required for effective teaching. They argue that successful technology integration in education goes beyond merely using digital tools; it necessitates a deep understanding of how technology interacts with subject matter and teaching methods. They emphasize that teachers must develop flexible, context-sensitive knowledge to adapt technology effectively to different learning environments. It highlights the complex, dynamic nature of teaching technology and underscores the need for continuous professional development to enhance educators' TPACK competencies.

Similarly, Chai, et al. [29] analyzed the theoretical foundations, research trends, and practical implications for teacher education. They highlighted how TPACK has evolved to address the complexities of integrating technology into pedagogy and subject content. They also emphasized the importance of teacher training programs in developing educators' technological competencies and adaptive teaching strategies. They identified challenges in TPACK research, such as inconsistencies in measurement and implementation. They suggested future directions, including the need for longitudinal studies and stronger empirical validation of the framework in diverse educational contexts.

2.5. Future Directions for Assistive Technology in the TPACK Model

Modise [30] explored that the TPACK framework can be enhanced by integrating assistive technology to promote inclusive practices in preservice teacher education. They emphasize the importance of equipping future educators with the knowledge and skills to use assistive tools to support students with disabilities effectively. They highlighted case studies and practical strategies for embedding assistive technology into teacher training programs, demonstrating its impact on foster accessibility and differentiated instruction. Further, it advocates continuous professional development, institutional support, and research-driven approaches to ensure the effective implementation of assistive technology in classrooms.

Harris, et al. [31] provides a comprehensive editorial on the evolution of TPACK research, examining its past developments, current applications, and future directions. They discussed how the framework has influenced teacher education, instructional design, and educational technology integration. They further highlighted challenges in TPACK research, including measurement issues and the need for more contextualized studies. They advocate for future research that refines the model, explores its applicability across diverse educational settings, and integrates emerging technologies. It also underscores the importance of ongoing collaboration among researchers and practitioners to enhance the effectiveness of TPACK in modern education.

2.6. Policy Recommendations for Integrating Assistive Technology in TPACK

Integrating assistive technology within the Technological Pedagogical Content Knowledge (TPACK) framework necessitates well-structured policies to ensure accessibility, sustainability, and teacher preparedness. Comprehensive teacher training programs must be institutionalized to equip educators with the skills and knowledge to integrate assistive technologies into their pedagogical practices. It highlighted that without adequate training, educators may lack the confidence and expertise

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to use assistive tools effectively, limiting their potential to enhance learning experiences for students with disabilities. Professional development initiatives should be continuous and adaptable, incorporating hands-on workshops, case studies, and collaborative learning experiences that emphasize the pedagogical integration of assistive technologies within the TPACK framework [30].

Moreover, sustainable funding mechanisms must be established to support the procurement, maintenance, and periodic upgrading of assistive technologies. Many schools, particularly in underserved regions, struggle with limited financial resources, which can hinder the implementation of inclusive learning tools. Governments and educational institutions should allocate dedicated budgets for assistive technology, ensuring that students with diverse learning needs have equitable access to digital learning resources [31]. Public-private partnerships with technology firms, research institutions, and non-governmental organizations can help drive innovation and accessibility by facilitating cost-effective assistive technology solutions and expanding educational outreach initiatives.

Inclusive curriculum standards must be developed to maximize the effectiveness of assistive technology within TPACK-based classrooms. These standards should align with universal learning design (UDL) principles, which advocate for flexible teaching methods that accommodate diverse learning styles [32]. Policymakers must ensure that digital accessibility guidelines are embedded within national education frameworks, mandating that assistive technology is incorporated into curriculum planning, instructional strategies, and assessment methods. Additionally, institutional policies should encourage collaborative lesson planning, where special education professionals, general educators, and technology specialists work together to design inclusive learning experiences that leverage assistive tools effectively [6].

Finally, robust evaluation mechanisms should be implemented to assess the effectiveness of assistive technology in enhancing student learning outcomes and teacher competencies. Data-driven decision-making is crucial for refining policies and ensuring that assistive tools meet educational goals. Policymakers should mandate regular assessments and impact studies, utilizing qualitative and quantitative research methodologies to evaluate student engagement, academic performance, and teacher satisfaction [31]. Establishing a feedback loop where educators and students can provide input on assistive technologies will facilitate continuous improvement and adaptation of these tools within the TPACK framework. By implementing these policy recommendations, educational institutions and governments can ensure that assistive technology is not just an add-on but an integral part of pedagogical strategies, fostering an inclusive, equitable, and future-ready learning environment. This holistic approach will empower educators to leverage technology effectively, bridging learning gaps and promoting academic success for all students, regardless of their abilities.

2.7. Case Studies of Assistive Technology Implementation in TPACK

The Technological Pedagogical Content Knowledge (TPACK) framework provides a robust structure for integrating technology into teaching, ensuring educators effectively balance technological, pedagogical, and content knowledge. Assistive technology (AT) is crucial in making learning more accessible for students with disabilities, enhancing engagement, and promoting equitable educational opportunities. Several case studies highlight the successful implementation of assistive technology within TPACK-based classrooms, demonstrating its impact on student learning outcomes, teacher effectiveness, and overall instructional quality.

2.7.1. Case Study 1: Speech-to-Text Technology for Students with Learning Disabilities

A study conducted by Marino, et al. [33] explored how preservice teachers integrated speech-to-text software into their lesson plans to support students with dyslexia and other learning disabilities. The findings revealed that voice recognition tools enabled students to participate more actively in writing assignments, reducing their anxiety about spelling and grammar. Teachers reported that incorporating this assistive tool within the TPACK framework required careful pedagogical adjustments, including modified lesson structures and individualized support. The study emphasized the

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importance of teacher training and hands-on experience in successfully integrating assistive technologies in diverse classes.

2.7.2. Case Study 2: Text-to-Speech Applications for Visually Impaired Students

In a study by Harris, et al. [31] teachers in an inclusive classroom integrated text-to-speech software to support visually impaired students. Using AI-powered screen readers, students could access digital textbooks, participate in online discussions, and engage with multimedia resources. The implementation process involved a combination of technological adaptation (selecting the most effective assistive tools), pedagogical modifications (providing students with training on how to use the software), and content accessibility adjustments (ensuring that course materials were compatible with assistive reading tools). The findings highlighted the importance of institutional support in ensuring that schools provide teachers with sufficient technological resources and training programs.

2.7.3. Case Study 3: Augmentative and Alternative Communication (AAC) Devices for Non-Verbal Students

Chai, et al. [29] investigated the integration of AAC devices in classrooms with non-verbal students. Teachers utilized tablet-based communication apps to facilitate student interactions and classroom participation. The research found that implementing AAC tools within the TPACK framework required extensive collaboration between educators, speech therapists, and technology specialists. The study underscored the need for interdisciplinary approaches, ensuring that assistive technologies are embedded within curriculum planning, teacher training programs, and institutional policies. These case studies demonstrate that integrating assistive technology within TPACK-based classrooms fosters inclusive and equitable education, enhancing learning experiences for students with diverse needs. Future research should explore long-term effects, focusing on student progress, teacher adaptability, and institutional best practices in implementing assistive technologies.

3. Methodology

3.1. Research Design

This study employs systematic literature review (SLR) as its primary methodological approach. Research on a specific topic follows the SLR process to identify study after rigorous evaluation and synthesis. The research method depends primarily on reviewing peer-reviewed articles together with books and conference papers alongside other scholarly publications. Through its systematic format this method ensures the evaluation process remains transparent along with achieving wide coverage and reproducibility in research findings. The findings of this study will achieve maximum reliability through strict adherence to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework which helps reduce bias levels. The systematic review process described by the PRISMA framework includes standardized steps which guide identification of sources as well as screening and eligibility assessment and study inclusion decisions. The chosen methodological approach functions well to study how preservice teacher education combines assistive technology with the UDL framework within the TPACK framework context.

3.2. Search Strategy

The research approach used a systematic method to locate pertinent studies which investigate how assistive technology matches with UDL standards using the TPACK framework within preservice teacher education programs. Several academic databases were thoroughly searched: Emerald Insight, ResearchGate, Google Scholar, ScienceDirect and Elsevier. Using Boolean operators with the terms "AND" and "OR" in the search queries helped narrow down the literature search to retrieve appropriate studies. The research utilizes specific keywords consisting of "assistive technology" and "Universal Design for Learning" "TPACK framework" and "preservice teacher education" and "inclusive education" to collect studies that match the research goals. The research only included English peer-

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reviewed articles and had no limitations on publication date to cover a wide array of available literature. A total of 256 records emerged from the first search while relevance screening followed for assessment.

3.3. Inclusion and Exclusion Criteria

Much care was taken to establish both inclusive and exclusive criteria for the selection of studies in this review. The review included research articles meeting these requirements: (1) analyzing incorporate assistive technology and UDL with TPACK, (2) studying teacher education, (3) being peer-reviewed publications and (4) offering theoretical or empirical information for the study. The research excluded investigations that failed to connect with this subject matter directly or lacked peer review status or availability in English or failed to maintain adequate methodological standards. A total of 82 research documents were eliminated at the first screening stage based on defined criteria. The 174 remaining records led investigators to retrieve 38 sources which turned out to be 33 exclusions due to various reasons including irrelevance and limited accessibility and information clarity. Five (5) laboratory findings matched the research parameters to be part of the final analysis.

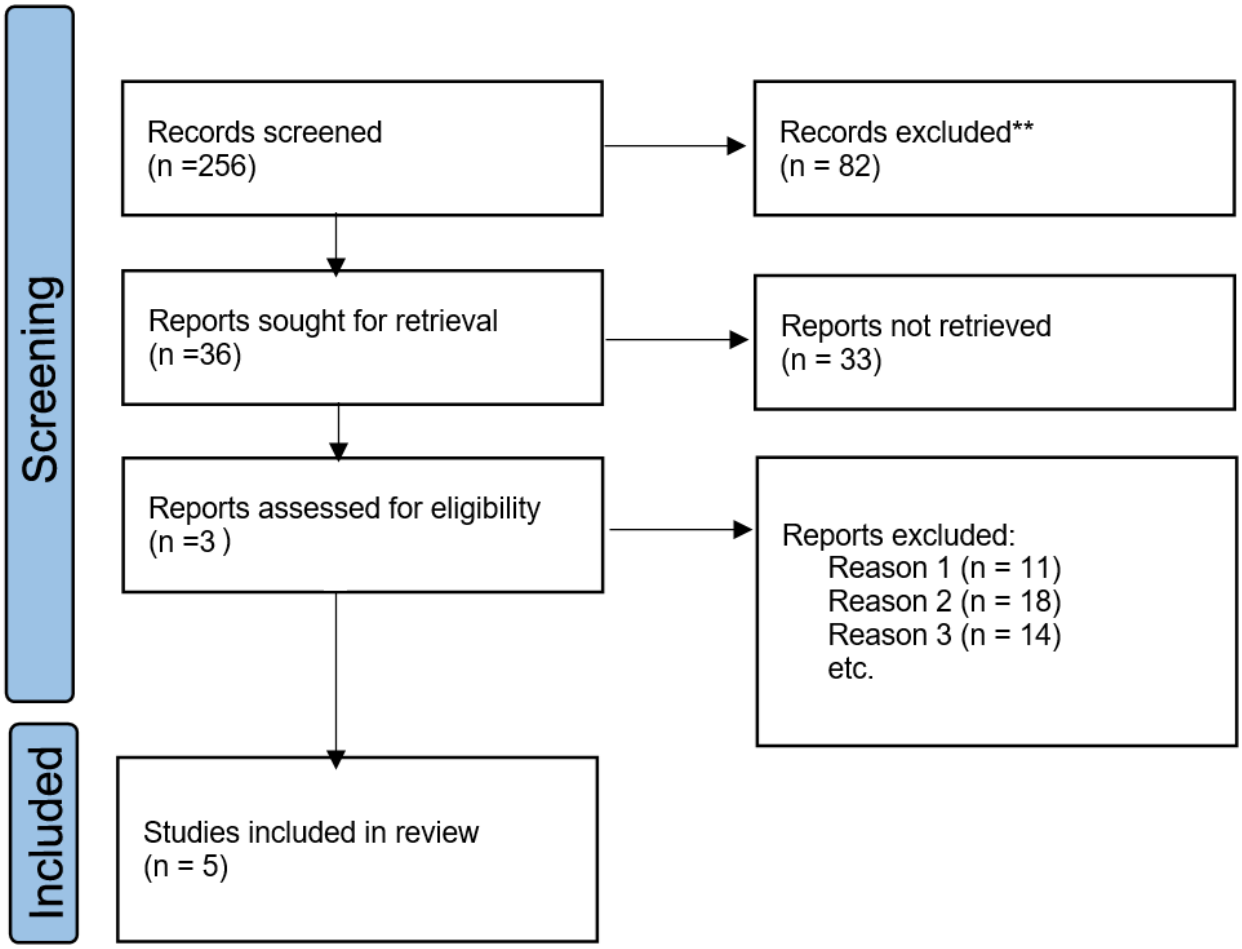

Figure 4.
PRISMA Flow Diagram for the Study.

3.4. Data Extraction

A systematic approach to data extraction allowed researchers to gather all important details from the chosen studies. A standardized data extraction form was created to document essential study characteristics of author(s) and publication date with research goals and methodology and key findings and implications for preservice teacher education. Thematic organization of extracted data helped researchers perform analysis and synthesis operations. Analysis of the literature focused on detecting recurring themes and trends about how assistive technology and UDL could integrate in the TPACK framework. The approach confirmed that the research findings were derived from the information contained in included studies and delivered thorough knowledge about the subject matter.

3.5. Ethical Considerations

Ethics remained the leading concern during all phases of the research procedure. Publicly released peer-reviewed databases provided all data for this research without any breach of ethical codes. Academic standards related to integrity were observed by providing proper citations and preventing plagiarism throughout the research. The study followed ethical research standards through comprehensive documenting steps including the search methods and both admission and elimination tactics and information gathering methods. The research approach provides a complete view of the methods that makes the study more trustworthy to readers while granting the opportunity for researchers to duplicate the investigation. The study maintains its findings validity through ethical principles thus adding valuable evidence to the discussion on inclusive education and teacher training research.

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Table 1.
Summary of the Literature Review.

Reference	Objective	Methodology	Findings
Moon, et al. [5]	The study examines how preservice teachers' concepts of technology integration evolve through scientific inquiry in their creative processes.	Convergent parallel mixed-method	The study found that design activities enhanced preservice teachers' scientific inquiry, technology integration, and epistemological understanding, fostering a scientific evidence-based mindset.
Thappa and Baliya [34]	This study assesses prospective teachers' familiarity with the TPACK framework in their preparation program.	Descriptive-Exploratory Research Approach	The study found varying levels of TPACK understanding among preservice teachers. Fewer than half were familiar with its subcomponents, and none grasped their integration. Most learned about TPACK outside their formal teacher education program.
Araújo Filho and Gitirana [35]	This study uses digital resources to investigate the TPACK-based knowledge of aspiring educators within a collaborative teacher education framework.	Exploratory Methodology	Despite being in the early stages of training, students demonstrated TPACK intersections, linking pedagogical and subject knowledge. While limited prior experience in teacher preparation was evident, they completed all five training stages.
Aşık [36]	Students demonstrated TPACK intersections, linking pedagogical and subject knowledge despite limited prior experience. They completed all five training stages.	Mixed-method research design, combining quantitative survey analysis to assess TPACK-EFL improvements	The study found significant TPACK-EFL improvement in STs, who positively perceived digital tools for enhancing motivation, engagement, and peer teaching effectiveness.
Chai, et al. [29]	This research explores how preservice educators' attitudes toward new learning cultures and school-based learning relate to their design dispositions, learning design practices, and TPACK factors.	Survey Research Methodology,	The study found that as teachers' TPACK competency increased, their learning perspectives and class design improved, shifting focus from fixed curricula to student-centered, digital, and collaborative learning.

4. Analysis and Discussion

4.1. Discussion

According to the findings above, exposing future educators to and providing them with experience with cutting-edge technology is vital. Owing to the nature of these training activities, preservice teachers now have a greater capacity to give students learning opportunities that are both distinctive and long-lasting. As Dorner and Kumar [37] clarified, their experiences may leave an epistemic imprint on teachers' long-term memories about incorporating and handling technology in the classroom. According to the findings of Du and Lyublinskaya [38] if aspiring teachers believe they can effectively integrate technology into their lessons, they are more likely to do so. Since preservice teachers collaborate closely with cooperating teachers throughout study teaching, teacher education

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programmers may educate cooperating teachers to provide needed support and promote technology integration. Cheng [39] emphasized that a mutually beneficial partnership that enables the incorporation of technology throughout all stages of education might be the most effective and time-saving strategy for ensuring that students graduate with the literacy skills they need to succeed. Making effective use of technology cannot simply be added to other projects as an afterthought. Instead, one must emphasize the need to adopt a holistic perspective that ensures the continued development of technology as a practical instrument.

It has been identified in the above findings that programmers must prepare teachers for the classroom and should not automatically assume that their graduates would be at ease incorporating technology into their lessons just because those graduates are users of technology in their personal lives. Pozas and Letzel [40] also identified that before preservice teachers attempt to employ technology integration in their classrooms, it is necessary for them to feel at ease with the process themselves; otherwise, they will give it a passing look. In addition, Liu and Kleinsasser [41] accentuated that programmers prepare teachers should include technology in every aspect of student education to familiarize future teachers with its use. This technique could increase the number of aspiring teachers who use technology in their lesson plans and classrooms. Considering this, Rowston, et al. [42] determined that even if there is a shift in the curriculum to integrate technological elements, it could not matter if schools do not have the means to implement such changes. Apart from that, the exposure that students have to various technology instruments in the classroom has a significant impact on the mentalities of their teachers.

The above analysis suggests that prospective teachers need to have experience with various educational technologies as part of their education and training. Teachers' technological pedagogical content knowledge (TPACK) demonstrates their confidence that they can modify and re-orchestrate the practices with which they are engaged. According to Nguyen [43] when it comes to integrating technology into classroom practice, the amount of training a teacher receives is not nearly as significant as a teacher's mentality and beliefs about the benefits of technology for the teaching and learning process. Furthermore, Lemon and Garvis [44] claimed that emphasizing enhancing the technological and pedagogy-related practice skills and approaches of preservice teachers may favor inclusive educational practice in the classroom. Integrating pedagogical practices with cutting-edge technology materials helps students enhance their inventive skills.

5. Conclusion

To conclude, incorporating assistive technology into the training of future teachers offers the possibility of improving the academic achievement of individuals. When arguing favor using text-to-speech technology, an individual with at least a bachelor's degree will have greater credibility. The learning outcomes teachers anticipate their students will acquire must be considered while evaluating curriculums. The attitudes and perspectives of teachers directly affect the extent to which students benefit from using technology in the classroom. Instead of focusing on integrating technology after learning barriers have been removed, as is typically the case, the TPACK paradigm emphasizes the UDL premise that argues for the use of technology to design accessible education initially.

It contrasts with the typical approach, which focuses on integrating technology after removing learning barriers. On-text neutral strategies for integrating technology into the classroom provide general approaches to the education challenge. However, classroom technology usage is situational and is, or at least has to be, considering factors such as curriculum, student background, grade level, and accessibility to appropriate technology and software. The TPACK paradigm emphasizes the universal learning design (UDL) that supports using technology to design accessible education from the start rather than retrofitting or adding technology after removing learning barriers. It contrasts with the traditional paradigm, which emphasizes adding technology after removing learning barriers. The determining factor is how the perspectives of preservice educators on integrating technology and their exposure to scientific inquiry impacted their creative processes during their careers. Aspiring educators

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gained a deeper understanding of scientific inquiry and had more optimistic viewpoints toward integrating technology. Consequently, it is possible to demonstrate that the interactions have formed new TPACK intersections. Exposure to various technology tools used in the classroom should be a required part of the training and education that future educators will acquire. Due to this, they will see a rise in their confidence while using computers, which is linked to familiarity and worldview. Due to this, they will have a better chance of using technology in their everyday routines. Educators' technical, pedagogical content knowledge (TPACK) reflects the degree to which they are self-assured in their capacity to adapt and reconfigure their professional practices.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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