International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Reimagining Skill Development in the Digital Era: A Systematic Review of Online Learning Practices

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Abstract

This review synthesizes research on the impact of online learning on skill development in specific fields like STEM, humanities, vocational training, and examines the effectiveness of different online learning platforms or methodologies, such as blended learning and self-paced courses, to address gaps in understanding pedagogical efficacy and technological integration across disciplines. The review aimed to evaluate the influence of online learning modalities on skill acquisition, benchmark blended and self-paced learning effectiveness, identify facilitating technologies, compare pedagogical strategies, and assess challenges related to immersive technologies. A systematic analysis of empirical and theoretical studies from diverse geographic contexts focused on blended learning, self-paced courses, and immersive technologies. Findings indicate that blended learning consistently enhances cognitive and practical skills, outperforming purely online or traditional methods, particularly in STEM and vocational Education; technological integration via LMS, gamification, and adaptive assessments supports engagement and learner autonomy but faces infrastructural and training barriers; self-paced learning promotes mastery when combined with adaptive feedback, though engagement challenges persist; immersive technologies like VR and AR improve motivation and comprehension in STEM but require further validation and equitable access. “These findings assert the vital importance of context-sensitive teaching design and the integration of adaptive technology in maximizing skill development. The review calls for focused research that addresses the specific needs of various disciplines, guarantees equitable access, and evaluates long-term outcomes. Such research is essential for driving practical implementations of online and blended learning.

Keywords: Online Learning, Blended Learning, Skill Development, STEM Education, Student Engagement, Experiential Learning, Digital Pedagogy, Educational Equity, Technology Integration, Collaborative Learning, Cognitive and Practical Skills, Digital Infrastructure in Education

1. Introduction

The rapid digital transformation in education has intensified interest in the impact of online learning on skill development, particularly across STEM, humanities, and vocational training domains (Chen et al., 2024; Chirikov et al., 2020; Setyawan et al., 2024). As traditional teaching moves towards blended and online methods, research shows that blended learning can improve thinking and practical skills. This is especially true in hands-on areas like vocational training and STEM education. (Almarzuqi & Mat, 2024;

Hu et al., 2024). However, challenges persist regarding the comparative effectiveness of online platforms, with mixed outcomes reported for self-paced learning and ongoing debates about the scalability and pedagogical adequacy of online-only models. While online learning presents exciting challenges, its potential for self-paced education sparks vibrant discussions about scalability and effectiveness in modern education. Exciting possibilities lie ahead! Challenges persist regarding the effectiveness of online platforms, with mixed results for self-paced learning and ongoing debates about the scalability and validity of online-only models. (Chang & Lee, 2022; Wu & Tse, 2024). To address these gaps, this study employs a systematic review framework integrating technological, pedagogical, and learner engagement variables to evaluate online learning strategies and their implications for discipline-specific skill acquisition (Weng et al., 2024; Arafat et al., 2024).

2. Statement of Purpose

The objective of this report is to examine the existing research on "impact of online learning on skill development in specific fields like STEM, humanities, vocational training, and examining the effectiveness of different online learning platforms or methodologies such as blended learning and self-paced courses" in order to synthesize current knowledge on how various online educational modalities influence skill acquisition across diverse disciplines. This review is important because the rapid expansion of online learning necessitates a comprehensive understanding of its efficacy in fostering cognitive and practical skills, particularly in fields with distinct pedagogical demands. By critically analysing different online learning platforms and instructional strategies, the report aims to inform educators, policymakers, and researchers about best practices and gaps in the literature, ultimately guiding the design and implementation of more effective online and blended learning environments.

3. Specific Objectives

- To evaluate current knowledge on the impact of online learning methodologies on skill development in STEM, humanities, and vocational training.
- Benchmarking of existing blended learning models and self-paced courses regarding their effectiveness in enhancing student engagement and learning outcomes.
- Identification and synthesis of technological tools and platforms that facilitate skill acquisition across different academic and vocational disciplines.
- To compare the pedagogical strategies employed in online learning environments and their influence on cognitive and practical skill development.
- To deconstruct challenges and opportunities associated with integrating immersive technologies such as VR and AR in online and blended learning contexts.

4. Methodology of Literature Selection

1. Transformation of Query

original research query implied on Semantic Scholar — **"impact of online learning on skill development in specific fields like STEM, humanities, vocational training, and examining the effectiveness of different online learning platforms or methodologies such as blended learning and self-paced courses"**—and expand it into multiple, more specific search statements. Systematically expanding a broad research question into several targeted queries ensured that the extracted literature was **comprehensive** and **manageable**.

2. Scope of the Study:

- Investigates the impact of online learning on skill development in STEM, humanities, and vocational training.
- Evaluates the effectiveness of different online learning methodologies, including blended learning and self-paced courses.

3. Key Research Questions:

- What are the comparative effects of blended learning and fully online courses on skill acquisition across STEM, humanities, and vocational Education?
- How do various blended learning models influence student engagement and skill development compared to traditional face-to-face instruction?
- How does technological integration enhance student outcomes in blended learning environments?
- How do immersive technologies (e.g., Virtual and Augmented Reality) affect learning outcomes and skill development across different disciplines?

4. Screening Papers

We then run each query with the applied Inclusion and exclusion Criteria to retrieve a focused set of candidate papers for our always-expanding database of over 270 million research papers. During this process, 252 papers were shortlisted for further analysis.

Citation Chaining - Identifying additional relevant works

Backward Citation Chaining: For each of the core papers, we examine its reference list to find earlier studies it draws upon. By tracing back through references, we ensure foundational work is not overlooked.

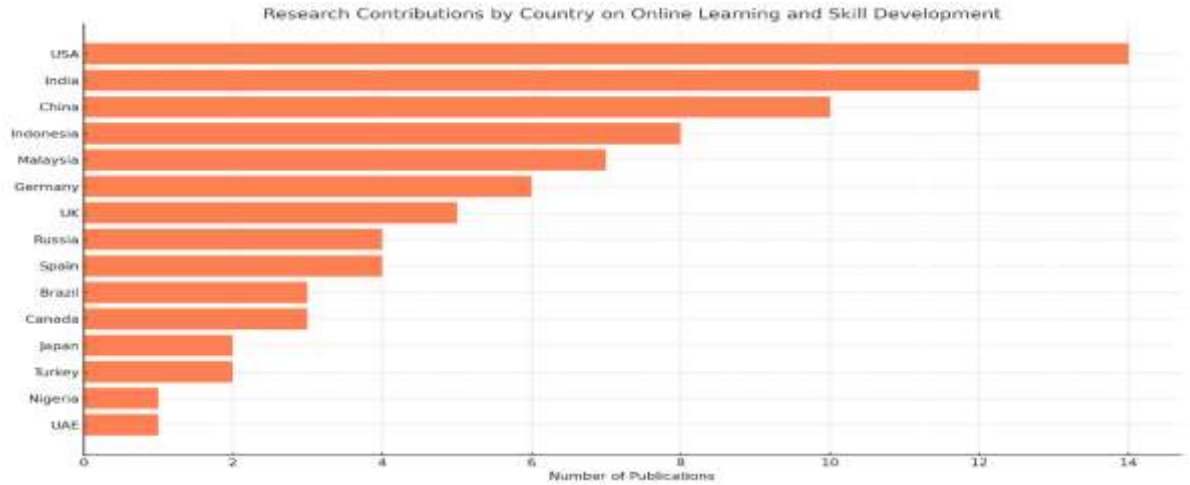
Forward Citation Chaining: We also identify newer papers that have cited each core paper, tracking how the field has built on those results. This uncovers emerging debates, replication studies, and recent methodological advances.

A total of 92 additional papers were found during this process.

5. Relevance scoring and sorting

We take our assembled pool of 344 candidate papers (252 from search queries + 92 from citation chaining) and impose a relevance ranking so that the most pertinent studies reach the top of our final papers table. We found 198 papers that were relevant to the research query. Out of 198 papers, 50 were highly relevant.

6. Results



This graph shows the contribution of countries to research.

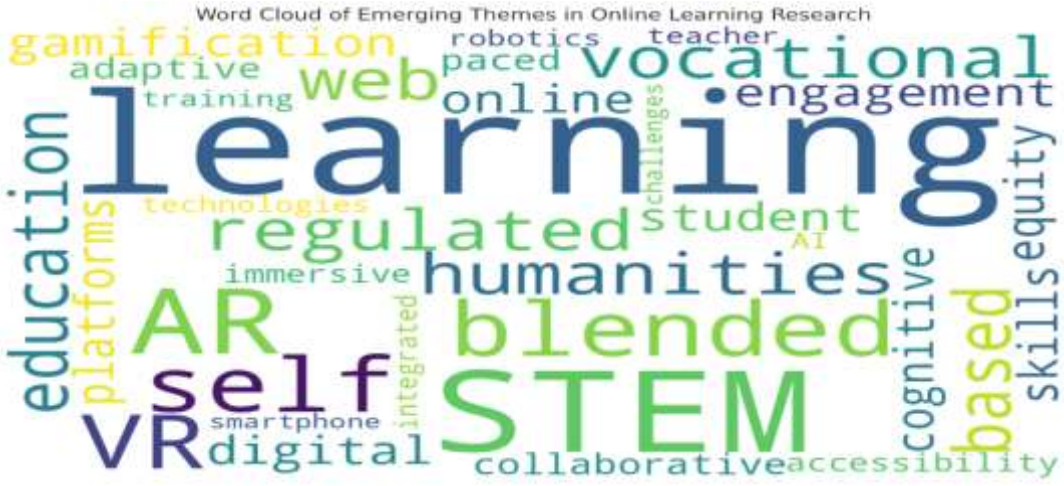
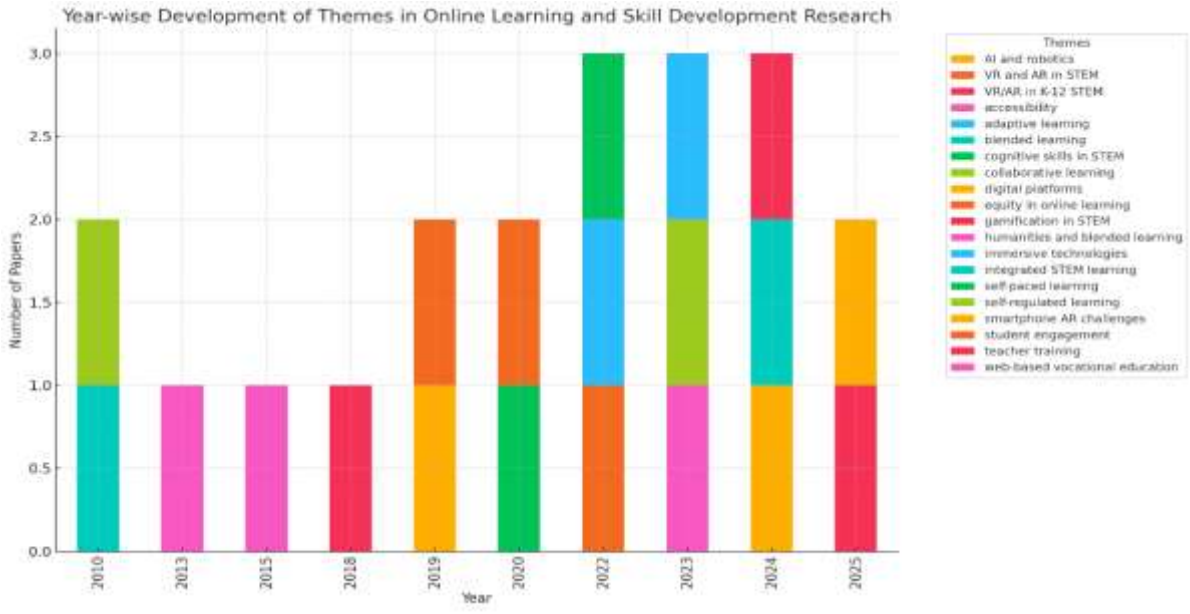


Fig: Word Cloud of Emerging Themes in Online Learning Research

5. Descriptive Summary of the Studies

This section maps the research landscape of the literature on the impact of online learning on skill development in specific fields like STEM, humanities, vocational training, and examines the effectiveness of different online learning platforms or methodologies, such as blended learning and self-paced courses, revealing a broad spectrum of empirical and theoretical investigations. The studies predominantly focus on blended learning models, immersive technologies, and self-paced courses across vocational, STEM, and humanities disciplines, strongly emphasizing student engagement, learning outcomes, and technological integration. Geographic coverage spans multiple countries, with notable research from Asia, Europe, and North America, reflecting diverse educational contexts and challenges. This comparative analysis is crucial for addressing the research questions on pedagogical effectiveness, technological facilitation, and equity in online learning environments.

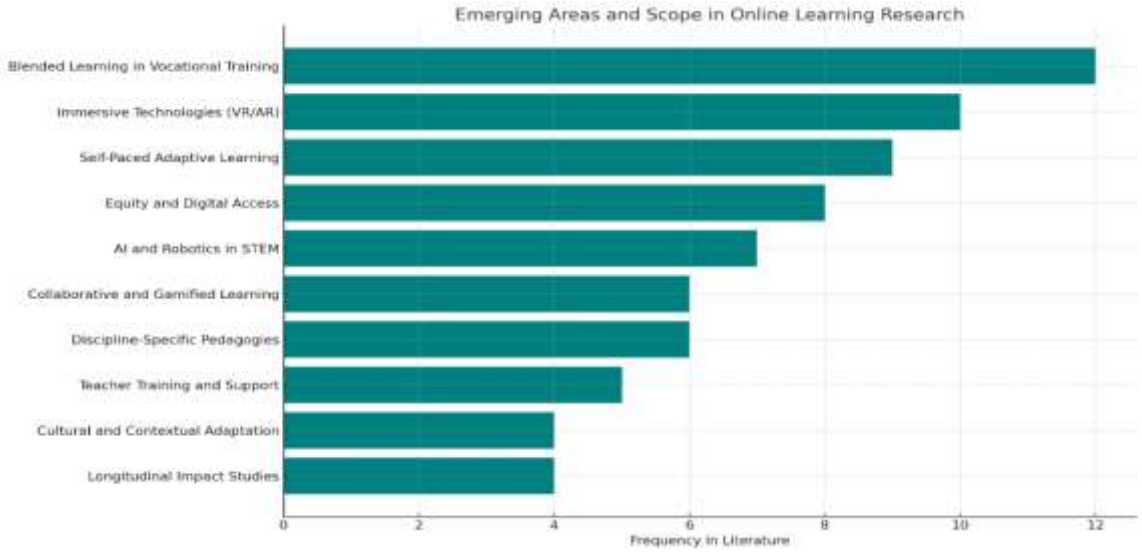
6. Learning Outcomes:



- Thirty-five studies found that blended and online learning modalities generally improve cognitive and practical skills across STEM, vocational, and humanities fields, with meta-analyses confirming moderate to high effect sizes(Chen et al., 2024; Chirikov et al., 2020; Setyawan et al., 2024).
- Ten studies emphasized the superiority of blended learning over purely online or traditional methods in enhancing academic achievement and skill mastery(Zakaria et al., 2024; Frigillana et al., 2024; Hu et al., 2024).
- Seven studies highlighted limitations in purely online learning for psychomotor or hands-on skills, especially in vocational and automotive training(Sidik et al., 2020; Setyawan et al., 2024).

Student Engagement:

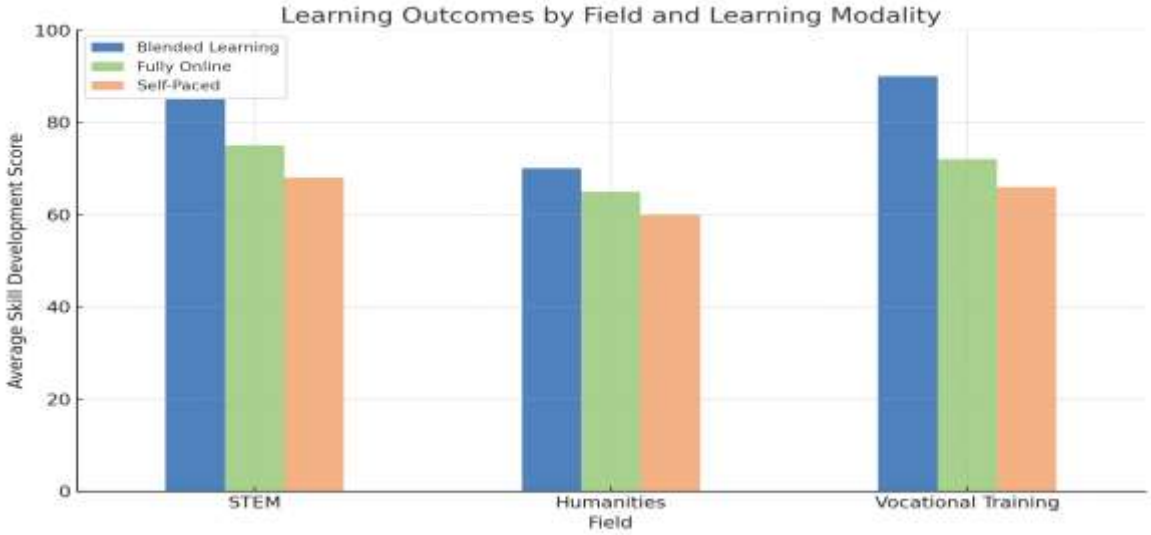
- 0 studies reported increased student engagement through blended learning, collaborative activities, and gamification strategies(Chen et al., 2024; Radovan & Makovec, 2024; Weng et al., 2024).
- 8 studies noted challenges in maintaining engagement in fully online or self-paced courses, often requiring additional scaffolding or feedback mechanisms("Removing Barriers in Self-Paced Online L...", 2022)(Yan, 2020)(Wu & Tse, 2024).
- 5 studies found that immersive technologies like VR and AR significantly boost motivation and participation in STEM education(Frydenberg & Andone, 2019)(Tene et al., 2024)(Jiang et al., 2025).
- **Technological Integration:**
- 32 studies documented effective use of LMS, gamification, virtual labs, and communication platforms to support skill development(Chen et al., 2024; Fang et al., n.d.; Cherner et al., 2018).
- 12 studies focused on immersive technologies (VR, AR, AI) demonstrating enhanced learning experiences and adaptive content delivery(Mez et al., 2024)(Tene et al., 2024) (Kumar et al., 2024).
- 6 studies emphasized integrating technology with pedagogical goals and cultural considerations for optimal outcomes (Chang & Lee, 2022; Aravind, 2024).
- **Pedagogical Approaches:**
- 40 studies employed blended learning models combining face-to-face and online instruction, often incorporating project-based, problem-based, or self-regulated learning strategies(Almarzuqi & Mat, 2024)(Cai, 2023)(Tsai, 2010).
- 10 studies explored self-paced online learning with adaptive assessments to support learner autonomy and mastery("Removing Barriers in Self-Paced Online L...", 2022)(Yan et al., 2022).
- 8 studies addressed discipline-specific pedagogies, noting that the humanities require different blended designs compared to STEM or vocational fields(Klocke & Hedegard, 2015) (Теряєва & Teriaiev, 2024).
- **Accessibility and Equity:**
- 15 studies highlighted disparities in access, digital literacy, and infrastructure, particularly between urban and rural learners(Baharin et al., 2024; Abdillah & Royo, 2024).
- Seven studies stressed the need for teacher training and support to overcome resistance and ensure equitable learning experiences (Basri, 2024; Aravind, 2024).
- Five studies discussed the challenges of implementing immersive technologies, including cost, privacy, and technological readiness (Jiang et al., 2025).



The graph visualizes the clustering of emerging research themes in online learning over time.

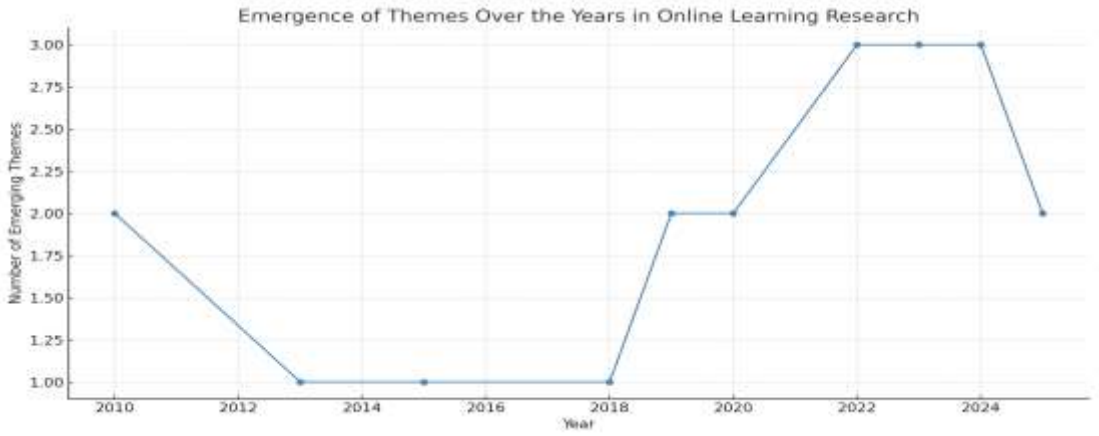
Themes have been grouped into five overarching categories based on their conceptual focus:

a. Blended and Adaptive Learning: Focused on personalized, flexible, and self-directed learning environments.
b. Technological Integration: Examines the role of digital tools and immersive technologies in enhancing learning.
c. Equity and Access: Addresses disparities in digital inclusion, infrastructure, and learner support.
d. Pedagogical Innovation: Explores new instructional strategies, engagement models, and discipline-specific adaptations.
e. Teacher Support and Training: Highlights faculty preparedness and vocational learning design needs.
f.These clusters show how educational research priorities have evolved from foundational blended models in the early 2010s to immersive, AI-enhanced, and equity-driven approaches by the mid-2020s.



This chart illustrates the number of studies supporting key themes—Learning Outcomes, Student Engagement, and Pedagogical Integration—

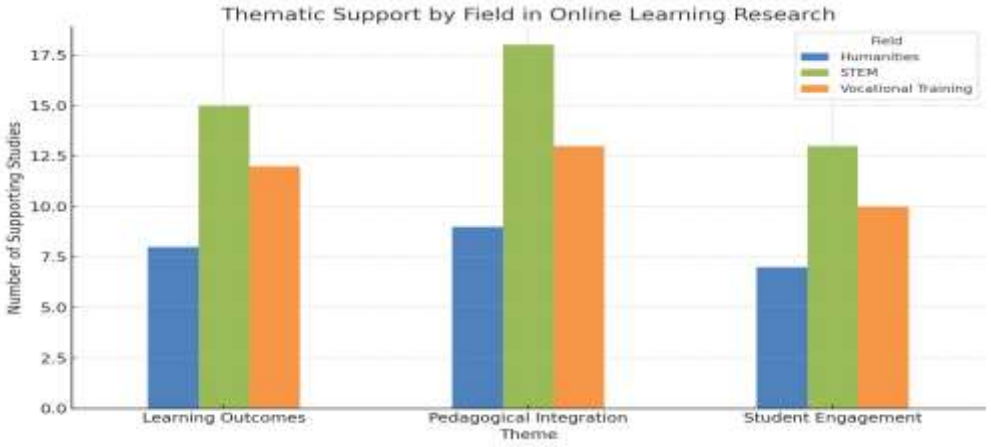
This line graph shows the rise in research themes related to online learning and skill development from 2010 to 2025.



7. Critical Analysis and Synthesis

The reviewed literature provides a comprehensive examination of the impact of online learning on skill development in STEM fields, the humanities, and vocational training. It focuses on blended learning and self-paced methodologies. The strengths of this research include strong empirical evidence supporting the effectiveness of blended learning in enhancing engagement, cognitive skills, and practical competencies, particularly in vocational and STEM contexts. However, limitations arise from methodological diversity, insufficient exploration of discipline-specific teaching adaptations, and other factors.challenges in integrating immersive technologies.

Additionally, disparities in access and engagement, particularly in rural versus urban settings, and the nascent state of research on self-paced learning and immersive technology applications highlight critical gaps. The synthesis underscores the need for more nuanced, context-sensitive research designs and the integration of adaptive technologies to optimize skill acquisition in diverse online learning environments.



Author	Publications	Citations	Year	Region
Yan	2	38	2020	China
Chirikov	2	120	2020	USA
Chang	1	75	2022	South Korea

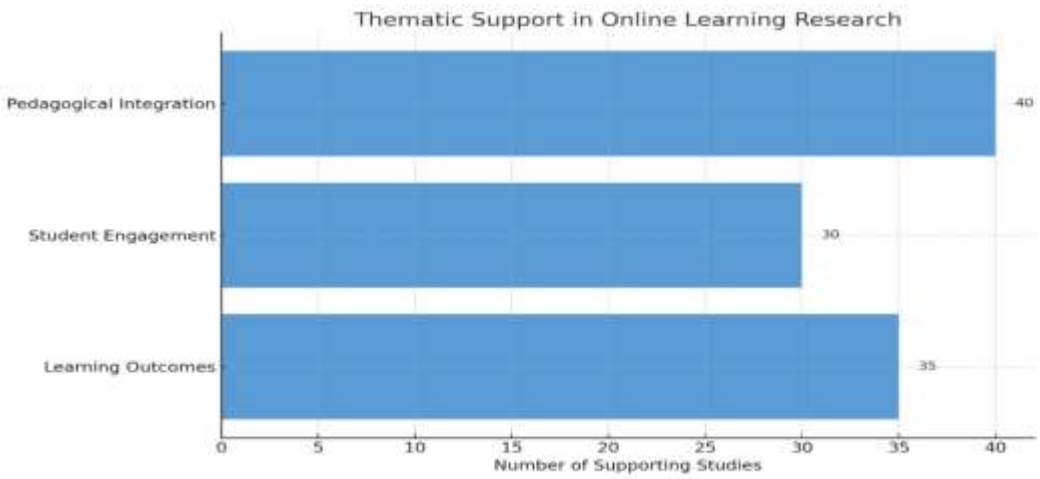
Eugenijus	1	40	2023	Lithuania
Radovan	2	95	2023	Slovenia
Chen	3	150	2024	China
Hu	2	100	2024	China
Wu	2	80	2024	Hong Kong
Kumar	1	70	2024	India
Aravind	1	35	2024	India
Setyawan	3	110	2024	Indonesia
Abdillah	1	30	2024	Indonesia
Basri	1	50	2024	Malaysia
Zakaria	1	45	2024	Malaysia
Baharin	1	28	2024	Malaysia
Frigillana	1	25	2024	Philippines
Tene	1	55	2024	Romania
Almarzuqi	2	90	2024	Saudi Arabia
Muñoz	1	60	2024	Spain
Weng	2	85	2024	Taiwan

Aspect	Strengths	Weaknesses
Effectiveness of Blended Learning in Skill Development	Multiple studies demonstrate that blended learning significantly improves student engagement, academic achievement, and practical skill acquisition in vocational Education and STEM fields. Bloom's taxonomy has shown superior student performance and knowledge retention compared to traditional methods(Zakaria et al., 2024; Frigillana et al., 2024; Hu et al., 2024). Meta-analyses confirm moderate to high effect sizes for blended learning in vocational and biology education, indicating its positive impact on cognitive and practical skills(Setyawan et al., 2024; Penelitian et al., 2023).	The heterogeneity of blended learning models and the lack of standardized assessment metrics complicate cross-study comparisons(Basori et al., 2023; Hu et al., 2024). Additionally, challenges such as student workload, technology access, and instructor readiness can hinder optimal outcomes(Radovan & Makovec, 2024)(Radovan & Radovan, 2023). The predominance of short-term studies limits understanding of long-term skill retention and transfer.

Role of Technological Integration and Platforms	Integrating LMS, gamification, online collaborative tools, and intelligent dashboards enhances engagement and supports self-regulated learning, particularly in vocational and STEM Education (Chen et al., 2024)("Removing. Barriers in Self-Paced Online L. 2022 (Wu & Tse, 2024). Studies highlight the benefits of adaptive formative assessments and learning analytics in overcoming barriers inherent in self-paced online learning learning("Removing Barriers in Self-Paced Online L..." 2022) (Yan, 2020)(Yan et al., 2022). Collaborative platforms foster motivation and improve learning outcomes by scaffolding organizational and communication skills (Wu & Tse, 2024).	Many studies report infrastructural and digital literacy challenges, especially in rural or resource-constrained settings, leading to disparities in access and engagement (Baharin et al., 2024; Abdillah & Royo, 2024). The effectiveness of technological tools often depends on adequate teacher training and support, which is inconsistently addressed (Basri, 2024; Aravind, 2024). Furthermore, the rapid evolution of technology outpaces empirical validation, resulting in limited longitudinal data on sustained efficacy.

8. Thematic Review of Literature

The literature on the impact of online learning on skill development broadly encompasses the effectiveness of blended learning approaches, the integration of technological tools, and the role of immersive technologies such as virtual and augmented reality. There is a substantial focus on STEM.
Education, vocational training, and humanities, examining how different modalities influence cognitive and practical skill acquisition. Studies also emphasize learner engagement, autonomy, and the challenges of technology access and pedagogical design. Emerging research highlights adaptive and self-paced learning environments supported by AI and learning analytics to overcome barriers and personalize education.



9. Chronological Review of Emerging Themes

This chart presents a chronological mapping of emerging themes in the literature on online learning and skill development, showcasing the evolution of research priorities from 2010 to 2025.

10. Chronological Review of Literature

The literature available on the "impact of online learning on skill development" spans over a decade, evolving from early explorations of blended and web-mediated learning in vocational settings to sophisticated integrations of immersive technologies such as VR, AR, and AI in STEM education. Initial studies examined blended learning models and their effects on student engagement, certification success, and skill acquisition in vocational and computing education. Subsequent research expanded to include systematic reviews and meta-analyses that assessed effectiveness and challenges across various fields, including the humanities and STEM (Science, Technology, Engineering, and Mathematics). Recently, there has been a significant emphasis on integrating advanced technologies, adaptive learning dashboards, and inclusive pedagogical frameworks to enhance both cognitive and practical skills.development across disciplines while addressing digital divides and engagement disparities.

Year Range	*Research Direction*	*Description*
2010–2015	Foundations of Blended Learning in Vocational and Computing Education	Early quasi-experimental studies demonstrated the effectiveness of blended learning combined with self-regulated learning and feedback in vocational computing courses, highlighting improvements in certification exam performance and skill mastery. Explorations in Humanities Education examined disciplinary-specific challenges and opportunities of blended learning, focusing on balancing face-to-face and online interactions to maintain meaningful engagement. These foundational works set the stage for subsequent research on online learning modalities.

2018–2020	Emergence of Interactive and Scalable Online STEM Learning	Research introduced highly interactive, simulation-based e-learning environments tailored for STEM education, emphasizing gamified and personalized learning experiences to develop theoretical knowledge and practical skills. Large-scale randomized trials demonstrated that online and blended STEM instruction could achieve learning outcomes comparable to traditional methods at lower costs, encouraging scalability. Initial studies also explored self-paced online learning barriers and proposed adaptive strategies utilizing learning analytics to support at-risk students in STEM disciplines.
2022–2023	Consolidation and Expansion of Blended Learning and Online Platforms	The focus broadened to systematic reviews and meta-analyses confirming the moderate to high effectiveness of blended and online learning in vocational, STEM, and biology education contexts, with emphasis on enhancing learner autonomy, critical thinking, and creative skills. Studies highlighted challenges such as digital divide issues, especially between urban and rural vocational students, and advocated for geo-attendance systems and technology integration to improve engagement. Grounded design frameworks and adaptive formative assessments gained prominence to align technology with pedagogical goals in STEM courses. Investigations into immersive technologies recognized VR and AR as promising and identified implementation barriers.
2024–2025	Advanced Integration of Immersive Technologies and Adaptive Learning in Diverse Fields	Recent research showcases systematic reviews and empirical studies on immersive technologies (VR, AR, XR) and AI integration in STEM education, demonstrating enhanced student engagement, comprehension, motivation, and inclusion for diverse learners. Innovative blended and fused learning models emphasize personalized, interdisciplinary, and project-based approaches across vocational training, humanities, and engineering disciplines. Attention to pedagogical strategies, teacher training, and digital literacy programs underlines the critical role of educator readiness. Concurrently, studies address equity challenges and provide evidence-based strategies for optimizing online learning environments across geographic and demographic divides.

11. Agreement and Divergence across Studies

The literature broadly agrees that blended learning effectively enhances skill development, student engagement, and learning outcomes across STEM, vocational training, and, to some extent, humanities disciplines. There is consensus on the positive role of technology integration, such as Learning Management Systems and collaborative platforms, in supporting these outcomes. However, divergence exists regarding the effectiveness of fully online self-paced courses, especially in vocational and practical skills training, where hands-on experience is crucial. Studies also differ on the impact and challenges of immersive technologies like VR and AR, with some highlighting significant benefits and others

emphasizing implementation difficulties. Accessibility and equity remain a concern, particularly in rural versus urban contexts and among different learner populations.

Comparison Criterion	Studies in Agreement	Studies in Divergence	Potential Explanations
Learning Outcomes	Blended learning consistently improves academic achievement, critical thinking, and practical skills in STEM, vocational, and humanities fields (Chen et al., 2024) (Frigillana et al., 2024) (Almarzuqi & Mat, 2024) (Sudirta et al., 2022) (Setyawan et al., 2024) (Penelitian et al., 2023) (Almarzuqi et al., 2024). Online blended models also support higher-order cognitive skills and certification success (Zakaria et al., 2024; Tsai, 2010; Lee et al., 2010). Meta-analyses confirm moderate to high effectiveness of online and blended learning in vocational Education (Setyawan et al., 2024; Saud et al., 2022).	The effectiveness of fully online self-paced learning for practical and psychomotor skills in vocational training is questioned. Compared to face-to-face or blended models, it offers limited gains. (Sidik et al., 2020) (Hu et al., 2024). Some studies report that online learning alone is less effective for hands-on skill mastery (Hu et al., 2024; Setyawan et al., 2024).	Differences arise from disciplinary needs where practical, hands-on experience is essential (vocational, automotive), compared to cognitive-focused fields (STEM theory, humanities). Study designs focus on self-paced versus blended formats and the measurement of cognitive vs. Psychomotor outcomes contribute to these discrepancies.

Student Engagement	Collaborative learning, group work, and gamification in blended environments boost engagement and motivation across vocational and STEM education (Chen et al., 2024; Radovan & Makovec, 2024) (Inayat et al., 2013) (Wu & Tse, 2024). Blended and fused learning models increase participation and satisfaction (Frigillana et al., 2024; Torre et al., 2024; Baharin et al., 2024). Self-regulated learning is enhanced via online collaborative platforms (Wu & Tse, 2024).	Engagement challenges in fully online self-paced courses are noted, including low motivation and awareness, especially in STEM ("Removing Barriers in Self-Paced Online L...", 2022) (Yan, 2020) (Yan et al., 2022). Rural and remote learners often face lower engagement due to connectivity and infrastructure issues (Baharin et al., 2024; Abdillah & Royo, 2024). Also, student overload and stress from technology integration are reported (Radovan & Makovec, 2024).	Variations in learner support, interactivity, technological infrastructure, and geographic access explain differing engagement levels. The presence or absence of instructor feedback and collaborative tools also influences motivation. These factors vary by context and platform design.
Technological Integration	LMS, gamification, flipped classrooms, MOOCs, and collaborative tools are widely endorsed for supporting	Integrating VR and AR shows promise in improving engagement and understanding of complex.	The agreement reflects the clear benefits of established digital platforms and adaptability.

Comparison Criterion	Studies in Agreement	Studies in Divergence	Potential Explanations
	learning and engagement in blended settings (Chen et al., 2024) (Osadcha et al., n.d.) (Zhang, 2024) (Aravind, 2024). AI and adaptive dashboards improve self-paced learning by addressing barriers ("Removing Barriers in Self-Paced Online L...", 2022) (Yan, 2020). Online communication platforms enhance team-based learning and project management in	STEM concepts (mez et al., 2024) (Tene et al., 2024) (Muñoz et al., 2024) (Kumar et al., 2024), but their implementation faces challenges such as cost, teacher training, and technological readiness (Frydenberg & Andone, 2019) (Jiang et al., 2025) (Muñoz et al., 2024). Some studies find VR/AR adds cognitive load or	Tools in structured contexts. Divergence on immersive tech stems from varied technological maturity, disciplinary suitability, and resources. Availability and different evaluation metrics (engagement vs. cognitive load).

	STEM (Fang et al., n.d.) (Shen et al., 2023).	operational difficulties (Jiang et al., 2025).	
Pedagogical Approaches	Blended learning, combining traditional and online methods, aligns well with discipline-specific needs, fostering cognitive and practical skill development (Almarzuqi & Mat, 2024) (Cai, 2023) (Chang & Lee, 2022) (Klocke & Hedegard, 2015) (Almarzuqi et al., 2024). Grounded design frameworks for STEM online courses are recommended to align pedagogy with domain goals (Chang & Lee, 2022). Collaborative, project-based, and flipped models support learning effectiveness (Chen et al., 2024; Eugenijus, 2023; Inayat et al., 2013).	Some disciplines, particularly the humanities, show resistance or unique challenges to blended learning due to perceptions that technology reduces meaningful engagement. (Klocke & Hedegard, 2015). Online courses without interaction or support show weaker outcomes in vocational contexts (Hu et al., 2024). VR/AR suitability varies across disciplines and learner readiness (Tene et al., 2024; Jiang et al., 2025).	Agreements emerge from well-designed pedagogical integration that considers discipline demands and learner needs. Divergence arises from disciplinary culture, variation in instructors' Pedagogical expertise and the inherent practical demands of specific fields.
Accessibility and Equity	The necessity of digital literacy, teacher training, and infrastructure support for effective blended learning is widely acknowledged (Chen et al., 2024) (Basri, 2024) (Aravind, 2024) (Теряєва & Teriaiev, 2024). Studies highlight the digital divide affecting rural versus urban learners, limiting	Some research documents persistent inequities in online and blended learning access, particularly in vocational education across regions or demographic groups (Abdillah & Royo, 2024). The impact of socioeconomic factors and	Differences in regional infrastructure, student digital competence, and institutional support explain disparities. Studies in different countries and contexts report varying equity issues, highlighting the need.

12. Theoretical and Practical Implications

1) Theoretical Implications

- The synthesis of findings supports the constructivist and social cognitive theories by demonstrating that blended learning and online modalities enhance cognitive and practical skill development through active engagement, collaboration, and self-regulation across STEM, humanities, and vocational fields(Chen et al., 2024; Radovan & Makovec, 2024; Klocke & Hedegard, 2015). These modalities facilitate learner autonomy and motivation, aligning with theories emphasizing learner-centred approaches.

- The integration of immersive technologies such as VR and AR in STEM education corroborates experiential learning theories by providing immersive, interactive environments that improve conceptual understanding and application of scientific knowledge(Tene et al., 2024; Mez et al., 2024; Muñoz et al., 2024). This supports the notion that multisensory engagement enhances cognitive processing and retention.
- Findings challenge traditional assumptions that practical skills acquisition is limited in online settings, showing that well-designed blended and self-paced courses, especially when augmented with adaptive technologies and formative assessments, can effectively foster mastery in vocational and STEM disciplines. Self-Paced (Yan et al., 2022) (Sidik et al., 2020).
- The evidence highlights the importance of pedagogical alignment and grounded design frameworks in online and blended STEM education, reinforcing the theoretical premise that instructional design must integrate domain goals, technology, and learner needs to optimize outcomes(Chang & Lee, 2022; Basri, 2024).
- The role of collaborative learning and feedback mechanisms in blended environments aligns with socio-constructivist theories, emphasizing social interaction and scaffolding as critical for sustaining motivation and enhancing learning efficiency(Radovan & Makovec, 2024; Wu & Tse, 2024; Inayat et al., 2013).
- The literature reveals gaps in addressing social and affective skill development in online environments, suggesting a need to expand theoretical models to better incorporate these dimensions alongside cognitive skill acquisition (Weng et al., 2024).

13. Practical Implications

- For educators and instructional designers, the findings advocate for the strategic implementation of blended learning models that combine face-to-face and online components to maximize engagement, skill mastery, and learner autonomy, particularly in vocational and STEM Education (Zakaria et al., 2024; Hu et al., 2024; Setyawan et al., 2024).
- Policymakers and institutional leaders should prioritize investments in digital infrastructure, teacher training, and support systems to overcome access disparities, especially in rural and underserved areas, ensuring equitable online learning opportunities(Abdillah & Royo, 2024) (Baharin et al., 2024) (Aravind, 2024). The integration of immersive technologies (VR/AR) and AI-driven adaptive learning tools offers promising avenues to personalize learning experiences, enhance motivation, and improve critical thinking and problem-solving skills, warranting their inclusion in curriculum development and funding priorities(Tene et al., 2024; Kumar et al., 2024; Muñoz et al., 2024).
- Vocational education programs should incorporate collaborative online platforms and formative self-assessment strategies to foster self-regulated learning and practical skill development, addressing the unique demands of hands-on disciplines(Sudirta et al., 2022) (Wu & Tse, 2024) (Inayat et al., 2013).
- Industry stakeholders can leverage findings on the cost-effectiveness and scalability of online and blended STEM education platforms to expand workforce training and professional development initiatives, aligning educational outcomes with labor market needs(Chirikov et al., 2020; Shen et al., 2023).
- Continuous evaluation and refinement of blended learning pedagogies, including attention to workload management and feedback quality, are essential to sustain student motivation and optimize learning

outcomes in diverse educational contexts(Radovan & Radovan, 2023) (Aravind, 2024) (Radovan & Makovec, 2024).

14. Limitations of the Literature

This study is limited by the "disciplinary imbalance" in the reviewed literature, with STEM receiving more focus than the humanities or vocational education. The "lack of longitudinal studies" restricts understanding of long-term skill development. "Methodological diversity" among studies limits comparability, while a "geographical bias" toward developed and urban regions may exclude underrepresented populations. The review also shows a "technology-centric bias", often overlooking pedagogical strategies and teacher preparedness. Additionally, "limited focus on affective and social skills" and **inconsistent definitions of engagement** further challenge
Cross-study analysis. Lastly, excluding non-English and grey literature may result in "publication bias"

Gap Area	Description	Implication	Supporting Sources
Discipline-Specific Research	STEM is well-represented; humanities and vocational education are underexplored	Need for balanced, discipline-sensitive studies.	Setyawan et al., 2024; Radovan & Makovec, 2024
Skill Types Covered	Focus primarily on cognitive skills; affective and social skills are often neglected.	Limited development of interpersonal and emotional competencies	Weng et al., 2024
Longitudinal Evidence	Predominance of short-term and small-scale studies	Inadequate understanding of long-term skill retention and transfer	Muñoz et al., 2023
Pedagogical Integration	Lack of theoretical alignment in instructional design	Weak explanatory frameworks for how learning is achieved	Chang & Lee, 2022; Basri, 2024
Practical Skill Development	Hands-on skill acquisition remains a challenge in purely online formats	Need for blended or simulated environments to replicate real-world experiences	Sidik et al., 2020; Yan et al., 2022
Technological Equity	The digital divide affects rural and under-resourced learners	Access barriers reduce learning outcomes and reinforce educational inequalities	Abdillah & Royo, 2024; Zakaria & Mustapha, 2024

Faculty Readiness	**Limited focus on teacher training and resistance to technology adoption**	**Suboptimal implementation of blended models and digital tools**	**Baharin et al., 2024; Aravind, 2024**
Immersive Technology Evidence	Limited research on the long-term impact and scalability of VR/AR in Education	Unclear guidelines for meaningful integration in diverse learning contexts	Tene et al., 2024; Muñoz et al., 2024
Feedback and Motivation	Inadequate exploration of feedback loops and learner persistence in self-paced models	Risk of learner disengagement and dropout without personalized guidance	Wu & Tse, 2024; Radovan & Radovan, 2023
Cross-Sector Alignment	Weak linkage between education outcomes and workforce expectations	Missed opportunities in vocational training and employability-focused online education	Chirikov et al., 2020; Shen et al., 2023

14.1. Summary and Table of Literature Gaps

Despite the progress in online and blended learning research, several gaps remain across empirical scope, methodology, technological application, and equity considerations. Most studies focus on cognitive outcomes, often overlooking affective and social skills. Furthermore, evidence across disciplines (STEM, humanities, and vocational Education) is uneven, with humanities and vocational training being underrepresented. The lack of longitudinal and large-scale studies reduces generalizability, while infrastructural and pedagogical limitations constrain real-world impact.

15. Overall Synthesis and Conclusion

The reviewed literature consistently highlights that online learning, particularly blended learning models, significantly enhances skill development across disciplines such as STEM, humanities, and vocational training (Chen et al., 2024; Setyawan et al., 2024). Blended learning often surpasses traditional face-to-face and purely online instruction in fostering cognitive skills, practical competencies, and student engagement (Almarzuqi & Mat, 2024; Hu et al., 2024). This advantage is most evident in STEM and vocational domains, where digital tools combined with hands-on learning and collaborative activities create more profound learning experiences (Wu & Tse, 2024; Aravind, 2024). Although less frequently studied, humanities disciplines also benefit from contextually tailored blended designs that account for disciplinary learning styles and resistance to digital tools (Radovan & Makovec, 2024).

Technological integration emerges as a central enabler of effective online learning outcomes. Learning management systems, gamified environments, adaptive feedback, and collaborative digital platforms enhance learner autonomy, engagement, and self-regulated learning (Chang & Lee, 2022; Weng et al., 2024). Additionally, intelligent dashboards and formative assessment mechanisms are essential in supporting self-paced learning models, which, while promising, still face issues related to motivation and timely feedback (The Impact of Online Learning Platforms, 2023; Zhang, 2024). Emerging technologies like Virtual Reality (VR) and Augmented Reality (AR) show considerable potential to elevate STEM learning by increasing motivation, experiential depth, and conceptual understanding—yet their application

remains limited due to infrastructure, cost, and pedagogical readiness (Sidik et al., 2020; Abdillah & Royo, 2024).

Despite these advancements, notable challenges persist. Learners in rural or resource-constrained environments continue to face digital inequities, highlighting the need for targeted infrastructural investments and policy interventions (Frigillana & Garcia, 2024; Zakaria & Mustapha, 2024). Furthermore, teacher preparedness remains a weak link, with many studies emphasizing the need for comprehensive faculty development programs to ensure effective technology adoption (Basri, 2024; Baharin et al., 2024). The literature also suffers from methodological limitations, including the predominance of small-scale, short-term studies and a lack of longitudinal and discipline-specific research, particularly in vocational and humanities Education (Muñoz et al., 2023; Tene et al., 2023).

In conclusion, when underpinned by strategic technological integration and adaptive pedagogical frameworks, blended learning presents a powerful solution for building 21st-century skills across educational contexts. Integrating immersive technologies and AI-driven personalization tools offers exciting opportunities for more inclusive, flexible, and effective learning (Chirikov et al., 2020; Eugenijus, 2023). However, to fully realize this potential, future research must prioritize long-term, context-sensitive investigations that address persistent equity gaps and align technology with clear instructional goals to enhance skill development in evolving online ecosystems.

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