Technology for equity: a systematic review of AI, adaptive tools, and digital platforms in differentiated instruction

Tecnologia para a equidade: uma revisão sistemática de IA, ferramentas adaptativas e plataformas digitais na instrução diferenciada

Jamil Suprihatiningrum [*1] **and Ahmad Syaripudin** [†1]

[1] *State Islamic University Sunan Kalijaga, Yogyakarta, Indonesia.*

Abstract

This study examines how artificial intelligence (AI), adaptive learning systems, and digital tools enhance differentiated instruction (DI) to advance educational equity in digital classrooms. Using a systematic review of 41 peer-reviewed studies published between 2015 and 2025, the study analyzes how different technologies support the four components of DI, namely content, process, product, and learning environment, under the PRISMA protocol. The synthesis identifies four main themes. Digital tools increase accessibility and foster multimodal engagement, though their adaptive functions often remain static. AI and adaptive systems enable real-time personalization but face persistent challenges related to algorithmic transparency, data demands, and contextual relevance. Innovative products and immersive environments such as virtual reality labs, educational games, and multimodal storytelling extend inclusion by providing multiple response formats, text-to-speech, and flexible submission options aligned with Universal Design for Learning principles. Teacher attitudes and institutional support consistently determine whether technological innovations lead to sustainable differentiation. The review demonstrates that technology strengthens DI only when educators integrate it with professional judgment, institutional commitment, and systemic equity frameworks. The findings offer actionable insights for teachers, researchers, and policymakers seeking to design digital learning environments that promote inclusion and educational justice.

Keywords: Differentiated instruction. Artificial Intelligence. Adaptive learning systems. Digital platforms. Equity in education.

Resumo

Este estudo examina como a inteligência artificial (IA), os sistemas de aprendizagem adaptativa e as ferramentas digitais fortalecem a instrução diferenciada (ID) para promover a equidade educacional em salas de aula digitais. Com base em uma revisão sistemática de 41 estudos revisados por pares publicados entre 2015 e 2025, o estudo analisa como diferentes tecnologias apoiam os quatro componentes da ID, a saber, conteúdo, processo, produto e ambiente de aprendizagem, seguindo o modelo PRISMA. A síntese identifica quatro temas principais. As ferramentas digitais aumentam a acessibilidade e promovem o engajamento multimodal, embora suas funções adaptativas frequentemente permaneçam estáticas. A IA e os sistemas adaptativos permitem a personalização em tempo real, mas enfrentam desafios persistentes relacionados à transparência algorítmica, à demanda de dados e à relevância contextual. Produtos inovadores e ambientes imersivos, como laboratórios de realidade virtual, jogos educacionais e narrativas multimodais, ampliam a inclusão ao oferecer múltiplos formatos de resposta, conversão de texto em fala e opções flexíveis de envio, de acordo com os princípios do Desenho Universal para a Aprendizagem. As atitudes dos professores e o apoio institucional determinam de forma consistente se as inovações tecnológicas levam à diferenciação sustentável. No geral, a revisão demonstra que a tecnologia fortalece a ID somente quando os educadores a integram ao julgamento profissional, ao compromisso institucional e aos marcos sistêmicos de equidade. Os resultados oferecem orientações práticas para professores, pesquisadores e formuladores de políticas que buscam projetar ambientes de aprendizagem digitais que promovam a inclusão e a justiça educacional.

Palavras-chave: Instrução diferenciada. Inteligência Artificial. Sistemas de aprendizagem adaptativa. Plataformas digitais. Equidade na educação.

Textoline
Linguagem e Tecnologia

DOI: 10.1590/1983-3652.2026.61658

Session:
Articles

Corresponding author:
Jamil Suprihatiningrum

Section Editor:
Daniervelin Pereira
Layout editor:
Saula Cecília

Received on:
September 9, 2025
Accepted on:
October 24, 2025
Published on:
April 13, 2026

*Email: jamil.suprihatiningrum@uin-suka.ac.id
†Email: 24204081005@student.uin-suka.ac.id

1 Introduction

Differentiated instruction (DI) is now widely acknowledged as crucial for meeting learner diversity. It addresses differences in readiness, interests, learning preferences, and sociocultural backgrounds by adjusting content, process, product, and the learning environment (Tomlinson, 2001, 2014). Instead of a one-size-fits-all model, DI emphasizes flexibility in both design and implementation to foster equity, engagement, and better learning outcomes (Ferrer; Naanep, 2025; Puzio; Colby; Algeo-Nichols, 2020; Ramaila, 2025; Sabir; Wang; Zou, 2024). Globally, including Indonesia, DI has been officially supported through curriculum reforms and inclusive policies aimed at reaching all learners, especially those from marginalized or linguistically diverse backgrounds (Marlina; Efrina; Kusumastuti, 2019; Ouyang; Ye, 2023; Smale-Jacobse *et al.*, 2019). Its value lies in its ability to reduce opportunity gaps, promote learner independence, and develop positive attitudes toward learning (Cullen; Oppenheimer, 2024; Donald; Ford, 2022; Saad; Abdullah, 2025). However, implementing DI can be difficult and requires teacher expertise, careful planning, and effective classroom management (Maulana; Helms-Lorenz; Irnidayanti, 2019; Van Geel *et al.*, 2019). Many teachers struggle to maintain individualized learning paths, track student progress, and manage diverse needs in large classrooms (Cevikbas; Kaiser, 2022; Darling-Hammond *et al.*, 2020; Kariippanon *et al.*, 2019; Kerimbayev; Akramova; Kassanov, 2025; Tetzlaff; Schmiedek; Brod, 2020). These challenges have increased interest in using technology to make DI more scalable, efficient, and adaptable across different settings.

Over the past two decades, digital transformation has facilitated a gradual shift toward more personalized learning models (Engelbrecht; Llinares; Borba, 2020; Mena-Guacas; Lopez; Garcia, 2025; Shemshack; Spector, 2020; Tetzlaff; Schmiedek; Brod, 2020). The rise of artificial intelligence (AI), adaptive learning platforms, and interactive tools has created new opportunities for responsive instruction. AI systems, including intelligent tutors and recommender engines, evaluate student performance in real time and adjust content dynamically (Gligorea *et al.*, 2023; Naseer; Ali; Khan, 2024; Sajja; Miller; Watson, 2024; Sayed; Mahmoud; Ibrahim, 2022; Taşkın, 2025). Adaptive platforms organize tasks based on learner input, enabling individualized pacing, while digital tools like learning management systems, educational games, and collaborative applications create multimodal environments that accommodate diverse learning preferences (Jose; Kumar; Sharma, 2024; Strielkowski *et al.*, 2024; Vincent-Ruz; Boase, 2022; Wang; Hwang; Wang, 2020). These technologies reduce the practical challenges teachers face when implementing DI because they automate assessments, provide tailored pathways, and enhance student engagement (Krishan; Al-Rsa'i, 2023; Palieraki; Koutrouba, 2021; Vaganova; Livshits; Smirnova, 2020). When aligned with DI principles, they have the potential to support large-scale personalization, even though issues related to contextual fit, ethics, and equity remain unresolved.

Theoretically, DI and educational technologies share constructivist, learner-centered foundations emphasizing scaffolding, mastery, and self-regulation (Damyanov, 2024; Donkoh; Amoakwah, 2024; Guo; Wang; Zhang, 2024). Adaptive platforms reflect Vygotsky's concept of the zone of proximal development by offering targeted support (Damyanov, 2024; Donkoh; Amoakwah, 2024; Guo; Wang; Zhang, 2024), while AI-driven personalization functions as formative feedback that sequences tasks based on learner performance. In practice, digital tools can enact DI principles by enabling flexible pacing, varied content, and real-time monitoring. However, the level of alignment depends on how these tools are designed and implemented. Some applications genuinely extend the logic of DI, while others offer superficial personalization with fixed content or opaque algorithms (Burner; Lindvig; Wærness, 2025; Chang; Kim; Lee, 2023; Kochmar *et al.*, 2021; Liao; Chen; Hwang, 2024; Murtaza; Ahmed; Khan, 2022). For technology and DI to work together effectively, their integration must be based on pedagogical frameworks prioritizing teacher agency and equitable outcomes.

Empirical evidence on technology-supported DI remains mixed, varying in strength, setting, and technological scope. Some studies show positive effects on formative assessment and motivation, while others indicate limited use or specific challenges in certain contexts (Burner; Lindvig; Wærness, 2025; Sree; Kumar; Gupta, 2024). Adaptive systems might benefit lower-achieving students more than high achievers, and dashboards heavily depend on teacher interpretation (Molenaar; Campen, 2019; Pozdniakov; Martinez-Maldonado; Tsai, 2025). Most research focuses on short-term outcomes,

leaving long-term factors like self-regulation, motivation, and inclusion less examined (Farrokhnia; Noroozi; Schut, 2025; Held; Mejeh, 2024; Zafar; Ali; Raza, 2024). These differences highlight the need for a thorough review that categorizes technologies, clarifies the conditions that support them, and situates DI within broader equity frameworks.

Previous reviews have examined aspects of DI and technology separately, often emphasizing digital personalization or AI ethics without exploring their intersection. For instance, Smale-Jacobse *et al.* (2019) focused on DI implementation in traditional classrooms, while Shemshack and Spector (2020) reviewed personalized learning terminology. Engelbrecht, Llinares, and Borba (2020) examined mathematics classrooms during digital transformation, and Damyanov (2024) addressed special education. In Latin America, some reviews have explored AI and digital technologies, but with limited pedagogical focus. Salas-Pilco and Yang (2022) mapped AI applications in higher education, identifying adaptive learning trends but overlooking how they align with DI. Silva León, Garcia, and Santos (2024) analyzed broader digital innovations, emphasizing entrepreneurship and social inclusion rather than classroom differentiation. Portilla, Smith, and Brown (2025) provided a global synthesis of AI in Education 4.0, highlighting algorithmic bias and personalization challenges without situating them in equity-oriented pedagogies. Meanwhile, Carrillo, Sanchez, and Rodriguez (2026) explored AI's structural and policy implications in Latin American higher education but did not address adaptive or differentiated learning processes. None of these reviews systematically investigates how AI, adaptive tools, and digital platforms jointly operationalize DI to promote equity.

Building on this gap, the present review examines how these technologies are integrated into DI and assesses how such integration advances educational equity across its four components (content, process, product, and environment). To achieve this aim, the review addresses three guiding research questions.

1. RQ1. How are AI, adaptive systems, and digital platforms used to implement DI across educational contexts?
2. RQ2. Which pedagogical, institutional, and contextual factors enable or constrain equitable technology-supported DI?
3. RQ3. In what ways do these technologies contribute to advancing educational equity through DI?

2 Method

2.1 Research design

This study followed a qualitative Systematic Literature Review using the PRISMA 2020 framework (Page; McKenzie; Bossuyt, 2021), as seen in Figure 1, to ensure transparency and reproducibility. It synthesized empirical studies from 2015 to 2025 on integrating AI, adaptive learning systems, and digital tools within DI. This period reflects a decade of rapid growth in AI and adaptive technologies in education.

The scope of "AI" in this review includes intelligent tutoring systems, machine learning–based recommender engines, and generative AI applications. "Adaptive systems" refer to algorithmic or data-driven platforms that personalize learning processes based on learner input or performance data. "Digital tools" encompass multimodal and collaborative technologies used in classroom contexts, such as virtual labs, educational games, and online learning platforms.

2.2 Data sources and search strategy

A comprehensive search was performed across six databases: Scopus, Web of Science, ERIC, ProQuest, ScienceDirect, and SpringerLink. The search strategy combined keywords and Boolean operators to identify studies on DI integrated with AI, adaptive learning systems, and digital technologies. The final search string used in all databases was:

> ("differentiated instruction" OR "differentiated teaching") AND ("artificial intelligence" OR "AI" OR "adaptive learning" OR "adaptive system*" OR "digital platform*" OR "digital tool*" OR "educational technolog*" OR "technology integration") AND ("kindergarten" OR "early childhood" OR "elementary" OR "primary" OR "secondary" OR "K-12" OR "higher education" OR "university" OR "undergraduate*" OR "vocational training").

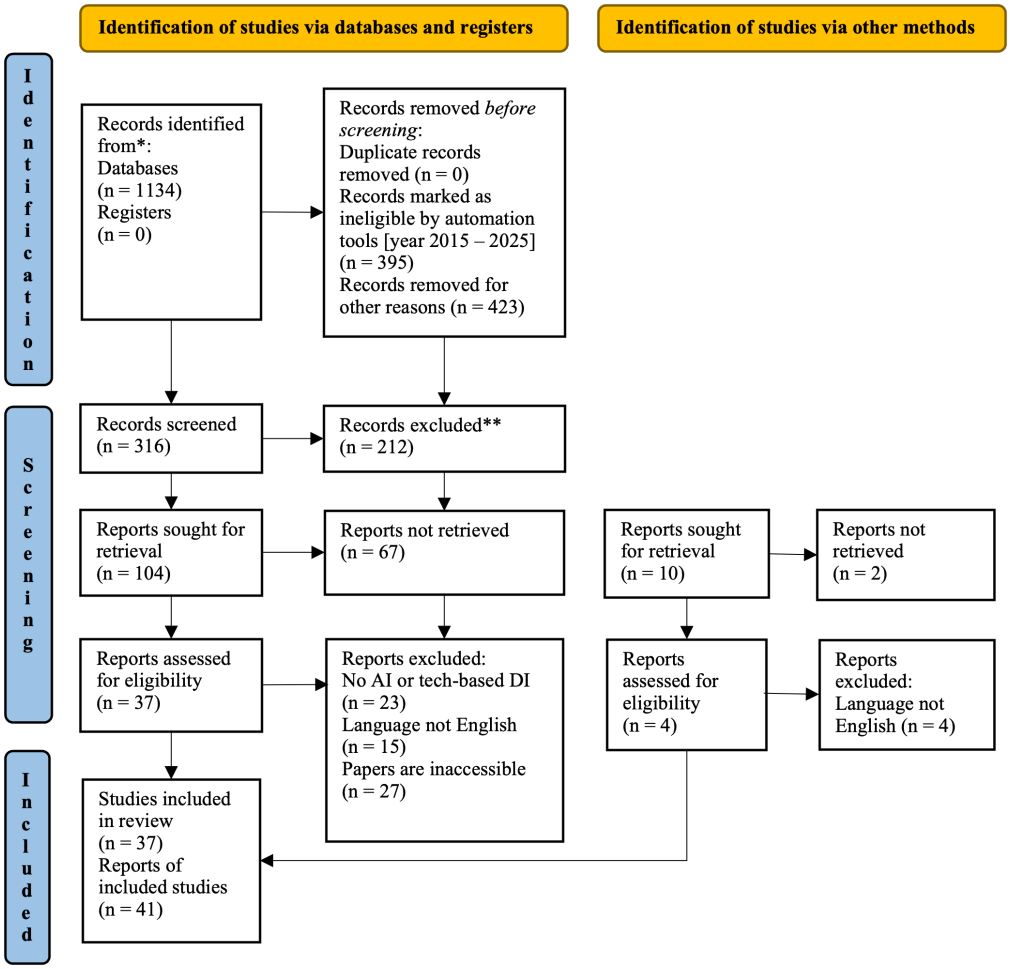

Figure 1. The review protocol.
Source: Own elaboration.

The formula used the wildcard symbol (*) to include word variations and linked conceptual groups with AND operators to ensure inclusive retrieval of studies on AI. Searches were limited to the title, abstract, and keyword fields and included educational level terms (e.g., kindergarten, K-12, higher education). All records were managed in EndNote, duplicates removed, and results verified through backward and forward citation tracking before applying the inclusion and exclusion criteria.

2.3 Inclusion and exclusion criteria

The review applied specific criteria to ensure rigor and relevance, summarized in Table 1. To maintain consistent data extraction and accurate interpretation of findings, only studies published in English were included. This decision was made because English dominates peer-reviewed academic publishing, and reliable translations are limited across databases. Although this may introduce language bias, it helped keep coding and quality assessment procedures consistent across all sources. The possible effects of this limitation are discussed in the final section of the paper.

2.4 Screening and selection process

After removing duplicates, two reviewers independently screened the titles and abstracts against the inclusion criteria. Potentially eligible studies then underwent full-text review, and any disagreements were resolved through discussion to ensure consistency. The process and exclusion decisions at the full-text stage were documented to maintain transparency.

Table 1. Inclusion and Exclusion Criteria.

Criterion	Inclusion	Exclusion
Publication type	Peer-reviewed empirical research (qualitative, quantitative, mixed methods)	Non-peer-reviewed reports, theoretical papers, or conference abstracts without full papers, grey literature
Publication period	2015–2025	Before 2015 or after 2025
Language	English	Non-English publications
Focus	Studies addressing DI combined with AI, adaptive systems, or digital platforms	Studies unrelated to DI or limited to conventional/non-digital instruction
Educational level	Early childhood, primary, secondary, higher, or vocational education	Studies not specifying or irrelevant to educational contexts
Availability	Full-text accessible	Abstract-only or inaccessible full text

Source: Own elaboration.

2.5 Data extraction and analysis

Data were systematically extracted using a structured template that covered: bibliographic details; study context; technology type; DI components; research design; and key findings. The coding system for thematic analysis was developed inductively and refined through iterative comparison. Initial codes based on Tomlinson's (1999) four DI dimensions were aligned with technology categories, pilot-tested on ten studies, and collaboratively refined into a final codebook. Thematic coding was supported by an AI-assisted text analysis tool to organize and cluster data during the initial synthesis stage. All coding decisions and thematic interpretations were manually verified by the researchers to ensure analytical consistency and validity, with each step documented for replicability and auditability.

We also constructed a co-occurrence matrix from the final codes (technology category, DI component, mediators, and equity dimensions) and created a thematic network (as presented in Figure 4) to visualize the connections among topics. An AI-assisted tool helped with early clustering, and all links were checked manually.

3 Findings and discussion

This section presents the main findings and discusses their implications. To give an overview, Table 2 maps the selected studies based on the types of technology used (AI-based systems, adaptive tools, and broader digital platforms) and the DI components they cover (content, process, product, and environment).

Across the reviewed period, the early studies (2015-2019) primarily focused on digital tools for differentiated content and formative assessment, reflecting the initial stages of classroom digitalization. In contrast, studies from 2020-2025 increasingly incorporated AI and adaptive learning systems, emphasizing personalization, data analytics, and equity considerations. This shift suggests a gradual evolution from tool-based differentiation toward intelligent, context-sensitive systems that align with equity and inclusion frameworks. These patterns help clarify how tools fit within DI frameworks and guide the synthesis below.

3.1 Publication and context overview

Research on technology-enhanced DI increased significantly across 41 studies after 2018 (Figure 2), aligning with digital transformation and remote learning. By level (Figure 3), the collection includes eight primary, 14 secondary, five higher/vocational, five teacher-education, and nine cross-level K-12 investigations. Geographically, the studies cover 23 countries across Europe, Asia, North America, and Oceania, allowing for cautious generalization while remaining aware of policy and infrastructure factors that influence implementation.

Table 2. Studies mapped by technology type and DI component.

No.	Authors	AI	Adaptive Tools	Digital Tool/Platform	Content	Process	Product	Environment
1	Meutstege, Van Geel, and Visscher (2023)	-	√	√	√	√	√	√
2	Hasanah, Suyatno, and Maryani (2022)	-	√	√	√	√	√	-
3	Min and Theng (2018)	-	√	√	√	√	√	
4	Valiandes, Neophytou, and Hajisoteriou (2018)	-	-	√	√	√	√	√
5	Smets, De Neve, and Struyven (2020)	-	-	√	√	√	√	√
6	Westbroek, Janssen, and Driel (2020)	-	-	√	√	√	√	√
7	Strogilos, Lim, and Binte Mohamed Buhari (2021)	-	√	√	√	√	√	-
8	Griful-Freixenet, Struyven, and Vantieghem (2021)	-	-	√	√	√	√	-
9	Vantieghem, Van de Putte, and Declercq (2020)	-	-	√	√	√	√	-
10	Valiandes (2015)	-	√	-	√	√	√	-
11	Karst, Förster, and Souvignier (2022)	-	√	√	√	√	-	-
12	Förster, Kawohl, and Souvignier (2018)	-	√	√	√	√	-	-
13	Iterbeke, De Witte, and Schelfhout (2020)	-	-	√	√	√	-	-
14	Maulana, Helms-Lorenz, and Irnidayanti (2019)	-	-	√	√	√	√	-
15	Songer, Ibarrola, and Mi (2019)	√	√	√	√	√	√	-
16	Wu, Wong, and Li (2019)	-	√	√	√	√	√	-
17	Easa and Blonder (2023)	-	-	√	√	√	√	-
18	Hasanah, Suyatno, and Maryani (2023)	-	-	√	√	√	√	-
19	Halil, Abdullah, and Yunus (2024)	-	-	√	√	√	√	-
20	Zervoudakis, Mastrothanasis, and Tsafarakis (2019)	√	-	√	-	√	-	-
21	Şentürk and Sari (2018)	-	-	√	√	√	√	-
22	Estaiteyeh and DeCoito (2023)	-	-	√	√	√	√	-
23	Spyropoulou, Wallace, and Poulopoulos (2025)	-		√	√	√	√	√
24	Shareefa, Moosa, and Hoo (2024)	-	-	√	√	√	√	√
25	Shareefa (2023)							
26	Yuen, Luo, and Wan (2023)	-	-	√	√	√	√	√
27	Malacapay (2019)	-	-	√	√	√	√	-
28	Gibbs and Beamish (2021)	-	-	√	√	√	√	√
29	Heng (2023)	-	√	-	√	√	√	√
30	Smets and Struyven (2018)	-	-	√	√	√	√	√
31	Vaganova, Livshits, and Smirnova (2020)	-	√	√	√	√	√	-
32	Palieraki and Koutrouba (2021)	-	√	√	√	√	√	√
33	Naseer, Ali, and Khan (2024)	√	√		√	√	√	-
34	Krishan and Al-Rsa'i (2023)	-	-	√	√	√	√	-
35	Howorth, Smith, and Jones (2024)	√	√	√	√	√	√	-
36	Kong and Yang (2024)	√	-	-	√	√	√	-
37	Kempe and Grönlund (2019)	-	√	√	√	√	√	-
38	Yunianto, Kusuma, and Sari (2024)	√	-	-	√	√	√	-
39	Woo, Guo, and Susanto (2024)	√	-	-	√	√	√	-
40	Chen, Yin, and Cheung (2025)	√	√	√	√	√	√	-
41	Sajja, Miller, and Watson (2024)	√	√	√	√	√	√	-

Source: Own elaboration.

3.2 Technology types used in DI

The review identifies four broad categories of technologies:

1. AI and machine learning (8 studies), including generative AI for writing support and feedback, intelligent assistants, optimization algorithms for grouping, and deep learning for adaptive pathways;
2. Adaptive learning platforms (8 studies) such as Learning Navigator, computer-based Learning Progress Assessment (LPA), and assessment-linked systems (e.g., Lernstand 5) that tailor instruction to readiness and performance;
3. General digital platforms and tools (20 studies), including digital games, Virtual Reality (VR) labs, ICT labs, online collaboration tools (Padlet, Google Classroom, Quizizz), and multimedia/story-

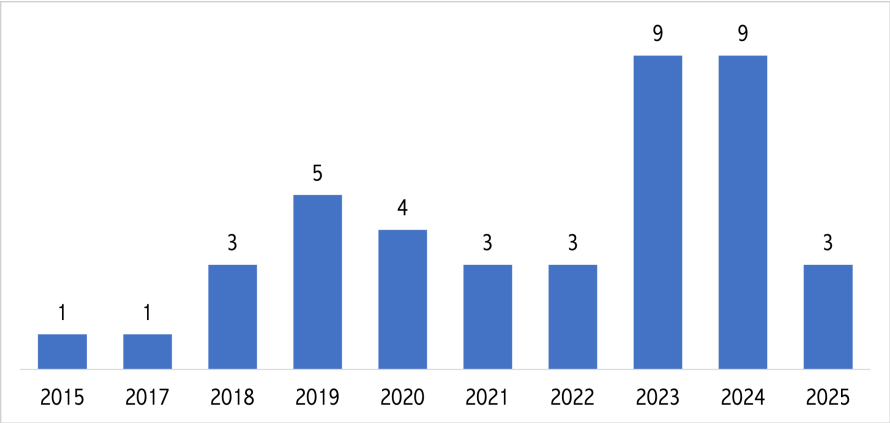

Figure 2. Number of publications by year.
Source: Own elaboration.

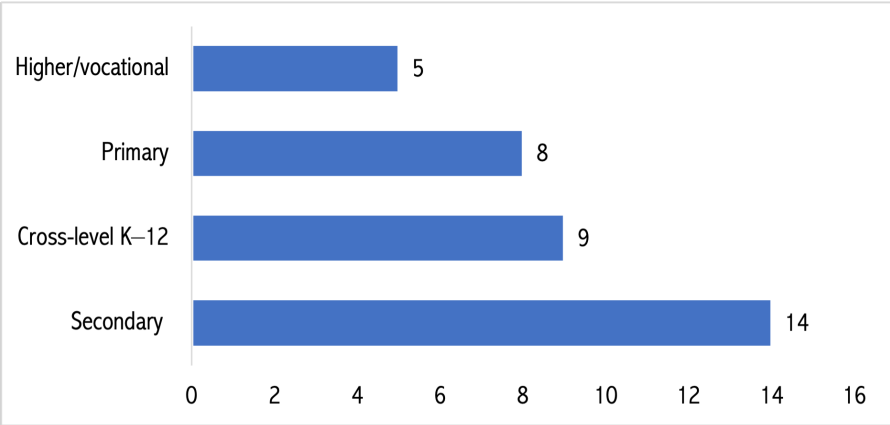

Figure 3. Number of publications by level of education.
Source: Own elaboration.

telling applications;

4. Conceptual/minimal-integration discussions (7 studies) focusing on DI frameworks rather than concrete tools.

3.3 Network visualization of technology-DI relationships

We generated a co-occurrence network in VOSviewer (v1.6.20) using the coded relationships among technology categories (AI, adaptive systems, and general digital tools), DI components (content, process, product, and environment), mediating factors (e.g., teacher mindset, professional development, infrastructure access, classroom constraints), and equity dimensions (e.g., accessibility, personalization, agency/autonomy). The network (Figure 4) consists of 17 items connected through 136 weighted links. In the map, node size reflects how frequently each item appears across the 41 studies, edge thickness represents the strength of co-occurrence between two items, and color indicates cluster membership as computed by the VOS clustering algorithm.

The red cluster (left) reflects classroom-level differentiation using digital tools, multimodal products, and inclusive learning environments under real instructional constraints. The green cluster (right) represents adaptive/AI systems, teacher professional development, and mindset, highlighting how personalization and agency depend on teacher capacity, algorithmic transparency, and infrastructural support. Bridge links (e.g., Process, Infrastructure Access) show that equitable differentiated instruction emerges from the interaction between pedagogical inclusion and adaptive technologies.

3.4 Trends in technology-enhanced DI integration

The review identified four key themes in the integration of technology into DI, as outlined in Table 3.

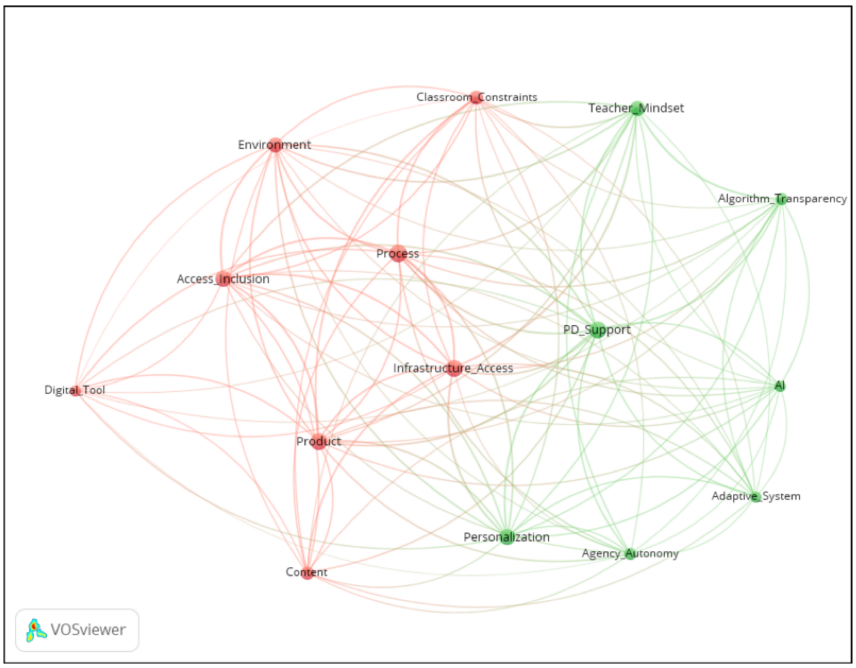

Figure 4. Co-occurrence network of technology, DI components, mediating factors, and equity dimensions.
Source: VOSviewer (version 1.6.18, Van Eck and Waltman (2010)).

Theme 1: Digital Tools for Content Differentiation

A consistent finding across the studies (Halil; Abdullah; Yunus, 2024; Hasanah; Suyatno; Maryani, 2023; Malacapay, 2019; Yuen; Luo; Wan, 2023) is that teachers make extensive use of accessible digital platforms such as Google Classroom, Padlet, Quizizz, and multimedia applications to differentiate learning content. These platforms support multimodal content delivery, provide tiered materials, and increase accessibility for students with varied readiness levels and diverse backgrounds. For instance, Quizizz allows teachers to conduct instant formative assessments with different difficulty levels, while Padlet facilitates collaborative curation of ideas that can be adjusted according to student ability or interest. The pedagogical reasoning behind these practices is consistent with Tomlinson (1999) and Annemieke *et al.* (2019), who argue that DI should begin by offering varied entry points into the content so that all learners can access the core concepts.

However, many of these tools operate at a static level of differentiation, where teachers prepare materials in advance with varying levels of complexity rather than making dynamic adjustments during the learning process. This pattern points to a gap between the potential of digital tools and how they are currently applied in classrooms. The literature emphasizes that teacher digital literacy and the availability of infrastructure are essential mediators (Cevikbas; Kaiser, 2022; Engelbrecht; Llinares; Borba, 2020). Without sufficient professional development and robust digital infrastructure, the promise of differentiated content risks remaining superficial. Prior research on technology-mediated personalization (Shemshack; Spector, 2020) also cautions that digital tools must move beyond mere content dissemination to support deep conceptual understanding and learner autonomy. Thus, the challenge in this theme lies not only in equipping teachers with digital tools but also in empowering them to utilize these tools in ways that extend beyond simple content variation.

Theme 2: Adaptive Systems and AI for Process Differentiation

The integration of adaptive learning systems and AI represents the most promising yet complex frontier of DI. Studies by Songer, Ibarrola, and Mi (2019) and Zervoudakis, Mastrothanasis, and Tsafarakis (2019), and Förster, Kawohl, and Souvignier (2018) highlight how platforms like Learning Navigator and algorithms like Particle Swarm Optimization (PSO) can automate group formation,

Table 3. Key themes, supporting studies, findings, and implications.

Theme	Supporting Studies	Key Findings	Implications
Theme 1: Digital Tools for Content Differentiation	Halil, Abdullah, and Yunus (2024), Hasanah, Suyatno, and Maryani (2023), Malacapay (2019) and Yuen, Luo, and Wan (2023)	Teachers commonly used accessible digital tools (e.g., Google Classroom, Padlet, Quizizz, AVP, social media) to deliver multimodal content, tiered materials, and accessible resources for students with varying readiness levels. These tools enabled flexible content delivery and improved accessibility but often lacked advanced adaptivity.	Enhancing teacher digital literacy and ensuring infrastructure availability are essential for leveraging digital tools effectively to support differentiated content.
Theme 2: Adaptive Systems and AI for Process Differentiation	Songer, Ibarrola, and Mi (2019), Zervoudakis, Mastrothanasis, and Tsafarakis (2019) and Förster, Kawohl, and Souvignier (2018)	AI-powered systems such as Learning Navigator and PSO algorithms supported automated group formation, personalized learning pathways, and real-time recommendations based on learner performance. These systems reduced teacher workload but faced challenges related to transparency, data requirements, and contextual fit.	Transparency of algorithms, teacher training, and data protection protocols are required to ensure effective and ethical use of adaptive and AI-based systems in DI.
Theme 3: Innovative Products and Inclusive Learning Environments	Wu, Wong, and Li (2019), Estaiteyeh and DeCoito (2023) and Spyropoulou, Wallace, and Poulopoulos (2025)	Technologies like Virtual Reality (VR), digital video games, and flexible digital products enabled students to produce diverse outputs and engage in context-rich, inclusive learning environments. Accessibility features (e.g., text-to-speech, multiple response formats) improved participation of students with diverse needs.	Teacher capacity-building for designing inclusive digital products and utilizing accessibility features is crucial for sustaining innovation and supporting diverse learners.
Theme 4: Teacher Mindset and Contextual Factors	Halil, Abdullah, and Yunus (2024), Hasanah, Suyatno, and Maryani (2023), Yuen, Luo, and Wan (2023) and Shareefa, Moosa, and Hoo (2024)	Teacher mindset, professional development, and institutional support strongly influenced technology-enhanced DI adoption. Positive attitudes and adequate support enabled effective integration, while infrastructure limitations, rigid curricula, and time constraints hindered implementation.	School policies, teacher professional learning, and mindset shifts are critical to sustain and scale technology-supported DI practices.

Source: Own elaboration.

provide personalized learning trajectories, and deliver real-time instructional recommendations. These systems embody the pedagogical principle of tailoring the learning process to each student's performance data, closely reflecting Vygotsky (1978) concept of the zone of proximal development (ZPD). By situating learners within their ZPD, AI-driven systems reduce teacher workload and allow for scalable personalization (Celik *et al.*, 2022; Seo; Tang; Smith, 2024).

Nevertheless, the literature points to several important challenges. Transparency and algorithmic bias remain unresolved concerns (Chang; Kim; Lee, 2023; Murtaza; Ahmed; Khan, 2022). Teachers often have a limited understanding of how adaptive systems generate recommendations, which can

result either in uncritical reliance or in mistrust. These systems also require large amounts of learner data, raising concerns about privacy, ethical use, and cultural relevance (Giannakos; Mikalef; Molenaar, 2025). Heinrich, Darling-Aduana, and Martin (2019) emphasize that successful integration depends heavily on contextual fit, since rural or under-resourced schools may face barriers such as limited bandwidth, insufficient hardware, and low levels of data literacy. The implication is that teacher training, algorithmic transparency, and data governance must accompany the adoption of AI-based DI to ensure that these tools promote equity rather than reinforce divides. This theme reveals a critical paradox. While AI and adaptive technologies have the potential to expand individualized learning at scale, their effectiveness ultimately relies on the pedagogical goals and ethical frameworks that guide their use.

Theme 3: Innovative Products and Inclusive Learning Environments

The third theme expands DI beyond content and process by focusing on student products and the creation of inclusive learning environments. Research by Wu, Wong, and Li (2019), Estaiteyeh and DeCoito (2023) and Spyropoulou, Wallace, and Poulopoulos (2025) demonstrates how technologies such as VR, digital video games, and flexible authoring tools enable students to produce varied and creative outputs while engaging in rich and immersive contexts. These studies align with constructivist theories of learning (Bruner, 1996; Piaget, 1972), which emphasize that learners deepen their understanding through the active creation and representation of knowledge in diverse forms.

Digital technologies also contribute to inclusivity by embedding accessibility features. Tools such as text-to-speech, multiple response formats, and personalized interface settings expand opportunities for participation among students with disabilities or special learning needs (Damyanov, 2024). In this sense, DI is framed not only as a pedagogical variety but also as a mechanism of equity that allows learners with diverse needs to fully engage. This perspective is consistent with the principles of Universal Design for Learning (UDL) (CAST, 2018), which emphasizes the importance of providing multiple means of engagement to sustain motivation and interest, multiple means of representation to present information in varied formats such as text, audio, or visuals, and multiple means of expression to allow students to demonstrate their learning in diverse ways. When DI is combined with UDL, the emphasis is placed on ensuring that technology does more than diversify instruction. It should also function as a tool to proactively remove barriers, making it possible for all learners to access and participate meaningfully in the learning process.

Yet, sustaining such innovations requires more than access to digital products. Teachers must be capacitated to design inclusive digital tasks, assess multimodal outputs, and integrate accessibility features meaningfully. Prior work (Molenaar; Campen, 2019; Pozdniakov; Martinez-Maldonado; Tsai, 2025) stresses that teacher interpretation of digital feedback is pivotal for transforming raw technological affordances into pedagogically valuable practices. Hence, this theme illustrates that innovative products and environments cannot be decoupled from teacher expertise and the embedding of curricula.

Theme 4: Teacher Mindset and Contextual Factors

The most decisive factor in technology-supported DI is not the technology itself but the mindset and context of educators and institutions. Studies (Halil; Abdullah; Yunus, 2024; Hasanah; Suyatno; Maryani, 2023; Shareefa; Moosa; Hoo, 2024; Yuen; Luo; Wan, 2023) consistently demonstrate that teachers' attitudes toward innovation, their access to professional learning, and the level of institutional support significantly influence implementation. Teachers with a growth-oriented mindset (Dweck, 2006) are more likely to experiment with digital differentiation. In contrast, those constrained by rigid curricula, time pressures, or a lack of infrastructure tend to adopt surface-level uses.

This is consistent with earlier research (Smale-Jacobse *et al.*, 2019; Van Geel *et al.*, 2019) showing that DI is inherently complex and depends strongly on teacher agency. Without institutional policies that provide sufficient time, resources, and incentives, even the most advanced technologies are likely to be underused. By contrast, supportive environments that encourage collaborative professional learning communities (Darling-Hammond *et al.*, 2020) allow teachers to share practices,

build confidence, and sustain innovation. Contextual factors, therefore, play a decisive role in shaping how technology-enhanced DI can be meaningfully implemented. As Li, Zhang, and Limniou (2021) note, cultural orientations toward hierarchy, autonomy, or innovation deeply influence how teachers interpret and adopt technology-enhanced DI.

The implication is clear that scaling DI with technology requires a systemic approach that balances teacher mindset, institutional support, and cultural context. Technology alone cannot overcome structural and attitudinal barriers but must be embedded within broader educational change efforts.

3.5 Cross-theme synthesis

Technology-enhanced DI is more than just a set of tools; it connects pedagogy, institutional frameworks, and equity efforts. Digital tools expand access to content, but without adaptive procedures and inclusive design, they can remain static. AI and adaptive systems offer scalability, yet opaque algorithms and data-heavy processes raise equity issues. Innovative products encourage multimodality and inclusion but seldom scale without teacher expertise and policy support. Teachers' mindsets and institutional conditions influence results across areas, highlighting that technology's value is socially shaped and dependent on pedagogical goals and systemic backing (SDG 4).

Most evaluations emphasize short-term engagement or test improvements; long-term outcomes like autonomy, self-regulation, critical thinking, and inclusion are less studied. Algorithmic opacity and inconsistent infrastructure risk are increasing disparities. Many studies view teachers as end-users rather than partners in design. Future research should explore AI governance in education, strengthen teacher agency through ongoing professional development, and tackle issues of access, bias, and sustainability. In this view, technology acts as a strategic partner, not a replacement, promoting personalization and educational justice when aligned with equity-focused pedagogy and institutional commitment.

4 Conclusion

This review explored how AI, adaptive systems, and digital tools are integrated into DI to promote educational equity. Analyzing 41 studies reveals that technology-enhanced DI operates as an ecosystem connecting pedagogy, institutional frameworks, and justice goals. AI and adaptive systems increase personalized learning options, while digital platforms and inclusive products encourage multimodal engagement. However, teacher agency, ethical governance, and systemic support are crucial for making sure that technological differentiation enhances rather than damages equity.

The findings redefine DI in the digital age as a process of pedagogical mediation, where technology gains significance through teacher-guided and ethically designed implementation. Future efforts should focus on enhancing teachers' AI literacy, promoting transparent and data-responsible practices, and incorporating digital-justice principles into institutional and policy frameworks. Long-term progress toward inclusive, technology-supported differentiation will rely on collaborative design among educators, researchers, and policymakers grounded in equity, ethics, and pedagogical purpose.

5 Limitations and directions for future research

While this review followed PRISMA 2020 for rigor and transparency, several limitations should be acknowledged. Limiting to English-language, peer-reviewed articles may have excluded relevant non-English or grey literature. The 2015-2025 time frame captures rapid technological changes but might omit emerging developments in generative AI. The diversity of study designs also constrained quantitative synthesis, making the findings interpretive. Future research should expand database coverage, include multilingual studies, and explore post-2025 innovations, especially regarding ethical governance, teacher AI literacy, and long-term equity outcomes.

References

ANNEMIEKE, E. Smale-Jacobse; MEELISSEN, Martina R. M.; VRIELINK, Ariane; MASTER, Benjamin S. Differentiated instruction in secondary education: A systematic review of research evidence. *Frontiers in Psychology*, v. 10, p. 2366, 2019. DOI: 10.3389/fpsyg.2019.02366.

BRUNER, Jerome. *The Culture of Education*. Cambridge: Harvard University Press, 1996.

BURNER, Tony; LINDVIG, Yngve; WÆRNESS, Jarl Inge. "We should not be like a dinosaur"—using AI technologies to provide formative feedback to students. *Education Sciences*, v. 15, n. 1, p. 58, 2025. DOI: 10.3390/educsci15010058.

CARRILLO, Mauricio Acevedo; SANCHEZ, Jose; RODRIGUEZ, Maria. Challenges and opportunities of artificial intelligence in Latin American higher education: A systematic literature review. *Revista InveCom*, v. 6, n. 1, p. 1–10, 2026.

CAST. *The Universal Design for Learning Guidelines Version 2.2*. [*S. l.*], 2018. Available from: https://udlguidelines.cast.org.

CELIK, Ismail; DINDAR, Mehmet; MUUKKONEN, Hanni; JÄRVELÄ, Sanna. The promises and challenges of artificial intelligence for teachers: A systematic review of research. *TechTrends*, v. 66, p. 616–630, 2022. DOI: 10.1007/s11528-022-00715-y.

CEVIKBAS, Mustafa; KAISER, Gabriele. Promoting personalized learning in flipped classrooms: A systematic review study. *Sustainability*, v. 14, n. 18, p. 11393, 2022. DOI: 10.3390/su141811393.

CHANG, Daniel H.; KIM, Hyeon; LEE, Jung-Sook. Educational design principles of using AI chatbot that supports self-regulated learning in education: Goal setting, feedback, and personalization. *Sustainability*, v. 15, n. 17, p. 12921, 2023. DOI: 10.3390/su151712921.

CHEN, Shuzhen; YIN, Hongbiao; CHEUNG, Alan Chi Keung. How professional capital empowers ICT Integration: The roles of teachers' constructivist belief, differentiated instruction and AI literacy. *International Journal of Educational Research*, v. 133, p. 102715, 2025. DOI: 10.1016/j.ijer.2025.102715.

CULLEN, Simon; OPPENHEIMER, Daniel. Choosing to learn: The importance of student autonomy in higher education. *Science Advances*, v. 10, n. 29, ado6759, 2024. DOI: 10.1126/sciadv.ado6759.

DAMYANOV, Kaloyan. Effective pedagogical strategies and support mechanisms for enhancing the learning outcomes of students with special educational needs: A systematic approach. *International Journal of Scientific Research and Management (IJSRM)*, v. 12, n. 10, p. 3700–3718, 2024. DOI: 10.18535/ijsrm/v12i10.el03.

DARLING-HAMMOND, Linda; FLOOK, Lisa; COOK-HARVEY, Channa; BARRON, Brigid; OSHER, David. Implications for educational practice of the science of learning and development. *Applied Developmental Science*, v. 24, n. 2, p. 97–140, 2020. DOI: 10.1080/10888691.2018.1537791.

DONALD, William E.; FORD, Neil. Fostering social mobility and employability: The case for peer learning. *Teaching in Higher Education*, v. 28, p. 672–678, 2022. DOI: 10.1080/13562517.2022.2145467.

DONKOH, Sylvester; AMOAKWAH, Albert. The Use and Challenges of Learner-Centered Pedagogy: Basic School Teachers' Perspective. *European Journal of Education and Pedagogy*, v. 5, n. 1, p. 66–71, 2024. DOI: 10.24018/ejedu.2024.5.1.774.

DWECK, Carol. *Mindset: The New Psychology of Success*. [*S. l.*]: Random House, 2006.

EASA, Enas; BLONDER, Ron. The development of an instrument for measuring teachers' and students' beliefs about differentiated instruction and teaching in heterogeneous chemistry classrooms. *Chemistry Teacher International*, v. 5, n. 2, p. 125–141, 2023. DOI: 10.1515/cti-2023-0005.

ENGELBRECHT, Johann; LLINARES, Salvador; BORBA, Marcelo C. Transformation of the mathematics classroom with the internet. *ZDM*, v. 52, n. 5, p. 825–841, 2020. DOI: 10.1007/s11858-020-01176-4.

ESTAITEYEH, Mohammed; DECOITO, Isha. Differentiated instruction in digital video games: STEM teacher candidates using technology to meet learners' needs. *Interactive Learning Environments*, p. 1–15, 2023. DOI: 10.1080/10494820.2023.2190360.

FARROKHNIA, Mohammadreza; NOROOZI, Omid; SCHUT, Alieda. Community of inquiry: A bridge linking motivation and self-regulation to satisfaction with e-learning. *The Internet and Higher Education*, v. 65, p. 100992, 2025. DOI: 10.1016/j.iheduc.2025.100992.

FERRER, Jorna May; NAANEP, Nathaniel. Enhancing Learning: Differentiated Instruction in Elementary Schools. *Journal of Interdisciplinary Perspectives*, 2025. DOI: 10.69569/jip.2025.222.

FÖRSTER, Natalie; KAWOHL, Elisabeth; SOUVIGNIER, Elmar. Short- and long-term effects of assessment-based differentiated reading instruction in general education on reading fluency and reading comprehension. *Learning and Instruction*, v. 56, p. 98–109, 2018. DOI: 10.1016/j.learninstruc.2018.04.009.

GIANNAKOS, Michail; MIKALEF, Patrick; MOLENAAR, Inge. The promise and challenges of generative AI in education. *Behaviour & Information Technology*, v. 44, n. 11, p. 2518–2544, 2025. DOI: 10.1080/0144929X.2024.2394886.

GIBBS, Kathryn; BEAMISH, Wendy. Conversations with Australian teachers and school leaders about using differentiated instruction in a mainstream secondary school. *Australian Journal of Teacher Education*, v. 46, n. 7, p. 97–113, 2021. DOI: 10.14221/ajte.2021v46n7.6.

GLIGOREA, Ilie; CIOCA, Marius; OANCEA, Roxana; GAMPOLO, Antonio; CIOCA, Lucian-Ionel. Adaptive Learning Using Artificial Intelligence in e-Learning: A Literature Review. *Education Sciences*, v. 13, n. 12, p. 1216, 2023. DOI: 10.3390/educsci13121216.

GRIFUL-FREIXENET, Júlia; STRUYVEN, Katrien; VANTIEGHEM, Wendelien. Exploring pre-service teachers' beliefs and practices about two inclusive frameworks: Universal Design for Learning and Differentiated Instruction. *Teaching and Teacher Education*, v. 107, p. 103503, 2021. DOI: 10.1016/j.tate.2021.103503.

GUO, Lu; WANG, Jun; ZHANG, Wei. The Exploration of the "Four-Fold Nature and One Price" Intelligent Learning Environment for Digital Circuit Courses. *SHS Web of Conferences*, v. 187, p. 04024, 2024. DOI: 10.1051/shsconf/202418704024.

HALIL, Nur Ihsan; ABDULLAH, Nor; YUNUS, Melor. A new program to foster inclusion: Unraveling language teachers' pedagogical practices to differentiated instruction. *International Journal of Language Education*, v. 8, n. 2, 2024. DOI: 10.26858/ijole.v8i2.64997.

HASANAH, Enung; SUYATNO, Suyatno; MARYANI, Ika. Conceptual Model of Differentiated-Instruction (DI) based on teachers' experiences in Indonesia. *Education Sciences*, v. 12, n. 10, p. 650, 2022. DOI: 10.3390/educsci12100650.

HASANAH, Enung; SUYATNO, Suyatno; MARYANI, Ika. Unlocking classroom potential: Exploring the mediating role of teacher mindset on embracing differentiated instruction. *International Journal of Learning, Teaching and Educational Research*, v. 22, n. 10, p. 433–452, 2023. DOI: 10.26803/ijlter.22.10.24.

HEINRICH, Carolyn; DARLING-ADUANA, Jennifer; MARTIN, Caroline. The potential and prerequisites of effective tablet integration in rural Kenya. *British Journal of Educational Technology*, v. 51, n. 2, p. 498–514, 2019. DOI: 10.1111/bjet.12870.

HELD, Tanja; MEJEH, Mathias. Students' motivational trajectories in vocational education: Effects of a self-regulated learning environment. *Heliyon*, v. 10, e29526, 2024. DOI: 10.1016/j.heliyon.2024.e29526.

HENG, Tang T. Lessons on educational borrowing and change: teachers' implementation of differentiated instruction in Singapore. *Pedagogy, Culture & Society*, v. 32, n. 5, p. 1285–1306, 2023. DOI: 10.1080/14681366.2023.2166094.

HOWORTH, Sarah K.; SMITH, Jane; JONES, Robert. Integrating emerging technologies to enhance special education teacher preparation. *Journal of Research in Innovative Teaching & Learning*, 2024. DOI: 10.1108/jrit-08-2024-0208.

ITERBEKE, Kaat; DE WITTE, Kristof; SCHELFHOUT, Wouter. The effect of ability matching and differentiated instruction in financial literacy education. Evidence from two randomised control trials. *Economics of Education Review*, v. 78, p. 101949, 2020. DOI: 10.1016/j.econedurev.2019.101949.

JOSE, Boby Chellanthara; KUMAR, Anil; SHARMA, Rajesh. Assessing the Effectiveness of Adaptive Learning Systems in K-12 Education. *International Journal of Advanced IT Research and Development*, v. 1, n. 1, p. 1–8, 2024. DOI: 10.69942/1920184/20240101/02.

KARIIPPANON, Katharina E.; CLIFF, Dylan P.; LANCASTER, Sandra J.; OKELY, Anthony D.; PARRISH, Anne-Maree. Flexible learning spaces facilitate interaction, collaboration and behavioural engagement in secondary school. *PLoS ONE*, v. 14, n. 10, e0223607, 2019. DOI: 10.1371/journal.pone.0223607.

KARST, Karina; FÖRSTER, Natalie; SOUVIGNIER, Elmar. Data-based differentiated instruction: The impact of standardized assessment and aligned teaching material on students' reading comprehension. *Learning and Instruction*, v. 79, p. 101597, 2022. DOI: 10.1016/j.learninstruc.2022.101597.

KEMPE, Anna-Lena; GRÖNLUND, Åke. Collaborative digital textbooks – a comparison of five different designs shaping teaching and learning. *Education and Information Technologies*, v. 24, n. 5, p. 2909–2941, 2019. DOI: 10.1007/s10639-019-09897-0.

KERIMBAYEV, Nurassyl; AKRAMOVA, Aliya; KASSANOV, Yerzhan. Intelligent educational technologies in individual learning: A systematic literature review. *Smart Learning Environments*, v. 12, n. 1, p. 1–30, 2025. DOI: 10.1186/s40561-024-00360-3.

KOCHMAR, Ekaterina; VU, Dung; BELFER, Robert; GUPTA, Varun; SERBAN, Iulian Vlad; PINEAU, Joelle. Automated Data-Driven Generation of Personalized Pedagogical Interventions in Intelligent Tutoring Systems. *International Journal of Artificial Intelligence in Education*, v. 32, p. 323–349, 2021. DOI: 10.1007/s40593-021-00267-x.

KONG, Siu-Cheung; YANG, Yin. A Human-Centered Learning and Teaching Framework Using Generative Artificial Intelligence for Self-Regulated Learning Development Through Domain Knowledge Learning in K–12 Settings. *IEEE Transactions on Learning Technologies*, v. 17, p. 1562–1573, 2024. DOI: 10.1109/tlt.2024.3392830.

KRISHAN, Iman Qasim; AL-RSA'I, Mohammed S. The effect of technology-oriented differentiated instruction on motivation to learn science. *International Journal of Instruction*, v. 16, n. 1, p. 961–982, 2023. DOI: 10.29333/iji.2023.16153a.

LI, Na; ZHANG, Xiaojun; LIMNIOU, Maria. A country's national culture affects virtual learning environment adoption in higher education: A systematic review (2001–2020). *Interactive Learning Environments*, v. 31, n. 7, p. 4407–4425, 2021. DOI: 10.1080/10494820.2021.1967408.

LIAO, Xiaofang; CHEN, Gwo-Jen; HWANG, Wu-Yuin. Design and implementation of an AI-enabled visual report tool as formative assessment to promote learning achievement and self-regulated learning: An experimental study. *British Journal of Educational Technology*, v. 55, n. 3, p. 1253–1276, 2024. DOI: 10.1111/bjet.13424.

MALACAPAY, Marjon C. Differentiated instruction in relation to pupils' learning style. *International Journal of Instruction*, v. 12, n. 4, p. 625–638, 2019. DOI: 10.29333/iji.2019.12440a.

MARLINA, Marlina; EFRINA, Elsa; KUSUMASTUTI, Grahita. Differentiated learning for students with special needs in inclusive schools. *In:* INTERNATIONAL Conference on Education and Technology (ICET). [*S. l.: s. n.*], 2019. v. 382, p. 678–681. DOI: 10.2991/icet-19.2019.164.

MAULANA, Ridwan; HELMS-LORENZ, Michelle; IRNIDAYANTI, Yeni. Measuring differentiated instruction in The Netherlands and South Korea: Factor structure equivalence, correlates, and complexity level. *European Journal of Psychology of Education*, v. 35, n. 4, p. 881–909, 2019. DOI: 10.1007/s10212-019-00446-4.

MENA-GUACAS, Andrés F.; LOPEZ, Juan; GARCIA, Carlos. Educational transformation through emerging technologies: Critical review of scientific impact on learning. *Education Sciences*, v. 15, n. 3, p. 1–28, 2025. DOI: 10.3390/educsci15030368.

MEUTSTEGE, Kyra; VAN GEEL, Marieke; VISSCHER, Adrie. Evidence-based design of a teacher professional development program for differentiated instruction: A whole-task approach. *Education Sciences*, v. 13, n. 10, p. 985, 2023. DOI: 10.3390/educsci13100985.

MIN, Win Ko; THENG, Lau Bee. Integration of digital social story intervention into differentiated instruction framework. *Journal of Integrated Design and Process Science*, v. 21, n. 4, p. 41–56, 2018. DOI: 10.3233/jid-2017-0008.

MOLENAAR, Inge; CAMPEN, Carolien A. N. Knoop-Van. How teachers make dashboard information actionable. *IEEE Transactions on Learning Technologies*, v. 12, n. 3, p. 347–355, 2019. DOI: 10.1109/TLT.2018.2851585.

MURTAZA, Mir; AHMED, Syed; KHAN, Muhammad. AI-based personalized e-learning systems: Issues, challenges, and solutions. *IEEE Access*, v. 10, p. 81323–81342, 2022. DOI: 10.1109/access.2022.3193938.

NASEER, Fawad; ALI, Sajid; KHAN, Waqas. Integrating deep learning techniques for personalized learning pathways in higher education. *Heliyon*, v. 10, n. 11, e32628, 2024. DOI: 10.1016/j.heliyon.2024.e32628.

OUYANG, Juanjuan; YE, Nanzhou. Differentiated instruction: Meeting the needs of all learners. *Curriculum and Teaching Methodology*, v. 6, n. 11, p. 57–61, 2023. DOI: 10.23977/curtm.2023.061111.

PAGE, Matthew J.; MCKENZIE, Joanne E.; BOSSUYT, Patrick M. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, v. 372, n71, 2021. DOI: 10.1136/bmj.n71.

PALIERAKI, Stefania; KOUTROUBA, Konstantina. Differentiated instruction in information and communications technology teaching and effective learning in primary education. *European Journal of Educational Research*, v. 10, n. 3, p. 1487–1504, 2021. DOI: 10.12973/eu-jer.10.3.1487.

PIAGET, Jean. Intellectual evolution from adolescence to adulthood. *Human Development*, v. 51, p. 40–47, 1972. DOI: 10.1159/000112531.

PORTILLA, Juri Evelyn Nuñez; SMITH, Mark; BROWN, David. Systematic review: Artificial intelligence (AI) in education 4.0. *Journal of Educators Online*, v. 22, n. 3, 2025. DOI: 10.9743/JEO.2025.22.3.13.

POZDNIAKOV, Stanislav; MARTINEZ-MALDONADO, Roberto; TSAI, Yi-Shan. Investigating the effect of visualization literacy and guidance on teachers' dashboard interpretation. *Journal of Learning Analytics*, v. 12, n. 1, p. 367–390, 2025. DOI: 10.18608/jla.2024.8471.

PUZIO, Kelly; COLBY, Glenn; ALGEO-NICHOLS, Dana. Differentiated literacy instruction: Boondoggle or best practice? *Review of Educational Research*, v. 90, p. 459–498, 2020. DOI: 10.3102/0034654320933536.

RAMAILA, Sam. Unveiling the Potential: A Systematic Review on Harnessing the Affordances of Differentiated Instruction. *Journal of Teaching and Learning*, 2025. DOI: 10.22329/jtl.v19i2.8561.

SAAD, Sharina; ABDULLAH, Amelia. Exploring learner autonomy: A conceptual perspective on self-directed learning in higher education. *International Journal of Modern Education*, v. 7, n. 24, p. 1304–1315, 2025. DOI: 10.35631/ijmoe.724092.

SABIR, Arisman; WANG, Yuanyuan; ZOU, Guijiao. Differentiation strategies in a multicultural classroom: A case study in an elementary school. *International Journal of Educatio Elementaria and Psychologia*, v. 1, n. 6, p. 319–334, 2024. DOI: 10.70177/ijeep.v1i6.1462.

SAJJA, Ramteja; MILLER, Alex; WATSON, Sarah. Artificial intelligence-enabled intelligent assistant for personalized and adaptive learning in higher education. *Information*, v. 15, n. 10, 2024. DOI: 10.3390/info15100596.

SALAS-PILCO, Sdenka Zobeida; YANG, Yuqin. Artificial intelligence applications in Latin American higher education: a systematic review. *International Journal of Educational Technology in Higher Education*, v. 19, n. 1, p. 21, 2022. DOI: 10.1186/s41239-022-00326-w.

SAYED, Wafaa S.; MAHMOUD, Ahmed; IBRAHIM, Eman. AI-based adaptive personalized content presentation and exercises navigation for an effective and engaging e-learning platform. *Multimedia Tools and Applications*, v. 82, p. 3303–3333, 2022. DOI: 10.1007/s11042-022-13076-8.

ŞENTÜRK, Cihad; SARI, Hakan. Investigation of impacts of differentiated instruction applied in a primary school in attitudes of students towards the course. *Cypriot Journal of Educational Sciences*, v. 13, n. 2, p. 240–248, 2018. DOI: 10.18844/cjes.v13i2.3359.

SEO, Kyoungwon; TANG, Jiliang; SMITH, Ashley. Augmented teachers: K–12 teachers' needs for artificial intelligence's complementary role in personalized learning. *Journal of Research on Technology in Education*, v. 57, n. 4, p. 876–893, 2024. DOI: 10.1080/15391523.2024.2330525.

SHAREEFA, Mariyam. Demystifying the impact of teachers' qualification and experience on implementation of differentiated instruction. *International Journal of Instruction*, v. 16, n. 1, p. 393–416, 2023. DOI: 10.29333/iji.2023.16122a.

SHAREEFA, Mariyam; MOOSA, Visal; HOO, Wong Chee. An investigation of K–12 teachers' perception and use of differentiated instruction based on qualification, training, and experience. *International Journal of Education and Practice*, v. 12, n. 2, p. 324–335, 2024. DOI: 10.18488/61.v12i2.3683.

SHEMSHACK, Atikah; SPECTOR, J. Michael. A systematic literature review of personalized learning terms. *Smart Learning Environments*, v. 7, n. 33, p. 1–20, 2020. DOI: 10.1186/s40561-020-00140-9.

SILVA LEÓN, Pedro M.; GARCIA, Ricardo; SANTOS, Luisa. Digital Technologies for Young Entrepreneurs in Latin America: A Systematic Review of Educational Innovations (2018–2024). *Social Sciences*, v. 14, n. 9, 2024. DOI: 10.3390/socsci14090537.

SMALE-JACOBSE, Annemieke E.; MEELISSEN, Martina R. M.; VRIELINK, Ariane; MASTER, Benjamin S. Differentiated instruction in secondary education: A systematic review of research evidence. *Frontiers in Psychology*, v. 10, 2019. DOI: 10.3389/fpsyg.2019.02366.

SMETS, Wouter; DE NEVE, Debbie; STRUYVEN, Katrien. Responding to students' learning needs: How secondary education teachers learn to implement differentiated instruction. *Educational Action Research*, v. 30, n. 2, p. 243–260, 2020. DOI: 10.1080/09650792.2020.1848604.

SMETS, Wouter; STRUYVEN, Katrien. Aligning with complexity: System-theoretical principles for research on differentiated instruction. *Frontline Learning Research*, v. 6, n. 2, p. 66–80, 2018. DOI: 10.14786/flr.v6i2.340.

SONGER, Nancy B.; IBARROLA, Maria; MI, Yang. Navigated learning: An approach for differentiated classroom instruction built on learning science and data science foundations. *Human Behavior and Emerging Technologies*, v. 2, n. 1, p. 93–105, 2019. DOI: 10.1002/hbe2.169.

SPYROPOULOU, Elissavet; WALLACE, Manolis; POULOPOULOS, Vassilis. Differentiated education using technology in junior and high school classrooms. *Encyclopedia*, v. 5, n. 2, 2025. DOI: 10.3390/encyclopedia5020071.

SREE, Sowmya; KUMAR, Ravi; GUPTA, Anita. Global significance of technology enhanced learning and teaching. *Power System Technology*, v. 48, n. 3, p. 756–763, 2024. DOI: 10.52783/pst.873.

STRIELKOWSKI, Wadim; FIRSOVA, Irina; AZAROVA, Svetlana; SHISHANOVA, Elena. AI-driven adaptive learning for sustainable educational transformation. *Sustainable Development*, v. 33, n. 2, p. 1921–1947, 2024. DOI: 10.1002/sd.3221.

STROGILOS, Vasilis; LIM, Levan; BINTE MOHAMED BUHARI, Nasreena. Differentiated instruction for students with SEN in mainstream classrooms: Contextual features and types of curriculum modifications. *Asia Pacific Journal of Education*, v. 43, n. 3, p. 850–866, 2021. DOI: 10.1080/02188791.2021.1984873.

TAŞKIN, Meltem. Artificial intelligence in personalized education: Enhancing learning outcomes through adaptive technologies and data-driven insights. *Human Computer Interaction*, v. 8, n. 1, 2025. DOI: 10.62802/ygye0506.

TETZLAFF, Leonard; SCHMIEDEK, Florian; BROD, Garvin. Developing personalized education: A dynamic framework. *Educational Psychology Review*, v. 33, p. 863–882, 2020. DOI: 10.1007/s10648-020-09570-w.

TOMLINSON, Carol Ann. Mapping a route toward differentiated instruction. *Educational Leadership*, v. 57, p. 12–16, 1999.

TOMLINSON, Carol Ann. *How to Differentiate Instruction in Mixed-Ability Classrooms*. Upper Saddle River: Pearson Education, 2001.

TOMLINSON, Carol Ann. *Differentiated Classroom: Responding to the Needs of All Learners*. 2nd Edition. [*S. l.*]: ASCD, 2014. ISBN: 9781416618621. Available from: http://site.ebrary.com/id/10883053. Visited on: 31 Mar. 2026.

VAGANOVA, Olga I.; LIVSHITS, Julia; SMIRNOVA, Julia. Level differentiation technology in vocational education. *Revista Amazonia Investiga*, v. 9, n. 28, p. 42–49, 2020. DOI: 10.34069/ai/2020.28.04.5.

VALIANDES, Stavroula. Evaluating the impact of differentiated instruction on literacy and reading in mixed ability classrooms: Quality and equity dimensions of education effectiveness. *Studies in Educational Evaluation*, v. 45, p. 17–26, 2015. DOI: 10.1016/j.stueduc.2015.02.005.

VALIANDES, Stavroula; NEOPHYTOU, Lefkios; HAJISOTERIOU, Christina. Establishing a framework for blending intercultural education with differentiated instruction. *Intercultural Education*, v. 29, n. 3, p. 379–398, 2018. DOI: 10.1080/14675986.2018.1441706.

VAN ECK, Nees Jan; WALTMAN, Ludo. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, v. 84, n. 2, p. 523–538, 2010. DOI: 10.1007/s11192-009-0146-3.

VAN GEEL, Marieke; KEUNING, Trynke; VISSCHER, Adrie; FOX, Jean-Paul. Capturing the complexity of differentiated instruction. *School Effectiveness and School Improvement*, v. 30, n. 1, p. 51–67, 2019. DOI: 10.1080/09243453.2018.1539013.

VANTIEGHEM, Wendelien; VAN DE PUTTE, Ina; DECLERCQ, Laurence. Professional vision of inclusive classrooms: A validation of teachers' reasoning on differentiated instruction and teacher-student interactions. *Studies in Educational Evaluation*, v. 67, p. 100912, 2020. DOI: 10.1016/j.stueduc.2020.100912.

VINCENT-RUZ, Paulette; BOASE, Nathan R. B. Activating discipline specific thinking with adaptive learning: A digital tool to enhance learning in chemistry. *PLOS One*, v. 17, p. 1–21, 2022. DOI: 10.1371/journal.pone.0276086.

VYGOTSKY, Lev S. *Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Press, 1978.

WANG, Shuai; HWANG, Gwo-Jen; WANG, Jun. When adaptive learning is effective learning: Comparison of an adaptive learning system to teacher-led instruction. *Interactive Learning Environments*, v. 31, n. 2, p. 793–803, 2020. DOI: 10.1080/10494820.2020.1808794.

WESTBROEK, Hanna B.; JANSSEN, Fred J. J. M.; DRIEL, Jan H. van. A practical approach to assessment for learning and differentiated instruction. *International Journal of Science Education*, v. 42, n. 6, p. 955–976, 2020. DOI: 10.1080/09500693.2020.1744044.

WOO, David James; GUO, Kai; SUSANTO, Hengky. Exploring EFL students' prompt engineering in human–AI story writing: An activity theory perspective. *Interactive Learning Environments*, v. 33, n. 1, p. 863–882, 2024. DOI: 10.1080/10494820.2024.2361381.

WU, Bo-Jyun; WONG, Sai-Keung; LI, Ta-Wei. Virtual titration laboratory experiment with differentiated instruction. *Computer Animation and Virtual Worlds*, v. 30, n. 3-4, 2019. DOI: 10.1002/cav.1882.

YUEN, Suet-Ying; LUO, Zili; WAN, Sally Wai-yan. Challenges and opportunities of implementing differentiated instruction amid the Covid-19 pandemic: Insights from a qualitative exploration. *Education Sciences*, v. 13, n. 10, 2023. DOI: 10.3390/educsci13100989.

YUNIANTO, Wahid; KUSUMA, Jaka; SARI, Ria. Investigating the use of ChatGPT to solve a GeoGebra based mathematics+computational thinking task in a geometry topic. *Journal on Mathematics Education*, v. 15, n. 3, p. 1027–1052, 2024. DOI: 10.22342/jme.v15i3.pp1027-1052.

ZAFAR, Quratulain; ALI, Muhammad; RAZA, Syed. Investigate how self-regulation strategies can enhance student autonomy, motivation, and long-term learning outcomes. *Journal of Policy Research*, v. 10, n. 3, p. 377–386, 2024. DOI: 10.61506/02.00356.

ZERVOUDAKIS, Konstantinos; MASTROTHANASIS, Konstantinos; TSAFARAKIS, Stelios. Forming automatic groups of learners using particle swarm optimization for applications of differentiated instruction. *Computer Applications in Engineering Education*, v. 28, n. 2, p. 282–292, 2019. DOI: 10.1002/cae.22191.

Author contributions

Jamil Suprihatiningrum: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing; **Ahmad Syaripudin**: Data curation, Formal analysis, Investigation, Project administration, Resources, Writing – review and editing.

Data availability

Research data is only available upon request.