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AI-Mediated Second Language Teaching and Learning in Secondary Schools: A Multifactorial Analysis of Opportunities, Challenges, and Strategic Imperatives

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Abstract

The rapid integration of artificial intelligence (AI) into educational systems has profoundly reconfigured the landscape of second language (L2) teaching and learning, presenting secondary school contexts with a distinctive set of opportunities and multifaceted challenges. Despite growing scholarly interest in AI-enhanced language education, research at the secondary school level remains comparatively sparse, with the majority of existing studies concentrated in higher education or decontextualized from the specific developmental, institutional, and pedagogical realities of adolescent learners. This paper addresses that gap by proposing and elaborating a reframed topic: AI-Mediated Second Language Teaching and Learning in Secondary Schools: A Multifactorial Analysis of Opportunities, Challenges, and Strategic Imperatives. Drawing on a comprehensive synthesis of peer-reviewed scholarship published between 2020 and 2025, the paper identifies and critically examines five interacting clusters of factors: (1) learner-internal factors, encompassing adolescent cognitive development, affective variables, motivation, and individual differences in AI literacy; (2) teacher-related factors, including pedagogical readiness, AI competency, professional identity, and technostress; (3) instructional and pedagogical factors, such as the design of AI-enhanced tasks, feedback mechanisms, and the promotion of communicative competence; (4) institutional and policy factors, including curriculum frameworks, resource equity, school-level AI governance, and systemic professional development; and (5) socio-cultural and ethical factors, comprising academic integrity, algorithmic bias, the digital divide, and the cultural embeddedness of language learning. The paper synthesizes these factors into an integrated conceptual model and proposes evidence-based strategies for

secondary schools navigating the AI era of L2 education. Implications for curriculum developers, language teachers, school administrators, and policymakers are discussed.

Keywords: Second Language Acquisition, Artificial Intelligence, Secondary School, EFL/ESL, Language Teaching, Adolescent Learners, Teacher Competency, AI Literacy, Academic Integrity, Educational Equity

Introduction

The emergence of artificial intelligence (AI) as a transformative educational technology has inaugurated an unprecedented chapter in the history of second language (L2) pedagogy. From intelligent tutoring systems and natural language processing (NLP) tools to large language models (LLMs) such as ChatGPT, Gemini, and Claude, AI technologies are fundamentally reshaping how languages are taught, practiced, assessed, and acquired across diverse educational settings (Son et al., 2025). The global AI-in-education market, valued at approximately $7 billion in 2025, is projected to grow at an annual rate exceeding 36% over the next decade, signaling an irreversible structural transformation in how educational institutions approach teaching and learning (Brookings, 2025). This expansion is not merely technological; it represents a paradigm shift in the epistemological assumptions, pedagogical practices, and institutional arrangements that have governed language education for over a century. Secondary schools—institutions serving adolescents in the critical developmental window between childhood and adulthood—occupy a particularly consequential position in this transformation. It is at the secondary level that L2 learners consolidate the intermediate-to-advanced proficiency necessary for academic, civic, and professional participation; that foundational attitudes toward language learning, technology use, and lifelong learning are formed; and that systemic factors, including curriculum mandates, resource constraints, and teacher preparation, exert their most decisive influence on long-term learning trajectories (Yang et al., 2024). The adolescent brain, characterized by heightened neuroplasticity and reward sensitivity, may respond distinctively to AI-mediated instructional environments—a recognition that underscores the importance of contextualized research at the secondary level rather than wholesale extrapolation from adult learner studies (Frontiers in Psychology, 2024).

Scholarly engagement with AI in language education has grown exponentially since 2017, with a marked acceleration from 2022 onward following the public release of generative AI tools. A twenty-year scoping review of 272 empirical studies on AI in language learning (2005–2024) documented a decisive shift from rule-based systems to advanced LLM applications, with chatbots accounting for 44.1% of recent AI interventions and commercial tools comprising 71% of the research corpus (Tandfonline, 2026). A meta-analysis of AI

interventions in L2 learning synthesized contextual, instructional, and socio-emotional moderators, finding that AI tools yielded significant positive effects on language learning outcomes, moderated by participant age, intervention duration, targeted language skill, and feedback design (Fathi et al., 2024). A systematic review of AI and English language teaching across 42 studies further confirmed that AI affordances span all four language skills—speaking, writing, reading, and self-regulation—while simultaneously revealing that 65% of existing studies were conducted in higher education settings, leaving secondary school contexts comparatively underexplored (Crompton, 2024). The theoretical foundations for understanding AI-mediated L2 education draw on several established frameworks in applied linguistics and educational technology. Krashen's (1982) Input Hypothesis and Affective Filter Hypothesis remain highly relevant: systematic reviews confirm that AI tools reduce foreign language anxiety and increase enjoyment, thereby lowering affective barriers to acquisition and creating optimal conditions for language intake (PMC, 2025). Vygotsky's (1978) concept of the Zone of Proximal Development (ZPD) finds practical expression in adaptive AI tutoring systems that scaffold learners at the precise boundary of their current competence (Kasneci et al., 2023). Long's (1996) Interaction Hypothesis, which posits that meaning negotiation drives acquisition, is extended by AI conversational agents that provide unlimited low-stakes practice opportunities beyond the physical classroom (Dong et al., 2024). The SAMR model (Puentedura, 2006), applied to AI in SLA contexts by Liang et al. (2025), reveals that most current AI integration clusters at the Substitution and Augmentation levels rather than achieving the Modification and Redefinition levels characteristic of genuinely transformative technology use—a finding with direct implications for curriculum design and professional development in secondary schools.

At the policy level, AI integration in secondary education has attracted urgent attention from international bodies. According to UNESCO's latest data, over two-thirds of secondary school students in high-income nations already use generative AI tools to support their schoolwork, yet only 10% of schools and universities worldwide had an official framework for AI use as of 2023 (UN News, 2025). UNESCO's Digital Learning Week 2025 convened ministers and education leaders from across the globe around a collective mission: AI in education must be human-centered, equitable, safe, and ethical, with sustainable digital infrastructure, inclusive regulatory safeguards, and culturally responsive design as non-negotiable pillars (UNESCO, 2025). National policy responses vary considerably: China integrated AI as a compulsory curriculum subject for all primary and secondary students from September 2025; South Korea rolled out AI-powered adaptive digital textbooks supported by $760 million in teacher training funding; and Australia implemented a phased National Framework for Generative AI in Schools from 2024 (DevelopmentAid, 2025). These developments signal that AI in secondary education has transitioned from an exploratory periphery to a central policy preoccupation—one that demands rigorous, contextually grounded research to inform practice. Despite this momentum, the literature reveals persistent and consequential gaps. Research on learner emotions in AI-assisted ESL/EFL learning confirms that higher education dominates the

evidence base partly because university students have greater linguistic competence and cognitive maturity, and because data collection is more logistically feasible at that level; as a result, the influence of AI-assisted language learning on secondary school students remains insufficiently understood (Frontiers in Psychology, 2025). K-12 students require distinct pedagogical strategies and developmental considerations that cannot be derived from adult learner findings, given differences in digital literacy, learner agency, and institutional infrastructure (Frontiers in Psychology, 2025). A systematic review of teacher professional development needs for AI integration in K-12 schools identified a significant gap in AI literacy among secondary educators, with EFL teachers demonstrating greater likelihood of sustained AI integration when they possessed substantive technological knowledge about AI-based language applications (MDPI, 2026). Compounding these gaps is a structural equity challenge: the International Telecommunication Union reports that 2.6 billion people remained offline in 2023, with internet access in Sub-Saharan Africa stagnating at 36%, while AI adoption in education remains below 15% across most African and Latin American secondary school systems due to device scarcity, broadband limitations, and culturally mismatched curriculum designs (DevelopmentAid, 2025).

This paper responds to these gaps by proposing and systematically elaborating a reframed analytical project: AI-Mediated Second Language Teaching and Learning in Secondary Schools: A Multifactorial Analysis of Opportunities, Challenges, and Strategic Imperatives. Drawing on a comprehensive synthesis of peer-reviewed scholarship published between 2020 and 2026, the paper organizes its analysis around five interacting factor clusters—learner-internal, teacher-related, instructional-pedagogical, institutional-policy, and socio-cultural-ethical—that together constitute the ecology of AI-mediated L2 education in secondary contexts. The paper proceeds as follows. Section 2 establishes the theoretical and conceptual foundations. Section 3 introduces the five-factor ecological model. Sections 4 through 8 examine each factor cluster in depth. Section 9 synthesizes the analysis and proposes evidence-based strategies. Section 10 discusses implications for research and practice, and Section 11 concludes.

Problem Statement

Notwithstanding the rapid expansion of AI tools in educational environments and the substantial body of empirical evidence documenting their efficacy in higher education L2 contexts, secondary schools face a critical preparedness deficit. The scale of adolescent AI adoption is not in question: Common Sense Media (2024) reported that approximately 70% of teenagers aged 13 to 18 already use generative AI tools for homework and language tasks, a figure that doubled between 2023 and 2025 according to Pew Research Center (2025) data on ChatGPT use among U.S. teenagers. Yet institutional responses have lagged markedly behind this adoption curve. As of 2023, only 10% of schools and universities globally had established an official framework governing AI use (UN News, 2025), and a 2024 School Pulse Panel survey found that only 14% of public K-12 schools in the United States were teaching students

about ethical or appropriate AI use (School Pulse Panel, 2024). This governance gap has profound consequences for secondary L2 education specifically: teachers lack structured guidance for integrating AI pedagogically and responsibly; learners use AI without the critical literacy necessary to evaluate its outputs; and institutions deploy or prohibit AI tools without the evidence base necessary to do so judiciously. The research community has not adequately addressed this deficit. Existing systematic reviews confirm that secondary school contexts are among the most underrepresented in the evidence base: 65% of AI-ELT studies have been conducted in higher education (Crompton, 2024), over 86% of AI-language learning studies focus on non-secondary contexts (Wah, 2025), and higher education dominates the field partly because university students' greater cognitive maturity makes them more accessible subjects for AI-mediated research (Frontiers in Psychology, 2025). The empirical literature on AI in secondary L2 education also tends to be geographically concentrated in high-income Asian contexts such as China, South Korea, and Japan, leaving secondary school systems in Sub-Saharan Africa, South Asia, the Middle East, and Latin America almost entirely unrepresented. These omissions mean that the pedagogical frameworks, professional development models, and institutional strategies being developed from the existing evidence base may have limited applicability to the majority of the world's secondary L2 learners.

At the teacher level, a cross-sectional survey of 1,454 teachers in a large urban school district found that secondary teachers were significantly less willing to permit AI chatbot use compared to teachers at other levels, and that secondary teachers reported the lowest rates of engagement with available AI training resources (Springer, 2025). A systematic review of teacher professional development needs for K-12 AI integration confirmed a wide gap in AI literacy among secondary educators, with many teachers lacking not only technical proficiency but the pedagogical judgment necessary to deploy AI purposefully within subject-specific instructional frameworks (MDPI, 2026). At the learner level, a study of secondary students using ChatGPT-4o found that while learners recognized the tool's utility for immediate feedback and knowledge building, fewer than half verified AI outputs against independent sources (Sivenas & Maragkaki, 2024; Common Sense Media, 2024)—a pattern of uncritical consumption that carries significant risks for language development, academic integrity, and epistemological formation. These converging deficits—at the learner, teacher, institutional, and policy levels—constitute the central problem this paper addresses: the absence of a comprehensive, empirically grounded, and ecologically contextualized analytical framework for navigating AI-mediated L2 education in secondary schools.

Objectives of the Study

In response to the problem delineated above, this paper pursues the following six specific objectives:

1. To critically examine the existing empirical literature on AI-mediated second language teaching and learning in secondary school contexts, identifying patterns of evidence,

methodological tendencies, and substantive research gaps that characterize the field as of 2026.

2. To analyze the learner-internal factors—including adolescent cognitive and neurological development, affective variables (motivation, anxiety, enjoyment), and AI literacy—that mediate secondary learners' engagement with and outcomes from AI-assisted L2 instruction.
3. To investigate the teacher-related factors—encompassing AI pedagogical competency, professional identity, technostress, and AI literacy—that shape the quality of AI integration in secondary L2 classrooms, and to identify evidence-based professional development approaches capable of strengthening these capacities.
4. To evaluate the instructional and pedagogical dimensions of AI-mediated L2 education in secondary schools, including the design of AI-enhanced tasks, the calibration of AI feedback for adolescent learners, and the alignment of AI integration with communicative language teaching (CLT) principles and metacognitive development goals.
5. To examine the institutional, policy, and socio-cultural factors—including curriculum governance, resource equity, the digital divide, algorithmic bias, academic integrity, and data privacy—that constitute the structural conditions within which AI-mediated secondary L2 education operates, and to assess their implications for equitable and responsible AI integration.
6. To synthesize the five-factor analysis into an integrated ecological model of AI-mediated L2 education in secondary schools and to derive from this model a set of evidence-based strategic recommendations for language teachers, curriculum developers, school administrators, and policymakers navigating the AI era of second language education.

Second Language Acquisition Theory in Technology-Mediated Contexts

Second language acquisition (SLA) research has long established that language learning is a complex, multidetermined process shaped by the interaction of learner-internal variables (cognitive capacity, motivation, affect, prior knowledge) and environmental variables (quality and quantity of input, interactional opportunities, instructional design, social context). The foundational theoretical frameworks most germane to AI-mediated L2 education in secondary schools include Krashen's (1982) Input Hypothesis and Affective Filter Hypothesis, Vygotsky's (1978) Zone of Proximal Development (ZPD), Long's (1996) Interaction Hypothesis, and Swain's (1985) Output Hypothesis. Each of these frameworks has received renewed relevance in the context of AI tools. Krashen's (1982) Affective Filter Hypothesis proposes that emotional variables—anxiety, motivation, and self-confidence—regulate learners' openness to language input. A systematic review of learner emotions in AI-assisted ESL/EFL learning confirmed that AI tools consistently reduce foreign language anxiety and increase enjoyment, thereby lowering the affective filter and creating more favorable

conditions for acquisition (PMC, 2025). Vygotsky's (1978) ZPD has been operationalized in AI contexts through intelligent tutoring systems and adaptive feedback mechanisms that scaffold learners at the edge of their current competence, mimicking the function of a more capable peer or teacher (Kasneci et al., 2023). Long's (1996) Interaction Hypothesis, which posits that negotiation of meaning in communicative interaction drives acquisition, finds new expression in AI-powered conversational agents that provide unlimited low-stakes interactional opportunities—of particular value to secondary learners who may be reticent to engage in human-mediated communicative practice (Dong et al., 2024).

A meta-analysis of AI interventions in L2 learning synthesized contextual, instructional, and social-emotional moderators, finding that the effectiveness of AI tools is not uniform across learner populations, educational levels, or instructional contexts (Fathi et al., 2024). Factors including participants' age, intervention duration, the type of language skill targeted, and the nature of feedback provided significantly moderated AI's impact on learning outcomes—underscoring the necessity of a multifactorial, contextually grounded analytical approach (Fathi et al., 2024).

Ecological and Socio-Cultural Perspectives on Technology in Education

Bronfenbrenner's (1979) ecological systems theory provides a valuable framework for understanding how AI tools are embedded within nested layers of influence that shape secondary L2 education: the microsystem (the individual learner and classroom), the mesosystem (school and family interactions), the exosystem (local school governance and curriculum policy), and the macrosystem (national educational policy, cultural norms, and global AI development trajectories). This ecological perspective underscores the importance of examining AI's influence not merely at the level of the individual learner or classroom, but across the full range of interacting systems that constitute the secondary school context. Socio-cultural theory (Vygotsky, 1978; Lantolf, 2000) extends this analysis by emphasizing that learning is fundamentally mediated by cultural tools and social interaction. AI systems constitute a new category of mediational tool, and their incorporation into L2 education necessarily involves negotiation with existing cultural norms around language learning, the role of the teacher, and the value of effort and struggle in the learning process. Research on secondary school teachers' experiences with generative AI tools found that educators navigate a complex landscape of opportunities and constraints shaped by their cultural and institutional context—with minority language contexts presenting distinctive challenges that mainstream AI systems, trained predominantly on dominant-language data, are often ill-equipped to address (Springer, 2024).

The SAMR model (Puentedura, 2006), which classifies technology integration along a continuum from Substitution to Redefinition, has been applied to AI in SLA contexts by Liang et al. (2025), who found that current AI applications in language education cluster predominantly at the Substitution and Augmentation levels, with few examples achieving the Modification and Redefinition levels associated with transformative educational change. This

finding has direct implications for secondary schools: the prevalent use of AI as a digital substitute for existing language drills or translation exercises, rather than as an enabler of genuinely new communicative and collaborative learning experiences, reflects a failure of pedagogical imagination that professional development initiatives must address.

An Ecological Framework for AI-Mediated L2 Education in Secondary Schools

Drawing on the theoretical foundations outlined above, this paper organizes its analysis around a five-factor ecological model of AI-mediated L2 teaching and learning in secondary schools. The five factor clusters—learner-internal, teacher-related, instructional-pedagogical, institutional-policy, and socio-cultural-ethical—are not independent; they interact dynamically, with changes in one domain rippling through others. Each factor cluster contains both enabling conditions that leverage AI to enhance L2 outcomes and constraining conditions that impede effective AI integration. The paper examines each cluster through this dual lens, drawing systematically on the most recent empirical research. This five-factor model is intended to serve not only as an analytical framework for the present synthesis but also as a practical planning tool for school administrators, curriculum developers, and language educators seeking to map the full landscape of variables relevant to their particular institutional context before embarking on AI integration initiatives. The model reflects the central premise of this paper: that responsible and effective AI-mediated L2 education in secondary schools requires simultaneous attention to multiple interacting factors rather than singular technological or pedagogical solutions.

Adolescent Cognitive and Neurological Development

Secondary school students occupy a distinctive cognitive-developmental position relative to both younger children and adult L2 learners. The adolescent brain is characterized by ongoing maturation of prefrontal cortical systems responsible for executive function, working memory, and impulse control, alongside heightened sensitivity of the reward system—a neurobiological configuration that shapes how adolescents engage with technologically enriched learning environments (Yang et al., 2024). Research examining structural properties of language-related neural pathways in junior (ages 13-14) and senior (ages 16-17) high school students found that age-dependent neuroplasticity moderated L2 syntactic performance, with the transitional period of adolescence representing a window of particular sensitivity to L2 input quality and quantity (Frontiers in Psychology, 2024). These neurological considerations have practical implications: AI tools that provide frequent, varied, and immediately rewarding language interactions may align well with adolescent motivational neuroscience, while those that demand sustained, decontextualized effort may encounter resistance. Cognitive individual differences, particularly working memory capacity, play a significant role in mediating how secondary learners engage with AI-generated language feedback and tasks. A study developing a cognitive load scale for AI-assisted L2 writing found that working memory capacity significantly influenced learners' ability to manage the simultaneous demands of

language production and AI interaction, with high cognitive load impairing rather than enhancing performance for learners with lower working memory capacity (Frontiers in Psychology, 2025). This finding has important implications for the design of AI-assisted language tasks in secondary classrooms: tasks must be calibrated not only to linguistic proficiency but to the cognitive demands of the human-AI interaction itself.

Affective Variables: Motivation, Anxiety, and Enjoyment

Affective variables constitute among the most powerful determinants of L2 learning outcomes in secondary contexts. A systematic review of learner emotions in AI-assisted ESL/EFL learning confirmed that AI tools exert consistently positive effects on learners' affective states: they reduce foreign language anxiety, particularly in writing contexts; increase foreign language enjoyment; and enhance willingness to communicate (PMC, 2025). These affective benefits align with Krashen's (1982) Affective Filter Hypothesis: by lowering anxiety barriers, AI-assisted practice creates optimal conditions for linguistic input to be processed and acquired. A study of AI tools' effects on EFL learners' engagement, enjoyment, and motivation found that AI integration led to significant improvements in all three affective domains, with learners reporting increased pleasure in language tasks previously associated with anxiety and reluctance (Derakhshan & Fathi, 2024). However, the affective picture is not uniformly positive. Secondary school students' emotional experiences in AI-powered classrooms span a wide range, from excitement to significant anxiety. Research by Xin and Derakhshan (2025) documented that learners' perceived inability to match AI-generated language standards, exposure to continuous AI feedback suggesting their work was perpetually improvable, and concerns about over-reliance on AI feedback generated new forms of anxiety and diminished self-efficacy. A study examining students' attitudes and AI anxiety in secondary settings found that while familiarity with generative AI supported acceptance, it did not automatically alleviate anxiety, with some students experiencing evaluation pressure from AI-driven feedback loops they perceived as unpredictable or overly critical (Arxiv, 2025). Affective responses to AI tools in L2 classrooms are thus neither uniformly positive nor negative but are mediated by task design, learner self-efficacy beliefs, and the pedagogical framing of AI use.

Motivation—the most extensively studied affective variable in SLA—is similarly multidimensional in AI contexts. Self-Determination Theory (Deci & Ryan, 2000) predicts that AI tools will enhance intrinsic motivation when they support learners' needs for competence, autonomy, and relatedness. Structural Equation Modelling by Zhang et al. (2025) found that AI and augmented/virtual reality literacy significantly predicted both academic engagement and motivational levels among EFL learners, with higher technological literacy associated with greater interaction, curiosity, and self-directed exploration. However, extrinsic motivational orientations—using AI for grade-related performance rather than genuine communicative competence—can produce surface-level engagement without deep learning, a risk that is particularly salient in secondary contexts where assessment pressure is intense.

AI Literacy and Digital Competence

A critical learner-internal factor shaping the effectiveness of AI-mediated L2 education is learners' AI literacy—their capacity to understand, evaluate, and critically engage with AI systems and their outputs. Research in secondary school contexts has revealed significant heterogeneity in student AI literacy, with many adolescents demonstrating high familiarity with consumer AI applications (chatbots, recommendation systems) but limited critical understanding of how these systems work, how they generate outputs, and how to evaluate their accuracy and limitations (Sivenas & Maragkaki, 2024). A study of secondary students using ChatGPT-4o found that students recognized the tool's utility for knowledge building, immediate feedback, and information access, but also identified significant constraints including content reliability concerns, anxiety about AI use, and privacy worries—limitations that only AI-literate learners can navigate productively (Sivenas & Maragkaki, 2024). The Common Sense Media survey of 1,045 teenagers (ages 13-18) found that while 70% had used at least one generative AI tool, only approximately half of those using AI for schoolwork checked the veracity of AI outputs against independent sources (Common Sense Media, 2024). This pattern suggests that the majority of adolescent AI users engage with these tools uncritically, accepting outputs without verification—a behavior with significant consequences for L2 learning, where AI-generated language samples may contain subtle errors, unidiomatic expressions, or culturally inappropriate content. Developing AI literacy in L2 learners must therefore be understood as a core pedagogical imperative of secondary language education in the AI era, not an optional enrichment activity.

AI Competency and Pedagogical Readiness

Language teachers are the most critical human factor in determining the educational quality of AI-mediated L2 instruction. Research consistently finds that teachers' AI competency—encompassing both technical proficiency with AI tools and the pedagogical judgment to deploy them effectively—is among the strongest predictors of meaningful AI integration in language classrooms. A study by Karaduman (2025) examining pre-service EFL teachers' perceived AI literacy and competency found that teachers who perceived AI as relevant to their professional practice and who possessed confidence in their AI knowledge held more positive attitudes toward AI use in the classroom and were more likely to integrate it purposefully. Conversely, teachers with low AI self-efficacy demonstrated avoidance behaviors and relied on surface-level tool adoption without deeper pedagogical integration. A cross-sectional survey of 1,454 teachers in a large urban school district revealed important differences in AI readiness across educational levels (Springer, 2025). Secondary school teachers were significantly less willing to permit AI chatbot use compared to elementary and middle school teachers, and high school teachers specifically prioritized learning strategies for guiding students' ethical AI use and detecting AI-generated work—concerns that reflect the distinctive academic integrity pressures of secondary contexts. Importantly, secondary teachers also reported the lowest rates of engagement with available AI training resources,

suggesting a structural disconnect between institutional professional development provision and its uptake at the secondary school level.

Frontiers in Education's (2025) systematic review of generative AI in K-12 education found that nearly 90% of reviewed papers emphasized the necessity of teacher professional development for AI-integrated classrooms, underscoring the importance of developing instructional approaches that build substantial, discipline-specific understanding of AI applications through authentic tasks. This finding reflects a broader consensus in the AI-education literature: that the most significant barrier to effective AI integration in secondary L2 classrooms is not the availability of AI tools but the absence of pedagogically sophisticated human expertise to deploy them purposefully.

Professional Identity, Technostress, and Role Transformation

The integration of AI into L2 education presents secondary school language teachers with profound challenges to their professional identity. As AI systems assume functions previously understood as distinctively human and professional—explaining grammar, generating feedback on student writing, creating teaching materials, simulating communicative interaction—teachers must renegotiate their understanding of what they do that is irreplaceable and valuable (Godwin-Jones, 2024). Research on EFL teachers in Chinese teacher education institutions documented a spectrum of psychological responses to digital transformation, from enthusiasm and expanded pedagogical creativity to technostress, digital fatigue, and existential anxiety about professional obsolescence (Frontiers in Education, 2025). In resource-constrained secondary schools, where institutional support for technology adoption is often limited, inadequate infrastructure and insufficient training were found to be key barriers negatively affecting teachers' digital confidence and long-term engagement. Technostress—the psychological stress arising from the demands of managing and adapting to new technologies—is a significant occupational hazard for secondary language teachers in the AI era. Studies have shown that technostress, digital fatigue, and inadequate institutional support can diminish teachers' motivation and hinder technology adoption, undermining the very pedagogical gains that AI integration is intended to produce (Frontiers in Education, 2025). Effective AI integration in secondary L2 contexts therefore requires not only technical training but sustained psychological and professional support—mentoring communities, collaborative planning time, and institutional recognition of the labor involved in thoughtful technology adoption.

The reconceptualization of teacher roles in AI-mediated L2 classrooms has generated a productive body of research. Studies by Moorhouse et al. (2023, 2024) identified complementary human and AI roles: while AI serves as interlocutor, content provider, teaching assistant, and evaluator, teachers retain essential functions as orchestrators of diverse resources, facilitators of critical inquiry, and cultivators of AI ethical awareness. This division of labor is not merely descriptive but prescriptive: secondary school language teachers who

understand their irreplaceable pedagogical functions are better positioned to integrate AI tools selectively and purposefully rather than wholesale or defensively.

AI Literacy for Teachers

Teacher AI literacy—encompassing technical understanding, critical evaluation of AI outputs, and ethical reasoning about AI use in educational contexts—is increasingly recognized as a core professional competency for secondary language educators. A review of language teacher AI literacy by Moorhouse et al. (2024) synthesized findings from 19 empirical studies (2023-2024) and identified five dimensions of teacher AI literacy: AI foundations and applications, AI ethics, a human-centered mindset, AI pedagogy, and AI for professional development. Teachers who developed all five dimensions demonstrated more sophisticated, pedagogically grounded approaches to AI integration than those who engaged only with technical proficiency. A survey of educators' perspectives on AI in EFL settings found that while in-service teachers expressed positive attitudes toward AI's advantages, significant proportions reported feeling unprepared and unsupported in integrating AI into their practice, and many remained uncertain about the ethical boundaries of AI use in their classrooms (Tandfonline, 2025). These findings point to the inadequacy of one-time professional development workshops in building the sustained, reflective AI literacy that secondary language teachers require. Longitudinal, job- embedded professional learning communities centered on AI-enhanced L2 pedagogy are better suited to developing the deep competence the field demands.

AI Tools and Language Skill Development

The landscape of AI tools available for secondary L2 instruction has expanded dramatically and now encompasses resources supporting all four language skills. For reading, NLP-powered platforms provide adaptive text leveling, vocabulary in context support, and reading comprehension monitoring tailored to individual learner profiles. For writing, automated writing evaluation (AWE) systems and LLM-powered writing coaches provide grammatical, lexical, and organizational feedback on learner texts. For speaking, AI-powered pronunciation assessment tools and conversational agents provide oral practice opportunities and phonological feedback. For listening, AI-generated multimodal materials and interactive audio resources extend authentic input opportunities beyond the limitations of the physical classroom. Research on the application of technologies in ESL/EFL education found that emerging technologies—including AI, virtual reality (VR), and augmented reality (AR)—are transforming pedagogical approaches and helping to mitigate common learning challenges (Frontiers in Education, 2025). VR-based language learning has been found to foster engagement and language acquisition through immersive, contextualized environments; AI image recognition integrated with self-regulation strategies has enhanced vocabulary acquisition while reducing anxiety; and gamified AI interactions have strengthened motivation and sustained engagement in secondary learners (Hsu et al., 2024; Zhang et al., 2025). A study using structural equation modeling found that EFL learners' AI and AR/VR literacy

significantly predicted both engagement and motivation, with more technologically literate learners benefiting more substantially from AI-mediated instruction (Zhang et al., 2025).

However, research also documents significant variation in AI tools' effectiveness across language skills. Writing has received the most research attention and the most consistent evidence of AI benefit, while speaking, listening, and reading have been less extensively studied in AI-enhanced secondary contexts (Wah, 2025). This skill imbalance in the evidence base carries practical risks: secondary schools investing in AI tools without attention to the full communicative competence framework may inadvertently de-emphasize oral interaction and listening—dimensions of language proficiency critical for authentic communication in the target language.

Feedback Design and Formative Assessment

Among the most educationally significant capabilities of AI tools for secondary L2 education is the provision of immediate, individualized formative feedback on learner language production—a pedagogical intervention with a robust evidence base for enhancing language acquisition. AI-generated feedback has been documented to provide learners with instantaneous guidance on grammatical accuracy, lexical choice, and organizational structure, reducing the temporal gap between production and feedback that characterizes teacher-mediated correction (Son et al., 2025). Secondary school students using ChatGPT-4o identified immediate feedback as one of the tool's primary educational affordances, describing it as enabling more frequent, self-directed revision cycles than teacher feedback could support (Sivenas & Maragkaki, 2024). Yet the design of AI feedback for secondary L2 learners requires careful pedagogical calibration. Feedback that is overly comprehensive, technically complex, or delivered at too high a frequency can generate cognitive overload and anxiety, particularly for learners with limited working memory capacity or low self-efficacy (Frontiers in Psychology, 2025). Research found that some secondary students experienced AI feedback as generating evaluation pressure and the unsettling perception that their work was perpetually insufficient (Arxiv, 2025). Effective AI feedback design for secondary L2 contexts therefore requires attention to feedback selectivity (prioritizing one or two target features per cycle), timing (spacing feedback to allow processing and revision), and framing (presenting feedback as formative scaffolding rather than summative evaluation).

The integration of AI feedback within broader formative assessment frameworks—rather than as a standalone corrective tool—represents a promising direction for secondary L2 pedagogy. When AI-generated feedback is embedded in assessment-for-learning cycles that include peer review, teacher conferencing, and learner self-assessment, it reinforces metacognitive development alongside linguistic accuracy. Heikkinen et al. (2023) found that when learners have access to meaningful, comprehensible data about their own learning progress through learning analytics dashboards, self-regulated learning skills are enhanced—a finding with direct applicability to secondary AI-mediated L2 contexts.

Communicative Language Teaching in the AI Era

The dominant pedagogical paradigm of contemporary L2 education—Communicative Language Teaching (CLT)—emphasizes authentic communication, meaning negotiation, and the development of pragmatic as well as formal linguistic competence. A persistent tension in AI-mediated L2 instruction is whether AI tools support or undermine these communicative goals. At their best, AI conversational agents extend communicative practice opportunities, enabling adolescent learners to engage in repeated, low-stakes interaction in the target language at any time and from any location—significantly expanding the communicative input available beyond the 45-minute secondary language class period (Dong et al., 2024). At their worst, AI tools reduce L2 interaction to mechanical, decontextualized form-focused exercises that replicate the worst features of grammar-translation pedagogy in a technologically sophisticated guise. Research applying the SAMR framework to AI in SLA found that the most transformative AI-mediated language learning involves human-AI co-construction of multimodal artifacts—a level of integration that enables genuinely novel communicative and cognitive engagement (Liang et al., 2025). Secondary school language programs that design AI integration around communicative task completion—using AI as a collaborative partner in project-based, content-integrated, or task-based language learning activities—are more likely to achieve redefinitive rather than merely substitutive technology integration. The challenge for secondary teachers is designing such tasks within the constraints of standardized curricula and examination systems that continue to prioritize form over function.

Curriculum Frameworks and AI Governance

The institutional and policy context of secondary schools profoundly shapes how AI is integrated into L2 education. Curriculum frameworks, examination systems, school-level AI policies, and national educational technology strategies all constitute structural forces that enable or constrain language teachers' pedagogical choices. An analysis of state education policy and AI in schools found a consistent pattern across jurisdictions: "the technology is new, but the challenges are familiar"—schools are navigating AI integration within legacy institutional structures not designed for the pace of technological change (NASBE, 2024). The OECD (2024) has highlighted the importance of updating curricula to prepare students for a future influenced by AI, emphasizing critical thinking and ethical considerations, and fostering cultures of experimentation and evaluation in pedagogical practice. At the school level, research has documented a persistent disconnect between AI policy creation and effective execution. An analysis of AI in high school education found that while many schools had established AI policies by late 2024, educators frequently described these policies as unclear; similarly, AI training was reported as available but a significant proportion of teachers had not engaged with it, suggesting that institutional capacity for meaningful AI integration remains underdeveloped despite growing recognition of its importance (Bowdoin, 2025). For secondary L2 programs specifically, the absence of AI-specific language curriculum

frameworks leaves teachers navigating AI integration without the professional scaffolding necessary for informed, consistent pedagogical decision-making.

A revealing longitudinal indicator is the finding from late 2024 surveys that only 14% of public K-12 schools in the United States reported teaching students about ethical or appropriate AI use (School Pulse Panel, 2024). This figure exposes a critical gap between the actual pervasiveness of adolescent AI use—with 70% of teenagers already using generative AI tools—and institutional preparation for that use. Secondary schools that have not developed explicit AI literacy curricula risk producing graduates who are sophisticated AI consumers but uncritical AI thinkers, ill-prepared for the ethical and epistemological demands of navigating an AI-saturated professional and civic landscape.

Resource Equity and the Digital Divide

Structural inequities in access to digital resources constitute one of the most significant institutional factors shaping AI-mediated L2 education in secondary schools. Schools with greater material resources can invest in teacher training, high-quality digital content, reliable broadband infrastructure, and one-to-one device provision—amplifying the advantages of already well-resourced learners and communities. Under-resourced secondary schools, by contrast, often lack the technical assistance and professional capacity to implement AI tools effectively, and their students face connectivity barriers that render cloud-based AI tools practically inaccessible (OECD, 2024; Arxiv, 2025). The OECD (2024) analysis of AI's potential impact on equity and inclusion in education found that the divide in access to AI-enhanced education extends beyond the mere availability of tools to include differences in instructional support, pedagogical contextualization, and integration into educational pathways. Students in under-resourced secondary schools risk being positioned as passive users of consumer AI tools rather than critical participants in AI-mediated learning—a distinction that carries profound implications for long-term educational and socioeconomic outcomes. Researchers emphasize that equity in AI-mediated education requires attention to learning design and institutional support, not technological access alone (Arxiv, 2025).

International research has documented the geographic concentration of AI-enhanced language education research and practice in high-income countries, with secondary schools in Sub-Saharan Africa, Southeast Asia, and parts of Latin America facing infrastructure constraints that render many AI integration strategies practically inaccessible (Bayly-Castaneda et al., 2024). For these contexts, AI integration strategies must begin with foundational infrastructure investment and community-centered needs assessment rather than tool-first adoption approaches transplanted from better-resourced settings.

Systemic Professional Development

Effective AI integration in secondary L2 classrooms depends on sustained, pedagogically grounded professional development that goes beyond one-time technology training workshops. Frontiers in Education's (2025) systematic review found that 90% of papers

examining generative AI in K-12 education emphasized teacher professional development as a priority, recommending the development of instructional approaches that build subject-specific AI application understanding through authentic learning tasks and foster AI literacy as an ongoing professional commitment. Secondary language teacher professional development in the AI era must address not only technical tool proficiency but also the pedagogical judgment, ethical reasoning, and critical AI literacy necessary for responsible classroom integration. An evidence-informed model of professional development for secondary L2 teachers in the AI era would include: structured opportunities for collaborative AI tool exploration within language-specific pedagogical frameworks; communities of practice where teachers share AI-integrated lesson designs and reflective case studies; school-based mentoring by teachers with advanced AI-pedagogical competence; and sustained engagement with emerging research on AI and L2 education rather than one-time introductory sessions. Institutional leaders must also recognize that the labor of thoughtful technology integration—evaluating tools, redesigning tasks, analyzing outcomes—deserves recognition in teachers' professional workload allocations rather than being treated as an additive expectation.

Academic Integrity and the Ethics of AI Use

Among the most pressing socio-ethical concerns associated with AI integration in secondary L2 education is the challenge to academic integrity. The remarkable capacity of LLMs to generate fluent, contextually appropriate text in target languages creates conditions in which the distinction between learner production and AI-generated content becomes difficult to maintain and verify. A survey of 1,454 secondary school teachers found that academic integrity concerns were among the most frequently cited barriers to permitting AI chatbot use in language classrooms, with high school teachers particularly focused on strategies for guiding ethical AI use and detecting AI-generated work (Springer, 2025). Research on student AI use patterns found that 26% of U.S. teenagers use ChatGPT for schoolwork—double the figure from 2023—with about half doing so with teacher permission (Pew Research Center, 2025). The academic integrity challenge is, however, more nuanced than simple dichotomies of "using AI" versus "not using AI" can capture. Secondary L2 learners who use AI to generate complete texts without engagement may undermine their own language development; those who use AI as a drafting and revision tool—generating initial scaffolding, then revising critically, then seeking teacher feedback—may be engaging in a form of assisted learning analogous to dictionary or grammar reference use. Developing clear, pedagogically grounded, and contextually appropriate institutional policies about acceptable AI use in L2 learning tasks—policies that distinguish between AI as a learning scaffold and AI as an academic shortcut—is an urgent priority for secondary school administrators and curriculum developers. Sivenas and Maragkaki (2024) found that secondary students themselves are aware of AI's academic integrity risks and can articulate sophisticated concerns about content reliability and appropriate use when given structured opportunities to reflect on these issues. This finding

suggests that adolescent learners are not passive recipients of AI tools but active ethical agents capable of engaging critically with questions of AI use—provided that their schools create the curricular space and guided reflection opportunities necessary for that critical engagement to develop.

Algorithmic Bias and Cultural Responsiveness

AI language tools trained predominantly on data representing dominant languages, dialects, and cultural contexts present significant risks of algorithmic bias that are particularly consequential in diverse secondary school populations. Automated assessment systems calibrated to native-speaker norms may unfairly evaluate the legitimate language use of multilingual learners, speakers of non-standard varieties, and students from linguistic minority communities. Research on secondary school teachers in Malta using generative AI for Maltese language teaching found that mainstream AI tools, trained on dominant-language data, were systematically less effective for minority language contexts—a finding that generalizes to the many secondary EFL/ESL classrooms worldwide serving learners whose linguistic backgrounds are underrepresented in AI training corpora (Springer, 2024). Cultural responsiveness in AI-mediated L2 education extends beyond language to encompass the cultural assumptions embedded in AI-generated content, task designs, and pedagogical approaches. AI tools trained on English-language data from dominant cultural contexts may generate materials that are culturally alien or alienating for secondary learners in non-Western contexts, reinforcing rather than bridging the cultural distance between learners' first language world and the target language community. Secondary L2 teachers in culturally diverse classrooms must develop the critical AI literacy necessary to identify and address these cultural biases in AI-generated materials before deploying them with students.

Privacy, Data Security, and Adolescent Vulnerability

Secondary school students—who are minors in most jurisdictions—occupy a position of particular vulnerability in relation to the data privacy implications of AI tool use. AI systems used for language learning collect sensitive behavioral data including writing samples, performance records, interaction patterns, and in some cases voice recordings, raising significant concerns about how this data is stored, processed, and potentially used beyond its immediate educational purpose. Research by the American Psychological Association (2025) documented concerning patterns of adolescent over-disclosure to AI systems: teenagers report using generative AI to discuss relationships, identity, and sensitive personal questions they are reluctant to raise with adults—data that represents a profound privacy risk given the commercial data collection practices of many AI providers. The European Union's General Data Protection Regulation (GDPR) and the EU AI Act's high-risk classification for most educational AI create a regulatory framework requiring schools to implement robust data protection measures before deploying AI tools with minor students. However, regulatory frameworks vary dramatically across national contexts, and many secondary schools in lower-

income countries operate without comparable legal protections. School-level data governance policies—specifying what data AI tools collect, how it is used, and who has access—are an essential institutional safeguard that secondary school leaders must prioritize before and during AI tool adoption.

Toward an Integrated Model of AI-Mediated L2 Education in Secondary Schools

The five factor clusters examined in this paper do not operate independently; they constitute an interacting ecosystem in which changes in one domain ripple through others. A learner with high AI literacy (learner factor) in a classroom with an AI-literate teacher (teacher factor) who designs purposeful communicative AI tasks (pedagogical factor) in a school with clear AI governance and adequate resources (institutional factor), situated within a culturally responsive and ethically grounded framework (socio-cultural factor)—this learner experiences AI-mediated L2 education at its potential best. Conversely, deficits in any single factor cluster—a teacher without AI pedagogical training, a school without infrastructure, a curriculum that ignores AI ethics—will constrain outcomes even when other factors are favorable. This ecological interdependence has important strategic implications. AI integration initiatives that address only one factor cluster—investing in AI tools without teacher professional development, or mandating AI use without addressing equity of access, or deploying AI feedback without developing learner AI literacy—are unlikely to produce sustained improvements in secondary L2 outcomes. Effective AI integration in secondary L2 education requires coordinated, simultaneous attention to all five factor clusters, with each school's strategy shaped by systematic diagnosis of its particular profile of enabling and constraining conditions.

Evidence-Based Strategic Recommendations Drawing on the empirical literature synthesized in this paper, the following evidence-based strategies are recommended for secondary schools seeking to navigate AI-mediated L2 education effectively.

Cultivate Learner AI Literacy as a Core L2 Curriculum Component

Secondary L2 curricula should incorporate explicit instruction in AI literacy—including how AI language tools work, how to evaluate their outputs critically, how to use them as learning scaffolds rather than substitutes, and how to navigate the ethical dimensions of AI use in language learning. This instruction should be integrated into language learning activities rather than delivered as a separate technology course, enabling learners to develop AI literacy within authentic L2 contexts. Activities such as comparative analysis of AI-generated and human-produced target language texts, structured reflection on AI feedback, and collaborative evaluation of AI tool accuracy can develop critical AI engagement alongside linguistic competence.

Invest in Sustained, Pedagogically Grounded Teacher Professional Development

Secondary school administrators must prioritize sustained, subject-specific professional development in AI-enhanced L2 pedagogy over one-time technology training events.

Professional learning communities in which secondary language teachers collaboratively explore, evaluate, and design AI-integrated lesson sequences—sharing successes, challenges, and reflective case studies—provide the sustained, contextualized learning most likely to build durable pedagogical AI competence. Pre-service teacher education programs must incorporate AI-enhanced language pedagogy as a core component of L2 teacher training, ensuring that new teachers enter the profession with foundational AI-pedagogical preparation.

Design AI Integration Around Communicative and Metacognitive Goals

Pedagogical designs for AI-mediated L2 instruction in secondary schools should be anchored in communicative language teaching principles and metacognitive learning goals, not in the technical capabilities of available tools. Teachers should ask not "what can this AI tool do?" but "how can AI be integrated to support the communicative and metacognitive development my learners need?" Task-based and project-based learning designs that incorporate AI as one resource among many—alongside peer interaction, teacher guidance, authentic materials, and learner self-assessment—are more likely to achieve transformative rather than substitutive technology integration.

Develop Clear, Contextually Appropriate AI Use Policies

Secondary schools must develop clear, pedagogically coherent institutional policies governing AI use in L2 learning tasks—policies that distinguish between legitimate AI scaffolding and academic dishonesty, that are communicated transparently to teachers, students, and parents, and that are regularly reviewed as AI capabilities evolve. These policies should be developed through inclusive consultative processes involving all stakeholder groups and should reflect the specific cultural, linguistic, and regulatory context of the school community. At the national level, educational ministries and curriculum authorities should provide guidance frameworks that support school-level policy development without mandating one-size-fits-all approaches.

Address Structural Equity as a Prerequisite for Meaningful AI Integration

Secondary schools and educational systems must treat equity of access to AI-enhanced L2 education as a prerequisite rather than an aspiration. Multi-stakeholder partnerships involving governments, technology developers, and civil society organizations are needed to address infrastructure gaps, device provision, and connectivity barriers in under-resourced secondary school communities. Universal Design for Learning principles should guide AI tool selection and task design, ensuring that technologies serve diverse learners across ability levels, linguistic backgrounds, and socioeconomic contexts. Data governance frameworks must protect the privacy rights of adolescent learners, with institutional AI policies aligned with applicable legal frameworks and regularly reviewed for compliance.

Implications for Research and Practice

This paper has several practical implications for key stakeholder groups in secondary L2 education. For language teachers, it underscores the importance of proactive, critical

engagement with AI tools within a framework of strong pedagogical principles rather than reactive adoption or avoidance. For school administrators, it highlights the necessity of systemic approaches to AI integration that simultaneously address teacher professional development, student AI literacy, institutional policy, and resource equity. For curriculum developers, it argues for the integration of AI literacy and AI ethics as components of secondary L2 curricula rather than as standalone technology modules. For policymakers, it advocates for evidence-based national frameworks that support local contextual adaptation rather than mandating uniform approaches across heterogeneous secondary school systems.

For the research community, this paper identifies several priority directions for future investigation. Longitudinal studies examining the sustained impact of AI-mediated L2 instruction on secondary learners' communicative competence, metacognitive development, and language learning motivation are urgently needed. The secondary school context—distinguished from higher education by its developmental, institutional, and curricular particularities—requires dedicated, contextualized research rather than assumption of transferability from adult learner studies. Research examining AI-mediated L2 education in non-English target language contexts, in low-income national settings, and in linguistically and culturally diverse secondary school populations would substantially broaden the generalizability and equity relevance of the field's knowledge base. Mixed-methods designs combining learning analytics, classroom observation, and in-depth interviews with students and teachers are particularly well-suited to capturing the ecological complexity of AI-mediated secondary L2 education.

Conclusion

The integration of artificial intelligence into second language teaching and learning in secondary schools represents one of the most consequential pedagogical developments of the contemporary era. This paper has argued that understanding and navigating this transformation requires a multifactorial ecological analysis that simultaneously examines learner-internal variables, teacher competencies and professional identities, instructional design principles, institutional and policy contexts, and socio-cultural and ethical dimensions. No single factor cluster, examined in isolation, can account for the complexity of AI-mediated L2 education in secondary contexts; all five clusters interact dynamically, with enabling and constraining conditions in each domain shaping outcomes across the others. The empirical literature reviewed in this paper supports a position of informed, evidence-grounded optimism about AI's potential to enhance secondary L2 education: to extend communicative practice opportunities, reduce affective barriers, provide individualized feedback, and support diverse learner needs in ways that complement skilled human teaching. It equally supports a posture of critical vigilance about the conditions under which that potential is realized—conditions that include teacher AI-pedagogical literacy, learner AI literacy, equitable resource distribution, culturally responsive tool design, robust ethical governance, and sustained institutional commitment.

Ultimately, the most important lesson of the literature is that AI is not a solution to the challenges of secondary L2 education but a powerful tool whose educational impact depends entirely on the quality of the human pedagogical judgment, institutional support, and ethical oversight that surrounds its use. Secondary schools that invest in those human and institutional conditions alongside technology adoption will be best positioned to realize AI's transformative potential for language learning. Those that do not risk deploying sophisticated technology in service of unchanged or diminished educational outcomes—an outcome the field cannot afford.

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