Proceedings of ICEIPI 2026 Symposium: Inclusive Education, Cultural Transformation, and the Ethical Dimensions of Learning
DOI: 10.54254/2753-7048/2026.LD32784

Research on the Integration of the Zone of Proximal Development Theory and English Teaching from the Perspective of Technology Empowerment (2015-2025)

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Abstract. In the context of digital transformation, technology has infused new vitality into Vygotsky's Zone of Proximal Development (ZPD) theory in English teaching. By examining key Chinese literature from 2015 to 2025, this article follows how ZPD and English instruction are integrated within technology-aided setups. The results indicate a ten-year shift from using single tools to having anintegrated, multi-technology ecosystem. This transformation, which is centered on personalized paths, immersive scenarios, and collaborative learning, boosts the efficiency as well as the students' capabilities.However, there are still quite a number of severe challenges existing, such as the unbalance between tool rationality and value rationality, the conflict between personalization and impartiality, and the gap between data and theory.This paper puts forward that future advancement ought to go beyond simply making use of technology. It endeavors to create a human - oriented, adaptable and equitable intelligent learning ecosystem, and also puts forward practical approaches and policy recommendations to guide the high - quality development of this domain.

Keywords: technology empowerment, Zone of Proximal Development, English teaching, research hotspots, research trends

1. Introduction

Since 2015, the digital transformation of global education has caused the continuous integration of technologies such as artificial intelligence and big data into teaching.Through policies like the Action Plan for Educational Informatization 2.0, China positions the high-quality development of education empowered by technology in a priority place and transforms the English teaching mode from one centered on teachers into one centered on students.Technology has come up with new approaches to address the challenges of personalized and contextualized teaching.The theory of the zone of proximal development put forward by Vygotsky, which differentiates the actual development level of students and the potential development level that can be attained under guidance, offers a vital framework for differentiated teaching and the establishment of scaffolds [1].It effectively resolves the problem that is applied to everyone in the same way and also helps students gradually enhance their language proficiency. With the power of technology, the constraints of time and space

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DOI: 10.54254/2753-7048/2026.LD32784

are broken through, and it can accurately identify students' recent developmental zones on the basis of personalized learning data and dynamically adjust teaching strategies, which indeed provides a solid technical support for the implementation of the theory of the recent developmental zone in English teaching.In the process of sorting out the integration paths of the theory of the zone of proximal development and English teaching under the technical empowerment from 2015 to 2025, it can enrich the theoretical system of educational technology integration, can develop operable teaching models and practical strategies for front-line teachers, and can also provide references for the teaching reforms of other disciplines.

Foreign scholars started researching the integration of the ZPD theory earlier. Western scholars have been exploring the applications of information technology since the 1990s. Since 2015, foreign research has presented various technical carriers, inter disciplinary viewpoints, and contextualized practical situations. For example, Luisvon Ahn's AI-based Duolingo platform can precisely find users' ZPD and create personalized learning routes. And the "VR/AR+contextualized language learning" framework by Dutch scholar Steven L. Thorne constructs immersive scenarios for contextualized supports. Foreign scholars emphasize the interdisciplinary integration of cognitive psychology, educational technology, and applied linguistics, and prioritize technology suitability, which means ensuring that technology serves students' development rather than just piling up [2].

Domestic research on such integration started around 2015, and with the development of educational informatization, research achievements have gradually increased, focusing on the application of technical carriers, the design of teaching models and the practice of single teaching links [3]. However, there are obvious deficiencies in domestic research: the disconnection between theoretical exploration and practical application, and the lack of frontline empirical research; technical integration is often lacking in accuracy, blindly pursuing novelty without accurately diagnosing students' Zone of Proximal Development (ZPD); over-reliance on a single disciplinary perspective; neglect of educational equity issues, leading to the uneven distribution of technological dividends. From the perspective of "technology empowerment", spanning 2015 to 2025, this paper explores the integration of the ZPD theory and English teaching by defining core concepts, analyzing practical models and typical cases. Visual analysis tools are used to draw maps of research hotspots and evolutionary trends, and the existing deficiencies are critically examined to propose future research directions, constructing a framework of "theoretical definition, practical analysis, trend judgment, problem reflection, and future suggestions". Literature retrieval selects core Chinese and foreign databases such as CNKI, Wanfang, Web of Science and Scopus, covering publications with relevant keywords from 2015 to 2025.

The research innovations are as follows: systematically sorting out the continuous time span of the ten-year research evolution; combining the comprehensive methods of literature review and visual analysis; based on the practical perspective of frontline teaching; focusing on educational equity and technology suitability. The key points include clarifying core concepts and theoretical compatibility, drawing research hotspots and evolutionary trends, exploring practical carriers and application models, systematically reflecting on existing problems and proposing future research directions.

2. Core concepts and theoretical basis

Technology empowerment makes use of modern information technology to promote innovation in teaching ideas, models, and methods. It is achieved through crucial carriers like AI for personalized ZPD scaffolding, VR/AR for immersive language environments, online platforms for collaborative learning, and big data for accurate diagnostics [4-6]. Vygotsky put forward the ZPD theory, which

DOI: 10.54254/2753-7048/2026.LD32784

differentiates between students' actual and potential developmental stages. It highlights feedback that spots gaps and directs gradual progress through social interaction and scaffolding establishment [1]. In English teaching, ZPD presents dynamic, personalized, and gradual features, matching technology empowerment in three main aspects: accurate orientation through data analysis, various scaffolding construction, and real-time developmental assessment [4,7]. This combination depends on constructivist learning theory [5], personalized learning theory, educational big data theory [6], and immersive learning theory. Altogether, it provides the theoretical basis for technology-aided English teaching that enables students' gradual language ability growth through cycles of diagnosis, scaffolded instruction, and dynamic evaluation.

3. Practical paths and effectiveness of the integration of ZPD theory and English teaching under technology empowerment

From the CNKI, the number of papers published on relevant research between 2015 and 2024 shows a fluctuating growth pattern (Figure 1). In the early stage (2015-2019), the annual number of published papers is less than 20. It reaches the peak during the observation period in 2020 and then returns to a stable state. This trend indicates that the research on ZPD leads to a research boom in 2020, yet generally speaking, it is still in the initial exploration stage and has not developed into a sustained and stable high-output period.

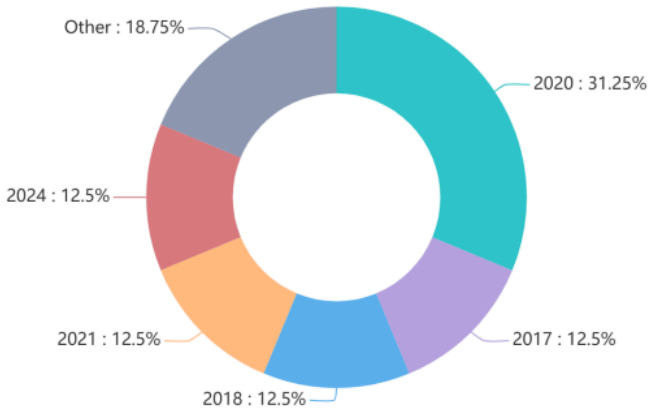


Figure 1. The proportion of the publications of the theme

3.1. Main practical carriers and application modes of technology empowerment

3.1.1. AI technology: design of personalized learning paths and scaffolding construction

In English teaching, artificial intelligence technology serves as the core carrier for the integration of ZPD theory. By virtue of its personalized, intelligent and dynamic capabilities, it accurately identifies students' ZPD and constructs adjustable learning scaffolds. In vocabulary teaching, artificial intelligence conducts multi-dimensional diagnosis through pre-assessment, pushes hierarchical and adaptive resources, provides real-time feedback on errors and generates learning reports at the same time. Thus, it creates a progressive scaffold that conforms to the characteristics of students' vocabulary acquisition, and can also construct virtual contexts by integrating virtual reality/augmented reality to improve the human-computer collaboration model [8]. For reading teaching, artificial intelligence diagnoses students' proficiency level. It supports learning with the

DOI: 10.54254/2753-7048/2026.LD32784

help of intelligent interaction and group discussions, provides real-time feedback and multi-dimensional evaluation, thus constructing scaffolds, solving the problems of insufficient interaction and fixed models in traditional teaching, and achieving precision and personalization [9]. In reading and writing teaching, artificial intelligence parses learning data to diagnose students' actual developmental level, customizes hierarchical writing tasks according to their cognitive characteristics and potential. This diagnosis-design-learning-feedback-improvement scaffold solves the problems of general guidance and delayed feedback, realizes personalized and precise teaching, and improves students' core competencies [10].

To sum up, the application pattern of AI, which includes precise diagnosis, customized path design, dynamic framework building, real-time feedback and progressive enhancement, corresponds well with ZPD theory, thus facilitating whole-process personalized tutoring in English study.

3.1.2. VR/AR technology: construction of immersive english teaching scenarios

The core advantages of VR/AR technology are reflected in immersion, contextualization and interactivity. By virtue of these advantages, it can overcome the shortcoming of "emphasizing knowledge over context" in traditional English teaching, construct simulated real scenarios for English language application, enable students to carry out language practice in the context, build contextualized learning scaffolds for students, and thus effectively expand students' Zone of Proximal Development.

In English listening and speaking teaching, the VR technology is mainly applied by creating a three-dimensional interactive listening and speaking training platform. Through the integration of various technologies it constructs a 3D virtual space which integrates visual auditory and tactile sensations shattering the traditional two-dimensional teaching model and creating various communication scenarios close to reality. At this time students can carry out immersive audio-visual comprehensive virtual interactive practice effectively avoiding the negative psychological states of students in terms of expression and also can encourage them to speak actively [11]. At the same time, it substitutes the traditional simulation based on formal instructions with a more real and vivid virtual scene which heightens the effect of two-way communication and interaction in the classroom.

The application approaches of VR/AR technology can be summed up as the construction of immersive scenarios the development of contextualized language practice the provision of interactive scaffold guidance the transformation of knowledge into abilities and also the enhancement of cross-cultural abilities.This method can effectively solve the problem of the lack of situationalization in traditional English teaching, enabling students to "learn while doing" and "learn while using", and also can achieve the simultaneous improvement of language proficiency and cross-cultural communication competence.

3.1.3. Online platforms: collaborative learning and expansion of the ZPD

Under the empowerment of technology, the online learning platform has become a crucial carrier which integrates the theory of the zone of proximal development and English teaching. Platforms which can forge a cross-temporal and cross-spatial collaborative learning environment for students. Students, when they interact and cooperate with their peers, can mutually motivate and help each other. Therefore, underachievers can go beyond their actual developmental stages with the help of high achievers; while the latter will obtain deeper understanding as well. Eventually, the respective nearest development zones of all students are usually expanded.

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In English classroom teaching, teachers can utilize online collaborative learning platforms to design group collaborative learning tasks. These tasks involve group cooperation in completing English reading analysis, group cooperation in compiling English stories, group cooperation in carrying out English debates, enabling students to divide labor, cooperate, communicate and discuss within the group. Teachers can keep real-time observation on the learning progress of each group through the platform, provide targeted guidance to groups with learning difficulties and establish collaborative learning scaffolds. In after-class autonomous learning, online platforms provide students with abundant English learning resources, English listening and reading materials. Students can independently select learning resources according to their own learning foundation and ZPD. Meanwhile, they can interact with teachers and peers through the message, comment and live broadcast functions of the platform to solve the problems encountered in learning. Moreover, online platforms can realize cross-school and cross-regional collaborative learning, allowing students from different regions and with different learning situations to communicate with each other, broaden their learning horizons and further expand the ZPD [12].

The application mode of online platforms can be described as collaborative task design, cross-temporal and spatial group collaboration, peer interaction and mutual assistance, teachers' precise guidance, independent resource expansion, and common ability improvement. This kind of pattern which fully embodies the social interaction concept of the ZPD theory can effectively cultivate the collaboration and autonomy.

3.2. Analysis of typical cases and effectiveness of integration practice

In a case overseas, a platform driven by artificial intelligence which is named Duolingo was developed by the team of Luis von Ahn.This platform, with its small bird brain model, analyzes the learning behaviors of hundreds of millions of users, accurately identifying each user's recent development area. Then, it dynamically generates personalized learning paths, adjusting the difficulty and optimizing the content order to realize "personalized learning", greatly enhancing the learning efficiency, especially for beginners.In China, the high school English teaching has fully integrated the 5E model with the project-based learning which is centered on the "artificial intelligence/virtual reality future technology product design" project.It causes students to go through the stages of engaging, exploring, explaining, expounding and evaluating so as to attain the three-in-one goal of "language + technology + ethics" thus enhancing the English proficiency, the technical comprehension as well as the ethical awareness [13]. Similarly, the Xinjiang Arts Institute combines the effective teaching model of O - AMAS with the "New Starting Point College English" course on the Chaoxing Learning Pass platform. It constructs a teaching system from before class to during class to after class, at that time the teachers continuously build learning scaffolds and design activities according to Krashen's "i + 1" hypothesis, fully enabling students to have subjectivity in learning [14]. All these cases all follow the core strategy, which is reflected in the diverse groupings with hierarchical goals, the various and targeted scaffold constructions, as well as the real-time feedback that enables the dynamic adjustment of scaffolds and the migration of the nearest development zone [15,16].

The integration of practice has indeed effectively enhanced the efficiency and the quality of English teaching. The technology can realize the precise location of the nearest development zone, avoid inefficient repetition, and transform teaching from knowledge transmission to competence cultivation. The research conducted by Linlin Xu, Lin Teng and Lin Wu on the written feedback of teachers in PhD students' academic writing shows that the feedback mainly emphasizes deficiencies rather than filling gaps. Students can identify gaps, but lack specific improvement methods to

DOI: 10.54254/2753-7048/2026.LD32784

overcome them [17]. This discovery directly inspires the technology - aided English teaching: the intelligent platform can play the role of “pointing out deficiencies” which frees teachers from repetitive error correction; the technology should focus on the link of bridging gaps and construct support by providing dynamic example libraries, personalized suggestions as well as peer review communities.

Moreover, in the process of designing learning activities,teachers need to set the difficulty within the students’ recent development zone and provide input that is understandable by people,for such a situation of "a bit more difficult but still achievable" can trigger language cognitive mechanisms and can also enhance internal motivation [18].Integrated practice can enable students to independently select resources and also develop plans according to their own recent development zones thus cultivating self - learning ability in this way. Meanwhile immersive scenarios such as VR/AR and online collaboration platforms can provide opportunities to use language in real life turning classroom knowledge into practical abilities and also solving the problem of "dumb English" in this way. In addition, collaborative learning can at the same time enhance students' communication abilities, cooperative abilities as well as problem-solving abilities, thus bringing about all-round quality development at that time.

4. Evolutionary trends and reflections on integration research

4.1. Trends on future research

During the period from 2015 to 2025, the integration of the emerging technologies and the theory of ZDP has become indeed more profound. In the future, there are trends of intelligent, integrated and lightweight applications [15]. In terms of technology, predictive and generative artificial intelligence will cooperate with learning theory to work out unique learning paths in line with Krashen's "i + 1" hypothesis. The low - code technology will intermingle with the blended learning to create a flexible environment which can support lifelong learning.The combination of artificial intelligence and metaverse technologies with education which is centered on literacy will be carried out, and high level thinking will be cultivated through immersive scenarios.Moreover, there is also the micro - certificate system in the digital infrastructure. It can ensure technological ethics and data management, and it can also enhance the fairness in education.

In the teaching aspect, the model will change from only involving a single technology application to a situation where various technologies are integrated together. The integration of technologies will transform from “simple accumulation” into “systematic coordination”, thus creating a closed loop of “data-driven- scenario-supported-precise service”; the teaching structure will shift from "fixed mode" to "overall reconstruction", enabling students to switch learning scenarios by themselves; the educational goal will be upgraded from knowledge transmission to double drive of literacy and ability, cultivating such T-shaped talents; and the teaching ecology will develop from “single-point support” to “overall adaptability”, covering aspects like infrastructure, resource libraries, teacher training and fair guarantee [16]. At the research level, future researches will delve deeper into combining cognitive psychology and computer science, carrying out long-term front-line practices with large-sample analysis, and constructing models suitable for China.

However, there are many major problems in the current research. First, the disconnection between theoretical research and practical application. Second, technical application is faced with the dilemma of suitability and fairness. Thirdly, there are limitations in the research methods, as the single method lacks large-sample empirical research and then the data silos impede the comprehensive application of data and fail to precisely find the nearest development zone.

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4.2. Suggestions for future research

In order to narrow the gap between theory and practice, theoretical researchers need to deeply interact with frontline teaching to develop usable models. Moreover, the education department should strengthen teacher training related to the theory of the zone of proximal development and technology integration. We need to establish communication platforms such as school-enterprise cooperation to help transform research results into practice and also feed back problems from practice to refine the theory.In order to make the technology application be appropriate and fair, the principle of "student-centered and teaching-oriented" should be used to guide the selection of technology carriers in accordance with the actual teaching needs and not to blindly pursue the new.The government should strengthen the digital investment in rural and remote areas so as to upgrade the infrastructure and also develop simple and low-cost technological tools which are suitable for different regional situations, ensuring that all students can profit from the technological empowerment and narrow the learning gaps.In order to make the research more scientific, future research needs to integrate quantitative and qualitative methods, to strengthen large-sample long-term empirical research with control groups, and also use visualization analysis tools such as CiteSpace to carry out bibliometric analysis and so on. In terms of data support, we need to break through the "data silos", collect and analyze comprehensive learning behaviors by constructing a unified educational big data platform and so on, and at the same time use artificial intelligence algorithms to accurately identify students' recent development zones so as to carry out more precise personalized teaching.

5. Conclusions and prospects

5.1. Main research conclusions

Between the years 2015 and 2025 there appeared quite a number of research achievements which are the integration of the theory of the zone of proximal development and technology-aided English language teaching.A theoretical framework is established which from the aspects of precise positioning building scaffolds and developing evaluation clarifies the corresponding relationship between the technology and the zone of proximal development (ZPD) Through artificial intelligence personalized learning virtual reality/augmented reality immersive situations and online collaboration platforms the research has worked out the core integrated route of "precise positioning - hierarchical design - building scaffolds - dynamic adjustment - ability improvement" effectively improving the teaching efficiency and cultivating students' autonomous learning and language ability.The core value consists in enriching interdisciplinary theories, changing English teaching from teacher - oriented knowledge transmission to student - centered ability cultivation, and at the same time offering references for the teaching reforms of other disciplines and promoting the digital transformation of education.5.2 Research Limitations and Future Prospects

5.1.1. Explanation of the limitations of this study

This paper has systematically collated and examined the investigations into the integration of the ZPD theory and English teaching under the impetus of technology from 2015 to 2025. However, there are still certain definite limitations. Firstly, with regard to the selection of literature samples, although relevant literatures from core domestic and foreign databases have been selected, due to the limitation of the databases' collection scope, some relevant research findings may not be included.

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Secondly, in terms of practical case analysis, the selected cases are mainly typical ones at home and abroad, not covering different regions, different school stages and different types of schools, and the representativeness of the cases needs to be further enhanced. Thirdly, in terms of the depth of research, the research on the integration of some emerging technologies (such as large language models) with the two is still in the initial stage of discussion, not conducting more in-depth empirical research, and the relevance and operability of the research conclusions need to be further strengthened.

5.1.2. Prospects for follow-up research directions and practical applications

Zhang and Xu carried out a study regarding Juku Correction Network's automated writing evaluation (AWE) from a ZPD perspective [19]. The study exhibited some significant different effects, with the writing scores of low - level learners being improved, while the high - level learners were not.All learners have more revisions because of automatic feedback, yet high-level students have greater fluctuations in their revisions and are not as trusting of the feedback content as low-level students.The lower-level groups have given higher scores to the perceived effectiveness, especially those that attach great importance to the support in terms of grammar and vocabulary.The findings show that AWE satisfies the needs of the nearest development zone for low-level learners regarding basic language proficiency, but fails to meet the needs of the nearest development zone for high-level learners in terms of content and writing skills, with high-level learners achieving the lowest scores on the feedback of "coherence of content and structure".So it is necessary to devise adaptive feedback systems that would adjust the depth of feedback according to language levels. Then, human-computer collaborative feedback models that should integrate automatic feedback, teacher feedback, and peer feedback need to be established. Moreover, emotional factors that have an impact on high-level learners' revision motivation need to be probed into.Teachers should transform AWE into a self - study tool for grammar correction of low - level learners and then develop teacher feedback centered on content, structure, and innovation for high - level learners.Learners, in accordance with their own levels of the recent development zone, can select feedback methods and make use of correction trajectories to diagnose changes in the recent development zone so as to implement precise interventions.

In the future research about ZPD and technology-assisted English teaching, there needs to be an enhanced exploration of emerging technologies like large language models, multimodal artificial intelligence, and metaverse applications, which are to be utilized for identifying students' ZPD and constructing learning support.For the localized research targeting different school stages (from primary school to university) and different school types (public, private, rural, urban), it is necessary to develop targeted integrated models, and teachers should use technical methods to dynamically evaluate to identify students' potential development levels [20,21]. As for the research on the English teaching evaluation system assisted by technology, it is necessary to establish a diversified evaluation combining formative evaluation and summative evaluation based on big data, and from the perspective of educational equity, it is necessary to explore to narrow the learning gaps between different regions and different backgrounds through technological empowerment.In practical applications teachers need to deepen their understanding of the theory of the zone of proximal development and technology empowerment and transform from "technology users" into "instructional designers" schools need to increase the construction of digital infrastructure and develop high-quality platforms and resource libraries the education department needs to strengthen policy guidance and teacher training to promote the sharing of high-quality resources and all of us jointly inject new impetus into the high-quality development of English education in China.

DOI: 10.54254/2753-7048/2026.LD32784

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