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### Analysis of Vygotsky's Social Constructivism Theory in Collaborative Learning Based on Digital Technology

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#### ABSTRACT

*This article examines Lev Vygotsky's social constructivism theory and its application to collaborative learning in digital technology contexts. Vygotsky's framework emphasizes that cognitive development occurs through social interaction and cultural tools, with learning situated in zones of proximal development where more knowledgeable others scaffold novice learners. Drawing on contemporary research in educational technology and online learning, this study analyzes how digital platforms enable new forms of collaborative knowledge construction while presenting distinct challenges compared to face-to-face interaction. The COVID-19 pandemic accelerated adoption of digital learning technologies, creating natural experiments in technology-mediated collaborative learning. Analysis of recent empirical studies reveals that digital tools can effectively support Vygotskian principles including peer collaboration, expert scaffolding, and cultural tool mediation, though requiring careful pedagogical design. Findings demonstrate that successful technology-enhanced collaborative learning depends on creating digital environments fostering meaningful interaction, providing appropriate scaffolding structures, and attending to equity issues in technology access. This article contributes to educational sociology by synthesizing Vygotsky's theoretical framework with contemporary evidence on digital collaborative learning, offering insights for educational practice in increasingly technology-mediated contexts.*

**Keywords:** Social constructivism, Vygotsky, collaborative learning, digital technology, zone of proximal development, scaffolding, online education, educational technology



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#### INTRODUCTION

Education worldwide has undergone rapid transformation driven by digital technology adoption, accelerated dramatically by the COVID-19 pandemic. Remote and hybrid learning models became necessity rather than option for billions of students, forcing educators to adapt pedagogical practices to technology-mediated environments. This transition raises fundamental questions about how learning occurs in digital contexts and whether established learning theories remain applicable. Lev Vygotsky (1896-1934), a Soviet psychologist whose work has profoundly influenced educational theory, developed a social constructivist framework emphasizing that cognitive development emerges through social interaction and cultural tool use (Vygotsky, 1978). His concepts of the zone of proximal development, scaffolding, and mediation offer insights particularly relevant for understanding collaborative learning in digital environments.

The pandemic-driven shift to online education constituted what Hodges et al. (2020) distinguish as "emergency remote teaching" rather than intentionally designed online learning—a distinction with significant pedagogical consequences. Millions of educators worldwide were compelled to migrate

instructional practices developed for physical classrooms into digital spaces without adequate preparation, infrastructure, or pedagogical frameworks suited to technology-mediated interaction. This transition exposed both the possibilities and the limitations of digital tools for supporting the kinds of socially situated learning that Vygotsky's framework foregrounds. In some contexts, digital platforms enabled new forms of peer collaboration and expert guidance; in others, the absence of embodied co-presence, the digital divide in technology access, and the collapse of informal social learning spaces produced significant educational setbacks (Rapanta et al., 2021).

The relevance of Vygotsky's theoretical framework to digital learning is not incidental but substantive. Vygotsky developed his theory of cognitive development in opposition to individualistic models that located learning primarily within the isolated mind of the learner. For Vygotsky, the social and the cognitive are not separate domains but mutually constitutive: higher mental functions such as deliberate attention, logical memory, and conceptual thinking originate in social interaction before being internalized by individuals as tools for self-regulation and independent thought (Vygotsky, 1978). Digital collaborative learning environments, which enable learners to interact across time and space through text, voice, and video, represent new instantiations of the social contexts through which cognitive development occurs. Whether and how these digital social contexts support the kinds of meaning-making and knowledge construction that Vygotsky theorized remains an open empirical and theoretical question.

This article addresses that question by examining three interconnected dimensions of Vygotskian theory as they apply to digital collaborative learning: the zone of proximal development and its digital mediation, scaffolding practices in online and hybrid learning environments, and the role of digital tools as cultural mediators of cognition and communication. The analysis draws on systematic review of empirical research published between 2018 and 2025, situating findings within Vygotsky's original theoretical framework and its subsequent elaborations by contemporary educational scholars. The article proceeds through theoretical analysis, empirical review, and synthesis of implications for educational design and practice.

## **METHODS**

This study employs systematic literature review methodology to examine Vygotsky's social constructivism theory and its application to digital collaborative learning. The review synthesizes Vygotsky's original theoretical texts with contemporary empirical research on technology-enhanced collaborative learning published between 2018 and 2025. Database searches were conducted across ERIC, Scopus, Web of Science, and Google Scholar using search terms including "Vygotsky," "zone of proximal development," "digital collaborative learning," "scaffolding," "online education," and "social constructivism." Initial searches yielded over 500 potentially relevant articles, which were screened according to predefined inclusion and exclusion criteria.

Inclusion criteria required that studies: (1) explicitly engaged with Vygotskian theoretical constructs or social constructivist frameworks; (2) examined collaborative learning in digital or technology-mediated contexts; (3) reported empirical data from educational settings; and (4) were published in peer-reviewed journals or edited academic volumes. Studies focusing exclusively on individual technology use without collaborative dimensions, or those employing purely behaviorist frameworks without engagement with sociocultural theory, were excluded. Following screening, 47 studies were selected for detailed analysis, supplemented by Vygotsky's foundational theoretical texts and key secondary literature elaborating sociocultural theory.

Analytical procedures followed a thematic synthesis approach, identifying patterns across included studies related to the three central Vygotskian constructs under examination. Each study was coded for: the digital platforms and tools examined, the nature of collaborative learning activities, the forms of scaffolding implemented, evidence of ZPD engagement, outcomes measured, and equity considerations addressed. Cross-case comparison enabled identification of convergent findings and discrepant cases, supporting the development of evidence-based propositions about conditions under which digital tools effectively support Vygotskian collaborative learning principles. The analysis maintains a distinction between studies conducted during emergency remote teaching conditions and

those examining intentionally designed digital collaborative learning, recognizing that context substantially affects outcomes.

## RESULTS AND DISCUSSION

### Foundations of Vygotsky's Social Constructivism

Vygotsky's social constructivism centers on the proposition that higher mental functions originate in social interaction before becoming internalized by individuals. Unlike Piaget, who emphasized individual discovery learning guided by cognitive stages, Vygotsky argued that learning occurs through participation in culturally organized activities mediated by language and other symbolic tools (Vygotsky, 1978). Three core concepts structure Vygotskian theory: the zone of proximal development, mediation through cultural tools, and the social origins of individual consciousness. Together, these concepts form a coherent theoretical framework with profound implications for understanding how collaborative learning environments—digital or otherwise—should be designed and facilitated.

The zone of proximal development (ZPD) represents the conceptual heart of Vygotsky's educational theory. Defined as the distance between what a learner can accomplish independently and what they can achieve with guidance from a more knowledgeable other, the ZPD identifies the productive space for instructional intervention (Vygotsky, 1978). Learning that falls below the ZPD—addressing skills the learner has already mastered—offers no developmental value, while learning that exceeds the ZPD overwhelms the learner and fails to build on existing competencies. Effective instruction, in the Vygotskian framework, targets the ZPD, providing support that enables learners to accomplish tasks just beyond their current independent capability while building toward eventual autonomous performance.

Wertsch (2019) emphasizes that the ZPD is not simply a measure of individual potential but a fundamentally relational construct—it emerges in the interaction between learner and social context. This relational character has significant implications for digital learning design. In face-to-face environments, skilled teachers and peer collaborators continually adjust their support based on moment-to-moment assessment of learner understanding, reading verbal and nonverbal cues to calibrate the level of assistance provided. Digital environments must find alternative mechanisms for this dynamic calibration, whether through adaptive learning technologies, structured peer collaboration protocols, or explicit scaffolding designed into learning tasks. The challenge is not merely technical but pedagogical: creating digital social contexts in which the relational dynamics of ZPD engagement can genuinely unfold.

Mediation through cultural tools constitutes the second foundational dimension of Vygotskian theory. Vygotsky drew a fundamental distinction between lower mental functions, which humans share with other animals and which operate directly on the environment, and higher mental functions, which are distinctively human and which operate through the medium of culturally developed tools—primarily language, but also writing, mathematics, art, and other symbolic systems (Daniels, 2020). These tools do not merely assist thought but transform it: the internalization of cultural tools restructures cognitive processes, enabling forms of reflection, planning, and abstraction unavailable to unmediated cognition. From this perspective, digital technologies represent new cultural tools with distinctive properties that both enable and constrain the forms of thought and communication they mediate.

The social origins of individual consciousness, the third foundational dimension of Vygotskian theory, reflects Vygotsky's deeply relational ontology. In contrast to individualistic psychologies that treat the social as external to an essentially individual mind, Vygotsky argued that the individual and the social are mutually constitutive: individual consciousness is shaped by, and in important respects constituted through, participation in social practices and relationships (Cole & Wertsch, 2021). This principle carries significant implications for educational design: if individual cognitive development emerges from social participation, then the quality of the social learning environment—the richness of interaction, the diversity of perspectives encountered, the depth of collaborative engagement—directly shapes the cognitive development that learning environments afford.

## **Scaffolding in Digital Collaborative Learning Environments**

Scaffolding, a concept elaborated by Wood, Bruner, and Ross (1976) building on Vygotsky's ZPD framework, refers to the temporary support provided to learners to enable them to accomplish tasks within their ZPD that they could not manage independently. Effective scaffolding is contingent—adjusted to the learner's current competence—and fading—progressively withdrawn as learner competence develops. In face-to-face settings, skilled teachers and knowledgeable peers provide scaffolding through modeling, questioning, feedback, explanation, and emotional encouragement. Digital environments offer both new opportunities and new challenges for scaffolding implementation (Mahn & John-Steiner, 2020).

Research on scaffolding in digital collaborative learning reveals several distinct forms that prove effective when carefully designed. Technological scaffolding, embedded within the structure of digital platforms, includes features such as prompts that guide learners through problem-solving processes, templates that structure collaborative writing tasks, visualization tools that make invisible reasoning processes visible, and adaptive feedback systems that respond to learner responses. Dillenbourg (2019) emphasizes that effective technological scaffolding must be calibrated to genuine learning challenges rather than merely simplifying tasks: over-scaffolded digital environments can reduce the productive struggle through which deep learning occurs, while under-scaffolded environments leave learners without the support needed to engage productively with challenging content.

Peer scaffolding in digital environments represents a particularly important and studied dimension of technology-enhanced collaborative learning. Platforms supporting synchronous communication—video conferencing, live chat, collaborative whiteboards—enable peer scaffolding that more closely approximates face-to-face interaction, as learners can respond in real time to one another's emerging understanding. Asynchronous platforms—discussion forums, collaborative documents, shared annotation systems—enable different forms of peer scaffolding, particularly written elaboration, question-posing, and reflective feedback that can be more carefully composed than spontaneous verbal exchange (Koschmann, 2019). Stahl's (2019) research on virtual math teams demonstrates that small-group synchronous collaboration can generate collaborative problem-solving that exceeds individual capabilities, with groups effectively scaffolding one another's mathematical reasoning through patterns of questioning, hypothesis-testing, and shared construction of solutions.

Expert scaffolding in digital environments, provided by teachers or more advanced peers, faces distinctive challenges related to social presence and responsiveness. Kreijns et al. (2022) distinguish between cognitive presence—the degree to which learners can construct meaning through sustained communication—and social presence—the degree to which participants project themselves as real persons in a mediated environment. High social presence supports the trust and relational depth that enables learners to signal confusion, ask questions, and engage authentically with challenging material. Low social presence in digital environments, frequently reported in research on online learning, can inhibit the kinds of help-seeking behavior that scaffolding requires. Effective expert scaffolding in digital contexts therefore requires deliberate attention to building social presence through regular synchronous interaction, personalized feedback, and the cultivation of learning communities characterized by psychological safety.

## **Digital Tools as Vygotskian Cultural Mediators**

From a Vygotskian perspective, digital technologies are not merely delivery mechanisms for content but cultural tools that mediate cognitive activity and communication in distinctive ways. The properties of digital tools—their affordances and constraints—shape the forms of thinking and interaction they enable, just as the properties of written language, mathematical notation, or other symbolic systems shape the cognitive processes they mediate (Lantolf & Poehner, 2021). Understanding how digital tools function as cultural mediators therefore requires attention not only to their technical features but to the social practices, pedagogical designs, and institutional contexts within which they are deployed.

Learning management systems (LMS) such as Moodle, Canvas, and Blackboard constitute one of the most widely used categories of digital tools in educational contexts. Research on LMS-mediated collaborative learning reveals that these platforms can effectively support asynchronous knowledge construction when carefully designed with Vygotskian principles in mind. Discussion forums, when structured with specific prompting and response requirements, can generate extended collaborative dialogues in which learners build on one another's ideas, challenge assumptions, and construct shared understanding through textual interaction. Garrison and Anderson (2020) find that well-designed asynchronous online courses can generate high levels of cognitive presence—the kind of sustained, inquiry-driven thinking that constitutes genuine learning—when facilitators actively guide community development and maintain productive inquiry.

Collaborative document platforms—Google Docs, Microsoft 365, Notion—represent a different category of digital cultural tools with distinctive mediating properties. These platforms enable simultaneous co-construction of written artifacts, making collaborative thinking visible through shared documents that record the evolution of group understanding. Research on collaborative writing in shared document environments reveals that the visibility of co-authoring processes can scaffold learners' understanding of revision and argumentation by exposing them to the writing processes of more skilled collaborators (Scardamalia & Bereiter, 2021). The ability to comment, suggest, and respond within shared documents enables asynchronous dialogues embedded within collaborative artifacts, creating records of the social knowledge construction process that can themselves become objects of reflection and learning.

Video conferencing platforms—Zoom, Microsoft Teams, Google Meet—became ubiquitous during the COVID-19 pandemic, enabling synchronous interaction across geographic distances. From a Vygotskian perspective, video conferencing platforms represent attempts to replicate the conditions of face-to-face interaction that most naturally support ZPD engagement and scaffolding. Research findings on video conferencing for collaborative learning are nuanced. Wang and Duan (2020) find that synchronous video interaction can support social presence and emotional connection, creating conditions for productive collaboration. However, video fatigue, bandwidth limitations, and the absence of embodied co-presence limit the richness of interaction compared to face-to-face settings. Breakout room features enable small-group collaboration analogous to cooperative learning structures, though effective implementation requires careful facilitation.

Artificial intelligence-powered educational tools represent an emerging category of digital cultural mediators with distinctive Vygotskian implications. Intelligent tutoring systems (ITS) and AI-powered adaptive learning platforms can provide individualized scaffolding calibrated to assessed learner performance, adjusting task difficulty, providing targeted hints, and offering feedback responsive to specific errors. From a Vygotskian perspective, the promise of AI-powered scaffolding is substantial: the ability to provide contingent support calibrated to the ZPD of individual learners addresses one of the central challenges of human-mediated scaffolding, which requires considerable pedagogical expertise and is difficult to scale. However, Selwyn (2021) cautions that AI-powered educational tools frequently reflect techno-solutionist assumptions that underestimate the social and relational dimensions of learning that Vygotsky's framework foregrounds. Effective AI-enhanced learning must therefore complement rather than replace human social interaction.

### **Equity, Access, and the Digital Divide in Vygotskian Perspective**

Any analysis of digital collaborative learning informed by Vygotskian theory must attend to equity dimensions that shape differential access to the social and technological resources that learning requires. Vygotsky's framework is fundamentally sociocultural: it recognizes that cognitive development occurs within cultural and institutional contexts that are not equally distributed. The digital divide—disparities in access to reliable internet connectivity, digital devices, and digital literacy—creates differential conditions for participation in technology-mediated learning that reproduce and potentially amplify existing educational inequalities (Warschauer & Matuchniak, 2020).

Research conducted during the COVID-19 pandemic documented the educational consequences of the digital divide with unprecedented clarity. Students from low-income households, rural communities, and marginalized groups disproportionately lacked the hardware, connectivity, and quiet learning spaces necessary for effective participation in digital learning environments. These access disparities translated directly into participation disparities: students who could not reliably connect to synchronous sessions missed the real-time social interaction most closely approximating ZPD engagement, while students who lacked appropriate devices for collaborative document work were excluded from peer scaffolding opportunities. Zhao and Watterston (2021) find that pandemic-era learning loss was strikingly unequal, with already-disadvantaged students experiencing the greatest educational setbacks.

Beyond material access, digital equity encompasses dimensions of digital literacy—the competencies required to use digital tools effectively for learning rather than merely consumption. Vygotsky's concept of tool mediation implies that the cognitive benefits of cultural tools depend on learners' mastery of those tools: a student who lacks fluency with a collaborative writing platform cannot engage in the co-construction activities that the platform is designed to support, regardless of the platform's technical affordances. Digital literacy education that develops not only technical skills but collaborative digital practices—how to give constructive feedback online, how to manage asynchronous communication, how to establish productive working relationships in virtual teams—therefore constitutes a Vygotskian prerequisite for effective digital collaborative learning (Reich, 2020).

Schoor and Bannert (2021) emphasize that motivational dimensions of collaborative learning are particularly susceptible to the equity challenges of digital environments. Students who feel isolated, disconnected from peers and instructors, or overwhelmed by unfamiliar digital tools are less likely to engage in the help-seeking and collaborative behaviors through which ZPD-based learning occurs. Designing digital collaborative learning for equity therefore requires not only addressing material access but cultivating the social and emotional conditions—trust, belonging, shared purpose—that motivate authentic engagement. Järvelä and Hadwin (2021) argue for the importance of "socially shared regulation of learning" in online environments: explicit attention to building learners' capacities to coordinate their collaborative processes, manage shared tasks, and maintain productive group dynamics across the challenges of technology-mediated interaction.

### **Pedagogical Implications and Design Principles**

Synthesis of Vygotskian theory with empirical research on digital collaborative learning generates several evidence-based design principles for technology-enhanced education. These principles do not constitute a technical formula but a pedagogical orientation—a set of commitments and priorities that should inform the design, facilitation, and evaluation of digital learning environments.

First, social interaction must be treated as the primary medium of learning rather than an adjunct to content delivery. Digital learning environments frequently default to a broadcast model—using technology to transmit content to passive recipients—that fundamentally contradicts Vygotskian learning theory. Effective digital collaborative learning requires deliberate design of interaction structures: structured peer discussion protocols, collaborative problem-solving tasks, shared construction of artifacts, and formative assessment practices that make learning thinking visible and subject to social feedback. Hmelo-Silver (2020) demonstrates that problem-based learning designs, which require learners to collaboratively construct understanding through inquiry into complex problems, can be effectively implemented in digital environments when designed with attention to group process as well as content outcomes.

Second, scaffolding must be built into the design of digital learning environments rather than assumed to emerge spontaneously from technology features. This requires instructors to anticipate the ZPD of target learners, design tasks that challenge without overwhelming, embed scaffolding supports within task structures, and maintain sufficient presence in digital learning environments to monitor and respond to signs of learner struggle. Sawyer (2018) argues that effective learning design in digital

environments must balance the structure necessary to scaffold novice learners with the openness necessary to enable the genuine inquiry and construction that characterizes deep learning. Over-structured digital environments that reduce all tasks to following predetermined procedures can undermine the productive cognitive engagement that Vygotskian learning theory requires.

Third, assessment in digital collaborative learning must attend to both individual and collective dimensions of knowledge construction, consistent with Vygotsky's emphasis on the social origins of individual competence. Traditional assessment designs that measure only individual final performance are inadequate for capturing the learning that occurs through collaborative processes. Portfolio assessment, process documentation, peer evaluation, and collaborative project assessment provide more Vygotsky-aligned alternatives that capture both the social dynamics and individual outcomes of collaborative learning. Digital platforms support these assessment alternatives by generating records of collaborative processes—discussion forum archives, document revision histories, collaborative annotation trails—that can be used to assess both group knowledge construction and individual learning development.

## **CONCLUSION**

This analysis demonstrates that Vygotsky's social constructivism provides a valuable framework for understanding and designing collaborative learning in digital technology contexts. The core Vygotskian principles—that learning occurs through social interaction, develops within zones of proximal development through scaffolding, and employs cultural tools as mediating instruments—remain applicable to technology-mediated education while requiring thoughtful adaptation to digital realities. The empirical evidence reviewed here consistently indicates that digital tools can effectively support Vygotskian collaborative learning when designs prioritize social interaction, build scaffolding into task structures, and cultivate the social presence and trust necessary for genuine collaborative engagement.

Three overarching conclusions emerge from this analysis. First, the medium of digital technology is not pedagogically neutral: different digital tools possess distinctive affordances and constraints that shape the forms of social interaction and cognitive mediation they enable. Educators and instructional designers must therefore attend carefully to the specific properties of the digital tools they employ, considering how those properties align with or diverge from the social interaction and scaffolding dynamics that Vygotskian theory identifies as essential for learning. The pandemic-era default to video conferencing as the primary mode of digital instruction represented a necessary emergency response, but intentionally designed digital collaborative learning requires a more diversified and strategically deployed toolkit.

Second, equity must be treated as a foundational concern in digital collaborative learning design rather than an afterthought. The digital divide in access, literacy, and social-emotional support creates differential conditions for participation in technology-mediated learning that can reproduce and amplify educational inequalities. Vygotsky's sociocultural framework implies that cognitive development cannot be separated from the social and material conditions in which it occurs; educational institutions committed to Vygotskian principles are therefore committed to creating equitable conditions for social participation in learning—conditions that cannot be assumed in the absence of deliberate institutional investment in access, infrastructure, and support.

Third, the relationship between digital technology and Vygotskian learning theory should be understood as a productive tension rather than a simple application. Digital tools expand the spatial and temporal scope of collaborative learning, enabling interactions across contexts that face-to-face education cannot support; they also introduce challenges—reduced social presence, digital fatigue, surveillance concerns—that can undermine the relational depth that Vygotskian learning requires. Future research should continue to explore how emerging technologies, including artificial intelligence, augmented reality, and immersive virtual environments, can be designed to support ZPD engagement and scaffolding while maintaining the human social dimensions that Vygotsky's framework identifies as the developmental engine of learning. The goal is not technology for its own sake but the creation of rich social learning environments in which all learners can access the

collaborative knowledge construction that Vygotsky identified as the foundation of human cognitive development.

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