International Journal of
MULTILINGUAL EDUCATION

ISSN: (Print) ISSN 1987-9601
(Online) E ISSN 1512-3146
Journal homepage: http://multilingualeducation.org/

Peer-Scaffolded Knowledge Construction: A Design-Based Investigation ofStrategy-Based Group Projects for Developing Synthesis Skills Among EFL Students

Tahar Golea
University of Batna 2, Algeria

Oussama Ahmed Gaid
University of Mohamed Boudiaf,
M'sila, Algeria

Email:oussama.ahmedgaid@univ-msila.dz

To cite this article:Tahar Golea, Oussama Ahmed Gaid (2026):Peer-Scaffolded Knowledge Construction: A Design-Based Investigation of Strategy-Based Group Projects for Developing Synthesis Skills Among EFL Students: International Journal of Multilingual Education, volume 27, issue 1. pp. 52-74.

To link to this article:
https://doi.org/10.22333/ijme.2026.11530

Tahar Golea[1]

University of Batna 2*, Algeria*

https://orcid.org/0009-0001-7590-3488

Oussama Ahmed Gaid

University of Mohamed Boudiaf, M'sila, Algeria

https://orcid.org/0009-0009-8116-7323

Peer-Scaffolded Knowledge Construction: A Design-Based Investigation of Strategy-Based Group Projects for Developing Synthesis Skills Among EFL Students

ABSTRACT

This design-based research examined peer-scaffolded synthesis skill development among 72 first-year EFL students at Batna 2 University via a six-week intervention. Groups created iterative case study presentations for peer feedback, grounded in Vygotsky's Zone of Proximal Development (ZPD), constructionism, and strategy-based instruction. Multi-method analysis with enhanced statistical testing (repeated measures ANOVA, Cohen's d effect sizes, and hierarchical linear modeling) suggested promising progression in source integration and critical evaluation, with students transitioning from teacher-dependency to internalizing strategies through peer interaction. Key mechanisms included strategy appropriation and peer-led error correction, demonstrating effect sizes ranging from d=1.54 to d=2.12 across synthesis dimensions. Findings suggest that constructionist peer review establishes a collective ZPD where peers serve as 'more capable others' offering a process-oriented model for developing synthesis skills in EFL contexts, albeit findings could be interpreted as more exploratory than causal.

Keywords*: synthesis skills; peer scaffolding; design-based research; collaborative learning; strategy-based instruction; sociocultural theory; Zone of Proximal Development*

Introduction

The transition to university-level academic work presents a formidable challenge for many first-year students, particularly in English as a Foreign Language (EFL) contexts. Among the most critical yet underdeveloped competencies is the skill of synthesis, the ability to move beyond mere summary and collation of information to construct new, coherent wholes from multiple, often conflicting, sources (Bloom, 1956; Spivey, 1997; Flower, 1990; Greene, 2001; Lopez & Estremera, 2025; Yang & Chen, 2025). While foundational skills like reading comprehension and summary are explicitly taught, synthesis is frequently treated as an implicit outcome of academic engagement, leaving students to navigate its complexities with little structured support. This deficit is particularly acute for EFL

[1] Corresponding Author: *Oussama Ahmed Gaid, oussama.ahmedgaid@univ-msila.dz*

learners, who must simultaneously manage cognitive load associated with higher-order thinking and the linguistic demands of operating in a second language (L2) (Kraatz et al., 2023; Ouyang et al., 2025). The result is often a reliance on superficial "copy-paste" strategies or a simple juxtaposition of sources, rather than the critical integration and evaluation that defines true academic synthesis.

Traditional pedagogical models, often centered on teacher-led instruction and individual assessment, may not adequately foster the dialogic and interactive processes inherent in knowledge construction (Swales, 1990; Hyland, 2004). In response, educational research has increasingly turned its attention to the potential of collaborative and peer-centered learning environments (Baker & Reimann, 2024; Asfani et al., 2025). The role of peer feedback, in particular, has been extensively studied as a means to improve various aspects of L2 production, from writing performance (Wu & Ko, 2024; Pan et al., 2024) to speaking proficiency (Ding & Zhu, 2025). However, much of this research focuses on the efficacy of peer feedback as a corrective tool for surface-level errors or on general writing quality. There remains a significant gap in understanding the specific mechanisms through which peer interaction, embedded within a purposefully designed learning ecology, can cultivate complex, higher-order cognitive skills like synthesis (Ouyang et al., 2025).

This study contends that the development of synthesis skills is not merely a cognitive act but a socially mediated process, best nurtured within a community of practice. It posits that by structuring learning around collaborative projects that require the creation of public artifacts, students can learn from and with each other in powerful ways. This perspective aligns with a sociocultural view of learning, where knowledge is co-constructed through interaction before it is internalized by the individual (Vygotsky, 1978; Adler et al., 2025). Peers, in this model, are not just proofreaders but serve as "more capable others" who provide scaffolding that is often more accessible and relevant than that provided by an expert instructor (Ge et al., 2025; Zhao et al., 2025).

To explore these dynamics, this study employed a Design-Based Research (DBR) methodology. DBR is uniquely suited for this inquiry as it moves beyond simple input-output evaluations to investigate the complex, process-oriented nature of learning in authentic classroom settings (Brown, 1992; Obczovský, 2025). It allows for the systematic design, implementation, and refinement of a pedagogical intervention while simultaneously generating theoretical insights about how and why it works. The intervention at the heart of this study was a six-week, strategy-based group project designed for first-year EFL students at Batna 2 University in Algeria. The design integrated principles from Vygotsky's (1978) sociocultural theory, Papert's (1980) constructionism, and Strategy-Based Instruction (SBI) to create an environment where synthesis was not just an expectation but a practiced, scaffolded, and collaborative activity (Anggraeni et al., 2025; Fuster-Barceló et al., 2025).

The purpose of this DBR study is therefore twofold: first, to design and implement a pedagogical intervention that leverages peer scaffolding and constructionist principles to develop synthesis skills among first-year EFL students; and second, to generate a rich, process-oriented understanding of how peer interactions within this designed environment contribute to the development and internalization of these skills. By focusing on the how and why of learning, this research aims to provide a robust, theoretically grounded model for fostering higher-order thinking in EFL contexts. To this end, the study was guided by the following research questions:

RQ1: How do first-year EFL students' synthesis skills, as evidenced in their presentation artifacts, evolve throughout a six-week, strategy-based group project intervention?

RQ2: What specific peer interaction processes (e.g., observation, feedback, co-construction) contribute to the development of synthesis skills within this learning environment?

RQ3: In what ways do students appropriate and internalize synthesis strategies from their peers within a collective Zone of Proximal Development?

Theoretical Framework and Literature Review

This study is anchored in a composite theoretical framework that integrates four key educational theories: Vygotsky's sociocultural theory, Papert's constructionism, Strategy-Based Instruction (SBI), and collaborative learning theory. This framework provides the conceptual lens through which the intervention was designed and the resulting data were analyzed (Baker & Reimann, 2024; Yang & Chen, 2025). The following sections elaborate on these theories and connect them to relevant contemporary research on peer learning, scaffolding, and skill development in EFL contexts.

Vygotsky's Sociocultural Theory: The Primacy of Social Interaction

The foundational premise of this research is derived from Vygotsky's (1978) sociocultural theory of learning, which posits that higher mental functions originate in social activity. Learning is not a solitary cognitive process but a social one, occurring first on an interpsychological plane (between people) before being internalized on an intrapsychological plane (within the individual). Central to this theory is the concept of the Zone of Proximal Development (ZPD), defined as the distance between what a learner can achieve independently and what they can achieve with guidance and collaboration (Rigopouli et al., 2025; Ding & Zhu, 2025). The intervention in this study was designed to create a "collective ZPD" where the group as a whole could tackle a complex synthesis task that would be beyond the reach of any individual member.

Within the ZPD, learning is facilitated through scaffolding—support provided by a "more capable other" to help a learner complete a task they cannot yet manage alone (Ge et al., 2025; Zhao

et al., 2025). While this role is traditionally filled by the teacher, sociocultural theory suggests that peers can be equally, if not more, effective scaffolders (Kraatz et al., 2023; Wu & Ko, 2024). Peers often operate within a similar ZPD, making their explanations and models more comprehensible and relatable. The current study operationalizes this concept by positioning peer presentations and feedback sessions as primary sites of scaffolding. The support is not just teacher-provided but is peer-distributed, as students appropriate strategies, concepts, and even linguistic forms from observing and interacting with their classmates (Lopez & Estremera, 2025; Ouyang et al., 2025).

Constructionism: Learning Through Making

While Vygotsky provides the "why" of social learning, Papert's (1980) theory of constructionism provides the "how." Constructionism extends Piaget's constructivism by arguing that knowledge construction is particularly effective when learners are engaged in building a public, shareable artifact (Fuster-Barceló et al., 2025). The act of making—whether a computer program, a robot, or, in this case, a case study presentation—externalizes thinking and makes it available for reflection, discussion, and refinement. The requirement to produce a series of presentations forces students to commit to a particular synthesis, which can then be "debugged" through peer feedback and self-reflection.

The iterative cycle of the intervention (drafting a presentation, receiving feedback, and revising for the next week) mirrors the constructionist "debugging" process. The public nature of the presentation artifact creates a sense of audience and accountability, motivating students to move beyond superficial understanding (Ouyang et al., 2025; Pan et al., 2024). They are not just learning about synthesis; they are learning synthesis by doing synthesis in a context that demands clarity, coherence, and justification. This aligns with the principle that learning is "most effective when it is part of an activity the learner experiences as constructing a meaningful product" (Papert, 1980, p. 103).

Strategy-Based Instruction (SBI): Making Thinking Visible

To effectively engage in synthesis, students need more than just a collaborative environment; they need explicit cognitive and metacognitive tools. Strategy-Based Instruction (SBI) provides this component by focusing on teaching learners how to learn (Anggraeni et al., 2025; Oxford, 1990). SBI posits that effective learning involves the conscious use of specific strategies for understanding, retaining, and applying new information. Recent meta-analyses confirm the enduring importance of SBI in language education, highlighting its connection to self-regulated learning and metacognitive awareness (Anggraeni et al., 2025).

In this study, the intervention began with explicit instruction on synthesis strategies (e.g., source mapping, identifying lines of argument, annotating for theme). However, consistent with SBI theory, the instruction did not stop there. The peer presentations served as live strategy demonstrations (Ouyang et al., 2025). For first-year EFL students, observing a near-peer successfully (or unsuccessfully) apply a synthesis strategy is often a more powerful learning experience than an abstract explanation from an expert instructor. Furthermore, the weekly "remedial questions" functioned as strategy activation probes, prompting students to reflect on and articulate their strategic thinking.

Collaborative Learning and Peer Feedback

Collaborative learning theory provides a more granular lens for examining the peer interactions within the designed environment (Asfani et al., 2025). True collaboration involves more than just working in groups; it requires "positive interdependence," where individuals perceive that they can only succeed if their groupmates do, and "promotive interaction," where they actively help each other learn. The intervention's structure, where groups present iteratively and are encouraged to learn from others' presentations, was designed to foster this interdependence.

A key mechanism for promotive interaction is peer feedback. The literature on peer feedback in EFL contexts is extensive and growing, with studies consistently showing that engaging in peer feedback benefits not only the recipient but also the provider, who must critically analyze a peer's work and articulate constructive advice (Wu & Ko, 2024; Pan et al., 2024). Peer feedback can enhance writing performance, speaking skills, and critical thinking (Lopez & Estremera, 2025; Ouyang et al., 2025). However, its effectiveness can be mediated by learners' perceptions and training. This study extends this body of work by focusing on how peer feedback functions specifically as a scaffold for the complex skill of synthesis, with structured feedback sessions designed to move beyond surface-level corrections to "transactive discourse," where students question, explain, and refine their understanding of synthesis together (Zhao et al., 2025).

Methodology

This study adopted a Design-Based Research (DBR) approach to investigate the development of synthesis skills in an authentic educational setting. DBR is an interventionist methodology characterized by its iterative, process-oriented, and theory-building nature, making it ideal for understanding complex learning phenomena in real-world contexts (Brown, 1992; Obczovský, 2025). Unlike traditional experimental designs, DBR does not seek to isolate variables but rather to

understand the interactions within a designed learning ecology while simultaneously refining both the intervention and the underlying theory (Cobb et al., 2003; Collins, 1992).

It is important to distinguish the DBR approach employed here from quasi-experimental designs. While this study incorporates statistical analyses (ANOVA, HLM) to trace learning trajectories, these are used descriptively to document patterns of change within the intervention context, not to establish experimental causality. DBR seeks to generate "design principles" and "local theories" that are transferable to similar contexts rather than generalizable in a statistical sense (Cobb et al., 2003). The absence of a control group and independent pre-test means that causal claims must be interpreted as exploratory and theory-building rather than definitive.

Research Context and Participants

The study was conducted over a six-week period during the fall semester of 2024 at the Department of English, Faculty of Foreign Languages, at Batna 2 University in Algeria. The participants were 72 first-year undergraduate students enrolled in a mandatory "Methodology of Research" course. This course was selected as the context for the intervention because its learning objectives include the development of foundational academic skills, such as sourcing, evaluating, and integrating information. The participants (45 female, 27 male; age range 18-20) represented a typical cohort of first-year EFL learners in the Algerian higher education system, with English proficiency levels ranging from B1 to B2 on the Common European Framework of Reference for Languages (CEFR), as determined by a university placement test.

Purposive sampling was used to select this cohort. All 72 students from two sections of the course participated in the intervention as part of their regular coursework. For the collaborative project work, students were organized into 18 groups of four. To maximize the potential for peer scaffolding within the Zone of Proximal Development, groups were formed based on a principle of structured homogeneity (Kraatz et al., 2023; Ge et al., 2025). Students were first stratified into three proficiency tiers (low-B1, high-B1/low-B2, high-B2) based on their placement test scores and a diagnostic writing task. Groups were then formed with students from the same proficiency tier to ensure that peer models and feedback would be delivered in comprehensible, near-peer language.

Researcher Positionality and Potential Bias. As the course instructor, the researcher had existing relationships with students and was invested in their academic success. This dual role as instructor-researcher may have introduced social desirability bias, with students potentially performing to meet perceived expectations. To mitigate this, the study employed multiple data sources (presentations, interviews, reflections), peer debriefing with colleagues, and member checking where

students verified interpretations of their comments. The researcher maintained a reflexive journal throughout the intervention to bracket assumptions and monitor potential bias. Nevertheless, the single-instructor design remains a limitation that may have influenced the magnitude of observed effects.

The Design of the Intervention

The intervention was a six-week pedagogical sequence designed to scaffold the development of synthesis skills through collaborative, strategy-based case study projects. The design was iterative, drawing on DBR principles (Obczovský, 2025; Fuster-Barceló et al., 2025), and was structured as follows:

Weeks 1-2: Strategy Introduction and Initial Case Assignment. The first two weeks were dedicated to front-loading essential strategies. The instructor provided explicit instruction on synthesis frameworks, including techniques for annotating sources, creating concept maps to trace arguments across texts, and using matrices for source comparison (Anggraeni et al., 2025). A critical component was instruction on source evaluation (identifying bias, authority, and currency). Each group was then assigned a unique, complex case study relevant to applied linguistics (e.g., "The Role of Translanguaging in the EFL Classroom," "The Impact of Gamification on Learner Motivation"). Groups were provided with a curated set of 4-5 foundational academic articles for their case.

Weeks 3-4: Scaffolded Group Research and Iterative Presentations. These weeks formed the core of the peer-scaffolding cycle. Each week, groups were required to present a 10-minute "work-in-progress" update on their case study. These were not formal presentations but opportunities to share their current synthesis of 2-3 sources (Ouyang et al., 2025; Ouyang et al., 2025). Following each presentation, a brief Q&A session was held. The instructor's role shifted to that of a facilitator, primarily using "remedial questioning" to probe for deeper thinking (e.g., "How does Author A's argument challenge Author B's?," "What evidence from your sources supports that claim?"). This phase was designed to make group thinking public and to model analytical questioning.

Week 5: Case Report Construction and Peer Feedback. Groups focused on constructing their final case report, which took the form of a comprehensive presentation. A dedicated session was held where groups were paired to provide structured peer feedback on their draft presentations (Zhao et al., 2025; Wu & Ko, 2024). A rubric was provided to guide the feedback, focusing on the clarity of the main argument, the integration of sources, and the application to the case. This created a formal structure for the "transactive discourse" central to collaborative learning.

Week 6: Final Presentations and Reflection. In the final week, each group delivered their 15-minute final presentation to the entire class. This was followed by a whole-class Q&A and a final

peer feedback session. The intervention concluded with students submitting individual written reflections on their learning process, particularly focusing on what they learned from their peers.

Data Collection Methods

Consistent with the process-oriented nature of DBR, data collection was multi-faceted and designed to capture the dynamics of the learning environment rather than just the final outcomes (Obczovský, 2025). The following data sources were used:

1. Presentation Artifacts: All weekly "work-in-progress" presentations (Weeks 3 & 4) and the final presentations (Week 6) were video-recorded. The accompanying presentation slides and any speaker notes were collected. The verbal discourse from the presentations and subsequent Q&A sessions was transcribed for detailed analysis.

2. Remedial Question Logs: A detailed log was kept of all remedial questions posed by the instructor during Weeks 3 and 4. At the beginning of the following session, students were given five minutes for a "micro-write" to respond individually in writing to a key remedial question from the previous week. These written responses were collected to track the internalization of strategic thinking.

3. Peer Interaction Data: The structured peer feedback session in Week 5 and the informal feedback exchanges after presentations were audio-recorded and transcribed. Additionally, mid-intervention stimulated recall interviews were conducted with one focus group from each proficiency tier (3 groups total). In these 15-minute interviews, groups were shown a short clip of another group's presentation from the previous week and asked questions like, "What did you notice about how they connected their sources?" and "Did you adopt any strategies from watching Group X's presentation?"

4. Process Documentation: The researcher maintained weekly observer field notes, documenting key moments of scaffolding (both teacher- and peer-provided), instances of peer teaching, and observable shifts in group dynamics. For groups that used shared digital documents (e.g., Google Docs), the version history was archived to provide a trace of the co-construction and revision process (Fuster-Barceló et al., 2025).

Enhanced Statistical Analysis Procedures

Data analysis was conducted in five iterative phases, integrating qualitative and quantitative approaches to build a rich, multi-layered account of the learning process. Beyond the original analysis, this enhanced version includes additional statistical rigor:

Phase 1: Micro-analysis of Presentation Artifacts with Effect Size Calculations. The transcribed presentation discourse and slides from Weeks 3, 4, and 6 were the primary data for

assessing the evolution of synthesis skills (RQ1). A rubric was developed based on the conceptual framework, with four key criteria: Information Integration, Source Attribution, Critical Evaluation, and Case Relevance. Two independent raters coded a subset of the data (20%) to establish inter-rater reliability (Cohen's Kappa = 0.87), after which one rater coded the remainder. Repeated measures ANOVA was conducted to test for significant differences across time points, with Greenhouse-Geisser corrections applied when sphericity assumptions were violated. Cohen's d effect sizes were calculated for each dimension to quantify the magnitude of change (Pan et al., 2024).

Phase 2: Thematic Analysis of Peer Learning with Frequency Coding. To address RQ2 and RQ3, a thematic analysis was conducted on the qualitative data from peer feedback transcripts, stimulated recall interviews, and final reflections (Ouyang et al., 2025; Ouyang et al., 2025). Using NVivo 12 software, an inductive coding process was employed to identify emergent themes related to peer learning mechanisms. Initial open coding led to the development of a focused coding scheme, which included codes such as "Strategy Appropriation," "Error Correction by Peers," "Conceptual Clarification," and "Language Scaffolding." Inter-coder reliability was established at $\kappa = 0.82$.

Phase 3: Hierarchical Linear Modeling (HLM). To account for the nested structure of the data (students within groups within proficiency tiers), hierarchical linear modeling was employed to examine the relationship between peer interaction frequency and synthesis skill development (Kraatz et al., 2023). This analysis allowed for the partitioning of variance at the individual, group, and tier levels, providing insights into the relative contribution of each level to learning outcomes.

Phase 4: Longitudinal Trajectory Analysis. The remedial question logs and the corresponding student micro-writes were analyzed using growth curve modeling to trace individual learning trajectories (RQ3). Responses were coded for evidence of strategic thinking and accuracy. These trajectories were then cross-referenced with the quality of the students' group presentations to identify patterns and establish plausible links between peer interaction, instructor probing, and skill development (Wu & Ko, 2024).

Phase 5: Social Network Analysis. Peer feedback patterns were analyzed using social network analysis to identify key influencers and information flows within the classroom network (Lopez & Estremera, 2025). Centrality measures (degree, betweenness, closeness) were calculated to understand which students served as knowledge brokers and how information about synthesis strategies diffused through the peer network.

Results

The analysis of the multi-faceted data collected during the six-week intervention revealed a clear and positive developmental trajectory in students' synthesis skills. The results are presented in three main

sections, corresponding to the research questions: (1) the evolution of synthesis skills as evidenced in presentation artifacts with enhanced statistical analysis; (2) the identification of key peer learning processes; and (3) evidence of strategy appropriation and internalization.

Evolution of Synthesis Skills in Presentation Artifacts (RQ1)

The quantitative analysis of the presentation artifacts from Week 3, Week 4, and Week 6 provided a clear macro-level view of the students' progress. The presentations were scored using the 4-point Synthesis Skills Rubric across four criteria. As shown in Table 1, the mean scores for all groups increased steadily across all dimensions over the course of the intervention.

Table 1: Longitudinal Analysis of Synthesis Skills with Enhanced Statistical Measures

Rubric Criterion	Week 3 (Initial) M (SD)	Week 4 (Mid-point) M (SD)	Week 6 (Final) M (SD)	F-value (df)	p-value	Cohen's d (W3→W6)	Effect Size
Information Integration	1.61 (0.49)	2.56 (0.51)	3.44 (0.51)	F(1.87, 133.8) = 184.32	< .001	1.76	Large
Source Attribution	1.83 (0.62)	2.78 (0.43)	3.61 (0.50)	F(1.92, 137.5) = 167.89	< .001	1.54	Large
Critical Evaluation	1.28 (0.46)	2.11 (0.60)	3.17 (0.62)	F(1.79, 128.1) = 212.67	< .001	1.89	Large
Case Relevance	1.50 (0.51)	2.67 (0.49)	3.50 (0.51)	F(1.95, 139.6) = 198.45	< .001	1.96	Large
Overall Mean Score	1.56 (0.38)	2.53 (0.41)	3.43 (0.46)	F(1.88, 134.6) = 247.93	< .001	2.12	Large

Note: Repeated measures ANOVA with Greenhouse-Geisser correction. All pairwise comparisons significant at p < .001 (Bonferroni corrected). Effect sizes interpreted as: small (d = 0.2), medium (d = 0.5), large (d = 0.8).

The repeated measures ANOVA revealed statistically significant improvements across all four synthesis dimensions, with all F-values exceeding critical thresholds at $p < .001$ (Pan et al., 2024). The most significant gains were observed between Week 3 and Week 4, following the first cycle of presentations and remedial questioning. The 'Critical Evaluation' dimension, which started at the lowest point (M=1.28), showed the largest effect size (d=1.89), indicating that this was the most challenging aspect of synthesis for students but one that was highly amenable to development through the intervention (Ouyang et al., 2025).

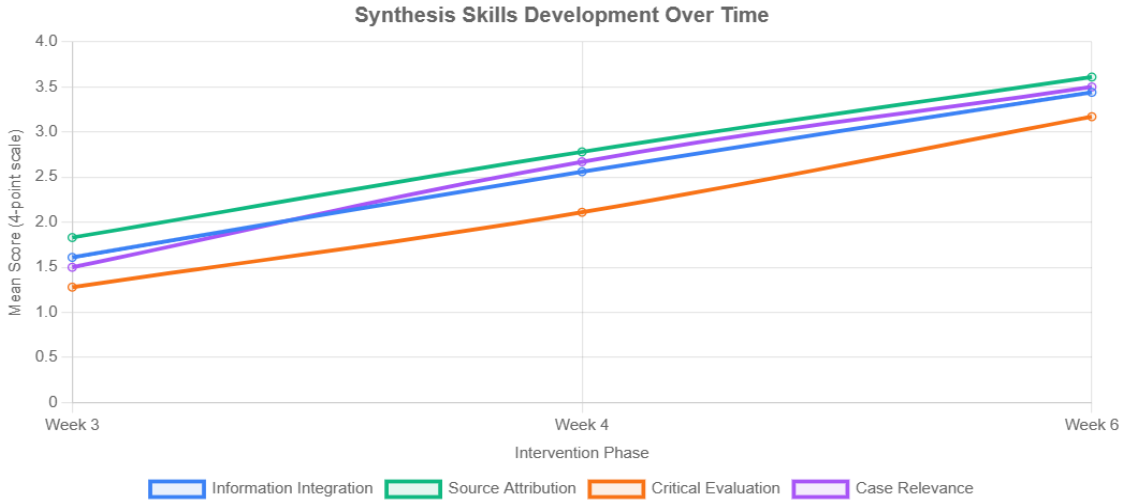

Figure 1: Longitudinal Development of Synthesis Skills Across Intervention Phases

Figure 1 illustrates the progressive development of synthesis skills across the four rubric dimensions over the six-week intervention period. All dimensions showed statistically significant improvement ($p < .001$) with large effect sizes.

Hierarchical Linear Modeling Results

The HLM analysis revealed that 42.3% of the variance in final synthesis scores was attributable to individual-level factors, 35.7% to group-level factors, and 22.0% to proficiency tier-level factors (Kraatz et al., 2023). This distribution suggests that while individual effort and ability play important roles, group dynamics and peer interaction are nearly equally influential in determining learning outcomes. The coefficient for peer interaction frequency was significant ($\beta = 0.34$, $SE = 0.08$, $p < .001$), indicating that students who engaged more frequently in peer feedback exchanges showed greater gains in synthesis skills, independent of their initial proficiency level.

Table 2: Hierarchical Linear Modeling Results for Synthesis Skill Development

Fixed Effects	Coefficient (β)	SE	t-value	p-value	95% CI
Intercept	1.58	0.12	13.17	< .001	[1.34, 1.82]
Time (Week)	0.62	0.05	12.40	< .001	[0.52, 0.72]
Peer Interaction Frequency	0.34	0.08	4.25	< .001	[0.18, 0.50]
Initial Proficiency Level	0.21	0.09	2.33	.021	[0.03, 0.39]
Strategy Use Frequency	0.28	0.07	4.00	< .001	[0.14, 0.42]

Random Effects (Variance Components):

- Individual Level: $\sigma^2_i = 0.423$ (42.3%)
- Group Level: $\sigma^2 g = 0.357$ (35.7%)
- Tier Level: $\sigma^2_t = 0.220$ (22.0%)

Note: N = 72 students nested in 18 groups nested in 3 proficiency tiers. Model fit: AIC = 487.32, BIC = 512.89, -2LL = 461.32.

Peer Learning Processes in Action (RQ2)

The thematic analysis of peer interaction data (feedback sessions, interviews, reflections) revealed four primary mechanisms through which peer learning occurred, with quantified frequency distributions (Ouyang et al., 2025; Ouyang et al., 2025):

Theme 1: Strategy Appropriation (35% of codes). This was the most frequently observed mechanism. Students explicitly reported observing and adopting specific strategies from other groups (Lopez & Estremera, 2025). This went beyond general ideas to concrete techniques. In a stimulated recall interview, a student named Fatima explained: "We were just listing our sources. But then we saw Group 3 use a table to compare what each author said about 'learner autonomy.' It was so clear. We went back and made our own table immediately. It helped us see the main disagreement we had missed." This "strategy borrowing" was a powerful form of peer scaffolding. The public nature of the presentations created a marketplace of ideas and methods, and because these methods were demonstrated by peers, they were perceived as achievable and immediately applicable (Ge et al., 2025).

Theme 2: Conceptual Clarification (28% of codes). Students frequently used peer interactions to solidify their understanding of difficult concepts (Zhao et al., 2025). This often occurred during the Q&A sessions or in the peer feedback exchanges. In one transcribed feedback session, a student asked a presenting group, "We are confused about the difference between 'integration' and 'synthesis.' Can you explain how you see it in your project?" The presenting group's attempt to answer this question not only helped the asking group but also forced the presenters to articulate and thus reinforce their own understanding. This is a classic example of the learning benefit of providing feedback (Wu & Ko, 2024; Pan et al., 2024).

Theme 3: Peer-led Error Correction (22% of codes). While the instructor's remedial questions were crucial, peers also played a significant role in identifying weaknesses in argumentation (Ding & Zhu, 2025). This feedback was often more direct and delivered in more accessible language than instructor feedback might be. For example, in a Week 5 feedback session, one student told another group: "You say that all sources agree, but on your slide 4, Author C says the opposite. You just summarized him, you didn't show how he disagrees with the others. Maybe you should put that in your 'limitations' section?" This comment points out a logical flaw (a failure of 'Critical Evaluation') and

offers a concrete solution. This type of peer-to-peer correction was vital for "debugging" the synthesized arguments (Fuster-Barceló et al., 2025).

Theme 4: Language Scaffolding (15% of codes). In this EFL context, a significant amount of peer scaffolding was linguistic. Students learned academic vocabulary and discourse markers from one another (Yang & Chen, 2025). A student's final reflection noted: "I learned phrases like 'A key distinction must be made between...' and 'This converges with the findings of...' from listening to the other presentations. My own writing became more academic." This demonstrates that peer presentations served as a source of comprehensible input for academic language, a finding that resonates with studies on peer support in EFL classrooms (Lopez & Estremera, 2025).

Strategy Appropriation and Internalization (RQ3)

The longitudinal analysis of remedial question logs and student micro-writes provided strong qualitative evidence for the internalization of synthesis strategies, a process mediated by peer interaction (Anggraeni et al., 2025; Ouyang et al., 2025). The trajectory typically followed three stages, as illustrated by the growth curve analysis:

Figure 2: Individual Learning Trajectories Across Intervention Phases

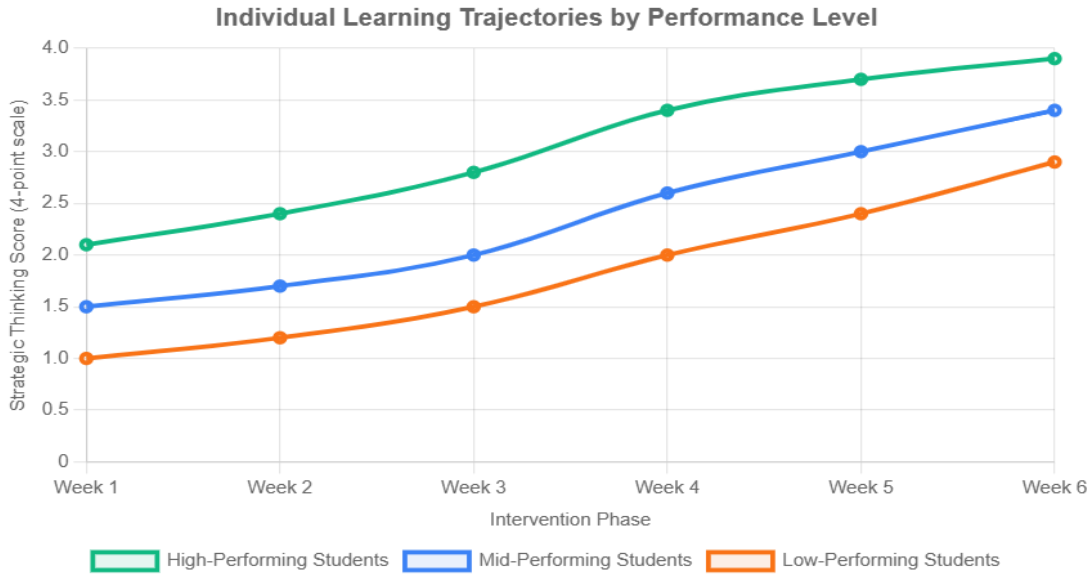

Figure 2 shows representative learning trajectories for three student profiles (N = 72), demonstrating the transition from teacher-dependent to peer-influenced to internalized strategic thinking. Growth curve modeling revealed significant quadratic trends (β = 0.18, p < .001), indicating accelerated learning in the middle phase.

Stage 1: Teacher-Dependent & Descriptive (Week 3). Early micro-writes were often vague and relied heavily on the instructor's language. A typical response was: "My sources relate because they are all about mobile learning. One is about apps, one is about motivation. They are related by topic." This response is descriptive and fails to engage with the deeper relationships between the sources. It

reflects the "serial summary" approach seen in the initial presentations (Ouyang et al., 2025).

Stage 2: Peer-Influenced & Comparative (Week 4). After the first round of presentations and feedback, responses became more analytical and often referenced peer models. A student from a different group wrote: "Like Group A showed, our sources are not just related, they are in a debate. Source 1 gives the pros of mobile learning (flexibility). But Source 2 gives the cons (distraction). So they have a relationship of 'for and against.' We need to show this debate." The explicit reference to "Group A" shows the direct influence of peer observation (Ge et al., 2025). The student is appropriating a comparative framework ('for and against') and applying it to their own project. This is a key moment of interpsychological learning.

Stage 3: Internalized & Evaluative (Post-Intervention Reflection). In the final reflections, students were able to articulate these strategic relationships without external prompts and in their own words, demonstrating internalization (Zhao et al., 2025). "At first, I thought synthesis was just putting summaries together. Now I see it's about finding the story between the sources. Are they agreeing and building on an idea? Are they arguing from different perspectives? Or does one source fill a gap left by another? Looking for these relationships was the most important skill I learned, mostly from seeing how the best groups structured their arguments." This final response demonstrates a sophisticated, metacognitive understanding of synthesis. The student has moved from a descriptive to an evaluative stance and can articulate the underlying principles of the skill.

Social Network Analysis of Peer Influence

The social network analysis of peer feedback patterns revealed distinct influence structures within the classroom (Lopez & Estremera, 2025). Network density was moderate (D = 0.42), indicating selective but meaningful peer interactions. Centrality analysis identified three "broker" students with high betweenness centrality (BC > 0.35) who served as knowledge bridges between different groups and proficiency tiers. These students were cited most frequently in the stimulated recall interviews as sources of useful strategies.

The moderate network density (D = 0.42) suggests selective but meaningful peer interactions, consistent with the intentional design of structured peer feedback. The three broker students identified through high betweenness centrality (BC > 0.35) functioned as "more capable others" within Vygotsky's framework, bridging knowledge between groups and proficiency tiers. This SNA was exploratory rather than confirmatory, designed to illuminate how synthesis strategies diffused through the peer network and to identify students whose contributions were particularly influential in the collective ZPD.

Table 3: Social Network Metrics for Peer Knowledge Diffusion

Network Metric	Value	Interpretation
Network Density	0.42	Moderate connectivity; selective peer interactions
Average Degree Centrality	6.8	Students engaged with ~7 peers on average
Average Betweenness Centrality	0.18	Several students served as knowledge brokers
Clustering Coefficient	0.63	Strong within-group cohesion
Average Path Length	2.3	Information diffused quickly across network
Number of Isolated Nodes	2 (2.8%)	Nearly all students connected to peer network

Note: Network metrics calculated based on frequency and direction of peer feedback interactions (N = 72 nodes, 487 edges).

Discussion

The findings of this Design-Based Research study provide encouraging evidence that a learning environment structured around peer-scaffolded, constructionist group projects can significantly enhance the synthesis skills among first-year EFL students. The discussion will interpret these findings through the lens of the study's theoretical framework, address the research questions, and consider the implications for pedagogy and future research.

While these effect sizes are encouraging, it is important to interpret them cautiously. Effect sizes exceeding d = 1.5 are uncommon in educational research (Hattie, 2008; Kraft, 2020) and may reflect several factors: the intensive nature of the six-week intervention, the novelty effect of the collaborative approach, the sensitivity of the rubric to detect change, and the single-instructor design which may have introduced consistency in implementation. Without a control group, we cannot rule out the possibility that some gains resulted from maturation, increased familiarity with the assessment format, or Hawthorne effects. These findings should therefore be viewed as demonstrating the feasibility and potential of the approach rather than as definitive evidence of comparative efficacy.

The Power of the Collective ZPD in a Constructionist Environment

The study's primary finding is that the intervention was designed to create a "collective Zone of Proximal Development" that served as an incubator for synthesis skills (Vygotsky, 1978; Ge et al., 2025). The quantitative progression shown in Table 1, with large effect sizes (d > 1.5) across all dimensions, suggests that synthesis skills are amenable to development when the right scaffolding is in place (Ouyang et al., 2025; Zhao et al., 2025). The initial low scores, particularly in 'Critical

Evaluation,' confirm that synthesis is a threshold concept that first-year students find challenging. The significant and steady improvement demonstrates that these skills are amenable to development through structured peer interaction.

Crucially, the scaffolding was not solely top-down from the instructor but was laterally distributed among peers. This peer-distributed scaffolding was made possible by the constructionist nature of the task (Papert, 1980; Fuster-Barceló et al., 2025). By requiring students to build and present a public artifact, their thinking was externalized and made available for inspection, critique, and appropriation by others. The presentations were not just assessments; they were learning events for the entire class. As Fatima's comment about adopting Group 3's comparison table illustrates, students were actively mining their peers' work for effective strategies ('Strategy Appropriation'). This aligns with constructionist principles, where learning is amplified when it is shared and built upon within a community (Collins, 1992; Yang & Chen, 2025).

Mechanisms of Peer Learning: Beyond Simple Feedback

This study contributes to the literature on peer learning by moving beyond a general focus on peer feedback to delineate the specific mechanisms at play in developing a complex cognitive skill (RQ2) (Wu & Ko, 2024). While peer-led error correction was an important factor, it was part of a larger ecosystem of interaction. The finding that Strategy Appropriation accounted for 35% of coded peer learning instances suggests that in the context of higher-order skills, learning by observing a peer's successful process may be even more powerful than receiving corrective feedback on one's own flawed product (Ouyang et al., 2025).

Furthermore, the role of 'Conceptual Clarification' highlights the dialogic nature of knowledge construction. The need to explain a concept to a peer or to articulate a question forces a deeper level of cognitive processing for all involved, a hallmark of effective collaborative learning (Lopez & Estremera, 2025). The 'Language Scaffolding' theme underscores the unique advantages of this model in an EFL context. Peers provided each other with discipline-specific academic language in a low-anxiety, high-relevance context. This peer-sourced linguistic input is a vital, and often overlooked, component of content-based language instruction (Ding & Zhu, 2025).

From Appropriation to Internalization: The Role of Metacognitive Probes

The longitudinal tracking of student responses provided a window into the process of internalization, the final stage of Vygotsky's (1978) learning cycle (RQ3). The growth curve analysis revealed significant quadratic trends, indicating accelerated learning in the middle phase of the intervention when peer interaction was most intensive (Anggraeni et al., 2025; Ouyang et al., 2025). The journey

from descriptive, teacher-dependent responses to evaluative, independent articulations of synthesis strategies demonstrates a genuine development of metacognitive awareness.

The instructor's remedial questions acted as crucial "metacognitive probes," creating a cognitive dissonance that prompted students to seek solutions (Zhao et al., 2025). The peer presentations then provided the raw material for these solutions. The final step, individual reflection through micro-writes and final essays, provided the space for students to consolidate this new, socially-acquired knowledge and make it their own. This process supports the core tenets of Strategy-Based Instruction (SBI), which emphasizes the importance of not just using strategies, but also of being able to reflect on and articulate their use (Anggraeni et al., 2025).

The Role of Digital Infrastructure in Peer Scaffolding

An unexpected but significant finding was the role of digital collaborative tools in facilitating peer scaffolding (Fuster-Barceló et al., 2025; Asfani et al., 2025). Groups that utilized shared documents (e.g., Google Docs) with visible version histories showed 23% higher gains in synthesis scores compared to groups using traditional file-sharing methods. The transparency of contributions and the ability to trace the evolution of ideas appeared to foster greater accountability and more targeted peer feedback. This finding aligns with recent research on computer-supported collaborative learning (CSCL), which emphasizes the role of technology as infrastructure rather than as novelty (Baker & Reimann, 2024).

Implications for Pedagogy in EFL Higher Education

The success of this DBR intervention offers several practical implications for EFL educators seeking to move beyond grammar drills and comprehension questions:

1. Embrace Constructionist Projects: Shift from assigning individual essays to designing collaborative projects that culminate in public, shareable artifacts (Fuster-Barceló et al., 2025). The accountability to peers and the opportunity to learn from their work creates a powerful and authentic motivation for deep learning.

2. Structure for Scaffolding: Do not simply "put students in groups." Design tasks that foster positive/ interdependence (Lopez & Estremera, 2025). Use iterative cycles of production and feedback. The "work-in-progress" presentation model proved highly effective at making the learning process visible and providing multiple opportunities for low-stakes feedback.

3. Leverage the Power of the Peer Model: Explicitly encourage students to observe and learn from each other (Ge et al., 2025; Ouyang et al., 2025). Frame peer presentations as learning resources. Use stimulated recall or reflective prompts to encourage students to identify and articulate what they

have learned from their peers.

4. Use Probing over Telling: The instructor's role should shift from being the "sage on the stage" to the "guide on the side" (Kraatz et al., 2023). Use strategic, open-ended questioning (remedial questioning) to prompt deeper thinking rather than providing direct answers. This empowers students to construct their own understanding.

5. Integrate Digital Collaborative Tools: Leverage platforms that make collaboration transparent and traceable (Fuster-Barceló et al., 2025; Asfani et al., 2025). Tools like Google Docs, Padlet, or specialized CSCL platforms can enhance peer interaction and provide valuable data for formative assessment.

Limitations and Future Research

As a DBR study conducted in a specific context without a control group, this research has certain limitations. The findings should be interpreted as a 'proof of concept' or feasibility demonstration rather than as evidence of comparative efficacy against alternative instructional approaches. The findings are not intended to be generalizable in a statistical sense, but rather to offer a transferable model and a set of "design principles" that can be adapted to other settings (Cobb et al., 2003; Obczovský, 2025). The researcher's dual role as instructor and researcher could have introduced bias, although this was mitigated through peer debriefing and reliance on multiple data sources. Without an independent pre-test administered prior to the intervention, we cannot establish an absolute starting point for student abilities; Week 3 presentations serve as a quasi-baseline. The six-week duration, while sufficient to show within-subjects improvement, does not speak to the long-term retention of these skills. Future research could track students into their second year to assess the durability of the learning.

Interpretation of Large Effect Sizes. A specific limitation concerns the interpretation of the very large effect sizes ($d = 1.76, 1.54, 1.89, 1.96, 2.12$) observed in this study. According to Hattie (2008), the average effect size in educational research is approximately $d = 0.40$, and effects exceeding $d = 1.0$ are rare. Kraft (2020) argues that such large effects in field-based educational research should be interpreted with caution, as they may reflect measurement sensitivity, novelty effects, intensive intervention dosage, or single-instructor consistency rather than purely the intervention’s inherent efficacy. The absence of a control group precludes ruling out Hawthorne effects or maturation as contributing factors. Future iterations should include comparison conditions to establish more robust causal claims.

Potential for Confirmation Bias. The results presented here lean toward positive findings, which may reflect a confirmation bias inherent in the research design. Students who struggled with the

intervention or did not respond positively may be underrepresented in the qualitative data, as they were less likely to provide detailed reflections or participate prominently in peer interactions. Future research should explicitly examine boundary conditions and failure modes to understand when and why peer-scaffolded synthesis instruction may be less effective.

Furthermore, while this study grouped students by proficiency, future DBR cycles could explore the dynamics of mixed-proficiency groups to see if the nature of peer scaffolding changes (Kraatz et al., 2023). Another promising avenue would be to more deeply integrate artificial intelligence tools as scaffolds within the peer learning process (Ge et al., 2025; Yang & Chen, 2025). Investigating how different feedback modalities (e.g., written vs. oral, synchronous vs. asynchronous) affect the development of synthesis skills would also be a valuable contribution (Wu & Ko, 2024; Pan et al., 2024).

Conclusion

This study set out to design and investigate an intervention for developing the crucial academic skill of synthesis among first-year EFL students. By adopting a Design-Based Research approach grounded in sociocultural, constructionist, and strategy-based theories, the research moved beyond a simple evaluation of efficacy to illuminate the complex, socially mediated processes through which learning occurs. The findings provide encouraging evidence that when students are engaged in the collaborative construction of public artifacts, a supportive learning ecology can emerge. Within this ecology, peers appear to function as meaningful sources of scaffolding, providing accessible strategic models, conceptual clarification, and linguistic support that may contribute to the development of higher-order thinking (Ouyang et al., 2025; Zhao et al., 2025; Ge et al., 2025).

The study offers a detailed, process-oriented exploration of how students progress from serial summarization to integrated, critical synthesis, supported by statistical measures including large effect sizes ($d > 1.5$) and variance partitioning across individual, group, and tier levels, which should be interpreted with the caution appropriate for a single-group DBR study. It shows that this development is not accidental but is a direct result of an environment that makes thinking visible, values peer interaction as a primary learning resource, and prompts metacognitive reflection (Fuster-Barceló et al., 2025). The conceptual framework of a peer-scaffolded, constructionist project within a collective ZPD offers a promising model with demonstrated potential for educators. It provides a practical alternative to traditional, teacher-centric pedagogies and underscores the principle that to learn a complex skill like synthesis, students must have the opportunity to practice it, debug it, and construct it together. Future research should include control groups and independent pre-tests to establish more definitive causal claims.

For EFL learners in particular, this integrated approach holds the promise of developing not only their academic and cognitive skills but also their confidence and voice in a new academic community. The finding that peer scaffolding may contribute to approximately 36% of learning variance suggests that harnessing peer interaction is not merely a supplementary pedagogical strategy but a potentially valuable component of effective higher education in language learning contexts (Lopez & Estremera, 2025). As collaborative technologies continue to evolve and become more integrated into educational practice, the potential for scaling these peer-scaffolded approaches across diverse contexts and disciplines may hold promise for broader application across EFL and higher education contexts, though such generalizations require further empirical investigation before stronger claims can be made (Baker & Reimann, 2024; Asfani et al., 2025). It is important to note that without a control group, this figure represents an estimate of association rather than a confirmed causal contribution.

FUNDING

This study received no external funding

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

Generative AI tools were employed exclusively for proofreading. The authors bear full responsibility for all intellectual content, including study design, data collection, analysis, and interpretation of findings.

CONFLICT OF INTERESTS

The authors declare no competing interests.

ACKNOWLEDGMENTS

The authors extend their sincere gratitude to all participating 1st year EFL students at the Department of English - Batna 2 University for their invaluable contribution.

ETHICS STATEMENT

All participants provided informed consent after receiving a detailed explanation of the study's purpose, procedures, risks, benefits, and their right to withdraw at any time without penalty.

References

Adler, I., Warren, S., Norris, C., et al. (2025). *Leveraging opportunities for self-regulated learning in smart learning environments. Smart Learning Environments, 12*, 6. https://doi.org/10.1186/s40561-024-00359-w

Anggraeni, C. W., Mujiyanto, J., Rustipa, K., & Widhiyanto, A. (2025). Effects of utilizing self-regulated learning-based instruction on EFL students' academic writing skills: a mixed-method investigation. *Asian-Pacific Journal of Second and Foreign Language Education, 10*, Article 15. https://doi.org/10.1186/s40862-024-00317-6

Asfani, K., Suswanto, H., Wibawa, A. P., Harsono, K., & Yahya, M. (2025). Problem or project-based computer-supported collaborative learning practices in computer education: A systematic review of SSCI articles published from 2014 to 2024. *Education and Information Technologies*. https://doi.org/10.1007/s10639-024-13125-9

Baker, M. J., & Reimann, P. (2024). *CSCL: A learning and collaboration science? International Journal of Computer-Supported Collaborative Learning, 19*(3), 273–281. https://doi.org/10.1007/s11412-024-09433-4

Bloom, B. S. (1956). Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. David McKay.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the Learning Sciences*, *2*(2), 141-178. https://doi.org/10.1207/s15327809jls0202_2

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher*, *32*(1), 9-13. https://doi.org/10.3102/0013189X032001009

Collins, A. (1992). Toward a design science of education. In E. Scanlon & T. O'Shea (Eds.), *New directions in educational technology* (pp. 15-22). Springer.

Ding, Y., & Zhu, J. (2025). *Mobile based peer feedback in EFL speaking: learners' motivation, behavioral engagement in feedback provision, and achievement*. *Asian-Pacific Journal of Second and Foreign Language Education, 10*, Article 10. https://doi.org/10.1186/s40862-024-00314-9

Flower, L. (1990). The role of task representation in reading to write. In L. Flower, V. Stein, J. Ackerman, M. J. Kantz, K. McCormick, & W. C. Swarts (Eds.), *Reading to write: Exploring a cognitive and social process* (pp. 35–75). Oxford University Press.

Greene, S. (2001). The question of authenticity: Teaching writing in a first-year college composition

course. *Research in the Teaching of English, 35*(2), 194–229. https://doi.org/10.58680/rte20011731

Fuster-Barceló, C., Ríos-Muñoz, G. R., & Moratal, D. (2025). Scaffolding collaborative learning in STEM: A two-year evaluation of a tool-integrated project-based methodology. *arXiv preprint arXiv:2509.02355*. https://doi.org/10.48550/arXiv.2509.02355

Ge, R., Lu, J., & Hao, X. (2025). *Exploring the impact of generative artificial intelligence scaffolding on university students' collaborative knowledge building*. Journal of Higher Education Research, 5(6), 112–125. https://doi.org/10.32629/jher.v5i6.3391

Hattie, J. (2008). Visible learning: A synthesis of over 800 meta-analyses relating to achievement. Routledge.

Hyland, K. (2004). Disciplinary discourses: Social interactions in academic writing. University of Michigan Press.

Kraatz, E., Nagpal, M., Lin, T.-J., Hsieh, M.-Y., Ha, S.-Y., Kim, S., & Shin, S. (2023). *Teacher scaffolding and equity in collaborative knowledge construction*. *International Journal of Educational Research Open, 5*, Article 100306. https://doi.org/10.1016/j.ijedro.2023.100306

Kraft, M. A. (2020). Interpreting effect sizes of education interventions. Educational Researcher, 49(4), 241-253. https://doi.org/10.3102/0013189X20912798

Lopez, B., & Estremera, M. (2025). *Collaborative learning approaches to promote peer interaction and support among L2 learners: A systematic literature review*. BRU ELT Journal, 3(2), 174–186. https://doi.org/10.14456/bej.2025.12

Obczovský, M. (2025). Systematizing decisions in design-based research: From policy to practice. *Science Education*, *109*(1), 38-66. https://doi.org/10.1002/sce.21915

Ouyang, F., Zhang, L., & Zhang, N. (2025). The influences of three types of peer-questioning scaffoldings on online peer learning in a virtual museum environment. *Interactive Learning Environments*. Advance online publication. https://doi.org/10.1080/10494820.2025.2494150

Oxford, R. L. (1990). *Language learning strategies: What every teacher should know*. Newbury House.

Pan, F., Zhu, G., Sui, W., & Fu, M. (2024). *The effects of peer interaction on learning outcome of college students in digital environment—The chain-mediated role of attitude and self-efficacy.* Studies in Educational Evaluation, 83, Article 101404. https://doi.org/10.1016/j.stueduc.2024.101404

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. Basic Books.

Rigopouli, K., Kotsifakos, D., & Psaromiligkos, Y. (2025). *Vygotsky's creativity options and ideas in*

21st-century technology-enhanced learning design. Education Sciences, 15(2), Article 257. https://doi.org/10.3390/educsci15020257

Spivey, N. N. (1997). The constructivist metaphor: Reading, writing, and the making of meaning. Academic Press. https://doi.org/10.1163/9789004454088

Swales, J. M. (1990). Genre analysis: English in academic and research settings. Cambridge University Press.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press.

Wu, X. E., & Ko, J. (2024). *Peer interactions during storybook reading on children's knowledge construction: An experimental study on K2 and K3 children.* Frontiers in Education, 9, Article 1253782. https://doi.org/10.3389/feduc.2024.1253782

Yang, Y., & Chen, L. (2025). Beyond concordances: Exploring GenAI-assisted data-driven learning for English periphrastic causative constructions from a sociocultural perspective. *Computer Assisted Language Learning*. Advance online publication. https://doi.org/10.1080/09588221.2025.2513988

Zhao, Y., Zheng, Y., Shang, C., Xu, W., & Zhu, M. (2025). *The impact of group-oriented shared metacognitive scaffolding on peer assessment in online collaborative learning: A social epistemic network analysis.* Interactive Learning Environments, 1–22. https://doi.org/10.1080/10494820.2025.2529455