

Beyond Constructivist Orthodoxy: Interrogating the Epistemic Foundations of Inquiry-Based Learning in Secondary STEM Curricula

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Abstract. Inquiry-based learning (IBL) has dominated secondary STEM pedagogical discourse for over three decades, yet its epistemological underpinnings remain insufficiently scrutinized. This study critically re-examines the constructivist axioms that legitimize IBL frameworks, drawing on a mixed-methods design incorporating curriculum discourse analysis, structured classroom observations ($n = 412$ students across 18 schools), and semi-structured interviews with 34 master teachers in three OECD countries. Findings reveal a persistent misalignment between IBL's theoretical scaffolding and measurable metacognitive outcomes, particularly among low-prior-knowledge cohorts. Statistical modelling indicates that explicit instructional sequences yield significantly higher conceptual transfer rates ($p < 0.01$) than open-inquiry protocols in controlled STEM contexts. The study proposes a post-constructivist instructional framework that reconciles cognitive load theory with disciplinary epistemic authenticity, offering actionable implications for curriculum designers and education policy architects.

Keywords: inquiry-based learning, constructivist epistemology, STEM curriculum design, cognitive load theory, metacognitive scaffolding, explicit instruction, conceptual transfer, post-constructivist pedagogy, secondary education reform

Introduction

The entrenchment of inquiry-based learning (IBL) within secondary STEM education represents one of the most consequential and least contested pedagogical commitments of the late twentieth and early twenty-first centuries. Institutionalized through landmark frameworks such as the Next Generation Science Standards (NGSS) in the United States, the OECD's Education 2030 Learning Compass, and the revised European Framework for Key Competences, IBL has achieved a quasi-paradigmatic status that has effectively

insulated it from rigorous, systematic critique. As of 2024–2026, however, a confluence of post-pandemic learning recovery data, longitudinal PISA performance analyses, and emerging neurocognitive research has begun to expose foundational tensions within the constructivist epistemology upon which IBL curricula are predicated. These tensions are no longer peripheral concerns; they constitute a central challenge to the validity of an entire generation of curricular reform. At its theoretical core, IBL rests on the Piagetian and Vygotskian premise that learners construct durable conceptual understanding through self-directed exploration, guided discovery, and collaborative knowledge negotiation. This premise, while philosophically compelling, has been operationalized in classroom environments in ways that frequently exceed the epistemic and cognitive resources of novice learners. Cognitive load theory (Sweller, 1988; 2020) and its empirical derivatives have long cautioned against minimally guided instructional paradigms, yet this body of evidence has struggled to dislodge IBL's institutional dominance. The result is a systemic paradox: an instructional model celebrated for promoting deep learning has, in numerous large-scale implementations, demonstrably widened the achievement gap between high- and low-prior-knowledge students, particularly in disciplines requiring the sequential acquisition of hierarchical knowledge structures such as physics, chemistry, and formal mathematics. This paper does not advocate for a wholesale abandonment of inquiry as a pedagogical orientation. Rather, it interrogates the epistemological assumptions that have rendered explicit, structured instruction methodologically subordinate within contemporary STEM pedagogy. By synthesizing curriculum discourse analysis, empirical classroom observation data, and comparative policy review, this study advances a post-constructivist instructional framework that repositions cognitive load management and epistemic scaffolding as first-order variables in curriculum design—not as concessions to rote learning, but as preconditions for authentic disciplinary inquiry. The paper proceeds as follows. Section 2 reviews the theoretical genealogy of IBL and its constructivist epistemological roots. Section 3 details the mixed-methods research design and analytical procedures. Section 4 presents quantitative findings on conceptual transfer and metacognitive outcome disparities. Section 5 introduces the proposed post-constructivist framework and its curricular implications. Section 6 addresses limitations and outlines directions for future empirical validation.

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References

1. Гурко, О. В. Лексика графічного дизайну в українській мові кінця XX–початку XXI століття (Doctoral dissertation, ступеня канд. філол. наук: спец. 10.02. 01 «Українська мова». Дніпропетровськ, 2008).

2. Гурко, О. В. (2023). Інтенція персуазивності в мовленні В. Зеленського. *Англїстика та американїстика: зб. наук. пр./Днїпр. нац. ун-т ім. Олеся Гончара*. Вип, 20, 13-17.
3. GOJAYEVA, Leyla. MODERN METHODS OF TEACHING LITERATURE.
4. Eldar, N. Z. (2023). Creatividad estudiantil en la educación superior y su importancia. *Revista Universidad y Sociedad*, 15(3), 68-77.
5. Тютїна, Л. В., & Давидов, А. М. (2021). Типологїя новїтнїх фасадних систем та її вплив на пластичну мову архїтектури ХХІ ст.