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Technology Teacher Agency in Navigating Resource Constraints to Support Creative Thinking in Vietnam

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Abstract. While Vietnam's 2018 General Education Curriculum formally mandates the cultivation of creative thinking within technology education, its implementation is frequently undermined by systemic resource constraints. This qualitative case study examines how teachers of technology enact agency to foster creative thinking in resource-constrained contexts. Data from four technology teachers included eight lesson plans, eight classroom observations, and twelve stimulated recall interviews. Data was analyzed using an ecological model of teacher agency, examining the iterational, practical-evaluative, and projective dimensions. Teachers enacted agency through strategic improvisation, pivoting from physical prototyping to conceptual ideation amid equipment shortages. Findings reveal that teacher agency is shaped by the interaction between teachers' past experiences, current material constraints, and future visions for their discipline. These results challenge individualistic capacity-building models, suggesting that policy should prioritize improving structural conditions to enable agency rather than focusing solely on skill enhancement. Finally, the study suggests that administrators should recognize improvisation as professional judgment by adopting adaptive lesson documentation formats and flexible evaluation criteria to sustain teacher resilience.

Keywords: Teacher agency; Technology education; creative thinking; ecological perspective; improvisation

1. Introduction

In 2018, Vietnam's Ministry of Education and Training (MOET) launched a competency-based general education curriculum that shifted focus from knowledge transmission to developing twenty-first-century skills such as creativity (MOET, 2018). Technology education plays a strategic role in this reform by fostering design thinking through project-based learning and hands-on

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engagement with real-world challenges (Nguyen & Angela, 2024). However, translating these objectives into practice is challenging. Teachers must navigate complex environments where resources, institutional cultures, and disciplinary hierarchies strictly define pedagogical possibilities.

A critical paradox emerges between policy mandates and classroom realities. While the curriculum demands creative pedagogy, technology education implementation is constrained by inadequate infrastructure and perceptions of the subject as manual training rather than innovation (Nguyen & Angela, 2024). Such resource-scarce contexts are characteristic of developing countries. This raises a crucial question: how do teachers enact agency under such conditions? From an ecological perspective, agency is an emergent achievement rather than an inherent capacity, shaped by the interplay of three dimensions: the iterational, the practical-evaluative, and the projective (Priestley et al., 2015). Teachers often achieve agency through improvisation and strategic adaptation. Understanding this process is crucial for bridging the gap between reform and practice.

Despite growing interest in teacher agency within educational reform, research remains predominantly Western-centric. Consequently, a significant gap persists in understanding how resource scarcity reshapes agency dynamics in developing countries (Ngo, 2021). While recent Vietnamese studies have begun addressing this gap (Tran et al., 2024; Vu, 2024), their focus has been limited to English language teachers. This focus overlooks the fact that teacher agency is inherently subject-specific and deeply mediated by disciplinary hierarchies. In Vietnam's exam-driven system, technology teachers possess less autonomy and institutional support than their colleagues in high-stakes disciplines (Dinh & Sannino, 2024). This uneven distribution of resources and recognition shapes the conditions under which these teachers enact agency. Consequently, examining technology teachers offers critical insights into how agency operates under compounded constraints.

This study addresses this gap by examining how Vietnamese technology teachers enact agency to foster creative thinking in resource-constrained environments. Specifically, it investigates how the three temporal dimensions of agency (Priestley et al., 2015) interact with material and cultural constraints to produce improvisation as a mechanism of transformative practice. The following research questions guide this inquiry:

1. How do technology teachers navigate the iterational, practical-evaluative, and projective dimensions of agency when fostering creative thinking under resource constraints?
2. How does improvisation function as a pedagogical manifestation of agency in response to material and cultural constraints?
3. How do material, cultural, and structural constraints shape teachers' ability to enact transformative pedagogical practices?

2. Literature Review

2.1 Teacher Agency in Creative Thinking

Teacher agency encompasses how educators navigate curriculum reforms through intentional choices and deliberate actions that yield meaningful changes (Li & Ruppar, 2021; Ngo, 2021). This conceptualization emphasizes three core pillars: intentionality, action, and transformative potential. However, rather than conceptualizing agency as a fixed capacity or an innate trait that teachers possess, this study adopts an ecological perspective that views teacher agency as a situated achievement emerging over time (Priestley et al., 2015). From this perspective, agency is not an inherent property but is realized through the continuous interplay between teachers' individual efforts and the material, cultural, and structural conditions of their work environments. This conceptual shift from agency-as-capacity to agency-as-achievement is crucial, as it explains why even highly competent teachers may struggle to enact change when contextual constraints are restrictive.

Recent applications of the ecological approach in Vietnamese educational contexts have demonstrated its usefulness for examining teacher agency across diverse settings(Dinh & Sannino, 2024; Tran et al., 2024). These studies emphasize that teacher agency arises from the dynamic interaction between teachers and the environmental resources and constraints shaping their professional practice. In this view, the study frames teacher agency as emerging from creativity-supportive environments, where teachers embrace uncertainty and actively shape pedagogy, moving beyond compliance toward transformative practice that develops students' creative thinking (Valquaresma, 2024).

In the context of creative thinking instruction, teacher agency becomes critical. Fostering students' creative thinking requires teachers to move beyond standardized pedagogical approaches and create learning environments that encourage experimentation, risk-taking, and divergent thinking (Anderson et al., 2022). This demands that teachers exercise agency in adapting curricula, designing open-ended tasks, and responding flexibly to students' creative processes (Dinh & Sannino, 2024). However, such agentic practices are contingent upon supportive institutional conditions that provide teachers with the autonomy, resources, and professional development necessary to cultivate creative thinking (Li & Ruppar, 2021). Thus, understanding teacher agency within an ecological framework is essential for examining how teachers navigate the complexities of creative thinking pedagogy in specific educational contexts (Priestley et al., 2015).

2.2 Technology Education in Developing Contexts

The implementation of technology education varies significantly across economic contexts. While developed nations have established robust infrastructure, developing countries face substantial material and structural barriers (Dinh & Sannino, 2024). In the United States and New Zealand, technology and engineering education is typically supported by well-established pedagogical frameworks and adequate facilities (Deck, 2022; Sung & Kelley, 2022). Teachers and students have access to maker spaces, modern equipment such as CNC

machines and Arduino kits, and tools necessary for completing the full engineering design process from ideation to physical prototyping (Sung & Kelley, 2022).

In contrast, developing countries present a different reality. In rural Bangladesh, schools suffer from severe shortages of digital equipment, internet connectivity, and stable electricity, creating a pronounced digital divide between urban and rural areas (Roy et al., 2025). Similarly, in Vietnam, despite the 2018 curriculum's high expectations for creative thinking and design competencies, implementation is constrained by material barriers. Vietnamese technology teachers often operate in environments with critical equipment shortages, where basic tools mandated by the curriculum are frequently absent from actual classroom instruction. This scarcity forces them to shift from physical making to conceptual ideation, a challenge rarely encountered in resource-rich contexts (Dinh & Sannino, 2024).

2.3 Improvisation as a Mechanism of Agency

In resource-constrained contexts under educational reform pressures, improvisation emerges as a critical mechanism of teacher agency. Rather than spontaneous reaction or temporary coping, improvisation represents a deliberate agency enactment where teachers craft responses to challenges created by new instructional materials and structural constraints (Nguyen, 2024; Priestley et al., 2015). It is the capacity to skillfully navigate intersecting structural and material constraints while maintaining pedagogical integrity (Priestley et al., 2015). Instead of passively accepting deficits, teachers actively redefine lessons in real-time. For example, in STEM education, teachers may select familiar topics and utilize available, cost-free materials to facilitate learning when faced with a lack of technological equipment (Le et al., 2021).

Improvisation plays a vital role in developing educational contexts, particularly in resource-constrained settings. First, it allows teachers to maintain the transformative aspirations of new curricula even when practical conditions do not permit standard implementation. Second, in equipment-scarce contexts, teachers demonstrate agency by utilizing available, cost-free materials to substitute for lacking technological equipment, thereby ensuring lessons remain practical and engaging (Le et al., 2021). Third, improvisation often functions as an undocumented practice to bypass bureaucratic hurdles, enabling teachers to foster creative spaces while maintaining formal compliance with rigid regulations (Dinh & Sannino, 2024). Thus, in technology education within developing countries, improvisation is not a sign of failure but an active strategy to overcome structural and material constraints.

2.4 The Ecological Model: Three Temporal Dimensions of Teacher Agency

Priestley et al. (2015) conceptualize agency through three temporal dimensions. The iterational dimension encompasses teachers' accumulated professional histories and established routines. Research indicates that STEM and technology teachers often maintain traditional, teacher-led instruction to avoid risks, which constrains innovation (Irving Bell, 2022). The 2018 curriculum's shift from knowledge transmission to competence development creates tension (Dinh & Sannino, 2024; MOET, 2018). Transitioning to creative exploration requires

breaking deep-seated instructional patterns and routines. While programs like ETEP equip teachers with modern pedagogical knowledge (Nguyen, 2024), their long-standing habits can both support and hinder creativity-focused instruction.
The practical-evaluative dimension represents teachers' contextual judgments within immediate circumstances. In technology education, constraints operate across interconnected levels. The scarcity of technological equipment and facilities fundamentally limits pedagogical implementation, forcing teachers to adapt by using available or free materials (Le et al., 2021). While teachers demonstrate agency through improvisation to navigate these deficits (Nguyen, 2024), such adaptation requires sophisticated professional judgment.

The examination-oriented culture marginalizes creative subjects, creating psychological constraints as teachers fear innovative methods may harm student test performance (Tran & Le, 2025). Despite being granted more autonomy under new reforms, teachers often perceive this freedom as a burden due to tight schedules, unclear guidelines, and excessive assessment requirements. To manage this, they exercise agency by balancing process-based grading and problem-solving with standardized requirements (Shanta, 2022). Supportive leadership and collaborative environments are identified as key factors in helping teachers navigate these structural and material constraints (Mburu, 2022).

The projective dimension comprises teachers' future-oriented visions. In the context of modern educational demands, teachers envision preparing students for innovation through design thinking and engineering problem-solving (Deck, 2022). However, critical tension exists between short-term goals and long-term visions of fostering breakthrough creative thinking and authentic open-ended problem-solving. Practical constraints often compel teachers to favor problem-solving within fixed frameworks over divergent experimentation. While the engineering design process provides a flexible pedagogical framework (Sung & Kelley, 2022), transitioning from curriculum implementer to transformative practitioner requires navigating conflicting professional mandates.

These three dimensions interact to produce agency as a situated achievement through localized curriculum adaptation (Tran et al., 2024), assessment innovation (Shanta, 2022; Tran & Le, 2025), and pedagogical risk-taking. Ultimately, fostering creativity depends not on individual skill alone but on the alignment between these temporal dimensions. Figure 1 presents the conceptual framework guiding this study, illustrating how these three dimensions interact within the context of technology education in Vietnam.

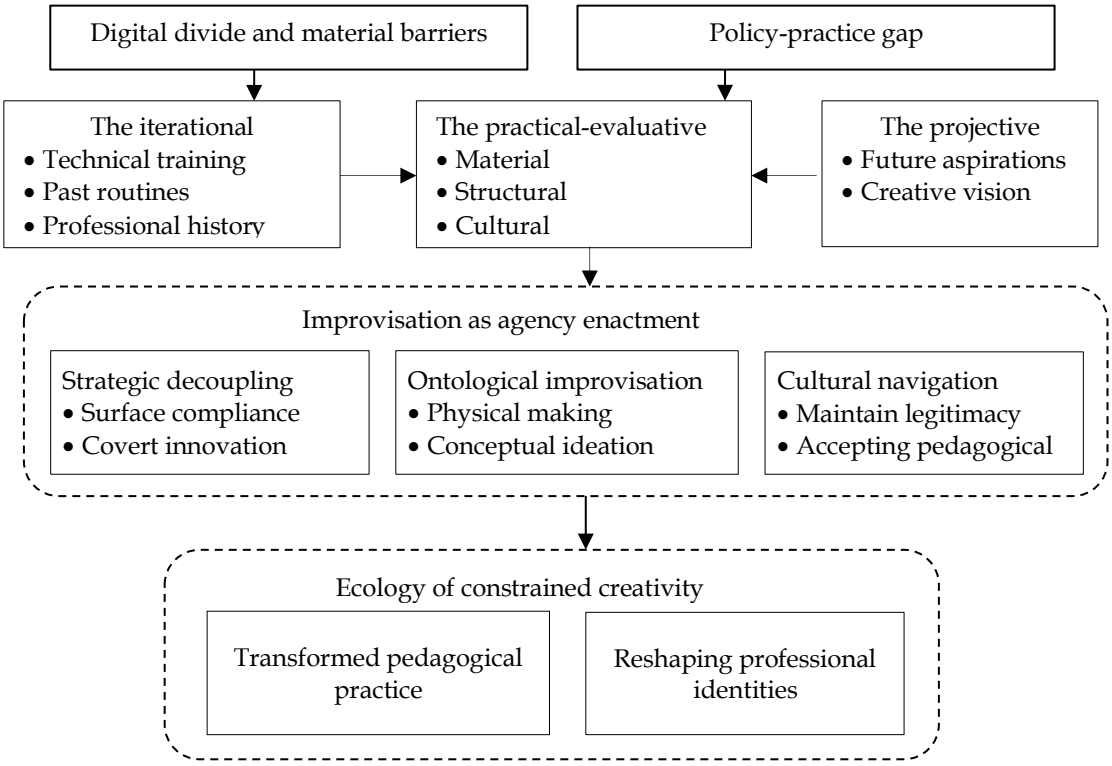

Figure 1: Teacher agency for creative thinking in technology education

3. Methodology

3.1 Research Design

This study employed a qualitative case study approach to examine how technology teachers navigate challenges while fostering creative thinking among their students. This methodological choice enables an in-depth understanding of complex pedagogical phenomena within specific socio-cultural contexts (Yin, 2012). The scope of this case is specifically bounded by technology instruction under the 2018 general education program. It focuses on how teachers develop students' creative thinking within resource-constrained environments. Data collection was conducted over a four-month period during the second semester of 2024 - 2025.

3.2 Participants

Participants were selected through purposeful maximum variation sampling. This approach was used to capture diverse expressions of teacher agency across various material and institutional contexts. Selection criteria included: (a) currently teaching technology according to the 2018 curriculum; (b) demonstrably engaged in implementing innovative pedagogical approaches to develop creative thinking; (c) willingness to participate in classroom observations and multiple interview sessions. Four technology teachers from different lower-secondary schools in Southern Vietnam were selected for the final sample. All participants held bachelor's degrees in technology education and had completed the ETEP professional development program. Teaching experience ranged from 5 to 16 years.

3.3 Data Collection

To ensure rigor and trustworthiness, this study employed triangulation through three data sources (Fusch et al., 2018), each designed to capture different dimensions of teacher agency as conceptualized in the ecological framework (Figure 1).

3.3.1 Lesson Plans and Classroom Observations

Two formal lesson plans per teacher were collected to examine how teachers officially framed creative thinking objectives within institutional requirements. These documents revealed tensions between curricular ideals and practical constraints. Additionally, two classroom sessions per teacher were video-recorded to capture real-time pedagogical responses to resource constraints and improvisational practices. Data collection was guided by a structured observation protocol adapted from the engineering design process framework (Sung & Kelley, 2022). This protocol focused on instructional strategies for fostering creativity despite material limitations and teacher-student interactions during open-ended tasks. It also captured instances of improvisation and critical pedagogical moments requiring immediate decision-making. Complementary field notes documented environmental factors such as equipment availability and classroom layout to provide deeper contextual depth.

3.3.2 Semi-Structured Interviews with Stimulated Recall

Twelve semi-structured interviews were conducted across three phases, to access the three temporal dimensions of teacher agency:

Phase 1: Explored teachers' professional backgrounds, training histories, and future-oriented visions for technology education. Sample questions included: "How has your professional training and past teaching experiences shaped your current approach to fostering creative thinking?" and "What are your long-term goals for students' development in technology education?"

Phases 2 and 3: Utilized stimulated recall methodology (Lyle, 2003), an introspective research technique that involves presenting participants with vivid prompts to evoke their memories of an original scenario. This methodology consists of two primary elements: objective information sources to aid participant recall and qualitative interviews examining the recalled events. During stimulated recall sessions, teachers viewed video segments of their own lessons to articulate in-the-moment decision-making and cognitive processes (practical-evaluative dimension), responding to prompts such as: "What were you thinking at this moment?", "What influenced this instructional decision?", "How did you navigate the gap between what you wanted to do and what was possible with available resources?", and "If you could redesign this lesson with unlimited resources, what would you change?" To minimize memory decay and enhance validity, all stimulated recall interviews were conducted within 24 hours of the recorded lessons.

All interviews were conducted in Vietnamese, audio-recorded, and transcribed verbatim. To ensure linguistic validity, 20% of transcripts were back-translated by

a bilingual education researcher, with discrepancies resolved through consensus discussion.

3.4 Data Analysis

Data analysis proceeded iteratively alongside data collection, allowing findings to inform subsequent interviews and observations. The analytical process followed the thematic framework of Braun and Clarke (2006). Data were primarily analyzed deductively, guided by Priestley et al. (2015) ecological model of teacher agency. All transcripts, field notes, and artifacts were imported into NVivo 14 software to facilitate systematic coding and theme development. Data was coded deductively based on Priestley et al. (2015) three dimensions, with additional inductive codes for emergent improvisation strategies.

Data from the three sources were triangulated through cross-case comparison matrixes that mapped themes across participants and data types. For instance, improvisational strategies identified in video observations were corroborated with teachers' articulated decision-making in interviews and evidenced in student artifacts. Contradictions or discrepancies were flagged for deeper analysis and explored in subsequent member-checking discussions.

To ensure reliability, two researchers independently coded 30% of the dataset, achieving substantial inter-coder reliability (Cohen's $\kappa = 0.82$). The remaining 70% was coded by the lead researcher and cross-verified through regular team meetings and analytic memos to challenge and refine interpretations. To enhance trustworthiness, member-checking was conducted with all four participants, who reviewed preliminary findings and provided feedback on interpretations. Their insights led to refinements in how improvisation was conceptualized as a mechanism of agency rather than merely a coping strategy. Additionally, an audit trail documenting coding decisions, analytical memos, and theme development was maintained throughout the study to ensure dependability and confirmability (Nowell et al., 2017).

4. Results and Findings

The findings reveal that teacher agency in technology education is enacted primarily through improvisation within resource-constrained environments. Analysis through Priestley et al.'s (2015) ecological framework illuminates three interrelated dimensions, each revealing distinct patterns of agency enactment. We triangulated data from eight lesson plans, eight classroom observations, and twelve interviews. We present findings organized into three dimensions: iterational, practical-evaluative, and projective, followed by a synthesis of cross-cutting patterns.

4.1 The Iterational Dimension: Persistence of Traditional Structures

In machining modules, for instance, learning objectives were consistently framed as identify components (n=6 plans) or explain principles (n=7 plans) rather than design solutions (n=0 plans). T2's plan exemplifies this pattern, allocating 30 of 45 minutes to textbook-based explanation with zero minutes designated for hands-on experimentation. This conservative planning reflected calculated responses to

institutional pressures rather than mere pedagogical habit. Triangulation with interview data revealed that assessment structures functioned as barriers to innovation. One teacher articulated this constraint explicitly.

> *"The district education office evaluates our effectiveness based on test scores. Last year, a creativity project worth 40% of the grade led to parent complaints because it didn't prepare students for knowledge-based university entrance exams. Now I stick to a 70-80% knowledge-based test ratio. It's a safer balance."* (T2)

Bureaucratic accountability mechanisms further reinforced this rigidity. Teacher T4 reported that her proposal to include innovation as a measurable learning objective was rejected by the vice-principal because it could not be assessed objectively. This tension between reform ideals and operational realities was further illuminated through T4's experience regarding the feasibility of design-based learning:

> *"I attended three training workshops on the new curriculum, all of which emphasized student-centered projects and creative problem-solving. But when I returned to school, reality hit me. We have 42 students per class, one computer room shared among 15 teachers, and lesson plans must be submitted two weeks in advance for approval. Last semester, I designed a prototype-building activity for electrical circuits. The equipment requisition took six weeks to process, and by then we'd already moved to the next unit. So now I teach innovation the way I was taught, through lectures and diagrams. The irony isn't lost on me, but what choice do I have?"*(T4)

T4's account illustrates how resource constraints and administrative rigidity compel even reform-minded teachers into strategic compliance. To satisfy formal reviews, teachers maintain traditional lesson plans while relegating creative pedagogy to informal classroom margins. Consequently, all participants consciously decoupled planned and enacted curricula as an essential survival strategy.

4.2 The Practical-Evaluative Dimension: Improvisation as Agency Enactment

Direct observations confirmed severe resource deficits: in seven of the eight sessions, essential equipment specified in the curriculum (e.g., CNC machines, Arduino kits) was entirely absent. Rather than abandoning pedagogical objectives, teachers employed adaptive pedagogical substitutions, pivoting from skills-based fabrication to conceptual design processes. This transition toward alternative instructional modalities occurred in six instances: design thinking and ideation (n=4), digital simulation (n=2), and peer-learning rotations (n=1). The case of T1 exemplifies this pattern. His formal plan mandated "explain machining operations and demonstrate lathe use." However, observation revealed a fundamental reframing of this objective:

> *Students were not passively watching videos as planned; instead, they actively engaged in animated mind-mapping of waste collection challenges and critiqued designs using recycled materials. T1 circulated, prompting: "How would you test if this design reduces worker strain?* (Observation field note, T1)

When questioned during the stimulated recall interview about this substantial deviation from his submitted lesson plan, T1 provided insight into his decision-making process:

> "*I couldn't just lecture for 45 minutes; these students need to do something, not just listen. So I grabbed some cardboard from the recycling bin and markers from my desk. Within five minutes, we pivoted to design thinking. The students actually engaged more deeply than they would have with the lathe. But here's the thing: I would never write that in my official plan. If inspectors see 'cardboard and markers' instead of CNC equipment, they'll flag it as substandard teaching, even though the learning outcomes were arguably better.*" (T1)

This candid reflection exposes the hidden pedagogical labor teachers perform to reconcile policy expectations with classroom realities. T1's improvisation was not spontaneous but drew upon professional knowledge. This shift from fabrication to ideation illustrates a deliberate effort to bypass material barriers while maintaining alignment with engineering mindsets. Similarly, T3's observed lesson on electronic circuits demonstrated comparable adaptability. Despite the absence of Arduino kits, T3 organized students into collaborative groups using Tinkercad simulations:

> *Students actively troubleshot virtual circuit failures, debating complex voltage calculations and component placements. T3 intervened during these moments, prompting them with critical questions: 'What happens if you increase the resistance here? In what ways does that specific change affect the overall integrity of your design?* (Observation field note, T3)

Stimulated recall interviews confirmed that these substitutions were enacted in the moment and deliberately omitted from formal documentation. As T2 noted during stimulated recall:

> "*The plan is for administration; the real teaching happens when I'm reading the room.*"

4.3 The Projective Dimension: Sustained Aspirations Through Adaptive Practice

Despite daily constraints navigating material scarcity and institutional rigidity, interviews revealed that teachers maintained a strong projective orientation toward transforming student mindsets. All four participants articulated pedagogical visions that transcended rote memorization, focusing instead on Industry 4.0 competencies and adaptive problem-solving. T1's reflection exemplifies this future-oriented stance:

> "*Vietnam is moving rapidly toward Industry 4.0, so students must learn to design and innovate with these advanced technologies rather than just operating machines. My ultimate goal is preparing them for future jobs that don't exist yet and solving complex problems we cannot currently imagine.*" (T1)

This projective dimension was consistent across participants. T3 emphasized "engineering thinking over technical skills," while T4 sought to develop "students

who see technology as a tool for community improvement, not just exam content." Critically, these aspirations were not merely rhetorical; they actively shaped the moment-to-moment pedagogical decisions documented during stimulated recall. For instance, when T2 justified his pivot to collaborative Tinkercad simulations in the absence of physical Arduino kits, he explicitly referenced long-term objectives:

> "*Even if my students never have the opportunity to touch a real circuit board in this class, they are fundamentally learning to think like engineers by troubleshooting complex problems, iterating on their designs, and collaborating effectively. Ultimately, that cognitive mindset matters far more than the hardware itself.*" (T2)

However, the sustainability of this agency remains precarious. Three teachers expressed concerns that without institutional recognition, their projective efforts risked exhaustion. As T4 noted:

> "*I can keep improvising, but how long before I burn out? The system rewards test scores, not the creativity I'm trying to build.*"

5. Discussion

This study examined how Vietnamese Ttechnology teachers enact agency to foster creative thinking within the constraints of the General Education Program. Drawing on Priestley et al. (2015) ecological model, it explored temporal dimensions of agency (RQ1), improvisation as an agency mechanism (RQ2), and how constraints shape transformative practice (RQ3). Findings reveal teacher agency as a situated achievement accomplished through strategic improvisation. This section synthesizes key findings, situates them within existing literature, and discusses implications for policy and practice.

5.1 The Ecological Achievement of Agency in a Transitioning System

The iterational dimension, shaped by teachers' professional histories, profoundly influences contemporary practice. Aligned with Dinh and Sannino (2024) and Le et al. (2021) this study confirms that Vietnamese teachers' training emphasized technical precision and procedural adherence over creative exploration. Teachers must actively work against ingrained habits to embrace student-centered, creativity-focused approaches. Instead of passive policy implementation, technology teachers exercised agency by strategically adapting the curriculum.

Similar patterns of professional agency have been documented among English educators (Le et al., 2021), suggesting that this phenomenon transcends disciplinary boundaries. This convergence validates the ecological model's applicability within Vietnam's educational landscape while highlighting systemic challenges that affect teachers across subjects (Dinh & Sannino, 2024). Within this environment, the projective dimension sustained teachers' commitment despite persistent obstacles. Teachers positioned technology education as essential preparation for Industry 4.0, aligning their discipline with Vietnam's economic modernization goals. This future-oriented mindset motivated continued innovation even when immediate conditions proved discouraging (Dinh & Sannino, 2024).

These three dimensions operated interdependently rather than sequentially. Teachers drew on iterational knowledge to inform improvisational strategies, employed practical-evaluative judgment to navigate present constraints, and sustained effort through projective commitment to reform ideals. This temporal integration reveals agency as an ongoing ecological achievement requiring simultaneous engagement with past, present, and future. Such a process is particularly complex within transitioning educational systems, where reform mandates often collide with established structures and limited resources.

5.2 Distinctive Challenges in Technology Education

Technology teachers in Vietnam face distinctive challenges rooted in material constraints. Unlike language instruction, which depends primarily on pedagogical approaches, technology education requires physical infrastructure such as maker spaces, CNC machines, Arduino kits, and fabrication equipment (Le et al., 2025). The absence of these resources directly undermines hands-on making and physical prototyping, rendering certain learning experiences impossible rather than difficult. This materiality barrier severely restricts the practical-evaluative dimension of teacher agency (Dinh & Sannino, 2024).

The material constraints force Vietnamese technology teachers to fundamentally shift from physical fabrication to conceptual ideation. They substitute digital simulations for physical experiments, cardboard models for machined prototypes, and visualization software for actual hardware programming. This contrasts sharply with well-resourced international contexts where adequate facilities allow students to build, test, and refine prototypes repeatedly (van Breukelen, 2022). This disparity reflects broader global inequalities in educational infrastructure, especially in developing nations that pursue curriculum reforms without adequate funding (Le et al., 2021; To et al., 2024).

Technology education also suffers from institutional marginalization within Vietnam's examination-oriented culture. As a non-examination subject, technology education receives limited resource allocation, often relegated to inadequate spaces (Le et al., 2021; Vu et al., 2024). The noise and physical activity inherent in design-based learning are frequently misconstrued by administrators as classroom disorder (Dinh & Sannino, 2024; Le et al., 2021). This cultural positioning undermines teachers' professional identity and complicates efforts to implement cognitively demanding design projects.

The interaction between materiality barriers and institutional marginalization produces a distinctive ecology of constraint specific to technology education in Vietnam (Le et al., 2021). Teachers must simultaneously improvise pedagogical alternatives to missing equipment while advocating for their discipline's relevance within examination-focused schools. This dual challenge remains under-theorized in literature on both Vietnamese educational reform and international Technology education (Dinh & Sannino, 2024; To et al., 2024).

5.3 From Fabrication to Ideation: Improvisation as Ontological Redefinition

This study's key finding is that technology teachers enact agency through improvisation that fundamentally transforms their discipline. Beyond routine

adaptation (Sawyer, 2021), improvisation reshapes the core of technology education, especially when resources are limited. Without machinery, teachers shifted from skills-based fabrication to design-led ideation, prioritizing engineering mindsets over traditional technical production (Sung & Kelley, 2022). This represents a fundamental redefinition rather than simple pedagogical adaptation. Teacher T2 centered his curriculum on the engineering design process, emphasizing conceptual ideation and digital simulation over physical construction (Le et al., 2025; To et al., 2024). Teachers reframed this approach as legitimate engineering education, prioritizing cognitive processes over fabrication outcomes rather than viewing it as inadequate (Sung & Kelley, 2022).

Applying Priestley et al.'s (2015) ecological framework, this finding suggests that the practical-evaluative dimension is a constitutive force in agency rather than a mere mediator. While resource-abundant contexts allow selection among pedagogical options (To et al., 2024; Truong & Tran, 2025), resource-scarce environments require creating new possibilities. For instance, substituting cardboard for CNC machining represented a transformative innovation. It was a strategic shift rather than a mere workaround (Maluleke & Gumbo, 2022). Thus, teacher improvisation generated novel forms of technology education rather than merely compensating for limitations.

This transformation operates through pedagogical translation, which preserves learning objectives while fundamentally changing learning activities (Dinh & Sannino, 2024). Teachers maintained essential engineering competencies such as systems thinking, constraint-based design, and iterative problem-solving while completely transforming the pedagogical vehicles for developing them. The cognitive demands of engineering design persisted while circumventing material constraints.This pedagogical translation required sophisticated professional knowledge. It integrated disciplinary understanding, pedagogical content knowledge, and contextual awareness (Saharuddin et al., 2025).

Material constraints enabled teachers to foreground cognitive dimensions of engineering that might be overshadowed in well-equipped contexts focused primarily on fabrication outcomes (Sung & Kelley, 2022). When physical making dominates, learning sometimes reduces to procedural skill development. Vietnamese teachers instead emphasized design thinking itself: collaborative ideation, constraint analysis, and design justification. This aligns with contemporary emphases in engineering education on computational thinking and engineering habits of mind that transcend specific tools or materials (Le et al., 2025). Although born from necessity, this approach aligns with current international thinking in engineering education. This suggests that resource constraints can produce pedagogically sound alternatives, not merely inferior substitutes.

These findings necessitate reconceptualizing improvisation within teacher agency theory. Previous research has treated improvisation as adaptive response (Sawyer, 2021), but this study reveals it as constitutive practice that reshapes disciplinary frameworks themselves. When Vietnamese technology teachers

improvised pedagogical alternatives to fabrication, they redefined technology education itself: its core activities, competencies, and purposes. This suggests that teacher agency theories developed in well-resourced contexts may require expansion to account for agency in global south educational settings.

5.4 Toward a Theory of Agency Under Scarcity

Teacher agency under scarcity operates through three interrelated mechanisms. The first mechanism is strategic decoupling, where teachers created implementation space by performing surface compliance with policy directives while innovating in practice (Ogwang, 2023). The second is ontological improvisation, where teachers fundamentally redefined their discipline to overcome material barriers, transcending tactical adaptation to reshape disciplinary identity itself. The third is cultural navigation, where teachers actively repositioned Technology education's institutional status by leveraging creative projects to demonstrate engineering thinking's value for Industry 4.0 preparation (To et al., 2024).

These mechanisms operated interdependently to produce an ecology of constrained creativity (Anderson et al., 2022). Strategic decoupling provided institutional space for innovation, which ontological improvisation filled through transformed practices. Cultural navigation reinforced this process by sustaining commitment and legitimacy amidst persistent challenges (Vu, 2020). Within this framework, the three temporal dimensions of agency functioned as interconnected resources: iterational knowledge provided foundations for improvisational strategies, projective visions motivated strategic risk-taking, and practical-evaluative judgments balanced immediate constraints with long-term aspirations (Anderson et al., 2022).

This perspective reveals that teacher agency in resource-scarce contexts is fundamentally different from agency in well-resourced settings (Groenewald & Arnold, 2025; Ogwang, 2023). Rather than choosing among available pedagogical options, teachers in constrained contexts engaged in ongoing creative problem-solving to generate viable alternatives. Rather than directly enacting reform mandates, they navigated contradictory institutional demands through strategic performances of compliance combined with innovation. Agency under scarcity is thus more creative, more precarious, more politically complex, and more transformative (Colicol et al., 2025; Tran, 2019).

6 Implications and Limitations

6.1 Theoretical Implications

This study makes three significant theoretical contributions. First, it conceptualizes "agency under scarcity" as a distinct phenomenon where practical-evaluative dimensions predominate. This suggests that the ecological framework (Priestley et al., 2015) requires re-contextualization for global south settings. Second, it reconceptualizes improvisation from routine adaptation to constitutive practice that can redefine disciplinary ontologies, shifting technology education from fabrication to ideation. This "ontological improvisation" challenges deficit narratives positioning developing-country teachers as mere implementers. Third,

viewing strategic decoupling as professional judgment refines policy enactment theory, highlighting that fidelity-based models often mistake creative adaptation for non-compliance.

6.2 Practical Implications

These findings have practical implications across three levels. At the policy level, curriculum reforms mandating innovation require commensurate infrastructure investment and explicit guidance for resource-scarce scenarios. For teacher education, strategic improvisation should be taught as a core competency. At the school level, administrators should recognize improvisation as professional judgment. Practically, this means replacing rigid compliance with adaptive lesson documentation and flexible evaluation criteria that prioritize pedagogical intent over material availability. Finally, schools should streamline equipment access and showcase technology education's value through community engagement.

6.3 Limitations

The four-participant sample, while providing qualitative depth, limits transferability across diverse Vietnamese contexts. The four-month timeframe captured practice snapshots rather than longitudinal trajectories, leaving questions about improvisation sustainability and career-stage evolution unanswered. Findings derive from Technology education where material constraints are particularly salient; generalizability to less resource-dependent subjects requires empirical verification. The study focused on teacher perspectives with limited examination of student learning outcomes.

6.4 Future Research Directions

Future research should pursue two directions to address current limitations. First, there is a need to expand the sample size through longitudinal and cross-disciplinary studies. This approach will clarify how agency evolves over time and test the framework across different subjects. Second, intervention research should be conducted to evaluate professional development programs for teacher improvisation. Testing these models in diverse settings would establish a robust framework for agency under scarcity that is transferable to other developing nations.

7. Conclusion

This study reveals that teacher agency in Vietnamese technology education operates through tactical navigation. Resource constraints reshape temporal dimensions of agency. While lesson plans dedicate a significant majority of time to teacher explanation for exam accountability, this compliance enables innovation within institutional margins. Frequent equipment shortages forced the majority of teachers to pivot toward conceptual design and modular projects. These undocumented improvisations demonstrate a strategic decoupling of planned and enacted curricula. This research extends ecological agency theory by conceptualizing constrained creativity, where improvisation drives change. Teachers exercise agency by exploiting structural gaps rather than achieving autonomy. However, this reliance on individual resilience creates a systemic paradox. While ingenuity maintains the facade of reform, sustainable

transformation requires shifting from individual effort to systemic support. Vietnam must provide material resources and re-evaluate Technology education within its exam-driven landscape.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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