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# Tinkering and Visible Thinking: Learning Environments as Cognitive Devices

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**Abstract:** This paper explores the theoretical and methodological potential of integrating Tinkering and Making Learning and Thinking Visible (MLTV) in the design of flexible learning environments. These environments are conceptualized as dynamic educational ecologies in which space, materials, and pedagogical practices interact to support active, reflective, and situated learning. Tinkering is interpreted as an epistemic and pedagogical practice grounded in exploration, material manipulation, productive failure, and iterative redesign, where making functions as a form of thinking and materials act as cognitive and relational mediators.
Within this framework, the MLTV approach foregrounds the documentation and visibility of thinking through reflective routines, multimodal artifacts, and shared narratives, transforming learning processes into observable, interpretable, and revisitable traces. Drawing on a critical review of the literature, the paper argues that flexible learning environments cannot be defined solely by spatial configurations, but by their capacity to activate learner agency, metacognition, collaboration, and inquiry.
Anchored in a Deweyan conception of experience, the contribution frames learning environments as cognitive and pedagogical devices that shape action and reflection. The integration of Tinkering and MLTV is discussed as a design-oriented framework for inclusive educational contexts, highlighting implications for educational design, documentation practices, and formative assessment, while outlining directions for future empirical research.

**Keywords:** Tinkering; Visible Thinking; Learning Environments.



## 1. Introduction

In recent years, educational research has increasingly emphasized the role of flexible learning environments in supporting meaningful, active, and situated learning processes. These environments are no longer understood merely as reconfigurable physical spaces, but as cognitive, cultural, and relational devices that shape learners' actions, interactions, and opportunities for participation. From this perspective, the learning environment is not a neutral backdrop for educational activity, but a constitutive element of the learning experience itself.

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Within this framework, Tinkering can be conceptualized as an epistemic and pedagogical practice that foregrounds exploration, material manipulation, productive failure, and iterative redesign as central mechanisms of knowledge construction. Rooted in the constructionist tradition introduced by Papert (1980), Tinkering frames making as a form of thinking, emphasizing the role of artifacts and materials as mediators of cognitive, social, and dialogic processes. Learning emerges through hands-on engagement, hypothesis testing, and continuous adjustment, rather than through linear transmission of predefined content.

Alongside Tinkering, the Making Learning and Thinking Visible (MLTV) approach provides a complementary methodological perspective focused on the externalization and documentation of thinking processes. Developed within the Project Zero research tradition, MLTV emphasizes the use of thinking routines, reflective dialogue, and multimodal documentation to render learning processes observable, interpretable, and shareable (Ritchhart, Church, & Morrison, 2011; Ritchhart, 2015). Making thinking visible supports metacognition, learner agency, and the development of shared cultures of inquiry.

Drawing on Dewey's (1938) conception of experience, this contribution adopts a view of learning environments as active participants in educational experience, capable of shaping inquiry and reflection. In this sense, the integration of Tinkering and MLTV offers a design-oriented framework for flexible learning environments in which making, thinking, and documentation are interconnected. The paper explores this integration as a pedagogical approach that supports agency, reflection, and inclusive participation, contributing to current debates on educational design and learning environments.

## 2. Tinkering as an Epistemic and Pedagogical Practice

Tinkering can be conceptualized as an epistemic and pedagogical practice that foregrounds the relationship between action, cognition, and meaning-making, positioning *making* as a central mode of knowing. Rather than being reduced to an informal or ancillary activity, tinkering represents a way of engaging with knowledge through exploration, manipulation, and iterative redesign, in which understanding emerges from sustained interaction with materials, tools, and contexts. This perspective challenges transmissive models of instruction by emphasizing learning as an active, situated, and generative process.

From a theoretical standpoint, tinkering is grounded in constructionist and design-based views of learning, which stress the importance of creating tangible artifacts as a means of externalizing and refining ideas. While early constructionist work highlighted the cognitive value of artifact construction, more recent scholarship has emphasized the epistemic role of *processes* such as experimentation, productive failure, and revision. In tinkering activities, knowing is not separated from doing; rather, it unfolds through cycles of action and reflection in which hypotheses are tested against material constraints and possibilities (Resnick, 2017).

A defining feature of tinkering lies in the epistemic function of materials. Materials are not neutral carriers of predefined meanings, but active mediators that shape perception, reasoning, and interaction. Their affordances invite particular forms of engagement, prompting learners to explore alternatives, negotiate constraints, and develop situated understandings. In this sense, materials participate in cognition by

making certain ideas possible and others problematic, supporting forms of reasoning that are embodied, exploratory, and context-sensitive. Research on maker-centered learning highlights how engagement with physical and digital materials supports conceptual development by linking abstract ideas to concrete actions and representations (Blikstein, 2013).

Tinkering is also characterized by a distinctive stance toward error and uncertainty. Rather than being treated as obstacles to learning, breakdowns, unexpected outcomes, and partial solutions are integral to the learning process. These moments generate opportunities for inquiry, interpretation, and redesign, fostering adaptive expertise and epistemic agency. Learners are encouraged to take responsibility for their learning trajectories, making decisions, revising strategies, and reflecting on the consequences of their actions. Such practices align with contemporary perspectives on agency in learning, which emphasize learners' capacity to shape both processes and outcomes of learning within given contexts (Engeström, 2015).

From a pedagogical perspective, tinkering gains particular relevance in relation to the design of flexible learning environments. Tinkerable contexts do not prescribe linear pathways or uniform solutions; instead, they support openness, variability, and multiple entry points. This flexibility allows learners with different backgrounds, interests, and modes of engagement to participate meaningfully, making tinkering especially compatible with inclusive and learner-centered approaches. Studies in maker education and learning sciences suggest that such environments foster collaboration, dialogue, and shared problem-solving, while also supporting individual exploration and self-regulation (Honey & Kanter, 2013).

Within educational settings, tinkering thus functions not merely as a method, but as a pedagogical orientation that redefines the roles of learners, teachers, and environments. Teachers act as designers of conditions for exploration rather than transmitters of knowledge, while environments are conceived as dynamic systems that support inquiry, experimentation, and reflection. This orientation provides a robust foundation for integrating tinkering with methodologies aimed at making learning processes visible and interpretable, setting the stage for a deeper analysis of how thinking can be documented and shared within flexible learning environments.

## 3. Making Learning and Thinking Visible: Documentation, Metacognition and Agency

The Making Learning and Thinking Visible (MLTV) approach provides a methodological and pedagogical framework that complements tinkering by focusing on the explicit articulation, documentation, and interpretation of thinking processes. While tinkering foregrounds learning through action and material engagement, MLTV addresses a critical epistemic challenge: how thinking that emerges through doing can be made accessible, discussable, and transformable within educational settings. In this sense, MLTV does not oppose hands-on learning, but deepens it by rendering cognitive processes visible and available for reflection.

At the core of MLTV lies the assumption that thinking is not a purely internal or private activity, but a socially mediated process that can be externalized through language, artifacts, and shared practices. Research on visible thinking emphasizes that learning is strengthened when learners are supported in making their reasoning explicit, revisiting their ideas, and engaging in dialogue around emerging understandings.

Rather than focusing exclusively on outcomes, MLTV shifts attention toward processes of sense-making, interpretation, and conceptual change, aligning with contemporary views of learning as iterative and non-linear (Ritchhart, 2020).

A central component of MLTV is the use of documentation as an epistemic practice. Documentation is not conceived merely as a record of activity, but as a tool for inquiry that supports noticing, interpretation, and meaning-making. Through written reflections, visual representations, photographs, diagrams, and material artifacts, learning processes are transformed into traces that can be revisited and reinterpreted over time. This process enables learners to develop metacognitive awareness by reflecting on how their ideas evolve, while also supporting teachers in understanding learners' thinking beyond observable performance (Knaflic, 2017).

MLTV is closely connected to the cultivation of cultures of thinking, understood as learning environments in which curiosity, questioning, and reflection are systematically valued. In such cultures, pedagogical routines function as scaffolds that make expectations about thinking explicit and sustain continuity across learning experiences. These routines do not prescribe specific answers, but structure opportunities for learners to reason, connect ideas, and articulate emerging understandings. From this perspective, visible thinking practices operate as design elements that shape participation and agency rather than as add-on strategies (Ritchhart & Perkins, 2008).

When integrated with tinkering practices, MLTV plays a crucial role in bridging making and meaning. The material interactions characteristic of tinkering generate rich, often tacit forms of knowing that risk remaining ephemeral if not documented and discussed. MLTV addresses this risk by providing conceptual and methodological tools for capturing the trajectories of thinking that unfold through experimentation and redesign. Documentation practices enable learners to connect actions with intentions, outcomes with interpretations, and individual insights with collective understanding.

Moreover, the integration of MLTV supports learner agency by positioning learners as authors and interpreters of their own learning processes. By engaging in documentation and reflection, learners gain greater control over how their thinking is represented and shared, contributing to a sense of ownership and responsibility. This orientation aligns with inclusive pedagogical approaches that value variability in expression and recognize multiple ways of demonstrating understanding (Meyer, Rose, & Gordon, 2014).

In this framework, MLTV can be understood as a pedagogical lens that amplifies the epistemic potential of tinkering. While tinkering emphasizes learning through action, MLTV ensures that such action becomes an object of reflection, dialogue, and transformation. Together, these approaches lay the groundwork for conceptualizing learning environments as cognitive and pedagogical systems in which thinking is both enacted and made visible.

## 4. Flexible Learning Environments as Cognitive, Spatial and Pedagogical Systems

The growing attention to flexible learning environments reflects a broader shift in educational research toward understanding learning as an emergent, situated, and relational process. Rather than being conceived as neutral containers for instructional activities, learning environments are increasingly framed as systems that actively shape

cognition, interaction, and participation. This perspective aligns with ecological and sociomaterial approaches to learning, which emphasize the interdependence between learners, tools, spatial arrangements, and pedagogical practices.

Flexibility, in this sense, cannot be reduced to the physical reconfiguration of space alone. While movable furniture, modular layouts, and access to diverse materials are important, flexibility primarily concerns the capacity of environments to support multiple forms of engagement, expression, and participation. Research on learning spaces highlights that environments become educationally meaningful when they allow learners to navigate between individual and collective work, experimentation and reflection, action and documentation (Oblinger, 2006). Such environments are designed to accommodate variability rather than uniformity, enabling diverse learning trajectories to emerge.

From a cognitive perspective, learning environments can be understood as distributed systems, in which thinking is not confined to individual minds but unfolds across interactions with artifacts, peers, and spatial configurations. Sociocultural and distributed cognition theories suggest that tools, representations, and spatial arrangements participate in cognitive activity by shaping what can be perceived, thought, and done (Kirsh, 2013). Within flexible environments, materials and spatial affordances guide attention, invite exploration, and scaffold problem-solving, making the environment itself an active component of the learning process.

The integration of tinkering and visible thinking practices further qualifies flexible learning environments as pedagogical systems oriented toward inquiry and reflection. Tinkering introduces openness, experimentation, and design-oriented action, while MLTV provides structures for documenting and interpreting emerging thinking. Together, these approaches transform learning environments into spaces where action is continuously linked to reflection, and where learning processes are rendered visible and discussable. This integration supports the development of metacognitive awareness and collective sense-making, strengthening the epistemic quality of learning experiences.

Flexible learning environments also play a crucial role in fostering learner agency and inclusion. By offering multiple entry points, modes of participation, and representational possibilities, such environments reduce barriers to engagement and support learners with diverse backgrounds, abilities, and preferences. Studies on inclusive learning design emphasize that environments promoting choice, adaptability, and transparency contribute to a sense of ownership and belonging, enabling learners to position themselves as active participants in knowledge construction (Benade, 2019). In this way, flexibility becomes a pedagogical principle rather than a spatial feature.

From a design perspective, conceiving learning environments as cognitive and pedagogical systems requires educators to adopt a design-oriented stance. Teachers are called to orchestrate conditions for learning by aligning space, materials, documentation practices, and social norms. This involves ongoing processes of observation, adjustment, and redesign, in which environments evolve in response to learners' needs and emerging practices. Such an approach resonates with contemporary views of educational design as an iterative and reflective process, rather than the implementation of fixed instructional models.

In conclusion, flexible learning environments can be understood as ecologies for learning in which space, action, and thinking are deeply intertwined. When informed by tinkering and visible thinking practices, these environments support inquiry,

agency, and inclusion, laying the groundwork for educational experiences that are both generative and reflective. This conceptualization prepares the terrain for discussing the broader pedagogical implications of integrating tinkering, documentation, and flexible design in contemporary educational contexts.

## 5. Implications for Educational Design and Future Research

This paper has examined the integration of Tinkering and Making Learning and Thinking Visible (MLTV) as a coherent design-oriented framework for flexible learning environments, understood as dynamic systems in which action, thinking, space, and documentation are deeply interconnected. By bringing together hands-on, design-based practices with structured approaches to the visibility and interpretation of thinking, the analysis has highlighted how learning can be conceptualized as an emergent, situated, and participatory process rather than as the linear acquisition of predefined content.

Across the three analytical dimensions explored tinkering as an epistemic practice, MLTV as a methodological lens, and learning environments as cognitive and pedagogical systems the paper has emphasized the central role of experience, agency, and reflection. Tinkering foregrounds learning through exploration, experimentation, and iterative redesign, positioning materials as active mediators of cognition. MLTV complements this perspective by ensuring that the thinking generated through action is documented, interpreted, and shared, transforming ephemeral experiences into durable traces for reflection and dialogue. Flexible learning environments, in turn, provide the conditions under which these processes can unfold in inclusive and generative ways.

From a pedagogical standpoint, conceiving learning environments as tinkerable and documenting spaces has significant implications for educational design. Such environments invite educators to move beyond prescriptive instructional models and to adopt a design stance oriented toward openness, adaptability, and responsiveness. Teachers are called to orchestrate spaces, materials, routines, and documentation practices in ways that support multiple learning trajectories, value learner variability, and foster metacognitive awareness. In this sense, flexibility emerges not as a purely spatial feature, but as a pedagogical principle that informs decisions about participation, representation, and assessment.

The integration of Tinkering and MLTV also contributes to inclusive educational practices by expanding the range of ways in which learners can engage with content, express understanding, and participate in knowledge construction. Documentation practices make learning processes visible and accessible, supporting formative assessment and reflective dialogue while reducing barriers linked to dominant modes of expression. This orientation resonates with contemporary frameworks that emphasize learner-centered design and the ethical responsibility of educational environments to accommodate diversity (Meyer, Rose, & Gordon, 2014).

Looking ahead, further research is needed to explore how this integrated framework can be enacted across different educational contexts and levels. Empirical studies could investigate how tinkering and visible thinking practices shape classroom interactions, learner agency, and teachers' design decisions over time. Particular attention should be given to teacher education and professional development, examining how educators learn to design, observe, and iteratively refine flexible learning

environments. In this direction, the integration of tinkering, documentation, and environmental design offers a promising pathway for rethinking contemporary educational practices in ways that are both innovative and theoretically grounded.

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