MPOWERME, LLC (Pediatric OT & SLP Services)
Play To Do™ (Education Consulting • Toy/STEAM Design • Research)
OT-Informed Project-Based Learning for Inclusive K–5 Classrooms

Warm-Up Effects & Engineering Readiness Analysis

Introduction: The Role of Warm-Ups in OT-Informed PBL

Warm-ups prepared students cognitively, physically, emotionally, and socially for hands-on engineering. These predictable routines reduced cognitive load and supported foundational executive function skills. Warm-ups introduce material behavior, connector logic, and structural reasoning. Gains represent motor-planning, engineering decision-making, and cognitive–motor integration.

What Warm-Ups Target: Foundations of Cognitive & Engineering Readiness

1. Material Fluency: Students explored tools, connectors, cardboard.
2. Motor Planning: Sequencing, bilateral coordination, alignment.
3. Part Discrimination & Structural Logic: Connector selection, angle testing, predicting outcomes.
4. Emotional & Cognitive Regulation: Supported smoother transitions into collaborative tasks.

Quantitative Findings: Warm-Up Gains Across Sessions

Warm-ups enhanced readiness, fluency, frustration tolerance, and independence across sessions.

Zoo Engineering Pilot - Key Findings

- +1.06 average growth within Session 1 (Warm-Up 1 → Warm-Up 2)
- Continued growth from Warm-Up 2 → Session 2
- Combined Material Fluency increased steadily

Engineering Reasoning Gains

Students demonstrated increasing connector logic, anticipatory planning, strategic reinforcement, and use of engineering vocabulary.

Zoo Pilot used the 3DuxDesign Zoo Challenge Materials – visit https://www.3duxdesign.com/
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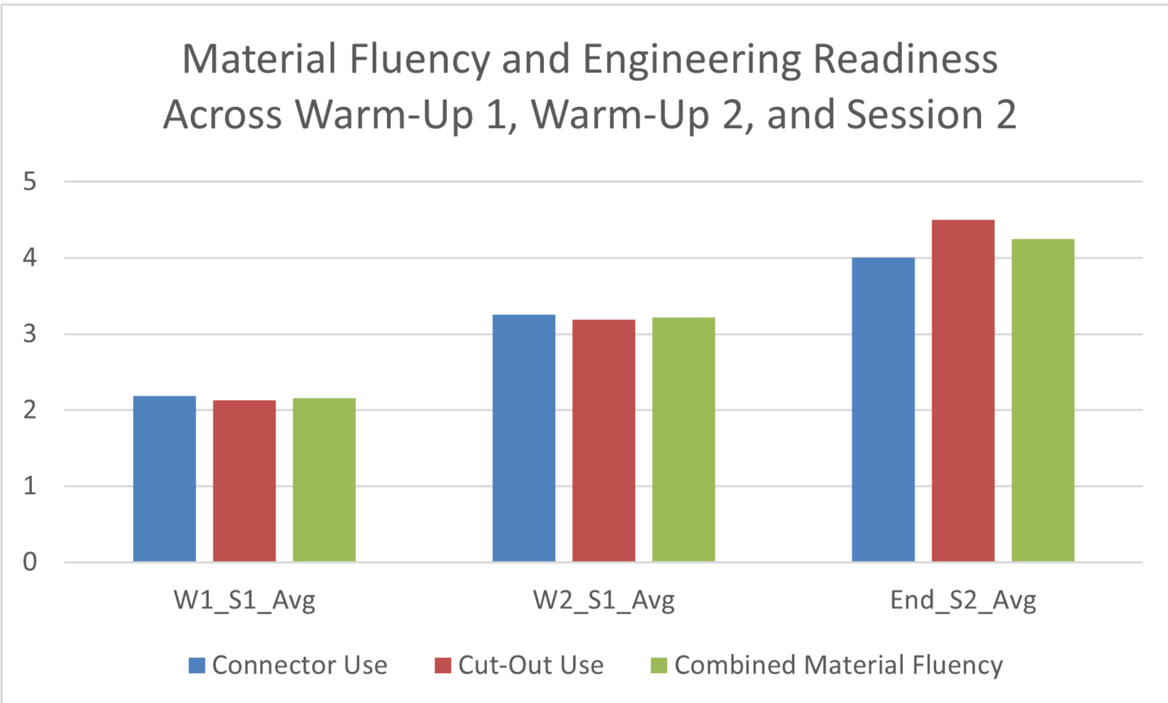
Graph 1 — Material Fluency Across W1, W2, and S2



Children showed significant gains in connector use, cut-out use, and overall material fluency within the 60-minute session that comprised of Warm-Up 1 to Warm-Up 2, demonstrating immediate improvements in motor planning, part selection, and structural decision-making. Continued growth from Warm-Up 2 to the end of Session 2 indicates that these early warm-up routines not only reduced initial frustration but also strengthened engineering readiness, enabling children to enter the main PBL challenge with greater confidence, efficiency, and problem-solving capacity.

Executive Function, SEL & Readiness Gains

Warm-ups strengthened task initiation, working memory, flexibility, and self-regulation.

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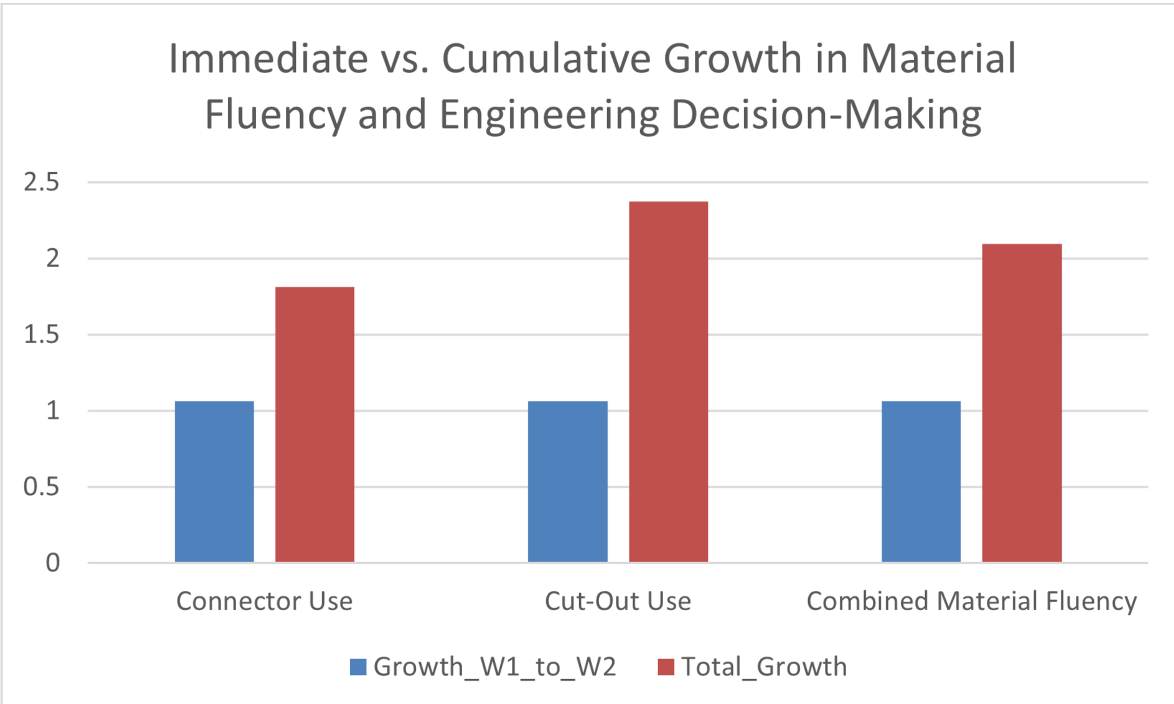
Graph 2 — Immediate vs. Cumulative Growth



This graph shows how quickly children improved during the warm-up segment (blue bars) and how much additional growth occurred after engaging in the full PBL experience (red bars). Children demonstrated strong "within-session" improvement in connector use, cut-out use, and combined material fluency during Warm-Up 1 → Warm-Up 2, meaning they quickly learned how the materials worked and which pieces to select for specific structural purposes. The larger cumulative gains from Warm-Up 1 → Session 2 indicate that warm-ups primed children for deeper learning, leading to more confident engineering decisions and increased efficiency during the main build sessions.

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Warm-Up vs Main Task Trends (Qualitative Summary Table)

Skill Domain	Observable Warm-Up Trends	Observable Main Task Trends	Interpretation
Material Fluency	Comfort handling materials and selecting connectors.	Increased independence and efficiency during building.	Warm-ups built fluency that transferred into confident engineering.
Motor Planning	Smoother sequencing of tool-use actions.	More coordinated, intentional movements.	Rehearsal improved readiness for multi-step tasks.
Frustration Tolerance	Reduced overwhelm and easier entry.	Improved persistence and recovery from mistakes.	Warm-ups supported emotional regulation.
Spatial Reasoning	Testing angles, predicting stability, aligning pieces.	Applied in reinforcement, balance, base width decisions.	Warm-ups acted as low-stakes rehearsals.
Collaboration Readiness	Students settled and prepared for group work.	Clearer communication and better coordinated roles.	Warm-ups primed social and cognitive readiness.

Interpretation

Warm-ups increase:

• **Tool fluency:** The ability to handle materials efficiently and confidently, understanding how tools and components behave, fit together, and respond

during construction.
This includes speed, accuracy, reduced trial-and-error, and smoother execution of building steps.

• **Part discrimination:** The ability to visually and tactilely distinguish between different types of materials or components, understand their functional differences, and choose the correct one for the intended purpose.

In the Zoo pilot, this refers to children learning to differentiate things like:

Connectors

- 90° vs. 180° connectors
- 3-way vs 4-way connectors
- Connectors that produce angles vs. connectors that extend length
- Which connector provides stability vs which provides flexibility

Cut-Out Pieces

- Different lengths
- Different widths
- Solid vs perforated pieces
- Shapes optimized for structure vs detail
- Pieces that add strength vs pieces that bend or drape

Function-Based Selection

Children weren't just grabbing a connector, they were *selecting:*

- **the right part for the job**
- based on **angle**, **length**, **load**, **fit**, and **structural purpose**

This is a *cognitive engineering skill*, not a fine-motor skill.

• **Structural reasoning:** The ability to predict how materials will behave when assembled, test structural hypotheses, adjust designs after failure, and understand how shape, angle, and connection points affect strength and stability.
This reflects early engineering thinking and spatial problem-solving.

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• **Confidence:** A student's growing belief in their ability to build, problem-solve, revise, and succeed -- even when facing initial frustration or design failures. Confidence grows as children experience repeated small wins during warm-ups.

• **Readiness for EF-heavy PBL tasks:** A state in which children are cognitively and emotionally prepared to engage in high-level PBL work requiring planning, working memory, flexible thinking, teamwork, and sustained attention. Warm-ups reduce cognitive load, making these executive processes more available.

Practical Takeaways for Educators

- 5–7-minute warm-ups
- Align warm-ups with engineering challenges
- Provide material exploration time
- Maintain predictable routines
- Include reflection moments

Summary Statement

Warm-ups function as UDL-aligned entry routines that scaffold sensory, motor, and cognitive readiness. Warm-ups played a critical role in readiness and inclusion. They prepared students for engineering tasks through regulation, skill activation, and confidence-building.

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