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Making Sense of Computing: Storytelling Dioramas as a Lens for K–8 Teacher Professional Development (RTP)

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Abstract

As PK–12 computing and engineering education continues to evolve, there is an urgent need for professional development (PD) to support educators in creating culturally relevant, community-connected learning experiences, particularly in rural regions with limited access to engineering and computing resources. This study draws from prior research in culturally responsive computing, storywork, and constructionist learning to examine the implementation of a storytelling diorama activity within a rural PD program. In this program, Appalachian K–8 teachers used Hummingbird robotics kits to design interactive scenes based on personal and community narratives. These scenes, integrated with lights, sensors, and motors, were used to explore engineering and computer science (CS) concepts.

This research-to-practice study aims to address the following research questions: (1) How do Appalachian educators engage with CS and engineering concepts through culturally grounded physical computing activities? and (2) What affordances and challenges do teachers identify in connecting computing to their local context?

Data sources include teacher-created artifacts and written reflections from a one-week summer PD program in Southeastern Appalachian communities. The findings suggest that culturally rooted design experiences supported teacher sensemaking around sequencing, input/output, iteration, and user interaction. Participating educators also reported increased confidence in integrating CS and envisioned more inclusive classroom practices, while the barriers included time constraints, limited material access, and misalignment with curricular standards.

This paper contributes a replicable PD activity and analytic insights into how culturally situated making can promote CS and engineering learning in pre-college contexts. The implications of these findings for the design of PD programs, the support of rural teachers, and the future cycles of co-designed curriculum will be discussed.

I. Introduction

As computing and engineering education expands across K–12 classrooms in the United States, there is growing recognition that teacher professional development (PD) must support not only technical competencies, but also culturally responsive, community-connected pedagogies [1]. Particularly in rural and historically underserved regions such as Appalachia, educators face challenges in adapting national standards and tools to the unique cultural and material contexts of their students [2]. Many schools in these regions lack computing infrastructure, ongoing PD opportunities, or curriculum that reflects local knowledge systems - barriers that compound inequities in access to high-quality computing and computer science (CS) education.

Research in culturally responsive teaching [3, 4] and narrative learning frameworks such as Storywork [5] supports the integration of learners' lived experiences and community histories into STEM learning. However, less is known about how these frameworks translate into meaningful PD experiences for in-service teachers, particularly those without formal computer science backgrounds, who are now expected to teach CS and computational thinking (CT) in ways that are both rigorous and locally relevant.

This paper builds on our previously published work-in-progress [6] that introduced a professional development program in Southeastern Appalachian communities. We outlined the conceptual rationale, logistical design, and preliminary sentiment data from a summer workshop in which K–8 educators created storytelling dioramas using Hummingbird robotics kits to integrate CS and engineering concepts with personal or community-based narratives. While our prior work established the foundation of the PD model and highlighted initial shifts in teacher confidence and engagement, this paper extends that research by offering a deeper qualitative analysis of teacher-created artifacts and reflective narratives.

We draw on the frameworks of culturally responsive pedagogy [3, 4], community-based Storywork [5], and constructionism [7] to examine how material making, storytelling, and cultural identity intersect in teachers' engagement with CS and engineering. Through qualitative analysis of teacher reflections and photos/videos of completed dioramas, we investigate the following research questions:

- **RQ1**: How do Appalachian educators engage with CS and engineering concepts through culturally grounded physical computing activities?
- **RQ2**: What affordances and challenges do teachers identify in connecting computing to their local context?

By centering rural teachers' voices and artifacts, this Research-to-Practice (RTP) study contributes a replicable PD activity and analytic insights into how culturally situated making can serve as a powerful entry point for computing and engineering education in pre-college contexts. We argue that culturally grounded design experiences are not only technically generative but also

identity-affirming, offering critical leverage points for equitable STEM learning. This interdisciplinary approach provides a new, replicable pathway for transforming computing and CS from an external requirement into an internal, culturally relevant tool for community empowerment.

II. Scholarship

Culturally responsive pedagogy (CRP) aims to bridge this gap by rooting instructional design in students' cultural backgrounds, values, and ways of knowing [3, 4]. Rather than treating culture as a barrier to be overcome, CRP positions it as an asset, what Moll et al. termed "funds of knowledge" [8], through which learners make sense of academic content. These funds may include family narratives, local practices, and survival strategies embedded within communities.

In the context of computing education, scholars have argued that culturally responsive computing (CRC) challenges the view that CS is culture-free or purely technical [9]. Instead, it promotes the idea that students should not only learn to code, but also learn why to code, centering community relevance, empowerment, and identity development as key learning outcomes. However, most CRC research has focused on student-facing interventions. Less is known about how in-service teachers, particularly those in rural communities, can engage in culturally responsive computing as learners themselves, or how PD models can scaffold these practices effectively.

In Indigenous and place-based education, storywork functions not only as a pedagogical tool, but also as an epistemology – a way of knowing rooted in narrative, identity, and relationships [5, 10]. For educators, storytelling can serve as a cognitive scaffold for complex technical ideas. Sequencing, conditional logic, iteration, and input/output systems are naturally mirrored in story structures with cause-and-effect arcs and character interactions.

Research in narrative-based STEM learning has shown that connecting technical design to personal or community stories promotes deeper engagement, reflection, and emotional resonance [10]. In our work with Appalachian educators, we build on this approach by viewing diorama design as both a technical and cultural practice, one that enables teachers to externalize abstract CS and engineering concepts through locally meaningful representations.

Constructionism emphasizes that learning happens most effectively when individuals are engaged in constructing tangible, shareable artifacts [7]. In contrast to instruction models that prioritize information delivery, constructionism focuses on knowledge building through active design and personal expression. Robotics kits and physical computing platforms offer a natural extension of this philosophy, allowing learners to test logic, build systems, and iteratively refine their ideas in visible ways [11].

Among these platforms, the Hummingbird Robotics Kit exemplifies a “low-floor, high-ceiling” tool that lowers entry barriers while allowing for increasingly complex, creative expressions of logic and engineering principles [12]. However, prior research has critiqued constructionist implementations for assuming culturally “neutral” contexts, often neglecting to incorporate learners' lived experiences or community knowledge into the design tasks [9]. This oversight can further marginalize students from rural or underrepresented communities who may not see their identities reflected in dominant computing narratives.

This study brings together these three strands to frame a professional development (PD) model that positions physical computing as a culturally situated act of making. We argue that teacher learning in computing is most powerful when:

- It involves hands-on, iterative design (Constructionism);
- It draws on teachers’ own community-based knowledge (CRP and funds of knowledge);
- It uses narrative as a structure for both personal meaning and technical sensemaking (Storywork).

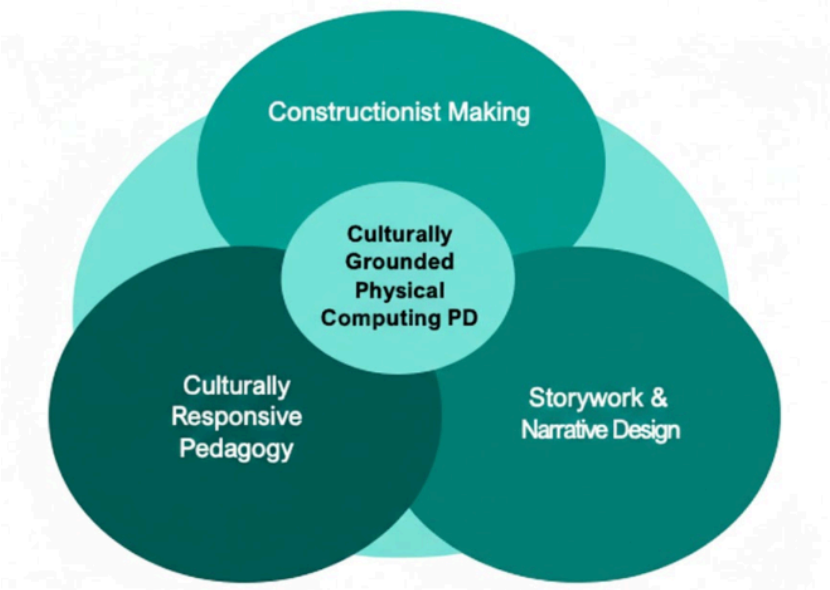

Figure 1. Conceptual Framework for Culturally Grounded Physical Computing PD

This conceptual lens informed both the design of the PD activity and our analysis of teacher artifacts and reflections. We explore how technical fluency, cultural identity, and pedagogical vision become intertwined in rural STEM education by enabling teachers to express their stories through robotics and creative designs.

III. Methods

Research Design

This study employs a qualitative case study design [13], grounded in a design-based community-engaged research (CEnR) framework [14]. The research is situated within a funded multi-year research-practice partnership (RPP) between a public institution and educators from Southeastern Appalachian school districts. This design was selected to explore how in-service K–8 teachers in rural contexts make sense of and apply culturally grounded approaches to computing and engineering education. The study foregrounds participant voice, local knowledge systems, and co-design as central to both the intervention and its evaluation.

Context

The professional development program was implemented during the summer of 2024, with follow-up sessions held in the fall designed to support implementation and reflection and co-facilitated by community and regional instructional coaches.

Participants included 22 in-service K–8 educators from six school districts in the Southeastern Appalachian region, representing a range of grade levels (grades 1 through 7) and teaching contexts (charter schools, multi-age classrooms), recruited through district partnerships and regional education networks.

Data Collection

To triangulate the analysis, multiple qualitative data sources were collected:

- **Teacher Artifacts**: Photographs and videos of completed dioramas, with emphasis on the use of CT concepts (e.g., sequencing, conditionals, input/output).
- **Written Reflections**: Post-session written responses guided by prompts that asked teachers to describe their design process, perceived learning, and classroom connections.
- **Fieldnotes and researcher memos**: Captured observational data and emerging patterns related to teacher engagement and collaboration.

All data were collected with IRB approval, and pseudonyms were used to protect participant confidentiality.

Data Analysis

Data were analyzed using thematic analysis [15], following Braun and Clarke's six-phase framework: (1) familiarization, (2) open coding, (3) theme development, (4) refinement, (5) definition, and (6) reporting.

Researchers independently coded the written reflections and artifacts, then met to reconcile codes and consolidate emergent themes. Themes were organized around the two guiding research questions:

- RQ1: Sensemaking of computing concepts through narrative-making
- RQ2: Affordances and barriers in context-specific implementation

Codes related to identity, place, agency, and design thinking were mapped back to the project's conceptual framework (Constructionism, CRP, Storywork).

IV. Findings

The analysis revealed three intersecting themes across participant artifacts and reflections: (1) engaging place and memory through narrative mapping, (2) using everyday experiences to structure computing logic, and (3) expanding teacher confidence and identity through culturally grounded robotics design. Three illustrative teacher stories are selected to demonstrate how storytelling served both as a medium for computational sensemaking (RQ1) and a lens for understanding the affordances and barriers of implementing culturally relevant CS in rural classrooms (RQ2).

A. Local Stories as Cognitive Scaffolds

All three participants grounded their dioramas in place-based narratives, drawing from lived experience, community history, and cultural memory. These stories were not only emotionally resonant but structurally effective: teachers intuitively aligned story elements with CT concepts like sequencing, event-driven programming, and sensor input/output.

Joanne, a first-grade teacher, designed a haunted house scene inspired by her experiences working in haunted cabin attractions before becoming a teacher. Her narrative evoked sensory details of Appalachian autumns - crisp air, Halloween excitement, and marshmallow roasting:

"Creating the diorama helped bring back some of those fond memories… It was a fun experience, and this time of year always takes me back to that time."

The diorama featured motion-activated lighting and servo-driven props (e.g., a bat) to simulate a haunted house. Joanne's sensemaking was deeply tied to the temporal rhythm of seasonal traditions, making abstract concepts like sequencing meaningful through emotional and cultural familiarity. The affordance here was the ability to anchor computing in a child-friendly, festive context. However, she also expressed concern about whether activities like this could be feasibly integrated into early elementary curricula due to time constraints and standardized testing pressures.

B. Everyday Objects as Entry Points to Computing Logic

Another key theme involved the transformation of everyday elements, such as roads, trees, and community spaces, into computing mechanisms. Teachers embedded sensors, motors, and lights in familiar objects to make CS concepts more intuitive.

Sandy, a 6th-grade math/science teacher, built her diorama around the Royal Blue ATV trails, a beloved recreational space in her home county. Her project simulated vehicle activity using three programmed controls:

- Press A: lights on
- Press B: lights off
- Press A + B: horn sound

By embedding input/output actions within the familiar context of a forested trail, Sandy highlighted how user interaction and feedback loops could be taught through place-based computing.

Her design process showed strong sensemaking by translating the logic of user interaction into an experience her students already understand. She later reflected on the value of this connection for her students: "*Maybe they could see that they could have a career in computer science — even though that is different than what anyone in their family has ever done*."

C. Expanding Teacher Confidence and Professional Identity

Participation in the PD not only increased teachers' technical skills but also reframed their understanding of what computing can be. Teachers reported a shift in perception, moving from seeing CT as purely technical to viewing it as expressive and relational.

Violet, another 6th-grade math teacher, created a diorama of a nostalgic drive-in movie theater, complete with programmable lighting, mechanical movement, and audio narration. Her scene honored a disappearing cultural tradition that once served as a community gathering space:

> *"Drive-ins were more than just a way to watch films… they were social hubs where families and friends gathered… It's one of my fondest memories from my childhood."*

Through this project, Violet began to see coding less as abstract logic and more as a form of multimodal storytelling:
"I used to think coding was like math… now I see it more like writing."

Her project illustrated sensemaking by mapping narrative flow onto computational steps. But just as importantly, it redefined CT as culturally expressive. Violet noted the affordance of emotional investment, which made robotics more approachable. Yet, she also described barriers: lack of curricular fit, concerns about debating sensitive topics, and limited student exposure to cultures beyond their own.

Joanne also emphasized a similar connection between community relevance and instructional purpose:

> *"It has to be relevant for their (students') lifestyle… I want them to be able to say, 'this makes a difference for my family and me.'"*

These reflections underscore the identity-building power of culturally grounded design, as teachers saw themselves not only as learners of computing but as facilitators of meaningful, inclusive, and place-based CS education.

V. Discussion

This study explored how rural Appalachian educators engaged with CS and engineering concepts through storytelling-based physical computing, and how culturally grounded contexts shaped the affordances and barriers they experienced. Findings demonstrate that when teachers are invited to design from their own lived experiences, computational concepts become less abstract and more relational, expressive, and accessible.

Narrative as a Scaffold for Technical Sensemaking

The findings demonstrate that narrative design served as a powerful entry point for Appalachian educators to make sense of CS and engineering principles. Teachers did not approach robotics as isolated technical tasks, but rather as stories to be crafted, debugged, and shared. The conceptual model integrating constructionism [7], culturally responsive pedagogy (CRP) [3,4], and storywork [5] was not only theoretically generative but also practically useful. Teachers' ability to map computational concepts such as sequencing, iteration, and input/output to narrative elements suggests that storytelling acts as both cognitive and cultural scaffolding**.**

This narrative framing lowered the technical threshold for teachers unfamiliar with robotics, while also offering emotional and cultural relevance. As Joanne noted, "*It has to be important to them… to their family."* Her haunted house diorama wasn't just a lesson in servo motors - it was an act of memory and identity work. Our findings extend this by showing that in-service teachers, especially those from under-resourced rural areas, benefit from PD that validates their identities and offers a "low-floor, high-identity" approach to CS integration.

Reframing Teacher Identity and Confidence

Teachers' reflections showed a clear shift in professional identity: from seeing CT as foreign or "too technical" to viewing it as a tool for student expression, cultural storytelling, and interdisciplinary learning. This finding resonates with work in Funds of Knowledge [8], which positions educators' cultural experiences as assets in the learning process.

Importantly, the PD enabled teachers to see themselves as *creators and facilitators* of computing, not just adopters of prepackaged curricula. For Violet, reframing coding as a form of writing helped integrate robotics into her pedagogical repertoire. In Sandy's case, connecting CS to a familiar local pastime helped her imagine new student futures. Such reframing is critical for rural regions, where a sense of disconnect from "mainstream" technology can hinder CS adoption.

These shifts are especially critical in rural regions, where many teachers have **l**imited exposure to CS themselves, and where computing is often seen as disconnected from community realities [2].

Implications for Pre-College Engineering and CS Education

This study suggests that computational making becomes more equitable and sustainable when it is deeply contextualized in place, story, and teacher identity. PD that centers local narratives can:

- Foster teacher confidence in both technical and creative domains
- Enable interdisciplinary integration, especially across ELA and social studies
- Build pathways for rural students to see themselves in computing

However, the study also highlights key challenges: constraints around time, curricular alignment, and access to materials remain persistent in under-resourced school systems. Thus, future PD efforts should pair culturally relevant design with ongoing support, shared resources, and sustained community partnerships.

VI. Conclusion

This Research-to-Practice study contributes a replicable model for culturally grounded professional development (PD) that integrates storytelling, physical computing, and community-connected pedagogy for K–8 educators in rural Appalachian contexts. Through a diorama design task using Hummingbird robotics kits, teachers engaged deeply with computer science (CS) and engineering concepts by embedding them within personal and local narratives.

Our findings suggest that narrative-based making supported teachers' sensemaking of technical ideas, such as sequencing and input/output, while also affirming their cultural identities and pedagogical agency. The integration of constructionist practices, culturally responsive pedagogy, and storywork enabled teachers to view robotics not as abstract or intimidating, but as a creative and meaningful tool for interdisciplinary teaching.

By centering the voices and assets of rural educators, this study highlights the importance of designing PD that affirms local knowledge, fosters confidence, and encourages curricular integration. As the field of pre-college engineering and computing education continues to broaden participation, this work underscores that access alone is not sufficient - educators must also be empowered to connect computing to the cultural and narrative fabric of their communities.

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