Tuning Into the Craft: Materials as a Driver of Learning Computing

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Abstract: Tangible fiber crafts are deeply connected to the history and future of computing and present promising contexts for diversifying materials for computer science education. However, it remains under researched whether diverse materials play a role in how computing is learned. This qualitative study fuses constructionist with posthuman perspectives to investigate computational learning with two fiber crafts. Findings present materials as active players in unfolding computational learning, with implications for the design of computational manipulatives.

Introduction

The educational use of tangible manipulatives dates back to Froebel's toys that were based on wooden blocks, yarn and string materials (Brosterman, 1997). Tangible computational manipulatives are rooted in constructionism that considers that learners come to know the world through the design of personal projects (Papert, 1980). Historically, tangible fiber crafts have been connected with computing and technology innovation. Most notably, the Jacquard loom has been considered a precursor of the earliest computers (Plant, 1995). However, it remains understudied how fiber crafts could drive computational learning with the risk to miss materialized biases. This study asked: *How do the material-discursive practices of weaving and manipulating fabric drive computational learning?* To answer this question, this study fused constructionist approaches to learning (Papert, 1980) with posthuman perspectives (Barad, 2003), flatten hierarchies of people and materials and can shift the analytical focus toward capturing emerging material-specific patterns and what they produce (Kuby, Spector, & Thiel, 2018). This is useful for tangible manipulatives because it promises possibilities for tracing the workings of materials in the production of knowing and can help uncover implicit deficit framings of learning (Kuby, 2018). This study analyzed the computational learning processes that are produced by the materiality of weaving and manipulating fabric in the context of a middle-school fiber crafts course. Findings present that matrix-based fiber crafts make it possible for youth to perform computational concepts (e.g., variables, conditionals) and show how learning is contingent on the materials being used. The non-neutral, active role of materials in tangible computational manipulatives has implications for theorizing the role of materials in computer science learning and the design of inclusive tangible manipulatives.

Methods

This qualitative study analyzed video data of two iterations of a six-session fiber craft course with 16 middle school students (ages 11-14; 8 girls, 8 boys) at a Midwestern charter school. The course focused on weaving and fabric manipulation (i.e., embroidering 2D graphics into 3D shapes). Video of the sessions captured youth's craft engagement and project videos recorded details of youth's artifacts. Content logs captured summaries of material processes that were required for crafting (e.g., stitches, heddles). The research team translated the youth projects into pseudocode (e.g., not shown to youth) as an analytical move to illustrate how crafts' material doings relate to computation. Thinking with posthuman perspectives (Jackson & Mazzei, 2012), the pseudocode translations made it possible to detect material-specific patterns over time to show what kind of computational learning the crafts produced. While the work analyzed both crafts, the poster focuses on one participant's weaving.

Findings: Material-discursive computational learning in fiber crafts

Through the interplay of heddle positions (i.e., bar for thread control), shuttle direction (i.e., yarn carrier), and youths' full body engagement patterns emerged that called for the performance of variables, conditionals, and functions. In weaving, variables became the repetitions of heddle positions and how long a pattern went on for. As youth lifted the heddle up and down, they produced conditional statements. For instance, in Devanie's pattern a lifted heddle (heddle == 1) called for her to weave left to right. A lowered heddle (heddle ==-1) called to weave from right to left. Weaving rows into the thread matrix through the regularly repeated coming together of youth and craft materials performed a while loop that the pseudocode translation made visible. The repeating process shifted typically automated and invisible computational aspects to the youth as they produced repetitions.
These concepts were also performed in fabric manipulation.

Over time, computation in weaving moved toward regularity. The set-up of the loom demanded this emergent regularity as weaving happened within the matrix of warp threads. This became apparent when comparing youth's woven skip patterns over time, where threads are skipped to produce pictorial elements on the fabric. Devanie's first skip pattern, similar to other youth, could not easily be translated into a function, which meant that the kind of repetition that posthumanist perspectives guided the analysis to look for were less present. This does not mean that there was no computation in these irregular patterns; the patterns were simply not regular enough to produce functions. However, over time, youth projects could be translated into pseudocode with functions. For example, Devanie's second skip pattern, which included a decreasing and an increasing triangle (Figure 1), showed an increase in complexity and regularity compared to her first skip pattern. The number of variables increased, now including four warp thread id numbers (i.e., x, y, a, and b), presenting warp thread ranges for both shuttle directions. To produce the increasing triangle the operation of the function was reversed ("def skip2").

```
def skip1(x,y,a,b,dur,heddle):
   i = 0
   while i<dur:
       if heddle == 1:
           start at warp 1
           skip warp in range (a,b)
           a -= 4
           b += 4
       if heddle == -1:
           start at warp 28
           skip warp in range (x,y)
           x += 4
           y -= 4
       if heddle == 1:
           heddle = -1
       if heddle == -1:
           heddle = 1
       i += 1
```

```
def skip2(x,y,a,b,dur,heddle):
   i = 0
   while i<dur:
       if heddle == -1:
           start at warp 28
           skip warp in range (a,b)
           a += 4
           b -= 4
       if heddle == 1:
           start at warp 1
           skip warp in range (x,y)
           x -= 4
           y += 4
       if heddle == 1:
           heddle = -1
       if heddle == -1:
           heddle = 1
       i += 1
```

Figure 1. Devanie's project (left) and pseudocode translation (center and right).

The loom required to weave into a fixed matrix of threads one row at a time. Youth-loom regular engagement produced fabric faster and with more increased complexity; the loom demanded development toward regularity. In the process of regular loom-child computing, Devanie's plus loom became the performance of automation. By contrast, computation in fabric manipulation moved 3D modeling into physical space and called for speculative distortion as computational learning.

Discussion

In both crafts, materials became active players that shaped what could be learned and experienced computationally. Posthumanist perspectives called to consider learning as a change toward or away from materially-drive repetitions over time, in which youth take part in alongside the craft materials. The pseudocode translations made these changes over time visible. The findings suggest that learning with the crafts included a becoming in-tune with the kind of disciplinary character that the crafts called for. This expands computational learning as it suggests computing is informed by materials and if we change the materials, we can change computational characters, how computation is done, and, hopefully, who sees themselves as doing computing. It points to the usefulness of considering a multitude of material for computational learning.

References

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