Child-material Computing: Material Collaboration in Fiber Crafts

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Abstract: In computer science education, fiber crafts remain largely disconnected from their historical role as models for computers. This risks overlooking a compelling, low-cost context for computer science learning and for exploring human-machine collaborative learning processes. Building on bodily-material collaboration, we analyzed the computational concepts associated with fiber crafts during a middle school course and found that computation was contingent on child-fiber collaborations. This has implications for theorizing materials as active participants in collaborative learning.

Introduction and background: Fiber crafts and computing

Fiber crafts are a compelling context for examining the material nature of collaboration in computer science learning, because textile manipulation occupies a pivotal role in the history of computing; the earliest computers were modeled after the Jacquard loom that used punch cards to program fabric patterns (e.g., Plant, 1995). Despite this connection, in computer science education fiber crafts remain largely disconnected from their historical role as models for computers. The field of e-textiles is a notable exception that highlights the potential of technology-augmented fiber crafts for high-quality STEM learning (Buechley, 2006). By swapping wires for conductive yarn, the practice of sewing becomes a way for youth to connect crafting, engineering, and computing (e.g., Peppler, 2013; Kafai, Fields, & Searle, 2014). However, we know little about the computational concepts used for non-technologically augmented fiber crafts or which learning processes they drive. Reinvigorating the historical connections of fiber crafts and computing promises a compelling low-cost context for computer science learning and for exploring human-machine collaborative processes.

The framework of bodily-material collaboration (Davidsen & Ryberg, 2015), focused on collaborative learning processes between children and new technological materials, invited us to expand notions of collaboration by framing materials as active participants. This poster examines youth's collaborative STEM learning processes as they perform fiber crafts. Our qualitative analysis of video data from a middle school craft course examines fiber crafts as a context for computer science education by showing how weaving mirrored the computer-programming notion of parallel processes. We discuss three child-material collaborative processes for computer science education and their implications for computer-supported collaborative learning.

Methods

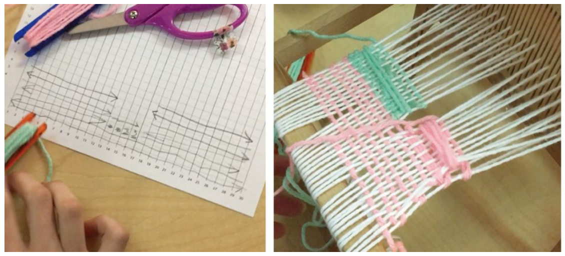
This qualitative study draws on data collected during a six-session craft course at a Midwestern public school to examine the inherent computational concepts of weaving and fabric manipulation. Each session lasted 60-90 minutes, was attended by eight middle school students, and was video-recorded. During the sessions, we also conducted 5- to10-minute semi-structured interviews with the youth about their design process. The interviews were also video-recorded to capture the youths' embodied meaning making. We analyzed youth engagement with the fiber crafts by iteratively coding the video for computational concepts of the K-12 Computer Science Framework (e.g., programming: functions, loops; computing systems: software and hardware) and transformed them to Python programming. Then we coded how youth described body movements in relation to computational concepts (e.g., tools used and how). For this poster, we present an illustrative case of a beginner's lace pattern woven into a tapestry by a middle school fabric-based computer, Jasmine, who had little prior experiences in computing and crafting. We first present how the project relates to programming and then turn to software and hardware at the site of the child-material collaboration.

Findings: Weaving parallel processes

When a computer program, the implementation of parallel processes requires the programmer to identify two patterns that progress simultaneously and to bring these together into a computer program. Through the creation of a lace pattern, Jasmine used this concept to move her project forward. Jasmine intended to weave an opening into her tapestry and explained her graphical project plan (Figure 1, left):

> *So this is the hole right here. And [the yarn] goes one way. Then, [the yarn] goes the other way. And then [the yarn] goes this way and then you skip these strings, where the hole is going to be, and then you go the same way and then you go this way and do the same as you did.*

In her explanation of the first three project plan lines, which include the first lace line, Jasmine's use of "skip these strings” suggests that she planned to use one yarn color on one shuttle (i.e., a carrier of yarn) to produce the design. The project plan arrows support this, where the arrow on line three points into the same direction before and after the “hole.” This seems to continue the row, rather than build both sides of the fabric in parallel.



```python
import turtle
lweave = turtle.Turtle(shape="square")
rweave = turtle.Turtle(shape="triangle")

def weave():
        for i in range (0,4):
                lweave.fd(200)
                rweave.fd(200)
                lweave.left(90)
                rweave.right(90)
                lweave.fd(20)
                rweave.fd(20)
                lweave.left(90)
                rweave.right(90)
                lweave.fd(200)
                rweave.fd(200)
                lweave.right(90)
                rweave.left(90)
                lweave.fd(20)
                rweave.fd(20)
                lweave.right(90)
                rweave.left(90)

rweave.fd(440)
rweave.left(180)
weave()
```

Figure 1. Jasmine’s weaving pattern, loom project, and Python code of pattern design.

On the loom, Jasmine engaged two yarn colors, teal and rose, on two shuttles to create her lace pattern (Figure 1, center). Alternating, she moved the teal shuttle from left to right and the rose shuttle from right to left, before shifting warp-thread positions. Both sides of the tapestry advanced in parallel. On graph paper, this would have been represented as two arrows pointing toward one another rather than in the same direction. As part of our analysis, we transformed all students’ weaving patterns into Python programming language to discover their inherent computational concepts. As Jasmine and the loom came together, the pattern changed into a more complex task that showed the use of functions, loops, and ranges as two processes emerged (Figure 1, right).

Discussion and implications

Thinking with the framework of body-material collaboration, we recognize that the Python code does not capture how Jasmine and the fiber craft materials came together to form a human-material collaboration. We identified three child-material collaborative processes that fostered the fiber crafts-based computation. First, Jasmine and the loom *simultaneously programmed and processed* the pattern instead of delegating tasks to the machine. For the lace pattern, the loom called for a shift in the computational process: Both sides needed to advance in parallel and, therefore, a change in programming was needed. Second, Jasmine *became a part of the emerging computation*. Through left-right movements, Jasmine’s arm plus the shuttle that held the “pixel-making” material (i.e., yarn) became the computational processing unit. Third, this *slowed down computing* and made the usually invisible computational processes visible. Together, these child-material collaborative processes highlight the active role of materials in what computation can become. Computation in fiber crafts seemed contingent on child-material collaborations. Leveraging these processes for computer science education could present a low-cost context for interrogating the role of humans in computation. Identifying contexts for exploring human-machine interactions such as fiber-based approaches to child-material computing, are of increasing usefulness for computer-supported collaborative learning as ubiquitously spreading computational algorithms alter learning processes and the role of people in relation to computation.

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