Sewing and weaving data: Analyzing fiber crafts as context for performing data processing and storing

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Abstract: Fiber crafts, including sewing, are connected to the history and future of computing. Yet, they are underrepresented in computing education. This qualitative study analyzed performed an iterative thematic analysis of artifact analysis sessions in which computer science experts examined middle school students' craft projects for evidence of challenging computer science concepts. This paper shows a weaving and sewing craft as context for performing data processing and storing with implications for computing education.

Introduction

Tangible manipulatives enable exploration of unfamiliar concepts through culturally-relevant body-based interactions (Horn, 2018). Using tangible manipulatives to facilitate computational learning is particularly compelling for students who are new to computing because the tools can readily provide access to complex computational ideas at an early age (Bers, et al., 2019). Materials like looms and fabric are traditionally associated with practices of people who are underrepresented in computing and are strongly connected to the history of computing (Abbate, 2012) as well as more recent computational development (Devendorf & Di Lauro, 2019). Yet, fiber crafts are often overlooked in computing education–apart from examples that the present study leans on an seeks to expand. Within educational research, electronic textiles (Buechley, 2006) have consistently proven to be a cogent context and notable exception for introducing youth—especially girls—to STEM disciplinary concepts, including accounts of circuitry learning (Pinkard et al., 2017). Fiber crafts have the potential to disrupt how we think about computing education especially because they introduce materials that are typically linked to decorative practices (Kafai et al., 2021; Keune et al., 2020).

Work is needed in the learning sciences to consider how the specific materials of fiber crafts (in this study weaving and fabric manipulation) align with computational ideas. Understanding how fiber crafts are aligned with computation can inform the creation of more diversity-oriented contexts. To investigate fiber crafts as a context for computing, I asked: *How do weaving and fabric manipulation support engagement with computation concepts (especially data processing)?* This qualitative study aligned fiber crafts with computational ideas through artifact analysis sessions of fiber artifacts by computer science experts. Craft projects were translated into pseudocode, a description of an algorithms in plain language, to illustrate computational concepts required for the crafts. The findings provide empirical evidence that crafts require engagement with processing and storing data with material parts and other computational concepts relevant for computational learning.

Methods

This qualitative study investigated fiber crafts for computational learning. The context of the study were university settings within which artifactual analysis (Pahl & Rowsell, 2019) of craft projects were conducted with computer science instructors at research-focused universities who were identified through university websites and recruited via email. Data sources came from the recorded artifactual analysis sessions with the instructors and focused on the instructors' experiences teaching computer science courses followed by a close look at fiber crafts artifacts to surface how fiber craft projects included computation. The analytical focus lay on understanding how the aspects mentioned by the instructors related to K12CS concepts (i.e., algorithms, variables, control structures, modularity, and troubleshooting) and beyond (e.g., data processing, memory). The explanations further served to translate the fiber crafts artifacts into pseudocode to highlight computational concepts. Some of this translation process was started by the instructors but expanded to illustrate how the crafts' material doings relate to computation.

Findings: Processing and storing data with material parts

Findings showed that instructors aligned the crafts with processing and storing data through material parts. The instructors recognized weaving as the organization of data in memory and the production of fabric rows as the exploration of data structures that were written into the memory of the fabric. One example of this was the gap that crafters produced by weaving with two separate shuttles, as if processing "two data structures at once," as one instructor explained. To produce the pattern, crafters wove mirroring row-by-row patterns. In the example project, the crafter passed blue yarn from right to left and yellow yarn from left to right to the center of the threads on the loom. When heddle positions changed (i.e., the loom threads changed positions), both yarns were moved in opposite directions toward the outer edges of the loom. The data that was stored within the fabric functioned like memory of the state of the computer and one instructor explained: "The state of the computer basically means, what is in the memory right now . . . This is useful for tracing what the algorithm did over time." According to the instructor, the fabric showed the evolution of the computer state over time, one horizontal thread at a time. Typically, this kind of memory gets overwritten in the computer.

The instructors also recognized the organization of data in memory with fabric manipulation. The crafting process in fabric manipulation depended on the number, location, and distance of visible intersection points on the matrix that were sewn together. Instructors identified the intersection points as variables that crafters had to engage to produce a pattern. For example, an instructor explained: "The dot . . . can be represented as a variable. And their coordination change[s] over time as you're sewing. Or their relation[ship], their distance changes, so they move around." The instructor proceeded to write a list of variables that would be filled as crafters selected which intersection points on the matrix (i.e., dots) to sew together. The sewing process changed the position of the intersection points as well as the distance between points, which produced folds. The instructors recognized the produced fabric folds as writing data to memory. One of the instructors said: "This is how the processor and memory work together. All they know about are locations of data, [its] coordinates, and what operations we can do on this data." Instead of producing machine-state memory, the graphic sewing pattern presented data that could be transposed onto the fabric through the language of stitches.

Discussion

Looking across how fiber crafts that the computer science instructors identified as computational presents fiber crafts as a promising context for computational learning, especially learning about data storage and processing. The machine state memory woven into the fabric made it possible for crafters to retrace, undo, and redo parts of their fabric designs. This further suggests alignment with troubleshooting that would need further investigation. Additionally, altering matrix structures can show how structures–whether grid points on fabric or thread arrangements on looms–direct performance. The contrasting engagement across two matrix-based crafts highlights the potential of designing for matrix play as a way to make computing a linear as well as a spatial artifact transformation process. Matrix play can make it possible to think three-dimensionally from the start, which can be useful for programming and algorithmic thinking that takes place in three-dimensional space with structures and matrices rather than on a flat plane (e.g., computational architecture, construction engineering).

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