TAKING DESIGN THINKING TO SCHOOL

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How the Technology of Design Can Transform Teachers, Learners, and Classrooms

ROUTLEDGE

14

THE MATERIALITY OF DESIGN IN E-TEXTILES

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The red, white, and blue star-shaped buttons caught Peter's eye on the first day of the electronic-textile workshop—they connected with Peter's patriotic sentiments. He decided to combine these buttons with a shirt with the same colour scheme that he had designed prior to the workshop. The upcoming 4th of July holiday gave him inspiration to create a 'display of fireworks' on his t-shirt using LEDs on top of the star-shaped buttons, and he added sound effects through low alternating notes from a buzzer.

Peter was one of the teachers who attended an electronic-textile, or e-textile, workshop as part of a summer professional development program in a mid-Atlantic town. In this vignette, what do we perceive as bringing about Peter's design decisions? Most conventional views of design would see Peter acting on and transforming the materials: Peter created the fireworks display with LEDs and the sound effects using a buzzer. On closer examination, the materials also appear to have agency, priming Peter's design choices. For example, the color of the materials seemed to prompt Peter's patriotic emotions, to work on his imagination, and to influence his actions toward a coherent design of a patriotic fireworks display. Imagine if these materials were not available and instead were replaced by glittering neon buttons or other materials not conducive to a patriotic theme. How then would Peter's artifact have been conditioned, and what form would the artifact have taken?

Traditionally, design has been perceived as a humanist endeavor, where the designer is the agent of the activity, concretizing an abstract theoretical concept into an artifact (Nelson & Stolterman, 2012; Cross, 1982). The designer brings about the "courses of action aimed at changing existing situations into preferred ones" (Simon, 1982, p. 129), and makes decisions about the materials,

proportion, and tools to achieve a desired outcome (Nelson & Stolterman, 2012). The designer is acting in an effort to provide a service (Löwgren & Stolterman, 2004). Design has also been defined as "a reflective conversation with the materials of the design situation" (Schön, 1983, p. 76). Here the designers' capabilities to listen and respond to the cultured and contextualized material are foregrounded. The designer makes decisions that bring about a desirable result amidst contextualized interactions in the discovering, designing, and reflecting (Schön & Wiggins, 1992). In these views, we often forget that the materiality of design conditions much of the direction of design. Like Peter in the summary of his design process above, it is hard to untangle just how much the person acts on the material to transform it, or *in what ways the materials condition the particular design artifacts that are nursed into being*.

We have been increasingly interested in looking at design through a materialist, post-structuralist, and post-humanist view that takes a "material turn" (Braidotti, 2013). In this view, agency is no longer owned and produced by human agents or designers alone, but is dispersed and distributed to different materialities or their assemblages and emerges as a consequence of their intra-actions (Barad, 2007). As opposed to "interactions," intra-actions do not presume independent entities and relations. Through agential intra-actions, boundaries and properties of the "components" of design become determinate, which in turn make particular embodied concepts meaningful. Hence, we focus not only on the actions of the designer, but also on the transformative agency of the materials. How is intention and agency shared between the designer and (perhaps preconditioned by) the materials themselves in the design process? A skilled designer selects appropriate starting materials to envision the project (knowing that other materials will take the project in an unwanted direction). Design materials become active agents that extend their reach from being and acting in the world, and designers become entangled with the being and acting of things (Barad, 2007; Rogers, 2009).

A "Material Turn" in Design

In his seminal work, Schön (1983) eloquently discussed the reflective interactions between the materials of the design and the designer, suggesting that these three entities (material, designer, and design artifact) are engaging in an interactive back-and-forth. It is this interaction between the material of design and the designer's craftsmanship that Nelson and Stolterman (2012) highlight as requiring our attention if we want to theorize and understand how design comes about. Their definition of materials in the design process goes beyond the physical material, encompassing also the ideas and cultural contexts within which design takes place. Thinking and doing are intertwined as the designer engages in dialogue with the materials. While the materials are attributed with a "voice" with which

they "talk back" to the designer, informing them about what can or cannot be done, it is the designer who selects which materials to bring to the design situation, which material voices are invited and heard, and how they are interpreted. Here, the material acts through the designer, facilitating the human intentions and expressing the desired design artifact. This suggests that the human designer acts with agency over the material to bring a design into becoming.

The becoming of a design continues after design time, once a design artifact is placed in use with those people for whom it was intended (e.g., Fischer, 2013). Specifically focusing on the act of tailoring digital design artifacts, Henderson and Kyng (1992) suggest that supporting design in use is desired as it increases agency of how artifacts can be shaped to better fit their particular situations of use. This notion of tailorability is tightly connected with human agency: at design time, a person made it possible for the design artifact to be tailored in the future, and, in this way, agency is intentionally transposed across time to another person who may tailor.

Design can be a process of mutual learning (e.g., Blomberg & Karasti, 2012). This process of reaching intersubjectivity is facilitated through materials of design that help "discuss current situations and envision future ones" through design-by-doing (Löwgren & Stolterman, 2004). Flexible and loosely structured materials are provided to participants of design, including paper prototypes or cardboard mock-ups to co-create dialogue about potential designs through the materials selected as communicative tools. These materials communicate unfinished and not-yet-thought-through designs and are intended to conjure up playful ways into design, in which participants communicate implicit understandings through visual and tactile means rather than words alone (Brandt et al., 2012). These are well-intended material ways for providing participants with expressive means and a voice to shape the process and product of design.

In the new materialist perspective of design, the role of physical materials is not subordinate to the agency of the designer. This may mean that objective, normative, or subjective messages that are embedded in the materials at creation and through extended use are foregrounded through the way materials are intra-acting with the human agents. The ways of doing that the materials communicate can be explored and they can teach us things that may be transferred to other materials (Cabral & Justice, 2013). They respond to the designer as well as make bids for action that can favor certain responses of the humans above others, evoking patterns of actions that can stretch across time and space. This highlights the importance of questioning which materials to invite to the design situation in order to expand the voice of the participants, and begs the question: what are the patterns that drive the material agent into the design, and how can we use this productively to invite design that is not preconditioning the results?

New domains are particularly advantageous for exploring this dynamic between material and designer because nearly everyone has something new to

learn in the design process in terms of properties of materials and their functionality. We illustrate these aspects through focal cases of participants designing with e-textiles—fabric-based artifacts embedded with electronics and small, wearable computers connected with conductive thread. The process of crafting with e-textiles allows participants to customize both the form and function of their artifacts (Buechley et al., 2013). E-textiles offer unique opportunities to explore the materiality of design, which pertains to the emergence of designs through an empirical process of material making and discovery (Orth, 2013). Furthermore, the computational aspects of e-textile designs, their "programming materiality," can emerge through similar cycles of experimentation and surprise (Berzowska, 2005).

Prior research on e-textiles focused on the designer in looking at aesthetics, remixing, and repurposing of designs (Fields et al., 2012; Kafai et al., 2011, 2012). Additionally, in the science, technology, engineering, and mathematics (STEM) domains, e-textiles effectively introduced circuitry concepts to youth (e.g., Peppler & Glosson, 2013). With regards to materiality, we looked at how e-textiles can potentially rupture traditional gendered scripts around electronics through the purposeful nexus of traditionally "masculine" and "feminine" tools and practices, which implicitly give girls hands-on access and leadership roles in the design process that are consequential for both learning and participation in STEM (Buchholz et al., 2014). This chapter extends this earlier work by exploring the agency of the design materials in conditioning the outcomes of design. We present the analysis of four focal cases of novice designers working on e-textiles to illustrate this phenomenon.

Workshop Description

Setting, Objectives, and Participants

Four focal cases were selected from among ten participants in a two-day (14-hour) e-textile workshop involving K-12 teachers in a mid-Atlantic town. Teachers signed up for the workshop as part of their Science, Technology, Engineering, Arts, and Mathematics (STEAM) professional development, which was a new priority of the school district. The district, seeking to integrate engineering and computer science into all subject areas and grade levels, commissioned the e-textiles workshop as one of several STEAM-related professional development activities. The goal of the workshop was to invite educators to explore e-textiles through personal projects as active participants and future facilitators of similar activities. Exploring the e-textile materials through design projects was intended for educators to explore connections between the materials and the STEAM fields they taught or planned to teach in their classrooms. On the first day of the workshop, participants were introduced to simple e-textiles circuitry, after which they sewed a practice project. They were then introduced

to the LilyPad Simple development board (a wearable computer), learning to program it with the visual programming software Modkit (http://www.modkit. com/micro). On the second day, participants worked on design projects. They were invited to bring a personal item to combine with a variety of materials provided by the workshop, such as buttons, sequins, ribbons, and a variety of fabrics.

Data Sources and Analytical Techniques

The design processes of all participants were captured through (1) pictures of participants working on their projects to capture the development of the artifacts over time; (2) participants' planning documents to reference initial starting points; (3) close-up pictures and videos of the final artifacts to compare design projects across participants; (4) daily observation notes to document the researchers' impressions; and (5) audio-recorded, semi-structured interviews (15–20 min) conducted at the end of the workshop to capture the participants' own reflections on their design artifact and process. Interview questions included: "What do you like most about your design?" and "Describe the process of making your e-textile. If there were something you could change about your e-textile design, what would it be?" Through the informal interviews, we hoped to unearth the tension between the designers' intentions and the affordances of the materials used. The metadata of the documents—each data point had a time-stamp—allowed us to re-construct a temporal narrative of the design processes. The combination of this data helped paint a broad picture of the design process, with the interview data providing a first-person perspective on the thoughts behind the designs. In this way, we sought to better understand the intra-actions between humans and materials in the workshop through augmented qualitative observations.

Focal Cases

To select focal cases, we searched the data for participants who actively sought to realize a specific design idea through their project, as opposed to those participants who took a more exploratory, tinkering approach to design. Of these two categories, the former more clearly demonstrates what we would traditionally describe as human agency in the design process, leveraging the materials on hand to execute an idea. By focusing on these cases, we sought to understand how material played a role in what could readily be seen as a human-centered design process. Of the five projects fulfilling this description, we further narrowed our selection by looking for cases with detailed documentation resulting in rich datasets for analysis. This produced three focal cases. For comparison, we chose a fourth focal case that did not meet the criteria. Participants of the first three focal cases brought additional materials from home for the personal project, whereas the participant in the fourth case only made use of what was available at the workshop.

To visualize the design processes, pictures and observation notes for each selected participant were placed on a timeline using Popplet (http://popplet.com/), an iOS and web-based visual mapping tool for capturing and organizing ideas. Audio interviews were transcribed so that important observation excerpts and periodic images of the design could be placed along a design timeline. Design moves were identified, including the initial ideation stage, and attempts were made to list the moves chronologically. From there, intra-actions of designer and material (i.e., how the materials were physically handled in the design process) were documented in relation to time.

We took a new materialist view of the participant's design process, placing emphasis on the material patterning of activity. The intra-action among the material is not limited to its impact on the designer using those materials, but rather the collection of designers and materials in the room leading to memetic intra-actions. One material can have a subconscious impact on the activity and material selection of other localized designs. For example, the introduction of motors can encourage a subconscious inclusion of spinning into even non-technical designs (e.g., spinning materials on fingers, the drawing of spirals, etc.) that was absent prior to the introduction of the motors. We see this as an emerging patterning of intra-action, where one material can create a motif that is explored in other designs and by other designers in unforeseen ways.

The materialist approach made visible how material agency was manifest and how it acted in the design processes of individual participants as well as how it stretched to encompass the overall workshop and the memetic intra-actions across participants and project specific materials. In the following section, we bring together four focal cases for further discussion that range in their intentionality and purposeful selection of materials in the design process. Through these cases, we look at the intersection of how we might see the material impacting the design process and the implications for design more generally.

Materials Evocating Artistic Expression

Peter, the designer in our first vignette, created a design that leveraged red, white, and blue star-shaped buttons—all materials that were provided in the workshop. He was an experienced art teacher with strong patriotic sentiments and likely gravitated towards these materials given his interests. On day 1 of the workshop, after seeing the buttons, Peter remarked, "I think we live in the greatest nation . . . I am always doing things with red, white, and blue." In fact, Peter had designed a t-shirt with the same colors and patriotic theme (see Figure 14.1) prior to the e-textiles workshop, and he decided to bring it the following day to incorporate it into his project. The upcoming 4 of July holiday and the programmable LED lights seemed to lead Peter toward a fireworks-inspired e-textile design. He programmed two pins of the LilyPad to create coordinating blinking lights with the LEDs. He then attempted to design for the
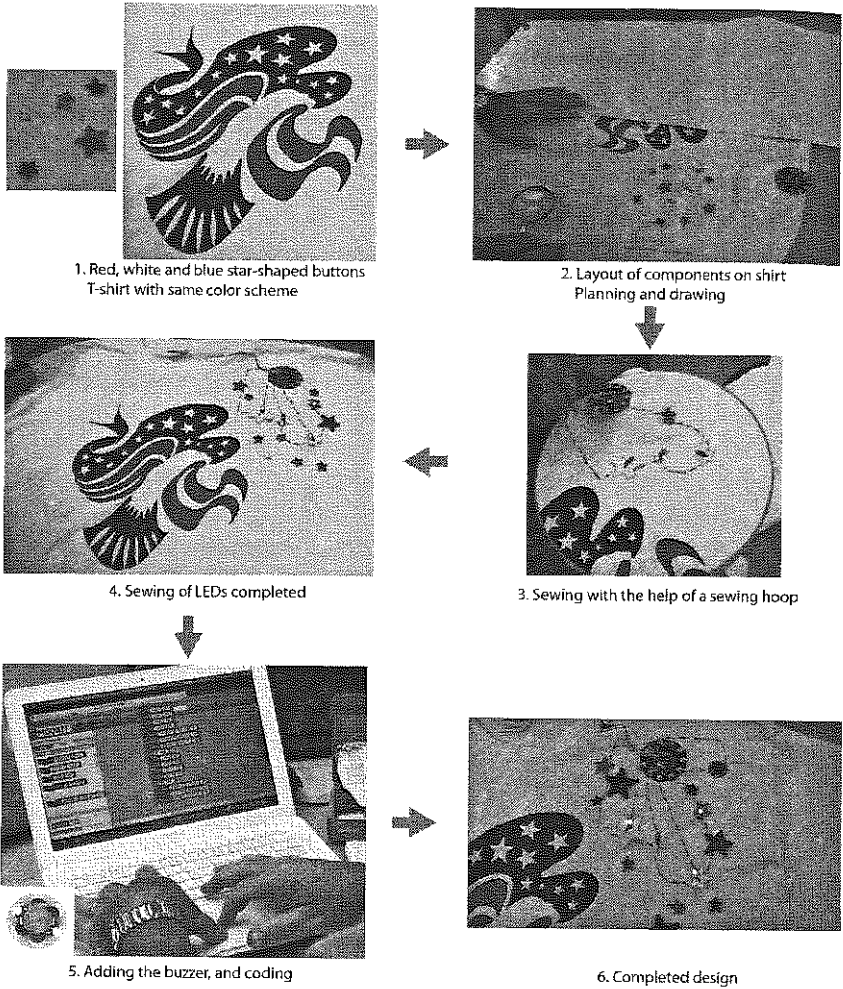
1. Red, white and blue star-shaped buttons
T-shirt with same color scheme

2. Layout of components on shirt
Planning and drawing

4. Sewing of LEDs completed

3. Sewing with the help of a sewing hoop

5. Adding the buzzer, and coding

6. Completed design

FIGURE 14.1   Photograph of Peter's e-textile design employing patriotic theme

following effect: "explosion of fireworks off in the distant sky, and the fact that
the buttons are large, medium, and small, it's that feeling of foreground, mid-
dleground, background." Peter worked to create this by outlining the LilyPad
on paper, laying the other components in place, and drawing the sewing lines.
This drawing communicated constraints, especially the complexities in sew-
ing. Having struggled with sewing on Day 1 of the workshop, Peter chose
four LEDs instead of the originally planned six LEDs to avoid the crossing
of sewing lines or short circuits. His plan was to join two LEDs to each pin.
Compared to other participants, he sewed especially meticulously, making use
of tools like a fabric pencil to draw sewing lines on his shirt, a sewing hoop, and

magnifying glasses. To evoke the loud popping of exploding fireworks, Peter added a buzzer to his design and programmed it to produce low alternating notes. Peter explained his choice of notes, "I am no musician . . ." but explained that he was searching for a fireworks-like sound effect. The other participants were also incorporating musical tunes in their designs.

Materials Demanding Preservationist Techniques

Mary, a technology integration teacher in her first year of teaching, had a personal interest in fine arts. To the e-textiles workshop, she brought a square-shaped fabric reproduction of Van Gogh's painting, *The Starry Night*, as the foundation for her e-textiles project (see Figure 14.2). The reproduction, while skewed on the color palette, aptly represented the short brushstrokes that, through swirling arrangements, give the post-impressionist painting idealized motion. Mary's design objective was to augment the stars of the print using LED lights that she would program to blink. She decided to use six LEDs, underscoring the vibrancy of the painted stars through illumination, which she would sew on top of the stars. Furthermore, Mary aspired to include a programmable buzzer into her design that would play a fragment of Don McLean's song, "Vincent (Starry Starry Night)," an homage to Van Gogh and his work. The fabric reproduction of the painting intra-acted with the designer and the other materials of the project (i.e., LEDs, song, circuitry). Here, it is precisely the alignment between the material and the intentions of the designer that brought Mary's project together. In Mary's words: "I really like how it came together in the end . . . I liked thinking about how you could make it, like, integrate it into an already-created idea." Starting with the painting offered Mary material constraints within which to locate and fixate her design. Here we see a technological complexity unfold, which is tightly coupled with the complexity of the material and aesthetic representation. This is analogous to the observations of our prior e-textiles workshops, where e-textile projects that leveraged a blank canvas (e.g., unicolored canvas bags or t-shirts) led to less complex designs, both in terms of circuitry and the designer's meaningful expression.

The choice of the painting and its aesthetic began to intra-act with the crafting techniques employed in the project. Mary laid out the LilyPad, LEDs, and buzzer on the fabric, and sketched the circuitry on paper. The sense of the picture being an art piece appeared to invoke conscientiousness on Mary's part to maintain its aesthetics; she was unwilling to let her stitches be seen on the front of the picture: "My design was on top of my stitching, because I already had a picture that I wanted, just to light up from behind. . . . I don't necessarily like how sewing looks if it's not done on a machine. It needs to be perfect." Mary's concern over marring Van Gogh's painting with stitching produced a preservationist response to the material. Mary was compelled to preserve the look and feel of the original painting, seeking out an alternative to a visible running stitch
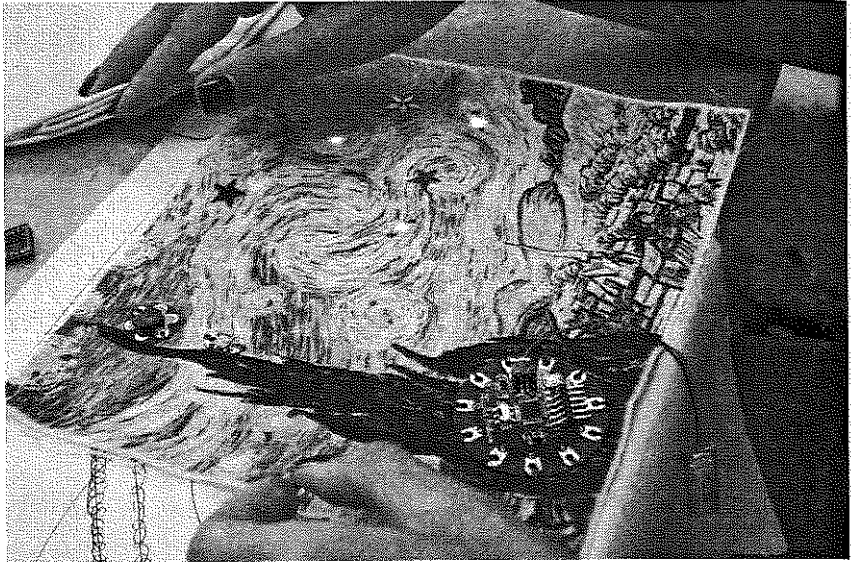
FIGURE 14.2 Photograph of Mary's design inspired by Van Gogh's *The Starry Night*

for the conductive thread. With the help of a facilitator, Mary found a solution that consisted of adhering translucent glue to the conductive thread at the backside of the fabric, which allowed energy to flow between the LEDs and the LilyPad invisibly to beholders without shorting the circuit. Struck by the hidden properties of the glue, Mary reflected on what her learning might mean for her teaching: "So I used the glue instead. I thought it was really interesting, thinking how it is an insulator. Because I was just thinking of it as a craft supply. But it would be a whole other lesson for students to talk about what is conductive and what is an insulator."

In sum, there were many aspects of the material that conditioned Mary's decision-making. Primarily, the painting evoked a preservationist mentality, which Mary used to augment but not disrupt the sanctity of the painting in her design. The painting acted as a conduit, attracting design choices that would shape the meaning of the rest of the material.

Materials Driving Memetic Spread

Steve, a technology literacy (and previously music) teacher, brought to the workshop a shirt that belonged to his four-year-old daughter. The shirt featured a heart-shaped outline that was colored with a sparkling print rendering the American flag (see Figure 14.3). He chose the shirt as a continuation of the illumination of the LEDs he planned to sew into the shirt: "This [shirt] seemed to stand out, because it already had sparkles on it, stars on it, or adding the twinkle

to them kind of seems to fit right in." Steve, like Mary, wanted to augment the theme of the e-textile through the use of the melodic buzzer. Due to his musical training, Steve invested time into programming the LilyPad buzzer to play a fragment of the national anthem, continuing the America motif of the shirt's print. "I wanted to find pieces of music that were patriotic, since it is a patriotic shirt." Steve, also like Mary, expressed a desire to hide the e-textile stitching within the t-shirt so that the circuitry would not disturb the visual aesthetic of the illustration on the shirt.

In assemblage, Steve and the design surfaced a connected challenge to the visually concealed stitching and LilyPad components. Steve's design was for his four-year-old daughter, and he was concerned that the LilyPad or the other components could scratch against her skin: "I wanted [the electronic components] to be hidden a little bit. But the problem with hiding something is that you have this device up against your skin, which could scrape, or cut, or irritate." He circumvented these nuisances by sewing the LilyPad onto a fabric square and tucking the fabric square to the back side of the shirt to form a protective barrier between the wearer's skin and the electronics.

During the workshop, the capabilities of a temperature sensor intrigued Steve as he considered the special needs of his daughter: "I have a daughter who has epilepsy, and it is actually triggered by her body temperature being so high. Then [the design] would be able to see, set, or maybe the shirt will start lighting up, I know her temperature is getting high while she is playing outside. Then I could quickly get a cooling rag . . . to put on her, so her temperature could come back down." Specifically in this statement, we see the intra-actions between Steve the designer, the temperature sensor, and his daughter's needs. Steve conceptualized the idea of using the temperature sensor and the LilyPad
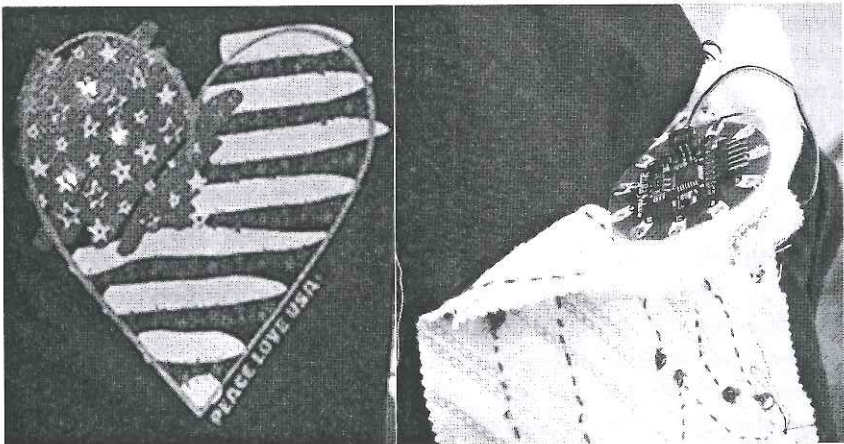

FIGURE 14.3 Photograph of Steve's heart-shaped rendition of the US flag

on the shirt as a "fever detector" for his daughter. He articulated his plan to program the LEDs to light when her temperature goes up, as an alert signal.

Steve's case is indicative of the intra-action between the materials and the designer in determining an emergent agency for the design. Steve's design process presents the conditioning of the available materials on ideation, as opposed to solely the idea formation conditioning the selection of materials: it was the introduction of the new materials that prompted the new ideas. Such a perspective underscores the material basis of human behavior and decision making. Across the vignettes, we see an intra-action among Steve's, Mary's, and Peter's projects: Steve's shirt continued the patriotic motif of Peter's design, Steve applied preservationist techniques similar to those Mary had employed (and maybe conditioned by the introduction of the nearby re-print of the Van Gogh painting). Both motifs, the patriotic ornamentation and the preservationist technique, were exceptional outliers to the hundreds of workshops we conducted. We hypothesize that the introduction of the Van Gogh painting and the red, white, and blue buttons guided the designs in those directions. From a new materialist point of view, we can see memetic spread among the designs.

Materials Facilitating Learning

Sophie was a fourth-grade teacher who started her teaching career after working as a risk analyst. Unlike the other highlighted participants, Sophie did not bring any of her own materials to the workshop. Instead, she used an undecorated canvas bag that was contributed by another participant as the basis for her e-textiles work. As one of the teachers who would be using e-textiles to teach circuitry, Sophie focused on learning the technicalities, such as polarity, making tight connections, and diverse debugging practices. Her first priority was for the computation and circuitry to work on her project, and to be sure she knew enough to guide her own students. Throughout her interview, Sophie returned to her students: "I honestly enjoyed it from start to finish because the beginning part, designing [the circuit], that works your brain, that is tough. It is a good challenge for your brain, and if it is a challenge for my brain, I can only imagine how it is going to challenge the students." Her design featured four LEDs programmed for a "strobe light" effect, with the circuitry visible on top of the canvas bag (see Figure 14.4). The on-off effect of the strobe light subtly communicated a modal morph of the thematic motif underlying the visual stitches. The stitches created a binary pattern of above and below the fabric surface, and the strobe light mimicked that. Sophie intended to use her project as a sample that she could show to her students. While the patriotic motif also made it around to Sophie, who connected the idea of "fireworks" to her design in her retrospective reflection, the materials conditioned her work in subtler, less consequential ways. For example, the decorations provided in the workshop caught her attention after she completed the circuitry design. As an afterthought, she hot-glued buttons of
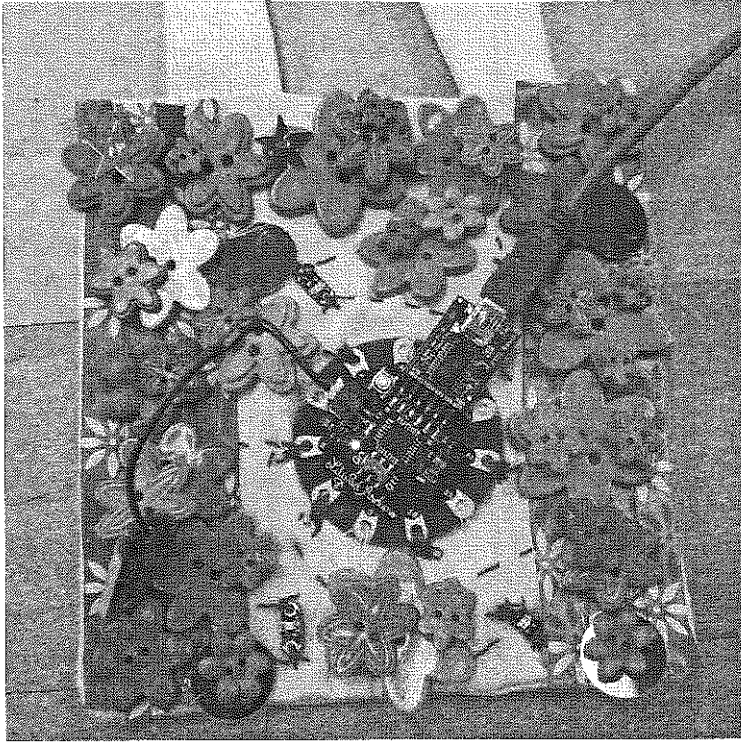
FIGURE 14.4   Photograph of Sophie's strobe light circuitry for a canvas bag

flower shapes and of various sizes in layers on top of the circuitry and canvas bag. Sophie explained her enjoyment of decoration and added: "Oh, just the creativity, how you could design anything you want." With this, she expressed hope that the instructional piece she produced would communicate the possibilities of e-textiles as educational materials beyond straightforward circuitry learning: "I want to keep it so I can show it as an example."

Discussion

The cases presented here each speak to the ways that materials initiate ideas that can take off and spread across participants and projects. In Mary's case, the *Starry Night* picture influenced the choice of sparking LEDs, tune, and techniques of sewing to maintain aesthetics. Peter's t-shirt drew inspiration from the red, white, and blue buttons seen on Day 1 of the workshop, intra-acting with the spatial position of the buttons, LEDs, and buzzer tone. In Steve's project, the potentially scratchy surface of the LilyPad inspired the alternative circuitry design that employed similar preservationist techniques of other designs in the

workshop. Sophie's case illustrates a subtler effect of materials, where a generic canvas bag did not initiate specific ideas or themes, and decorative materials were not considered in the ideation stage.

As with many design endeavors, the materials chosen early in the process ended up conditioning future design decisions and selection of subsequent materials. While experienced designers understand the affordances of particular materials for an idea and will seek out the appropriate materials for those design decisions, at times the full consequences of those choices in the design process are not fully known from the beginning. They stay in the background or unravel through design, becoming clear only after design-time.

Our research is pointing to the agency unfolding as people and things intra-act in the design process, resulting in an intra-action between material and instinctual choice. Each of the vignettes provided here reveal the designers making choices based on the originally selected materials, revealing the importance of the designers' material selection can be—understanding that they need to work *with*, and not *against*, their materials. This back-and-forth between the designer and their materials speaks to the often under-theorized weight that materials play in the design process.

The implications for how we think about the preparation of future designers cannot be missed. Cross (2006) describes how designers are "immersed in material" and how they draw upon these materials in their thinking. Importantly, good designers need to have the "ability to both 'read' and 'write' in this culture: they understand what messages objects communicate, and they can create new [objects] . . . which embody new messages" (p. 9). Material knowing (i.e., knowing what things are, how things work, and what meanings they represent) is very important to the process. Purposefully introducing a wide range of material early in development—a shared goal of early childhood educators, but less emphasized in K–12 education—encourages this type of material knowing. For example, early childhood classrooms often include free play where children can explore the forms, parts, and uses of diverse materials, such as geometrically complex seashells, simplistic wooden blocks, and printing patterns with found objects like Osage oranges. An implicit understanding of the affordances and constraints, as well as an appreciation and knowing about composition and social meanings of materials, are practiced. By contrast, in schools, less diverse materials are part of everyday learning situations. Students miss out on continued unraveling and surfacing of more complex ideas that are embedded within the materials of early childhood. An equal emphasis on the cultural, historical, and social meaning of the material is crucial. Materials come to us with a set of designed agendas, and sedimented with historic, cultural, and social identities that must be reckoned with in the design process. As we design our everyday learning environments, we need to consciously engage these material histories as we select materials (digital and physical) to be used in the design process as well as when we design physical learning spaces.

This material perspective of design conditions us to rethink the design of our learning environments, particularly those in which we provide materials to engage participants in design. Besides exposing participants to different types of materials to help them touch, feel, imagine, and connect to their ideas and imagination, the physical environment should also support the discovery of new properties of materials, new techniques, and the incubation of new ideas. In K–12 contexts this could involve active engagement with materials and discussions of what the materials mean to youth during brainstorming sessions. This discussion could create an openness or receptivity (attention) to the materials, connecting to youth's inner thoughts and ideas (Chamorro-Premuzic, 2009), leading to creative design processes.

Conclusion

Through four focal cases, we attempt to shift focus from the designer as the only active agent in design to understanding more about the materiality of design. Agency during design can emerge from the intra-action of the designer and materials. Even the more subtle ways in which material agency presents itself through design, as in the case of Sophie's e-textile, could be explored through closer examination of exploratory, tinkering approaches to design in which the designer did not enter the design spaces with concrete ideas. Makerspaces that provide a variety of tools and materials can empower designers to react and respond to the different materials that in assemblage spread a wide array of messages, patterns, and motives across making projects. These learning environments can enable designers to uncover the physical and sociocultural meanings of materials and become spaces for capturing geo-historic records of new material ways. In an effort to shift agency over to the designer, we need to focus on both the educational environments and the building of records.

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Design thinking is a method of problem-solving that relies on a complex set of skills, processes, and mindsets that help people generate novel solutions to problems. *Taking Design Thinking to School: How the Technology of Design Can Transform Teachers, Learners, and Classrooms* uses an action-oriented approach to reframing K-12 teaching and learning, examining interventions that open up dialogue about when and where learning, growth, and empowerment can be triggered. While design thinking projects make engineering, design, and technology fluency more tangible and personal for a broad range of young learners, their embrace of ambiguity and failure as growth opportunities often clash with institutional values and structures. Through a series of in-depth case studies that honor and explore such tensions, the authors demonstrate that design thinking provides students with the agency and compassion that is necessary for doing creative and collaborative work, both in and out of the classroom. A vital resource for education researchers, practitioners, and policymakers, *Taking Design Thinking to School* brings together some of the most innovative work in design pedagogy.

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