Texture, Buttons, Sound and Code: The Role of Modal Preference in the Formation of Leadership Identities

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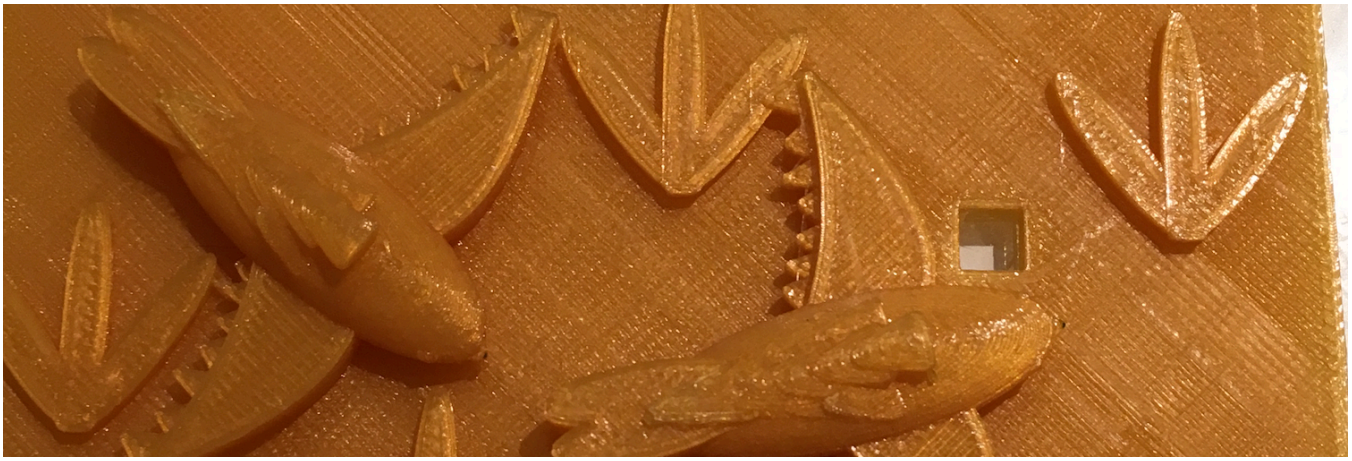

Figure 1: 9th grade students' tactile retelling of a page from D. Fleming's picture book, "In the Small Small Pond."

ABSTRACT

This paper examines a making project in a 9th grade English language arts (ELA) class through the lens of a multimodal theory of literacy. Groups of student retold popular picture books in a tactile form for an audience of children with visual impairments. They embedded interactive audio in their 3D printed pages using copper tape and Makey Makey boards that interacted with Scratch programs to play student composed-sound. Some students gravitated to certain modes and tools while designing their tactile books, and in becoming relative experts in those modes and tools, took on leadership roles within their groups. This study considers how giving students the opportunity to compose in multiple modes with a variety of tools during a collaborative design experience may offer opportunities for the development of leadership identities.

CCS CONCEPTS

• **Applied computing → Education**

• **Social and professional topics → Assistive technology**

KEYWORDS

1. Purpose

Literacy researchers have shown that when students engage in multimodal composition they are likely to draw on everyday literacy practices that are often neglected and undervalued in schools [10]. Projects that involve multimodal composition tend to support a broader notion of literacy, and thereby potentially "invite" a broader group of students to take on leadership roles in design, production, and team management [3,4,5]. This has been shown to be true in a variety of classrooms for a variety of student groups. Some students who are labelled as "struggling" with traditional academic literacy tasks, have been shown to flourish when given the opportunity to compose in visual modes and focus on subject matter they find personally relevant [1,9,18,19].

Thus far work in this area has focused primarily on the production of multimodal texts that combine image and printed text, with some inclusion of video and audio layers. This study covers an expanded selection of semiotic resources including tools ubiquitous in the Maker movement (including TinkerCad, 3D printers, Makey Makeys, and Scratch), and modes (tactile and audio) with affordances that make them appropriate for transmediating popular picture books into a form that better meets the needs of children with visual impairments. This study is part of a larger study of teens' multimodal design in maker spaces [1].

A key question for this study is: How can the act of composing in a variety of modes with a variety of tools contribute to the development of students' leadership identities in a collaborative tactile picture book composition project in a 9th grade English Language Arts class? In keeping with the theme of this conference, "creating a sustainable ecosystem for making in education," we suggest that a key element of sustainability is the adoption of making tools and practices by non-STEM educators. The considerable resources necessary for building and maintaining a maker space (or the equivalent capability) is more easily justified to school administrators when an argument can be made for the value of the space for disciplines beyond STEM. This study contributes to this in two ways: demonstrating a potential "fit" by integrating making and multimodal composition in ELA; and offering new theoretical insights by examining the process from a multimodal perspective.

2. Theoretical Framework

For the purpose of this study we look at making in the classroom not as an engineering task or a design challenge, but as an act of composition or meaning making that may lead to the emergence of new identities. We draw primarily on two theoretical perspectives: A multimodal theory of literacy, and a sociocultural theory of identity.

2.1 Multimodal Theory of Literacy

A social semiotic theory of multimodality seeks to investigate meaning in a way that does *not* privilege verbal language over other meaning-making resources [11,12]. Instead it attempts to account for the materiality of modes, "socially shaped and culturally given semiotic resource for making meaning," [11]. Within the last decade, literacy researchers have increasingly taken up this framework as a means of challenging the traditional conceptions of literacy that are common in schools. As high-stakes tests have taken a more prominent role in our education system, and standardized curriculum aligned to those tests has proliferated, traditional language-centric notions of literacy are being reinforced in schools. [20]. This is occurring even as other social institutions are actively recognizing the potential of forms of communication that are treated as "un-academic" in school settings. The result is that literacy in school often does not resemble literacy in other contexts [13,14]. A multimodal theory of literacy, therefore, functions as tool for better understanding the complexities of how we make sense and communicate. It allows us to examine making as a literacy event [2] that, one could argue, belongs in an ELA classroom alongside other forms of composition.

2.1.1 Modal Preference

Kress [12] notes that for both individual and cultural reasons, people seem to prefer to rely on different modes for certain types of communication. Smith's [18] mixed methods study of multimodal composition provides a clear view of how modal preference can influence the way students engage in an open-ended project. Other researchers have examined how mode and tools interact to mediate students' composing processes and products [1,18].

2.2 Sociocultural theory of identity.

Identity does not exist solely within an individual. It is relational, and, thus, can only exist within social contexts [7]. When an individual is consistently identified in a certain way, this is referred to as the "thickening" of identity [8]. This can be influenced by both institutional and local processes. School culture, curriculum and pedagogy all can contribute the thickening students' identities as learners [21].

Institutions that proliferate a narrow view of academic competence and success may contribute to individuals rejecting the identity of "learner" altogether [16]. Conversely, multimodal composition that draws upon and values literacy every-day literacy practices has been shown to have the potential to contribute to the emergence of "literate identities" [17,19] among individuals who have previously been positioned as deficient students.

3. Methods

3.1 Overview and design. This study made use of the combined resources of two research projects: a study of project-based learning (PBL) in 9th grade ELA [1] and a study of tactile picture book making for visually impaired children by middle and high school students, primarily in library Maker spaces [1]. For this study we adapted the tactile picture book curriculum for the 9th grade ELA setting. Changes included eliminating certain interim design tasks that weren't closely tied to the final product, and having students work in groups to compose 3D printed tactile picture books with integrated audio functionality. We employed a formative design approach [6,15], iteratively designing sessions based on ongoing analysis and feedback. While we began the project with a plan for implementing the modified curriculum, we made daily changes to that plan based on observations and discussions with the research team, the teacher and students. For example, we added a mini-lesson on Tinkercad design after observing that the initial session was insufficient. We also chose not to have an extended sound design mini lesson, but chose instead to have research team members with experience in sound production meet with groups as needed, modifying their instruction based on the experience of the group members and the type of sound design task they set for themselves. In addition, we designed a written reflection based on the teacher's

requirement for including certain writing tasks in her curriculum. In this way we were able to adapt the curriculum designed for informal learning spaces to a fundamentally different learning environment of an academic English class, with individual and institutional requirements that emerged in relation to a group's initial foray into making with an unfamiliar set of tools.

3.2 Participants. This study took place in a high school located in the Western U.S. Traditionally a farming region, it is experiencing urbanization as new industries locate and the population expands. The school serves approximately 84% White and 14% LatinX students, with 16% eligible for free or reduced lunch. The teacher is an experienced ELA teacher in her third year of participation in the PBL project. The class was chosen, in large part, for the teacher's having previously shown a willingness and facility for collaborating on experimental variations on projects. We served as co-teachers, leading sessions that focused on new technologies and design skills. Each class ended with a quick debriefing and revision of upcoming plans, and SLACK served as an almost daily communication tool. In addition to the teacher, we frequently had in the class 3 (and as many as 4) researchers, with expertise including tactile design, multimodal design, 3D printing, sound production and computer programming. During three sessions no researchers were present. The 9th grade general education ELA class included 29 students who self-selected into 6 design teams. The data analysis used data from 22 permissioned students. 5 students identified themselves as having had previous experience with 3D printing and 4 students had prior experience with the Scratch programming environment. Approximately half the class had done some video or sound production. No one had experience building circuits or with tactile picture book design.

3.3 Instructional experience.

3.3.1 Empathy building
To build awareness of individuals with visual impairments as agentive and accomplished, students watched videos, including an interview with the first blind person to climb Mt. Everest, a young child fluently reading Braille, and a blind man who uses echolocation to navigate public spaces while riding a bicycle. They also had a class visit with a computer programmer who was visually impaired.

3.3.2 Tactile immersion
We used a series of immersive tactile experiences to help students better understand the needs of their end users. While listening to a picture book being read aloud, students took turns being blind folded and drawing scenes from the book on a Sensational BlackBoard, a tool for creating tactile, raised line drawings. They observed and took notes on how their partners used their hands to navigate the space of the page. They also sculpted characters from another picture book (again while blindfolded) with modelling clay. They then attempted to identify, by touch, the tactile drawings and sculptures made by their classmates. This experience was intended to help students understand the sort of salient features that can make tactile art readily comprehensible.

3.3.3 A circuit in a book
In preparation for embedding sound in the tactile pages, students first used copper tape, a Makey Makey board and a simple Scratch program to embed a sound "button" in a copy of a page from "Where the Wild Things Are," by Maurice Sendak. They did this by creating a makeshift button with copper tape and placing in it "under" the page. This button was connected to a Makey Makey with alligator clips. They used their button to interact with a Scratch program designed to play a sound they recorded to augment their "Wild Things" page. Some students placed their button under the text, and recorded themselves reading the words from that page. Others recorded sound effects or exclamations related to the characters on the page. In this way we introduced students to several tools they would use to develop their final product, as well as to the different categories of sounds that could be used to augment a story book.

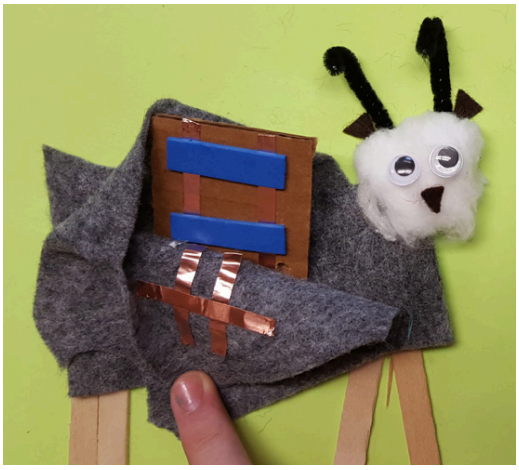

Figure 2: Copper tape button embedded in a crafted goat.

3.3.4 Salient features and texture
We read "The Very Busy Spider," by Eric Carle as part of an ongoing discussion of "salient features" which must be clearly emphasized in order for representative tactile art to be comprehensible. Pairs of students chose a page from the book and created a tactile version using crafting materials. Students took care to emphasize salient features and choose materials with a texture that resembles that object it was being used to represent (e.g. cotton balls for wool). Students again embedded "sound" in their page, this time facing a

greater challenge of how to create a button that could be discovered by touch without dramatically changing the texture and shape of the tactile art. These pages were assembled into a single tactile version of "The Very Busy Spider."

3.3.5 Tinkering with Tinkercad
At this point we began experimenting with Tinkercad, an application well suited for introducing design for 3D printing. A member of the research team with extensive experience in this area guided students through the main functions of the app. Students began composing objects by arranging and joining polyhedrons. Most experimented with making animals, as nearly all the books they would be transmediating contained animals, while others experimented with designing objects such as a piece of swiss cheese or a chocolate chip cookie.

3.3.6 Planning and designing the 3D pages
Most groups chose books with more pages than was feasible for the group to create within the allotted time. Groups therefore had to choose certain pages to omit. In many cases the text on a page in one of the picture books contained more characters than would fit in the space allotted for Braille on the tactile pages. Students therefore had to reduce the text so it would fit, while retaining the essential meaning and feeling. One group, which had chosen a book without words, chose to add text so that young readers would have the chance to practice reading Braille. Many of the original pages contained complex background images that could not be coherently reproduced in a tactile, bas relief form. Groups had to decide what to omit and how to create a clear setting in lieu of that omission. These plans were recorded as storyboards and shared with peers, so that groups would receive feedback before the 3D designs were created.

At the beginning of the 3D design phase (but after students had experimented with designing objects in Tinkercad) we showed students thingaverse.com, a repository of user generated 3D objects that can be downloaded and printed or remixed into new 3D objects. The final book pages were assemblages of original objects, remixed objects from thingiverse, and objects borrowed directly from thinginverse, as well as Braille text that was generated from a template for creating 3D printable Braille. In addition, all the pages contained a small, square hole that would be used for creating sound buttons and 2 holes for binding the pages together into a book.

3.3.6 A sound button made from tape
Our plan for students to create simple sound buttons on the 3D printed pages using copper tape proved to be problematic. We planned to run tape circuits over the back of the 3D pages and through a small hole so that "touching the hole" would result in a finger completing the circuit and playing the sound. However, students found that the conductivity of the tape was greatly reduced when it was folded around corners and the design was unreliable. This gave students an opportunity to solve an unexpected problem. A member form each group was given the task of working on a solution. Student ended up collaborating across groups to share their designs.

3.3.7 Sound Design
Rather than doing an extended mini lesson on sound design, research team members with experience in this area met with groups individually to discuss their plans and provide the technical assistance they might need. Most groups used a combination of speech recorded on a smart phone and sound effects downloaded from a website such as soundbible.com.

Sounds were loaded into a Scratch program template that would interact with a Makey Makey connected to the copper tape buttons on the tactile pages. Because of time constraints, we did almost no direct instruction with Scratch. Students who took on the task of managing their group's Scratch program thus had a responsibility to learn the basics of Scratch by taking tutorials and asking for help from peers and instructors.

3.3.8 Sharing and reflecting
Students were asked to share and reflect on their work throughout the design process. The completed a written reflection and a survey. They received feedback from peers and instructors on each stage of the process. They also travelled to a local elementary school to present their work to 2nd and 3rd graders, and to explain the purpose of creating tactile picture books. Before their completed books were collected to be packaged and sent to children whose parents had requested tactile books, groups presented their work to classmates, explaining their design choices and describing the parts of the projects they found to be most challenging and rewarding.

3.4 Data sources and analytic approach. Student data sources included the team picture books (3D pages with tactile illustrations, Braille text, and sound enhancements), Tinkercad 3D design files, Scratch programs for playing sounds, storyboards, and presentations, along with individual written reflections. Other data sources included field notes, session materials, photos, and a classroom video.

Three students who emerged as leaders in their design groups and are the focus of this analysis. Carter, Carlotta and April (pseudonyms), took on leadership in 3D design, creating a functioning sound button and creating a Scratch program for playing audio clips, respectively. For these three students, we reviewed written reflections, survey responses,

individual interviews, field notes and video focusing on evidence of the thickening of leadership identity. Such evidence includes actions, written text or speech indicating leadership status or the positioning of a student as the center of productive group activity. Specifically, we coded surveys, reflections, interviews and video of final presentations for mentions of the three students in connection to leadership. We also noted when the focal students expressed interest in a particular mode or tool. We examined classroom video and field notes for evidence that the students were positioned at the physical center of group activity, and for instances in which members of other groups consulted them for help.

4. FINDINGS

Our data suggest that these focal students gravitated to certain modes and tools in designing their tactile books, and in becoming relative experts in those modes and tools, took on leadership roles within their groups. Kress tells us that, "humans may have different orientations to modes and ensembles of modes – maybe with specific preferences for the temporal or the spatial, for image or speech, for the gestural or the domain of bodily movement as in dance, and so on" [11]. We saw evidence of distinctive modal preference among our focal students. While there were approximately 5 students in the class with some experience with 3D printing, and approximately 4 students who had some experience with Scratch programming, *every* student was working with multiple unfamiliar tools (no students had prior experience with Makey Makey boards or the Braille app) to create a text that was itself an unfamiliar assemblage of modes. This allowed for leadership to emerge along lines of interest and expertise, rather than through assigned roles. A closer look at the experiences of three student reveals that mutually acknowledged leadership roles coincided with modal and tool preferences.

4.1 Three students who stood out as "mode-tool leaders"

4.1.1 Carter

Carter had no prior experience with 3D printing. During the first day working with Tinkercad he began constructing a turtle. When asked why, he stated that he chose it because texture would be important for kids reading the tactile books, and turtles have a distinctive shape and texture. He created the texture of a turtle shell by "sinking" polyhedrons into a hemisphere, then flattening the combined objects. Later during the design of his pages for his group's tactile version of "In the Small Small Pond," by Denise Flemming, he again used this "sinking" technique. This time he partially "submerged" parts of turtles, ducks and frogs into the tactile page in such a way that the surface of the page itself was recognizable as the surface of the pond (see Figure 3).

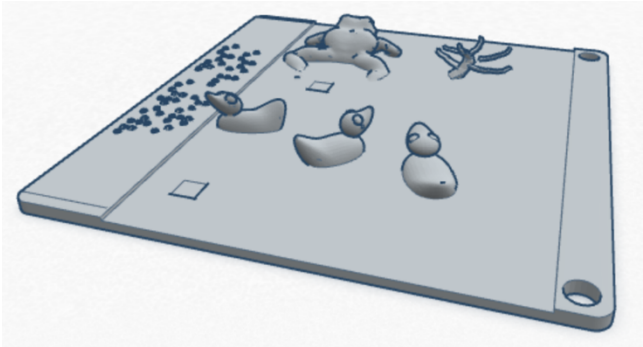

Figure 3: 3D printed page showing frog, stick and ducks partially submerged in the surface of the "pond."

One of the principles of tactile design is salient features must be clearly represented. In order to achieve this, students frequently made the decision to simplify and reduce the number of objects on a page. An attempt to represent a complex background image on a tactile page is likely to be confusing to someone who is visually impaired. The tactile version of *In a Small, Small Pond,* which has colorful, impressionistic illustrations, required a great deal of simplification and reduction. Carter's technique for representing the surface of the pond demonstrates an awareness of both the requirements of his audience and the affordances of the tactile mode. As such, his design was noted to be among the best by classmates. His technique of using the surface of the page as the surface of the pond was adopted by teammates for other pages in their book when appropriate. As Carter had done with turtle, his group attended to the texture of objects more than any other group, most notably by adding overlapping feathers to birds (see Figure 1).

Carter and his group mates identified him as a leader in the group, particularly in terms of 3D design. Members of other groups also sought him out for assistance with 3D design. During the interview when asked why he took on a leadership role around 3D design, he responded, "I don't know. It just made sense to me, and I was able to help people."

4.1.2 Carlotta:

One of the primary technical challenges of this project was the design of the copper tape "buttons" that worked with the Makey Makey to embed sound in the tactile pages. Each page had one or two small, square holes in it. The plan was to have a bit of copper tape come through the hole from the back of the tactile page in such a way that touching the hole with a finger completed the circuit and the sound played. But it didn't work. The tape was not well suited for conducting electricity around corners. Several students took great interest in this technical challenge, most notable Carlotta.

Carlotta took one of her group's tactile pages, a roll of copper tape, a Makey Makey, and a laptop, and cloistered herself in a corner of the library. She tried dozens of tape configurations including using multiple layers and broader patches. Several designs worked better than the original, but were not, according to her, satisfactory. Finally, Carlotta tried placing the tape on the front of the tactile page instead of the back. This resulted in "buttons" that were close to 100% reliable. I suggested that she share her design with her classmates, but she wasn't done. She wanted to continue experimenting with some variations on where and how much tape to place on the page in order to minimize the degree to which the tape interfered with the tactile experience and to strengthen the design (the tape also proved to be prone to falling off the page with moderate use).

When she did share her design, Carlotta quickly became a sort of consultant for all copper tape related issues in the room. Despite the fact that her 3D designs were simple assemblages of 3D objects borrowed from thingiverse.com, and she played no role in her group's sound design, both she and her group mates acknowledged her as a primary leader, no doubt because she was the one who solved "the button problem."

Figure 4: One of Carlotta's series of tests for developing a reliable copper tape button for Makey Makey.

4.1.3 April:

April took a week long Scratch programming workshop when she was in middle school. She enjoyed it enough that, even though she had no subsequent exposure to computer programming, she is considering it as a career.

In order to have the Makey Makey buttons play sounds, groups had to build out a Scratch program template we had designed. Time constraints prevented us from doing any extended instruction in Scratch programming. The template was designed, therefore, to be as easy as possible to work with for a novice user. Despite our intentions, it proved to be one of the main sources of confusion in the project. For April's group, however, April and her Scratch program became the hub of all work flow. Students recorded speech in quiet corners of the library, found sound effects to accompany the speech, then brought their work to April, who sat at a table in the middle of the library, for testing. She showed them how she converted file formats and uploaded sound clips to Scratch. She showed them how to properly connect the wires and cables. "OK, push the button," she would say quietly, then watch and listen to see if all the pieces were working together. If there was a problem, she would politely instruct her class mate on how to solve the problem.

Similar to Carter and Carlotta, April's affinity for a certain mode (sound) and tool (Scratch) led to her taking on a leadership role connected to that tool, as a well as a general leadership role within the group. Unlike the others, whose connection to a mode seemed to be born out of fascination and facility, April's connection to Scratch was at least in part due to experience.

For each of these students, their peers seemed to viewed their leadership as extending beyond their mode or tool of preference. One group mate stated that April was the leader of the group because, "She knew how to do everything." In fact, April's only notably unique knowledge came from her prior experience with Scratch and her persistence in figuring out its application in this context. Similarly, one of Carter's group mates stated, "I think that Cam was the overall leader of the group because he always directed us and told us what we had to do." This does not match our observations of the group. On the contrary, he tended *not* to be the first to speak, and offered suggestions primarily when his advice was solicited. Finally, one of Carlotta's group mates described her as the leader of the group because, "she was always on task and made sure everything was done." On the contrary, Carlotta's productively obsessive work on building a working button could also be viewed as a digression during which she ignored all other parts of the project. It may be that in developing unique facilities for working with unfamiliar tools, these students earned a sort of status that extends even beyond the scope of those tools. However, we lack the breadth of necessary data to make stronger claims on this this matter, as these opinions were reflected only briefly in the survey data.

In addition to the three focal students we saw other students identify themselves as leaders. 10 of the 22 surveyed saw themselves as a leader of their group (there were 6 groups). While each student was self-assigned 2 or more tactile pages to design, 16 indicated that they took ownership of part of the project beyond the assigned pages. This includes being in charge of sound design, circuit building, cover pages, programming, determining how to transmediate text into Braille, and assisting group mates with 3D design.

Students seemed to be drawn to different parts of the project. In response to the survey question, "In what part of developing your tactile book did you feel the most creative and why?" we saw a range of answers. Some felt most creative when designing 3D pages. Others preferred the experience of designing sounds, creating buttons, composing with craft materials, working with Braille, programming with Scratch, assembling pieces to make a complete book, or even presenting their work to a group of elementary school students. Furthermore, when asked which tool they found the most interesting 41% answered Tinkercad, 27% the Braille app, 18% Scratch and 14 % Makey Makey.

This data may hint that the trends we observed for the three focal students were prevalent throughout the class, however, without more comprehensive video and interview data we are unable to confidently determine if this is the case.

5. Implications

When printed text is the only mode of expression that we value in a classroom we are not reflecting the sort of communication that is valuable in our everyday and professional lives. The tools and modes commonly found in Maker spaces represent semiotic resources that have an ever growing place in a comprehensive definition of text. Puzzling with the best way to simulate the texture of a tortoise shell is analogous to a poet puzzling over a perfect word, or a novelist trying out dozens of opening lines. But not all students are inclined to joyously play with words. Instead of "It was the best of times, it was the worst of times," some are more likely to obsess over the perfect application of copper tape, or the best way to arrange a series of triangles to simulate the texture of a feather. These puzzles are contained within broader puzzles: How do we transliterate the "feel" of story told with pictures and printed text to one told with tactile objects, braille, buttons and sound? How do we convey setting with an assemblage of modes that cannot simply "show" a background? Such acts may not be conventionally literary, but they are undoubtedly in service of a story.

In keeping with the conference theme of creating a sustainable ecosystem for making in education, these results may help contribute to an argument for making in schools beyond the STEM classroom: A broader view of composition allows for a broader set of successful identities among composers [9,17,19]. Similar to the way in which previous studies have shown positive shifts in identity around literacy and writing, we witnessed positive shifts around leadership identity that appear to be associated with specific modes and tools. Our findings also suggest the value of allowing students the freedom to pursue experiences and roles of interest, rather than assigning roles. We anticipate that further study of making in education from a perspective of a multimodal theory of literacy will reveal further benefits.

6. ACKNOWLEDGMENTS

Forthcoming.

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