CHAPTER 13

TACTILE PICTURE BOOK MAKING AND MULTIMODAL COMPOSITION: STUDENTS DESIGN FOR EQUITY IN ENGLISH LANGUAGE ARTS

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ABSTRACT

Purpose – *The purpose is to expand multimodal composition frameworks and practices to include tactile design and use of maker technologies, situated in a larger context of designing for equity and increasing access to picture books for children with visual impairments.*

Design – *As part of the Build a Better Book project, we designed workshops to engage students in composing tactile books enhanced with sound and Braille for young children with visual impairments. Education undergraduates in a children's literature class crafted tactile retellings over a 2-session workshop, and high school students in an ELA class designed and fabricated 3D printed tactile books over several weeks.*

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Findings – *Both preservice candidates and high school students developed awareness of the importance of inclusive, equity-oriented design of picture books, and especially for children with visual impairments. They collaborated in teams, developing design skills manipulating texture, shape, size and spatial arrangement to express their tactile retellings and enhanced meaning with sound. The high school students had more ~~opportunity~~ to build technical and computational thinking through their use of Makey Makey, Scratch, and TinkerCad.*

Practical Implications – *Multimodal composition and making can be effectively integrated into preservice candidates' literacy education, as well as high school English Language Arts, to develop multimodal communication and inclusive design skills and values. Success depends on interdisciplinary expertise (e.g., children's books, tactile design, making technologies, etc.), and sufficient access to physical and digital materials and tools.*

AQ1 **Keywords:** Tactile design; multimodality; maker education; children with visual impairments

The School of Education classroom is humming with activity and conversation as undergraduate students in a children's literature course collaborate to create tactile retellings of popular children's picture books (see Fig. 1). They are designing for a particular audience, young children with visual impairments. Piles of craft materials spill off the tables – construction paper, pipe-cleaners, clay, cotton balls, sandpaper, glitter, miscellaneous textured objects, all possibilities for tactile expression. In one corner, a few students gather around a sound station with Makey Makey electrical circuitry materials and a laptop with Scratch, a programming language. They are making sound buttons and recording narration and sound effects for their team books. In another corner, several students are writing Braille text with a slate and stylus, adding another mode and layer of meaning.

Teams review their books, discussing how they might tell the story in just four to six scenes. What's essential to the story? How might children with visual impairments 'read' the characters and action through touch and sound? They brainstorm ideas, some begin to sketch, while others dive into 'making' – crafting an object, trying it out on their base paper-page, problem-solving, and trying again (and again). Some close their eyes to perceive their illustrations through the touch of both hands, surfacing potential confusions and re-designing their elements. There is lots of talk and sharing of materials, ideas, and strategies. On each team, some students gravitate to the sound or Braille stations, intrigued by opportunities to work with these modes and tools to enhance their team's picture book. All join in to assemble the pages to retell their story.

At the end of two sessions of 'building a better book', students share their books and reflect on their experience. Many respond that it has expanded their understanding of what a book can be, and how important it is to design books that are accessible for all children, including those with visual impairments. Some appreciate the artistic aspect of design and crafting; others point to the feeling of accomplishment at learning a new technology skill. Several volunteer to continue work on designing a 3-D printed version of their crafted tactile story. It is not clear how this experience will influence students' future teaching practices, book selection, or valuing of diversity. It is a start.

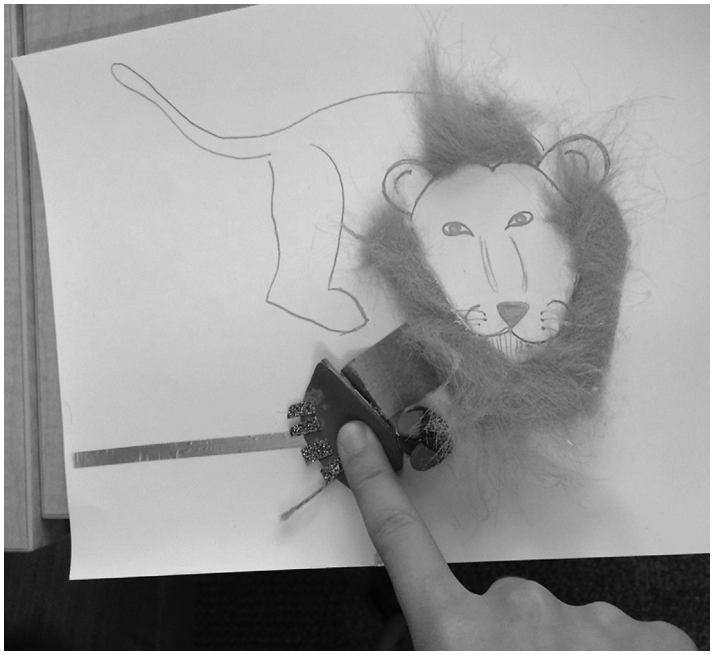

Fig. 1. Crafting a Tactile Retelling of the Fable, *The Lion and the Mouse.* This student is testing the sound button which will play the lion's dialogue when connected to ~~m~~akey ~~m~~akey and ~~s~~cratch. Rough glitter paper accentuates the claws and soft yarn expresses the lion's mane.

INTRODUCTION

This scenario, drawn from one of our children's literature classes, suggests the potential of expanding multimodal composition to include tactile design and use of maker technologies, while simultaneously expanding perspectives on what it means to be a reader, and how children with visual impairments have a right to high-quality, accessible picture books (Stangl, Hsu, & Yeh, 2015; Stangl, Jernigan, & Yeh, 2015).

As part of the Designing Tactile Books project (Yeh, Forsyth, & Dalton, 2016), we are working with colleagues to explore tactile picture book making in a range of settings and contexts: An undergraduate children's literature class, a university outreach service project with education and engineering student-interns, and multiple library maker space workshops. The work is also informed by our study of project-based learning in ninth grade English Language Arts (ELA) (Boardman, Polman, Garcia, Dalton, & Hunt, 2017).

Across these informal and formal learning spaces and contexts, it is becoming increasingly clear to us that this investment of time and resources is worthwhile, both from a multimodal composing perspective, and from a diversity and social justice perspective. Whether pre-service education candidates, ninth graders in an

ELA class, or youth and librarians in Library Maker Spaces, many individuals were motivated to engage in sensory design experiences and fabricate inclusive, tactile designs for blind children (note that we use the term blind children, as well as children with visual impairments; this is in accordance with the practices of the National ~~Blind Federation~~). Even those with a more vague sense of the imperative of inclusive design, invested in developing skills and identities, using tools, and modes of expression that are authentic outside of school.

Our enthusiasm for this work is tempered by questions we have regarding feasibility and capacity building, especially in formal education spaces such as Schools of Education and K-12 schools. We are an interdisciplinary team and rely on one another's expertise in literacy, tactile design, 3D printing, and maker education in designing workshops. We also have access to digital tools and craft materials that are not always readily available in teacher education or ELA classrooms. These are factors to consider when integrating projects that combine composing and making. One general criticism is that bringing making into schools subverts the essence of the maker experience, which values interest and problem driven exploration, tinkering, and creation of products that are shared with a public audience (Halverson & Sheridan, 2014).

Perhaps even more important for us as literacy teachers is the question of the relevance of multimodal composition that extends into making territory. We argue that tactile expression can be an important aspect of multimodal communication, especially given the low-cost maker technologies that are now available for novices. Composing and making are converging as modes expand. In addition, there are literacies embedded in making, as expert makers demonstrate (Tucker-Raymond, Gravel, Kohberger, & Browne, 2017). However, some raise a concern that extending multimodal composition to include tactile expression and digital making tools is beyond literacy teachers' expertise. It is also a question of time and resource investment. Given the real challenges of high stakes assessment and curricula tied to state and Common Core State Standards (CCSS, 2017), integrating multimodal composition-making into ELA might detract from the investment needed for high-quality reading and writing achievement.

In the remainder of this chapter, we make an argument that multimodal composition and making are converging and should become a valued literacy practice in schools, and correspondingly, a valued goal of teacher education. We present a conceptual framework, along with a ~~detailed~~ description of how we design and enact tactile picture book making workshops with undergraduate education students. We highlight key findings and discuss implications for integrating an expanded view of multimodal composition and inclusive tactile design into teaching and learning in schools. Along the way, we share resources and invite others to join in the conversation and, in the spirit of a composer–maker community, to play with tactile multimodal composition.

BUILD A BETTER BOOK TEAM AND PROJECT GOALS

We are part of the Build a Better Book team, an interdisciplinary group at the University of Colorado-Boulder that includes Tom Yeh, Computer Science, Stacy

Forsyth and Kathryn Penzkover, Science Discovery, Abigale Stangl, ATLAS, Ben Walsh and Kristina Stamatis, School of Education, and Anne Cunningham, a tactile artist who teaches at the Colorado Center for the Blind. We both (Dalton and Musetti) teach an undergraduate course in children's literature. Dalton's research focuses on digital literacies and universal design for learning (UDL); Musetti's interests focus on children's literature and reading.

The primary goal of the larger Build a Better Book research, development, and outreach project is to expand blind children's access to picture books and visual texts, as well as youth's opportunities for inclusive design and multimodal, tactile composition. We are interested in including blind and sighted individuals as both consumers and producers of multimodal texts. A second goal of the work is to increase interest and participation in science, technology, engineering, and mathematics (STEM), with an intent to engage those who are underrepresented in STEM-related professions. For pre-service and literacy teachers, the latter goal is supported through explicit literacy and STEM/STEAM connections that can translate into classroom practice. We also connect to state Professional Teaching Standards which include teaching for diversity as an important goal across disciplines. In this chapter, we focus primarily on integrating tactile picture book making into an undergraduate teacher education course on children's literature, although we draw on the past two years' experience working with youth, librarians, and teachers in informal maker spaces and formal ELA classes.

To get a sense of our work on the Build a Better Book project, we invite you to view a brief video introduction to one of our projects at http://stemforall2017.videohall.com/presentations/938 and browse the Tactile Picture Book website (https://tactilepicturebooks.org/). We have begun developing a Workbench site with an array of workshop activities that you may use and adapt for your students (https://www.workbenchplatform.com/bb).

CONCEPTUAL FRAMEWORK

We draw on multiple perspectives to guide our work in tactile multimodal composition, including making and project based learning (Honey & Kantor, 2013; Polman, 2000), multimodality (Kress, 2003; Kress & Van Leeuwen, 2001; New London Group, 1996), and UDL (Rose & Meyer, 2002). For our work with pre-service teachers and educators, we also find Mishra and Koehler's (2006) technology integration framework, TPACK (e.g., technology, pedagogy, and content knowledge) helpful in designing workshop experiences and community.

PROJECT-BASED LEARNING AND MAKER EDUCATION

Project-based learning and Maker Education share a base in constructivist (Dewey, 1938) and constructionist theories of learning (Harel & Papert, 1991). Simply put, we learn by doing. Project-based learning emphasizes interest and problem-driven inquiry, production of products and performances over time, feedback and support from experts and peers, use of tools and practices characteristic of the field outside of school, peer collaboration, authentic audience, and reflection (Polman, 2000).

Similarly, Maker Education (which has always been present outside of school in one form or another) emphasizes design and fabrication of products (making) for a public audience. Halverson and Sheridan (2014) described key features and practices of maker spaces. The making happens in a Makerspace that offers tools, materials, and a community of makers. Communities range in age and expertise and often includes both physical and online spaces for social interaction and learning. Creativity, tinkering, and innovative product development are valued, and there is an expectation that makers will contribute to one another's learning. Although time, space, and membership are typically fluid and unstructured, many Maker Spaces offer workshops to develop production-related specific skills.

The Build a Better Book project reflects important principles of project-based learning and Maker Education, although there is a fair amount of variation across contexts, depending on the participants, goals, and duration of the workshop. For example, we worked with a ninth grade ELA teacher and one class of students over several weeks to immerse them in tactile picture book making for young children with visual impairments. This was a strong enactment of project-based learning and making. As Table 1 illustrates, students moved from developing empathy and awareness of inclusive design to crafting and adding sound to tactile illustrations to designing 3D books in TinkerCad that were 3D printed. Their 3D designs were shared with Tom Yeh's lab for final assembly and mailing to families. The class also shared their books and sensory experiences with second and third graders, travelling to a nearby elementary school. Although the audience and purpose were set by the instructor, students decided whether to participate in this project and then had many options for choice in book selection, design, and use of tools. These students pursued interests in working with particular tools and modes, such as sound, or TinkerCad, and developed identities as experts and resources in their class (Walsh, 2017).

By way of contrast, integration of the Build a Better Book project into our Children's Literature classes was a short-term project and is closer to the Making workshops that are offered in Maker Spaces than a fully developed project experience that is interest or problem driven with extended time for ideation, iterative making of a product for a real audience, etc. In planning for the Children's Literature course, we have designed two versions, one for two sessions of 4.5 hours, and the other for one session of 2.25 hours. There were trade-offs made as making experiences were tailored to meet more constrained goals of multimodal composition and designing for equity. Across all of our work, designing for children with visual impairments is a non-negotiable goal since it is of utmost importance to develop an awareness of, and appreciation for, the value and benefits of inclusive design. The second non-negotiable goal is that workshop participants must fabricate some aspect of a tactile picture book using digital tools and physical materials. In the Tactile Picture Book Making Workshop section that follows, we describe the versions in detail and discuss the affordances of each workshop design.

MULTIMODALITY

Since the early work in multiliteracies (New London Group, 1996), there has been a growing acceptance in education that literacies are multiliteracies, and that

Table 1. Tactile Picture Book Making Workshops in a Children's Literature Course and a Project-Based Learning Ninth Grade ELA Class.

Goal	Activities
Empathy and perspective-taking	• View video of blind child fluently reading a book with Braille and a tactile illustration and discuss how the child constructs meaning.
Build awareness of individuals with visual impairments as agentive and accomplished, strategically using tools and human resources.	Ninth Gr. ELA: • View and discuss videos of the first blind person to climb Mt Everest and kayak the Colorado River, a blind person who rides his bike using echolocation. • Class visit with blind computer programmer.
Tactile immersion Heighten awareness of tactile sensory perception and expression.	• Wear blind folds and draw on a sensory board to create raised lines and shapes on paper. • Continuing with blind folds, listen to book read aloud and sculpt clay pieces which they exchange with a classmate, using touch to hypothesize its identity.
Tactile design principles and tools Learn about principles and tools in preparation for making (Specific tools are presented during the session in which they will be used)	• Brief instruction and demonstration of tactile design principles for visually impaired individuals, with 3D printed and craft book examples. • Materials and tools briefly introduced: Craft materials, Makey Makey, and Scratch. • Braille slate and stylus. Ninth Gr ELA: • Tinker Cad, Thingiverse, and 3D Braille app.
Book choice and brainstorming fabrication plans	• Teams select picture books or scenes for tactile retellings, identify key scenes, plan design strategies, and roles. • Some sketch and storyboard their book.
Fabricate tactile books with craft materials	• Make 3D book retelling with craft materials. • Some record narration and sound effects and make sound buttons with Makey Makey and Scratch. • Some compose short Braille text with slate and stylus. • Some assemble pages into book.
Share products and reflect	• Share tactile picture books and reflect on experience.
Design and fabricate tactile picture books with TinkerCad and 3D printer	Ninth Gr ELA • Students repeat the tactile design process for a 3D printed version of a book, using TinkerCad, Thingiverse, and a 3D printer. Sound is added with Makey Makey and Scratch, and Braille is composed with a 3D app. • Formative feedback is obtained from other students and grades 2–3 children.
Books shared with families	• 3D printed pages are assembled by engineering student interns and mailed to families.

literacy is a set of multimodal practices. Two key multimodality concepts that are important for our Build a Better Book work are "mode" and "design" (Kress, 2003; Kress & Van Leeuwen, 2001). We read, compose, learn, and communicate through multiple modes of image, sound, movement, and words, using a range of physical and digital tools (Hull & Nelson, 2005; Mills, 2015). Modes are culturally and historically constructed and carry affordances, with some more suited to particular content and communication goals than others. For example, cooking videos demonstrate techniques in a different way than a written cookbook

description, while a trail map highlights visual information at a glance in a way that an audio description, which is temporal in nature, does not. Designs are assemblages of modes, which together, express meaning that is more than the constituent parts, it is a lamination, or fusion of meaning. Multimodal compositions are designed and produced with physical and digital tools that similarly offer affordances. Just as a hammer invites pounding into an object, a video-editing tool offers a visual interface that structures a process of layering still and moving image, and sound.

Students can be quite intentional in designing digital multimodal compositions (Dalton et al., 2015) and often pursue modal preferences, developing identities as a sound producer or a visual artist (Smith, 2016; Walsh, 2017). However, multimodal composition is also conceptualized as an embodied, affective experience that cannot be explained or understood in relation to design decisions and metalanguages (Ehret & Hollet, 2014; Leander & Boldt, 2013). This resonates with Maker movement representations of making as an embodied experience. We suggest that multimodal composition is a mix of intentionality and logic, and affective embodiment. Sometimes, intentional design decisions are driving composing-making processes, and sometimes processes unfold in the moment, felt, rather than planned. It is this view that provides a more useful foundation for Build a Better Book tactile composing making.

Much of the research and instruction on multimodal composition in ELA contexts has focused on digital forms of expression, such as slide shows, videos, blogs, podcasts, photo essays, digital comics, etc. (for an overview, see Mills, 2015). In the Build a Better Book project, we find ourselves revisiting the power of crafting with physical materials that have long been part of early literacy and arts classrooms. However, in our longer term workshops, we extend this tactile crafting experience to digital design experiences using TinkerCad and 3D printing. It is only through digital fabrication that we can meet our goals for disseminating to families and schools. For blind children, the affordances of tactile materials are that they can represent an object through outline, shape, texture, size, dimension, accentuation of salient details, and spatial arrangement. Since many blind individuals have some residual sight, color and contrast can also be a design feature. For example, a mouse is known by its small round body, long tail, pointy snout, whiskers, and cupped ears. The texture of the body is soft, short fur. If sound is added, mice have a distinctive squeak.

Whether making crafted or 3D printed picture books, we have asked students to add digital sound, recorded narration and sound effects using Makey Makey sound circuits and Scratch, an open source programming language. In some cases, makers also embed Braille as a tactile mode of language expression. Their choice of Braille tool matches the book format – a 3D Braille app for the 3D printed books and a slate and stylus for composing Braille on paper. The Build a Better Book Project is designed to make the notion of mode and material affordances especially salient for composers–makers as they venture into a less familiar experience of storytelling through tactile and sound expression. They transmediate meaning from one set of modes and format (a picture book) to another set of modes and format (Siegel, 1995). Fig. 2 shows an

Fig. 2. Ninth Grade Students Compose and Fabricate a Tactile Illustration of "Pete the Cat at the Beach" using Tinker Cad, a Braille app, and a 3D Printer.

example of students' transmediation from picture book to 3D printed retelling. The larger intent is to expand inclusive design capacity as students engage in ~~client-~~centered design.

UDL AND DESIGNING FOR EQUITY

UDL is a set of values, as well as a set of design principles for designing curriculum and learning environments (Dalton & Jocius, 2013; Rose & Meyer, 2002). The three UDL design principles are to provide learners: Multiple means of engagement; multiple means of action and expression; and multiple means of representation (see CAST.org for a wealth of UDL resources). At its core UDL rests on the belief that society benefits as a whole when we design for learners' specific needs. A classic example is the invention of closed captioning for TV. Originally designed to provide access to TV content for individuals who are deaf or hearing impaired, today captioning is more widely used by individuals who are not hearing impaired. As many of us can attest, captioning can be quite useful when watching video on a treadmill, waiting for a flight departure, or viewing a foreign film.

UDL is also a matter of equity in education. All students have the right to access and participate in grade-level curriculum and assessment (Individuals with Disabilities Education Improvement Act of 2004, 1997/2004). The U.S. National Education Technology Plan (2016) pushed further, recommending that UDL guide the design, selection and integration of technology in schools.

We have designed Build a Better Book workshops to reflect UDL's core values of access and participation, with a specific focus on the design of picture books for children with visual impairments. In addition to serving goals of offering

accessible picture books (UDL principle: Provide multiple means of representation), the project develops youth and pre-service teachers as multimodal composers and makers (UDL principle: Provide multiple means of action and expression). Finally, for both the makers and readers of the tactile books, we aim to support students in making choices, pursuing interests, and becoming more self-aware and strategic learners (UDL principle: Provide multiple means of engagement). Previous UDL research on the design of enhanced e-texts and composing environments has resulted in positive literacy outcomes for students with and without disabilities (for overview, see Dalton & Rose, 2015). In the Build a Better Book project, we are extending UDL in a new direction, learning how tactile picture book making workshops offers opportunities for students to develop multimodal storytelling design skills and identities in the context of a meaningful design task – making tactile books for young children with visual impairments.

TECHNOLOGY, PEDAGOGY, AND CONTENT KNOWLEDGE (TPACK)

Mishra and Koehler's (2006) TPACK framework is widely used in education, highlighting the complexities of technology integration and the multiple entry points for pre-service and teacher development. For example, in our Children's Literature class, students are developing content knowledge about picture books (e.g., authors, titles, genres, etc.), pedagogical-content knowledge about how to teach with children's literature (instructional strategies for critically examining a book for bias or performing in reader's theatre), technology-content knowledge (learning about Internet resources for children's literature authors and illustrators) and technical-pedagogical-content (instructional strategies for scripting and video-editing a digital book trailer using book and genre content). The Build a Better Book project further develops TPACK as pre-service teachers build on familiar experiences retelling stories and composing with digital tools and their developing knowledge of picture book design. Less familiar or new knowledge and skills are developed in relation to tactile design for children with visual impairment, moving meaning from flat, printed illustrations and text to 3D expressions, composing sound enhancements for their illustrations, and working with making tools, such as Makey Makey and Scratch.

BUILD A BETTER BOOK PROJECT IN A CHILDREN'S LITERATURE COURSE

Participants

Each of the three Children's Literature classes included 27–30 undergraduate students, most of whom were in an elementary teaching licensure program, with some pursuing education minors. The vast majority identified as female. In addition to the instructor, two doctoral students from the Tactile Picture Book project joined the class to take the lead on the sound station and to provide just-in-time support to individual students and teams.

WHAT COUNTS AS A BOOK? WHO GETS TO READ PICTURE BOOKS?

A powerful experience at the beginning of each Children's Literature course is a trip to our university libraries' special collections, where librarians have prepared a book exhibit that pushes the boundaries on what it means "to be a book." Imaginative book constructions include a wine bottle filled with small pieces of paper with writing, a quilt that unfolds to tell a story, a small wooden box with papers connected in accordion style, an intricate pop-up book, a series of wordless paintings, and other incredibly artful expressions. This experience lays the foundation for our work critically examining picture books, especially in relation to readers' construction of meaning and emotional response as they interact with an assemblage of image, media, and words in a particular book format. In subsequent classes, students continue to expand the notion of what counts as a "book" as they read and listen to eBooks and audio books.

These experiences prime pre-service teachers to consider how modes express meaning in laminated holistic designs, and how visual images are not accessible to young children with visual impairments. What would it be like to listen to someone read aloud "Where the Wild Things Are," without seeing Maurice Sendak's fantastical illustrations? Even the most vivid verbal description of Max and the Wild Things dancing cannot fully capture what is expressed visually in the illustrations. In fact, nothing can replace the illustrations, but are there ways that they can be experienced that go beyond verbal description? That is a goal of building a better book through tactile design, learning through transmediating meaning from one mode to another, or assemblage of modes (Siegel, 1995; Smith, Kiili, & Kauppinen, 2016).

TACTILE PICTURE BOOK WORKSHOP, VERSION 1 FOR CHILDREN'S LITERATURE COURSE

In Version 1 of the Children's Literature class, which included 4.5 hours of class time, we engaged students in abbreviated versions of empathy and perspective building, sensory immersion, and design of tactile books with craft materials (see Table 1 for an overview of the goals and activities for this version as well as the extended ~~12 session~~ workshop for the ninth grade ELA class). We also included options for sound enhancements with Makey Makey and Scratch tools and Braille writing with a slate and stylus.

The students worked in teams to choose their books and created products in a composition-making community with support for using physical and digital tools and materials. This experience was similar to the workshops offered within Maker Spaces that are designed to develop skills and making of products, yet different in that the skills were not decontextualized. Students had a goal and an audience for their work. Given the time constraints, we were not able to move from crafted tactile design to TinkerCad design and 3D printing. Although students gave each other feedback as they worked within their teams, the kind of iterative

making and feedback characteristic of making could not be accomplished within the condensed time frame. The tactile books served as real books, and could potentially be shared with children in pre-service candidates' practica and future classrooms. However, they were not suitable for sharing with young children with visual impairments (e.g., the pages were fragile and often contained small pieces that could become ~~unattached~~, including copper tape for the sound buttons). Nevertheless, feedback from students indicates that this two-session workshop successfully addressed the goals of designing for equity and expanding multimodal composition.

TACTILE PICTURE BOOK WORKSHOP VERSION 2: SOUND AND TEXTURE ENHANCEMENT

Version 2 of the workshop was even more streamlined – just one class session – and thus the goals were revised to focus on awareness of inclusive design and multimodal composing. In this case, we scaffolded the making experience by providing color printouts of picture book illustrations that could be enhanced with sound and texture. Sound design was the primary focus, again using Makey Makey and Scratch tools, with designing texture with craft materials a secondary focus. The empathy and tactile immersion experiences were kept, but the more in-depth experiences of designing and crafting a tactile retelling of a picture book were let go. Students' individual pages were assembled into one enhanced version of their book, Maurice Sendak's *Where the Wild Things Are*. Fig. 3 presents an example of one team's enhancement of an illustration.

MULTIMODAL COMPOSITION-MAKING IN ELA: WHAT WE'RE LEARNING

Book Selection, Choice, and Design Task Constraints

Book selection matters. For retellings, we selected an array of high-quality books that we knew appeal to children. Why invest this kind of effort in books that are not? For Workshop 1, we offered several possible titles that varied in artistic style and storytelling: *That is Not My Hat* by Jon Klassen, *Dear Primo, A Letter to My Cousin* by Duncan Tonatiuh, *The Lion and the Mouse* by Jerry Pinkney, and *The Hare and the Tortoise* by Eric Carle. Each team chose their book. The variation in book content and illustration style meant that there would be substantial variation in students' compositions. The retelling task was complex and required a high degree of team interdependence to communicate the story in four to six scenes that shared a design aesthetic and story coherence[2].

For Workshop 2, we selected one book, Maurice Sendak's Caldecott Award winning *Where the Wild Things Are* and each team chose one page to enhance. Sendak had been featured in an author study and students were familiar with the book and illustrations. The artwork is in the style of surrealism, offering multiple opportunities to superimpose textured elements. Colorful language, adventurous

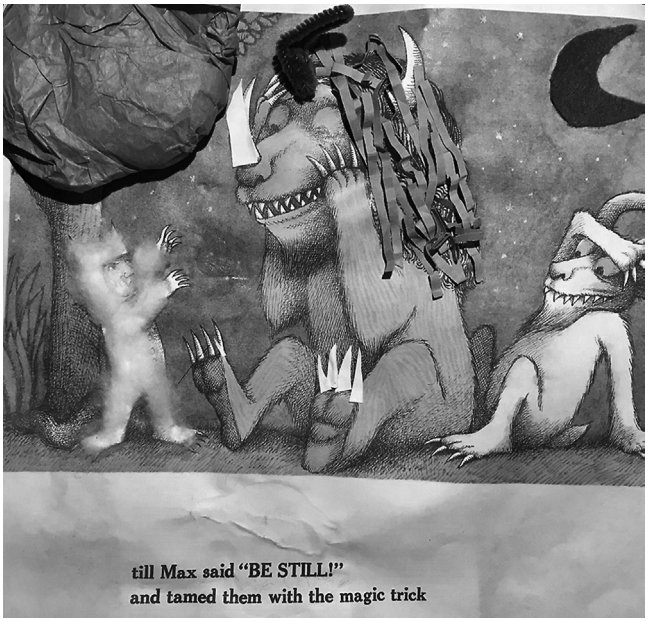

Fig. 3. Within a One-Session Workshop, Enhancing an Existing Illustration Allows Students to Focus on Texture and Sound Enhancement for their Illustration from Sendak's *Where the Wild Things Are*.

characters, and a variety of settings combined to make this classic text a good choice for experimenting with embedding sound and texture.

The decision to enhance existing illustrations in Workshop 2 substantially constrained the retelling task, allowing more time to focus on sound and some craft embellishment of the page, with less time for tactile design and storytelling. Students enjoyed both experiences, but there are obvious differences in the two experiences. In both cases, the project was more like the drop in workshops offered in Maker Spaces than the extended project in the ninth grade ELA class that was characteristic of project-based learning.

MULTIMODAL COMPOSITION, MAKING, AND TACTILE PICTURE BOOK DESIGN

Workshop 1 focused on tactile design, broadly, with sound and Braille as secondary modes for storytelling. We shared examples of tactile design and did a brief think aloud using pages from *If You Give a Mouse a Cookie* to illustrate how to select or combine key scenes that could retell the complete story. We asked "What is essential in this illustration?" What might be deleted? For important objects, such as the mouse and the cookie, what are the salient details that would support perception and meaning making? We briefly mentioned that one or two people

on each team could work on sound design and Braille text as additional modes for meaning, directing students to work stations where a doctoral student was positioned to help them. We did not attempt a mini-lesson in using Makey Makey and Scratch, relying instead on just in time help at the sound and Braille station table. Our approach resulted in considerable investment in the tactile design from all students, as well as interest-driven investment in sound and Braille composing by one or two members of each team.

Workshop 2 focused on sound, with secondary attention to texture enhancements of color printed illustrations. The mini-lesson focused on these aspects in more depth, presenting examples and demonstrating how to connect Makey Makey circuits, build sound buttons, and record and program sound in Scratch. A "How To" video was also shared. The design challenge questions were also focused: How could sound make illustrations more accessible? Would they add sound effects? Music? The characters' voices? A "voice over" of the printed words? How could texture enhance character or setting? And, how could texture and sound enhance the overall picture book reading experience?

Given the focus on sound design, there were more layers to the sound track for *Where the Wild Things Are* than found in the Version 1 workshop books. Sound included narration, sound effects, character dialogue, and music. Student narration of exact phrases from the original book was the most common sound, followed by character dialogue, such as mother calling or Max saying "I'll eat you up." Sound effects, such as a lion's roar for a Wild Thing, were also common. They were used to reinforce character's action in a plot event, or an onomatopoeia supporting character dialogue. In one instance, students added background music to set the mood for the beginning of the story.

The technical nature of sound design and use of unfamiliar making tools such as Makey Makey and Scratch meant that the instructor and a doctoral student moved feverishly from table to table assisting with the mechanics of circuit and button construction. One student emerged as an expert, and joined in providing technical assistance. Nevertheless, tinkering and problem-solving was restricted, as students felt time pressure to complete their page and wanted to follow the directions on "how" to construct the sound, rather than problem solve iterative solutions.

In addition to technical assistance, there was much conversation and sharing in process as students thought about the role of sound in making the story and illustrations more meaningful to a child with visual impairment. Students were prompted to apply the read-aloud techniques that they had been developing to this new context: Consider your audience when you're narrating the text aloud. How could you use tone, intonation, and expression to communicate meaning? What might you accentuate with your voice? How might your pitch change when reading character dialogue? Sound effects were also encouraged: What sound effect might support the reader's perception of character, setting, or plot event?" AQ2

Upon completion of one or more embedded sounds, students turned their attention to embellishing the pages with craft materials such as felt, cotton balls, pipe cleaners, beads, glitter, sequins, rubber bands, and balloons. They were prompted to consider which features of a particular object (a character, a part

of the setting, etc.) needed to be most salient to support tactile perception of the object and reinforce the storyline.

Workshop 2 focused specifically on one aspect of tactile design – texture enhancement of existing illustrations, while Workshop 1 approached tactile design quite broadly (e.g., line, shape, size, outline, texture, dimension, spatial arrangement, deletion of elements, and increasing salience of element features). Students in Workshop 1 composed more elements and played with a range of tactile design techniques, in what was a more complex design task. They transmediated (moved) meaning from the original book pages to their own tactile pages, with tactile illustration, sound, and Braille, engaging in complex design processes. However, the constrained task of Workshop 2 allowed students to dive deeper into sound and texture, completing a meaningful product within one class session.

DESIGNING FOR EQUITY AND SENSORY IMMERSION

In both workshops, students viewed a video of a young child fluently reading an illustrated page with Braille and examples of tactile books. We thought this was essential, first to help shift perspectives from viewing blind children as having a very restricted life, to viewing them as accomplished readers and agentive learners. Second, we wanted to demonstrate that tactile picture books, while limited in availability, are a real thing in the world. The availability of relatively inexpensive technology like TinkerCad and 3D printing is opening new opportunities for making and disseminating tactile books, and even though that would not happen in a one- or two-session workshop, we wanted students to be aware of the larger implications of inclusive design and access to picture books for all children.

Both workshops also engaged students in sensory experiences that heightened their sensitivity to touch, such as molding a clay object while blindfolded and then exchanging them to hypothesize about the object's identity. We had more time in Workshop 1, so students also draw simple lines and shapes on a sensation board. These kinds of embodied experience seemed to motivate students to want to figure out the best possible ways to express their story through touch. They engaged in a user-centered design, thinking about how children with visual impairments might interact with their books and construct meaning. As they designed for these children, many students became more aware of how sighted children interact with picture books and the potential benefit of tactile books for these children, as well. This reflects a UDL perspective, although few would have used this terminology. Instead, they talked about making books accessible to all readers.

Even when only participating in a one-session workshop, there was evidence of impact and transfer to students' final project, authoring and illustrating a picture book in print or multimodal format. Demonstrating an awareness of the importance of designing for readers with diverse needs, many incorporated craft materials to offer a tactile sensory experience. For example, one student designed a board book for toddlers using different textures of fur as a vehicle to teach about animals. Another made a laser-cut wordless, colorless, picture book depicting

the life cycle of a tree, and another integrated sound into her book with Makey Makey and Scratch, composing a 2:51 minute audio recording of a mindfulness exercise, including music and oral meditation, that played as the book was read.

Students' reflections from both workshops showed awareness of the complexity of meaning making with tactile image, texture, sound, and Braille. They also were more critically aware of access issues and the potential for multimodal books to support children with visual impairments, as well as other children.

WORKSHOP DESIGN RECOMMENDATIONS AND INTERDISCIPLINARY COURSE CONNECTIONS

The Children's Literature Course, and potentially a literacy methods course, offer strong contexts for integrating a one- or two-session workshop on tactile picture book making and design. If working within a short time frame, we recommend that the workshop focus on an overarching goal of developing an appreciation of inclusive design, and particularly the design of tactile picture books for young children with visual impairments. There are four core experiences: Introduction to the design task and audience; tactile sensory immersion; teams' making of tactile pages to retell a picture book and presentation and reflection on the experience. This workshop plan can be accomplished with craft materials, Internet resources, and a picture book and does not require specialized technical knowledge of sound and Braille tools.

Some tips for integrating a tactile picture book workshop into a Children's Literature course include:

(1) Schedule the tactile picture book workshop after students have some experience analyzing picture book illustration elements, such as line, color, layout, and style, as well media and format.
(2) Select a high-quality picture book with a strong plot and illustrations for the class to retell in 3D illustrations. Make copies of the pages so that each team has their page for reference.
(3) Gather materials: Blindfolds and playdoh/clay for sensory experience; craft materials such as construction paper, textured papers, pipe cleaners, cotton balls, ribbon, glue, scissors, etc.
(4) Bookmark Internet resources: Use the Tactile Picture Book website to learn about this initiative and view tactile books at https://tactilepicturebooks.org/. A Google search will yield many tactile illustration images. View a short video of a blind child fluently reading a tactile illustration and Braille at https://www.youtube.com/watch?v=MB8cUjzt_7U.
(5) If you plan to include Braille text, order two sets of a Braille writing slate and stylus (est $10 per set). Download and print a Braille alphabet card (http://www.nbp.org/nbp/images/braille/alphabet_card.jpg).
(6) If you plan to add sound enhancement, order one or two basic Makey Makey sets (about $12 each), and set up an account to use the open source Scratch program https://scratch.mit.edu/. Copper tape is also needed to make the sound buttons.

Our experience co-teaching a 12-session tactile picture book project in a ninth grade ELA class suggests the power of working in a project-based learning-making framework that allows for extended time to ideate, tinker, problem solve, fabricate, and share with a public audience (see Table 1). The use of making technologies would also be deepened with more time. The ninth graders engaged in craft design and then had the time to learn how to design a 3D retelling book with TinkerCad, Thingiverse, and a 3D Braille app, creating pages that were 3D printed and assembled for families with a child with visual impairment.

One possible solution to this dilemma is collaborating with the instructor of an instructional technology course, often a required course in education licensure programs. Another option would be to connect with a science methods course. Students could participate in a two-session workshop in their children's literature course, move the work to their technology course where they would use a 3D design program and fabricate their 3D printed book, and then end with a joint celebration of teams' tactile books before the books are shared with children, either directly through mailing to families or through local libraries. This would allow students to be part of a making experience as part of project-based learning.

CLOSING

At the time we were writing this chapter, Dalton and Yeh of Computer Sciences were recruiting undergraduate students in engineering and education to intern on a university outreach project to expand Yeh's Tactile Picture Book Project. Interns will be mentored as they work together to design customized 3D printed tactile picture books for families around the world with blind children. The larger Build a Better Book team met last week to have a maker session of our own, and invited the new interns to join us. The energy and excitement in the room was palpable as we shared news, tools, and some children's books about the human body (we wanted to learn more about designing informational books, given our previous focus on fiction).

For the next two hours, we pursued interests and curiosity – one group new to TinkerCad followed Kat, an expert who led them through a series of design steps, artist Ann and science educator Stacey worked with a craft cutter and different materials to figure out which might be best for a tactile diagram of the bones in the hand (working from an image in Magic School Bus's *Inside the Human Body* book), computer scientist Tom and educator Ben tinkered with a sound production board to construct a better way of integrating sound into our 3D books, and Abby, a tactile design researcher and Shalini, a recent college graduate who is blind and has expertise in tactile diagrams and Braille, collaborated on constructing a physical model of the human backbone using wikisticks, clay, and brads. The interns took a break to see Yeh's 3D printing lab and plan next steps for their internship. Toward the end of the session, Kat took 3D sensor images of several of us and will 3D print sculptures. Throughout, there was quiet intensity, laughter, showing, tinkering, and personal connections. As we prepared to leave, the education interns gathered around me, sharing their excitement. They got

the literacy connections. They got the importance of making. They got the value of collaborating on an interdisciplinary team. And, they got the importance of designing for equity. One student exclaimed, "Bridget, you didn't tell us what a big deal this project is!" Big deal projects, more powerful learning.

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AUTHOR QUERIES

AQ1: Please provide at least six keywords as per EMP style guide.

AQ2: Please provide the opening quote for the phrase "…character, setting, or plot event?".

AQ3: Please provide publisher name and location for reference Yeh, et al. (2016).