CuddleCode: An Emotional Connection to STEM for Girls

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Abstract

CuddleCode is a customizable and programmable stuffed animal for girls ages 6-10. It aims to increase female engagement in STEM by allowing for a more feminine and emotionally-connected approach to technology. CuddleCode consists of a main body along with various interchangeable body parts embedded with sensors and outputs which can be affixed to the stuffed animal's exterior and programmed using the block-based programming environment MakeCode. Through designing and assembling their own stuffed animal, girls build an emotional relationship with the stuffed animal and its various parts. This emotional relationship provides a foundation upon which they begin to understand and develop an interest in working with technology. In providing an emotional connection between the physical and the digital, CuddleCode enables the transition of reasoning from physical to formal environments.

Keywords: transitional object, programming, STEM, gender-inclusivity, feminine practices

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A Lack of Women in STEM

The STEM fields suffer from a lack of female representation. In 2016, only 21% of engineering and 19% of computer science bachelor's degrees were awarded to women (National Science Foundation, 2019). The percentage of computer science bachelor's degrees awarded to women in 2016 showed an 8% decrease from its previous standing of 27% in 1997 (National Science Foundation, 2019).

This gender disparity begins at a very young age. Adults are much more likely to buy STEM-related toys for young boys than for young girls (Inman & Cardella, 2015). Children as young as 6 years old have been found to believe stereotypes that boys are more capable than girls in the areas of engineering and computer programming (Master et al., 2017, p. 101). These stereotypes can be attributed to cultural expectations as well as a lack of female exposure to STEM experiences. This can lower girls' senses of self-efficacy or interest in these subjects, consequently diminishing their motivation to pursue them further (Master et al., 2017, p. 101).

Our nation's economic prosperity, productivity, and competitiveness require a strong STEM workforce, one which can be strengthened by the creativity and problem solving introduced by diverse participation (Sax et al., 2016, p. 571). It is not just our national well-being at stake. Participation in STEM can impact the independence and economic security of women as individuals. The average earnings for STEM occupations in May 2015 was $87,750, almost twice the average income of those not in STEM occupations (Fayer et al., 2017, p. 6). Increasing the representation of women in technology would ensure that those involved in developing technological solutions provide diverse perspectives and provide women with access to the same opportunities for career advancement and economic prosperity as men.

A Disregard for Feminine Practices in STEM

Approaches to increasing female participation in STEM often overlook the value of practices already inherent to feminine culture. Rather than expand upon the educational potential within traditionally-feminine practices and artifacts, most efforts either focus on the creation of “girls only” spaces or encourage girls to engage with traditionally masculine tools and activities (Buchholz et al., 2014, p. 295). These approaches imply that the only path to success in STEM is for girls to either be protected from boys or adapt to be more like them (Buchholz et al., 2014).

Computer science instruction traditionally emphasizes structure and linearity, placing value on careful and deliberate planning (Turkle & Papert, 1990, p. 151). This is in contrast to a more “concrete” approach in which one tinkers and experiments, then evaluates and renegotiates until a desired effect is achieved (Turkle & Papert, 1990, p. 135). Concrete approaches seem to coincide with “proximality,” or close relationships with the objects of study (Turkle & Papert, 1990, p. 147). Many women prefer to develop close relationships with computational objects, but the computer culture shuns this in favor of structured, plan-based approaches (Turkle & Papert, 1990, p. 150).

By disregarding the value of feminine practices, approaches, and proximality, the computer culture effectively excludes many girls and women from engaging in STEM.

Theoretical Framework

Constructionism and the Maker Movement

Constructionist theory highlights the ways in which children learn through the creation of artifacts that hold personal relevance and can be shared publicly (Papert, 1993). In constructionism, children draw upon inspiration from their own lives and cultures and leverage prior knowledge and experience in their designs and creations. Constructionist learning environments support children with “objects-to-think-with,” objects found within their culture that enable them to connect with complex intellectual concepts (Papert, 1980, p. 11). Through manipulating these objects, children are empowered to reflect on their thinking and refine their mental models based on their interactions and experience (Papert, 1980).

Some credit Seymour Papert, the father of constructionism, with laying the theoretical groundwork for the maker movement (Martinez & Stager, 2013, p. 17). This movement consists of people (also known as “makers”) who design and build artifacts and contribute to the community through sharing information about their artifacts and processes (Halverson & Sheridan, 2014, p. 496). Makers learn to take ownership of their creations, engage in problem-solving, and gain a greater understanding of technology through exploration (Dougherty, 2013). These projects hold great personal relevance as they are made for the maker or their community. The act of making can be found in both informal and formal learning environments, including homes, museums, libraries, and schools (Halverson & Sheridan, 2014, p. 501).

The maker movement has been celebrated for its “democratizing effects” in enabling “almost anyone” to innovate and create through the use of cheap parts and accessible tools (Hatch, 2014, p. 10). However, this movement is still largely dominated by white males, and the majority of maker experiences include stereotypically male activities such as interaction with robotics, electronics, and vehicles (Buechley, 2016).

By identifying the child as an active participant in the construction of their own knowledge rather than a passive consumer of information, constructionist theory encompasses many concepts that inherently increase inclusivity and diversity in learning experiences. These notions illuminate the necessity of incorporating traditionally-feminine practices, tools, and materials into STEM experiences as a means to provide a more welcoming avenue for girls.

Epistemological Pluralism

“Epistemological pluralism” recognizes that concepts may be approached from many different angles and celebrates various “ways of knowing” other than the traditionally accepted and taught ways (Turkle & Papert, 1990, pp. 129-153). Piaget’s “epistemologie genetique” classified structured and formal reasoning as the final stage of development, implying that the other ways of knowing were not as developed or valid (Turkle & Papert, 1990, p. 129). In contrast, epistemological pluralism argues that many types of reasoning are valid and that there need not necessarily be a progression from one “stage” to the next. The term “bricolage,” used by Lévi-Strauss (1968) to describe a “savage” process of tinkering and experimentation, is celebrated by epistemological pluralism as a valid and useful approach to knowledge (Turkle & Papert, 1990, p. 129). Adults working in science and mathematics often exhibit this more concrete approach in their work, in contrast with the abstract, formulaic way of thinking typically enforced in classroom instruction (Turkle & Papert, 1990, p. 130).

In his classic constructionist text, *Mindstorms*, Papert (1980) contrasts the traditional use of classroom computers as tools used to teach the child with his vision in which “the child programs the computer” (p. 5). This distinction is especially important as he introduces computer programming as a means by which children can tinker and experiment in their approach to problem-solving. Papert states that the act of programming the computer provides a means by which formal knowledge may be accessed in a more concrete manner. He calls attention to real-world models present in our culture that children may reason with, noting that “one-to-one correspondence” (p. 22) is modeled in the cultural context of setting each place at the dinner table with one fork and one knife. In surfacing these cultural models, he also highlights their deficit in modelling less concrete concepts such as procedural thinking. For the concepts where cultural models do not exist as a tool for reasoning, Papert discusses the value of a computer as an “object-to-think-with” (p. 23) in providing a model for reasoning in a more concrete fashion.

Emotional Connections

Sherry Turkle, building on this concept of an object-to-think-with, stated that “We think with the objects we love; we love the objects we think with” (Turkle, 2007, p. 5). The profound notion of loving an object-to-think-with is a key motivator for the development of this study, which seeks to identify ways to enable emotional relationships between girls and technology. Turkle and Papert (1990) describe the types of “intimate relationship” that can be developed between a scientist or maker and their object of study, stating that there is a strong correlation between a more concrete or “bricolage” type of thinking and “proximality, a style of relating to the objects of work" (pp. 145-147). To enable a bricolage approach to programming, this study aims to establish this proximality, or closeness to their work, in young girls.

Turkle and Papert (1990) describe a young girl, Anne, who has an intimate relationship with the objects of her Logo programming environment. She "psychologically places herself in the same space as the sprites," and from this perspective is able to better understand the concepts involved in programming them (p. 144). Through "body syntonicity," defined by Papert (1980) as the ability to reason about an object based on one's understanding of their own body, she connects on an emotional and physical level with the objects of study, thus enabling her to develop her knowledge about programming.

The sprites in the Logo environment serve as "transitional objects" for Anne. A transitional object is one which serves to bridge the gap between formal, abstract knowledge and a child's physical, "body knowledge" (Papert, 1980, p. viii). Both "cognitive and emotional artifacts," these objects connect emotionally with the interests and motivation of each child to enable them to explore and manipulate their capabilities (Eisenberg, 2003, p. 34). In contrast with the "screen-based transitional object" of the Logo sprite, childrens' activities, hobbies, and interests provide a wealth of tangible transitional objects. Children form emotional connections with objects which are "collectible; or huggable; or something that you give to your parents; or something that you miss when you take a trip and leave it at home; or furry; or a million other things" (Eisenberg, 2003, p. 34). Imagine a young girl clutching a doll or stuffed animal tightly to her chest, giving it a kiss, or presenting it to family and friends. The integration of technology into emotional artifacts such as these could enable children to identify a personal meaning and connection to programming.

Cultural Contexts

Rather than focus on *bringing girls into STEM practices*, efforts to increase female representation should focus on *bringing STEM into girls' practices*. By integrating with various cultural contexts, maker education has the potential to connect with a broader range of participants. In this way, a diversity of avenues into STEM would empower individuals to embrace their "socially valued" identities and "gendered histories" (Buchholz et al., 2014, p. 295).

While technology-oriented activities like robotics and video games tend to be viewed as pertaining to boys' interests, crafts such as sewing, weaving, and clothing design have historically aligned more closely to the interests of girls (Buechley et al., 2006, p. 56). Replete with opportunities to engage with mathematical concepts, crafts and their materials could serve as transitional objects for young girls.

One example of incorporating STEM into traditionally feminine objects and materials is that of "electronic textiles," or "e-textiles." This practice integrates the traditionally masculine practices of engineering and computing into the feminine cultural contexts of crafting, sewing, and embroidery. Popularized by inventions such as the sewable LilyPad Arduino created by Leah Buechley, the practice of e-textiles encompasses the creation of clothing, wearables, and artwork embedded with an array of electronic components including LEDs, sensors, and microcontrollers (Kafai et al., 2014, p. 533). Makers of e-textiles sew or embroider electrical connections into the design of their creations using conductive thread or fabric. This practice has attracted a new audience to engage with computing and served to confront societal ideals of what is considered making (Kafai et al., 2014, p. 538).

The success of e-textiles in providing new pathways to STEM for girls and women suggests that integrating technology into other cultural and gendered contexts could provide even more pathways. As each child is a unique synthesis of many identities, it follows that a variety of cultural contexts will provide the most pathways to inclusivity within STEM.

CuddleCode

CuddleCode is a customizable, programmable stuffed animal which seeks to create a welcoming avenue for girls to engage in STEM experiences by celebrating and encouraging feminine practices in programming. Its design emphasizes tinkering and bricolage rather than enforcing structure and careful planning. CuddleCode is designed to enable young girls to connect with their computational object on a personal and emotional level, increasing their general interest and engagement in STEM.

CuddleCode aims to be hugged, cuddled, and shared with family and friends. It seeks to enable girls to explore and manipulate its capabilities through the acts of physical assembly and computer programming. Girls playing with CuddleCode will be empowered to create a stuffed animal unique to them. The modular design encourages girls to iterate on their designs by modifying the appearance and functionality of the stuffed animal. This ability to personalize and modify seeks to offer a stronger emotional connection than a typical stuffed animal: one can make her CuddleCode fit her own personal vision of how she wants her stuffed animal to look and behave.

Overview

CuddleCode consists of a main body along with a variety of small parts attached to it. The egg-shaped, plush body is about 10 inches tall and made out of a felt material that can be easily adhered to with Velcro. The body is the core mechanism: it conceals a microcontroller within and contains a discrete USB outlet for charging and programming.

All of the stuffed animal's parts are contained in an internal pouch within the body. These parts are a variety of shapes and sizes, each with its own sensor or actuator embedded within. The form of each part serves as an indicator for how it might behave; for example, a round, white piece of felt that resembles an eye performs as a light sensor and a red, mouth-shaped piece contains a speaker to produce sound. The intent of the design is not to be prescriptive as to how the part must be used, but to provide visual cues that enable children to easily identify the affordances of each piece. Each part has a patch of Velcro enabling it to be easily adhered to and removed from the body. A child may select a part from within the body's internal pouch and attach it onto the exterior of the body. Any unused parts may be stuffed back inside the body and tucked away.

Each part is connected to the body's microcontroller with a long, thin, fabric-covered line. These lines appear to come directly from the body's internal pouch, as the microcontroller is concealed within the body of the stuffed animal on the other side of the pouch. This concealment is a purposeful decision to background physical connections and allow the child to focus on what the parts do and how they interact without the added necessity of understanding the microcontroller's configuration.

Figure 1

Example of Assembled CuddleCode

To program her CuddleCode, a user will connect one side of a USB cable to the USB port on the side of the body and the other side to her computer. Within the MakeCode programming environment (Version 5.15.20; Microsoft, 2020), she may then open the CuddleCode template code, which was built by the researcher to map each part to its associated pin and provide the functions and variables responsible for communicating with each part. Once this template is loaded, she may utilize its preset functions and variables to program her stuffed animal.

Design

The design of CuddleCode foregrounds the interoperability of parts and pieces through its use of Velcro and illuminates each part's functionality through their relationship to the human body. It emphasizes personalization by providing a variety of parts that can be utilized in multiple ways.

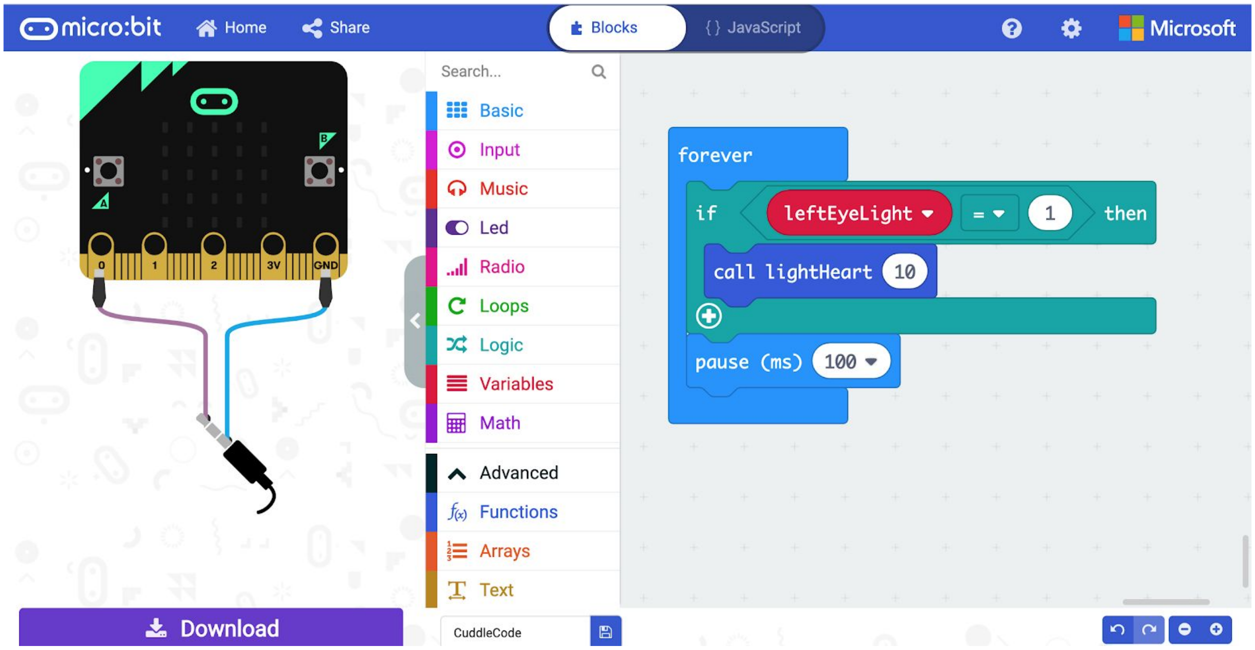
In using bold white hand-stitching and felt material, CuddleCode aims to be reminiscent of traditionally-feminine textile crafts, suggesting that its design can be modified and augmented with additional parts and pieces.

The electrical connections between the internal microcontroller and CuddleCode's body parts are concealed in order to prevent these complexities from distracting from the overall goals of modification and play with the logic controlling the various parts. The microcontroller itself is hidden from view in order for participants to see the stuffed animal as one programmable entity rather than necessitate an understanding of the differences between a microcontroller and its various inputs and outputs. Template functions and variables are provided in order to facilitate play with *what* the sensors and outputs do and *how* they can be manipulated to interact with each other without the concern of *why* they have these affordances.

The functions and variables provided in the MakeCode template will help parents and children to recognize and tinker with the functionalities of each body part. By running a function called *"lightHeart,"* they will see that CuddleCode's heart can light up. Similarly, the template code will have sample blocks containing logic such as *"if leftEyeLight = 1"* that will help them to understand that the eyes are capable of sensing light in the room. These sample blocks will also provide the participants with an introduction to conditional logic. From playing around with the "if" and "else" blocks, they will learn how to control the state of the stuffed animal to be dependent on certain criteria. Figure 2 shows a screenshot of an example "forever" loop within the MakeCode environment which evaluates the value of the template variable *leftEyeLight* prior to invoking the template function *lightHeart.*

Figure 2

Screenshot of MakeCode Web App With CuddleCode Template Functions and Variables



CuddleCode serves as an initial introduction to technology. Girls who connect with CuddleCode and want to develop their knowledge further will be encouraged to look "behind the curtain" into the circuitry and sensors, but these features are purposely concealed in order to avoid the gender stereotypes that many electrical or robotic-looking devices carry with them, as well as to maintain the focus on developing personal connections with the technology.

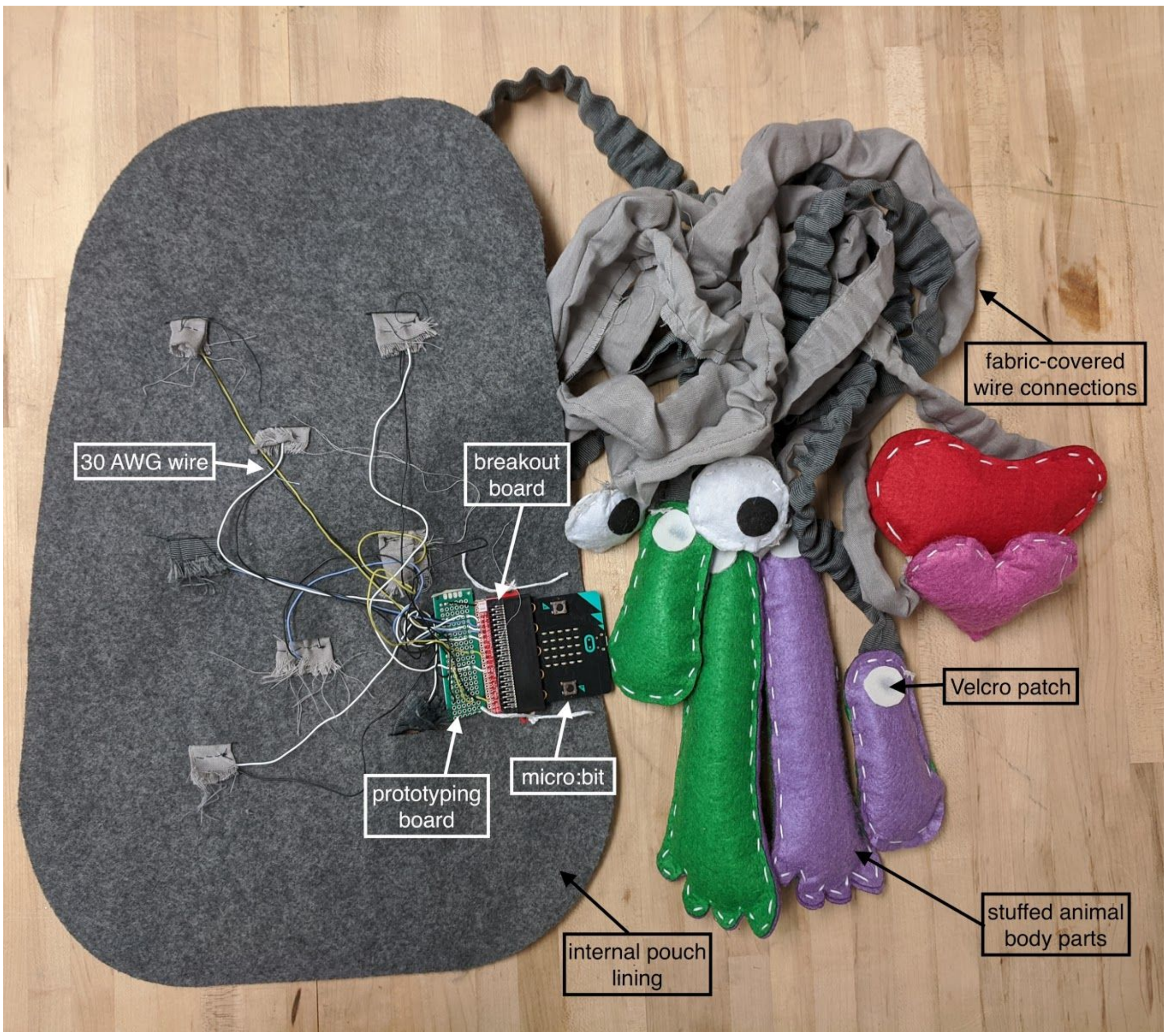
Technical Specifications

The microcontroller within the body is a BBC micro:bit. The micro:bit was selected for this implementation due to its ease of programmability using the block-based program MakeCode in addition to its ability to support a sufficient number of inputs and outputs for the design. Each stuffed animal part contains a sensor. The sensor's positive and negative terminals are each connected to a 30-gauge wire: both of which are then strung through a long, thin piece of fabric.

Discrete holes within the body's internal pouch (Figure 3) allow these lines to be fed through from the internal pouch, where the parts reside, into the main body, where the microcontroller resides. The wires are then soldered to a prototyping board, which is connected by a breakout board to the ground and each input or output (I/O) pin of the micro:bit.

Figure 3

Electrical Connections Fed Through Internal Pouch Lining



Research

This study seeks to identify ways in which girls may be supported in developing stronger interest and engagement in STEM experiences. The theoretical framework suggests that the integration of feminine practices and ways of knowing with the maker experience will foster an emotional connection to STEM in girls, which will consequently lead them to become more interested and engaged in future STEM endeavors. To investigate this hypothesis, the following research questions will be addressed:

1. Can incorporating maker experiences into feminine cultural contexts establish an emotional connection to technology in young girls?
2. Does the establishment of an emotional connection to making increase young girls' overall interest in, and understanding of, technology?
3. What types of support help to facilitate the integration of feminine practices with maker experiences?

Participants

This study will comprise a series of individual research sessions conducted with four to six parent-daughter dyads. Participants will be selected from a diverse range of socioeconomic status and ethnicity. The diversity of participant backgrounds follows "most different systems design" (Anckar, 2008) in order to focus the analysis on variables that are independent of these factors. The daughters in each dyad will be between the ages of 6 and 10 years old, as most children of this age have little prior experience with programming, are capable of understanding the logic required to program the prototype, and are likely to still have an interest in play with stuffed animals.

The inclusion of a parent in each dyad serves to provide support and facilitation that is an authentic representation of what the daughter might receive in playing with CuddleCode in her own home. By inviting parental participation, the study seeks to elicit similar parental support to that which they would provide in assisting their child with homework. Parents who are involved in their children's homework participate in "collaborative learning," a process by which they scaffold, explain, or simplify tasks based on their understanding of their child's specific learning abilities and comprehension (Hoover-Dempsey et al., 2001, p. 204). Thus, the inclusion of a parent in the dyad will aid in identifying the types of scaffolds, explanations, and simplifications that may facilitate the child's interactions with CuddleCode.

Procedure

Each dyad will participate in a two-hour research session. At the beginning of each session, the daughter will be asked to participate in a brief interview to assess her knowledge, experience, confidence, and interest in computer programming. Following the interview, the dyad will be presented with a short tutorial to introduce the dyad to the use of MakeCode to program CuddleCode. The researcher will demonstrate how an input sensor may be used to control an output by programming CuddleCode's heart to beat for 1 second when an eye senses darkness. Next, the dyad will be invited to tinker and experiment with CuddleCode for 30 to 45 minutes. Finally, the daughter will participate in a concluding interview designed to assess any changes in her knowledge, experience, confidence, and interest in computer programming.

Data Sources

Data will be collected in the form of audio-visual recordings and transcriptions, photographs, and screen recordings. This data will be collected for each dyad's research session.

A comparative case study method (Ragin, 2014) will be applied to analyze the data collected from each individual dyad.

Interviews

Pre- and post-study interviews with the child will be conducted at the beginning and end of each study. These interviews will follow a semi-structured format in which the researcher may ask follow-up questions or divert from the interview guide in order to gather more pertinent information. The parent will be present for the duration of the interview, though the researcher will focus on eliciting responses from the child. Both interviews will pose similar questions regarding the child's understanding, interest, and preconceptions about computer programming (See Appendix for complete list of interview questions).

Audio-Visual and Screen Recordings

Each study will be audio- and video-recorded from the beginning of the pre-study interview until the conclusion of the post-study interview. These recordings will allow the researcher to facilitate and adapt the study as necessary without the distraction of taking extensive field notes. The researcher may write down specific observations or interactions as a reminder to revisit them in the recordings, but will prioritize engaging as a facilitator over taking detailed field notes.

The laptop provided for each dyad's use will be configured to capture a screen recording of their interactions with the MakeCode environment as they program their CuddleCode. Through observing the dyad's interactions with MakeCode, the researcher will be able to identify the approaches and processes the dyad applies throughout the study.

It will be critical for the researcher to understand the interplay between what is heard, what is seen, and what is created, as each of these aspects can be misinterpreted when taken out of context. For this reason, the screen recordings and audio-visual recordings will be time-stamped and transcribed using multimodal transcription (Bezemer & Mavers, 2011). This transcription will provide the researcher with more context when analyzing an interaction.

Photographs

The researcher will take photographs to document the various ways in which CuddleCode is assembled by the dyads. These photographs will include any body parts that are attached to the stuffed animal as well as any additional materials or objects that the dyad decides to integrate into their design.

Data Analysis

Beginning with a deductive approach, descriptive coding will be utilized to classify data according to the theoretical framework and research questions. Data will initially be classified into five general codes: “emotional connection,” “interest in technology,” “understanding of technology,” “feminine practices,” and “facilitation.” From these codes will emerge more specific sub-codes relevant to the data and the theoretical framework. Using matrices, the coded data will be cross-referenced by timestamp to demonstrate changes over time.

The “emotional connection” code will include instances in which the child appears to relate to CuddleCode in a personally meaningful way or in which she shows fondness for the stuffed animal. Data coded with “interest in technology” will be instances in which a child demonstrates an interest in working with technology, whether she is speaking of past experiences or demonstrating interest in the technological tasks of the study. “Understanding of technology” will indicate occurrences in which the child demonstrates knowledge of technological concepts, engages in problem-solving, or develops increasingly complex code over time. “Feminine practices” will denote instances in which the child engages in tinkering or experimentation, mentions or engages in crafts such as sewing to enhance her design, or makes reference to gendered concepts including stereotypes and societal expectations. The code “facilitation” will be applied to the moments in which a parent provides guidance, support, or demonstration to assist the child in problem-solving or achieving a specific goal. The coding scheme outlined in Table 1 describes the behaviors and evidence that will be used to identify occurrences of each code.

Table 1

Coding Scheme

Code	**Indicators**
Emotional Connection	Child smiles or laughs, hugs CuddleCode, anthropomorphizes object(s), speaks of personally meaningful applications such as making for themselves others
Interest in Technology	Child engages extensively with MakeCode environment, appears focused and energized, asks many questions regarding the functionality of the code and technology
Understanding of Technology	Code becomes increasingly complex over time, child employs problem-solving strategies
Feminine Practices	Child “tinkers” or experiments, refers to feminine practices such as sewing or crafting, makes reference to gendered concepts including stereotypes and societal expectations
Facilitation	Child requests assistance or asks for clarification. Parent offers or provides explanation or demonstration.

Analysis of Interviews

Pre- and post-study interviews will focus on the girls' interest in and emotional connection to technology and programming. The questions are designed to provide the child with an opportunity to discuss the experiences that are personally meaningful and relevant to her. These interviews will be contrasted in order to identify any shifts in the presence of the five codes that may be attributed to the child's interaction with CuddleCode.

Analysis of Audio-Visual and Screen Recordings

In analyzing the multimodal transcripts of audio-visual and screen recordings, the researcher will pay particular attention to body language, facial expressions, dialog, and on-screen code modifications to identify instances of the five codes outlined in Table 1.

The child's body language, facial expressions, and dialog can be indicators of their level of engagement, interest, understanding, or enthusiasm for a task. The researcher will pay close attention to moments in which these characteristics seem to shift or become particularly noticeable. These moments will be coded according to Table 1, and then further divided into emergent sub-codes that will serve to provide more insight into each trend.

Instances in which the screen recordings indicate code modifications are likely to demonstrate moments in which the child or dyad exhibit shifts in approach or thinking. For example, if a dyad were to repeatedly make a minor code change and click "Download," this would be a potential display of tinkering and experimentation. The researcher would consult the corresponding audio-visual interactions to confirm or deny the presence of the code "emotional connection" in this case, and then code the transcript accordingly.

Analysis of Photographs

The photographs will document the ways in which CuddleCode is physically placed, manipulated, and configured. The physical proximity of the stuffed animal to the dyad could provide a possible indicator of emotional closeness. An “irregular” arrangement of body parts on the stuffed animal may indicate experimentation, playfulness, or personalization. Frequent modifications to the stuffed animal’s configuration could be an indicator of experimentation, problem-solving, or personalization. As the researcher analyzes different aspects of the dyad’s interactions with CuddleCode, other phenomena and themes will likely begin to surface.

Expected Results

Emotional Connection

The first research question seeks to identify if incorporating maker experiences into feminine cultural contexts can establish an emotional connection to technology in young girls. In a similar manner to the way in which Turkle & Papert’s Anne adopted the perspective of her sprites, girls playing with CuddleCode will psychologically put themselves in the space of their stuffed animals to program them from within that perspective. Through interacting with their CuddleCode stuffed animals, they will learn that each body part, or component, has the ability to either “do” or “tell” something to the main body. They will recognize that some components have the ability to perform actions, such as light up, while others have the ability to report on their status, such as sensing pressure. In connecting the stuffed animal’s body parts with their own abilities to sense or act, girls will be able to leverage their understanding of the way their own bodies work in order to further comprehend the abilities of the stuffed animal. This body syntonicity is hypothesized to strengthen their emotional connection to the stuffed animal.

The soft and cuddly nature of CuddleCode is hypothesized to be reminiscent of the girls' own stuffed animals and dolls. It is expected that girls will display their emotional connection to CuddleCode by making reference to similar artifacts in their personal experience. They may also display this emotional connection by hugging or cuddling their creation or proudly showing it off to the adult in the dyad. One question in the post-survey asks the girls who they think might enjoy playing with CuddleCode; this question is designed to identify if the girls feel compelled to share their creation with others, another indication that they feel an emotional connection to the artifact.

Interest and Understanding

The second research question asks whether the establishment of an emotional connection to making increases young girls' overall interest in, and understanding of, technology. It is expected that the girls' interest and understanding of technology will increase throughout the course of the study. In the MakeCode environment, this development may be demonstrated by an increase in the exploration and use of functions or variables or by developing increasingly complex logic statements. Similarly, in dialog, it may be demonstrated by asking increasingly relevant questions, making more accurate predictions, or simply seeming more engaged and excited about the task at hand.

It is expected that the emotional connections established will contribute to an increased interest and understanding of technology; this will be evidenced by the girls' use of body syntonic language or anthropomorphism when describing or asking questions regarding the functionality of the stuffed animal. This type of language might include statements such as "I want my heart to blink when my arm is squeezed" or "it won't know that I've touched the arm if…" The first statement is an example of body syntonic language in which the girl places herself in the metaphorical shoes of her stuffed animal, while the second is anthropomorphising language in which a human quality, the ability to "know," is attributed to the stuffed animal. Other evidence of an emotional connection's impact on the girls' interest and understanding may be found in statements regarding what the girls want to build in the future, which would likely indicate that they have developed an interest in continuing to make with technology.

Facilitation of Feminine Practices

The final research question seeks to identify the types of support that might help to facilitate the integration of feminine practices with maker experiences. This research question has more of an exploratory focus, making it difficult to hypothesize potential findings. Salient aspects of the dyads' interactions will foreground the types of facilitation most pertinent to supporting both the emotional and cognitive aspects of feminine maker experiences.

While the design of CuddleCode alludes to the feminine practice of crafting through its use of familiar craft materials such as felt, Velcro, and hand-stitching, interactions with the stuffed animal do not inherently include crafting. The results of the study will likely indicate ways in which crafting could be more seamlessly integrated. These indicators may take the form of comments such as "I wish I could make my own…", "what if I made a…", or "can I decorate it?"

It will also be important to identify ways in which the concrete practice of tinkering and bricolage can be successfully facilitated in interactions with CuddleCode. The adult in each dyad is expected to provide some element of scaffolding for the child. The correspondence between each scaffold provided and the girl's consequent demonstration of understanding will illuminate which scaffolds are most effective in bridging the gap between the child's physical and abstract understanding of the stuffed animal.

Limitations

Given the small sample size of this study of only four to six parent-daughter dyads, it will not be possible for the distribution of participants to be representative of a diverse array of backgrounds and socioeconomic statuses. In assessing the results of the study, it will be critical to acknowledge the impact of the participants' backgrounds and cultures on their experiences and preconceptions. What surfaces as relevant to the participants of this study may not be applicable to all young girls. This should be accounted for in discussions of the study results.

Only one CuddleCode prototype was created, requiring the same artifact to be used for all participants. This limitation adds a significant lack of crafting opportunities for the participants, as it requires that the original prototype not be irreversibly modified from one study to the next. CuddleCode will be used directly out of the box without any physical crafting or making. As the design intends to connect with girls' cultural identities as crafters, it can be enhanced by requiring them to engage in the act of crafting.

The most significant limitation of this study is its timeframe. Sessions with each dyad are designed to last a maximum of two hours over the course of one day. To fit within this constraint, many opportunities for engaging with the stuffed animal as a transitional object will necessarily be omitted. An aspect of e-textiles that supports their effectiveness as transitional objects is their transparency of engineering and computing concepts (Kafai et al., 2014, p. 538). By physically sewing the circuitry in their creations, makers of e-textiles are forced to confront concepts like short-circuits, polarity, and resistance. CuddleCode's circuitry is deliberately hidden from sight, as the design prioritizes tinkering with logic over the opportunity to expose girls to the concepts of circuitry and electronics.

Conclusion

Women are noticeably underrepresented in STEM. From a young age, girls learn to identify as non-technical. Feminine practices, interests, and artifacts are considered less technical than their masculine counterparts. Rather than focus on *bringing girls into STEM practices*, efforts to increase female representation should focus on *bringing STEM into girls' practices*. Constructionism and the maker movement provide a framework for doing just that. In emphasizing emotional connections' importance in knowledge construction, constructionist theories describe the educational potential inherent in diverse cultural practices.

CuddleCode serves as a feminine "object-to-think-with," enabling an emotional relationship with technology in young girls. By providing a transitional object through which girls can relate to technology, this artifact has the potential to increase their understanding of, and interest in, STEM practices.

Implications

The findings of this study will serve to demonstrate ways to integrate STEM into traditionally feminine practices. Building upon e-textiles' success in attracting females to computing and technology, CuddleCode aims to identify other feminine practices which may serve to provide similar bridges to STEM for young girls.

Kafai et al. (2014) mentioned in their study of e-textiles that one must explore "whether the very notion of disruption may, in practice, reify what it is intended to change" (p. 552). In other words, by using feminine practices as an "entry point to computing," (p. 552) it is possible that studies such as these serve to reinforce gender stereotypes. While the intent is to embrace feminine practices as inherently relevant to STEM, it would be irresponsible to simultaneously reinforce notions that girls are not equipped to engage in more "masculine" practices such as robotics and engineering. This surfaces a need for a longitudinal study on how integrating feminine practices with STEM may impact stereotypes surrounding girls' potential to engage with the traditionally "non-feminine" aspects of STEM.

While CuddleCode seeks specifically to increase female representation in STEM, it is important to note that many non-white communities are also underrepresented in this area. By demonstrating ways in which cultural contexts can build emotional connections, this study can serve as a roadmap to engage a diversity of communities in technology.

Eisenberg (2003) said "what constitutes comfort, or a feeling of safety, is highly personal – it is likely to be as idiosyncratic a judgment as any person, child or adult, is called upon to make" (p. 40). By acknowledging the idiosyncrasies of each individual, he emphasized that there is not one universal panacea: what serves as an emotional artifact for one child may be ineffective in connecting with another. Rather than prescribe CuddleCode as the ultimate solution for increasing female presence in STEM, this study presents one possibility of many that has the potential to attract a new type of audience. The implications from this study should be applied to other contexts and used as a basis for identifying even further avenues through which others may connect to STEM.

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Appendix

Pre-Workshop Interview

1. Today, you and your (mom, dad, etc) are going to get to make a stuffed animal together. How does that sound?
2. Do you have a favorite stuffed animal at home?
    a. What's its name?
    b. What type of animal is it?
    c. What is your favorite thing about it?
3. Have you ever heard of computer programming, or coding?
4. What do you think programming, or coding, is?
5. Have you ever coded or programmed before? Maybe you've done Code.org at school or played with something like Scratch or Makey-Makey?
6. How do you feel about coding? Do you like it, or find it fun, or find it frustrating?

Post-Workshop Interview

1. Tell me about what you made!
2. What does it do?
3. How did you make it do that?
4. Did you enjoy making the stuffed animal?
    a. Why (not)?
5. What was difficult about making it?
6. What was fun?
7. What do you think programming, or coding, is?
    a. If necessary, explain that the process they completed in MakeCode was considered programming
8. How do you feel about coding? Do you like it, or find it fun, or find it frustrating?
9. I only have one of these stuffed animals right now, and I have to keep it so other girls can play with it too, but if one day I were to make many more, what kind of people do you think might want one? A sibling/cousin/friend? You?