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Intergenerational E-Textile Workshops for Engineering and Social-Emotional Learning (Fundamental)

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In this paper, we share the findings of an exploratory study on the use of e-textiles and potentially extended reality (XR) technologies for intergenerational engineering learning.

Rationale

The role of families in STEM learning. Although families are often an overlooked factor in the positive engagement of students in STEM topics, family relationships and dynamics have a large bearing on student achievement, interests, enthusiasm, and beliefs surrounding ability [1]. When considering how to engage students with engineering topics, family members, especially those in a parental or senior role can act as a catalyst for engagement. Individuals acting in a parental role are the main contributors to a student's career aspirations, and support behaviors related to science from these parental sources contribute to increased science achievement and a greater likelihood of a choice of science-oriented careers in students [2]. Student interests, career, and education choices are heavily influenced by malleable factors, including their confidence, expectations of success, and societal norms. The Expectancy-Value theory identifies and categorizes these factors into two main groups, self-efficacy beliefs - the aforementioned confidence and expectations of success - and associated values or connotations; both of which can be potentially shaped heavily or entirely by household environment and family [3], [4].

Family intervention to improve learning outcomes and student attitudes is best utilized in collaborative and bonding activities. In the broader context of education and overall student confidence and achievement, it is shown that, "the families of academically successful students view their family as a source of mutual emotional support and connectedness" [5].

This connectedness is provided by quality time, emotional support, approval, reassurance in times of distress, clear communication, and collaborative problem-solving. Taking these factors into consideration, the benefits of incorporating an intergenerational aspect into an engineering engagement project become clear. Workshops and projects, directly and indirectly, generate many opportunities for collaborative problem-solving and teachable moments. The crucial aspects of a successful collaborative project are respectful communication, trust, and shared problem-solving, which both contribute to the family's spirit of togetherness [6] and resultantly to a student's overall well-being and success. Additionally, when challenges arise, family members are provided opportunities to develop the student's sense of personal efficacy. By taking the time to teach about perseverance and personal responsibility they can actively encourage persistence in the face of challenges [5], a valuable skill for students engaging in STEM or engineering topics that may be challenging or unfamiliar.

The role of narratives and quilts in sensemaking. Narrative and perspective-taking experiences have demonstrated their ability as tools for promoting empathy [7], and the historical role of quilts in cultural and intergenerational storytelling makes them useful supplements in the contexts we are exploring. Evidence suggests narrative-based and mediated perspective-taking experiences are more effective at increasing empathy than interventions without [8] and quilts have served as storytelling tools and supplements in many communities around the world and in the United States, especially in

traditionally underserved communities. One example of this are quilt codes that were used along the underground railroad to relay messages [9]. Whether it may be through patterns, designs, colors, or fabrics that tie into a greater narrative, "quilts can have hidden 'secret codes' to send us special messages about the people who made or used them [10]." Quilts serve as an additional source of sensory information which serves to deepen narrative experiences.

Narrative and perspective-taking experiences become even more effective when immersion can be increased. The greater sense of immersion, provided by additional sensory inputs, for example combining both audio and visual components, has been shown to increase self-reported empathy in narrative and perspective-taking activities [11]. The aforementioned quilts are just one example of providing additional sensory input for increased immersion. As an artifact that can be touched, quilts are indispensable learning tools for all ages and help stimulate creative thought, integrate learning, and involve all the senses [10]. Furthermore, XR technologies like Augmented Reality (AR) and Virtual Reality (VR) are promising social-emotive learning tools that can increase the effectiveness of traditional exercises meant to elicit empathy or sympathy in individuals by increasing immersion. Perspective-taking is directly benefited by the additional immersion that AR technology provides [8]. The use of AR can make social-emotional learning experiences more interactive and realistic, which benefits the development of empathy and intergroup relationships, two important factors for the development of youth regardless of the context.

The need for connection during a global pandemic. In the wake of the coronavirus pandemic especially, activities that can be used to connect students to their families and peers are crucial. The negative effects of social isolation are extremely concerning, and go far beyond a student's educational successes and failures. "Loneliness reliably increases the risk for developing mental health problems, cardiovascular disease, infectious illness, cognitive decline, and increased mortality [12]." The connectedness of students to their peers and families has been demonstrated to not only benefit their educational outcomes and interests as mentioned earlier, but it has an impact on overall well-being. School closures and the resultant isolation impacted students' mental health and as lockdowns progressed many students engaged in online learning were more likely to exhibit symptoms of depression and anxiety [12]. Although direct social interaction can be difficult to supplement, it is clear the urgency of the growing loneliness epidemic necessitates the development and investigation of existing and new potential social-emotive learning tools.

Data Collection Context

Two parental-youth cohorts— one of mother and son (C1); the other of mother, daughter, and son (C2)— participated in and were observed throughout an E-Textile quilt square workshop. Participants were first given a brief presentation consisting of an explanation of simple circuits and an overview of e-textiles and their practical applications. Each participant then created an E-Textile quilt square representative of an experience or memory during the Covid-19 pandemic and chose or recorded a corresponding sound. Instruction and assistance were provided by facilitators, but parents and youth were encouraged to collaborate with and assist each other with design and fabrication. Participants' quilt squares were uploaded to a central database used to create an interactive AR quilt with participants' unique sounds assigned to their squares.

‘E-Textiles’ primarily refers to wearable technology such as clothing with integrated electronic functionality [13]. In the context of this study, E-textile is used to refer to circuits constructed with conductive thread and sewable electronics on fabric.

The non-circuitry materials available included felt, fabric markers, pipe cleaners, pom-poms, and hot glue. The e-textiles circuits were constructed using components from the LilyPad system, a system of sewable electronic components [14]. Each circuit consisted of a LilyTiny LilyPad Board, multicolored LilyPad light-emitting diodes (LEDs), a LilyPad coin cell battery holder, and stainless steel conductive thread. The LilyTiny board used includes a microprocessor which allows four outputs with distinct LED patterns. In using the e-textiles and constructing their stories using the technology, families together practiced engineering and science knowledge including that of circuits, problem solving, and debugging.

Approach

The overarching research questions for our larger research study are:

> RQ1: How does collaborative creation of physical artifacts encourage social-emotional learning by making individuals feel part of a community and facilitating communication of personal narratives?
>
> RQ2: How and in what ways do participants learn about engineering, physical computing, and craft through participation in this workshop experience?
>
> RQ3: What role does intergenerational learning play in youth’s STEM career aspirations?

The data collected consisted of field observations, audio-video recordings of participants, semi-structured interviews, the quilt squares, and the resultant AR experience. Data analysis included the creation of content logs, where-in participant behaviors, remarks, and apparent emotions throughout the workshop were recorded. Additionally, the final artifacts and participant notes and sketches were collected and analyzed within the additional context provided by the narratives that inspired them.

Technological Framework

This study is part of a larger investigation of intergenerational workshops alongside place-based AR experiences. Below is a brief explanation of the ARQuilt application developed alongside this study.

The ARQuilt application is a Progressive Web Application built in SvelteKit, a framework for creating mixed-rendering web applications, built on top of the user interface framework Svelte [15]. For AR rendering, it utilizes A-Frame, “a web framework for building virtual reality (VR) experiences… based on top of HTML” [16]. It stores and retrieves data from a Firebase Realtime Database, and Cloud Storage for Firebase.

When the user opens the application, they are prompted to target a physical quilt square or image target, which if recognized will display the corresponding community quilt around the image target. The squares themselves feature gaze interactions such that when a user centers their view on a square, it will expand to indicate it is currently selected, and play its associated sound.

Findings

Below are observed behaviors and conversations that informed the outcomes of the research study ordered chronologically by cohort. These findings elucidate the dynamics of the cohorts and contextualize them within the research questions of the study. We discuss these findings further in the following Discussion section.

Cohort-1

The participant's difference in design provides the opportunity to contrast perspectives of the same experience (RQ1):
During the initial discussion of what participants did during the pandemic the mother of C1 says, "We did a lot more hiking since we had the weekends free." A facilitator replies, "You could each make a different hiking square and see how they compare." The mother of C1 then grabs her own materials and remarks, "That might be good because we both imagine the pandemic differently." The mother and facilitator laugh.

The son of C1 is possessive over his chosen narrative (RQ1):
A facilitator suggests to C1 they begin their design process by drawing out what they want their squares to look like. Shortly thereafter a second facilitator suggests, "Maybe do a square to represent the outdoors, and another to represent all the other stuff you did during the pandemic?" The mother of C1 responds, "I'll take the outside because that was my highlight" to which her son responds, annoyed, "I'm doing the outside mother."

The son is unmotivated and uninterested until his mother begins to lead by example (RQ3):
The mother of C1 pulls over the pad that has up to this point been directly in front of her son and begins sketching a design. Her child who had been idle up to this point, despite encouragement from his mother and facilitators begins to sketch alongside his mother.

The son is teasing and critical of his mother's design and understanding (RQ2 & 3):
While facilitators are attempting to assist with circuit building the child of C1 'narrates' mother, parodying Bear Grylls. He says, "She doesn't understand electricity, for it is a new concept for her." When asked by his mother to stop he says, "It seems mother is criticizing our narrator despite the fact that she has never seen electricity before in the field." Soon thereafter he sarcastically remarks, "imagine putting a light on the sun," in reference to his mother's design.

The son of C1, again, is possessive over his ideas and narrative, responding with hostility when he is questioned (RQ1 & 3):
A facilitator verifies that the mother and son of C1 will be creating two separate squares to do with hiking. The mother of C1 offers to her child, "you can do your own" to which the child, annoyed, responds, "I know, I am doing my own idea, Mother."

The child of C1 is uncooperative and slightly malicious towards his mother. She, whether in an attempt to diffuse the situation as a result of feeling genuine discouragement, does not validate her son's rude response (RQ3):

The mother of C1 asks her child if he would cut out a tree for her to which the child responds, “if you were such a genius, you would be able to cut a tree.” The mother doesn’t respond, seemingly frustrated or offended.

The mother of C1 lacks confidence in her design and expresses her negative feelings about it aloud (RQ3):
The mother of C1 mumbles to herself inaudibly concerning her ongoing square. Her child seeks clarification asking, “what’s stupid mother?” She responds, “I said, ‘this looks stu- not so good.’”

The son of C1 expresses a gendered preconception surrounding sewing. His mother doesn’t address the statement (RQ2 & 3):
The child of C1 asks his mother if she has finished sewing her quilt square, to which she responds affirmatively. He justifies her success, saying, “it’s because sewing is the women folks' job.” The mother of C1 does not respond.

The son of C1 appears to hold gendered preconceptions that he uses to affirm himself either despite or perhaps in spite of his mother’s disapproval. Although the mother of C1 is clearly unhappy with the behavior, she fails to directly address it or make a clear statement of her disapproval (RQ3):
The child of C1 asks his mother for help pushing a needle through a particularly thick piece of his project as he has previously done in the sewing portion of the workshop, but upon managing to break through he remarks, “I got it, I’m using my manly man hulk strength.” His mother gives a judgmental or perplexed look in response. The child of C1 asks, “are you making fun of me mother?” and she responds, “No I’m making fun of you making fun of…” She trails off.

Cohort-2

Despite the focus on one cohort member, the entire family remains invested and collaborative (RQ 2 & 3):
While the facilitator is assisting the son of C2, the mother and sister are actively listening, and providing feedback alongside the facilitator.

The son of C2 is enthused and positive (RQ3):
The son of C2 exclaims, “I love yours!” in reference to the design his mother is drafting.

The mother of C2 is positive and encouraging of her children (RQ3):
The facilitator moves to assist the mother of C2 with her design and jokes, “you have two experts now.” The mother of C2 happily repeats the sentiment saying, “I have two experts now!”

The daughter of C2 demonstrates a good understanding of the circuits taught only a moment ago. The cohort feels comfortable freely exchanging information, and the daughter is comfortable with and capable of teaching her mother (RQ2 & 3):
The facilitator and mother of C1 are discussing the placement of an LED on the design. The daughter of C2 confidently interjects, points to the square, and says, “this should go on the wheel.” The mother of C2

muses a bit more before her daughter says, “you could either put it here or here,” while pointing out the different potential locations.

The son of C2 asks for help in an unconventional way, and his mother responds lightheartedly, encouraging him without completing the task for him and removing his personal agency (RQ3):
The mother of C2 questions her son, “you’re gonna cut your water right?” in an effort to keep him productive. He responds, asking, “how do I cut the water, mom?” She is surprised by his request and jokingly asks, “are you kidding me?” after which her son clarifies, “I know how to cut, right? But, I have to cut the water.”

The mother of C2 has a positive, confident attitude (RQ 2 & 3):
The mother of C2 comments on how the LED prototyping C1 is doing is cool, which prompts a facilitator to explain the use of alligator clips for prototyping the final circuits. The facilitator then offers C2 the opportunity to prototype with alligator clips as well, to which the mother of C2 responds, “I think we’re a go for it kinda group.”

The participants of C2 are collaborative and value each other’s opinions (RQ1 & 3):
The daughter of C2 asks her mother to look at a portion of her square. The mother of C2 responds with an energetic, “Cute!”
The mother of C1 asks, “What colors should I use, kids?”

Discussion
Participants’ learning outcomes in the workshop experience were largely shaped by their preconceptions of personal ability and their personal enthusiasm surrounding various aspects of the workshop (RQ2). There was a clear correlation between parental attitude, student attitude, and observed engagement throughout the fabrication and brainstorming processes (RQ3). Furthermore, the collaborative development of and experiencing artifacts facilitated discussion of and encouraged participants to consider the similarities and differences of their personal experiences (RQ1).

The mother of C1 was overall less personally confident than the mother of C2 in circuitry, sewing, and crafting, demonstrated by self-deprecating comments made throughout the workshop. The child of C1, in contrast to his mother and the other youth participants, demonstrated overconfidence, speaking down to his mother and questioning her intelligence. Additionally, the youth of C1 derogatorily gendered the sewing portion of the activity describing it as, “work of women folk”, and referencing his “manly-man hulk strength” in a moment of success. In spite of his confidence, he was less engaged in most aspects of the workshop despite being consistently behind compared to other participants. Even when his mother engaged in prototyping with alligator clips, utilizing the full spectrum of tools available for design and understanding, the youth of C1 was uninterested. (RQ2 & 3)

The dynamic of C2 was remarkably different from that of C1 and reinforced the correlation between positive parental attitude and positive child attitude. The mother of C2 was confident in her crafting and sewing skills, and initially adopted a teacher role relative to her son and daughter; apparently lacking personal investment in the activity, but after the introduction of novel technology and experience in the forms of E-Textiles and circuit building she became more flexible in her assumed role and enthusiastic with her participation, freely switching between workshop participant/learner herself and teacher for her children. Her enthusiasm and confidence were contagious to her children and all three members of C2 freely exchanged compliments and asked each other for criticism or advice despite differing personal designs. (RQ2)

In both groups, the design and creation of physical artifacts ameliorate the exchange of narratives and experiences. In the case of C1, despite depicting the same experience, the mother and son each have their own interpretations and critical details which are discussed throughout the creation process and revealed in the contrasts between their final quilt squares. In C2, all three members choose to depict different experiences: The mother- creating pottery; the daughter- the family dog; and the son– swimming at the pool. Although the squares each depict distinct experiences, the cohort still discussed their perceptions of each other's narratives and informed each others' designs, which in turn led to a greater understanding of and appreciation for the experiences. This is evident in their contagious and constant positivity and affirmations surrounding each other's designs and narratives.

Current Research Plan / Direction

This exploratory study was conducted by an interdisciplinary team from Boston College, Utah State University and Massachusetts Institute of Technology. This study will be used to iterate on workshop and app designs, as well as provide data to guide future investigations. Areas of improvement in workshop design include: improving instructions to benefit participant comprehension of objectives and concepts and providing more intuitive E-textile components, materials, and tools. Additionally, the workshop, whether conducted, in conjunction with an investigation or not, would be improved with a greater number of cohorts. Overall, the project seeks to improve the design and implementation of culturally responsive, intergenerational workshops in the context of engineering and physical computing; observe and investigate the processes of learning in the relevant contexts; understand the influence of intergenerational learning on STEM culture, knowledge, and enthusiasm; and, determine how physical artifact creation and place-based XR experiences contribute to social-emotional learning. Besides the main research objectives, the technological framework of the AR quilt application can serve as inspiration for other social-emotional learning tools utilizing XR technologies, or be directly modified to display other visual audio experiences in a similar manner. The final application will be made publicly available and open for modification.

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