



Integrating Cultural Relevance into a Behavioral mHealth Intervention for Native American Youth

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Native American communities are disproportionately affected by a number of behavioral health disparities, including higher rates of depression, substance abuse, and suicide. As mobile health (mHealth) interventions gain traction as methods for addressing these disparities, they continue to lack relevance to Native American youth. In an effort to explore the design of relevant behavioral mHealth intervention for Native American communities, we have developed ARORA (Amplifying Resilience Over Restricted Internet Access), a prototype behavioral mHealth intervention that has been co-designed with Native American youth, a community advisory board, and a clinical psychologist. In this paper, we qualitatively analyze our co-design and focus group sessions using a grounded theory approach and identify the key themes that Native American community members have identified as being critical components of relevant mHealth designs. Notably, we find that the Native American youth who participated in our focus groups desired a greater level of didactic interaction with cultural and behavioral health elements. We conclude with a discussion of the significant challenges we faced in our efforts to co-design software with Native American stakeholders and provide recommendations that might guide other HCI researchers and designers through challenges that arise during the process of cross-cultural design.

CCS Concepts: • **Human-centered computing** → **User centered design; Participatory design; Ubiquitous and mobile devices.**

Additional Key Words and Phrases: mHealth; Native American; behavioral health; rural computing

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1 INTRODUCTION

In the United States, Natives¹ living on tribal lands experience severe behavioral health inequalities, with higher rates of suicide, depression, and anxiety than any other racial group [3, 13, 25, 69, 108]. Generations of historic trauma caused by violent and oppressive colonizing policies have resulted in higher rates of poverty, food insecurity, substance abuse, and chronic diseases such as type II diabetes, coronary disease, and stroke—all of which are comorbid with diagnoses of depression and anxiety [29, 51, 51, 78, 81, 116]. Significant barriers to accessing behavioral health care include: geographically sparse placement of health clinics, lack of trained health professionals practicing on or near tribal lands, stigmas around mental illness, and lack of perceived cultural relevance of behavioral health interventions [69]. In particular, Native youth are negatively impacted by behavioral health inequities on tribal lands, with suicide listed as the second leading cause of death for Natives 10-34 years old; the suicide rate for Natives ages 15-19 was 2.3× greater than the rate for non-Hispanic Whites [109].

However, the landscape around behavioral healthcare is changing, presenting new opportunities for addressing behavioral healthcare inequalities in Native communities. As mobile devices (e.g., smartphones and tablets) become less expensive and more pervasive, research and community efforts seek to integrate these devices into efforts aimed at addressing a myriad of health inequalities through mobile health (mHealth) interventions. While a number of behavioral mHealth interventions have emerged over the past five years, they have been designed predominantly from a Western perspective². Given that one of the significant barriers for accessing behavioral health care for many Natives is the lack of perceived cultural relevance, an investigation of the potential opportunities afforded by behavioral mHealth for Native populations must examine mHealth interventions through the lens of cultural relevance.

Thus, we have assembled an interdisciplinary team of researchers and designers in order to address the following research questions:

RQ1: *How can we incorporate Native culture and values into a behavioral mHealth intervention in a way that is culturally-relevant and meaningful?*

RQ2: *What elements of a behavioral mHealth intervention do various Native stakeholders perceive as being most critical to long-term engagement?*

To answer these questions, we used a community-based participatory research approach to work with a community advisory board (CAB) of six members to ideate the initial design of ARORA (Amplifying Resilience Over Restricted Internet Access³), a behavioral mHealth prototype designed specifically to help cultivate mindfulness skills for Native youth (12-18 years old). While there are a number of skills that contribute to stress-coping and resilience, we focused on mindfulness skills as they are rudimentary for other practices that promote resilience [59, 64] we designed ARORA to (i) align with psychological best-practices for cultivating healthy mindfulness skills in youth and (ii) be culturally relevant to Native youth. We then evaluated the prototyped with two recorded focus groups comprised of 11 Native individuals between the ages of 12-18 years old. We analyzed the

¹In the Southwest United States, where we have formed community partnerships, most people who identify as AI/AN prefer to be called “Native,” so we use the preferred terminology to reference people who are Indigenous to the United States throughout the paper, unless describing people with a particular tribal affiliation, in which case we will use the tribal affiliation [8].

²We use the term “Western” throughout this paper as it is used by Brayboy [10]. With this usage, Western means “Eurocentric and White supremacist.”

³The acronym is meant to be a homonym of aurora, which can refer to the Latin word for “dawn” or the the polar lights that appear in Arctic and Antarctic night skies. The name was intended to connect to the positive cultural significance of lights in darkness for many Native American and Alaska Native communities.

transcribed recordings of the focus group sessions using a grounded theory approach and identified emergent themes corresponding with RQ1 and RQ2.

Our paper is organized as follows: in Section 2 we contextualize the challenges for mHealth and behavioral health interventions in Native communities. In Section 3 we provide an overview of related work. In Section 4 we discuss the frameworks that guided our research and methods. In Section 5 we describe the ARORA app and the iterative development cycle that was used to create a prototype that will be used in larger scale pilot testing. In Section 6, we discuss results for RQ1 and RQ2 based on our CAB design sessions and focus groups. We discuss limitations and future work in Section 7 and conclude in Section 8.

2 BACKGROUND

5.2 million Americans identify as American Indian/Alaska Native (AI/AN) either alone or in combination with another race [107]. There are currently 573 federally recognized tribes in the United States, each with unique cultural practices, stories, histories, and languages [77]. One of the critical challenges for designing technologies and interventions with and for Native communities is the complexity of Native identity. Not only are there various tribal identities, but also significant cultural differences between Natives who have grown up on tribal lands and those who have grown up away from tribal lands. Moreover, many Natives travel between living on tribal lands and off tribal lands, following economic and educational opportunities as well as familial needs.

2.1 Behavioral health inequities in Native communities

Numerous studies conducted over the past three decades have identified significant inequities between rural and urban communities with respect to behavioral health care access and availability [28, 32, 33, 35, 45, 46, 51, 86, 87, 89, 94, 102, 103]. Disproportionately and consistently higher rates of suicide [15], stress-related illness [14, 15] and functional impairment [35, 104] have caused suicide, stress, anxiety, and depression to rank as some of the top concerns for the rural health agenda [35, 110]. These disparities exist in part due to lack of trained behavioral health professionals in rural communities [35, 45, 103], lack of locally-placed behavioral health clinics [2, 7, 35, 91, 94], lack of community-based preventative measures [7, 35], lack of perceived anonymity when accessing behavioral health services [11, 51, 87, 91, 94], stigmas surrounding mental illness and behavioral health care [7, 11, 35, 51, 87–89, 94], and lack of perceived need for behavioral health care [35, 51, 87]. The rural-urban behavioral health care divide is particularly pronounced in tribal lands [3, 13, 25, 69, 108], which often face the same issues as many rural communities with respect to accessing behavioral health care [3, 25, 69], but must also cope with significant historical trauma [29, 47, 118] and cultural dissonance with existing behavioral health care practices [69], which can act as additional barriers to accessing behavioral health care services. Moreover, studies have observed that stress-inducing factors such as economic hardship [51, 81] and stressful life events (e.g., food insecurity, substance abuse, death in the family) [51, 78, 116] are more prevalent in communities on tribal lands than in non-tribal counterparts [90, 108]. Behavioral health issues are particularly problematic because they contribute to factors that impact long-term health for individuals and communities [6, 27, 32, 35, 62, 68, 71, 104, 110]. Economic studies of behavioral health interventions have demonstrated that by investing in behavioral health care, there is an overall reduction in total health care costs to a community [75, 115, 121].

2.2 mHealth challenges for Native communities

While mHealth and telehealth represent promising avenues for addressing health inequities for rural, remote, and small urbanized areas, these types of health services often assume that users have reliable and sufficient Internet connectivity. Depending on the data needs of the platform,

mHealth interventions can have significant network performance demands, such as low latency (to support real-time interactivity) and high bandwidth (to support multimedia streaming, download, and upload). Even without significant quality of service demands, most mHealth platforms assume ubiquitous Internet access. Unfortunately, these assumptions do not hold for many tribes. In the United States, tribal lands represent some of the most severe digital divides with respect to Internet connectivity (for both fixed and mobile broadband) [30]. Notably, even as federal agencies, such as the Federal Communications Commission (FCC), report improvement in connectivity in tribal lands, there is evidence that federal broadband coverage data is prone to over-reporting [39]. These digital inequalities are rooted in a number of causes, including the rurality of many tribal lands, rugged geography, low population densities, economic inequities, and historic oppression of Native peoples by the U.S. federal government [24].

mHealth platforms can also be problematic for Native communities by ignoring data sovereignty. As sovereign entities, tribes have the right to manage ownership, control, access to, and possession of data collected from tribal members [31]. As most mHealth services are hosted in the cloud and do not formalize ownership, access, and control mechanisms that center on tribal data sovereignty policies, it can be politically challenging to deploy mHealth interventions in tribal communities that are not designed to respect tribal data sovereignty. Thus, designing for tribal data sovereignty is a significant consideration discussed in Section 5.2.

3 RELATED WORK

3.1 mHealth for Behavioral Health

With the increase in technology usage over the past decade, mHealth has become more prominent. mHealth is intended to serve as medical practice either through or with the aid of mobile technology [40].

The effectiveness of mHealth applications has been heavily debated by mental health professionals. However, the vast majority of mental health apps available for people with emotional concerns have had limited peer-reviewed research conducted on their efficacy [40, 119]. Those that have been studied predominantly support the use of cognitive behavioral therapy (CBT) approaches in improving mental health outcomes [49], and use standardized, self-administered depression measures such as the Patient Health Questionnaire, or PHQ-9 [63]. One example of a CBT mHealth intervention is “The Get Happy Program,” designed to help depressed participants in a clinical trial [117]. Participant PHQ-9 ratings indicated a significant decrease in depression immediately after and three months after the treatment.

Another CBT-based mHealth application, CopeSmart [61], was designed to promote positive mental health and emotional self-monitoring among adolescents. CopeSmart was tested among forty-three adolescents with 75% of the participants in the trial acknowledging the application’s effectiveness in improving their mental health and 70% indicating that they would recommend it to a friend. The participants reported that their daily mood ratings were one of the most useful components of the app. Notably, the mere rating of mood helped users to become more mindful of their current state and promoted emotional well-being. CopeSmart also provided coping tips and mental health resources, but youth used this component less frequently due to perceived lack of relevance.

The Wysa app combined CBT techniques with a chat bot to help its users work through stress, depression, and anxiety [105]. While an evaluation of Wysa revealed that frequent users of Wysa’s chat bot feature reported significantly greater improvement in depression according to the PHQ-9, Wysa did not help all of its users improve their mental health, as it failed to establish a sense of human connection among users [53].

Based on these studies, we note that engaging activities are more engaging and important to adolescents than passive activities, such as reading information about coping mechanisms. We also note that while CBT methods demonstrate the ability to improve mood and depression when implemented in mHealth apps, authentic social communication is a feature that is worth investigating as part of an intervention design [19, 26, 52, 84]. The studies emphasized that future investigators should involve youth in intervention design in order to ensure that the approach developed was useful and engaging.

Wiederhold suggests that Augmented Reality (AR) will have immediate applications with anxiety disorders, depression, Internet Gaming Disorder, autism spectrum disorder, and increasing empathy [119]. Shrier recently reported on the use of AR games for adolescents with social learning and communication deficits [92]. Called “Reliving the Revolution,” this AR game intended to promote social learning, communication, and interest in learning about American history. Following game’s trial, participants claimed that they felt fully immersed in the game and engaged with the learning activities. This was enhanced because they were required to interact with other people and physically go to different locations to be successful in the game [92]. While “Reliving the Revolution” does not focus on mental health or social learning, Shrier’s study does show that AR games provide an arena where users can practice interpersonal skills.

3.2 Behavioral Health Interventions for Indigenous Communities

Studies investigating mental health interventions reveal that universal, positive psychological interventions have long-term benefits for high-risk and traumatized youths and adolescents [26, 58, 66, 93, 96, 111]. The most effective interventions are often strength-based and enhance resiliency [41]. They also typically integrate CBT and mindfulness approaches towards problem-solving and coping; enhance social and interpersonal competency; capitalize on strengths; and enhance values-based goals [50, 72, 84, 85]. Moreover, studies of successful behavioral health therapies for Native youth reveal that a strengths-based approach that is also culturally relevant tends to be most effective [1, 36, 60, 70, 83]. Given these findings and the high rates of psychological distress associated with Native adolescents, we propose the design of a universal⁴ positive psychology-focused behavioral health intervention tailored specifically to Native youth. This type of intervention will be a first-of-its-kind, combining elements from mHealth, universal interventions, social and emotional learning, geosocial gaming, and AR technology. Critically, we seek to ensure that the design of the proposed intervention can be made accessible to even the most rural parts of Indian Country through the design of a novel network architecture that localizes services closer to the communities who use them.

3.3 Participatory Design with Youth

Our work also relates to participatory design with youth. Of particular relevance is Druin’s Cooperative Inquiry approach, which emphasizes contextual inquiry, participatory design, and technology immersion [22]. Importantly, Cooperative Inquiry recognizes that working with children, rather than “adults as proxies for children” can illuminate nuances in technology engagement and preferences that are impossible to replicate with adult proxies. Our work employs participatory design methods from the Cooperative Inquiry approach in our youth focus groups, particularly through activities such as “low-tech prototyping,” using pen and paper drawing to provide youth participants with a mechanism for expressing their visions for new features and interfaces for ARORA [22, 67].

⁴“Universal intervention” is a term used in the context of social emotional learning programs that focus on providing preventative care resources that could be used by all youth in all settings of a particular community [101].

As Cooperative Inquiry has been developed and applied, we find that our work is similar to approaches that seek to help youth engage with technology through facilitating expressions of “like,” “dislike,” and “missing/new feature ideas”; and establishing a trusting, mutual inquiry relationship between adult researchers and youth [23, 42, 120].

This study also relates to work that examines the methodological issues and challenges that are associated with critical youth studies [4] and participatory design work with youth [97]. Best’s edited compilation of essays on critical youth studies examines how the “worlds we occupy matter to the worlds we study [4].” Indeed, our own work recognizes some of the methodological considerations that must be taken in order to accommodate the “unseen” realities experienced by youth participants that move between different contexts. In this way, our work relates to work by Guha et al., which seeks to help youth navigate collaborations that span a “shrinking and developing” world that involves digital and economic inequities [42]. In the context of these methodological challenges, our work represents an additional complication as researchers help youth participants articulate technology experiences, preferences, and needs across their own diverse and dynamic experiences in rural and urban settings across tribal, non-tribal, and intertribal contexts (as delineated in Section 2).

4 METHODOLOGY

In this section, we detail the theoretical frameworks that guided our research as well as the data collection and analysis methodology used to address our research questions. A rough outline of our activities over an 18-month span are as follows: months 1-3 were dedicated to recruiting CAB members; months 3-6 were dedicated to interviewing CAB members and developing a codebook based on our interviews; months 6-12 were focused on developing an initial ARORA prototype and demonstrating it to CAB members for further feedback; months 12-15 involved revising the ARORA prototype based on feedback; months 15-17 were spent recruiting youth focus group members and running youth focus groups while simultaneously developing our codebook for analysis to inform the subsequent focus group discussion; and month 18 was dedicated to running our second youth focus group.

4.1 Guiding Theories

Native communities in the United States experience a disproportionately higher rate of physical and psychiatric morbidity than the general population, while facing greater challenges and shorter life expectancies than other Americans [21]. Consideration of culture is critical to the design and implementation of effective interventions for Native Americans [60]. Current programs that integrate culture do so in a continuum ranging from more superficial approaches that adapt Western-based interventions to approaches that are entirely culturally-centered and grounded. Studies suggest that culturally-grounded approaches are much more effective with Native populations as they draw on cultural strengths, agency, power, and language to enable community-driven health changes [21, 60, 65].

Community-based participatory research (CBPR) and tribal participatory research (TPR) are promising approaches for improving health equity in a culturally-grounded manner [65, 114]. CBPR and TPR effectively bridge the gap between investigators and communities. CBPR is a collaborative process between researchers and the community stakeholders, involving community members at every step of the process: idea formation; data collection and analysis; interpretation; and dissemination [56, 57]. CBPR allows for the development of culturally relevant interventions that are designed and implemented in a way that builds community capacity and leads to enduring changes. Key principles of CBPR include partnership, empowerment, community control, mutual benefit, holism, action, communication, and respect [57]. Similarly, TPR embodies these principles,

but tailors them toward Native communities [65]. TPR views tribal communities as sovereign nations and respects their rights in the research process. Tribal communities provide oversight in all aspects of the research, including review, guidance, and ensuring that it is consistent and respectful of community values, traditions, and culture.

Methods that can be used for CBPR and TPR include key informant interviews, focus groups, photovoice, community forums, and community advisory boards (CAB). CBPR and TPR can also rely on quantitative data collection methodologies such as surveys or review and synthesis of previously gathered reports and health records [55].

4.2 CAB Design Sessions

Our initial CAB members were identified through our university contacts. We contacted potential members, stating we were looking for Native professionals who had experience working in the field of mental health, particularly with Navajo and Hopi youth. Those initially contacted provided further professional references resulting in a total of six CAB members.

4.2.1 CAB Participants. Our CAB consisted of three men and three women. All six worked or volunteered in high schools, inpatient and outpatient behavioral health centers, as well as public health education and community services both on tribal lands and in Flagstaff, AZ (a small urban bordertown adjacent to Navajo Nation). Ages of the CAB members ranged from 27-62; five had bachelor degrees or higher. Four members were affiliated with Navajo Nation; two with the Hopi Tribe. The CAB members all lived in “mostly urban” settings, but all of them had spent considerable time living on their rural tribal lands.

4.2.2 Identifying CAB Design Values. We met with the CAB members in a design meeting that involved iterative interviews and group sessions. After introducing ourselves and presenting the CAB with our motivation for designing ARORA, we asked them to identify what they believed would be the most appropriate and necessary cultural values that should be incorporated into a positive psychology behavioral health intervention (RQ1). Similarly, we asked the CAB to describe what they thought would be important to achieve sustained engagement (RQ2). Notably, we sought to identify design elements and community factors (e.g., support systems such as families, elders, teachers) that might help youth engage with the app in a sustainable manner. After an initial meeting with each of the CAB members (in small groups of 2-3 CAB members and two investigators or in one-on-one interviews), we leveraged a grounded theory approach using open coding and axial coding methods to identify critical components for cultural significance and user engagement for Native youth [99, 100]. We then implemented a prototype version of ARORA based on these codebooks and we used this prototype to guide a second round of feedback about what should be maintained in the alpha version of the app that would be shown to youth focus groups. The resulting axial codes are described in Table 2.

4.3 Data Collection & Analysis

For the development of the ARORA prototype platform, we used an iterative and qualitative approach. We held informant meetings and focus groups with key stakeholders in order to determine interest and relevance, as well as to gain input and feedback about how to develop a meaningful program. We recruited youth from a variety of community organizations to participate in focus groups in order to gain their input about the strengths and weaknesses of ARORA, once an alpha version was developed. These youth trialed ARORA in two different small group settings and provided the investigators with specific feedback.

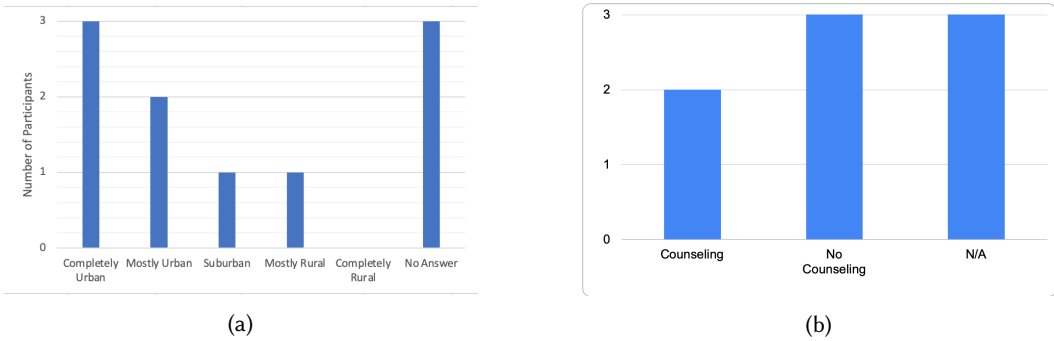


Fig. 1. Demographic data for (a) areas in which participants live and (b) participants' counseling experience.

ID	Ethnicity	Gender	Age
F1-4	Navajo	Male	15
F1-5	Navajo/Lakota	Male	12
F1-6	Navajo/Lakota	Male	13
F1-7	Native	Male	NA
F1-8	Native	Male	18
F2-1	Native	Female	13
F2-2	Native	Female	NA
F2-3	Navajo	Female	16
F2-4	Navajo	Female	14
F2-5	Navajo	Female	13

Table 1. Demographics of focus group participants. Note that “ethnicity” was a blank field where participants were allowed to write in their own responses. This enabled us to capture the range of ethnic identities with which Natives might identify. Note that ‘NA’ is used in this table to represent that the participant did not answer.

4.3.1 Recruitment of Focus Group Participants. We used two methods of sampling for our youth focus groups. First, CAB members posted notices in their communities about upcoming focus groups and recruited individual youth from their own community organizations. Second, once initial youth participants were established, we then utilized “snowball sampling” to recruit more [38, 48]. This form of recruitment relies on trusted community ties whereby subjects are asked to assist investigators by suggesting additional potential subjects. The difficulty with this approach is that the representativeness of the sample is not guaranteed, as participants tend to recruit people they know well. However, this methodology is critical to helping investigators overcome the historical mistrust between Native communities and academia.

4.3.2 Demographics of Focus Group Participants. While our design process was informed by formal and informal interviews with CAB members, the data used to address RQ1 and RQ2 is based on both interactions with our CAB and also youth focus groups. We held a total of two youth focus groups. Participants completed a demographic survey prior to focus group discussion. This survey consisted of six contained questions about age, gender, ethnicity, profession (or education status), experience with technology and psychological counseling, and primary place of residence.

We describe the demographics of our participants in Table 1 and Figure 1. We recruited a total of 10 focus group participants. The first focus group (F1) consisted of five male participants and the second focus group (F2) consisted of one male participant and five female participants⁵.

Most participants identified as living in “completely urban” or “mostly urban” contexts. It is worth noting that responses were based on current dwelling-place and not necessarily on longer-term concepts of dwelling-places. In addition, urban for these youth referred to Flagstaff, which is a small urban community. We discuss the significance of dwelling-place in Section 7.1.

4.3.3 Analysis of Focus Group Data. Each of the youth focus group meetings was audio recorded and for each session we had one or more dedicated note takers. We transcribed the audio recordings to text, and then used NVivo v.12 (QSR International) data analysis software to conduct constant comparison analysis of the transcriptions [79]. We used a grounded theory approach to guide our qualitative analysis of focus transcripts, allowing us to elicit themes that emerged in response to RQ1 and RQ2. This method leverages the constant comparative approach initially delineated by Glaser and then described by Strauss and Corbin and further delineated as a process for HCI researchers by Muller and Kogan [37, 74, 99, 100]. These themes were extracted in three iterative phases. We transcribed the audio recordings and engaged in an open coding process to identify major thematic categories. We then engaged in an axial coding process, in which we identified sub-categories and diagrammed how these sub-categories connected different open code categories to each other. Overall, we categorized the focus group transcriptions into a total of 11 open codes, which were clustered into four categories using the axial coding method. Informed by our research questions, we used the selective coding process to identify three categories for further exploration in the subsequent focus group: Culture, Design, and Effectiveness. We regularly reviewed the codes and when discrepancies in classification occurred, we held discussions until consensus was achieved by all three primary investigators. In total, we collected 128 minutes of audio recordings, which translated into 146 statements from 10 individuals. These transcribed recordings represent the data from which we discern results in Section 6.2.

4.4 Statement of Positionality

This research was led by investigators from computer science, clinical psychology, and graphic design. While none of the primary investigators are affiliated with Navajo Nation or Hopi Tribe, one of the investigators has experience developing strengths-based behavioral interventions for Hopi and Navajo youth specifically, and Indigenous communities in general. Another investigator has experience working with tribal communities to develop and evaluate networked technologies for resource-challenged contexts. These previous experiences have informed our approach to participant recruitment, CBPR, and iterative design.

4.5 Ethical Considerations

The methodologies used in this work received approval from the Northern Arizona University (NAU) IRB and conformed to the Arizona Board of Regents Tribal Consultation Policy with regards to working with Native research participants. Prior to participating in focus groups, all adult participants signed an informed consent form. Similarly, all focus group participants under the age of 18 were required to have a legal guardian sign a parental consent form and were themselves required to sign an assent form. CAB participants were offered compensation at a rate of \$25/hour for every design session in which they participated. Youth focus group participants were compensated with \$25 VISA gift cards.

⁵Participant F1-8 participated in both focus groups. In the first group, he was the oldest in an all-male group. In the second group, F1-8 was related to two of the other participants.

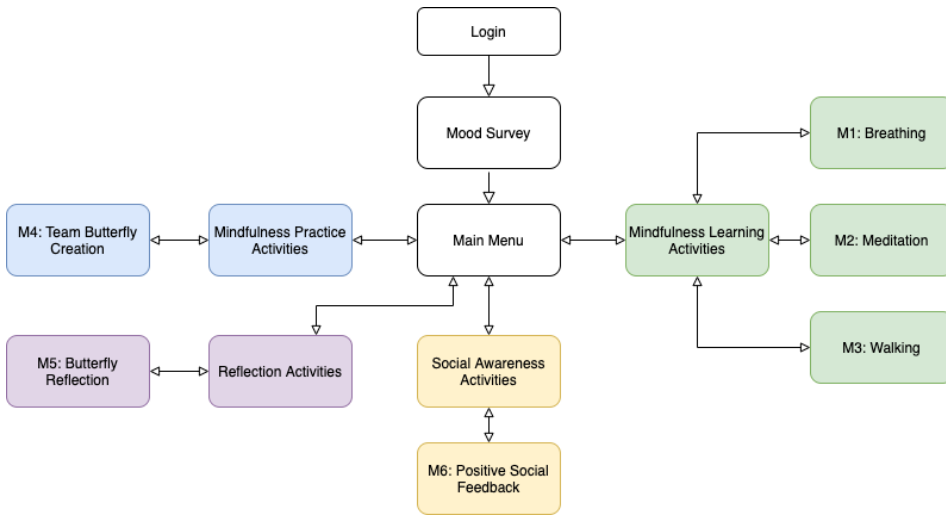


Fig. 2. Flowchart of ARORA user activities.

5 ARORA PROTOTYPE INTERVENTION

In order to explore RQ1 and RQ2 with CAB design sessions and youth focus groups, we developed ARORA (Amplifying Resilience Over Restricted Internet Access), a prototype of a behavioral mHealth intervention that incorporates evidence-based practices for increasing mindfulness with Hopi and Navajo visual themes. The prototype was designed iteratively during CAB design meetings to ensure a best-effort first attempt at an intervention prototype that could subsequently be evaluated by youth focus groups. Here, we provide details about the general intervention flow as well as implementation details.

5.1 Intervention Flow

A flowchart of user activities is diagrammed in Figure 2. We use the notation “MX” as a way to code each mental health activity that is part of the intervention. For example, “M1” represents the activity where users engage in breathing exercises. Based on evidence-based programs that have been successful with disadvantaged, high-risk and traumatized youth, the ARORA smartphone app is designed to incorporate four main types of positive psychological intervention activities: mindfulness, emotional and cognitive coping skills, cultivation of resiliency factors, and prosocial skills development. In an effort to evaluate its effectiveness over time, users are required to log into the program on a daily basis and complete a simple mood survey that allows ARORA to track and measure progress.

The alpha version that we used as a software artifact in focus groups implemented only the mindfulness learning activities. However, we involved the CAB and focus groups when developing the overall prototype designs for all of the resiliency activities. It is critical to note that

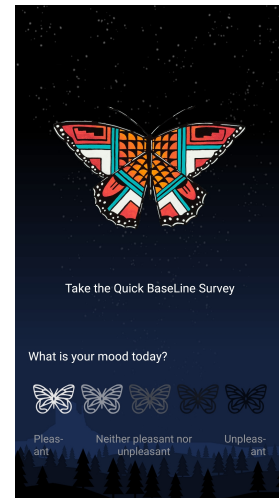


Fig. 3. Mood survey screen used to collect data from users adapted from the Affect Balance Scale [9]. ©Duane Koyawena.



Fig. 4. Screenshots of (a) M1, (b) M2, and (c) M3 Mindfulness Learning Activities. We note that the butterfly in M1 is a less stylized butterfly than what is presented in the mood survey home screen (Figure 3) because we wanted to explore users’ reactions to visuals had more generic designs and visuals with culturally grounded designs.

ARORA has been developed with our Native community partners in iterative phases. We present the activities as we presented them to the CAB and focus group participants.

5.1.1 Mood Surveys. The mood surveys that users complete on a daily basis are limited to two questions to ensure completion and prevent fatigue. The questions are: *What is your stress level today?* and *What is your mood today?* These questions are derived from the Affect Balance Scale to evaluate current mood and stress. Responses are provided using a five-point Likert scale where “0” is “none” and “5” is “extreme [9].” Our modifications try to make the questions more easily understandable to young users and we use a scale anchored in “Pleasant” (0), “Neither pleasant nor unpleasant” (3), and “Unpleasant” (5).

5.1.2 Mindfulness Learning Activities. In order to provide our users with a foundation for mindfulness, the program systematically taught three evidence-based mindfulness activities which are denoted in the remainder of the paper with the succeeding parenthetical notations: slow, deep breathing (M1); meditation (M2); and meditative walking (M3) [5, 16, 20, 59, 64]. Mindfulness refers to the maintenance of a moment-by-moment awareness of thoughts, feelings, bodily sensations, and the surrounding environment. While there are many different ways to teach mindfulness, slow, deep, abdominal breathing and meditation are often foundational skills.

The type of mindfulness meditation used in the ARORA app integrated a previously trialed meditation practice used extensively by one of the authors with Hopi and Navajo youth during her experience as a volunteer clinician in the community [34]. The approach paired mindful

observations with specific nature imagery (water, mountains, space/air, flowers/plants). For example, while breathing, youth were given the imagery: “I see myself as still as water. Breathing out, I reflect things as they truly are” or “I feel space, moving gently like a breeze, letting go of that which is not helpful; gentle wind and space.” It is a modification of a meditation developed by Hanh [43]. Self-paced walking is a mindfulness based activity that builds on these meditative practices; audio guided walking with mindfulness instructions has been associated with the reallocation of attention toward task-related thoughts, down regulation of perceived activation, and enhancement of affective responses [5, 16, 20].

5.1.3 Mindfulness Practice Activities. We provided users with opportunities to practice mindful awareness using M4, a cooperative, team-based activity that leverages asynchronous interactions and an AR interface to enable users to practice the mindfulness skills of being aware of teammates’ needs, being aware of their own needs, and being aware of surroundings. The current iteration of the game involves teams of 2-6 users. The team is tasked with pulling together different augmented reality butterfly objects to create a new type of special butterfly. In order to successfully complete the task, users must coordinate which butterfly objects other participants have and then determine what is still needed to be able to have the correct set required by the game. Users can then catch extra butterflies needed to accomplish the task in AR mode by walking mindfully in their surroundings and practicing skills from M3.

5.1.4 Reflection Activities. To give users an opportunity to reflect on lessons learned during M1-M4, M5 presents butterflies users have collected in M4 in an atrium. When a user clicks on each butterfly, the butterfly is shown along with a mindfulness phrase that can be practiced in M2 and M3. Two examples of a mindfulness phrase presented along with a butterfly are: “You have a solid mountain within you. You are capable of being solid, stable, and centered, no matter what happens” and “Gentle wind and space are all around you, reminding you of quiet. Letting go of that which is not helpful, breathing in the calm; feeling free.” The phrases are explained in-depth in M5, giving the user time to review the concepts they have practiced so far in ARORA.

5.1.5 Social Engagement Activities. Finally, we have provided a minimal social networking interface to allow users to practice giving and receiving positive social feedback. When users (or teams of users) have accomplished a mindfulness task (M1-M5), the achievement is broadcast to each users’ social feed. In response, users can provide positive reinforcement of these accomplishments through “liking” each others’ accomplishments or providing positive feedback selected from a collection of pre-written statements.

5.2 Implementation Details

The ARORA mobile app is implemented as an Android app for Android 10. Integration and software usability testing have taken place using the Motorola Moto G7, Samsung Galaxy S8, and Google Pixel 3a. ARORA relies on a client-server architecture. The ARORA server is implemented on Ubuntu 18.04 using the Django REST framework. The ARORA REST API consists of 75 endpoints. Critically, the ARORA architecture assumes that the ARORA server will be implemented as an edge-based server. This means that even if users are located in places with limited or unreliable Internet connectivity, as long as they are connected to their local area network, they can connect to the ARORA server. Ultimately, ARORA is designed as a distributed system, so that users can connect to a primary server that is located on their local area network, but their interactions with users hosted on other primary servers are supported asynchronously through periodic server synchronization. This technique enables robust access to services in spite of the pernicious Internet inequalities experienced by tribal communities [24, 30, 39]. Moreover, by hosting the services

Axial Codes	Open Codes
Behavioral focus	·Mindfulness is an appealing skill to teach youth and fundamentally consistent with traditional Indigenous practices and values
Colors & symbols	·Incorporate animals and spirit totems ·“Flying” insects and animals are relevant and appropriate for Hopi and Navajo tribes ·Use traditional and Southwestern color palette ·Use natural imagery
Place	·Sense of place with the earth was noted as an important cultural relationship and connection and should be emphasized ·Mindfulness activities should integrate awareness of place along with awareness of self
Games	·Incorporate traditional games ·Incorporate hunting and gathering games ·Games should be cooperative
Community orientation	·Focus on working towards the needs of others and group
Engage nature	·Use symbols that engaged symbology of natural cycles (e.g., four seasons, four directions) when teaching youth about mindfulness ·Teach youth awareness about being in the present in a meditative state when outdoors
Orally-based culture	·Use audio instructions
Writing style	·Use minimal text ·Text should be fifth grade level
Safety	·Restrict location-based features so that if young children are involved, they are encouraged to access these features when they are within the range of adult supervision

Table 2. Open codes and axial codes that emerged when discussing the pre-prototype versions of ARORA with CAB members. We leveraged these concepts in the initial prototype that we showed to youth in subsequent design sessions.

locally on a tribal owned and controlled network, any data collected or stored on the ARORA servers are under tribal jurisdiction. Thus, this architectural design is responsive to tribal data sovereignty [31].

6 RESULTS

6.1 CAB Design Meetings

As we designed the ARORA prototype, we considered nine different components and received CAB suggestions and feedback on best practices for implementing the components in ARORA. We summarize the components and subsequent CAB suggestions in Table 2. We report our findings about the CAB’s design suggestions and feedback as they pertain to RQ1 and RQ2.

6.1.1 RQ1 Results. There were several specific and general ways that the CAB suggested implementing components into the ARORA prototype in order to appropriately reflect Navajo and Hopi cultures.

Mindfulness. When we first met with CAB members, we presented the four cornerstones of evidence-based programs for high risk youth (e.g., emotional and cognitive coping; social and interpersonal enhancement; mindfulness; development of resiliency skills). While they liked all of these ideas, they thought mindfulness would be the most appealing. This was because it was fundamentally consistent with their traditional Indigenous beliefs and foundational to their cultural teachings. We thus decided to start with mindfulness for the alpha version.

Symbols. In one of our design sessions, members of the CAB discussed the usage of different animals and spirit totems as meaningful symbols that could be used in the app to impart feelings of comfort, strength, and familiarity to Native youth. As we started brainstorming about different nature-based symbols, it became clear that Hopi and Navajo cultures made distinctions between the meanings of different symbologies that required a subtle cultural understanding to implement in an appropriate manner. For example, for Hopi ways of understanding, the lightning symbol might signify power, whereas for Navajo way, lightning can symbolize a bad omen in certain contexts. Moreover, for both Hopi and Navajo, some symbols, stories, and lessons were only appropriate to discuss during certain times of the year (although content subject to these rules were not always consistent between Hopi and Navajo). We also found that some symbols that had similar significance to Navajo and Hopi tribes might have meanings that were too nuanced for non-Hopi and non-Navajo designers to implement. One example of this can be found in the coyote symbol, which could have a range of meanings depending on context. Sometimes the coyote is seen as a trickster; sometimes the coyote is a teacher and helper; and sometimes the coyote is seen as sinister. Some CAB members believed that by including the coyote in the app we would attract trouble and/or negativity for users.

As we continued a multi-phase discussion with CAB members around symbols that could bring depth and positivity to the app, we were introduced to a local Hopi artist who had curated a new art exhibit at the Museum of Northern Arizona called, "Pivot: Skateboard Deck Art [76]." The exhibit showcased over 100 unique pieces from 30 Native artists from throughout the Southwestern region. A major goal of the exhibit was to enable Native artists to express their traditions in a contemporary format and to show some of the commonalities between different Southwestern Indigenous art styles. As researchers, we saw this exhibit as an opportunity to better understand how cultural symbols might be used in very contemporary formats that could be compatible with translation to imagery used in a mobile app. As the researchers engaged with this exhibit, they noticed the common motif of flying insects and animals, particularly butterflies. When the researchers brought up the possibility of using the butterfly as a symbol in the app, both Hopi and Navajo CAB members were very positive.

"I think the butterfly has a real simple concept but a span of meaningfulness from individual to individual. It's about always being in a state of transition, no two people are going to be starting at the same transformation. I guess that is something that will be interesting for all of the kids and there's that teaching of having them aspire to be something graceful." (CAB Participant)

Specifically, CAB members noted that the butterfly had simple and positive connotations in both Hopi and Navajo cultures and its symbology was apt for a behavioral mHealth intervention, i.e., it represented growth, positivity, and grace. As a result of this conversation, we contacted one of the Hopi artists from the Pivot exhibit and commissioned him to design a butterfly for usage in our prototype (as seen in Figure 3).

Sense of place. When talking to our CAB members about how some mindfulness activities might involve AR or physical activities that took place in the surrounding environment, they noted "sense of place" with the earth as an important cultural relationship and connection and should be emphasized in the app prototype. Thus, the location of activities was an important consideration when determining how to implement mindfulness learning activities. CAB members also noted

that traditional Indigenous ways are intertwined with nature. The CAB liked the idea of using meditation symbols that engaged the symbology of nature (e.g., air, fresh plant growth, water, mountains) when teaching youth about mindfulness. They also liked the idea of including a mindful walking exercise that could be used to connect youth to their natural surroundings and encourage them to use physical activity and nature as a way to be present. Once outside in nature, we could reinforce the symbology we were using in the breathing and meditation exercises (of air, fresh plant growth, water, and mountains) in real time.

We implemented these suggestions in the Mindfulness Learning Activities. Two of the three Mindfulness Learning activities (M2 and M3) included imagery to take note of sense of place. In M2, users are encouraged to conceptualize their body in the context of their natural surroundings as a way for soothing and presence. Specifically, they are guided through a series of meditations that center on natural symbology suggested by our CAB, including air, vegetation, water, and mountains. For example, if a user decides to meditate on the natural element of water, they are presented with a simple screen depicting a blue feather and asked to reflect on the properties of water (e.g., fluid, refreshing, reflective) and to consider how they might mimic those properties in their own thoughts and actions. In M3 activity, users are asked to walk around their surroundings and to see if they recognize elements in their environment that remind them of meditation elements from M2. Users are asked to pay attention to how they feel when they see these elements and to reflect on how they can incorporate their positive associations with these elements into their own mental state.

Cooperation vs. competition. When developing M4, we wanted to ensure that activities were engaging for youth, but also aligned with traditional Navajo and Hopi values. In our initial design sessions with a Navajo CAB member, we began to ideate on mindfulness practice activities that could draw from traditional Navajo stick, shoe, and string games [18]. However, as we delved into the possibilities of integrating these games, we found that traditionally, they should only be played during certain times of the year. Given our desire to evaluate the prototype with youth focus groups throughout the year, we did not want functionality to be limited, but we also did not want to implement a traditional game (or even a game inspired by traditional games) that was not appropriate for the traditional cultural context. In brainstorming other options, we found that more general traditional activities, such as hunting, gathering, and making, could be crafted into game-like activities in which users could practice mindfulness. When we presented the concept of a scavenger-hunt type activity that used AR, Hopi and Navajo CAB members agreed that this would be appropriate as long as the game aspect focused on cooperative interactions instead of competitive interactions as it was critical in both cultures to cultivate a communal conceptualization of success instead of an individual version. In practice, this might look like users playing games that would require them to consider communal consequences of actions and to help support each other in order to “win.”

We integrated these suggestions into our initial design of the Mindfulness Practice activity, which centers on a scavenger-hunt activity that requires users to gather butterflies into a basket through an AR activity. At the beginning of the activity, users are placed into a team. The team is given a “recipe” that will generate a special type of “super butterfly.” For instance, the recipe might require each player to have three orange butterflies, two yellow, and six blue butterflies in their basket. Users are then required to communicate their needs with other users in an asynchronous manner. Users can then give other users some of their own surplus butterflies if it matches others’ needs. If they cannot fulfill their teammates needs, they can go searching for more butterflies on their teammates’ behalf. The team will continue this cycle of expressing needs and fulfilling needs until the “recipe” conditions are met and the new butterfly can be created. To support asynchronous communications between users in the case of limited network availability, users have a span of

time over which the recipe needs to be completed in order for the team to be successful. While this activity is still being implemented, a story board for the game was presented to users in the youth focus groups.

Cycles. Both Hopi and Navajo CAB members also noted the cultural importance of the Four Sacred Directions and integrating the concept of seasonality and cycle into the app design in order to be culturally attuned. For many tribes, the Four Sacred Directions are representative of seasons and cycles that occur in life, with each direction being associated with a different developmental phase in a person's life; East is infancy and childhood, South is young adulthood, West is middle-age, and North is old-age. In each of these stages, there are critical lessons to be learned and skills and values to practice and focus on. Critically, CAB members expressed how moving through the development cycle in the correct order resulted in personal completeness.

As a design team, we tried to reflect the cycle of Four Sacred Directions in the ARORA prototype by requiring users to have to navigate through phases of the app that we felt corresponded with the development cycle of each the Four Sacred Directions. When a user starts, they are required to orient themselves and set their intentions for mindfulness through the Mindfulness Learning activities. Next, users are required to gain understanding of their surrounding environment and practice mindfulness of others and themselves through the Mindfulness Practice activity. Next, users are given the option to engage socially with each other through positive affirmations of each other's activities. Finally, users are given the opportunity to reflect on their process through the cycle by reflecting on the butterflies that have been gathered in their basket. As users go through the process again, they bring the reflections from their previous cycle back into their next round of Mindfulness Learning activities.

6.1.2 RQ2 Results. With respect to suggestions for techniques that might promote intervention effectiveness, CAB members focused predominantly on the communication style used in the app and safety precautions.

Communication style. CAB members noted that for both Navajo and Hopi, interpersonal communication was predominantly oral. They also expressed concern that some youth who used the app may have limited reading skills or may only speak and read English as a second language. CAB members specifically asked that text-based instructions for how to use the app be limited and that instructions should be given orally rather than in a written form. In order to accommodate the CAB's suggestion in the prototype, we provided oral instructions for all mindfulness activities. When designing the mood survey, we wrote instructions at a fifth grade reading level.

Safety. In addition to communication style, CAB members also noted that a production version of ARORA should carefully consider limiting its operation to "safe places." This conversation stemmed from concerns that some youth may be in an urban setting when using this app, or in an extremely isolated rural setting. The CAB asked that the production version keep the location restricted so that if young children are involved, they are still within the range of adult supervision and only using the app in areas designated as safe by trusted adults. While we have not implemented any location restrictions in the ARORA prototype, this is something that we are carefully considering for a version that would be piloted with youth in the context of school or formal after school programs. We envision that the ARORA server that is deployed in communities could be configured by teachers, parents, and school administrators to ensure that certain location-based aspects of the app (i.e., Mindfulness Practice activities that rely on AR or Mindfulness Learning activities such as mindful walking) are restricted to be used only when a user is on a certain WiFi network or in a certain set of geocoordinates determined by GPS.

Category	Axial Codes	Open Codes
Culture	<i>Colors & symbols</i> <i>Engage nature</i>	<p>TC-1=Incorporating constellations into the app could help make it appear more related to Native culture.</p> <p>TC-2=The app could implement features that make it appear more directed towards Native adolescents.</p> <p>TC-3=The app should teach its users about the cultural significance of each of its activities.</p> <p>TC-4=Native culture can be further ingrained in the app with the incorporation of culturally significant animals.</p>
Design	<i>Sounds</i> <i>Engage nature</i> <i>Behavioral focus</i>	<p>TD-1=The background noise in activities should consist more of relaxing music (e.g., nature sounds or traditional cultural music) than voiceover.</p> <p>TD-2=Activities that require the most attention and are the most distracting from the real world are more effective.</p>
Effectiveness	<i>Colors & symbols</i> <i>Games</i> <i>Community orientation</i> <i>Customization</i> <i>Sounds</i> <i>Behavioral focus</i>	<p>TA-1=Working together to accomplish a goal in a game like “Superfly” would help users bond with one another</p> <p>TA-2=Being prompted by the app to physically move or breathe is effective in helping its users relax.</p> <p>TA-3=Being able to choose the background music and type of voice-over in activities will help users immerse themselves into the app and relax.</p>

Table 3. RQ1 and RQ2 categories identified from focus group sessions.

6.2 Youth Focus Groups

6.2.1 RQ1 Results. We report on the sub-themes identified with cultural relevance that emerged during our focus groups in Table 3. It is noteworthy that despite the fact that assessing perceived cultural relevance of the ARORA prototype during our youth focus groups, only 7.5% of the total statements during the focus groups pertained to cultural themes. Upon reflection, this could reflect a general discomfort of discussing culture and perceptions with non-tribal people (i.e., the primary three authors) from outside their tribal communities or in a group setting with peers. We identified four major sub-themes associated with cultural relevance.

Explicit explanation of cultural significance. Two sub-themes emerged around the perception that the prototype did not seem to really integrate cultural aspects (TC-2 and TC-3). For example, several participants stated that the app appeared to be a more general behavioral health app, rather than a behavioral health app designed specifically for Native people. One participant explained this,

stating “[*The app*] could [be] more about the culture...because it just kind of sounds like it just wants you to meditate. It doesn’t seem like it’s made for a specific people, it just wants you to calm down.”

When we pointed out some of the features that we had implemented per CAB members’ suggestions for how to integrate cultural relevance, focus group participants commented that it would be good to have the cultural relevance of those features commented on explicitly. In one example, focus group participants explained that it would be helpful to have the cultural significance of a butterfly explained explicitly in the prototype. In another example, a participant mentioned that they would like to see the Hopi or Navajo symbology of colors explicitly explained. This person gave the example that Navajo believe that turquoise is a healing color, and it would be nice to have that explained to the user when they encountered turquoise elements initially so that they would associate future elements with that sense of healing and well-being.

More engagement with nature symbology. Another common set of sub-themes that emerged centered on expanding engagement with Hopi and Navajo nature symbology (TC-1 and TC-4). Interestingly, in both youth testing sessions, several participants expressed interest in incorporating star constellations as one way to make the app more culturally meaningful. Some users suggested either creating games and activities based around constellations or having constellation-related “prizes” that could be given to users upon completing certain tasks. Users commented on how constellations contributed both to their sense of place and also presented a way that they felt particularly connected to Navajo and Hopi cultures. Interestingly, CAB members who had suggested traditional string games also talked about how string games drew from constellations as metaphors.

Participants also noted that it would be nice to see more specific regional plant symbology incorporated into the app. For example, during the meditation, participants mentioned it would be good to have more specific plants to meditate on as well as an explanation on why that plant had culturally significant or medicinal uses. Some examples of plants that participants mentioned as being interesting were blue corn and sage. It is noteworthy that participants themselves did not quite know what the significance of these plants were, but they knew that they were culturally important and said that it would be nice to have that integrated into the app.

6.2.2 RQ2 Results. The majority of focus group feedback centered on how the app could be designed to ensure long-term interest and engagement by users. We identified two main themes in this vein: app design and effectiveness of activities. We report on the total number of statements associated with these themes and the corresponding sub-themes in Table 3.

Immersion. One of the sub-themes related to long-term effectiveness had to do with the immersiveness of the app activities (TC-2). Specifically, users believed that the point of the activities was distraction: “*I guess that was kind of the point, being more distracted to take your mind of things to be calm.*” This was an interesting perception as it seemed like the participants thought that by becoming less aware of their physical surroundings and physical selves, they would more easily achieve a sense of calm. We note that participants did report a greater connection to the mindfulness activities that emphasized physical awareness in their breath (M1) and outdoor surroundings (M3), connecting these with a sense of well-being. Thus, users all liked the activities (M1 and M3) that engaged their physical bodies and physical surroundings the most.

When participants reported that they liked M1 the best, they noted enjoying how the app helped them to tune into their breathing rhythm and indicated that this felt calming. When participants indicated that they liked M3 the best, many suggested that this was tied to enjoyable physical sensations. For example, one participant commented that the sensation of movement contributed to well-being: “*I like how [the walking] makes me get up and move and it feels nice on my legs.*” In another example, when a different participant was asked to describe what they noticed during their

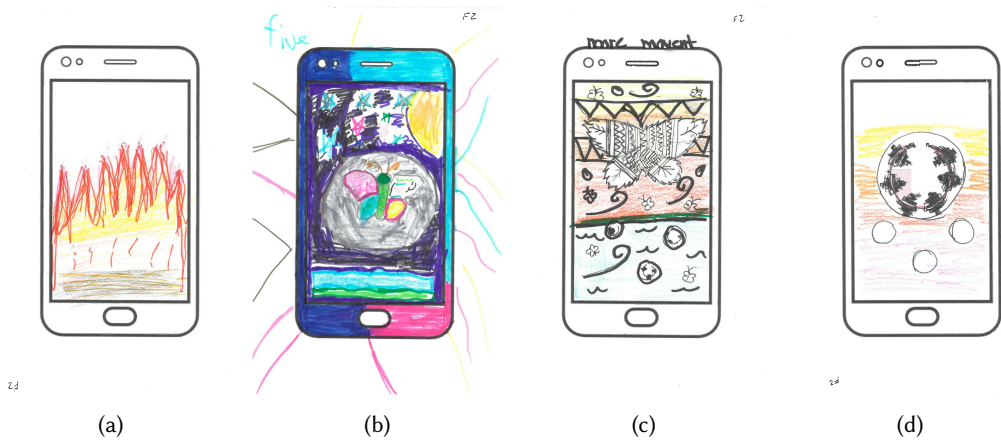


Fig. 5. Participant drawings suggesting customizable main menus they would like to see. Depicted scenes focused on nature, including (a) fire theme, (b) galaxy theme, (c) windy meadow theme, and (d) sunset theme.

favorite activity (M3) they identified that their physical sensations were connected to their bodily sensations: “Plants, trees, what I’m walking around, what rocks are around. How my feet and legs felt.”

Notably, most participants did not like the implementation of M2, although they said that the concept of meditation was not necessarily ineffective. Many noted that in a meditation activity, they would want less verbal guidance and more soothing background noise or music. Specific suggestions for background music included “Native [American] drumming” and “powwow drumming.” Participants noted that this would also make the app feel more culturally relevant.

Cooperation vs. competition. While we had not implemented the Mindfulness Practice activity, M4, we did present a storyboard for the activity to participants. A few of the younger focus group participants thought that M4 would be more engaging with a competitive and aggressive component, stating: “I think the butterflies should battle.” More participants agreed that they liked the idea of collaborative games, with one participant stating: “I like it, I like the idea of working together to accomplish a goal.” In further discussion, some of the participants determined that having a blend of cooperative and competitive would be engaging for many, for example, having teams compete against each other to see who could build their super butterfly the fastest would be a way to motivate more team cooperation but allow for competition. We note that the desire for competition was different from what was advised by the CAB and we discuss this further in Section 7.4.

Customization. All participants noted that they thought a more customizable experience in the app would lead to a more engaging experience over the long-term. Specifically, participants wanted to be able to alter background images and voice elements in ways that they found to be most relatable. For example, one participant noted that they thought users should be able to customize the voice that was providing instructions throughout the app: “I think you should be able to choose between different voices. Like a man’s voice and a woman’s voice. A more calming voice or more energetic.” In light of the CAB’s emphasis on oral communication for app usability and effectiveness, we anticipate that incorporating different types of narrator voices would be a positive direction for investigation. It would allow different tribal members, even from similar geographic regions, to personalize the program and create a more culturally relevant intervention. Narrators with similar tribal affiliations would then reflect specific linguistic patterns that are familiar and associated with the users’ tribe [73].

Another aspect of customization that participants brought forward was the idea of being able to change background images. When prompted for what these background images might look like, several participants wanted to draw their examples using paper, crayon, pencils, and markers. Some of the examples are shown in Figure 5. All participants wanted to customize the background in a manner that maintained the natural visualizations, but in ways that highlighted different natural elements (Figure 5a), places in the universe (Figure 5b) and earth (Figure 5c), weather (Figure 5c), and times of day (Figure 5d). In Section 7.3, we discuss how customization might be a way to enable greater cultural relevance.

7 DISCUSSION & TAKEAWAYS

Designing digital technologies that facilitate collaborative work within Native communities requires careful consideration of mobility and infrastructure as they relate to the physical and cultural realities of Native people. Here we identify major takeaways from our experience engaging in participatory action research with Native community stakeholders.

7.1 Sensitivity to Indigenous Experiences with Research

One of the unanticipated challenges for this project was navigating the process of engaging with tribal sovereignty. Originally, we had planned to engage youth focus group participants from a Bureau of Indian Education boarding school in Flagstaff. Complications arose when we began pursuing IRB approval to engage with students as focus group participants. In order to receive approval from our institution, we were required to obtain a letter of approval from the school's board of directors. However, the board of directors would not provide approval until we obtained IRB approval from Navajo Nation (the tribe with which the majority of students were affiliated). When we reached out to Navajo Nation's Research Review Board, we were informed that they did not have jurisdiction over research that took place outside of Navajo Nation's tribal lands. Understandably, the school board of directors was hesitant to grant approval without receiving approval first from Navajo Nation, particularly because consenting parents would be located on tribal lands. This hesitation points to a dark history of the unethical treatment of Native research participants by university researchers [95, 98].

After a year of trying to find a way to work around this deadlock, we shifted our plan to work with Native youth from small urban areas bordering tribal lands⁶⁷. These students were recruited through various community organizations centered on the well-being of Natives. By switching to working with this population, we entered a different design space even though the experiences of youth and their families may have been somewhat comparable to those of youth and families associated with the boarding school. Generally, in Native communities, there is a distinction between "urban Indians" and individuals who live on tribal land (colloquially referred to as the "rez"). However, when living in a small town that sits on the border of tribal lands, it is common for Native individuals to live both "on the rez" and as "urban Indians" during their youth, depending on the social and economic circumstances of their families. Thus, while the youth that we worked with lived in Flagstaff, AZ and considered themselves to be urban, many had experiences living on the rez or visiting relatives for extended periods on the rez. This nuance is

⁶Based on institutional policy, we communicated our intentions of working with youth who were members of Navajo Nation, but living outside of tribal jurisdiction to the Navajo Nation Research Review Board, and we were told that we could proceed without requiring Navajo Nation IRB approval

⁷The Organization for Economic Cooperation and Development considers small urban areas to be those that have populations between 50,000-200,000 [80]. Critically, these areas are much more sparsely populated than large cities or metropolitan areas. Moreover, by recruiting youth from a town that bordered tribal lands, we increased the probability that youth were well-acquainted with life on tribal lands and may have spent significant time with relatives living on tribal lands.

worth noting in the ongoing discourse of computing and HCI in urban vs. rural contexts; whereas urban and rural are often presented in HCI literature as being discrete identity states [44], in our work urban and rural correspond to a continuum of identity states that a Native individual might occupy throughout their lifetime. Our work contributes to the larger CSCW community by illuminating the reality that for some communities, collaboration must be supported for individuals who mobilize between diverse cultural and geographic spaces that have variable access to social and technical collaborative infrastructure. **Takeaway:** *When designing technologies that support collaboration in Native communities, it is critical to understand the nuances of identity and day-to-day experience created by the layers of policy surrounding tribal sovereignty and jurisdiction.*

7.2 Need for Flexibility with CAB

In Sections 4 and 6.1, we describe the process of recruiting members for the CAB and the critical role they played in recruiting participants for the youth focus group. A significant challenge that we experienced in our design process was identifying members for our CAB who had professional experience working with Native youth as well as personal experience with the behavioral health challenges faced by Native youth in tribal communities. Given that our design team did not have any representatives from Navajo Nation or Hopi Tribe, it was critical to convene a CAB that could help us compensate for this lack of perspective. Given that many of our prospective CAB members worked with high-risk Native youth and functioned as underrepresented professionals in their various fields (e.g., behavioral health, medical health, and education), they were often oversubscribed. Thus, a significant challenge was working flexibly with people who desired to be CAB members and co-designers, but who already had exorbitant demands made on their limited time.

While all CAB members were eager to participate and expressed a strong desire to see an intervention like ARORA designed and built for Native youth, we still faced major challenges convening most CAB members into formal design sessions. To accommodate our CAB member's schedules (which were often incompatible with each other), we adopted a more agile approach to design sessions. In order to collect the information gathered and analyzed in Section 6.1, we reached out to CAB members and set up informal, one-on-one coffee meetings in order to get feedback on designs. We met some of the CAB members at their workplaces when schedule restrictions did not permit them to leave. Two CAB members, graduate students working on advanced degrees in psychology and interdisciplinary health, were invited to participate in our weekly design sessions that were held as a team of investigators. These members represented the most consistent community presence in the design process. While much of the discourse between CAB members happened asynchronously through the design team, we were able to identify common threads for critical components that needed to be included in the prototype design. **Takeaway:** *Design sessions should flexibly accommodate many different modes of design feedback in order to compensate for the demands made on stakeholders' resources.*

7.3 General Cultural Design

Designing mHealth interventions to be culturally relevant for Natives as a general population is a considerable undertaking. There are 573 federally recognized tribes in the United States, each with its own distinctive culture and background. While there are some similarities of experience (especially with respect to Native experiences with Settler Colonialism), there are critical nuances that distinguish one cultural perspective from another. This represents a significant scalability challenge: *At what point is culturally relevant design for a heterogeneous people group too general to be relevant?*

In our work with ARORA, we sought to address this challenge by selecting two different tribes from the same Northern Arizona region: Hopi and Navajo. In Section 6.1.1, we described how similar symbols and stories may be used by both tribes, but the nuances of meanings made it difficult to use these symbols and stories in a general manner while maintaining cultural relevance and appropriateness. To address this, we discussed ideas with CAB members and discoursed around the tensions between cultural similarity and differences in Southwestern tribal culture. In this context, we felt that we were at least successful by avoiding a design that participants felt was “wrong” or culturally inappropriate.

As reported in Section 6.2.2, several of our youth focus group participants suggested that ARORA allow customization for narrator voices and imagery. One of our artist CAB members suggested having youth design the actual imagery that went into the app, based on their own aesthetic preferences and tribal traditions. For example, if the common theme were flying insects (e.g., butterflies, fireflies) and birds (e.g., hummingbirds, eagles), users could personalize the style, patterns and colors of the imagery. This would offer users a catalogue of designs and themes to choose from, allowing them to select imagery that was culturally familiar, visually stimulating, or personally meaningful. By incorporating users in the actual design process we would add an additional layer of participation by users. It would keep the imagery of the app contemporary, prevent the app from becoming stagnant or outdated, and allow us to personalize the app for people of disparate or multiple tribal affiliations. **Takeaway:** *It is critical to distinguish between what is culturally general and culturally specific when designing for a community comprised of individuals from different (or multiple) tribal affiliations. Future work is needed to understand the threshold at which Native cultural relevance becomes too generalized to be effective for increasing the efficacy of behavioral health interventions.*

7.4 Importance of Including Youth

Results from Section 6.2 demonstrate how youth perspectives on design might deviate from adult perspectives. In particular, our own results contribute to the larger CSCW community by demonstrating how collaboration in communities that span considerably diverse cultural spaces might necessitate design that draws explicit connections between form (i.e., what the user does) and function (i.e., how these actions are intended to impact the user). We initially relied on our CAB for design suggestions. Where the CAB members had a rich understanding of their respective cultures and how to represent it in the app, the nuances of culture were not always transparent to the youth that trialed the app and these connections were “lost in translation” from design concept to implementation. For example, the CAB members recognized that integrating mindfulness concepts into the app was an inherent way to teach foundational Navajo and Hopi concepts of awareness and easily perceived a connection between the mindfulness activities and Indigenous practices for cultivating mindfulness. However, when using the app during the focus groups, the youth perceived one of the mindfulness activities (M2) as a distraction from their life and issues more than as a means for teaching culturally valued concepts of attentiveness and awareness. This points to a need for design and implementation to make a more direct connection between mindfulness practice and individual culture. **Takeaway:** *Significance of cultural design elements may need to be communicated more directly to users in the design, especially when co-designing with collaborators who represent different age groups.*

The youth and CAB members had different ideas about what to include in the app to make it appealing, such as including constellations and competition. Many youth wanted competitive gaming in the app, which was CAB members perceived as less desirable. As suggested in the results, a combination of these principles (cooperation and competition) may increase the appeal of the app while allowing it to remain consistent with Indigenous values. **Takeaway:** *Designing platforms for*

computer-supported collaboration between Native youth and Native cultural communities may call for a blending of practices that help Native youth immersed in Western culture engage with the values and principles of their Indigenous culture.

It is noteworthy that the youth enjoyed more physical than cognitive applications of mindfulness. As highlighted in Section 6.2.2 youth most appreciated M1 (breathing) and M3 (mindful walking). Youth reported feeling most disconnected from M2 (meditation). We learned that we need to reassess our design of M2 by including simpler verbal instructions, offering narrator choices and Indigenous music, and emphasizing physicality in the meditation.

Previous work demonstrated that youth did not like (or use) separate psycho-educational modules when included in a behavioral health app [61]. We hoped that narration about how to use mindfulness practices would be sufficient to teach the concepts. Based on our findings in Section 6.2.2, we learned that explicit connections between in-app practices (M1-M6), cultural values, and psychological purposes need to be drawn for youth. For example, the narrator in the M2 activity could more directly explain how mindful observance is a Navajo or Hopi concept and then point out the psychological benefits of using these approaches. This would then provide youth with an explanation for why using these procedures could help them and encourage them to see the value in the activities. **Takeaway:** *Youth desire explicit didactic elements when engaging with interventions that leverage cultural and behavioral health elements. Future work will need to identify the balance with which psycho-education elements are integrated into mHealth interventions.*

7.5 Limitations

The main limitation of this study is the limited number of participants. As discussed in Section 7.2, it was difficult to find CAB members who had the time to work with our team. This limited the number of adults who were able to provide perspective into cultural design best practices, although there was significant agreement between CAB members as to what was most important and appropriate to include in ARORA. We also had a limited number of youth involved in the youth focus groups. While the effects of the limited number of participants on our results are not clear and we did not observe significant disagreement of opinion amongst youth participants, we anticipate that there is a significant amount of design space that could be explored by involving more youth and increasing our representation of the intersectional diversity of Native youth.

Another limitation was the lack of synchronous interaction between CAB members. Again, as noted in Section 7, it was challenging to convene all the CAB members into a single group for design sessions. This was less than ideal as it prevented CAB members from dialoging directly about their experiences and perceptions about what might be culturally necessary for inclusion. Our experience working with the CAB echoes findings from Clark et al., which find Native participants to be forthcoming about topics of culture with researchers when engaging in one-on-one dialog (interview style), although this may be due to a selection bias as participants all had to consent to discussing topics of cultural relevance in the context of youth behavioral health and mobile technology [17]. It is unclear if this dynamic would have been present in a group dialog session involving multiple CAB members, as this environment might make the perceived roles of participants as co-researchers less defined [17]. Finally, we note that while many of our methodologies and takeaways are likely to be relevant for designing with Native youth, we only involved participants affiliated with Navajo Nation and Hopi Tribe.

7.6 Directions for Future Work

Our results and takeaways broach a critical line of inquiry that is fundamental to future CSCW research that investigates methods for designing, implementing, and sustaining decolonizing computer-mediated collaboration, specifically: *What design methodologies are still needed to bring*

*colonized peoples together across diaspora, culture, and infrastructure disparities to do the challenging work of decolonization*⁸? This line of inquiry relates to postcolonial computing introduced by Irani et al. in that it acknowledges that research and practice are “culturally located and power laden” as a matter of fact, allowing researchers and practitioners to broaden their understanding of good design practices [54]. However, decolonizing CSCW would seek to develop methods and practices that would explicitly support computer-mediated decolonizing work across communities. We anticipate that next steps towards a formalized decolonizing CSCW methodology will involve characterization of grassroots movements that appropriate existing computing platforms for decolonizing work [12, 24, 82, 95, 112, 113] and the development of computing research and design methods centered in repatriation of Indigenous life and land.

We seek to continue our development of decolonizing CSCW research and design methodologies as we continue the work detailed in this paper. As ARORA has evolved and as our CAB has spread word about the project to their communities, we have developed a partnership with a Hopi-run youth organization operating out of the Hopi Reservation. This partnership will allow us to more deeply probe research questions around the scope of effectiveness of culturally-centered design as we iterate through the design and implementation of M4-M6.

8 CONCLUSION

Behavioral mHealth represents a promising mechanism through which to address behavioral health disparities for Natives on tribal lands, but there is a need for work that investigates how behavioral mHealth interventions can be designed to be culturally relevant. In this paper, we describe the design of a prototype of a behavioral mHealth intervention which we investigate through the lens of CAB design sessions and youth focus groups. By leveraging a community-based participatory research framework and grounded theory analysis, we identify suggested components that should be integrated into an mHealth intervention that is relevant for Native youth and report on our discourse with CAB members on how these would be best implemented into a digital mobile app format. In analyzing our discourse with focus group participants, we found that participants sought a more didactic mHealth intervention, with requests for explanations within the intervention that focused on *why* elements were culturally relevant and *why* certain mindfulness activities contributed to well-being. We discuss the takeaways of lessons learned through the process of co-designing a culturally relevant mHealth app with Native youth and community stakeholders, and point to directions for future research that investigates and develops methods for decolonizing CSCW.

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⁸We use the definition of “decolonization” from Tuck and Wayne: decolonizing work brings about the “repatriation of Indigenous land and life [106].”

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