Kumu Connect: Culturally-Authentic AI Tools to Enable Educator Agency and Data Sovereignty for Hawaiian K-12 CS Education

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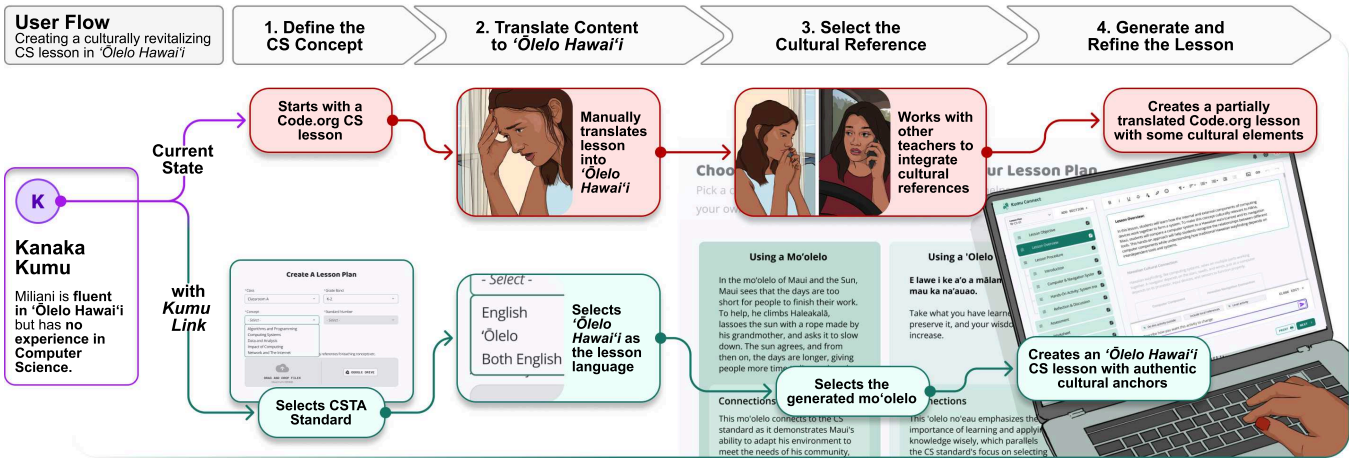


Figure 1: Kumu Connect enables Miliani, a *Kanaka Maoli* (Native Hawaiian) educator who is fluent in *ʻŌlelo Hawaiʻi* (The Hawaiian Language) but has no experience in Computer Science (CS), to create a culturally-revitalizing CS lesson in *ʻŌlelo*. User flows with and without using Kumu Connect are shown above.

Abstract

The erasure of Indigenous cultures is a painfully enduring legacy of U.S. imperial history, producing disparities in culturally-relevant curricula, thus barring Indigenous students from resonant educational experiences. In Hawai'i, where Hawaiian instruction was banned for 91 years, culturally-relevant curricula gaps are most severe in Hawaiian-language education and technical fields like Computer Science (CS). Large Language Models (LLMs) are positioned to address these disparities, yet raise concerns of cultural misrepresentation and data sovereignty. We ask: how can LLMs serve educators of varying familiarity with Hawaiian culture while safeguarding Hawaiian knowledge? Addressing this question, we present Kumu Connect, an LLM-assisted culturally-revitalizing CS lesson plan generator, co-designed with Native Hawaiian educators. This work contributes design requirements, a situated case study, and "future imaginaries" paired with design provocations to highlight how community-engaged development can inform culturally-authentic and pedagogically useful AI tools that address CS and culture knowledge gaps and uphold Indigenous data sovereignty.

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CCS Concepts

• **Social and professional topics** → **Race and ethnicity**; **Cultural characteristics**; **K-12 education**; *Computer science education*; • **Human-centered computing** → **Participatory design**; Usability testing; • **Computing methodologies** → *Artificial intelligence.*

Keywords

culturally-responsive design, AI in education, LLMs, Education technology, Indigenous education, low-resource languages, co-design

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1 INTRODUCTION

Within their lifetimes, today's children are expected to face unprecedented climate crises, including heatwaves, floods, droughts, and wildfires [41], as well as increased conflict, widespread poverty, and decreased access to education [118]. For Indigenous children, this builds upon decades of systemic harm from colonizing forces upon their cultures, languages, and knowledge systems [117]. Many Indigenous children have been cut off from their ancestral scientific and technological knowledge, a violation to their right to information and education [117]. This fundamentally undermines future climate actions, by eroding Indigenous knowledge systems–formed through generations of land stewardship and lived experience–that offer validated solutions, such as sustainable agriculture practices [44], for these crises [117]. Access to culturally-revitalizing education is a necessity for both addressing current educational inequities and empowering Indigenous students with these knowledge systems as they define future environmental science, technology, public policy, and more. However, as another result of the systemic suppression of Indigenous cultures and languages, resources for culturally-revitalizing curricula are scarce, and few educators possess the domain expertise, cultural background, and language fluency to address these curricula gaps [40, 86, 88].

Artificial Intelligence (AI) tools for education have grown exponentially in recent years, with research exploring how these tools can address the aforementioned challenges, such as educator shortages [55] and educators' knowledge gaps in CS and emerging technologies [88], through rapid educational materials generation [26, 39, 49, 78, 120] and support mechanisms that enable educators to teach unfamiliar concepts [54, 74, 78]. Additionally, researchers have explored LLMs' potential to create educational experiences customized to students' needs, interests, and cultural backgrounds [39, 49, 114]. However, the applicability of LLMs for culturally-revitalizing curricula generation for Indigenous education is underexplored, with existing research focused on off-the-shelf AI tools, surfacing important concerns regarding data sovereignty, cultural representation, and educator agency [78].

To understand this understudied area, this work focuses on *Kanaka Maoli* (Native Hawaiian) communities and Hawaiian educational settings, where many of these factors converge. *Kanaka Maoli* children are acutely aware of the impacts of colonization, tourism, and military occupation, through traumas including the 2023 Lāhainā wildfires [64] and systemic inequities in K-12 education [88], health [82, 110], and youth well-being [123]. At the same time, Hawai'i uniquely supports culturally-relevant education in its public schools, through Hawaiian Education efforts that mandate the promotion of Hawaiian language, culture, and history [48, 92], as well as its Kaiapuni programs in public schools, which provide *'Ōlelo Hawai'i* (The Hawaiian Language) immersion education [47]. This is due to the advocacy efforts of *Kanaka Maoli* educators and cultural practitioners to promote *'āina*-based learning, which honors Hawaiian ways of knowing. *'Āina*, which means "that which sustains us," refers to the interconnected place, people, culture, creatures, and environment. However, resource and educator shortages hinder this work, especially in STEM efforts and Kaiapuni classrooms. *'Ōlelo Hawai'i*, a vital medium through which *Kanaka Maoli* children learn Hawaiian culture, is considered a "low-resource" language, a consequence of a decades-long ban that left 2,000 speakers by 1978 [92]. This context motivates this work, as educators and students need support mechanisms for culturally-revitalizing education, centering Hawaiian epistemologies as the foundation from which students can shape their futures.

We build on scholarship on Indigenous AI [8, 18, 69, 71] and Indigenous futurism [9, 68, 70], which calls for restructuring how we conceptualize these technologies, grounding them in Indigenous epistemologies, centering community voices, and utilizing futuring as a method to envision technology for future generations. We engaged community members, including educators, cultural practitioners, and *'Ōlelo Hawai'i* speakers–all stakeholders in the effective transmission of Hawaiian culture and language to children–in **co-designing LLM-assisted tools for culturally-revitalizing CS curricula generation in Hawaiian educational settings.**

This work centers on the creation of Kumu Connect, a web-based, human-in-the-loop LLM application designed to support culturally-revitalizing CS curricula generation in Hawai'i public schools and Kaiapuni programs. Kumu Connect leverages LLMs with a novel dataset of *'ike kūpuna* (ancestral knowledge) to integrate it into generated content while carefully ensuring that *Kanaka Maoli* (Native Hawaiian) communities maintain data stewardship and sovereignty [19, 100]. Kumu Connect facilitates educators' lesson curation, guiding them through selecting the appropriate CS standards [23], the delivery language (English or *'Ōlelo Hawai'i*, the Hawaiian language), and vetted cultural references, allowing educators to choose Hawaiian *mo'olelo* (stories), *'Ōlelo No'eau* (proverbs) [97], and/or cultural practices related to their selected CS concept (Fig. 1).

We conduct two years of formative relationship building and iterative community-based development, and share our motivations, findings, research activities, and design decisions. We employ community-based approaches such as co-design and *talk story* (a Hawai'i Creole[1] term for an informal, relational conversation). We present the generation and editing workflows that foreground educators' expertise and enable effective use of LLM outputs, ensuring that lesson plans are culturally-appropriate, place-based, and pedagogically useful. We describe our most recent co-development activities, involving the system evaluation of Kumu Connect with 36 Hawai'i public school and Kaiapuni program educators and *talk story* with cultural practitioners to continue our query into the LLM's use of *'ike kūpuna* in Hawaiian Education. Our results

[1]Hawai'i Creole or Hawai'i Creole English, referred to as "Pidgin" locally, is an English-based creole language recognized by the U.S. Census Bureau [24, 99]

illustrate that Kumu Connect achieved a meaningful balance of cultural authenticity and pedagogical utility, while making CS concepts accessible to non-technical educators. Additionally, we adopt Lewis' [67, 68] "future imaginaries" concept and present four community visions for Hawaiian AI, to capture the forward-looking ideas surfaced from evaluation, *talk story* and our reflections.

Our work contributes: (1) design requirements to guide the development of educational tools that utilize LLMs to align with Indigenous values, pedagogical practices, and language nuances; (2) the development of Kumu Connect as a case study for how iterative co-creation with communities early in development processes reveals pathways to culturally-grounded, accurate, and useful educational AI tools; and (3) a set of "future imaginaries" [67, 68] for Indigenous AI, each accompanied by a design provocation for HCI researchers and practitioners.

2 BACKGROUND

2.1 Related Work

2.1.1 Culturally-Revitalizing CS Education. Research shows that centering students' culture in CS curricula enhances student engagement and outcomes, while fostering deeper connections toward culture, community, and their own identities [15, 21, 22, 31, 76, 81, 104, 111, 115]. By incorporating local references and familiar stories, this pedagogical approach directly relates STEM concepts to experiences in students' day-to-day lives [61, 101]. In Hawai'i, this takes form in *'āina*-based education, which tie learning to local environments, community knowledge, *and* Hawaiian epistemologies [9, 45, 57, 63, 86, 87, 96]. Hoffman at al's [50–52] and Nelson et al's [86] work illustrates how some Hawai'i educators have implemented culturally-revitalizing CS to engage students in culture and subject matter by incorporating local knowledge and Hawaiian values, like *mālama 'āina* (to care for the land) [86]. While successful, these studies demonstrate the outsized time and experience needed for such efforts, making scalability extremely difficult. The outputs of these studies are contextual to the point of non-transferability, even to other schools on the same island, and, with the exception of Nelson et al's [86] work, offered only in English.

Creating culturally-revitalizing curricula requires domain expertise *and* deep experience in the relevant culture [49, 51, 76], as well as language fluency for immersion settings, meaning the majority of educators are not equipped to lead these efforts [88]. The burden falls hardest on educators with this advanced skill set to both create their own materials–a time-consuming process [83]–and support their fellow educators [40]. Yet because *Kānaka Maoli* (Native Hawaiians) are critically underrepresented in CS [88], there are very few educators with necessary skills to modify and translate existing curriculum modules (from Code.org, etc.), let alone invent new modules that embrace Hawaiian epistemologies, meaning, in reality, very very few *Kānaka Maoli* children receive culturally revitalizing CS education. Tools to support educators in this are incredibly scarce [51, 88], especially in *'Ōlelo Hawai'i* (the Hawaiian Language) [40, 86].

2.1.2 LLMs for K-12 Lesson Generation and Culturally-Revitalizing Pedagogy. HCI and AI research demonstrates how LLM-assisted tools hold potential to bridge gaps between curriculum goals and effective classroom delivery by generating curriculum-aligned lesson plans [10, 34, 37, 60, 77], while also supporting adaptive learning [28] and enhancing student engagement [6, 105]. Early adopters feel that LLMs can serve as a valuable brainstorming partner for innovative teaching strategies while reducing educators' workloads [37, 53, 58, 59, 79]. However, educators need content that is accurate, unbiased, and suitable for diverse learners, presenting a primary issues in the use of LLMs for educational content generation. LLMs are prone to hallucinations, regularly producing inaccurate, biased, or culturally-insensitive material [29, 75, 85, 103, 113]. This creates a burden for educators, requiring them to review and refine LLM-generated outputs to ensure accuracy. Even with review, stereotypes and misrepresentations can make it into the curricula, creating a hostile learning environment for minority students.

Few prior works have explored the use of AI for culturally-relevant CS curricula generation. Notable related work includes He et al.'s [49] study on educator-AI collaboration in creating culturally-responsive curricula material for Latine students. The study found that educators needed expertise in and agency to enact cultural and pedagogical knowledge – plus AI literacy – in order to effectivity create novel curricula materials using off-the-shelf generative AI tools [49]. In the specific context of Hawai'i, Mhasakar et al.'s [78] study on educators' perceptions of off-the-shelf generative AI tools found that many educators viewed these tools, in their current state, somewhere between useless and harmful for Hawaiian education, with concerns spanning from misinformation to digital colonization of cultural stories and language. The study surfaced challenges regarding trust, data sovereignty, and authenticity, illustrating how LLMs largely embed Western-centric biases while lacking awareness of non-Western cultures [78].

2.1.3 Indigenous AI and LLMs for Low-Resource Languages. The development and deployment of LLMs for Indigenous education–especially those with low-resource languages–presents technical constraints and ethical concerns regarding data sovereignty, digital colonization, and the reinforcement of power imbalances [3, 84, 89]. LLMs are primarily trained on dominant languages [46] and are known to underperform for non-English languages, even if they have a large corpus of data [119]. LLMs are especially poor at answering queries in "low-resource" languages which have comparatively little raw text available and therefore can not sufficiently represent the language and its social, cultural, or historical contexts [43, 102]. This leads to inaccuracies, mistranslations, and cultural misrepresentations [4, 95, 124], making many general-purpose LLMs useless, or even harmful for Indigenous education.

In developing AI tools for Indigenous education, decolonial [1, 62, 68, 70, 80, 107, 116] and postcolonial lenses [56], Indigenous HCI [62] and Indigenous AI protocols [69] offer pathways to grounding work in Indigenous epistemologies, leveraging community-led approaches to model development [69], and prioritizing culturally-sensitive NLP techniques [94]. This literature highlights the importance of community-based co-design early in the process, as hegemonic HCI practices perpetuate dominant narratives, trends, and biases [5, 9]. Lewis [67] describes how conversation and co-design activities in the Indigenous AI protocol's formational workshops [69] resulted in "future imaginaries," [68] which are visions for *"what our communities will be like in one hundred, five hundred,*

or a thousand years" [67]. These works inform how we co-create with communities, centering participatory methods, and build the intermediate systems as design probes for conceptualizing visions for AI in Indigenous education.

Research exploring how AI tools align with the cultural and linguistic priorities of Indigenous communities remains limited. Highly related work includes Pinhanez et al.'s [94, 95] research on using AI for the documentation and revitalization of Brazilian Indigenous languages and Shedlock et al.'s [106] expository case on transferring Indigenous knowledge to an LLM through *te reo Māori* (the Māori language) inputs, from interviews on Māori protocols of *pōwhiri* (welcoming visitors). To our knowledge, no prior studies have evaluated the reception of these systems in Hawaiian Education, including Kaiapuni programs, where the preservation of *ʻŌlelo Hawaiʻi* and culture are paramount.

2.2 Positionality Statement

Our team is composed of cultural insiders and outsiders, representing a range of proximity to Hawaiian culture. Hester and Helekahi-Kaiwi are *Kanaka Maoli* (Native Hawaiian), and Diego is *kamaʻāina* (local) with *Kanaka Maoli* family. The remaining authors are cultural outsiders. Our team comprises almost entirely racial/ethnic minorities in a U.S. context, with the majority being underrepresented minorities in STEM fields. Helekahi-Kaiwi's, Diego's, and Hester's roles align with Udoewa's [116] Radical participatory design (RPD) models for "community member as facilitator" and "community member as designer," roles in which they equally represent their community *and* lead or contribute to research and design. For our cultural outsider team members to best serve as allies, we have developed an on-boarding process that emphasizes allyship development, through readings, conversations, and reflections, in parallel to incremental access to community partners.

3 ITERATIVE DEVELOPMENT PROCESS

Over two years of iterative development of Kumu Connect with ~50 educators and cultural practitioners in Hawaiʻi, we have explored our primary research question: **How can LLM-assited educational tools support educators with varying familiarity of Hawaiian culture deliver authentic culturally-revitalizing CS education to *Kanaka Maoli* children, while protecting Hawaiian knowledge and ensuring data sovereignty?** This process began in April 2023, branching off from an existing project with a Kaiapuni program at a public K-10 school in Oʻahu. Inspired by existing research on decolonial HCI [1, 62, 68, 70, 80, 107, 116], we used community-based research and design approaches, being mindful of the history of extractive Western research on the *Kanaka Maoli* community and the immediate trauma of the 2023 Maui wildfires [2]. We identified asset-based design [93, 122], co-design [5, 20], and participatory design [27, 65] as valuable frameworks for our context. We prioritized relational activities that respected community partners' limited availability, enabled co-design with educators, and elevated conversation and interaction.

The work is outlined in the following section in four distinct phases (Fig. 2): (1) Foundational Research & Definition, (2) Concept Design & Evaluation, (3) AI Model Research & Definition, and (4) AI Model Development & Evaluation. We engaged community members who work with children–educators, cultural practitioners, and *ʻŌlelo Hawaiʻi* speakers–through co-design activities, *talk story*, collaborative task analysis, and cycles of user testing and feedback, as outlined in Table 1 and Fig. 2. These engagements shaped both the scope and function of the LLM, guiding its use of *moʻolelo*, appropriate cultural references, and values-based instructional framing.

Table 1: Research Activities

ID	Phase	Participants
T	Education landscape in Hawaiʻi & Kaiapuni programs	10 Educators
O	Context-building & Asset Identification	10 Days
CT	User Testing of Initial Concept	2 Educators
TA	Task Analysis Validation	2 Educators
U	User Testing of Design Prototype	11 Educators
S, I	Perspectives on AI Tools in Hawaiian Education	15 Educators
P	User Testing of Prototype & Quality Analysis of LLM Outputs	36 Educators
TS	Perspectives on LLMs & Traditional Knowledge	8 Educators & Cultural Practitioners

Table 2: Findings to Design Requirements

Finding	Design Requirement
Stand-in educators have varied backgrounds	Accommodate range of backgrounds/expertise
Frequent subbing creates discontinuity in learning	Serve as a centralized resource for educators
Most educators do not feel confident teaching CS	Feel approachable & not overwhelming
Place-based schools lean on low tech solutions	Align with existing educator expectations
Teachers are open to new tools that improve efficiency	Demonstrate immediate practical application
ʻŌlelo branch has fewer teaching resources	Use language & references relevant to ʻŌlelo branch

3.1 Foundational Research & Definition

Research started with a review of context-setting literature on CS education in Hawaiʻi, Hawaiian history, culture, knowledge systems, and current systemic issues [17, 30, 32, 33, 38, 66, 86, 90, 98, 112]. Concurrently, we focused on building relationships with community partners and having regular conversations on the topics above. Beyond establishing foundational knowledge, this step was important for our non-Kanaka team members to be informed so as to mitigate the harm they might perpetuate in interacting with the *Kanaka Maoli* community.

After this context-setting, we engaged with our partner school and educators through 10 sessions of *talk story* and 10 days of site visits. Through these activities, we surfaced educator perspectives related to: (1) teaching motivations; (2) current tools & assets;

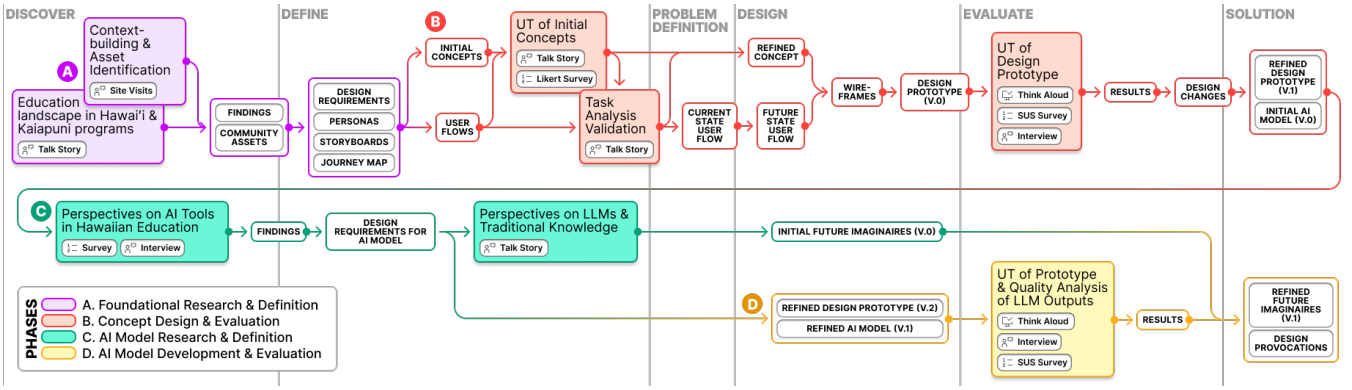


Figure 2: Research activities and outcomes by phases: (a) Foundational Research & Definition, (b) Concept Design & Evaluation, (c) AI Model Research & Definition, and (d) AI Model Development & Evaluation.

and (3) considerations when creating, planning, and implementing lessons. Our analysis of collected data resulted in identification of community assets and a set of findings and corresponding design requirements, as presented in Table 2.

We produced research artifacts to capture the use case, including *personas* [14], *storyboards* [42], and *journey maps* [108]. We created two personas to demonstrate common uses for Kumu Connect: (1) Kanaka Kumu: a non-technical *Kanaka Maoli* (Native Hawaiian) educator who is fluent in *ʻŌlelo Hawaiʻi* and has no experience with CS and (2) Tech Teacher: a technical *mahlihini* (local) educator who has little knowledge of Hawaiian culture. We focus on the use case of creating a culturally-revitalizing CS lessons for a majority *Kanaka Maoli* classroom. The user flow (Fig. 1, top row) illustrates the pain points a Kanaka Kumu faces in creating culturally-revitalizing CS lessons - an arduous process that often necessitates multiple educators and hours of labor for a single lesson.

3.2 Concept Design & Evaluation

After this foundational research and definition of the problem space, we designed the concept that became Kumu Connect. Taking the findings and design requirements from the foundational research phase, we distilled this information into three concepts, which we tested and refined through *talk story* with educators at our partner school. Through these activities, we developed Kumu Connect from a concept to a design prototype (Fig. 3), which we then tested with 11 educators at our partner school, through a Wizard of Oz usability test [25] and System Usability Scale (SUS) questionnaire [72].

We used inductive thematic analysis [109] to analyze transcripts and identify key trends. Our analysis of testing session recordings surfaced 105 findings, which we categorized into 25% validations (for feedback that aligned with foundational research, Section 3.1), 19% usability issues, 8% missing info (for content that could be added but did not impact usability, such as seating charts), and 48% speculations (for new features or changes, ranging in implementation difficulty). We then translated each finding into design change recommendations, which were mapped along a priority matrix, using the axes of low-to-high impact vs. low-to-high effort. These design changes informed the current interface as it exists today, as outlined in Section 4: System Design & Implementation.

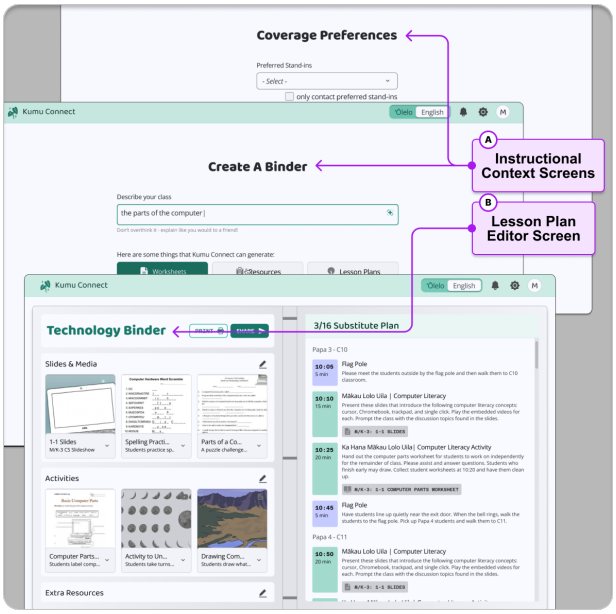


Figure 3: The initial design prototype for Kumu Connect, including (a) the instructional context screens and (b) the lesson plan editor screen, in a "binder" layout.

3.3 AI Model Research & Definition

After more than a year of iterative design and prototyping, we shifted our focus to developing Kumu Connect's AI model, starting with a study on Hawaiian educators' experience, concerns, and hopes regarding generative AI tools in Hawaiian Education. With this effort, we aimed to identify design requirements for appropriate and useful AI tools for Hawaiian educational contexts. For this research, we conducted surveys with 15 educators teaching across K-12 grade levels and semi-structured interviews with four educators, all from public schools with Kaiapuni programs.

We created our survey and interview protocol around a set of core themes identified through the aforementioned research activities, focusing on (1) barriers, constraints, and tensions that exist

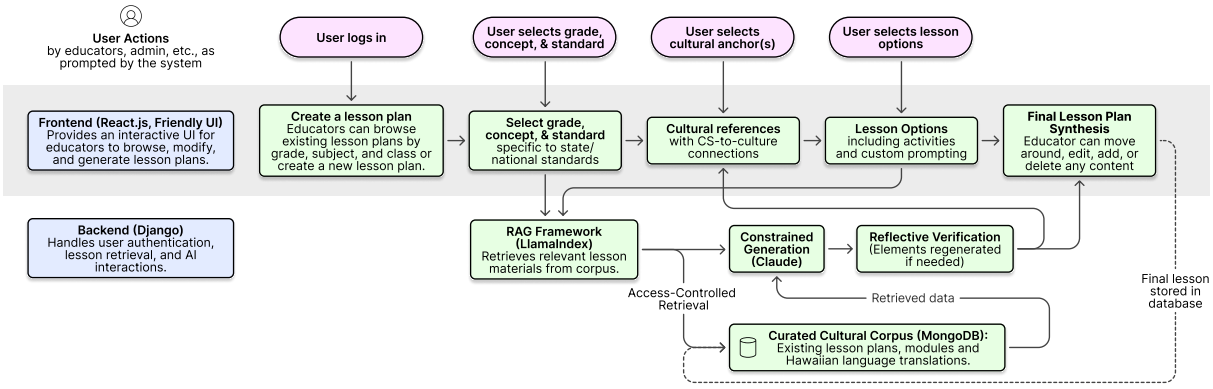


Figure 4: The architecture of Kumu Connect front-end and back-end, with user actions while creating a lesson plan

when using AI tools to create accurate and appropriate, culturally-revitalizing CS lessons and (2) challenges educators–who may be cultural insiders or outsiders–face when designing, adapting, and delivering these lessons for *Kanaka Maoli* (Native Hawaiian) children. The themes were: Cultural Sensitivity and Representation; Data Sovereignty and Ethical Concerns; Workforce and Impact on Educators; Usability and Accessibility; Perceived Opportunities and Risks; Practical Suggestions and Design Recommendations; and Vision and Future Outlook. We analyzed survey answers and interview scripts via deductive thematic analysis [13] and compared how the themes appeared across participants.

We found that AI tools fail to reflect Hawaiian cultural knowledge, have default Western assumptions, give untrustworthy or false outputs without sources, and are difficult to use without support and training. Additionally, we established design requirements for Kumu Connect, stating that it must: (1) default to Hawaiian ways of knowing; (2) ensure all generated content draws from verified Hawaiian sources; (3) identify and remove content that is factually or culturally-inaccurate before it reaches the educator; and (4) keep educators in control of content selection and lesson plan composition.

3.4 AI Model Development & Evaluation

To satisfy our design requirements, we utilized Retrieval Augmented Generation (RAG) [73] in the architecture of Kumu Connect (Fig. 4, to prioritize a set of validated Hawaiian sources over global knowledge systems. The foundation of this system is a curated database populated with curriculum modules, detailed curricula frameworks, an *ʻŌlelo Hawaiʻi* CS terminology database, and other cultural artifacts developed through two prior projects with Kaiapuni educators. This repository of trusted materials serves as a privileged grounding source of cultural knowledge for the generation process, acting as a safeguard against the Western-centric biases of base LLMs while complementing the model's own pretrained knowledge.

The generation process for culturally-revitalizing materials is orchestrated through a three-phase prompting strategy designed for cultural accuracy and pedagogical relevance. Explicit safeguards, informed by educator interviews (Fig. 5.a), are included to minimize fabrication. For example, we include statements such as "*You MUST ground your response in the provided Contextual Information from our validated Hawaiian curriculum materials*" when context is available, and "*Do NOT invent new moʻolelo, characters, or proverbs.*" It is instructed to adopt the persona of an expert in Hawaiian culture and an experienced K–12 educator and tasked with producing exactly one *moʻolelo*, one *ʻŌlelo Noʻeau*, and one cultural practice.

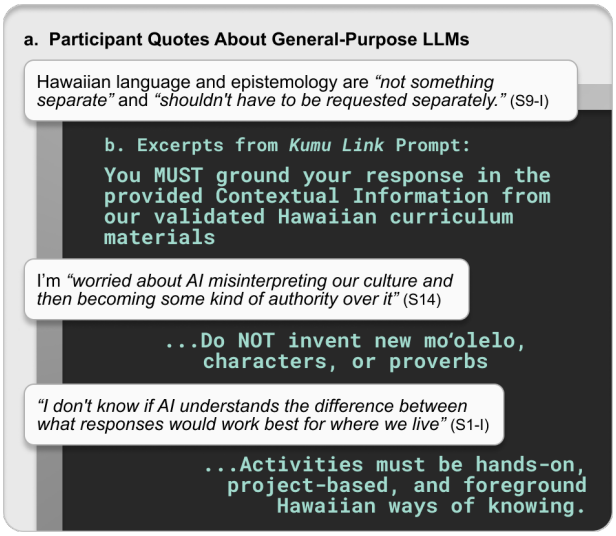


Figure 5: (a) Participant quotes from surveys and interviews about general-purpose LLMs in Hawaiian education, paired with (b) excerpts from the Kumu Connect prompt.

We conducted multiple rounds of internal evaluations with cultural experts to ensure educational suitability and to iteratively refine our prompt. The complex work of retrieval, multi-component prompt engineering, and reflective verification is abstracted by the backend, allowing the educator to interact with a simple, structured frontend interface. The evaluation of this phase is detailed in Section 5: Evaluation.

4 SYSTEM DESIGN & IMPLEMENTATION

Kumu Connect is designed around a user flow that prioritizes cultural integrity, verification, and educator agency, as illustrated in

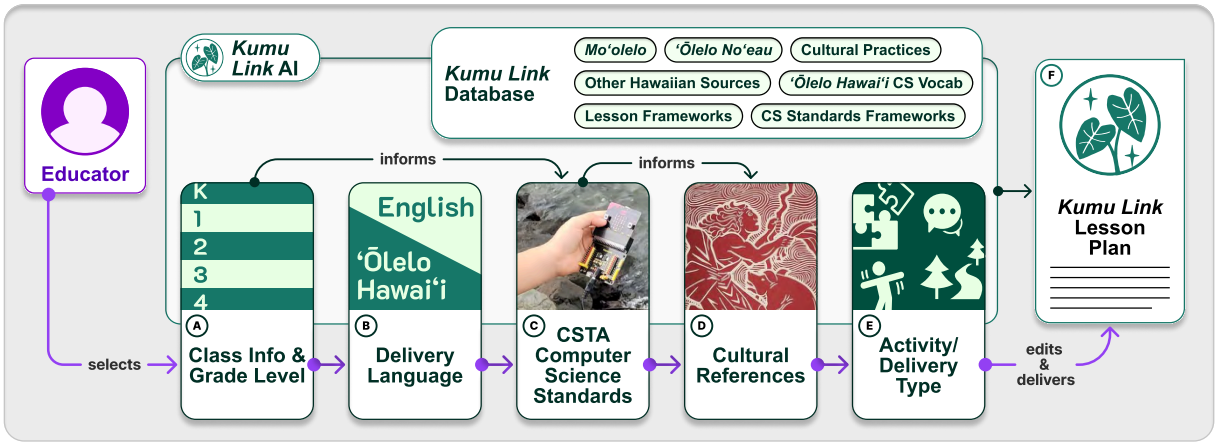


Figure 6: Elements that make up (f) a Kumu Connect lesson, including (a) Class Info, (b) delivery language, (c) CSTA Computer Science Standards, (d) Cultural References, and (e) delivery/activity type.

Fig. 1 (bottom row) and Fig. 6. In the following section we describe Kumu Connect's human-in-the-loop generation process in detail, outlining its overall function, user flow, and implementation details.

4.1 User Step: Define the Instructional Context

The educator's journey begins with defining the core parameters of their lesson (Fig. 7), including:

- Grade Band: K-2, 3-5, 6-8, 9-10, 11-12 (Fig. 7.b)
- Computer Science Teachers Association (CSTA) Concept [23] (Fig. 7.c)
- CSTA Standard [23] (Fig. 7.d)
- Delivery language: *'Ōlelo Hawai'i* or English (Fig. 7.e)
- Optional Add-ons: Materials that the educator wishes to include in the lesson, which can be uploaded to Kumu Connect, such as existing worksheets, vocabulary, or rubrics (Fig. 7.f).

These initial selections serve as the foundational context for the system. This structured input constrains downstream generation to be both grade-appropriate and conceptually relevant.

4.2 Generation: Constrained Generation

In the first phase of generation, **Constrained Generation**, the system constructs a prompt that incorporates the educator's requested instructional context. The system then performs a retrieval step over our curated cultural corpus, surfacing relevant *mo'olelo*, *'Ōlelo No'eau*, and exemplar curricular materials. These retrieved passages are then supplied to the LLM (Claude 3.7 Sonnet [7]) as contextual input alongside the educator's request.

At this stage, the model can proceed in one of two ways: when passages are highly relevant and contextually specific, the model picks directly from these materials (retrieval-anchored generation); in cases where retrieval is sparse or less specific, the model instead draws on its pretrained cultural knowledge. In both cases, the model is tightly constrained through prompt engineering.

4.3 Generation: Reflective Verification

The system moves to a second phase, **Reflective Verification**, which acts as an internal quality assurance mechanism, mimicking a peer-review process. The output from the generation phase is passed to a second, verification-focused LLM call. This prompt provides the model with the original user query, the generated elements with their claimed sources and instructs the model to act as a critical reviewer and evaluate the generated elements against several criteria: (1) Authenticity, by cross-referencing the output against the provided source context; (2) Conceptual Alignment, by assessing if the connection to the CS concept is meaningful and not superficial; and (3) Safety, by performing a final check for any potentially misinterpreted or harmful content.

If an element is flagged as failing any of these checks, it is automatically regenerated with more targeted constraints. This two-pass pipeline generation followed by verification was essential for achieving our design goal of hallucination reduction and ensuring the cultural references presented to the educator are trustworthy. The final, validated references feed into the user step below.

4.4 User Step: Select Cultural References

The next screen (Fig.8) presents three distinct cultural elements that Kumu Connect generates for the selected CS concept:

- A *mo'olelo* (story)
- An *'Ōlelo No'eau* (proverb)
- A *cultural practice* (activity, tradition, or skill)

Each reference is accompanied with a CS-to-culture "connection" description (Fig. 8.b), which explains which aspects of the reference mirror aspects of the CS concept. The user can generate more options (Fig. 8.c), adding them to the carousel, and have the option to attach their own cultural references, such as local *mo'olelo* (Fig. 8.d).

4.5 Generation: Lesson Plan Synthesis

After the educator has selected their preferred cultural reference(s), we implement the third and final generation phase: **Lesson Plan Synthesis**. In this phase, the system initiates a final LLM call to

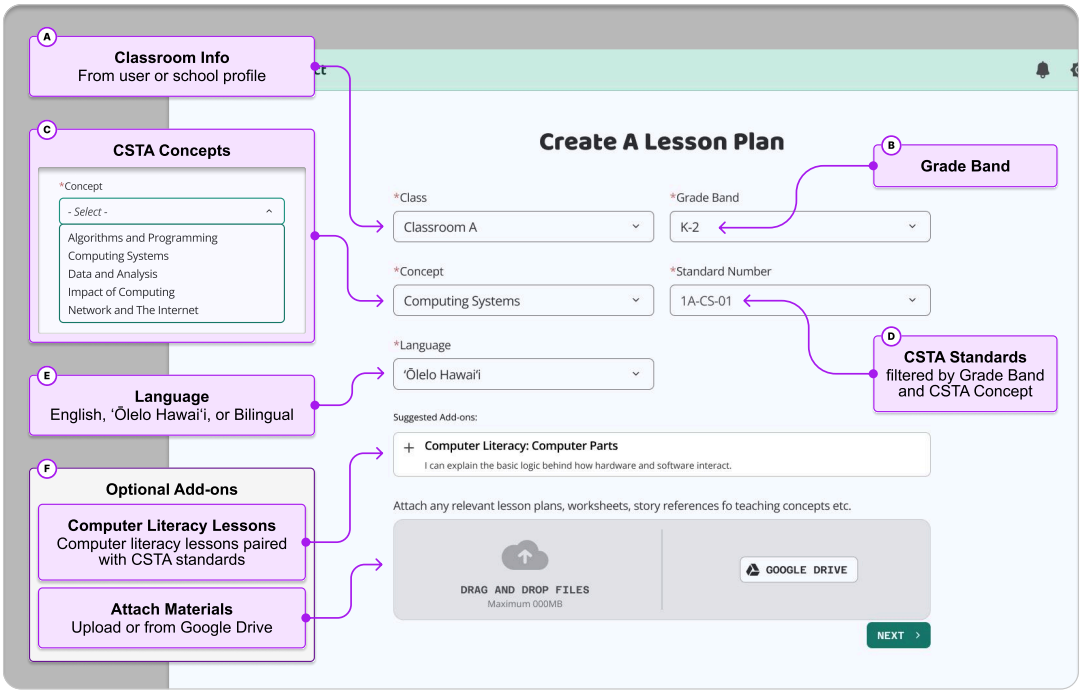


Figure 7: Annotated Instructional Context screen, showing fields for (a) classroom info, (b) grade band, (c) CSTA concept, (d) CSTA standard, (e) content language, and (f) optional add-ons, including computer literacy lessons and attaching materials.

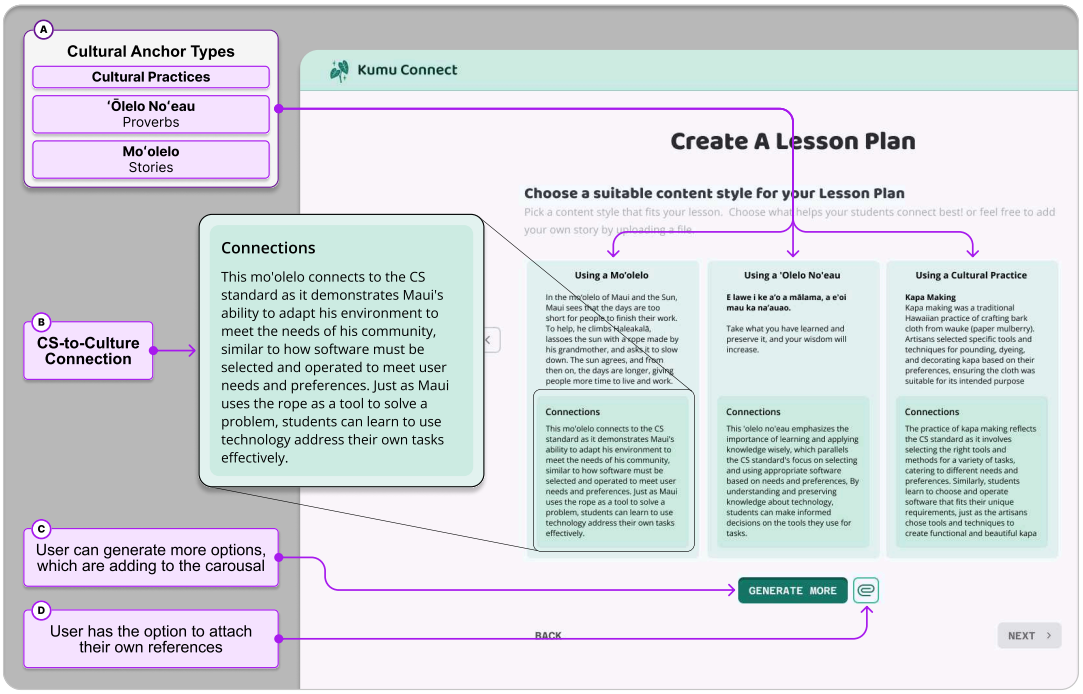


Figure 8: Annotated Cultural References screen, with (a) the three generated cultural reference types, (b) CS-to-Culture connection blurb, (c) option to generate additional references, and (d) option to upload references.

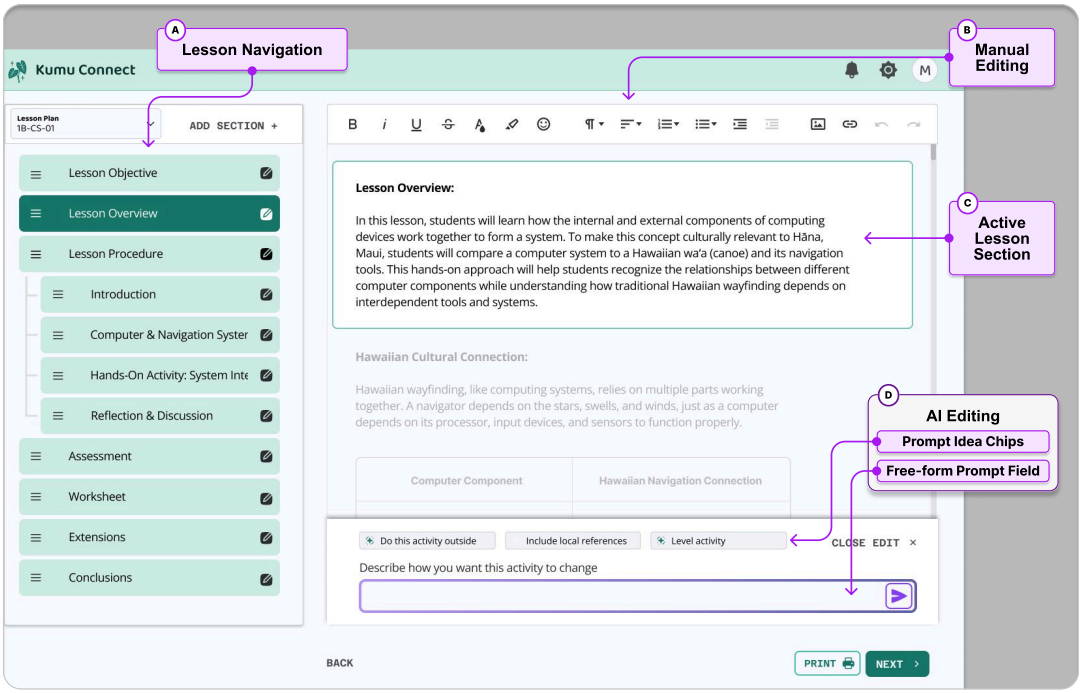


Figure 9: Annotated Lesson Plan Editor screen, showing the "editing" view for (a) the left-side lesson navigation, (b) the manual editing bar, (c) the active lesson section that's currently being edited, and (d) the LLM-assisted editing bar, with prompt ideas choice chips and a free-form prompt field.

synthesize the complete lesson plan. The prompt for this phase is structured to ensure pedagogical soundness. It provides the model with the complete context: the grade level and CS standard, the educator's chosen cultural reference, and any optional content the educator may have uploaded. The prompt then mandates a specific output structure, instructing the model that "*The lesson plan MUST be structured with the following sections: Lesson Title, Learning Objectives, Materials, Lesson Activities (including a Hook, Guided Practice, and Independent Practice), Discussion Prompts, and Assessment.*" This strict templating ensures that every generated lesson is consistently formatted and follows a logical pedagogical flow. Furthermore, the prompt guides the content's characteristics, directing that activities should be "*hands-on, project-based, and foreground Hawaiian ways of knowing.*" This final synthesis step transforms the curated cultural elements into a classroom-ready artifact.

4.6 User Step: Refine the Lesson

In this stage, the system shifts agency firmly to the user, positioning them as the ultimate expert and decision-maker. The user's selections are assembled by the model into a complete lesson plan containing:

- Learning objectives linked to the CSTA standard [23].
- Activities integrating the selected cultural elements.
- Discussion prompts that foreground Hawaiian knowledge.
- Assessment appropriate for the grade level.

This final output is rendered in an editable format (Fig. 9), allowing the educator to make final modifications before saving or exporting their lesson. This multi-stage, educator-in-the-loop process ensures that the final output is not merely LLM-generated, but LLM-assisted and educator-approved.

5 EVALUATION

5.1 Methods

For a culturally-grounded generative LLM like Kumu Connect, a standard quantitative comparison to baseline LLMs is not only insufficient but can be misleading. Such benchmarks prioritize raw output over contextual appropriateness and safety. Therefore, our evaluation methodology is intentionally rooted in our community-based design process. We assess Kumu Connect's effectiveness through the lens of its intended users: educators in Hawaiʻi whose judgments provide the most valid measure of the system's quality and impact.

For user testing with educators, we utilized semi-structured task-based think-alouds with benchmark quantitative questions. We complemented this with *talk story* with cultural practitioners and educators about data sovereignty and LLMs for Hawaiian education. This approach also called for nimble study protocols that can be responsive to our participants' needs, allowing us to change as needed to center on the participant. For example, our user testing protocol was in English, but when Helekahi-Kaiwi observed that UT22 seemed more comfortable communicating in *ʻŌlelo Hawaiʻi*, Helekahi-Kaiwi conducted their testing session entirely in *ʻŌlelo*

Table 3: Participant Positionality to Hawai'i

Positionality	Pilot	S1	S2	S3	TOTAL
Kanaka Maoli (Native Hawaiian)		5	8	2	**15**
Kama'āina (Local)	2*	6	2	6	**16**
Mahlihini (Recent arrival)		2			**2**
Other or Prefer Not to Respond		1		2	**3**

S1 = School 1, S2 = School 2, S3 = School 3

* Both pilot participants are former educators of School 2

Hawai'i. We also used snowball recruitment method, where participants referred others within their trusted networks. This reinforced a relationship-based recruitment process, rather than relying on impersonal or institutional outreach.

We defined our evaluation via four dimensions:

- **Cultural Accuracy:** Does the generated *mo'olelo* (story), *'Ōlelo No'eau* (proverb), or cultural practice exist in Hawaiian tradition and is it represented faithfully? We assessed accuracy relative to educator feedback and expertise.
- **CS-to-Culture Connection Quality:** Is the CS-to-culture connection understandable and usable? We measured connection quality based on educator feedback.
- **Pedagogical Usefulness & Immediate Usability:** Does the lesson meaningfully convey the targeted computing concept? Is it age-appropriate, correctly sequenced, and practical for classroom use? We assessed usefulness via educator perspectives complemented by an internal review of content validity by CS experts.
- **Trustworthiness:** Do educators feel confident that the generated lesson and cultural references can be safely introduced into their classrooms without extensive correction? This dimension integrates both cultural and pedagogical trust.

With these dimensions in mind, we created our study protocol, translating metrics into a mix of qualitative open-ended questions and quantitative Likert scale questions. We included questions on teaching experience, positionality to Hawai'i, and experience with LLMs to evaluate how these factors impact each metric. The fourth author, Helekahi-Kaiwi, reviewed the research instruments for cultural sensitivity.

5.1.1 Study Design. We conducted a two-phase **User Testing Study** with 36 educators across three schools, including Hawaiian immersion and general education schools, to evaluate both the usability and LLM functionality of the Kumu Connect platform. Our selected schools, represent a range of Hawai'i public schools: School 1 is a Native Hawaiian Majority public K-5 school, School 2 is a Native Hawaiian Majority public K-10 school with a Kaiapuni program, and School 3 is a predominately white public K-5 school. As described in Section 2, all three of these schools are required to deliver culturally-relevant Hawaiian education, with the Kaiapuni program required to do so in *'Ōlelo Hawai'i*. These educators represented a range of positionality to Hawai'i, as detailed in Table 3.

In the first phase, we presented participants with a Figma[35] design prototype to test the usability of the application in a task-based and think-aloud session. After answering initial warm-up questions, participants completed three tasks: (1) generate a lesson plan for 2nd graders on 'Computing Systems' using Hawaiian *mo'olelo*, (2) edit a section of the lesson plan to use a summative assessment, and (3) add a new classroom management category to the lesson plan. After completing the tasks, educators filled out the System Usability Scale (SUS) survey and answered open-ended questions about their experience. This phase helped assess overall usability and identify design gaps before functional development.

In the second phase, the same participants tested a working version of Kumu Connect's AI model, and given the task to create a lesson plan, but this time deciding all inputs (grade, concept, language, etc.) and selections (cultural references) themselves. Educators rated system outputs using five-point Likert scale items, complemented by open-ended reflections. The open-ended questions evaluated the quality of the cultural references, the CS-to-cultural connections, how well the user flow supported educators' workflow, and the quality, usability, and relevance of the generated lesson plan. Throughout this session, we asked educators about their positionality to Hawaiian culture, their confidence in assessing cultural content, and how they would rate system outputs from their own positionality. We concluded with closing questions on additional feedback and desired changes or features.

In parallel to our User Testing study, we conducted five ***Talk Story* Sessions** with 8 cultural practitioners, educators, and technologists who work with *Kanaka Maoli* children and/or 'āina-based practices. These conversations explored current practices for 'āina-based learning, pathways for cultural reconnection for *Kanaka Maoli* youth, and perspectives on LLMs and traditional knowledge, focusing on notions of data sovereignty and aspirations for Hawaiian LLMs for 'āina-based education. Prioritizing trust, we did not record these sessions, instead establishing research questions beforehand and taking minimal notes in a physical notebook during the session[2]. We held and recorded post-*talk story* discussions with the research team, to capture impressions, issues, and findings. The goal of the *talk story*, in combination with the qualitative feedback from user testing, was to develop a multi-perspective understanding of community needs, wants, hopes, and concerns regarding LLMs in Hawai'i, as well as capture speculations about future Hawaiian LLMs, an effort we continue in future work. We expand on ideas from these sessions in Section 6.

5.1.2 Analysis Methods. To analyze our user testing data, we conducted an inductive thematic analysis [109] of the testing scripts to surface new themes and capture the breadth of participants' insights. To analyze our *talk story* data, we also applied inductive thematic analysis [109] but to our post-*talk story* discussion transcripts, aiming to make our analysis reflexive by incorporating our varied interpretations into theme development [16]. The first and third authors open coded the transcripts, identifying trends in feedback on usability, content quality, cultural representation, usefulness/relevancy, and speculations for future features or tools.

[2]Quotes from *talk story* participants–indicated by the "TS" prefix–are from researchers' recollection, as sessions were not recorded. All *talk story* quotes have been reviewed and approved by their "speaker."

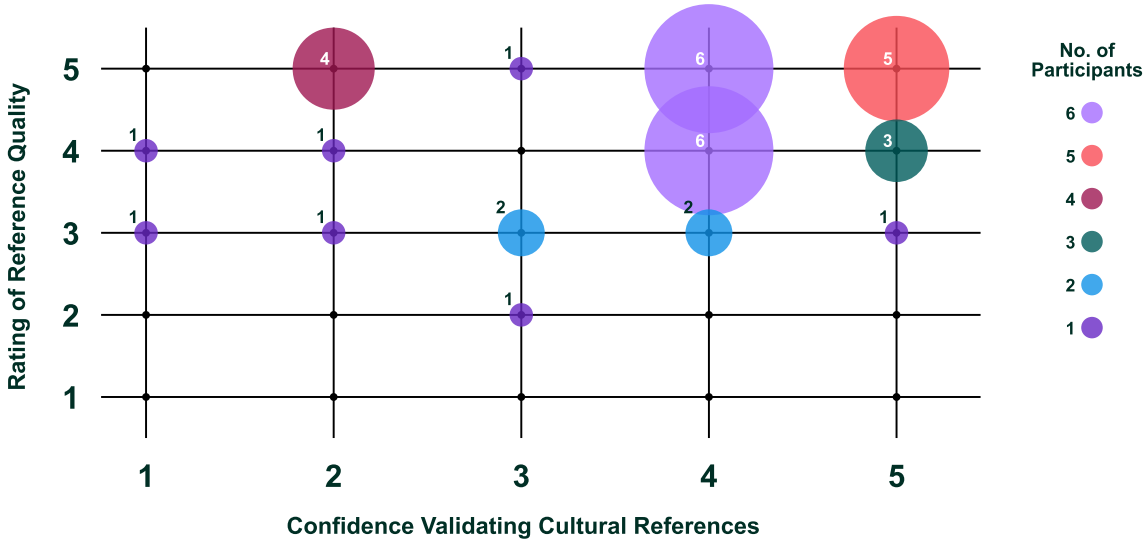


Figure 10: Bubble chart comparing participants' confidence in validating cultural references (x-axis) with their ratings of reference quality (y-axis), for the cultural references Kumu Connect generated. Larger bubbles represent more participants. Higher confidence aligned with higher quality ratings, with the most frequent responses at confidence 4 with quality 4 and 5 (six participants each), and at confidence 5 with quality 5 (5 participants).

To compliment this qualitative analysis, we also evaluated quantitative questions from user testing with descriptive statistics, and calculated the System Usability Score (SUS) [72] from participant answers. The first and second authors calculated the quantitative findings from user testing, paying special attention to how data varied by school type and user's positionality to Hawai'i. The first, second, and last authors synthesized these findings into the evaluation below.

5.2 Evaluation Results

5.2.1 Cultural Accuracy. A primary goal of our system was to produce culturally-accurate content that educators could trust. Participants rated the quality of the generated cultural references highly, with an average score of 4.20 out of 5 (Fig. 10). The 23 participants who reported high confidence in their own cultural knowledge (a score of 4 or 5) rated the system's output quality even higher, at an average of 4.35 out of 5. This critical finding demonstrates that the system's outputs were perceived as authentic by those with strong cultural grounding, aligning with the design requirement for cultural provenance. P18, a Kaiapuni educator at School 2, spoke highly of each reference type, highlighting how they were grounded in place and tradition: "*This is beautiful. The story is related to where we are right now. The proverb- Yes, we always use proverbs as lessons. This is a good hands-on [cultural practice]. I like this.*"

Educators had varying reactions to the localized relevance of generated cultural references. P18 shared he "*liked that*" the lesson went "*more into depth*" with cultural references that "*the kids have prior knowledge*" of. P1 explained that, while the generated *moʻolelo* "*is a very good general story,*" she would like to generate "*a story that is specific to the ahupuaʻa (land division) or the mokupuni (island).*" P27's comments reinforced this desire for more familiar references. She explained that having both a new *moʻolelo* and a new CS concept "*might be a lot*" for students, who would do better if the lesson included tools, like Scratch, or *ʻŌlelo Hawaiʻi* vocabulary that students"*were familiar with.*"

Beyond the cultural relevance of the generated cultural references, educators spoke about their potential for immediate pedagogical value. The cultural reference feature itself was rated as exceptionally useful with an average rating of 4.68 out of 5 (Fig. 11), and this sentiment of practicality was echoed in qualitative feedback. P36 specifically spoke about Kumu Connect's benefit for educators who lack the cultural background, describing it as "*a great way for them to get really short summaries*" and "*embed that into their curriculum.*" P10 spoke to the broadened use Kumu Connect enables, as "*it definitely gives access to people that don't have a lot of experience with the cultural background.*" P12 brought up the need for additional guidance for *mahlihini* educators, stating that while she could see that the lesson was "*pretty high quality*" and could validate that the *moʻolelo* was "*pretty accurate,*" she speculated that a *mahlihini* educator might not be well-equipped for this same vetting: "*I'm just thinking if I came to this study and I wasn't from Hawaiʻi, I would be like, 'yeah, it looks good.'*" She explained further that "*we have some teachers who come from the mainland and they don't have a connection to Hawaiʻi, so they wouldn't know how to use [cultural references].*"

5.2.2 CS-to-Culture Connection Quality. Educators responded positively to the CS-to-culture connections, overwhelmingly finding this feature to be meaningful and useful. Educators shared how this aspect reduced the cognitive load of making these links, made the CS concepts and themes more accessible to educators, and opened up new ways of teaching and thinking. During testing sessions, educators emphasized that they are "*struggling constantly*" (P30) to find cultural resources and establish meaningful connections

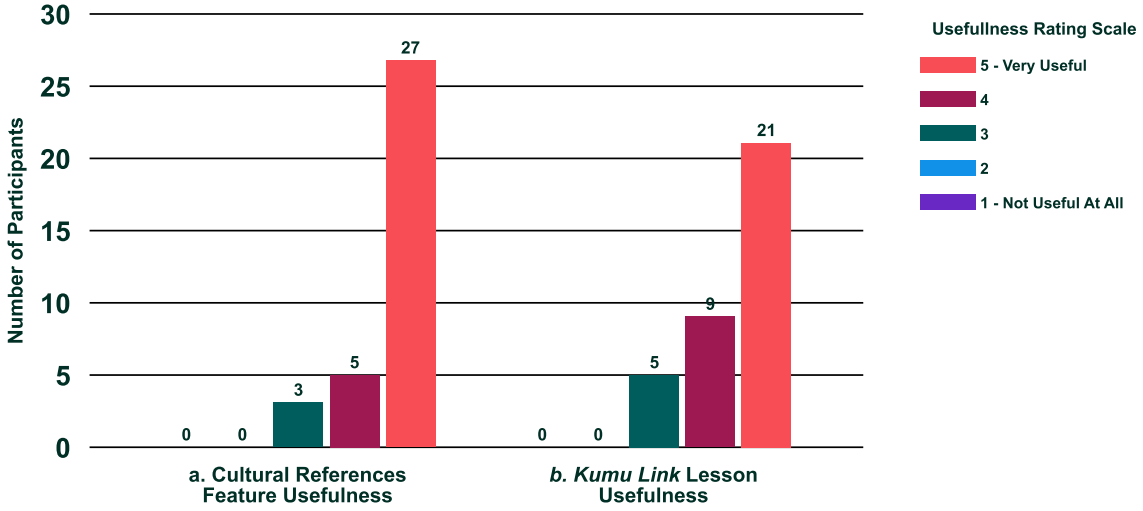


Figure 11: Side-by-side bar charts showing participants' usefulness ratings for (a) the Cultural References feature and for (b) the Kumu Connect Lesson. Ratings range from 1 (not useful at all) to 5 (very useful). No participants selected 1 or 2 for either feature. Ratings for the Cultural References feature skewed slightly higher, with 27 participants rating it 5 compared to 21 participants rating the lesson a 5.

between Hawaiian culture and the educational standards. Educators often felt that Kumu Connect would reduce this burden, as it made finding these resources and connections "*so quick and so easy*" (P36). Kumu Connect also made connections from CS concepts to cultural ideas that educators shared they "*never would have connected*" (P36) themselves, but became evidence through Kumu Connect's CS-to-Culture connection feature: a portion of the interface labeled "Connections" (Fig. 8.b). P7 observed that this specific feature helped her "*see the relationship.*" P30 reiterated this view:

> *"I like that it gives 'here's how this is going to connect' because after I read the second sentence I was like 'I don't know. That feels like a stretch.' But if you went around the themes of balance and adaptation, then you can easily connect the two topics that feel quite far away."*

P24 summarized this phenomenon and the impact it could have for non-technical educators, stating that "*[Kumu Connect] is already helping the non-Computer Science teacher who has to teach Computer Science understand the [CS] standard.*" The system's ability to surface these connections addresses a core challenge identified in our formative research: the time and expertise required to thoughtfully integrate cultural elements into technical subjects.

5.2.3 Pedagogical Usefulness & Immediate Usability. Beyond generating high-quality ideas, Kumu Connect excelled at structuring them into practical, classroom-ready lesson plans. The system demonstrated high overall usability, achieving an average SUS score of 78 out of 100 which indicated a "Good" user experience (Good $\geq$ 71.4) [72], approaching the threshold for "Excellent" (Excellent $\geq$ 85.5) [72]. The pedagogical usefulness of the final generated lesson received an average score of 4.45 out of 5 (Fig. 11). Educators reflected on the time saved in lesson preparation and the advanced curricula design tasks that Kumu Connect enabled by establishing a robust foundation as an inspiration and spring-board. Many educators reported that they could deliver the lesson Kumu Connect generated with little-to-no changes. When asked if the generated lesson required modifications before delivery P5 shared that she "*could use [the lesson] as it is*" and P18 explained that the lesson "*pretty much covered [everything needed]*" and was a "*very clear step-by-step process.*" P19 spoke to the quality of the *ʻŌlelo Hawaiʻi*: "*The ʻŌlelo Hawaiʻi is good, I don't see anything I'd change*" illustrating how the lesson would be immediately usable in Kaiapuni classrooms. P26 explained how, as an experienced educator, lack of time is a primary barrier to creating lesson plans, as she otherwise has the skills and experience to create high-quality lessons. She described how "*for people who already know how to do [write lesson plans] and have had years of experience, [Kumu Connect] is great because you just go, 'bam' and it's done. You know what it's supposed to look like, you just didn't have the time to put it down on paper.*"

Educators who wanted to edit the generated lesson, explained how Kumu Connect provided a foundation that enabled them to do more precise work, such as further refining the lesson to their students' needs and researching the referenced *moʻolelo* for themselves. P14 explained how Kumu Connect would allow her to skip the high labor back-and-forth that she had experienced with other available AI tools:

> *"Compared to the [tools] like ChatGPT or Gemini or even Magic School, I feel like this is a lot more thorough. It puts out more than what I would expect the other AIs to do. I feel like this [lesson plan] is something I would modify* some, *but not where I'm picking and choosing as much because I'm trying to make what I* really *want. This does like the bulk of the work."*

P36 shared that Kumu Connect is *"extremely helpful for teachers*" even "*as a launch pad or just to generate ideas,*" sharing how educators currently spend "*hours trying to generate a lesson plan that's only going to last us 45 minutes."* Overall, Kumu Connect's pedagogical structure resulted in content that many educators felt could be used immediately, as-is or for advanced curricula design tasks. This immediate usability directly addresses our goal of reducing the time and effort educators spend on curriculum development.

5.2.4 Trustworthiness. We received no comments doubting the accuracy of the CS content and an internal review of the generated lesson from STEM experts confirmed the generated lesson were pedagogically aligned. Although we validated that the CS-to-culture connection made CS concepts more accessible to educators, many educators desired visuals and resources to confidently deliver the concept themselves. As P24 explained, *"We all have to grade this and none of us are Computer Science educators. So it's so foreign to us."*

Regarding trust in the cultural content, some educators expressed the need for sources to confidently validate the cultural references. With *moʻolelo* in particular, educators expressed the difficulty of accessing if a *moʻolelo* is fabricated or a valid version that they have not encountered before, as there are often many versions of each *moʻolelo*. P14 explained how the generated version of the *moʻolelo* was unfamiliar to her, which didn't mean it was fabricated, but called for extra checking:

> *"When I think of Hina, it's not this story. I feel like I would take a minute to double check it because it's something that I'm just not familiar with. ...especially because they vary throughout the island."*

P14 shared that *moʻolelo* also vary by family, so "*maybe I don't know the story, but maybe my students know this story.*" P9 voiced that Kumu Connect's verification note was enough to validate the *moʻolelo*, and that it was the location of the sources that was an issue. Upon seeing the verification note in the generated lesson plan, she said, "*Oh, here! It is verified by Hawaiian Mythology, Martha Beckwith. Okay, that makes me feel better about that.*" and clarified that she would need this information "*ahead of time,*" much earlier in the process.

Taken together, our evaluation results show that Kumu Connect achieves a meaningful balance between cultural authenticity and pedagogical utility. The alignment of strong quantitative ratings, particularly from educators most confident in their cultural knowledge, with qualitative feedback on the system's immediate usability demonstrates that educators view it as both trustworthy and practical. By reducing preparation time and effort, the system allows educators to devote more energy to advanced curricula design tasks, further customizing lessons to their particular students, as well as the core work of teaching their students. Importantly, Kumu Connect generates substantive, integrated connections between computing concepts and Hawaiian culture, with the CS-to-culture connection feature and the generated lesson making the CS concepts culturally-relevant and more accessible to non-technical educators. In doing so, the system supports educators not only in efficiency, but in advancing culturally-revitalizing pedagogy, improving the quality of culturally-revitalizing lessons and broadening the reach os such education to exponentially more *Kanaka Maoli* children.

6 DISCUSSION

6.1 Design Requirements for AI Tools for Culturally-Revitalizing Education

Throughout two years of development, we have established and refined **design requirements to guide the development of LLM-assisted educational tools for culturally-revitalizing CS education, to support Indigenous children in learning their ancestral culture, languages, and knowledge systems**. Below, we present our current iterations, strengthened with findings from existing research on culturally-responsive LLMs for education. The applicability of these requirements to specific Indigenous groups requires additional contextual nuance, as is intended. For our work, we calibrated these requirements for Hawaiian Education and *Kanaka Maoli* students, to inform our implementation of Kumu Connect and future work in these efforts. The design requirements for LLM-assisted educational for Indigenous educational settings are as follows:

6.1.1 Epistemological Alignment, Data Sovereignty, and Transparency. AI tools for culturally-revitalizing education must **align with Indigenous epistemologies** in the framing of cultural elements and the organization of data. Additionally, these tools must **enable data transparency and sovereignty**, ensuring only validated sources are used, safeguarding against hallucinations, providing transparent attribution, and enacting community-defined data protocols. By defaulting to contextual ways of knowing and providing data transparency, the burden is taken off of *Kanaka Maoli* educators to check and validate cultural information for themselves, fellow educators, and their students. This aligns with existing research which emphasized the need for upholding data sovereignty [69, 78] and enabling source transparency and validation [78], as well as the CARE Principles for Indigenous Data Governance [100].

6.1.2 Support Mechanisms and Teacher Agency. Although transparent and validated sources might address concerns of unchecked misrepresentations and hallucinations, our *talk story* illustrated that *mahlihini* educators need more resources, training, and support to deliver culturally-revitalizing curricula in an authentic manner for their *Kanaka Maoli* students. Therefore, AI tools for culturally-revitalizing curricula generation must **provide support mechanisms for educator knowledge gaps in culture, language, domain, and AI**, thus reducing the systems reliance on individual expertise and preventing the propagation of misleading or culturally-insensitive information. In parallel, these AI tools should **enable educators to maintain authority and control over content**, giving them authority over areas of expertise, such as pedagogy, classroom context, language, and domain knowledge. In this way, AI tools can uplift and prioritize educator expertise, without *relying* on individual expertise in order to create successful, authentic lessons. This aligns with existing research which calls for educator agency over generative curricula tools [12, 49, 78] and increased educator support and training for AI tools [49, 78].

6.2 "Future Imaginaries" for AI Tools for Indigenous Education

In this section, we present four visions for future AI tools for Indigenous education, drawing from Lewis' [67, 68] Future Imaginary framing. These futures emerged from surveys, interviews, user testing, and *talk story*. We discuss how these ideas could manifest in the context of a future Hawai'i–when today's children are elders–and their broader implications for teams developing similar tools for Indigenous education.

6.3 *'Ike* by *Ahupua'a*: Culturally-Reflective Data Structures & Decentralized LLM Frameworks

Our first "future imaginary" envisions culturally-reflective data structures, co-created with community knowledge-keepers to authentically mirror and support Indigenous epistemologies. This vision stems from educators speculations during testing, about how Kumu Connect's could generate hyper-local cultural references, with participants most often referring to a desire to have cultural references be specific to their *ahupua'a* (land division).

Throughout our testing, educators expressed how the disconnect between Western information systems and Hawaiian knowledge systems impacted their ability to access AI outputs, not because they believed the cultural references to be fabricated, but because cultural references vary by place, family, time of year, and more. Western information systems, which organize data by concepts such as subject designation and individual authorship, often have misalignment with Indigenous knowledge systems, making the tools that rely on these systems unhelpful and harmful for Indigenous educational settings [78]. In contrast, provenance and lineage of Hawaiian knowledge is critical, as it ties the knowledge to people, families, places, and events [91]. Additionally, Hawaiian use of *mo'olelo* (stories) and proverbs vary from Western uses, in that they often accurately record historical and geographical phenomenon as diverse as the hydrologic cycle [11], the ages and volcanic origins of the islands [36], and the best time of the year to plant various crops in specific places [44]. Educators in interviews and testing imagined hyper-local data systems with organization and provenance that reflect Hawaiian ways of linking knowledge, with many echoing that these would "make a huge difference" (S2-I) for themselves and their students' lives.

This idea calls for the co-creation of culturally-grounded datasets, developed through community contributions, prioritizing the role of cultural practitioners and elders to ensure alignment with Hawaiian epistemologies. To enable provenance, the dataset could have community-designed access protocols established through continued co-development with community partners based on CARE and FAIR data governance principals [19, 100, 121]. With this culturally-reflective dataset and protocols established, educational AI tools can align with Hawaiian ways of linking knowledge. For example, this could be explored through hyper-local small language models built for specific *ahupua'a*, cultural practice, and curricula subject. These models would ensure cultural references and *'āina*-based practices are highly contextualized for the students learning and practicing them. The hyper-locality of such systems presents an additional opportunity for addressing data sovereignty, by making knowledge functionally useless outside of its context. This can be strengthened through physical safeguards, such as proximity sensors, that require educators and students to be in a particular space to have access to information or the tool itself. This safeguard reinforces that knowledge is intrinsically tied to place, and ensures that the tool inherits the physical access protocols of each space, whether a school, a particular classroom, or a cultural site. **In envisioning futures for AI in Indigenous education, we imagine data structures and protocols that foreground respective Indigenous epistemologies. Rather than mapping Indigenous knowledge to Western AI architecture, these future data structures would mirror culturally-reflective practices of knowledge organization, connection, linage, and protection.**

6.4 Usability and UX/UI Alignment with Data Sovereignty

For *Kanaka Maoli* educators, children, and broader community, data sovereignty is important prevent harms and support culturally-revitalizing education. Educators explained how Kaiapuni educators need to be able to decide "*what knowledge is meant to be shared and what isn't*" with AI tools, because "*maybe a kumu isn't willing to share where they learned this from and the students in their class are learning a unique lesson. ...that's part of the the immersion process. ...that's how you know where you come from*"(S5-I). Thus, for some educators, tools like Kumu Connect must guarantee them total control over how their stories and knowledge are used, both in their own curricula creation and in how that knowledge is or isn't shared. To enable this agency, the user experience and interfaces of such tools must mirror both the aforementioned culturally-reflective data structures and the educator's data sovereignty needs. The usability of this flow is critical in educational contexts, where efficient use of time is a primary constraint. This expands on existing Indigenous data sovereignty protocols [19, 69], by establishing data sovereignty as a usability principle. **LLM-assisted tools for Indigenous education call for data sovereignty to be recognized as a core principle of usability in HCI. Data sovereignty then shapes user experience and interfaces, defining how culturally-reflective structure and protocols are made visible and actionable in everyday use of the created tools.**

6.5 Cultural Proximity Awareness: Nuanced Personas, Access Protocols, and Acceptable Outcomes

Educators and cultural practitioners voiced deep concern with the potential repercussions of misinformation and cultural misrepresentation in LLM outputs going unnoticed, claiming they could negatively impact students' education and conceptualizations of identity and Hawaiian culture. Educators worried the Western bias of LLMs could cause "*a whole generation*"(S1-I) to view their own culture through a colonized lens and put Hawaiian culture at risk for LLM-powered digital colonization.Many educators speculated that the severity of these risks were partially mediated with Kumu Connect. Yet the risk varied with each user's positionality to Hawai'i due to the importance of validating sources, a process *Kanaka Maoli* educators and some *kama'āina* educators felt comfortable conducting, but *mahlihini* educators would not have the context

or background to do. TS4 (technologist and cultural practitioner) discussed how educators delivering lessons with *moʻolelo* they are unfamiliar with can be problematic, as they lack the critical context one would have if they had learned the *moʻolelo* through cultural practice. He posed a fundamental question: "*if someone doesn't know these stories, should they really be teaching them?*"

This finding calls for educational AI tools to recognize the range of cultural proximity in Hawaiian educational setting, and be designed appropriately for each user type's positionality. For example, such a system would recognize that a cultural novice will not be able to deliver the same lesson a cultural practitioner could, even with additional teaching aids. This calls for creating multiple personas with corresponding access protocols that embody community expectations, and acceptable outcomes that acknowledge varying degrees of cultural proximity within educational settings. How an outcome is deemed as acceptable would be determined by the community, and center the experiences of the Indigenous students in the classroom. For example, an acceptable outcome for a cultural novice persona could be to establish foundational knowledge and cultural competency, enabling them to deliver lessons that use broadly applicable and validated knowledge. **We imagine future LLM-assisted tools for Indigenous education reflect the varying degrees of cultural proximity present in Indigenous educational settings, with a community-informed understanding of personas, access protocols, and acceptable outcomes. Although the acceptable outcome may support culturally-ignorant educators, the goal for this future is to enable the success of the Indigenous children taught by such educators by mitigating harms within the classroom and broadening access to culturally-revitalizing education.**

6.6 Like a *Kumu* Would: Incremental Learning Mechanisms & Controlled Data Release:

This "future imaginary" for Indigenous AI explores how AI tools could enact culturally-grounded data release protocols, by emulating traditional social practices for knowledge transfer and protection. This idea first emerged from talking story with TS1 (cultural practitioner and artist) and TS2 (cultural practitioner and AI researcher). They explained how they have learned *ʻāina*-based practices from their own *kumu* (educator), with the example of traditional stone wall building. They shared how it takes many hours, often over many years, to become attuned to how rocks will fit best together, with the *kumu* letting you learn through experience and failure. TS2 explained how this learning style differs from Western classrooms and the attitude of "*there are no stupid questions,*" as students are expected to put genuine effort into solving a problem before asking for advice.TS1 shared how the "*demeanor of a kumu*" could be applied to AI tools, as a way for AI tools to protect traditional knowledge, thus enabling data sovereignty "*the same way [kumu] have always protected data,*" through incremental learning, rigorous student effort, and conversation.

This concept requires AI tools to emulate traditional social practices for knowledge protection and sharing, encouraging educators and students to rigorously engage as cultural practitioners in order to be permitted to learn more. For example, AI tools could question and probe the user, before providing deeper answers in return, also reinforcing culturally-reflective data structures and protocols. This feature could foster educators' cultural practice, incrementally expanding on their current knowledge and directing them towards increasingly local Hawaiian knowledge. For this learning practice to be authentic and protect knowledge, it will require time *and* effort from the user, not simply allowing knowledge to be "unlocked" through attrition. **We look to the past to imagine future AI tools for Indigenous education that emulate the ways Indigenous peoples have protected and shared knowledge for generations. In this "future imaginary," an AI tool's user experience and interface are active sites where cultural practices of care, responsibility, and knowledge transfer are sustained and renewed.**

7 CHALLENGES & LIMITATIONS

Although our team is *Kanaka-Maoli*-led with *Kanaka Maoli* and *kamaʻāina* teammates in vital roles, we acknowledge that our non-kanaka team members will miss critical cultural context in their interactions with our partners and their interpretation of participant feedback. Additionally, our relational methodology presents geographic bias in participant recruitment, with over-representation for the Windward Coast of Oʻahu, and potential positivity bias in user testing feedback, due to long-standing relationships within the research team's communities. Lastly, while this work is rooted in the specific context of Hawaiian education, the insights into bias, cultural relevancy, data sovereignty, and participatory design have potential to extend beyond Hawaiʻi, offering a framework for rethinking how LLMs should be developed and deployed in any community where culture and context matter. However, this paper does not explore generalization and cautions researchers from assuming transferability between distinct Indigenous groups without community-based studies and comparison.

8 CONCLUSION

This work contributions design requirements, Kumu Connect as a case study, and "future imaginaries" to guide the development of LLM-assisted educational tools for Indigenous educators and students. This exploration is crucial for several reasons. It expands the conversation on educational equity for Indigenous students, especially those with "low-resource" languages. It highlights the need to ensure AI tools respect and preserve Indigenous cultures and languages, to prevent digital colonization and instead promote Indigenous futures for today's children. Finally, it provides actionable insights for HCI researchers and developers to co-create LLM-assisted technologies that are not only effective but also culturally-grounded and -trustworthy for educators and students in Indigenous educational settings.

The concerns and risks with LLMs in Indigenous educational settings are serious and need to be addressed. In pursuing this work, we are inspired by the *ʻŌlelo Noʻeau "I ka wā ma mua, i ka wā ma hope,"* which conveys an important Hawaiian value: "we look to the past as a guide to the future" [97]. That *ʻike kūpuna* is not only critical for culturally-revitalizing education, but to our research processes as we navigate tensions with Western systems. Just as

Hawaiian *ali'i* (chiefs) exercised their agency and transformed Western technologies with intention and discernment [11], we see a path forward inspired by their example.

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9 Selection and Participation of Children

No children participated in this work.

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A Glossary of Terms

A.1 ʻŌlelo Hawaiʻi Terms

- **ʻŌlelo Hawaiʻi** - The Hawaiian language
- **moʻolelo** - stories
- **ʻŌlelo Noʻeau** - Hawaiian proverbs
- **Kānaka Maoli** - Native Hawaiians (singular: Kanaka Maoli)
- **kamaʻāina** - a child of the land: a non-kanaka local
- **kumu** - educator
- **kūpuna** - elder
- **ahupuaʻa** - land division
- **ʻāina** - that which sustains us: place, community, environment

A.2 Hawaiian Creole English Terms

- **talk story** - an informal, relational conversation