Indigenous Technology Empowerment Model: A Community-based Design Framework

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***Abstract*—This paper addresses the lack of social and cultural inclusion in the design of systems and products based on emerging technologies. Through a review of existing design processes, and focusing on Virtual Reality (VR) and Indigenous Peoples as examples, we conclude that existing design approaches for such technologies are not socially and culturally inclusive, don't consider users as a community with its protocols and knowledge, and are not suitable for marginalized groups such as Indigenous Peoples. Through a collaborative project aiming at a prototype VR gathering place for Indigenous communities, we investigate the needs and concerns of community members and propose a framework consisting of a new information system model and its design process. We refer to this framework as Indigenous Technology Empowerment Model (ITEM), which is implemented using a hierarchical community involvement approach and elements we call Participatory Action Unit (PAU). Our prototype development follows this framework, and a qualitative analysis of community participation shows the initial success of our approach in empowering the communities to play an active role in the design process and identify the important technical features to be worked on. Our research also identifies proper community training as an essential component of a community-based design process.**

Keywords—technology, virtual reality, community, indigenous, design, model

I. Introduction

Technological advances are driven by a variety of factors, such as scientific curiosity, economic development, and social needs. The interests, needs, and concerns of different groups of people have always influenced technical developments, but in many cases, they have been overshadowed by mainstream demands, scientific curiosity, and commercial considerations [1,2,3]. This is particularly evident and problematic for marginalized groups such as Indigenous peoples and other racialized communities (ethnic minorities). Emerging technologies such as the internet of things (IoT), artificial intelligence (AI), augmented/virtual reality (AR/VR), and other innovations in information technology (IT) can be essential in serving many users. However, the diversity of user groups and their specific concerns have frequently been an afterthought of technology design, if considered at all, and the under-representation of many marginalized groups has resulted in design processes and, consequently, products that are not inclusive [4]. By inclusion, we refer not only to reflecting the needs, opinions, interests, traditions, and protocols of all groups, but also to allowing their active participation and making sure they benefit from the designed products and services.

While design approaches such as User-Centered and Participatory Design (UCD and PD) [5] promote the consideration of end users' needs and concerns or their active involvement in the design process, these methodologies are not designed for user involvement at the community level. Communities have collective knowledge, protocols, and concerns that cannot be appropriately included through common methods such as user studies and focus groups [6]. New efforts to establish community-based research practices [6,7] have identified a more systematic approach, full engagement, and proper process models as significant research gaps, which we discuss in the next section.

Inspired by recent work to define Indigenous protocols for Artificial Intelligence (AI) [8], we aim to define a more inclusive and community-based participatory framework for the design, development, and use of innovative and emerging technologies. These technologies are less known and established for various user groups, which acts as a barrier in their participation. As an example, we focus on VR technology and applications that have unique interactive and immersive features making them strong candidates for various communication, entertainment, and education purposes [9,10,11]. Their role as replacement or addition to physical interaction has been particularly emphasized since COVID pandemic [12].

We also illustrate the notion of community-based design within the context of the Indigenous Peoples of Canada, who, despite increasing attention, have not been empowered to design, use, and own technological solutions properly [13]. It's been shown that Indigenous People have specific knowledge and protocols that can be essential and helpful in technology development [14,15,16]. Indigenous knowledge can provide information on what is helpful for Indigenous communities and how to develop products and services for them. It can also offer novel insights helpful for developing products targeting other communities and users. For example, early findings of our prototyping and pilot project on a VR Gathering Place show that Indigenous communities have a much broader understanding of the concept of "place" and follow a multi-purpose notion where a space can be used for more than one purpose; a meeting place is also an education centre and a venue to exhibit art and culture. This notion can change the design of VR experiences and the process of engineering requirement management. On the other hand, Indigenous communities have specific protocols that are guidelines for managing relationships with other humans or non-humans, such as animals or the environment. These protocols manage critical aspects such as respect, authenticity, consultation, and ownership that must be considered in a community-centred design process. For example, it is essential that the community not only benefits from a project but also controls the design process and maintains ownership. Such a protocol suggests a new design process that involves

the community at all levels and stages of design and development; it requires a more democratic and inclusive process and makes training a fundamental aspect of design and development. While knowledge and protocols can differ for any Indigenous community, they share many principles and can be used as guidelines when working with other communities.

Our goal is to investigate technical features, design methodologies, and best practices that empower Indigenous communities to engage and play an active role in the design, development, and deployment processes for VR technology and applications. Noting that the affordances of a technology do not just depend on its technical features but the abilities and interests of potential users to adopt them [10], we aim to address the following questions:

1. What specific concerns, interests, or protocols do these groups have for the use of VR? Such protocols can relate to ownership, authenticity, presentation, and respect, and incorporating them into the design process will lead to a wider, more effective, technology adoption and use by Indigenous communities and so more social, cultural, and economic impacts.
2. What specific affordances can VR provide for these target groups? It is essential to understand which features of the technology are in fact, of interest and importance to the community, as opposed to cool or curious.
3. What technical features can be developed to address the identified items from questions 1 and 2? This question will lead to novel research on technical features that are missing but required.
4. How can existing VR design and development methodologies be improved to be more inclusive? Finally, this is the main question in this paper, which aims at making the design process more inclusive so that the community can indeed participate in answering the previous questions and building new technologies and applications.

We propose a revised model of information systems [17] and a hierarchical community involvement that we refer to as the Indigenous Technology Empowerment Model (ITEM). Through a prototype development for a VR gathering place, we investigate the effectiveness of our proposed framework and seek to answer the above research questions.

International and Canadian VR markets have grown significantly in recent years [18]. Understanding how to design VR systems in an inclusive way is beneficial to the industry and economy as it creates new applications and markets, for example, authentic storytelling for Indigenous peoples who have very limited presence in this area, mainly through a few individual artists [15]. But more importantly, such an inclusive design process benefits the society by removing systemic barriers that omit certain communities from the technology design process. Many initiatives, such as the Truth and Reconciliation Commission (TRC) [19] and various anti-racism, anti-sexism, and accessibility efforts have recommended respectful cooperation toward removing these barriers and ensuring inclusion. However, there have been few formal and systematic efforts so far to incorporate Indigenous and other marginalized communities into the process of technology research and development, especially in the rapidly growing field of VR. Our research is a step towards addressing these shortcomings of inclusivity within this rapidly growing sector of VR technologies. Lessons learned for inclusive community-based participatory design can be further expanded to other countries, communities, and emerging technologies.

II. Related Work

A. Designing with Users

To address the issue of user inclusion, methodologies such as user-centred design (UCD) and participatory design (PD) [5] promote design processes that engage users directly. However, while they have been successful in establishing a connection between technology developers and users, they do not provide specific guidelines for working with communities, as opposed to a series of individual users. The target groups are commonly defined statistically as those with similar demographics but are not necessarily represented as holistic entities with group values and characteristics. A paradigm shift for looking at users not as a group of individuals but as members of a holistic community with its own characteristics has been pursued in areas such as community psychology, and researchers have suggested generic approaches for co-production with communities that include interdisciplinarity, public value, authenticity, and reflection [13,20].

Preece [20] proposed the participatory community-centred design, a process used primarily for developing online communities, rather than engaging existing online communities. Lachney et al. [21] introduced the notion of community participation in Culturally Responsive Computing (CRC) with a focus on education. O'Donnell et al. [13] propose a "whole community" approach that discusses technology adoption and uses at three levels of individual/household, community services/organizations, and local infrastructure, as opposed to initiatives such as the Technology Acceptance Model (TAM) [22] that are more individual-based. The International Indigenous Design Charter [16] is an example of introducing specific "protocols for sharing Indigenous knowledge in professional design practice" [16]. Peters et al. [7] recommended HCI practitioners to go beyond participation when working with Indigenous Peoples and consider user-led recruitment, user-led training, and user-led workshops to achieve user-leadership and empowerment. They do not provide specific frameworks and processes to ensure these will happen, although their experience and recommendations are invaluable. Despite these efforts, there is a lack of theoretical models and systematic approaches for empowering communities to participate in technology design and development. Cooper et al. [6] provide a recent review of Community-Collaborative Research (CCA). They identified three main groups of concerns: establishing partnership, enabling participatory models, and sustaining the results, and stated, "the limited involvement of communities in these research stages across the included articles suggests a systemic disconnect between the theory and the practice of CCA" and a lack of community integration at all levels and stages of the project. The review had suggestions for future research, such as defining communities, facilitating contestability, and building from community knowledge and practices. A new model that focuses on a process with community involvement is in line with these suggestions.

B. Inclusion in VR

VR systems offer unique features such as immersion, presence, and interactivity plus flexibility (e.g., not constrained to physical laws), embodiment, and multimodality (ability to combine different media, input methods, and usage contexts) [10]. Considered together with different user interests and abilities, these features define the potential VR affordances to different user groups. These potentials have not been fully utilized due to the non-inclusive nature of design processes [10].

The notion of inclusion is starting to be considered in VR [4, 23]. A growing effort has been dedicated to making general-purpose VR systems more accessible. Dombrowski et al. [4] follow the principles of Universal Design [23] and propose seven pillars of accessible VR for equitable use, flexibility, simplicity and intuitiveness, perceptible information, tolerance for error, low physical effort, and size and space for use. To address accessibility as a high-priority issue, HMD manufacturers are beginning to include certain criteria for developers to embed accessibility features into their VR applications. However, there are limited academic studies on the application and efficacy of these features due to their novelty. The ability to customize different aspects of the VR experience is one of the main accessibility challenges [24], and involving persons with disabilities in the design and development process, as opposed to an afterthought, has been suggested as an essential step to address these challenges [3,24].

Munafo et al. [25], in one of the earlier studies about gender bias in modern VR technology, stated that "the virtual reality head-mounted display Oculus Rift induces motion sickness and is sexist in its effects." A significant number of studies have confirmed this and suggested that other examples of gender bias exist regarding the sense of presence and perceived realism (higher for men) [26], perception of avatar [27], learning abilities [28], and attention [29]. LGBTQ+ VR users have received much less attention in research and development. The primary topic of research in this area is related to using VR as a tool for the LGBTQ+ community with limited systematic models for community engagement [30,31].

The aging population has also been investigated by VR researchers but mostly on how VR technology can enhance their well-being. Lee et al. [32] and Soltani [33] are among these researchers. VR has also been used as a tool for raising awareness about racial issues and increasing empathy towards other social groups [34]. But in all these cases, the research has been more "for" particular groups, rather than "with" and "by" them. The efforts to make VR technology more inclusive have mostly focused on making the products inclusive and not the design process.

C. Indigenous Peoples and VR

Educators around the globe have teamed up with Indigenous communities to promote Indigenous cultures but also expose Indigenous communities to modern technologies. Stanton et al. [35] conducted a case study that evaluates the Digital Storywork Partnership (DSP) to advance the goals of Indian Education for All (IEFA) from the state of Montana. While this study did not introduce anything regarding ICTs, the collaboration between the educators and the Indigenous population has shed light on a possible way to teach Indigenous cultural lessons to the participants.

The advances in VR hardware and software, combined with the increased availability, have made VR an attractive solution for creating engaging experiences related to Indigenous storytelling and education [15]. While such VR applications for and by Indigenous peoples are increasing, important questions have remained unanswered, such as how to ensure authenticity and ownership. Rodil [36] argues that using IT by the community means dealing with a foreign design, which suggests the importance of participatory design processes. In a recent study, Wallis and Ross [37] discuss an Indigenous-centred VR production framework within the context of sample projects. They show that existing productions present different levels of involvement from Indigenous peoples (from user to participating or main designer) and repeated trends such as the use of "VR to express and realize Indigenous futurism; provide new articulations of Indigenous activism, and embody connections." The limited number of participatory VR design projects does not allow a proper definition of a design process customized for VR experiences with and for Indigenous peoples and other ethnic communities.

Recently developed frameworks for collaborating with Indigenous peoples and managing the resulting data, such as ownership, control, access, and possession (OCAP) [38]; Findable, Accessible, Interoperable, and Reusable (FAIR) [39]; and Collective benefit, Authority to control, Responsibility, and Ethics (CARE) [40], are starting to appear in data-heavy subjects like AI [8] but have not been considered within the context of interactive technologies like VR with special features such as immersion, presence, and interactivity. While the notion of inclusion is starting to be considered in VR [4, 23], it is mostly focused on accessibility [24] and gender bias [2], and ethnic/cultural communities are commonly subjects or users of these projects [34,41]. A dedicated design process and novel technical features that are specifically of interest to different communities, especially Indigenous Peoples (such as control of the level of presence, VR asset management, multi-purpose design, and collaboration) are new concepts that our research investigates. Further research is required to not only design new VR experiences, but also (1) define a new participatory design process and framework for VR that is inclusive of Indigenous Peoples, and (2) investigate technical features to support such experiences.

III. Research Approach

A. Overview

Our literature review showed that there is a clear research gap related to how VR can be helpful for Indigenous communities, what technical features will be of interest, and what process models will empower the communities to participate in the technology design and development. We identified that proper community participation in a design process involves multiple requirements:

1. community presence at all levels and tasks from management to evaluation
2. commitment to follow community protocols
3. investigating necessary technical features

Based on these requirements, in partnership with an Indigenous organization, and inspired by research on hierarchies of engagement and understanding [42], we proposed a hierarchical community-based VR design and

development approach. This hierarchy forms a pyramid of community involvement with an increasing number of members as we descend. It involves the community in three levels: (1) management and planning, (2) research and development, and (3) evaluation. Community leaders and elders have an active role in level 1. Level 2 is formed around the Participatory Action Unit (PAU), which includes academic, industry, and community members working on specific tasks such as creating a prototype, designing a sub-system, or investigating a new feature. Any project is made of multiple PAUs, which can do research design, or development. Level 3 includes community members and other potential users involved in user studies and the open use of developed products. This hierarchical structure follows an iterative process of cycles with brainstorming/planning, design/development, and open-use evaluation by the community at large. The process not only designs and develops a VR experience incrementally, but also gives the community an opportunity to constantly monitor the process and generate new ideas for technical features to be investigated and added.

To investigate the effectiveness of this model, we identified a VR gathering place as a prototype experience that can be helpful for Indigenous communities and at the same time be suitable as a test bed for our proposed model. Following our model, we hoped to answer the following research questions:

1. How effective is the proposed model in empowering the community to lead the design process?
2. What are specific community concerns and interests regarding VR?
3. What are specific technical features that are missing in order to address the items identified in question 2 and facilitate the proposed model?

B. Method

We used a qualitative participatory action research model [43] to answer the research questions. We also planned a follow-up phase to work on the design, development, and evaluation of the technical features identified in response to question 3, but that phase is beyond the scope of this paper.

In consulting with our partner, *Indigenous Culture and Media Innovations (ICMI)*, the university-based research team decided to create a VR-based meeting place that authentically represents an Indigenous environment. Our initial brainstorming showed that Indigenous Peoples commonly use space for multiple purposes; a gathering can be for collaboration or decision-making but can also be educational or ceremonial. As such, the virtual meeting room includes three major themes: a "circular" room to represent the notion of the circle of gathering, various exhibition and presentation facilities, and separate spaces for smaller groups.

For creating such a gathering place, we followed our proposed hierarchical model with the Director of the partner organization and an elder participating in the project leadership together with a university professor who specializes in VR. Due to the small scope of our prototype and our logistic limitations, we formed only one Participatory Action Unit (PAU) as an example, and with two community members and two university research assistants. Finally, we recruited community members for evaluation. PAU went through an iterative process where the design features were evaluated and discussed by the PAU members and the project leadership. Notes were taken through all group meetings for qualitative analysis to collect insights in addition to the community evaluation.

The evaluation was done through open access to the first version of the gathering place prototype by the volunteers from different Indigenous communities recruited by the partner organization for this purpose. Participants used the prototype and discussed it through written feedback and interviews which were later coded and underwent thematic analysis.

Our data collection was qualitative through observation, discussion, and interview, followed by emergent coding [44] for members of the research team, and written open-ended feedback and interview for community participants, followed by an abductive theory elaboration analysis [45], as detailed in Section IV.A.

The methodology was approved by the university research ethics board. The next section provides details on models, tools, and materials used for research.

C. Models and Instruments

Following Technology Acceptance Model (TAM) [22], we considered perceived usefulness and perceived ease of use as two parameters that can contribute to the acceptance of the VR technology and the particular prototype we were developing. We used Participatory Design [5] as our initial design approach to increase both of those two parameters, but extended and contextualized it to our hierarchical framework that we hoped would engage our target group not just as users but empowered participants. Finally, we used Zhang & Benjamin's model of information systems [17] as a basis for categories of concerns and needs to consider when analyzing the collected data, as discussed under Findings.

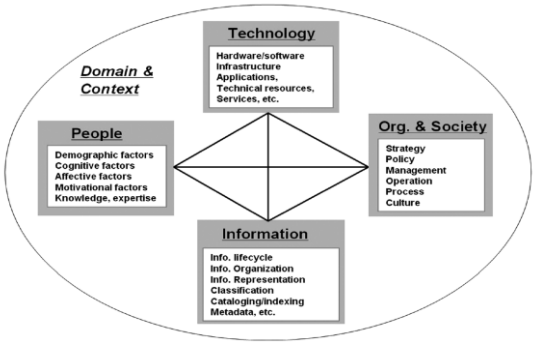

Fig. 1. Information Model (I-Model) by Zhang and Benjamin [17]

To design the VR experience, we followed a series of brainstorming on various visual and functional aspects of the multi-purpose environment, as shown in Fig. 2. Our collaborative approach was based on existing guidelines such as Indigenous Design Charter [16] and recommendations by Peters et al. [7] (user-led recruitment, training, and workshops), as implemented through our proposed hierarchy. To develop and deploy the prototype system, we used a WebXR-based educational VR framework developed earlier by our research team [46]. We chose a web-based framework to offer the most flexibility and multi-platform options. Development was done in Javascript using Three.js and A-Frame. VR environment screenshots are shown in Fig. 3.

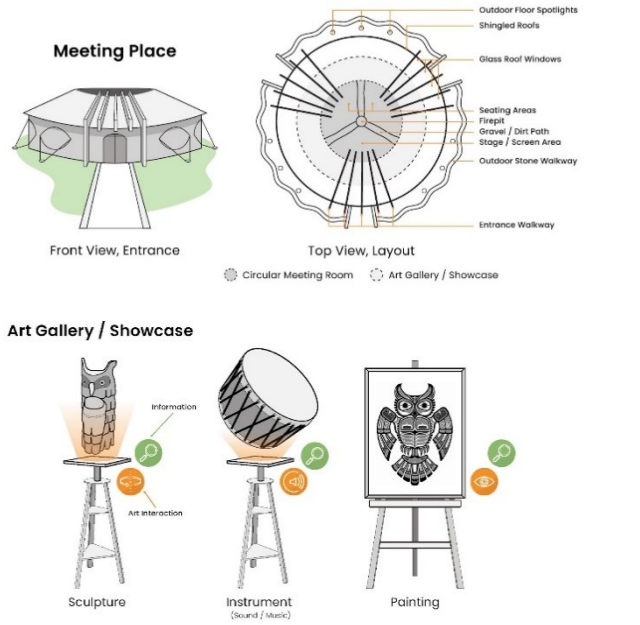

Fig. 2. Design Elements

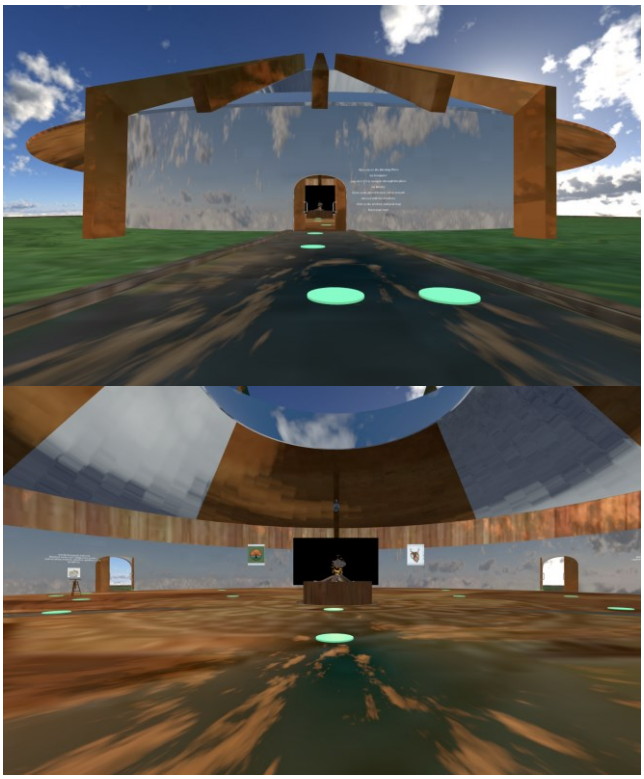

Fig. 3. VR Environment

For the purpose of this paper, our goal was not to create a fully functional VR gathering place, but to investigate the design process through an early prototype. As such, our environment supported a single-user experience with navigation, interaction with exhibited 2D ad 3D artefacts to get more information, starting and watching videos, and accessing PDF/image presentations.

To collect insights from our PAU members and community participants, we used the following questions as conversation starters:

1. What potential applications do you see for using VR for Indigenous communities? Virtual meetings, exhibitions, education and training, etc.
2. What specific needs or constraints do you think should be considered? Protocols, traditions, etc.
3. How useful can the gathering place prototype and its future developments be for Indigenous applications?
4. What technical features would you add to the prototype? Different forms of avatar presence, connection or moving to other online and VR resources, different ways of collaborating with others, etc.
5. How do you think the community members should be involved in the design of this and other VR applications for Indigenous communities?

D. Experiment

Our experiment to collect data and answer our three research questions was divided into two parts: (1) prototype development, where we observed and collected data from the Indigenous members of the research team (n=4) through interview and observational note-taking, and (2) open-to-community evaluation where we made the prototype available to community members to use at their own convenient time, trying all the available features, and then offer written or in oral feedback (n=6).

The research team followed an iterative process involving brainstorming, development, and internal evaluation, for about six months. PAU members constantly met with the project leadership, took notes of the process, and documented all design decisions.

The participants were recruited after the prototype was in a stable state. They evaluated and provided feedback in an open format and over a three-month period. They were encouraged to use mobile, head-mounted, and desktop platforms to interact with the system. They were offered the option of online interview or written feedback at the end of their evaluation.

IV. Findings

A. Data Collection and Analysis

Observing and interviewing the Indigenous members of the research team were our first sources for data collection. Our initial brainstorming showed the importance of a multi-purpose environment, a circular shape, and the ability to showcase artworks and other cultural artefacts. These were used as the basis for our gathering place prototype. Throughout the 6-month design and development, the research team met bi-weekly, took notes, and documented all design discussions, following a memoing-style data collection [47]. At the end of this period, we interviewed all Indigenous members of the research team. By analyzing memos and interview transcripts using emergent coding [44], various themes emerged, which were categorized as Space, Customization, Communication and Collaboration, Simulation, and Respect, as shown in Table I.

The second group of data came from community participants. Unlike the research team members who were all interviewed, all six participants chose to provide detailed written feedback. Using Zhang and Benjamin's model [17], the research team used the concepts of Technology, People, Society, and Information/Content as starting point of an

abductive, theory elaboration, and qualitative analysis [45]. We started by looking for codes related to these concepts but allowed for new concepts to emerge through two rounds of coding and comparing the codes with the insight generated by the research team. Fig. 4 shows the final codes and themes from participants' data.

Co-design/Collaboration, Communication, People (User and Contributor), Experience, Education, Protocols, and Accessibility were the major themes identified by the participants, which closely relate to what the research team members identified. The theme Experience was a more comprehensive term that included what the research team had identified as Space and Simulation. This could be more generally referred to as Content, although it overlapped with the Technology used to deliver the content too. Protocol was related to Respect and could be generalized into Process.

The participants identified the ability to customize based on the host nation's culture as an essential requirement, in addition to multi-purpose design and rights management tools. New research questions were raised, such as the ability to simulate physical activities such as dancing and feasting and their possible effect, and the effect of avatar's transparency and interaction level on the VR experience. These were examples of how Indigenous knowledge and traditions inspired new features or research directions.

TABLE I. INSIGHTS FROM THE RESEARCH TEAM

Themes	Specific Points of Interest
Space	Safe space Build relationships Share ideas, work, art, and knowledge Learn Circular shape with direction Kids room Water and journey Multi-purpose and multiple connected apps Art exhibition
Personalization & Customization	Avatar appearance Transparency of avatars Interactivity Voice control
Communication & Collaboration	Chat or voice or emoji Meeting rock Uploading and interacting with objects Working on things together Playing games and gamification Creating new rooms
Simulation	Feast, breaking bread, feeding and eating and smoking etc. Dance and other physical activities Gifts
Respect	Copyright Protocols Customization based on the host nation

Frequency absolute

Each code counts separately.
(Only passages that are assigned to the selected code are counted.)

	p1	p2	p3	p4	p5	p6		Passages in the code
Co-design	-	-	-	2	1	1		4
Collaboration	2	5	2	4	1	1		15
Communication	1	-	1	-	-	-		2
Interaction Structure	1	1	3	-	-	3		8
Interaction models	-	3	1	-	1	1		6
Invite System	-	-	-	1	-	-		1
User and Contributor	2	2	4	1	-	-		9
Artists and Developers	-	2	1	-	-	-		3
Motivated Learners	-	-	2	1	-	-		3
Youth	-	1	1	-	2	-		4
Elders	2	1	1	-	-	-		4
Experience	-	-	-	-	-	-		-
Activities	-	-	-	-	3	-		3
Space and Objects	-	1	5	1	1	-		8
Objects and Assets	1	-	-	-	-	1		2
Place	2	-	1	1	1	-		5
Player and Community Representation	2	1	2	1	1	-		7
Visual	-	-	3	-	-	-		3
Movement	-	-	1	-	-	-		1
Sounds	1	1	2	-	-	-		4
Educate	1	-	1	2	-	-		4
Learning Process	-	-	3	-	3	2		8
Purpose of education	-	-	1	2	2	-		5
Protocols	3	1	3	1	1	-		9
Constraints	-	-	-	-	-	-		-
Accessbility	1	-	3	-	-	4		8
Passages in the text	19	19	41	17	17	13		126

Fig. 4. Themes and Codes from Participants' Data

B. Discussion

The analysis of our collected data offers initial responses to the research questions.

How effective is the proposed model in empowering the community to lead the design process?

The proposed process allowed the community leaders to play a management role while other community members were actively involved in the development. While some technical aspects of the work (particularly 3D programming) could not be done by the Indigenous members, we were able to offer training and recruit talents who could participate in the content and experience design process. This ensured that the ideas behind the prototype were directly from the community and not the research team and the community members had access to all assets and could control the process. The need for training was clearly highlighted in our experience, which we felt was not clear in existing theoretical models such as TAM or I-Model. Such a training includes various skills from programming to 3D modeling/animation and graphic design. While user-friendly software development tools are available (for example, for games and even VR), most of them have limited functionality and may not work with intended VR framework such as WebXR. Even with the aid of these visual non-technical tools, the users need to understand the concepts and have certain related skills, so the need for training remains essential.

What are specific community concerns and interests regarding VR?

As suggested by previous work [35,36,37,41,42], respect to community protocols was clearly a significant concern. Many visual aspects, designed by non-Indigenous members, were corrected, especially to deal with authenticity and artist rights. Being able to control the development process and the experience itself (by individuals or host nations) was also highlighted as an important concern. Involving various stakeholders, such as youth and proper education, were among other points, as shown in Fig. 4. Overall, we believe the prototype was able to take an initial step in answering our second research question and identifying priorities.

What are specific technical features that are missing in order to address the items identified in question 2 and facilitate the proposed model?

Our findings identified various technical features that are missing or incomplete but required to address the community concerns. These features are the basis of our next phase of research and include abilities such as experience management (from uploading content to linking different experiences through a hub), avatar customization (from appearance to the level of interaction), simulation of physical activities (such as dancing or feasting), and different forms of collaboration.

Overall, our findings suggest that the existing models for technology adoption do not offer enough emphasis on process-related concerns such as protocols and training/education. On the other hand, separating people and society, as seen in I-Model, may ignore the close connection of individuals to their communities. As such, we propose a new model that together with our hierarchical participation approach, we refer to as Indigenous Technology Empowerment Model (ITEM), as shown in Fig. 5.

In this model, the People component represents stakeholders and can be at the individual, group, or community level. Content represents the user experience (actions, information, etc), and Technology is a collection of technical tools that make the creation and deployment of that experience possible. While these three form the user experience, Process is what binds them together and involves both developer and user aspects, such as protocols and development phases. ITEM more closely matches the significant aspects of technology development for Indigenous communities, compared to models such as TAM or I-Model, as it emphasizes the importance of the underlying process and highlights three key aspects of the user experience.

In particular, by giving Process a key role, ITEM draws attention to elements of the design and development process particularly:

- The formation of PAUs and establishing the participation hierarchy to ensure an integrated role for the community members,
- Training and education as essential elements that allow the above participation.

Together, these elements will go beyond technology adoption and use and empower the community to lead the process and own and sustain the outcomes.

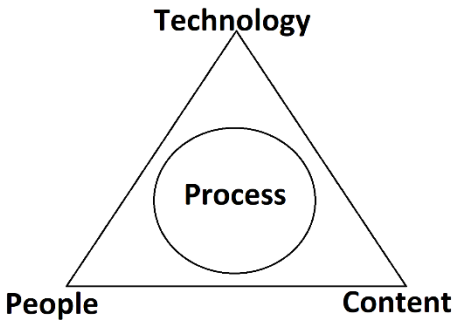

Fig. 5. Indigenous Technology Empowerment Model (ITEM)

Match & Contribution

Our work contributes to the IEEE TEMS field of interest (particularly product design and development and social impact) by proposing a more inclusive community-based model for technology design, demonstrated through VR for Indigenous Peoples. It is in line with the IEEE ICE conference theme on Human, Socio-Economic, Political and Cultural Dimensions of Emerging Technology, as it investigates a more inclusive way of engaging communities with emerging technologies.

V. Conclusion

A. Limitations

Due to the exploratory nature of the research, we used a qualitative approach relying on observations and interviews, followed by coding and thematic analysis of the qualitative data. While a smaller number of participants is expected in such methods, we understand that with only ten Indigenous community members and one prototype, our results are still preliminary. An increased number of participants and implementing some of the requested features will allow us to define and collect quantitative metrics that help investigate

acceptance and use of the technology by target communities. Example of these metrics are those defined by TAM (ease of use and usefulness) and more objective usability factors such as efficiency, and effectiveness.

Studying and comparing multiple VR applications (including generic ones and those not based on the proposed process) will result in a more reliable conclusion. Comparing our prototype to a generic application could be a good indication of the suitability of the proposed process.

While we tried to train two PAU members, as a small prototype, we had limited training abilities, which in turn resulted in limited involvement. We assume that more training could only strengthen the outcomes of the project.

We experimented only with VR but generalized ITEM as a more comprehensive technology model. While VR is a good example, some aspects of our findings, such as simulation, could be specific to VR.

Last but not least, we appreciate the difference between academic research projects and professional design or even industrial R&D projects. While our project was primarily research one, incorporating application development allowed us to emulate a more professional/industry project. More efforts are needed to investigate ITEM in different types of projects and identify possible variations from advanced research to product development.

B. Concluding Remarks

While there has been criticism of existing design approaches due to the focus on individuals, suggesting multi-user alternatives [48], a community is more than multiple members and defines a new holistic entity. Our research aimed at investigating a process model that incorporates community-level knowledge and protocols. Through this investigation, we gathered two types of new insights, those that apply to all technologies and those that are specific to VR. Our findings showed the potential of our proposed community-based approach and its related model in better engaging the community members in the design and development of applications based on VR as an example of emerging technologies. Our primary contribution is to offer a novel model of community engagement that goes beyond participation and allows empowerment [49] for communities to not just use but also own and create technology-based products and experiences. We also identified a series of technical features that are of interest to VR designers who work with Indigenous communities.

The research team learned invaluable lessons on working with communities, such as the need to properly train the non-Indigenous members on Indigenous protocols, to work closely with Indigenous partners prior to any decision and not make assumptions, and to respect the schedule and timing of partner and community organizations and allow for extensions.

Our work is in line with recent efforts to bring the concepts of culture, community, and inclusion into the technology design process [50][51]. We extend such initiatives by proposing new process models that can formalize the co-design and go beyond ad-hoc collaborations.

C. Future Work

Our research is an early effort toward a new model of collaborating with Indigenous communities. While we expect that our model can be generalized to other communities, further research is needed to establish a more comprehensive community-based design process model that incorporates variations in target groups. Future work can also aim at addressing the limitations by expanding the project to include other process models, more VR applications, a larger number of PAUs and participants, multiple community partners, and non-VR technologies.

In his book, *Designs for the Pluriverse*, Arturo Escobar [52] builds on other studies, particularly alternatives to the dualist ontology as the basis of Western modernity, and presents ontological design as "a means to think about, and contribute to, the transition from the hegemony of modernity's one-world ontology to a pluriverse of socio-natural configurations" and autonomous design as a particular approach with the basic insight that "every community practices the design of itself." As such, he promotes the definition of local and community ontologies as the basis of design. Our idea of incorporating community knowledge and protocols in the design process is in line with this ontological approach. Our belief in a more pluralistic worldview/ontology results in the need for a more inclusive design process, and community worldviews/ontologies can contribute to both Content and Process components of the proposed model. Better theoretical and practical implementation of an ontological design approach in our model is another area of future research.

Lastly, efficient ways of providing training and also sustaining the developed products (owned by the community partners) are other directions for future investigation.

REFERENCES

[1] Daniels JR, Geiger TJ., "Universal Design and LGBTQ (Lesbian, Gay, Transgender, Bisexual, and Queer) Issues," *Creating Equal Access and Opportunities for Success*. Online Submission. 2010

[2] Maloney D, Freeman G, Robb A., "Social virtual reality: ethical considerations and future directions for an emerging research space," *In 2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, 2021

[3] Mott M, Cutrell E, Franco MG, Holz C, Ofek E, Stoakley R, Morris MR., "Accessible by design: An opportunity for virtual reality," *In 2019 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, 2019

[4] Dombrowski, M., Smith, P. A., Manero, A., & Sparkman, J., "Designing inclusive virtual reality experiences," *In International Conference on Human-Computer Interaction (pp. 33-43).* Springer, Cham, 2019

[5] Abras, C., Maloney-Krichmar, D., & Preece, J., "User-centered design," *Encyclopedia of Human-Computer Interaction*. Thousand Oaks: Sage Publications, 37(4), 445-456. 2004

[6] Cooper N, Horne T, Hayes GR, Heldreth C, Lahav M, Holbrook J, Wilcox L., "A systematic review and thematic analysis of community-collaborative approaches to computing research," In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems,* 2022

[7] Peters, D., Ardler, T., Hansen, S., Mooney, J., McMullan, J., & Calvo, R. A., "Participation is not enough - Towards Indigenous-led co-design," *ACM International Conference Proceeding Series*, 2018

[8] Lewis, J. E., Abdilla, A., Arista, N., Baker, K., Benesiinaabandan, S., Brown, M. & Whaanga, H., "Indigenous protocol and artificial intelligence," position paper. 2020

[9] Scavarelli, A., Arya, A., Teather, R., "Virtual Reality and Augmented Reality in Social Learning Spaces: A Literature Review," *Virtual Reality,* 2020

[10] Steffen, J. H., Gaskin, J. E., Meservy, T. O., Jenkins, J. L., & Wolman, I., "Framework of affordances for virtual reality and augmented reality," *Journal of Management Information Systems*, 36(3), 683-729. 2019

[11] Suzuki, S. N., Kanematsu, H., Barry, D. M., Ogawa, N., Yajima, K., Nakahira, K. T., ... & Yoshitake, M., "Virtual Experiments in

Metaverse and their Applications to Collaborative Projects: The framework and its significance," *Procedia Computer Science*, 176, 2125-2132. 2020

[12] Kerdvibulvech, C., & Dong, Z. Y., "Roles of artificial intelligence and extended reality development in the post-COVID-19 Era," *In International Conference on Human-Computer Interaction* (pp. 445-454). Springer, Cham. 2021

[13] O'Donnell, S., Beaton, B., McMahon, R., Hudson, H. E., Williams, D., & Whiteduck, T., "Digital technology adoption in remote and northern Indigenous communities in Canada," *In Canadian Sociological Association 2016 Annual Conference*. University of Calgary, Calgary, Canada. 2016

[14] Fraser, T., "Mapping with Indigenous Peoples in Canada", in *Digital Mapping and Indigenous America*, Hess, J. (Ed.) Routledge. 2020

[15] https://imaginenative.org/indigital-space-vr

[16] Kennedy, R., Kelly, M., Greenaway, J., & Martin, B., *The International Indigenous Design Charter: Protocols for sharing Indigenous knowledge in professional design practice*. Deakin University. 2018

[17] Zhang, P., & Benjamin, R. I., "Understanding information related fields: A conceptual framework," *Journal of the American Society for Information Science and Technology*, 58(13), 1934–1947. 2007

[18] https://tracxn.com/explore/Virtual-Reality-Startups-in-Canada

[19] https://www2.gov.bc.ca/assets/gov/british-columbians-our-governments/indigenous-people/aboriginal-peoples-documents/calls_to_action_english2.pdf

[20] Preece, J. "Online communities: Designing usability, supporting sociability," 2000

[21] Lachney, M., Eglash, R., Bennett, A., Babbitt, W., Foy, L., Drazin, M., & Rich, K. M., "pH empowered: community participation in culturally responsive computing education," *Learning, Media and Technology*, 1-22. 2021

[22] Marangunić N, Granić A., "Technology acceptance model: a literature review from 1986 to 2013," *Universal access in the information society*. 2015

[23] Menke, K., Beckmann, J., and Weber, P., "Universal design for learning in augmented and virtual reality trainings." *Universal Access Through Inclusive Instructional Design*. Routledge, 294-304, 2019.

[24] Phillips, K., "Virtual Reality has an accessibility problem," *Scientific American*, Opinions, Jan 29, 2020.

[25] Munafo, J., Diedrick, M., & Stoffregen, T. A., "The virtual reality head-mounted display Oculus Rift induces motion sickness and is sexist in its effects," *Experimental brain research*, 235(3), 889-901. 2017

[26] Felnhofer, A., Kothgassner, O. D., Beutl, L., Hlavacs, H., & Kryspin-Exner, I., "Is virtual reality made for men only? Exploring gender differences in the sense of presence," *Proceedings of the International Society on presence research*, 103-112. 2012

[27] Schwind, V., Knierim, P., Tasci, C., Franczak, P., Haas, N., & Henze, N., "These are not my hands! Effect of Gender on the Perception of Avatar Hands in Virtual Reality," *In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (pp. 1577-1582). 2017

[28] Makransky, G., Wismer, P., & Mayer, R. E. (2019). A gender matching effect in learning with pedagogical agents in an immersive virtual reality science simulation. Journal of Computer Assisted Learning, 35(3), 349-358.

[29] Porras-Garcia, B., Ferrer-Garcia, M., Ghita, A., Moreno, M., López-Jiménez, L., Vallvé-Romeu, A., ... & Gutiérrez-Maldonado, J., "The influence of gender and body dissatisfaction on body-related attentional bias: An eye-tracking and virtual reality study," *International Journal of Eating Disorders*, 52(10), 1181-1190. 2019

[30] Hernandez, G., "Queering the Archive: An Integration of Web Development and Virtual Reality as a Tool for Social Justice," Doctoral dissertation, Mills College, 2018

[31] Acena, D., & Freeman, G., "In My Safe Space": Social Support for LGBTQ Users in Social Virtual Reality.," *In Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems* (pp. 1-6). 2021

[32] Lee, L. N., Kim, M. J., & Hwang, W. J., "Potential of augmented reality and virtual reality technologies to promote well being in older adults," *Applied Sciences (Switzerland)*, 9(17). 2019

[33] Soltani, P., "A SWOT Analysis of Virtual Reality for Seniors," *Virtual and Augmented Reality in Mental Health Treatment*, 78–93. 2018

[34] Peck, T. C., Seinfeld, S., Aglioti, S. M., & Slater, M., "Putting yourself in the skin of a black avatar reduces implicit racial bias," *Consciousness and cognition*, 22(3), 779-787. 2013

[35] Stanton, C. R., Hall, B., & Carjuzaa, J., "The Digital Storywork Partnership: Community-centered social studies to revitalize Indigenous histories and cultural knowledges," *Journal of Social Studies Research*, 43(2), 97–108. 2019

[36] Rodil, K., "Reflections on Visualization in Cross-Cultural Design," *In At the intersections of traditional and indigenous knowledges and technology design* (pp. 319-340). Informing Science Press. 2015

[37] Wallis, K., & Ross, M., "Fourth VR: Indigenous virtual reality practice," *Convergence*, 27(2), 313-329. 2021

[38] FNIGC, "Barriers and Levers for the Implementation of OCAP," *International Indigenous Policy Journal*, 5(2), 1-11, 2014

[39] https://www.go-fair.org/fair-principles/

[40] Global Indigenous Data Alliance, *CARE principles for Indigenous data governance*. GIDA https://www. gida-global. org/care., 2019

[41] Leong, T. W., Lawrence, C., & Wadley, G., "Designing for diversity in Aboriginal Australia: Insights from a national technology project," *In Proceedings of the 31st Australian Conference on Human-Computer-Interaction* (pp. 418-422), 2019.

[42] Marwick B, Shoocongdej R, Thongcharoenchaikit C, Chaisuwan B, Khowkhiew C, Kwak S. "Hierarchies of engagement and understanding: Community engagement during archaeological excavations at Khao Toh Chong rockshelter, Krabi, Thailand," *Transcending the Culture-Nature Divide in Cultural Heritage: Views from the Asia-Pacific Region*. 2013.

[43] Kemmis, S., McTaggart, R., Nixon R., *The action research planner: Doing critical participatory action research*. 2014

[44] Corbin, J., & Strauss, A., *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Los Angeles, CA: Sage Publications, 2008

[45] Fisher, G., and Aguinis, H., "Using theory elaboration to make theoretical advancements," *Organizational Research Methods* 20(3): 438–464, 2017

[46] Scavarelli, A., Arya, A., and Teather, R. J. "Circles: exploring multi-platform accessible, socially scalable VR in the classroom." *IEEE Games, Entertainment, Media Conference (GEM)*. IEEE, 2019.

[47] Miles, M.B. & Huberman, A.M., *Qualitative data analysis: An expanded sourcebook*, Sage, 1994

[48] Fleury, S., and Chaniaud, N. "Multi-user centered design: acceptance, user experience, user research and user testing." *Theoretical Issues in Ergonomics Science*, pp 1-16, 2023

[49] Seth, A. *Technology and (dis) empowerment: A Call to Technologists*. Emerald Group Publishing, 2022.

[50] Guerrero Millan, C. "Living Data Systems: Co-Designing Community-Based Methods And Local Technologies For Inclusive Socioeconomic Alternatives." *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*. 2023.

[51] Cattaneo, T. "Introduction on Design for Vulnerable Communities." *Design for Vulnerable Communities*. Springer International Publishing, pp 1-17, 2022.

[52] Escobar, A. *Designs for the pluriverse: Radical interdependence, autonomy, and the making of worlds*. Duke University Press, 2018.