A Serious Game for Dena'ina Language and Heritage

Xinyue Zhang and **Yi Wang,** Beijing University of Posts and Telecommunications

Donita Slawson, Maria Williams, Robert Boeckmann, and Pradeeban Kathiravelu, University of Alaska Anchorage

This article presents the research, design, and development of Dnigi, a serious game to facilitate learning Alaska Native heritage, focusing on Dena'ina language and history. We envision Dnigi as a learning aid, targeting an undergraduate audience as developers and users.

Several Indigenous languages and cultures are critically endangered due to more influential settler communities and majority cultures occupying their land and the subsequent centuries-long destruction of identity for the Native communities. Indigenous knowledge sharing can be challenging due to generational trauma and systematic oppression that has left the community with minimal resources to learn and appreciate their languages and traditions. Language revitalization and maintenance efforts are carried out by the respective Native elders and Indigenous scholars across the globe to counter the threat of their languages and cultures disintegrating and eventually disappearing.[1] Indigenous scholars have led the research to protect their language, heritage, cultures, traditions, and identity through innovative approaches. Commonly, educators propose serious games as an active learning strategy, using games to assist pedagogy, deviating from the usual entertainment purposes of the

games and traditional lecture-style classrooms where the students are passive learners.[2] Similarly, Indigenous researchers seek approaches to effectively leverage serious games in teaching Indigenous languages[3] and heritage.[4] Many recent innovations in serious games and game-based learning are yet to be fully leveraged and used appropriately in reviving Indigenous cultures and heritage.

Place-based learning provides avenues for a sense of place in education, preserving cultural identity and traditions.[5] Indigenous cultures value their lands and their attachment to the land. As such, educational efforts that incorporate the essence of the land yield better learning outcomes. Many universities have introduced courses on Native heritage as part of the curriculum. The University of Alaska Anchorage offers Alaska Native language courses and Alaska Native perspectives for all undergraduates as part of the undergraduate degree requirements. Subsequently, over the years, computer science undergraduates have developed capstone projects in collaboration between the Departments of Computer Science and Alaska Native Studies. These initiatives have created new synergies in Indigenous research, allowing undergraduates to understand and appreciate the cultural identity of the land and enriching the sense of belonging of the Indigenous students.[6] One synergetic approach was the development of serious games, which allowed computer science undergraduates to develop the game. At the same time, the students of Alaska Native studies can then use those games as learning aids.

This article proposes an extensible serious game framework that can be adapted to support different languages and heritage content, with content added over time to expand on the features and data presented in the game. Our overarching goal is to develop a serious game for Indigenous heritage and knowledge sharing. We devised a modular architecture that allows the game to be incrementally expanded to include additional features and content to increase the player's curiosity with time. While the approach and architecture are generalizable, considering our own resources toward developing the content on places and languages, we limited our focus to Alaska in the implementation.

Following our devised architecture, we developed *Dnigi*, a map-based serious game framework for knowledge sharing of Indigenous history, focusing on Alaska Native heritage. Dnigi means "moose" in the Dena'ina language. Moose roam the streets of Anchorage and the lands of the Dena'ina people. As an animal that plays a vital role in the Alaskan ecosystem, moose is part of the lives of Alaska Natives. *Dnigi* facilitates an active learning approach to learning Alaska Native history and heritage by exploring the regions of Alaska and understanding its rich, diverse Native history by playing this serious game. Developing serious games for cultural revitalization requires collaborations across generations and diverse educational backgrounds. In the context of Alaska, we posit that cooperation among the computer science students and faculty in developing such serious games and the students using the serious game as a learning aid in their Alaska Native studies courses will provide a sense of place to the Native youth.[7] The University of Alaska Anchorage is on Dena'ina Ełnena (the land of the Dena'ina people). Dena'ina is the critically endangered language originally spoken in the areas currently encompassing Anchorage and its surrounding lands in south-central Alaska. *Dnigi* focuses more specifically on Dena'ina language and heritage, encouraging the players to seek the Dena'ina land on the map of Alaska and explore its sites when they play *Dnigi*.

The "Literature Review" section provides a brief literature review depicting the context and motivation behind our research strategy. The "Methods" section illustrates our approach in developing *Dnigi* in the context of Alaska Native heritage and the Dena'ina language. The "*Dnigi* User Experience" section highlights the features and the game. The "Discussion" section presents an overall discussion on related work, summarizes our contribution, provides our reflections and narratives in working on this project, and concludes the article with future work.

LITERATURE REVIEW

Developing and using serious games can be an effective active learning strategy for Indigenous cultural heritage,[8] filling a gap in intergenerational knowledge sharing.[9] Building serious games to preserve local languages can be an effective place-based education[10] approach for programming classes of computer science curriculum.[11] These serious games also enable further dissemination of Indigenous knowledge among the players when used in Indigenous heritage and language classes.[12] Incorporating Indigenous education into the university curriculum is essential in reconciling the long history of the land and its people.

Computer science researchers and Indigenous scholars have collaborated to develop serious games for several Indigenous languages and cultures.

Serious games are used with virtual reality (VR) and simulations for education.[13] Such recent innovations are also incorporated into learning and teaching Indigenous language and culture. Culturally responsive teaching practices are leveraged to promote education and revitalize Indigenous cultures worldwide. Serious game genres help teach Indigenous languages to a wide range of students by leveraging second language acquisition theories.[14] Such efforts help revive critically endangered Indigenous languages by promoting their use as a second language among Native students and others.

Project-based learning based on Indigenous culture has enhanced learning outcomes in computer science education.[15] Specifically, the Aboriginal Computer Education Through Storytelling (ANCESTOR) program explores computer science as a career option through digital storytelling to address cultural literacy and computer science education with Indigenous youth in British Columbia, Canada.[15] Edutainment refers to the entertainment elements, such as video games, used in education to aid active learning methodologies.[16] When used in teams, such edutainment frameworks can provide a peer-learning environment that is more accessible for minority and Indigenous students compared with traditional lectures. These inspiring success stories highlight the potential of Indigenous research in computer science.

By incorporating social elements and allowing the students to compare their progress in a nontraditional format, such as through scores in leaderboards, gamification in educational applications motivates the users to learn the content effectively with minimal supervision from the instructor. One notable example in language

acquisition is Duolingo,[17] which also includes language sessions in Indigenous languages such as Navajo and Hawaiian (Ōlelo Hawai'i).

Research cautions us of the adverse learning outcomes of game-based learning[18] and gamification in education, including loss of performance, undesired behaviors due to bad planning of the game, indifference to the game due to lack of personal connection, and declining effect due to gradual loss of interest in the game.[19] Therefore, we incorporate the game-based learning approaches in *Dnigi* with more focus on the content with a moderate amount of game aspects to increase the curiosity among the students, considering the best practices in developing such educational serious games.

METHODS

We developed *Dnigi* for Alaska Native heritage as a Python-based open source application. Its source code can be found at https://github.com/XinyueZhang-Ada/Dnigi. Our development strategy aims for eventual adoption and contributions (both on content and software) from the user and developer community in and outside Alaska.

Alaska is a vast land with many distinct Native languages and Indigenous peoples. *Dnigi* is a map-based game that directs the player to the Dena'ina land on its map of Alaska. We define Dena'ina Ełnena as the "treasure place" in *Dnigi*, where the players have to use their avatar to find the Dena'ina land and then move around and learn about places, language, and culture. Exploring Dena'ina allows the players to score points. *Dnigi* contains detailed insights into the Dena'ina language and land while providing a global overview of the diverse Alaskan culture and heritage. Using the location of an avatar

that a player can move around on the map of Alaska in the game, *Dnigi* challenges the player to locate and learn about the sites with specific details added while providing a summary of the different tribal lands and linguistic communities of Alaska. *Dnigi* presents the user with a chatbox powered by machine learning to facilitate learning about the places in Alaska of significant importance to the Alaska Native people. It evaluates the user's progress with quizzes and their successful exploration of the Dena'ina land. *Dnigi* thus applies the edutainment research findings in designing and developing a serious game for the Dena'ina language and heritage.

We started the implementation by testing different technical stacks. The map of Alaska is a crucial part of *Dnigi*, as a place-based serious game. Among the potential alternatives, Unity based on C# does not work well with the Leaflet-based maps and the large language model (LLM) application programming interfaces (APIs), which *Dnigi* leverages to respond to user queries as part of the game. Therefore, we chose Python/Flask combined with Leaflet and Baidu LLM APIs to extract text from different Alaska sources online. We use HTML5, JavaScript, and CSS as core technologies in user interaction. Leaflet and Bootstrap framework make our map display and graphical interface more friendly to diverse users. We use JavaScript Ajax to process and transfer the user's interactive information from the web page. We use Baidu's Qianfan Model API as the LLM to interact with users by responding to the questions they enter through a chat-like feature incorporated into *Dnigi*.

The player can press the keyboard arrows to move the agent up and down, left and right. The treasure place is in

the lower middle of the entire plate, as it is in south-central Alaska, with the whole map of Alaska covering the total display area. The players can also click the LLM agent display in the game to ask questions, which can quickly give the player the answers. The player can also double-click the search box to view sample questions, as Figure 1 illustrates. Since this is an LLM trained by Internet sources, the answers can be inaccurate or contain outdated language or discontinued words for places and communities. Choosing a question from the drop-down box will ensure a more accurate answer as those questions are verified for accuracy and sensitivity. The modular nature of the *Dnigi* architecture allows its components to be seamlessly replaced by other alternatives. We will replace the current LLM feature with more accurate LLMs when available.

Audio and video elements are a crucial part of the game narratives. We curate datasets of publicly available audio and video materials as part of *Dnigi* data. Dena'ina language learning materials are presented as flashcards as the player progresses. We incorporate a local data store (rather than a cloud or remote repository) into the application to store the Dena'ina heritage and language lessons in audio, video, and text formats to minimize the latency caused by retrieving these materials from remote online sources.

DNIGI USER EXPERIENCE

Entering *Dnigi*, the first thing that comes to the player's attention is a navigation card containing the introduction, aim, how to play *Dnigi*, and other game navigation tips. The *Dnigi* game begins when the user clicks the "Start" button. If the player wants to view the navigation card again during the

game, they can click an orange round button prominently and consistently displayed in the upper left corner, as Figure 2 illustrates. These buttons and flashcards are customizable. The flashcards are available in the local file system as images and are retrieved and displayed by the program. We host minimal data in GitHub due to data volume. However, locally, the content can be richer in diverse multimedia formats. In addition to the local storage functioning as the knowledge base, *Dnigi* also fetches content from freely available online sources.

The main body of *Dnigi* is a map of Alaska that can be zoomed in and out. The blue borders divide different Alaska Native areas, each with its unique Indigenous language and culture. The player can click on any area within the light blue area on the map to see brief Indigenous information for that area, including language, region, and cultural family. Figure 3(a) shows

some examples of introductions to various Alaska Native regions, separated by the Native language of the area. As Figure 3(b) depicts, *Dnigi* will prompt the player to find the treasure place when the agent is moved to the Dena'ina area. We primarily used publicly available data on Dena'ina heritage and language, including the names of the places in the Dena'ina language. However, this location-based discovery can be expanded with more custom data.

A prominent blue button is available for the player to click, displaying five buttons as Figure 3(b) illustrates. Clicking the first four of these five buttons will present detailed information on the Dena'ina language and heritage in various formats, as Figure 4 shows. The last of the five buttons is the "Test" button, which provides the quiz functionality when clicked. Thus, *Dnigi* quizzes the player to evaluate how much Dena'ina knowledge they have acquired.
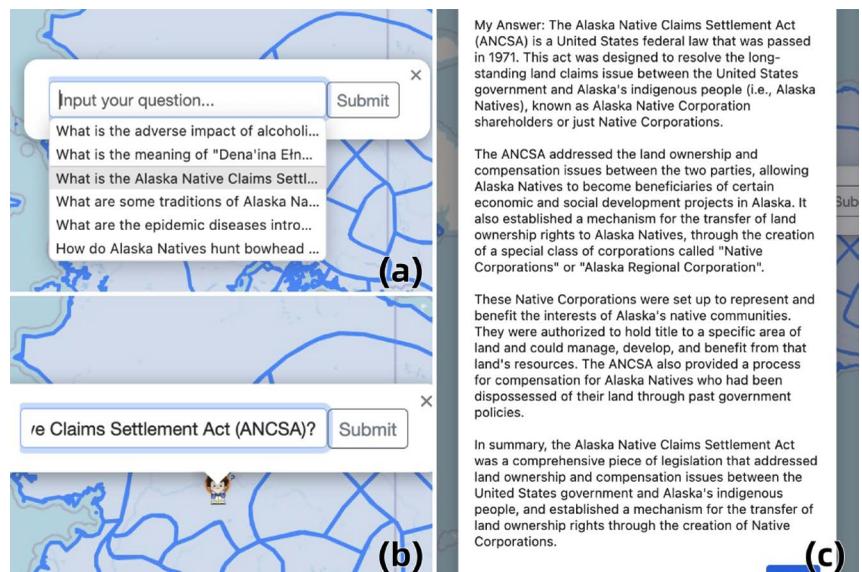

FIGURE 1. Ask the LLM agent questions. (a) Sample questions shown in the dropdown box. (b) Choose a question. (c) Get the answers.

Figure 4(a) shows the introduction. This gives the player a brief introduction to Dena'ina, inspiring the user to continue playing. Figure 4(b) displays some interesting videos about the Dena'ina language and the rich Dena'ina heritage. Figure 4(c) contains several audios in the Dena'ina language or about the Dena'ina heritage, including details about Indigenous place names in the Dena'ina land. The player can pause and loop these audios according to their preferences. Figure 4(d) shows flashcards as learning aids for the Dena'ina language.

The representative flashcard shown in Figure 4(d) is the Dena'ina alphabet. It contains sample words for each letter in Dena'ina, along with their English translations and pictures for the word, making it easier for the player to remember. The flashcards are stored in the local data store. More flashcards can be added to expand on the game content as we find, create, digitize, record, and curate the language and heritage materials.

A click on the last (that is, rightmost) button, "Test," as shown in Figure 3(b), brings a small quiz for the player to

evaluate what they have learned about the Dena'ina language and heritage from the flashcards, videos, and audio recordings. The quiz opens up a display with questions, as Figure 5 illustrates. The test process is straightforward. As shown in Figure 5(a), the game will prompt a warning message when the player does not choose any answers. Figure 5(b) shows how the answer is selected. After the player selects all the answers, *Dnigi* gives a result card with green font indicating the correct answer and red font indicating that the answer chosen by the player is wrong and shows the number of correct answers and the total number of questions, as shown in Figure 5(c). The quizzes and scores encourage the players to collect higher points.

If the player wants to repeat the quiz, they can click the blue "Restart Quiz" button below or click the "Close" button in the upper right corner to return. The displayed questions are chosen from a collection, and the order of the questions is randomized. This randomization ensures the quiz measures the player's level of knowledge rather than their ability to memorize and remember the position/letter of the correct answer.

DISCUSSION

Serious games have been leveraged in culture revitalization and preservation research across languages and communities. Taiwanese Indigenous heritage has been shared through *Papakwaqa*, a serious game that presents the language and culture of the Atayal tribe.[4] *Papakwaqa* has a data tier, a logic tier, and a presentation tier. How *Dnigi* curates and presents its content is comparable to *Papakwaqa*. Taiwan also has the greatest diversity among Oceanic language groups,
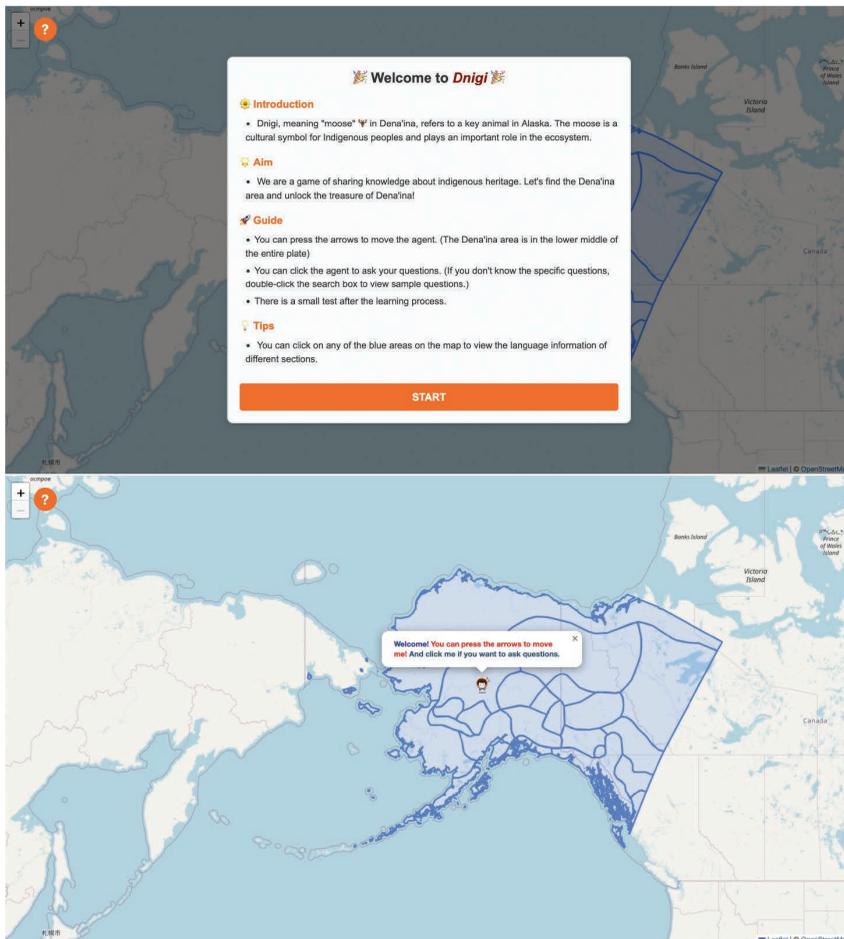

FIGURE 2. The navigation card and a first look at the *Dnigi* prototype.

similar to the diversity of Alaska. *Papakwaqa* contains a rich set of content with 2D and 3D visuals, aiming to be a learning aid for school students. WhiteStone,[3] an interactive projection device designed based on Qiang epics, uses and evaluates serious games for the Qiang language and culture. Qiang does not have a written format. As a language and culture passed through generations orally, a serious game may not be able to adopt all the features of knowledge transfer available to languages with written text. WhiteStone has to cater to these additional challenges that did not apply to *Dnigi*.

Alaska Native communities continue to display courage and resilience, which are also reflected in the applications developed by Alaska Natives. *Never Alone* is an Alaska Native game that highlights the resilience of the Alaska Native communities.[20] *Never Alone* uses Iñupiaq storytellers to share the story of the main character and her pet fox as they go on an adventure consisting of blizzards, an adversary, and supporting spirits from nature. Through an interactive and engaging game visual and flow, *Never Alone* aims to educate the players about the Alaska Native heritage and perspectives without overwhelming them with content. These previous works have inspired us in the development of *Dnigi* as a serious game on Alaska Native history and heritage, with a focus on the Dena'ina language and community.

We built *Dnigi* as a proof of concept with coauthors from diverse communities. Slawson is a Dena'ina from Tyonek, AK, USA. Williams is a Tlingit from Tikahtnu, AK, USA. Slawson teaches the Dena'ina language to undergraduate students at the University of Alaska Anchorage. Her original Dena'ina content provided flashcards to test the game locally. Williams is the chair of the Department of Alaska Native Studies. Zhang is a Manchu from Tangshan, China. Manchu is a critically endangered language, a state it shares with Alaskan Native languages such as Dena'ina and Tlingit. We bring our perspectives and living experiences into implementing *Dnigi* based on research by the Indigenous education community and wisdom shared by Alaska Native elders.

Dnigi can be used in Alaska Native heritage introductory courses. Efficiency in using the program as a learning aid in classrooms needs further evaluation based on student engagement, satisfaction (which can be measured through semester-end faculty evaluation surveys), and success (measured by comparing the student grades across the years, before and after using *Dnigi* as a learning aid). Due to its modular architecture, *Dnigi* can also be used in similar courses across different cultures and languages when the program source code is modified for various places and languages and incorporating the appropriate local content on language and heritage after verifying the content accuracy with the respective Native elders. Such heritage awareness can include artistic/archaeological and architectural/natural heritages. Thus, the knowledge base can continue to expand to cater to such vast and diverse knowledge bases.

As future work, we envision a more extensive collaboration with the Alaska Native elders, bringing their firsthand opinions as an elders' council. We will curate and incorporate additional sites and flashcards in future versions of *Dnigi* as we learn and understand the heritage more from the culture bearers. The elders' council will ensure that the cultural sensitivity and heritage are accurately illustrated in *Dnigi* before releasing the complete application with its data for public use or use in classrooms. We currently limit the "treasure place" to the Dena'ina land. While we could
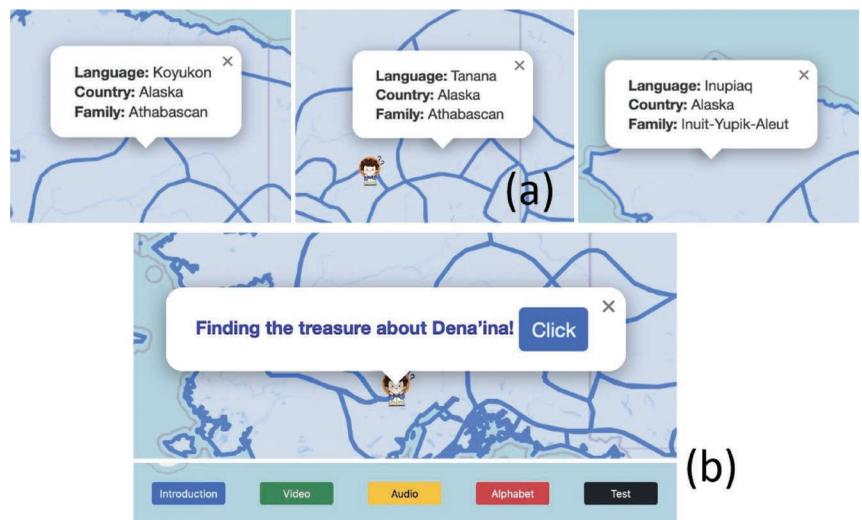

FIGURE 3. The *Dnigi* experience: (a) Examples of Alaska Native area introduction. (b) Exploring Alaska with *Dnigi*.
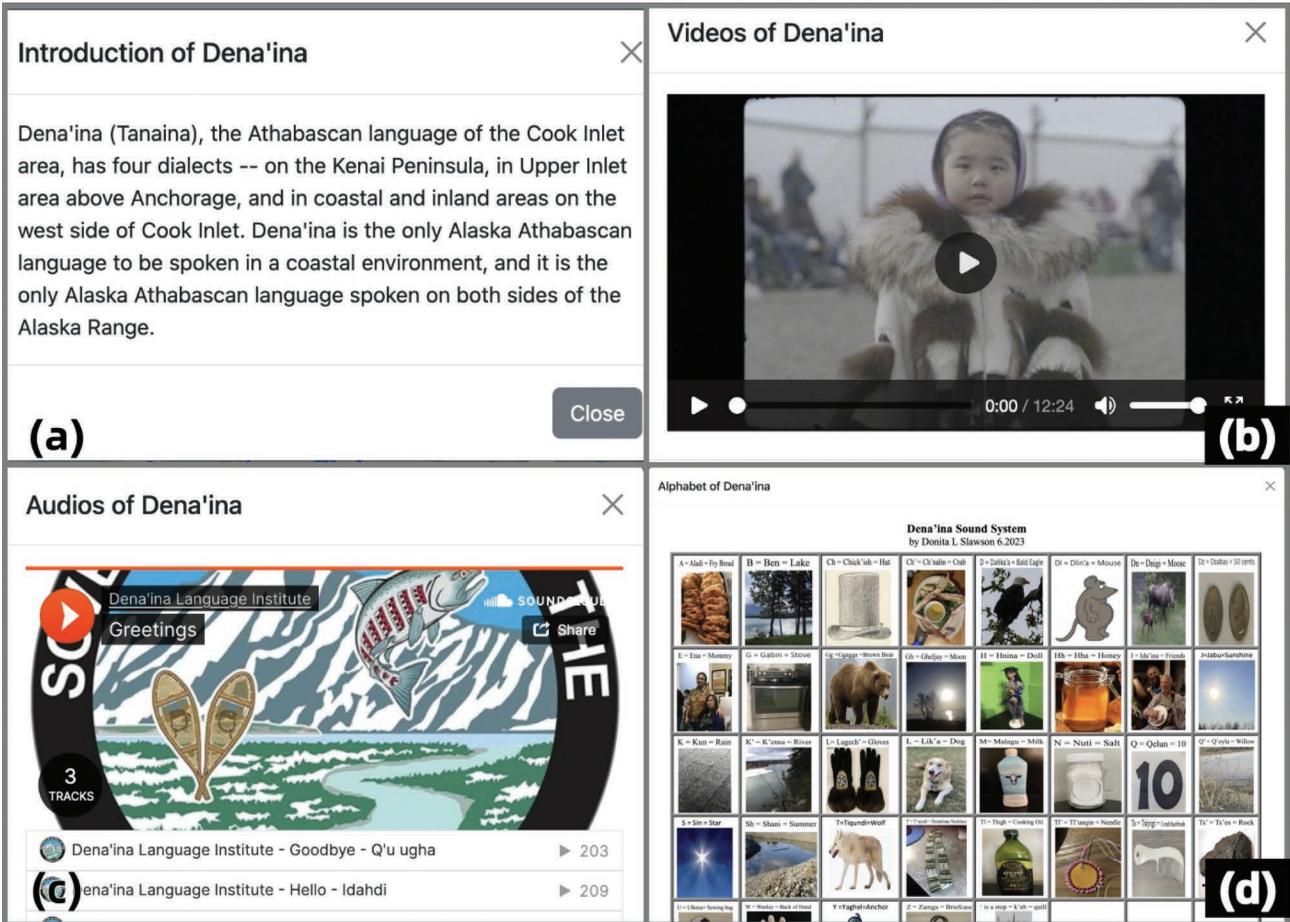
FIGURE 4. The first four parts of the Dena'ina treasure: (a) introduction, (b) videos, (c) audios, and (d) flashcards.
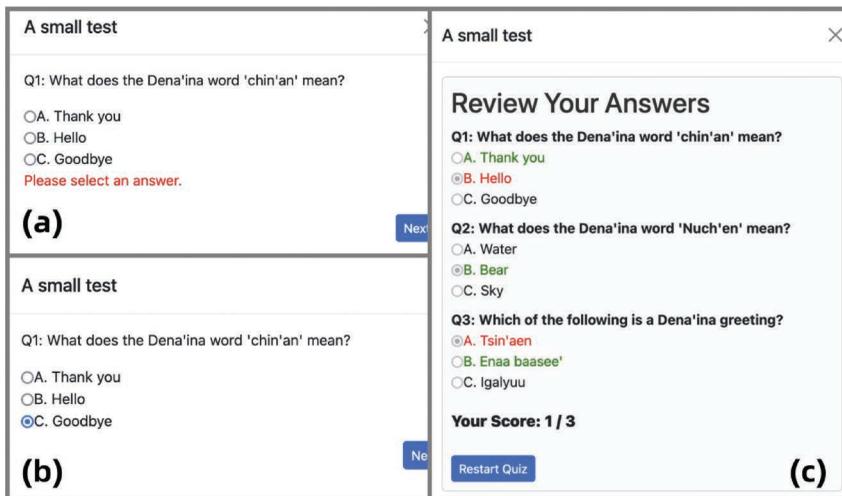

FIGURE 5. A small quiz to evaluate student learning. (a) A question. (b) The player selects an answer. (c) The quiz is graded, indicating the right (green) and wrong (red) answers.

expand the treasure place to cover the entirety of Alaska, that would be a significant undertaking (on curating cultural content and materials from diverse languages rather than the programming challenges) due to Alaska's rich cultural and linguistic diversity. We leave it as a vision for the future. We consider the current LLM feature to show the potential for an LLM integration in *Dnigi* rather than as authentic or precise source material, given the nature of LLMs to provide inaccurate and incomplete responses based on the data they are trained on. In future iterations, we propose to use specific datasets curated locally and train our own LLM for accurate and

ABOUT THE AUTHORS

XINYUE ZHANG is a Ph.D. researcher at Beijing University of Posts and Telecommunications, Beijing 100876, China. Her research interests include serious games and active learning. Zhang received her B.Sc. in software engineering from the Minzu University of China, Beijing. Contact her at xinyuezhang@bupt.edu.cn.

YI WANG is a professor at the Beijing University of Posts and Telecommunications, Beijing 100876, China. His research interests include LLMs and serious games. Wang received his Ph.D. in information and computer science from the University of California, Irvine. Contact him at yiwang@bupt.edu.cn.

DONITA SLAWSON is an instructor of Alaska Native studies at the University of Alaska Anchorage, Anchorage, AK 99508 USA. Her research interests include Alaska Native cultural practices, Dena'ina heritage, and innovative pedagogical practices. Slawson received her B.A. in multi/interdisciplinary studies at the University of Alaska Anchorage. She serves as the cultural project manager at Chickaloon Native Village, tribal administrator at the Native Village of Tyonek, and archivist at Kenaitze Indian Tribe. Contact her at dlslawson@alaska.edu.

MARIA WILLIAMS is a professor of Alaska Native studies and Alaska Native studies department chair at the University of Alaska Anchorage, Anchorage, AK 99508 USA. Her research interests include Alaska Native cultural practices, history, and innovative pedagogical practices. Williams received her Ph.D. in ethnomusicology from the University of California, Los Angeles. Contact her at mdwilliams6@alaska.edu.

ROBERT BOECKMANN is a professor of psychology at the University of Alaska Anchorage, Anchorage, AK 99508 USA. His research interests include social justice, social identity, and value discrepancy and the legitimacy of legal authorities. Boeckmann received his Ph.D. in psychology from the University of California, Berkeley. Contact him at rjboeckmann@alaska.edu.

PRADEEBAN KATHIRAVELU is an assistant professor of computer science at the University of Alaska Anchorage, Anchorage, AK 99508 USA. His research interests include software-defined systems, circumpolar north, and service-oriented architecture. Kathiravelu received his EU Erasmus Mundus Ph.D. in distributed computing from Instituto Superior Técnico, Universidade de Lisboa, Portugal, and Université catholique de Louvain, Belgium. He is a Member of IEEE. Contact him at pkathiravelu@alaska.edu.

more culturally sensitive responses from the LLM agent.

We propose incorporating augmented reality to identify the player's current location and include those location-specific details in the map as the player moves. In this first version, we built *Dnigi* as a web-based serious game application. We propose to extend it to a mobile game application that can be deployed on smartphones and VR headsets, which could then better utilize the user's real-time location, in addition to the current approach of moving an avatar to simulate their location in a virtual exploration style. Such expansion would then provide players with an immersive experience in exploring their surroundings in an augmented reality style. Additional layers of rewards and levels can be incorporated, although the current version is minimal, focusing on the content and extensible architecture rather than a rich gaming experience. ∎

ACKNOWLEDGMENT

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