Technology Inclusion via Endangered Language Learning Application: An Explorative Case Study with Remote Nganasan Community

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ABSTRACT

Digital learning, although extremely popular with tech-savvy users, is still not widely studied in the context of remote communities for endangered language learning. To support technology inclusion, it is also imperative to motivate and engage users for long-term use. We have developed a gamified storyline application for a moribund language, Nganasan (Samoyedic branch of the Uralic language family), and conducted a remote user study, where three teachers autonomously utilized the application at a local school in the Taymyr Peninsula (Northern Siberia, Russia) with 22 children, aged from 7 to 12 years. The results indicate that the application was fun, engaging, and appealing for most children, whereas teachers demonstrated the desire to use the application further and contribute to its development. The analysis of usage patterns, obtained from the three tablets sent to the school, suggests that cooperative work was motivating and engaging for the children from the remote community in Taymyr. We further discuss the value, drawbacks, and learned lessons that can be useful for future research on digital learning and technology inclusion with remote communities.

KEYWORDS

Technology inclusion; Children in remote communities; Underserved users; Language Learning; Endangered Languages; Cultural Competence; Tablet-based learning; Nganasan; Taymyr

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CCS CONCEPTS

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1 Introduction

Digital learning has been a popular topic of research for several decades, especially within Child-Computer Interaction (CCI) and Computer-Supported Collaborative Learning (CSCL) fields. As technology becomes more ubiquitous inside and outside the school environment, educators and researchers have been exploring the use of mobile devices for classroom learning. The benefits that digital learning include are ease of access to information and multimedia content, enhanced communication between students and teachers, and an increased level of self-determination [1, 12]. In addition, mobile devices provide an "*interactive, collaborative, and ubiquitous environment for language learning*" [8]. Although there is a large body of research showing benefits of mobile and tablet-based language learning in terms of improved motivation, engagement, and positive experiences, economic resources and national wide guidelines are needed for ethically acceptable implementation of tablets in early childhood education [19, 22, 23, 26]. Further, applying digital learning in the curriculum allows educating children with important skills, which are essential to living in contemporary society [6]. Technology inclusion for children living in remote and rural areas has gained growing interest in CCI research in the last decade [15, 17]. However, research on digital learning for an endangered language by communities living in geographically remote areas is limited. In addition to the remoteness of the user group, where there are limited opportunities for interaction and inclusion in the design

process; there are also few resources available for the endangered language for digitization [33].

As a response to the gap between demand and supply, there is a growing interest in developing applications to revive endangered or dying languages. Such applications are not only seen to preserve indigenous language and culture and further promote language learning among younger generations [11] but also increase opportunities for digital inclusion, especially among children living in remote communities. Moreover, it is expected that the next billion users of the technology will be mobile-first [5] and possibly belonging to rural or remote communities. Hence, by designing a digital learning solution for endangered languages, it is possible to address language revitalization and promotion while enabling technology inclusion in remote communities.

Projects with indigenous Australian communities [8] for learning indigenous languages with digital applications show a multitude of benefits; from increasing motivation and interest in learning the native language, to simultaneously being introduced to new technology. This blend of native (language) and new (technology) allows communities to be digitally included and overcome the barrier of low literacy and lack of technology skills. However, studies on how technology is used for native language learning in underserved and remote communities are also limited [32]. Especially, there is a lack of research on how to develop and adopt technologies in remote communities without having direct access to them. Underserved communities might have geographical, political, or socio-economic reasons for restricted access to technology. This can be further exacerbated due to poor infrastructure, lack of information, and lack of resources to purchase devices even when there is interest in utilizing them. Physical or online access to the community itself can also be a challenge. Thus, the community is understood to be remote in two ways – limited access to the community by researchers and the community's limited access to technology.

In this work, we conducted a user study with 22 schoolchildren and three teachers living in the remote district of the Taymyr Peninsula, in Northern Siberia (Russian Federation). We developed a gamified language learning storyline-based application for the endangered language – Nganasan, which is spoken by no more than 100 people, most of whom are over the age of 60 years[1]. The aim of the study was to understand the technology usage behavior and motivation of children living in remote communities and to design future applications based on the results to support the learning of similar languages. The user study can itself be considered remote, as researchers had limited access to the teachers at the school. The practicalities of the study were agreed remotely between the school headmaster and linguist researcher; there was no communication or access to teachers during the study. A short Skype interview was conducted with two (out of three) teachers after the study had ended. To address the lack of observations and communication, the application collected automated log data, supported with paper-based user experience dairies, filled in by students and teachers for the duration of the study.

This work builds a case for introducing digital learning in a form of an endangered language-learning application for a school environment with a goal to enable technology inclusion in the remote Nganasan community. The findings from the remote study, with teachers being moderators, indicate a strong motivation to learn and adopt technology in a classroom environment in addition to a high level of engagement with a gamified storyline application. Furthermore, our case demonstrates one approach towards technology inclusion in remote communities by delivering digital solutions addressing community needs and aspirations [29], e.g., promoting their native language and culture. In addition, our application can be further extended, generalized as well as applied to other endangered languages of the Uralic branch via modification of text configuration files.

This paper is organized as follows. First, we describe previous work on digital learning and gamification, indigenous language learning, and technology inclusion for remote communities. We then present the application design, study methodology and continue with data analysis. The results of the remote user study are detailed next. Lastly, a discussion on the main findings is presented and the work is concluded.

2 Related Work

In addition, to support learning processes in a classroom environment, the integration of technology in schools is essential to provide the skills students need to live in a fast-developing world [6]. Other benefits include enhancing the communication between teachers and students [12] and providing a collaborative and interactive environment [8] for language learning. Nevertheless, in remote locations, such as the Taymyr Peninsula, the use of technology is still limited due to several factors. In this section, we firstly discuss digital learning, including motivating strategies, like gamification and storyline method, and further provide cultural background connected to the topic of technology inclusion and indigenous language promotion and learning.

2.1 Digital Learning, Gamification and Storyline method

Educational institutes all over the world are already working on integrating digital learning into their curriculum as well as encouraging their students to use technology for out-of-school learning. The most recent literature review on second language learning [1] summarized 26 studies and demonstrated that in a majority of cases, in addition to improved language acquisition and increased intrinsic motivation, digital learning games benefit in the development of new competencies and skills, collaborative behavior, and the feeling of autonomy. However, to be successful, educational games should encompass the following features: user-friendliness and interactivity, the feeling of challenge and goal-accomplishment, self-determination, and constant feedback and rewards. Digital learning should not necessarily be applied through games, however, the use of game elements, e.g. gamification, to raise motivation and engagement is becoming extremely popular [10]. Previous studies have shown that mobile-assisted learning applications, employing elements of gamification, have

[1] This data is taken from Russian web – Data on the final results of the 2010 All-Russian Population Census of Russian Federation, http://www.gks.ru/free_doc/new_site/perepis2010/perepis_itogi1612.htm

resulted in a positive and effective learning experience [9, 12]. Gamified applications offer an immersive environment and provide meaningful interactions with game objects to accomplish a learning task. Apart from motivating and engaging users, gamified environments can provide appropriate cultural and linguistic knowledge [26]. The storyline method, or providing a story or narrations as a context for carrying out language learning activities, is another pedagogical strategy to address intrinsic motivation by immersing learners and increasing their involvement in a learning task [2, 28].

Another important factor affecting the success of using digital learning is teachers' attitude towards using it in a classroom environment [3], where a lack of teachers' confidence and competence, as well as resistance to change, can create barriers to the successful adaptation of technology [6]. For instance, a study with Swedish preschoolers [19], focusing on teachers' perspective, discussed tablet-based learning of mother tongue. It identified a desire and positive attitude towards using digital tablets for language learning among teachers, as it may not only motivate children but also provide means for social inclusion and equity from an early age. However, to achieve this, teachers pointed out the need for a national strategy and clear guidelines, since especially in early childhood education, the ethical responsibility of the educators should be seriously worked out

The use of tablets in the classrooms has become popular in the last decade with the release of the first-generation iPad in 2010, especially for learning a foreign or native language [21, 22]. Further, the study by Xiao-Bin Chen [8] explored the use of tablet-based learning outside the classroom and found that when students take responsibility for their learning process, they tend to develop their own learning strategies through self-designed activities and topics, and are more involved in their own learning process than when being guided by a teacher. Therefore, it can be said that digital learning, inside and outside of the classroom, is intrinsically motivating and engaging for students, and has overall positive learning outcomes.

2.2 Technology Inclusion via Digital Games in Remote Communities

Previous work with rural Indian children explored the language learning for children from remote communities employing mobile and game-based learning applications [15, 17, 18, 20]. Kam et al. studied the design of digital games, which they based on traditional (physical) rural games, to allow children to utilize their existing gameplay skills in mobile-based learning. When handing out phones to children in remote communities, they also faced several socio-cultural challenges towards technology acceptance – from boys' use of technology being prioritized over girls', to a lack of reliable electricity access for charging the devices. While the results of their work indicate a motivation to learn and a potential for technology inclusion via gamified approaches on handheld devices, their focus was on the English language and not the children's native or ancestral language. It can be argued that the motivation to learn English is high in the Indian context [24], however, Kam et al.'s work still shows the potential of gamified learning out of school settings, where the onus and motivation towards learning were sustained by the children.

Much has changed since Kam et al.'s work with regards to technology access - it is expected that the next billion users of the technology will be mobile-first [5] and possibly belonging to rural or remote communities. Hence, designing a mobile or tablet-based application remains the right approach for remote communities to include them technologically and socially. However, such an application should be designed considering socio-cultural challenges to avoid negative effects on technology adoption. Hence, it is critical to investigate not only culture-related aspects, such as social desirability [14] but also social and economic factors, influencing remote communities.

2.3 Nganasan Remote community: Language Revitalization and Promotion

Nganasan is a small-numbered indigenous minority, located on Taymyr Peninsula, Russia; their language and culture on the border of extinction with only 100 native speakers[1]. Russian Federation is a multilingual state with more than 100 minority languages spoken; only 35 of those have a status of national languages. Most of the minority languages are endangered and used only in traditional livelihoods [33]. Russian is the only official language and thus, the legal language of education and documentation[2].

Russian Federation has a centralized educational system determined in Federal Law and administrated by the Ministry of Education, which means that the contents of education should correspond to the national educational standards. Although Nganasan, indigenous people of Taymyr, lived on Taymyr territory for over 1,000 years, they have no official status and is not mentioned in the title of Taymyr National district, a part of Krasnoyarsk Krai (an administrative region). The region is a legal entity of the Federation and all the important decisions concerning Taymyr are made in its center, the city of Krasnoyarsk in 2,000 km to the South from Taymyr [34]. Hence, despite Nganasan have a right to get an education in their national language, there is no governmental support or resources to implement it; Nganasan language is taught as a second language in some schools. Lack of digital solutions, presented by governmental structures and other issues related to remote communities (e.g., no direct access to the internet, lack of foundational skills in technology interaction, and cultural values) are the main factors that slow down technology adaptation [31]. Lack of access to technologies result in decreased literacy skills development and, thus prevent the participation of people from remote communities in contemporary society [7].

In the last two decades, the research on preserving indigenous people, their culture and language, with technology is steadily growing. The study by Galla [11] suggests that digital technology is a compelling tool for indigenous language revitalization, as it facilitates the learning process by not only granting direct access to information from any geographic location but also by creating an environment for collaboration and knowledge sharing between the learners (youth) and speakers (elders). Moreover, the technological skills, acquired while learning may be used to document, create and develop language learning resources for future generations. Multiple research studies [11, 13, 25, 26, 31] already show the opportunities and potential of applying media, social networks,

[2] Federal Law N273-F3 "Education in the Russian Federation" article 11

games and gamified applications, and digital storytelling to address the issue of preservation and documentation of indigenous cultures and languages. For instance, work by Crow et.al. [8], explored the use of a tablet-based virtual game world for learning Maori, and endangered language in New Zealand. They demonstrated that students' engagement increased, and the effectiveness of learning new vocabulary improved as the time taken to learn a new word decreased. Another study [26] investigated the impact of using a gamified application for learning vocabulary compared with teacher-led instructions. In contrast to the previous example, this study indicated that students' performance was better with a teacher and concluded that technology should complement, rather than replace, human interaction for enhanced learning outcomes.

Within the context of remote communities, giving teachers autonomy over technology usage in their classroom provides an additional opportunity for digital inclusion of the entire community and not only the students. The Australian project 'Getting In Touch' [7], promoted technology inclusion in remote indigenous communities by directly involving native speakers of the language in learning the application design and development process.

In our study, we addressed digital exclusion through tablet-based learning of a native Nganasan language in a remote community to explore the acceptance of technology and its usage pattern in a school environment. With limited access to the users, teachers introduced the application to the students and moderated the sessions, with minimal researcher involvement. In this way, the members of the remote community had autonomy towards their and their students' digital learning, whereas, and researchers were able to study the self-driven motivational aspects of technology inclusion.

3 The *NganasanMe:* Culture and Language-Learning Application

To address technology inclusion and provide digital means of learning a native language, we designed and developed the *NganasanMe* application. It aims not only to enable digital language learning but also to evoke curiosity and interest in Nganasan culture by establishing a connection between the language, their everyday life, personal and collective history. Therefore, the application was deployed based on storyline method [2]: the materials and appearance were connected to the local environment including national clothes (used nowadays on cultural events and partially in everyday life) and learning content (words related to the remote location weather and animals. The application uses the language of children communication (Russian), as the school curriculum in Taymyr is taught in Russian.

To activate the story plot development while learning, the application uses an imaginary character and personal profiles based on animal pictures. A culturally representative avatar, an imaginary female character named *Dizar* (a Nganasan girl name meaning 'Sun Ray'), guides the usage flow of the application and interactions by providing instructions and encouragement. The familiar and personalized profiles grant children an opportunity for developing their own stories. Hence, to strengthen the storyline method while simplifying the process of logging and switching between users, the student profiles are represented by images of animals; each student should select their animal image and log in to the system by selecting it before a session. The application supports up to 8 student profiles and

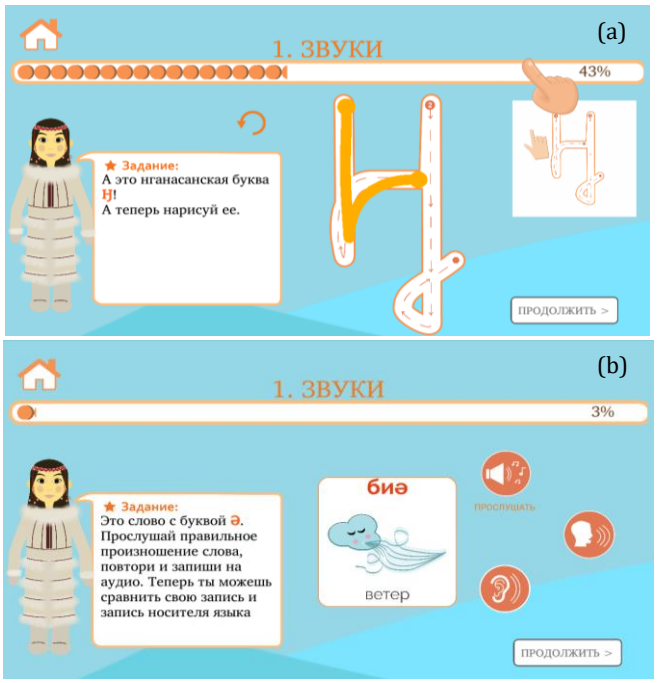

Figure 1. Screenshots from the NganasanMe application: letter drawing task (a) and listen-record-listen task (b)

is designed for both individual and pairwise use. If two students are working as a pair, then each of them must select his/her animal profile.

The application utilizes appealing user interface design in a flat design and starts with a brief introduction to the history of the Nganasan language and community in a form of text and, alternatively, audio. To engage children in the language learning process, the application utilizes gamified elements, e.g., a guiding avatar, badges, a progress bar, and game-like quizzes for language learning [10]. A progress bar, which is visible during lessons and quizzes, is used to visualize the learning progress. Children also get rewards through badges and positive reinforcements after each task.

The application is developed in Unity and can be deployed on any operating system, e.g. Android or iOS, in which Unity runs. In our team, we have a linguistic anthropologist who has extensive experience of fieldwork with Nganasan and who was responsible for the linguistic content of the application. Our goal was to develop software, which can be easily expanded and adapted for other engendered languages. Hence, the content of the application (learning materials, such as words, recordings and pictures) is added to the application in CVS-text configuration files, thus, making it possible to extend the materials by people with no prior coding experience.

The application consists of two lessons: 1st lesson covers specific Nganasan letters and sounds, and 2nd lesson consists of five parts covering all Nganasan alphabet and related vocabulary. The application also includes five quizzes that were required to be completed to proceed further. In both lessons, the tasks are based on simple game-like quizzes, such as (1) select the Russian translation of the Nganasan word from three alternatives, (2) select the Nganasan translation of the Russian word from three alternatives, and (3) train the pronunciation of Nganasan words (via listening to a native speaker's recording, then recording own sound and then comparing both recordings

- see Figure 1., bottom. In addition, depending on the lesson topic, other tasks are added. For instance, in the 1st lesson, which is focused on language-specific letters learning, the users draw the shapes of the letters (Figure 1, top) and select the correct letter for the presented word from 3 alternatives, while in the 2nd lesson the students play the memory game before practicing new words.

Due to the nature of the remote user study, automated data is logged for each profile for each session to analyze the usage patterns. The data is stored on the device's local storage and is programmed to be sent via email when the device is connected to WIFI. The logged data consists of the start-time and end-time for each task, the number of incorrect selections (errors) per task, and whether the session was individual or in pairs. If the sessions are done in pairs, the data is saved for both the student profiles. The logging process ends when the participants close the application or log out, thus returning to the profile-selection screen.

4 Remote User Study Methodology

This chapter presents the methodology of the remote user study, conducted to explore technology usage behavior and motivation in a remote Nganasan community. The requirements for conducting a user study remotely differs from a standard user study due to the lack of control and no direct contact with the participants. Hence, this section provides an in-depth description of the user study process, including the reasoning for selected data collection tools, preparations on our side, the participant demographics, and the procedure recommended to the teachers in the remote community.

4.1 Data collection tools

To measure children' engagement and motivation with the application, we needed to collect both subjective data and performance metrics, e.g., amount of time spent with the application, number of lessons and tasks done during that time and number of mistakes made. Objective metrics, including the timestamps and participants' ID for each task, number of errors and session length, were logged on the tablets' local storage. Having no direct access to children, nor online solutions to connect with them, we identified the need to collect qualitative data via paper-based tools. Children' and teachers' responses were planned to be collected right after every session with the application. To address this need, we designed the NganasanMe learning diary for students to collect qualitative data and, in addition, to support the work with the application. The diary is designed in the same style and color scheme as the game and introduces the application by narrating a story from a Nganasan girl, *Dizar*, who invites children to learn the Nganasan language together with her.

The diary collects materials in three parts: background questionnaire, session questionnaires, and a final questionnaire on the experience with the application and gamified learning in general. *Background questionnaire* is designed using creative and engaging series of tasks, such as drawing, filling empty spaces and selecting from multiple answers and collects participants' name, age, grade number, family pictures, hobbies and interests as well as adaptation to and experience with technology (e.g. tablet, smartphone and PC/laptop).

*The session questionnair*e is a short 5-statement 5-point Likert-questionnaire with a smiley-o-meter scale adapted from Read et al.'s Fun Toolkit [27] (1 = extremely negative smiley face; 5 = extremely positive smiley n face). The first statement asks how the participant feels today, while the other four collect their experience, asking how fun, interesting, and engaging the sessions were and if the participant is satisfied with their performance. To let the participants freely express their feelings or add additional information, we added the box for drawing at the back of the questionnaire paper. The *final questionnaire* collects the overall reaction to the application via the SUXES usability questionnaire [30]. Also, it included 6 statements on gamified learning (utilizing 5-statement Likert-questionnaire with a smiley-o-meter scale) and open-ended questions about positive and negative aspects of the game and suggestions for improvements.

Teachers' diary was designed also in three parts, including a background questionnaire, session questionnaire, and a final questionnaire. Background questionnaire collects teachers' name, age, education, years of teaching experience, and the level of technology use. The session questionnaire, which is supposed to be filled after every session for a group of students, collects how the teacher perceives the situation in class while working with the application. The final questionnaire collects opinions on gamified digital learning in general and insights on how to increase the quality of the application for the classroom environment. Both questionnaires use a 7-point Likert scale (1 = extremely negative; 7 = extremely positive) to collect responses.

In addition to mentioned automated log data and learning and teachers' diaries, we managed to conduct one Skype session with two teachers after the study was over. The semi-structured interview session consisted of 15 questions designed to gain a clear picture of the procedure that was followed and challenges that arose during the study.

4.2 Preparations & Sending

We prepared three Android tablets (HUAWEI MediaPad T3, with a 10-inch screen), 24 copies of children' learning diaries and 5 copies of teachers' learning diaries to be sent to Taymyr. In addition, we prepared a USB stick with all materials and the application APK file in case of any problems with the application. Instead of relying on postal services, we agreed with a colleague, who was visiting the area, to transport all materials for us. Considering border crossing formalities and the restrictions on geographical access to the Taymyr area, we also prepared official documents to accompany our materials to avoid unnecessary complications with authorities. Since we could not be present for the duration of the study, we provided open-ended instructions on how to work with the application (e.g., that children should work under one personal user profile on the same tablet) and how to fill in their learning diaries (e.g., after every session with the application).

4.3 Participants

The children, who took part in the study, were students of the school that was collaborating with the researchers. The official permission from school officials was gathered before the study. The children participated in the study during school, in their classrooms, and in the presence of their teachers. The teachers had full autonomy in selecting the participants among students studying the Nganasan language at the school. The researchers did not contribute to participant selection and were not present at the school during the study.

As result, a significant amount of the target population participated in the remote study: 22 school students, aged from 7 to 12 years (M=9), and three teachers (32, 52 and 61 years). The children-participants studied in 1st - 5th grades in one local school. For both children and teachers, the Russian language is the primary language of communication, children's language skills correlate with their age. The experience with technology among the participants was low, as only five participants (four of them aged 11-12, and one aged 8) used a smartphone, tablet, and PC in their daily life. In contrast, four participants did not use any technology at all, four participants used only smartphones, three participants use only tablets, one participant used only a PC, and five participants use both PCs and smartphones. These devices are mostly used for gaming, watching movies, studying, and communicating via social networks.

As for teachers, one of them used a smartphone, laptop and PC and two others use the only laptop in their daily life. The technology is mainly used to make educational presentations and prepare audio and video materials. Technology inclusion in the classroom happens through these presentations and multimedia materials the teachers create. As for the level of Nganasan language skills among the participants, only *15 participants* responded to the question; six children (40%) indicated that they know many words in Nganasan, five (33%) knew a few words, four (27%) can speak a little, and one (7%) did not know the language. Of the three teachers, two are Nganasan semi-speakers with eight and 25 years of teaching experience, and one is a native speaker with 39 years of teaching experience.

4.4 Procedure

The application was used by the participants as a part of their classroom lessons (single or doubled lesson, from 45 to 90 minutes) in pairs or individually for the duration of one month. The introduction part, e.g., reading the story with Dizar and filling in the background questionnaire happened during the first session, guided by a teacher. Further, the participants worked with the application during their Nganasan lesson and filled in *the session questionnaire* after every session. At the end of the user study period, participants and teachers filled in their final questionnaires. All paper material was scanned and together with the log data, was sent to us via email and WhatsApp. Subjective data was encoded into excel files and translated into English by a native Russian speaker. Log data was simplified and analyzed using MatLab. The results from the quantitative data analysis are described next.

5 Results

In this chapter, we describe the results of the remote user study, including the analysis of log files from the application as well as the analysis of subjective data from a skype meeting and learning diaries. Due to the nature of the study and lack of control from researchers, there were two main challenges with data collection and analysis. First, adherence to the learning diaries was mixed as some students were regular and others not that much. For the teaching diaries, only one teacher filled in the final questionnaire. We also speculate that some pages from the learning diaries might have been misplaced, lost, or not scanned back to us – adding to the issues in data collection and retrieval. Automated log files received from one of the tablets were corrupted, and although we managed to recover them, it is difficult to confirm that no data was lost. Second, sessions with the application were conducted freely during the regular Nganasan language teaching schedule for five weeks (mid-April to mid-May 2019). This means that sessions vary in duration, the number of lessons and tasks completed, and whether done individually or in pairs and further, with a new partner or a previous one. On the flip side, such a wide variation between sessions for each participant makes for an interesting case to study the usage of the application "in the wild".

5.1 Participant performance and progress

In total, there were 42 sessions with the application (23 in pairs and 19 individual) and a total of 16 hours and 42 minutes were spent using the application. Participants, in pairs and/or individually, completed between one and six sessions with the application, with an average of 3 sessions per participant (SD=1.4). Of the 21 participants, only three participants had six sessions, while fourteen had three sessions or less and four had four to five sessions. One session took on average 23 minutes and 18 seconds (min=2.2; max=70.5). Only one participant had not progressed further than lesson one, while nine participants (40%) completed the application (reached the last quiz), and eight of them continued to work further, repeating the tasks.

There is wide variation between each participants' usage of the application including the number of sessions, duration of each session, number of lessons and tasks. Further, participant pairing behavior is also not always consistent. This makes it difficult to compare performance and progress statistically. Therefore, Figure 2 visualizes participant behavior and usage, and showcase participants' grouping pattern and performance. It demonstrates that most participants usually paired up or formed small groups of 3-4 students. Next, we report the usage behavior based on pairing (three participants, who worked individually, four constant pairs and three groups of participants, who changed their pairs).

Individual participant performance: Looking at individual participant usage, we noticed that only three participants (P12, P18, P19) used the application individually with only one (P18) who had more than two sessions. It is difficult to comment on exactly why P12 and P19 did not continue using the application but their average time and tasks per lesson are already considerably proficient. This could indicate that the application was too easy for them to retain interest and engagement.

Paired-participant performance: The participants who worked in pairs showed more motivation towards using the application and increased learning progress. For instance, pair A (P4-P5) had two sessions with the application with dramatic improvements already in the second session when compared to their first. In pair B, P6 had five sessions with the application, pairing with P7 for three of them, and showing improvements both when working as a pair and individually. The pair C (P13-P14) worked together for three sessions and showed improvements in the average time per lesson with a similar number of tasks covered in each lesson. Lastly, pair D (P20-P21) worked both individually and as pair for multiple sessions, reducing their average time per lesson between their first and last sessions while completing the same number of tasks per lesson. Further, chronologically marked sessions for group A (formed with P1, P2, P3) illustrates that the average time taken per lesson decreases drastically in subsequent sessions, showing their improvements in using the application.

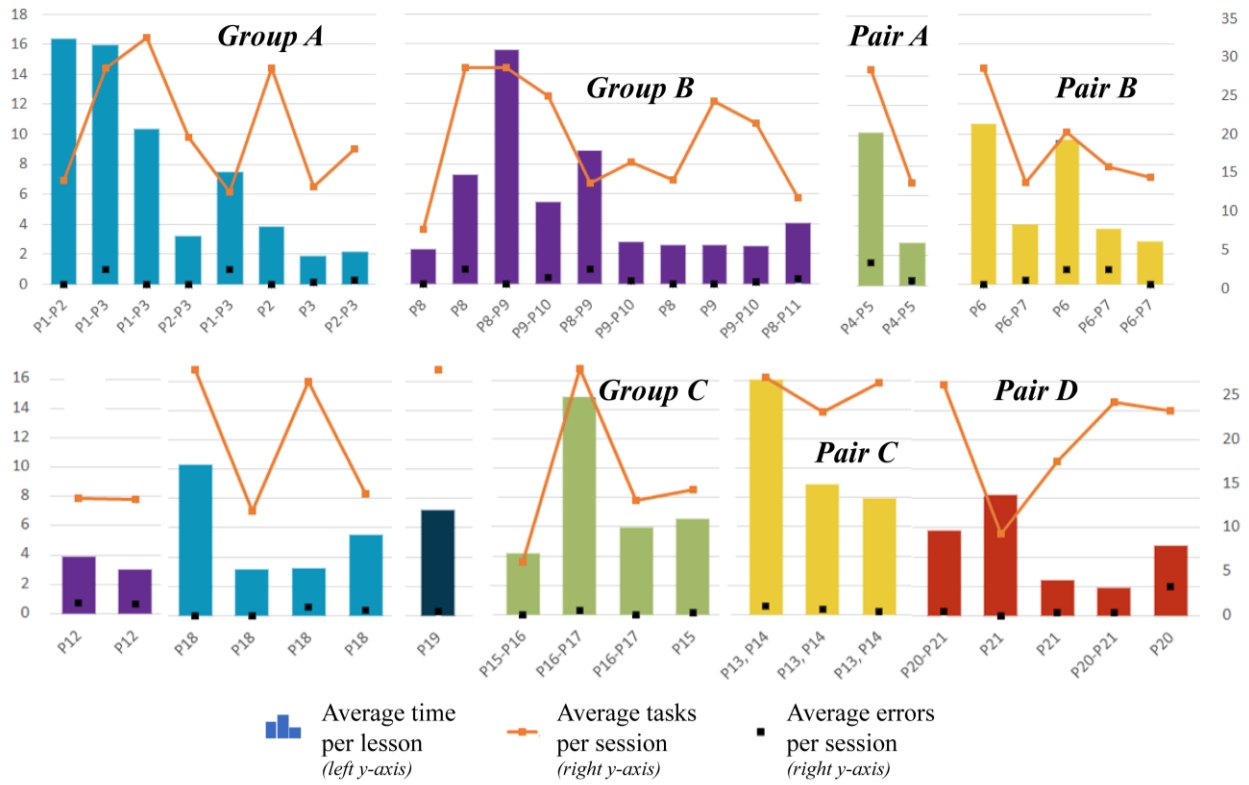

Figure 2. Participant performance for each session conducted with NganasanMe application. (The x-axis lists the participant numbers; the y-axis (left) denotes the average time per lesson in minutes; y-axis (right) denotes the average number of tasks completed per lessons; black points (marked on the y-axis on the right) are used to show the average number of errors per lesson.

The average tasks completed per lesson and the number of errors per lesson remain somewhat similar between the first and last sessions for these participants. The pairing behavior of group B (formed with P8, P9, P10 and P11) seems to suggest that as participants became familiar and comfortable with the application, lessons, and tasks, they helped or paired with a new learner (P8-P11 pair). Group C (formed with P15, P16, and P17) as opposed to group A, showed an increase in average time per lesson in subsequent sessions, which can be attributed to the increase in the number of tasks performed per lessons. Therefore, it is difficult to comment on their performance improvements, but they were interested and motivated to continue using the application over multiple sessions.

In summary, Figure 2 illustrates that most students were motivated. Several can be called leaders who had the greatest number of sessions with the application and continued working and repeating the lessons individually or in pairs, helping other partners. Thus, P1 and P3 from group A, P8 and P9 from group B and both participants from pair D and P18 had 4 or more sessions, clearly demonstrating their motivation and desire towards using digital learning game *NganasanMe* in a classroom environment.

5.2 User experience and subjective feedback

The overall reaction to the *NganasanMe* application was extremely positive from both the students and teachers. However, one of the reasons for extreme reactions can be social desirability bias, which is especially revenant for eastern cultures [14].

Student experiences: In total, 56 session questionnaires were filled by students with a maximum of four sessions. This indicates either loss of data or low adherence to filling in the questionnaire after the 4th session.

In overall, the students expressed a positive attitude and joy towards using the application, and many of them left drawings (e.g., smiley faces, an illustration of learned words and letters) and warm regards to the researchers in their learning diaries (Figure 3). For instance, a 4th grader who had only one session wrote: "*It was very cool and funny to play on tablet and meanwhile learn Nganasan*", or a 3rd grader, who had 2 sessions left a beautiful drawing and wrote *"I am so glad!").*

Figure 3. Children's drawings

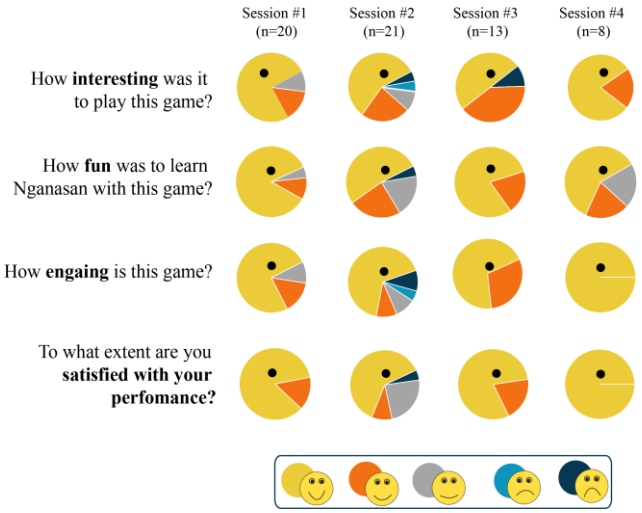

Figure 4. UX questionnaire as answered after every session; N represents the number of participants for a given session

Figure 4 shows the division of students' answers to the session questionnaire for each session, answered on a five-point smiley-o-meter [27]. It shows that more than half of the answers to all the questions were marked as extremely happy. However, we note here that the user study procedure itself varied between grades, supposedly due to different teachers, which results in a variation of sessions numbers. Thus, all 3rd graders had from 2 to 4 sessions and left no negative responses during their study process. Between 4th and 5th graders, only two students left negative responses in their final sessions (which in practice were the 2nd and 3rd session of the overall study process). None of the first graders had more than two sessions; three of them selected neutral smileys under fun and personal performance statements in Session 2.

In total, 17 children responded to the final questionnaire (4th graders left it blank). All of them showed a positive attitude to learning languages with a game (M=5) and 88% would like to continue playing this game (M=5), while one 5th grader was negative, and one was neutral. Further, 88% of the participants were positive and 22% were neutral about playing this game at home (M=5). All the participants agreed or highly agreed, that the game was useful, interesting, and entertaining. However, three participants from the 1st and 2nd grades disagreed that the game was easy to learn, natural, and effortless. Further, all the participants liked to study the Nganasan language with this game (M=5) and agreed they learned a lot (M=5), including new words and their correct pronunciation. The data showed no relation between the level of Nganasan prior to using the application and engagement with the application. Similarly, previous experience with technology has no effect on how students perceived it.

The most engaging and fun learning task (by teachers and the majority of students) was found to be a listen-record-listen task, where students practiced the correct pronunciation based on native-speaker recordings. Further, in the final part of the learning diaries, which collected ideas on how to make the application better and more engaging, the students asked to add more lessons and suggested including more games as well as more difficult tasks and learning materials (such as phrases, sentences, stories). During the skype meeting, two teachers also expressed the desire to continue working with the application in a classroom environment and agreed to share their learning materials and collaborate when developing new lessons.

Teacher feedback and experiences: During the skype interviews with teachers, one teacher explained that the application was not yet suitable for 1st graders, since they supposed to have only speaking hours and writing lessons start in the 2nd grade. The negative responses were left by two participants from 2nd grade during their second session. One of them dropped, but another continued working with the application for two more sessions and left only extremely positive responses. To summarize, the figure illustrates a positive perception of the application among students who had more sessions, indicating that negative reaction may be party explained with no prior experience of technology.

As is seen from Figure 3, there is a significant student drop-off by the end of the study. During the interviews, the teachers did not mention any negative issues which can be linked to this decrease; however, several reasons may explain it. Since the procedure of the application usage varied, not all classes were able to work with the application for more than two sessions; for instance, 1st and 4th graders (eight students) had only two sessions with the application. For 5th grade students, the application was too easy, and some completed all the lessons with three sessions. Further, some of the students may not simply attend the school classes.

One of the teachers shared their experience on utilizing the application in a school curriculum during our skype meeting: *"Everything went well. It is sad there were only 2 lessons in the application, and we cannot move forward".* Also, in the learning diary, one of the teachers mentioned that *"kids expected more lessons and were ready to learn their native language with the app."* From the analysis of the teachers' session questionnaire (answered on a 7-point Likert scale), we identified that children had fun working with the application (M=7) and were interested in the game elements (M=7). Also, children were engaged with the learning process (M=7) and motivated to learn the language with the application (M=7). Further, one of the teachers strengthens the case for utilizing the application in the school curriculum by commenting that "it helps to learn the native language and increase the interest towards the language learning process."

In summary, the result demonstrated an *overall positive user experience* and *significant variance* in the number of sessions. However, based on both objective and subjective data, we cannot conclude that the adoption of technology was successful. One teacher and 4th graders had only two sessions and did not continue further for unknown reasons. Important to mention, that 4th graders left positive responses to their learning diaries, but the teacher's perspective is lost since the teacher did not participate in the post-interview. Therefore, the teacher's role should not be underestimated when approaching remote communities for technology inclusion.

6 Discussion

With this article, we introduce a case study for teacher-led technology inclusion in remote communities. We developed a digital learning application for the endangered Nganasan language and sent three tablets with the application to a school in Taymyr, a remote community in Northern Siberia. In addition

to collecting usage log files from the application, we utilized paper-based data collection tools (e.g., the learning diaries for students and teachers) to study their technology usage behavior, user experience, and motivation. Three teachers incorporated the application to their regular Nganasan classes among 1-5th grades for five weeks. The researchers were not present or involved in the study process and had limited contact with teachers and school officials. In this way, teachers, and possibly also their students, had autonomy over the use of the application and tablets.

6.2 Children's experience with *NganasanMe*: the application for endangered language learning

From the perspective of children, they left extremely positive reactions to studying their ethnic language with a tablet-based gamified application based on the storyline method. Also, they showed interest and desire to use the application for more lessons with increased complexity and variation of tasks. Most of them had engaging and interesting learning experience while studying new materials, e.g., new vocabulary together with its correct pronunciation. Since no relation was found between the student engagement with the application and their prior knowledge of the Nganasan language, it may be assumed the application was engaging despite the knowledge level.

Furthermore, our result demonstrated that as students became more confident technology users, they started to be more interested and engaged in the study process; the user experience was relatively higher at the final sessions. Despite only 40% of the participants completed all the lessons and quizzes, 89% of those students continued practicing and repeating the tasks, clearly showing the desire to learn the language with a tablet-based game. Despite the drop of students by the end of the study can be explained with other reasons, it may also demonstrate a low achievement, especially compared to the high verbal estimation. Thus, we assume the high degree of social desirability bias prevented us from getting more accurate information on the children's motivation from the questionnaires. Hence, in accordance with existing work [16, 18], in the studies with remote communities, it is of high value to explore cultural and socio-economic background [14] and utilize tools (e.g., based on objective metrics) to measure motivation more accurately.

In our case, objective metrics also demonstrated a variation in flow and usage patterns depending on the grade number (and the leading teacher) and session number. For instance, for the 1st-grade students, the materials from the application were too complex, and thus, some of them found that the application required too many efforts and is hard to learn. Similarly, some 2nd-grade students found their 2nd session to not be interesting nor engaging. On the contrary, older students from 3-5th grades showed more eagerness and interest in the game; especially 3rd graders, who had the greatest number of sessions and extremely positive answers in their learning diaries accompanied with drawings. Hence, considering the readiness of teachers to be involved in the development process and the interest in digital learning among students, developing the application further and adopting it for all age groups would be one way to provide technology inclusion and positively affect the promotion of dying language learning. These findings are on par with Carew et al. [7], who propose using native or familiar languages for indigenous groups, for technology to be effective at social inclusion of such communities.

Considering the usage behavior and motivation, the log data analysis contributed to understanding the usage patterns of the application in a classroom environment. Most of the students worked with the application multiple times, in pairs or individually. Only three participants worked with the application individually, two of them having multiple sessions. The rest prefer to collaborate with others, pairing with the same participant or creating groups and changing pairs dynamically. This behavior is expected in a classroom environment, where groups of friends might decide to work together and negotiate pairing for each session. However, this can be also explained with a limited number of tablets (three) per session, which accounted for two to five students.

Therefore, it can be said that applications designed for the remote environment should support collaboration and group work, as participants enjoy or prefer working with their friends and peers, helping, and motivating each other. This finding resonates with previous work on introducing technology in an underserved environment, including mobile-based learning for out-of-school rural Indian children [17] and also computer-based learning for rural Indian school children [4], [23]. In both cases, children shared devices and worked collaboratively. Moreover, our results indicate that children, who participated in collaborative learning, were more engaged with the application and showed better results (e.g., decreased session time in relation to the number of tasks made).

To conclude, our study demonstrates the potential of utilizing digital learning to promote technology inclusion in the context of remote communities. Local children and teachers showed enthusiasm towards native language learning via a tablet-based application and showed a desire to take an active part in the future development of the application, thus, being even closer to the technology.

6.1 Technology inclusion through teachers

Previous work already indicates that teacher's attitudes and motivation to deploy technology in their classroom can influence student's learning outcomes [6][21][26]. In our work, even when the teachers had limited personal technology experience themselves, the application usage data reflects an acceptance of technology in the classroom by two of three teachers. Further, subjective data analysis also demonstrates a positive attitude towards the gamified application for language learning from both students and teachers. Two teachers out of three showed positive reaction and enthusiasm towards using digital technology during their class, even though, as mentioned earlier, none of them had a prior experience of working with a tablet.

The only negative received feedback was that the application had a limited number of lessons. Teachers and students were expecting to use the application for a longer period and to fully cover their teaching curriculum. However, the process of integrating technology into a classroom environment was not extremely successful. One teacher, although initiated the process of using the application for two sessions, did not finish it, despite the overall students' reaction to the application was positive. The reasons are unknown since this teacher did not participate in the post-interview.

On the other hand, two teachers, who participated in the post-interview, showed a willingness to contribute to the application development. They agreed to share their teaching material and provide feedback on the design of the new lessons.

Further, they shared that a centralized system of education puts all teaching methods and materials in a strict framework. That might be one of the reasons why they wish to share their teaching materials since they have no possibilities to utilize our application otherwise. This behavior of seeking out technology for the classroom and embracing change is in contrast with Bingimlas' [6] findings. They found that a lack of access to resources, and subsequently lack of competence and confidence in using technology were large barriers towards technology integration within a classroom. In our case study, we found out, that, despite similar barriers, school children and their teachers are motivated to use technology in the classroom.

Overall, the teachers' positive attitude and desire to develop the application further to align it with their curriculum, indicates that remote communities, despite limited access to and experience with technologies, are ready to adopt them. An important way to further establish teachers' and students' motivation to adopt technology in the classroom comes from the nature of the study itself – of being remote. Three teachers and their students, having no enforcement from the researchers and no extrinsic motivators, still preferred to use the application and spend their time using it. Two out of three teachers completed the five-week study and showed a desire to integrate it into their study program. This indicates that people from remote communities, despite limited technology exposure, access, and experience, potentially value its use. Although not inquired in this study but reflecting on work by Kjallander et al. [15], using a tablet-based learning application provided opportunities for social inclusion and equity for young children. Similarly, we purport that teachers and students in our study, living in the remote district of Taymyr, associated potential technology experience and use with opportunities for global inclusion and equity.

6.3 Limitation and Future Work

A major limitation of our remote user study was the lack of control and observations, which we tried to replace with automated log files. Despite we collected both objective and subjective metrics, it was impossible to link these data to draw clear conclusions. Further, due to no access to communication with children, we cannot conclude the reasons behind the sessions flow, e.g. why some participants had only one or two sessions and what reasons been hidden behind their negative responses. In addition, the remote setting of the study also resulted in missing data: some learning diaries by children and teachers were not filled in completely or lost in addition to missing log file. To address arisen issues, the methods of gathering live data from children should be found, e.g. recording video or audio feedback through provided devices or even recording the process of working with the application. However, due to the logistics and bandwidth limitations, these approaches could further complicate the data collection.

To further promote technology inclusion in remote communities of Northern Russia, we plan to arrange online participatory workshops with children and extend the spread of application to other cities and villages of Taymyr. Further, conducting remote user studies outside the school environment would provide more insight in improving the application in terms of learning, cultural appropriateness, and technology adoption.

7 Conclusion

While technology inclusion for remote communities has been a topic of research for the past decades, motivating the use of technology through a native language learning application for the classroom environment has not been studied as much. To explore this topic further and contribute to the fields of HCI and CSCL, we developed a tablet-based learning application - *NganasanMe* and sent three tablets together with paper-based data collection tools to study technology usage behavior and motivational aspects of local students and teachers.

Our findings showed a positive attitude of two teachers towards the use of digital learning in a classroom environment and a desire to participate in the further development of the application. Children were engaged with tablet-based learning of their ethnic language, especially in collaboration with their classmates, and were looking forward to completing new lessons with the application. Based on our case study results it can be concluded that the children of the remote community were motivated to utilize a digital means of learning and practicing the language of their predators despite their prior knowledge of the language. Although our results did disclose social desirability bias via contradiction between all-positive diaries and usage drop, there is still evidence of positive effects on student engagement, learning and technology adaptation in a classroom environment. Further, our findings showed that the most motivated students would act as the leaders: they not only practiced and repeated their lessons but also helped other students with the application Hence, by providing people in remote communities with devices and the means of digital learning, we addressed the barriers of technology inclusion in remote areas and affected their collaboration not only in language learning but also in the development of technical skills, which are essential for their integration to society of today.

The cultural and socio-economic situation in a remote location should be taken into account. In the conditions of an authoritative and centralized social system, it is especially difficult to introduce new methods; every innovation should go through educational bureaucracy and introduced into the curriculum. That is why the contents to be learnt should follow the officially accepted textbook. On the other hand, games can be used as an addition to the official system and thus, the gamified application is potentially the best form to be used if the researcher wants to avoid bureaucratic procedures. Thus, the development of an application for minority language learning demands not only knowledge of the local environment and local culture but also understanding of the overall system of management of education curriculum, in the other words, multilevel cultural competence.

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