How Teacher Feedback Helped Reimagine, Redesign, and Recode a Sustainability Education App

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Abstract - Pollution, deforestation, and climate change have been taking a toll on Kazakhstan's fragile ecosystems. The consequential challenges of food insecurity and resource depletion are further exacerbated by the growing population in densely populated cities such as Almaty, Astana, and Shymkent. Despite Kazakhstan's initial efforts towards carbon neutrality and setting a target to achieve it by 2060, there is still significant work to be done to reach that goal. Governmental and public efforts are impactful, but educational and technological approaches are also crucial to effectively addressing the issue. So how can we make that possible? Over the last three years, researchers at Lehigh University in the United States and Almaty Management University in Kazakhstan have collaborated on developing Save Tuba. Save Tuba is a gamified sustainability platform that aims to educate students in grades second to fifth about building sustainable habits through inquiry-based learning techniques. The application utilizes two powerful pedagogical tools, gamification, and inquiry-based learning, to create a dynamic and collaborative learning environment that actively promotes long-term habit formation and behavior change. Our approach involves emotional engagement through interactive games and activities to encourage meaningful interactions with surroundings and peers. This paper details the use of teacher feedback from focus group discussions to enhance our approach to addressing environmental problems and building a better application.

Keywords - gamification, inquiry-based learning, humancentered design

I. INTRODUCTION

Kazakhstan faces significant environmental challenges that require attention and action. One pressing issue is air pollution with several cities including Almaty and Astana experiencing dangerously high levels of particulate matter and pollutants. Kazakhstan's investment in fossil fuels accounted for twenty-one percent of its GDP and more than fifty percent of its exports in 2021 [1]. This persists despite the country's efforts towards its 2013 declaration of transforming into a green economy by 2050 and signing the Paris Agreement. Water scarcity and pollution are also concerns, particularly in regions heavily reliant on irrigation for agriculture. Additionally, deforestation and

desertification pose threats to biodiversity and ecosystems, while improper waste management contributes to land and water contamination. These issues are compounded by a growing population and industrial development. Addressing environmental issues is essential to safeguarding Kazakhstan's natural resources, promoting sustainable development, and ensuring a healthier future for its citizens.

A series of policies and partnerships in the last decade have catalyzed a movement toward implementing sustainability education at all levels. At the 2020 Climate Ambition Summit, the President of Kazakhstan, Kassym-Jomart Tokayev, promised the country would be carbon neutral by 2060. In the interest of Save Tuba, the most important milestone for Kazakhstan's environmental programs was also in 2020, when the "United Nations Development Programme in Kazakhstan (UNDP) and the Ministry of Education and Science launched a joint project on developing environmental education in Kazakhstan" [2]. Regarding the country's sustainable development, ex-President N. Nazarbayev set the task of transitioning to a "green economy" by 2050 [3]. Although this initiative has created a regulatory framework for sustainable development, there is still an acute need for modernizing the education system and greening its content [4].

Children's impact on their social systems is widely overlooked but has a substantial impact. Where much of the anticipated change is found within the existing social systems, there is, "a significant body of evidence highlighting the role of young people as change agents" [5]. Another study states there is a prominent difference in parents' behavior based on their children's habits. A study by Proctor and Gamble found that in the US, "nine in ten parents reveal that their children influence their sustainable behavior at home" [6].

Save Tuba is a mobile game application for students aged eight to eleven to educate them on sustainable behavior through gamification and inquiry-based learning techniques [7]. The project is a multi-year collaboration between Lehigh University and Almaty Management University under the aegis of the Global Social Impact Fellowship program. Save Tuba engages its users emotionally through the main character, Tuba, which is an endangered saiga antelope found in the Kazakh Steppe. Students interact with this character while completing learning exercises and activities to gain a practical understanding of sustainable education. Game characters and emotions have been shown to affect cognitive abilities such as long-term memory and creative problem-solving [8]. Based on past focus group insights, the application focuses on six important concepts, such as pollution prevention and waste management, which are executed through curriculum and software development.

Past focus groups reveal that there needed to be an increase in the ease of application navigation and engagement for long-term usage [9]. Teachers found the instructions for games and activities confusing. Hence, the suggested utilizing visual aids and prompts to communicate the instructions clearly, ensuring an intuitive and user-friendly interface. Another amendment was devising a reward system that incentivizes users to strive towards achieving specific milestones within the game curriculum. In response to these suggestions, a refined leaderboard was implemented to curate a friendly, competitive environment among students, as shown in Figure 1.

This article describes how Save Tuba was reimagined, redesigned, and recoded with human-centered design as the nexus of the process. Human-centered design has four components: clarification, ideation, development, and implementation [10]. Throughout the team's process, teacher feedback provided clarification and was incorporated into the design process to enhance the application's product-market fit. The paper outlines the process of making changes to the application through teacher input in three broad categories: curriculum, application development, and teacher interface. Teacher involvement aided the development of Save Tuba, ensuring that it aligns with their instructional needs and effectively supports their teaching objectives.

Students are the target audience for the application, as they will be the end users benefiting from its educational content. Additionally, it is important to note that the facilitators utilizing the application are the teachers themselves. The application is designed to support and enhance their teaching methodologies. In this context, the schools serve as the customers of the application, as they will integrate it into their educational programs. Additionally, the Ministry of Education in Kazakhstan plays a crucial role as a main customer, as they oversee and endorse educational initiatives within the country. To demonstrate the application's effectiveness and value for students, the validation process involves obtaining feedback and input from teachers and experts, who act as credible evaluators of its educational impact and usability.

II. REDESIGNING SAVE TUBA

Genesis: Games have often proven to be the biggest motivators for affecting children's behavior. Chuang et al. concluded in their experimental study that computer and video games can benefit children's development and learning, contributing to their cognitive development [11]. Popular mobile applications like PokemonGo and Subway Surfers, along with educational applications like Duolingo and Quizlet, have made a massive impact on children's psyches and permanently modified their behavior and

Fig. 1. Leaderboard



Fig. 2. Lesson Screen



Fig. 3. Mastery Exercise

mindset by incorporating a blend of gamification and inquirybased learning strategies. Application-based approaches to education have become popular due to the rise of smartphones and the Internet [12]. After assessing the current habit-building strategies in other applications, Save Tuba is designed to integrate the best practices from these applications to emotionally engage their audience through exciting games and quizzes while simultaneously educating them on natural science topics from their curriculum, as shown in Figure 2.

Teacher feedback: Gathering feedback from teachers is a crucial aspect of evaluating the effectiveness of our approach. Focus group discussions were conducted in Almaty during May 2022 with IRB approval from Lehigh University and Letters of Support from participating schools. Through these focus groups, the teachers provided essential feedback on various aspects, including the usability, curriculum, pedagogy, user interface, and integration of our application into the school system. Their input holds excellent significance due to their status as industry veterans.

Save Tuba is tailored for Kazakhstan's national curriculum to ensure seamless integration into classrooms. The teachers serve as invaluable resources through their understanding of the students' educational needs. Additionally, they are enthusiastic about assisting the team in formulating appropriate questions and activities to enhance the application's engagement and level of challenge.

The team organized and thoroughly analyzed the ratings and evaluations, and necessary measures were taken to address the identified shortcomings.

a) Difficulty: According to teachers, the games are perceived as interesting and valuable, whereas they find the quizzes lacking in sufficient difficulty. The team's research and translation efforts were highly appreciated; however, the main suggestion was to enhance the curriculum's level of challenge and difficulty.

In order to create quizzes and games that meet the school standards without overwhelming students and peaking their interest, the curriculum team requires additional support and resources. Therefore, establishing partnerships with teachers and government officials, who can assist in refining and evaluating our curriculum, becomes imperative for the success of the venture. The team is currently working on a new draft of grades two through five curriculum.

b) Engagement and creativity: The value of the gamified system was recognized by the teachers, as it not only engages students' minds creatively but also provides support in learning the school curriculum. Teachers suggested incorporating activities and games that go beyond traditional textbooks, which would encourage creative inquiry, and critical thinking among students. Therefore, emphasis was placed on reworking the mastery questions, an example of which can be found in Figure 3.

A major challenge with the curriculum in Kazakhstan is that it emphasizes rote memorization, lacking practical application. Withal, the process of developing a comprehensive curriculum that aligns with educational standards and promotes effective learning poses its own set of challenges. The curriculum team is compiling additional resources and guidance to ensure that the application meets the necessary criteria. Additionally, the implementation of the teacher's feedback on new games poses challenges for the team due to the necessity of using complex algorithms, user interactions, and data management, which require specialized programming skills.

This led the team to recognize the significance of ensuring the application's code is dynamic and adaptable instead of static and rigid. By doing so, the team can enhance the development of more challenging and multi-faceted features within the application. Additionally, the team had to incorporate translations into Kazakh and Russian languages in addition to the original English content. This added complexity to the codebase, considering different language structures, character sets, and linguistic nuances. Following feedback from teachers about unclear translations, the curriculum and software teams collaborated closely to address and overcome these challenges.

c) Performance and practicality: Teachers provided positive feedback regarding the app's practical need through the market gap for such a learning tool, which aims to cater to all stakeholders' needs. However, teachers also emphasized the importance of their long-term relationship with the application and their students' performance. It was clear that Save Tuba needed to become a two-way interface, where students can engage with the application through its various features, while teachers are equipped with the ability to monitor student progress and carry out relevant tasks. Thus, the inclusion of a teacher interface became essential to facilitate these requirements.

This website was constructed using WordPress, incorporating a plugin that utilizes CSS shortcodes to interact with the application's backend database. The most significant obstacle encountered throughout the process revolved around authentication and authorization. This particularly involved ensuring the secure protection of pages containing sensitive information to prevent unauthorized individuals from accessing them. One specific example is the class information page, which required additional measures to maintain its confidentiality and limit access to authorized users only.

III. CONCLUSION AND NEXT STEPS

Through extensive fieldwork, the team had the valuable opportunity to gather insightful feedback from teachers

regarding the usability, curriculum, pedagogy, user interface, and integration of our application into the school system. This hands-on approach allowed us to gain a deep understanding of the challenges and requirements faced by teachers in their daily teaching practices. Armed with this knowledge, the team made significant changes to the application, ensuring it aligns effectively with the needs and preferences of educators.

The feedback provided by teachers proved crucial in refining our development process. By engaging them as expert advisors, the team tapped into their wealth of experience and expertise, allowing us to create a curriculum that is not only relevant and comprehensive, but also pedagogically sound. Their input guided us in making informed decisions about content selection, instructional strategies, and assessment methods, ensuring that our application provides an engaging and effective learning process. Furthermore, involving the teachers in this collaborative experience fostered a sense of ownership and investment in the application's success, as they played an active role in shaping its development.

This paper highlighted the journey of Save Tuba, a gamified approach to educating young citizens and building sustainable habits. Save Tuba has implemented an all-new approach to inquiry-based learning and, in May 2023, launched a beta version 2.0. This project was made possible through the collaborative efforts of Lehigh University and Almaty Management University. The team strongly believes that by implementing such revolutionary pedagogical techniques, it can better educate and engage the younger citizens of Kazakhstan as well as expand to other countries in Central Asia and beyond.

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