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Development of a Children's Educational Dictionary for a Low-Resource Language Using AI Tools

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Abstract: Today, various interactive tools or partially available artificial intelligence applications are actively used in educational processes to solve multiple problems for resource-rich languages, such as English, Spanish, French, etc. Unfortunately, the situation is different and more complex for low-resource languages, like Kazakh, Uzbek, Mongolian, and others, due to the lack of qualitative and accessible resources, morphological complexity, and the semantics of agglutinative languages. This article presents research on early childhood learning resources for the low-resource Kazakh language. Generally, a dictionary for children differs from classical educational dictionaries. The difference between dictionaries for children and adults lies in their purpose and methods of presenting information. A themed dictionary will make learning and remembering new words easier for children because they will be presented in a specific context. This article discusses developing an approach to creating a thematic children's dictionary of the low-resource Kazakh language using artificial intelligence. The proposed approach is based on several important stages: the initial formation of a list of English words with the use of ChatGPT; identification of their semantic weights; generation of phrases and sentences with the use of the list of semantically related words; translation of obtained phrases and sentences from English to Kazakh, dividing them into bigrams and trigrams; and processing with Kazakh language POS pattern tag templates to adapt them for children. When the dictionary was formed, the semantic proximity of words and phrases to the given theme and age restrictions for children were taken into account. The formed dictionary phrases were evaluated using the cosine similarity, Euclidean similarity, and Manhattan distance metrics. Moreover, the dictionary was extended with video and audio data by implementing models like DALL-E 3, Midjourney, and Stable Diffusion to illustrate the dictionary data and TTS (Text to Speech) technology for the Kazakh language for voice synthesis. The developed thematic dictionary approach was tested, and a SUS (System Usability Scale) assessment of the application was conducted. The experimental results demonstrate the proposed approach's high efficiency and its potential for wide use in educational purposes.

Keywords: low-resource language; ChatGPT; children's education; Kazakh language; artificial intelligence

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1. Introduction

Linguistic dictionaries are typically designed for adults and older children, often containing complex terms and specialized language. These can be difficult for younger audiences to comprehend. In contrast, children's dictionaries employ simpler, more understandable language appropriate for a specific age group. They often feature bright illustrations to aid in the visual memorization of words. The primary differences between dictionaries for children and adults lie in their purpose, language, and methods of presenting information.

In many countries, preschool education is considered to play a compensatory role for children who have not received support from their immediate environment, i.e., from home [1]. Researchers such as Tsiolkovsky and Goldstein [2] have shown that children with delayed speech development can catch up with their peers and improve their communication skills and literacy if they receive support. This is confirmed by Grabmayer [3] and Lennox [4]. It is also evident that children with extensive reading experience from various media and environments where parents are involved in reading have higher phonological awareness, broader letter knowledge, and more extensive vocabulary than children who engage in reading. Preschool educators in various global studies have reported that many children have poor speech and language development and, therefore, need support [5]. It is known that children with poor communication skills can develop both active and passive vocabulary if they receive the right support [6]. In this case, "right" means individually adapted. Thus, reading aloud can be seen as a tool for improving communication [7]. One of the tasks of preschool educators is to observe children's communication abilities based on each child's capabilities.

In the era of active digital society development, the importance of effective communication becomes apparent from an early age. Every child, regardless of their native language or social background, should have equal opportunities to learn their native language. Preschools and schools play a crucial role in developing language skills and serve as the foundation for children's education. Quantitative differences in children's speech behavior are observed in early preschool years. According to G. Lyamina's research [8], the volume of independent speech utterances during a 30 min play period changes as follows: for children aged 2 to 2.5 years, the average speech activity is 25–28 words; for children from 2.5 to 3 years—70–80 words; for children from 3 to 3.5 years—110–115 words [8]. Speech development delay can be diagnosed during the period when speech should already be developed, namely, at 3–4 years.

Speech development delays can be diagnosed during the period when speech should be well-developed, typically around 3–4 years. Vocabulary development in children is closely tied to their ability to understand words that denote objects in their immediate environment, actions associated with those objects, and their characteristics. In the first two years of life, a word functions as part of a complex influence from adults, including gestures, intonation, and the situation in which the word is spoken. The word then becomes an integrating signal. As children grow, the number of words they use increases rapidly, although the rate of growth slows down. For children aged 3–5 years, mastering the clear referential meaning of words and their specific meanings is central, and by 5–6 years old, they begin to develop a system of so-called everyday concepts, which predominantly have emotional-figurative visual connections. The clarification of the semantic content of words at 6–7 years old begins to gain momentum, related to acquiring new knowledge about the world and developing an aesthetic attitude towards words and speech in general.

This study makes a new contribution to understanding early childhood education by proposing the creation of a topic-based dictionary of the Kazakh language using artificial intelligence (AI). Unlike existing studies focusing on resource-rich languages, this work explores resource-poor languages, such as Kazakh, and addresses the unique challenges associated with their morphological complexity and the lack of available educational resources. The morphological analysis of the generated sentences and word phrases on the specific topic gives an ability to choose the most optimal elements of the dictionary that are well adapted for children of a certain age. Moreover, the dictionary is elaborated for an audio and visualization model that provides a qualitative educational approach for children.

Creating a dictionary for children will help achieve goals such as increasing the availability of educational resources, personalized learning, preserving and developing languages with limited resources, providing support for parents and teachers, and improving the quality of linguistic data.

The development of automated dictionaries for children using AI is a necessary field of research that combines linguistic knowledge with AI capabilities to create educational

tools. These thematic dictionaries can play a crucial role in enhancing preschool children's language learning, cognitive development, and cultural awareness.

Adapting AI technologies to educational resources for children, including in the Kazakh language, can significantly impact the approach to linguistic and cultural education, making it more engaging and effective. Using AI, educators can provide a personalized learning experience that meets the developmental needs of children, promoting deeper learning of their native and additional languages.

Speech disorders in preschool children are a serious issue worldwide. Research in this area is highly relevant as the number of children with delayed speech development increases every year. The number of parents seeking help from special centers and speech therapy specialists is also growing. The development and application of new technologies using natural language processing methods and machine learning are highly demanded to address this issue in the Kazakh language.

The article describes such stages as project planning, language analysis, needs assessment, cultural considerations, community involvement and validation, monitoring and updating, sustainability, and future expansion. Generally, the structure of the paper is organized in the following way. The introduction describes the needs assessment and cultural aspects of creating and researching a children's dictionary. Section 2 provides an extensive literature review where many significantly essential papers related to the development of children's dictionaries, speech recognition, and text generation are described. The literature review will analyze the Kazakh language and its applications in developing children's speech in other languages. Section 3 discusses the methodological approach applied to developing the children's dictionary, its evaluation, and designing the dictionary visualization and audio voice module. The methodology section describes community involvement, how the verification was carried out, and considers the developed dictionary's sustainability. Section 4 fully describes the architecture and process of the children's dictionary formation using ChatGPT and the Kazakh language POS patterns. Section 5 analyzes the obtained dictionary by evaluating the closeness of generated dictionary phrases and sentences to the original word using the cosine similarity, Euclidean similarity, and Manhattan distance metrics. Section 6 is devoted to creating the developed dictionary's visualization and audio voice module. Finally, Section 7 concludes the research by analyzing all the steps taken to develop a children's dictionary for the low-resource Kazakh language using modern AI tools. Future expansion, updating, and monitoring of the created dictionary will be discussed in the conclusion and future work. All these aspects will be discussed in detail in the article.

2. Literature Review

The application of AI to create various methods, tools, and techniques that impact the development of children's speech is one of the first steps in addressing social and communication problems.

M. Verburg's research [9] is intended to understand the methodologies for developing dictionaries tailored to a specific age group of children. D. Nkomo, in his work [10], analyzes the needs of African children for dictionaries, highlighting the critical importance of their accessibility and practicality. Figure 1 presents the key characteristics that a dictionary should have.

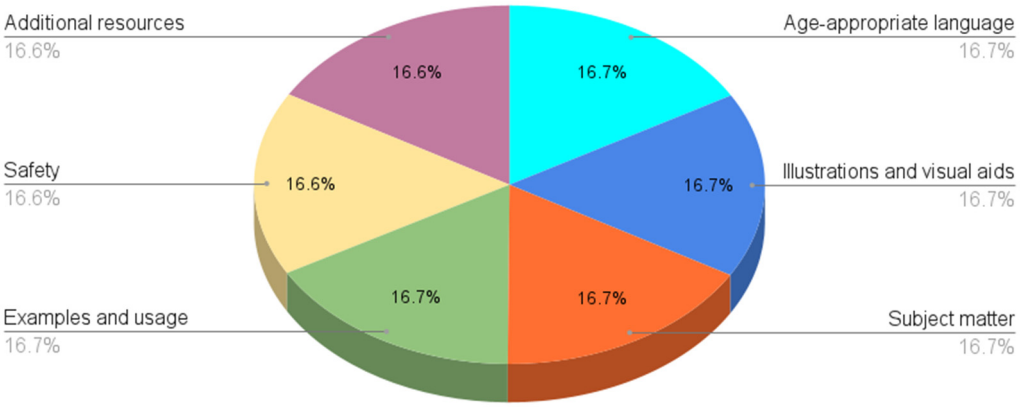

Figure 1. Important parameters for the development of thematic dictionaries for children [9–11].

Based on this diagram, it can be seen that the development of a children's dictionary takes into account many didactic and linguistic aspects that are directly related to the language's characteristics.

The study by Dan Zhao and Hai Xu [12], dedicated to optimizing the development of English–Chinese children's dictionaries, points out that thematic dictionaries intended for an adult audience are often not suitable for children because adult dictionaries use more complex language and terms that may be beyond children's comprehension. Children's cognitive abilities are still developing, so adult dictionaries can be too complex and confusing. In contrast, children's dictionaries are designed with age-appropriate features, including simple language and illustrations, which facilitate learning and understanding. Thus, adult dictionaries are not suitable as educational tools for younger students.

Next, we will compare children's and adult thematic dictionaries, considering the aforementioned dictionary development parameters, as shown in Table 1.

Table 1. Comparison of children's and adult thematic dictionaries: features and applicability [12–14].

Feature	A Thematic Dictionary for Children	A Thematic Dictionary for Adults
Content	Simple, child-friendly vocabulary	A complex and comprehensive vocabulary, including specialized terms
Goal	Improve basic language skills and learning	Provide detailed information on various professional fields
Age	Adapted to the level of understanding of children of different ages	It assumes a high level of literacy and knowledge of the subject
Definitions	The definitions are simple, concise, and often accompanied by examples	The definitions are provided with detailed technical descriptions, without any simplifications
Illustrations	Frequent use of colorful illustrations helps to better understand and remember the text	A minimum of illustrations or their complete absence; more attention is paid to the text
Design and format	Bright, fascinating to interest children Divided by topic to facilitate the study of specific categories	A more formal and dense format designed for familiarization. It is divided alphabetically or by area/topic, which provides systematic access to information

The comparison highlights that dictionaries for adults may be unsuitable for children due to the complexity of content, lack of engaging elements, and inappropriate materials. Terms and explanations in such dictionaries are often too complex and can overwhelm a child's perception, making understanding more difficult. Additionally, adult dictionaries typically lack interactive elements or visual aids, making them less attractive and interesting for children, which may reduce their interest in learning new words.

Research disseminates practices for developing and using applications and mobile technologies related to human communication and interaction, as reported by doctors, for

children with various speech disorders. The development of phonological awareness, i.e., manipulating the language structure, from an early age is essential for acquiring literacy skills. Communication technologies aimed at learning play a key role and can stimulate the interest and thinking of today's children living in a digital society.

Currently, the App Store, Google Play, and Play Market offer a vast number of speech development applications for children. However, few of them meet the standards of effective education from a developmental psychology perspective [15–17]. The increased use of educational applications provides additional opportunities to support language development, for example, by introducing children to new words just like in storybooks, especially when applications are used jointly between a parent and a child. Joint media use between parent and child reduces time costs. However, it should be noted that only 20% of parents report using applications with children aged 2 to 4 most of the time [18], although for children aged 0–2, this figure rises to 49%, and for children aged 0–8, 80% of parents report using applications with their child most or some of the time.

Parents and children can use applications to expand their language vocabulary, especially when learning in the application is embedded in an authentic, meaningful, and purposeful context [15,19]. Several studies conducted to date have shown that children can learn new words through applications [20–23].

A multilingual thematic dictionary for primary school students was created based on design and development methodology [24]. Authors [25] identify the educational impact of AI technologies as a tool to help children develop ethical and critical thinking skills.

Studies by specialists (speech therapists, defectologists) at the Astana Rehabilitation Center have shown that children produce sound reactions from birth [26]. A one-year-old child should be able to pronounce at least 10–15 words, a two-year-old around 300 words, and a child over three years old should communicate freely. A normal three-year-old child should have a vocabulary of 800–1500 words. The absence of two-word phrases at the age of 2 years and older, such as ("ana ber"—mom give it, "tamak zheymin"—want to eat, "dalaga baram"—go outside . . .), and at age 3, a small vocabulary, poor pronunciation, and inability to express their desires and thoughts through speech are considered abnormal [27].

Currently, research in Kazakhstan actively focuses on speech recognition in the Kazakh language, machine translation to Kazakh, and the use of AI in Kazakh speech recognition by scientists such as Sharipbay A.E., Bekmanova G.T., Tukejev U.A., Mansurova M., Amirgaliyev E.N., Musabayev R.R., Mamyrbayev O.Zh., and others [28,29]. These works present research and results on Kazakh speech STT (Speech to Text) and TTS (Text to Speech) tasks based on neural network models using datasets from adult speakers with correct pronunciation. Unfortunately, the analysis and recognition of children's speech have not been considered. The lack of specialized electronic and accessible resources complicates the development of this field.

The study [30] developed a dictionary of Kazakh language synonyms for children with weak speech skills using the Word2Vec method, grouping the dictionary by special word groups. The proposed model can be integrated into various educational and language applications to improve children's vocabulary and speech skills. This approach depends on input resources for training and requires significant computational resources.

When examining scholars' work, it can be seen that many use neural networks and machine learning methods to achieve their goals and solve various problems. In his work, Lukashik [31] demonstrates the application of corpus linguistics and generative AI tools for terminology development in the Kashubian language. The study proved that ChatGPT offers a faster and more efficient method for terminology extraction compared to traditional corpus linguistics, although it requires human oversight to ensure data accuracy. R. Ponnusami's research [32] focuses on using the ChatGPT-3 model for text generation in the Tamil language. The results showed that the model successfully performs text generation tasks and is applicable for educational and entertainment purposes.

The use of AI in education, especially through chatbots like ChatGPT, has significantly expanded and enhanced learning opportunities from early childhood to higher education.

AI, especially in the form of chatbots, has been effectively integrated into educational institutions, assisting children with tasks such as pronunciation and spelling. While AI offers benefits such as personalized learning and constant availability, it is emphasized that it should complement rather than replace human educators, ensuring a comprehensive and effective educational process [33].

AI-driven thematic dictionaries also demonstrate the potential to support children with special educational needs. For example, I.A. Pisarev's ontological approach [34] includes thematic dictionaries that use computational linguistics and lexical-semantic field analysis, as well as AI for adapted learning for children.

Analyzing researchers' works focused on the Kazakh language, we can highlight Gaziza Yelibayeva's research [35], which discusses the search for phrases in the Kazakh language based on ontology, illustrating the technical capabilities for developing educational tools based on AI that could support dictionary creation. These tools can help systematize vocabulary and facilitate effective language learning through intuitive search processes and semantic networks. Table 2 presents a comprehensive description of research in this area.

Table 2. Comparative analysis of research in the field of language innovations and educational resources.

Researcher	Year	Language	Methodology	Age Group	Developed
Marek Lukasik	2024	Kashubian	Corpus Linguistics	for all age groups	Terminology in the Kashubian language
Mubashir Munaf, Hammad Afzal, Naima Iltaf, Khawir Mahmood	2023	Urdu	mBERT, mT5	for all age groups	Methods of Summarizing Texts
R. Ponnusami	2023	Tamil	ChatGPT-3	for all age groups	Generating texts in Tamil
Prabhi Siddhesh Kadam	2021	English	Research in the form of a questionnaire	2–5 years old	The impact of multimedia on learning skills
Lou Parmavati et al.	2022	English–Indonesian–Balinese	DnD	primary school	Multilingual thematic digital dictionary
Gaziza Yelibayeva et al.	2021	Kazakh	Ontology	for all age groups	Dictionary phrases in the Kazakh language

Based on the analysis of the studies presented in Table 2, it can be noted that the development of a dictionary for preschool children for cognitive languages is not yet so developed. After all, creating and preparing a dictionary for the Kazakh language using AI is a very difficult and new approach that can significantly contribute to this area's development and help many children in speech development.

The integration of visualization and voiceover modules in educational tools has been a significant area of research. Various studies have highlighted the importance of visual and auditory aids in enhancing language learning, particularly for young children. According to Piaget's theory of cognitive development [36], children in the preoperational stage (ages 2–7) benefit greatly from visual aids as they rely heavily on visual thinking and imagery. Similarly, Vygotsky's work [37] emphasizes the role of social interaction and language in cognitive development, supporting the use of voiceover to facilitate learning.

Studies have shown that visual aids, such as images and videos, can significantly enhance vocabulary acquisition in young learners. For instance, a study by Verhallen and Bus [38] demonstrated that children who were exposed to multimedia storybooks showed improved vocabulary and comprehension skills compared to those who were only given traditional books. Using images and animations helps contextualize new words, making them easier for children to understand and remember.

The application of AI in educational tools has further enhanced the effectiveness of visualization and voiceover modules. AI-driven tools can provide personalized learning experiences by adapting to each child's individual needs. For example, AI algorithms can analyze a child's progress and adjust the difficulty level of the content accordingly. Studies have shown that personalized learning can significantly improve educational outcomes [39].

The use of AI for text-to-speech (TTS) technology has also advanced significantly, making it possible to generate high-quality, natural-sounding voiceovers. This technology can be particularly beneficial for children learning to read, as it allows them to hear the correct pronunciation of words and phrases. Research has shown that TTS can support reading development by providing auditory reinforcement and aiding in recognizing written words [40].

Visualization and audio support modules significantly enhance children's learning experience by making the educational process more engaging and effective. According to Professor Prem Sunder in "The Effectiveness of Audio-Visual Aids in Teaching-Learning Process," [41] audio-visual aids stimulate students' interest and curiosity, providing intrinsic motivation and making learning enjoyable. This is achieved by transforming traditional verbal instruction, which can often be monotonous, into a dynamic and interactive experience that captures students' attention. Sunder's research involving 10th-grade students and teachers in Gohana City demonstrated that those exposed to audio-visual aids performed significantly better than those who received traditional instruction, highlighting the effectiveness of these tools in enhancing educational outcomes.

On the other hand, the longitudinal study by Sundqvist et al. on "The relationship between children's exposure to screen media and vocabulary development" [42] suggests a nuanced perspective. While the study found a negative relationship between excessive screen media use and vocabulary development, it underscores the importance of balancing screen time with other forms of learning. The study tracked children from infancy to early childhood, revealing that high-screen media exposure could impede language development. This suggests that while audio-visual aids are beneficial, they must be moderated and integrated thoughtfully within a broader educational strategy to prevent potential adverse effects on language skills.

In summary, visualization and audio support modules are valuable in making learning more effective and engaging for children, as demonstrated by the positive impacts on motivation and performance in Sunder's study. However, as indicated by Sundqvist et al., it is crucial to monitor and balance the use of these tools to ensure they complement rather than hinder overall cognitive development. Integrating audio-visual aids in a balanced manner can foster an enriching learning environment that supports the all-round development of children.

Moreover, visualization and voiceover can help children develop their cognitive skills, including analyzing, synthesizing, and making decisions. This can be especially useful when learning new or complex topics.

Over the past ten years, digital media have become more accessible and increasingly used among preschoolers [43], largely due to intuitive design. According to the UK Occam report, by 2018, 58% of children aged 3 and 4 used tablets; 19% of them had their own tablets. Thus, young children are surrounded by educational technologies and are native users of smartphones, tablets, and computers; therefore, they have been called "digits", a term emphasizing the fact that digital media have been present in their lives since birth.

In conclusion, it can be noted that if you create an application that uses a correctly compiled children's thematic dictionary, it can significantly improve the development of speech in children.

3. Methodology

This section presents the full methodology of the proposed approaches to building the dictionary adapted for children aged 3 to 5 with a sufficient level of speech development and language skills to be able to independently express words and phrases in the Kazakh

language, as well as the ability to maintain attention and concentration during the process of recording and reproducing speeches in the Kazakh language that were selected for recording. During the study, with the permission of the parents, an experiment was conducted with children aged 3–5 years who live in Almaty, Kazakhstan. The experiment was conducted the following way: the group of educators was given an application for teaching the spoken Kazakh language to children, and the educators used it to teach the children. The children are ordinary children of the Kazakh group, mostly boys.

Children begin to develop speech at different ages. For example, at 2–3 years of age, a child starts to speak distortedly: words he or she made up, words with mistakes, and different sounds. Then, by 3–5 years, the child's speech becomes more intelligible, he or she begins to use verbs in speech, and the number of pronouns, adverbs, and adjectives increases. That is, he or she begins to speak correctly. This age is considered the most correct time for studying the development of a child's speech [44].

The children were selected for the study based on certain criteria, including their age (2 years 11 months–5 years 11 months) and their level of literacy development in [45]. In addition, the child's ability to control their behavior and attention could be an important criterion since these were the skills that were studied in the study. Thus, the children included in the sample met the specified parameters and were ideal candidates for studying the influence of inhibitory control on the development of literacy skills.

In this article, we aimed to investigate the speech development of Kazakh-speaking children in this age range to understand any common speech difficulties better and provide appropriate interventions where needed. By focusing on this specific age group, we were able to gather valuable information about the typical speech patterns and potential problems faced by Kazakh speakers aged 3 to 5 years.

It is based on methodological rigor, which is a key concept to ensuring the validity and reliability of scientific research. The principles include the general description of the development of the children's dictionary. The subsequent steps provide thorough descriptions of each phase regarding selecting research methods and tools, including the adequacy and validity of the methods used in the context of the tasks at hand. The lowest level provides smaller details, such as the correctness and presentation of results, which, although less critical, are also important for the overall perception and evaluation of the work. By following these levels of rigor, the methodological section ensures the high quality and integrity of the research conducted with the most prominent obtained results.

The methodological part of building a qualitative dictionary for children encompasses several important stages that contribute to thoroughly describing its design, evaluation, and enhancement. The development of the children's dictionary includes the following parts:

- The generation of reference words is a significant step that allows getting the basic important words on which the successive generated phrases and sentences rely. The ChatGPT model is effectively employed in this step to generate a comprehensive list of reference words, and the basic initial words serve as a dictionary's foundation and are selected based on the relevance and frequency of their use by children. The variety of reference words is defined by adding support parameters highlighting the necessity of including five nouns, adjectives, verbs, and adverbs in the list of reference words. In addition, after all phrases and sentences are generated, their meaningfulness and adequacy are checked and verified by specially qualified linguists and educators.
- The obtained reference words are then utilized to generate phrases and sentences that form the children's dictionary. These phrases and sentences are formed in English; translating them into Kazakh using a high-quality translation system is also essential. Here, the Google Translate system is used.
- When the phrases and sentences are translated into Kazakh, the filtering phase takes place. In this phase, all phrases and sentences go through morphological analysis to ensure their grammatical correctness. They are split into bigrams [46] and trigrams [47] that present very simplified forms of words. Bigrams present a sequence of two consecutive words in the text. For example, there is a sentence "Natural lan-

guage processing is interesting". The bigrams of this sentence will be [("Natural", "language"), ("language", "processing"), ("processing", "is"), ("is", "interesting")]. At the same time, trigrams include a sequence of three consecutive words. The trigrams of the sentence will be [("Natural", "language", "processing"), ("language", "processing", "is"), ("processing", "is", "interesting")]. The use of bigrams and trigrams helps in text analysis and pattern recognition in natural language processing. Then, specially prepared templates are utilized to filter the content and align it with educational standards. This step proves that the generated phrases are age-appropriate and favorable to learning.

The whole methodological structure is shown in Figure 2.

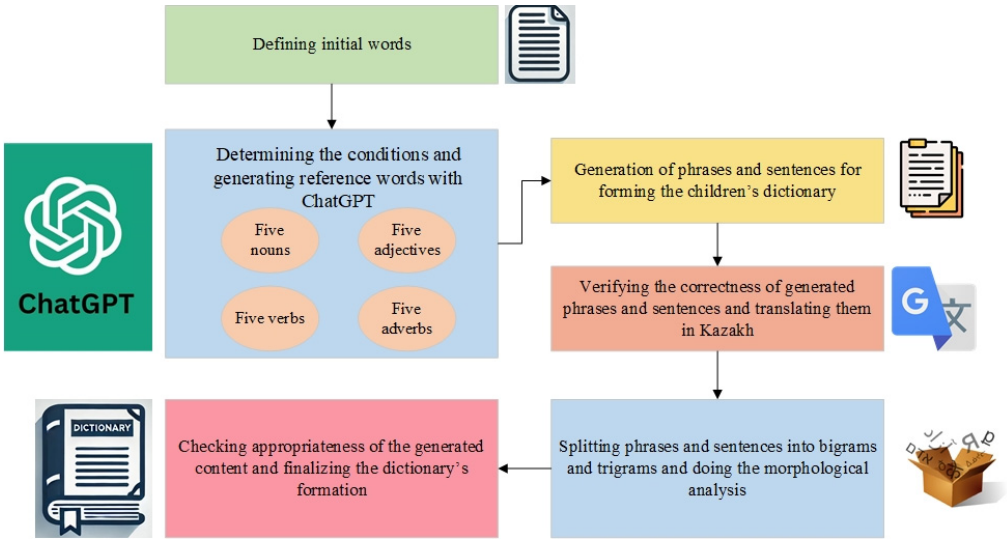

Figure 2. The structure of the proposed methodology.

Although the phrases and sentences were initially checked for usefulness and adequacy, it was essentially important to prepare them for building the structured content of the dictionary and subsequent audio and visualization module. Therefore, additional evaluation metrics, such as cosine similarity, Euclidean distance, and Manhattan distance, were utilized to check the importance of phrases and the order in which children are going to train and educate themselves with the designed module. The description of the phrases and sentence generation is described in Section 5.

The formed dictionary of phrases and sentences is then extended with the audio and visualization module that consists of a didactic game developed as the primary tool for delivering the dictionary's content. The visualization component is crafted with child-friendly graphics and animation of phrases and sentences from the formed dictionary to capture children's attention and facilitate learning. The designed cognitive load ensures that visual elements support rather than overwhelm the learning process. The audio component is synchronized with visual elements and provides a seamless learning experience. The development and specifications of the audio and visualization module is shown in Section 6.

The importance of eye contact and other communication cues is also evident in studies of how and when young children learn from video and other forms of digital media, which was considered in [48].

The study found that communicative pedagogical contexts promote the development of conceptual thinking in children aged 4 and 5, helping them to analyze and classify information more consciously and purposefully [49]. Interaction with an adult who actively draws the child's attention to specific properties of objects helps children better understand and use this information in various situations.

All the important stages of the children's dictionary formation are shown in Sections 3.1–3.3.

3.1. The Generation of Reference Words for the Children's Corpus Using ChatGPT

In this study, an important task was the generation of reference words. The generation is realized with the use of ChatGPT, which was developed by OpenAI and is based on the GPT (Generative Pre-trained Transformer) architecture, trained on vast amounts of textual data. It is considered one of the most advanced models in the field of natural language processing nowadays. Since Kazakh remains a low-resource language [50], AI models, including ChatGPT, still make significant errors when generating sentences and texts in this language. Therefore, using English as the source language is preferable, as virtually all language models work excellently with it. This approach helps increase the accuracy of the initially generated data, minimizing possible errors and inaccuracies.

First, in the generation of reference words, a list of initial English words was formed based on three main themes that help children better understand their surroundings: animals, gardens, and toys.

This list of words was presented as (1):

$$W = \{w_1, w_2, \ldots, w_n\}, \quad (1)$$

where W is a set of words relevant to children aged 3 to 5.

The complete list of words for three thematic categories is presented below:

1. Animals: Hippopotamus, Eagle, Wolf, Goose, Giraffe, Hare, Goat, Cow, Cat, Swan, Lion, Fox, Bear, Mouse, Sheep, Deer, Rooster, Python, Parrot, Elephant, Dog, Tiger.
2. Garden: Banana, Carrot, Cherry, Apple, Potato, Flower, Tree, Pear, Watermelon, Cucumber, Berry, Tomato, Garden, Fruit, Apricot, Pepper, Lemon, Beet, Vegetable, Pumpkin.
3. Toys: Dolls, Cars, Toy trains, Toy helicopters, Stuffed animals, Robots, Lego, Puzzles, Building blocks, Ninja turtles.

After forming the list of words according to the given categories, a list of semantically related reference words was generated for each word in the list. The ChatGPT models have an extensive vocabulary and can use various synonyms and semantically related words, increasing the output data's variability. This is especially useful where a high degree of diversity is needed but may not always be suitable for tasks requiring high accuracy. Therefore, to better control the reference words, categories of parts of speech are specified: in this case, five words are needed for the parts of speech: nouns, verbs, adjectives, and adverbs. The formulation of reference word generation is presented in the following way.

For each word $w_i \in W$, a set of semantically related words was generated with the use of ChatGPT (2):

$$R(w_i) = ChatGPT(\{r_{i1}, r_{i2}, \ldots, r_{im}\}), \quad (2)$$

where $R(w_i)$ is the set of semantically related words for w_i received by the use of ChatGPT.

The obtained variety of reference words is explained by the complexity of ChatGPT models that are trained on large volumes of data and have an extensive database of words and their associations in phrases and sentences. These models deeply analyze the contexts in which given words are used and compare them with the contexts of other words. Words that appear in similar contexts are assigned higher weight values, while words related to the original word in specific and limited scenarios receive lower weight values. For example, the following words were generated by ChatGPT as related words for "banana": ['fruit—0.95', 'plantain—0.92', 'yellow—0.89', 'tropical—0.85', 'peel—0.83', 'potassium—0.80', 'smoothie—0.78', 'ripe—0.75', 'sweet—0.72', 'smooth—0.70', 'curved—0.68', 'nutritious—0.65', 'healthy—0.63', 'delicious—0.60', 'banana—0.58', 'quickly—0.55', 'easily—0.52', 'softly—0.50', 'carefully—0.48', 'happily—0.45', 'blend—0.43', 'slice—0.40', 'peel—0.38', 'munch—0.35', 'devour—0.33', 'beat—0.30', 'mash—0.28', 'mix—0.25', 'boil—0.23', 'fry—0.20', 'bake—0.18', 'grill—0.15', 'spread—0.13', 'melt—0.10', 'dry—0.08', 'crumble—0.05', 'crush—0.03', 'blend—0.02', 'slurp—0.01', 'puree—0.005'].

The structure of reference word generation is shown in Figure 3.

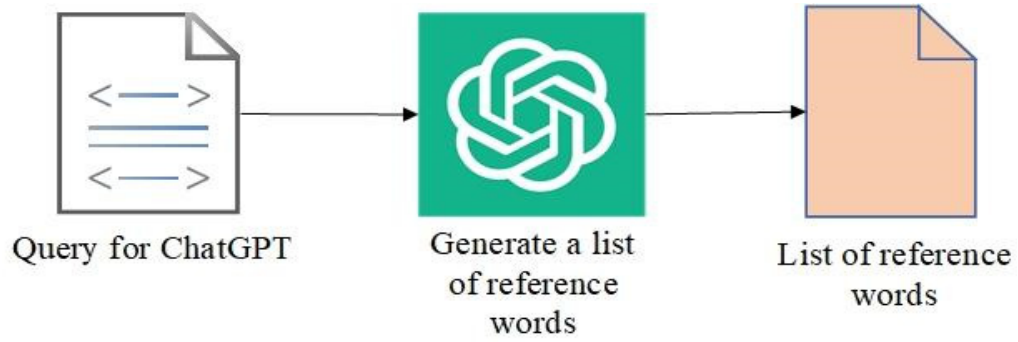

Figure 3. The structure of reference word generation.

3.2. The Generation of Phrases and Sentences for the Children's Dictionary

After forming the list of words for four parts of speech, the next stage involves generating phrases and sentences. It is expressed as (3):

$$S_i = ChatGPT(w_i, R(w_i)), \tag{3}$$

where S_i is the set of phrases and sentences generated for the word w_i and its related words $R(w_i)$.

A set of specific conditions was defined for the words in each category for better generation results, and the list of obtained words was included in the ChatGPT query. The conditions are specific to each category. Important aspects of phrases and sentences involving animals include their size, color, diet, and habitat. For garden plants, the focus is on size, color, taste, and place of growth. For toys, characteristics such as size, color, structure, and other features are essential.

For example, the following phrases and sentences were generated by ChatGPT for Banana: [yellow bananas are sweet and ripe; tropical plant grows easily in sunshine; delicious fruit with potassium and vitamins; smoothie blend with sliced banana fruit; healthy snack for happy munching time; softly peel and carefully slice banana; nutritious and delicious, easily devoured; quick snack of a yellow banana; curved fruit grows in tropical regions; easily mashed for yummy banana bread; smoothie blend of ripe banana and berries; happy kids love to slurp smoothies; healthy snack option for quickly munching; yellow bananas easily blend into smoothies; ripe fruit slices spread on toast; carefully peel bananas for baking treats; delicious and nutritious banana fries; softly mash for a healthy treat; slice, blend, and slurp banana smoothie; nutritious snack quickly devoured by kids; potassium-rich fruit for a healthy snack; easily crushed for yummy banana ice cream; ripe banana slices easily spread on toast; delicious banana smoothly blends in smoothies; healthy snack quickly devoured by children].

After the generation of phrases and sentences, it was also required to translate them from English to Kazakh. In this way, the Google Translate system was implemented (4):

$$T(S_i) = GoogleTranslate(S_i) \tag{4}$$

The whole structure of phrases and sentence generation and their translation to Kazakh is presented in Figure 4.

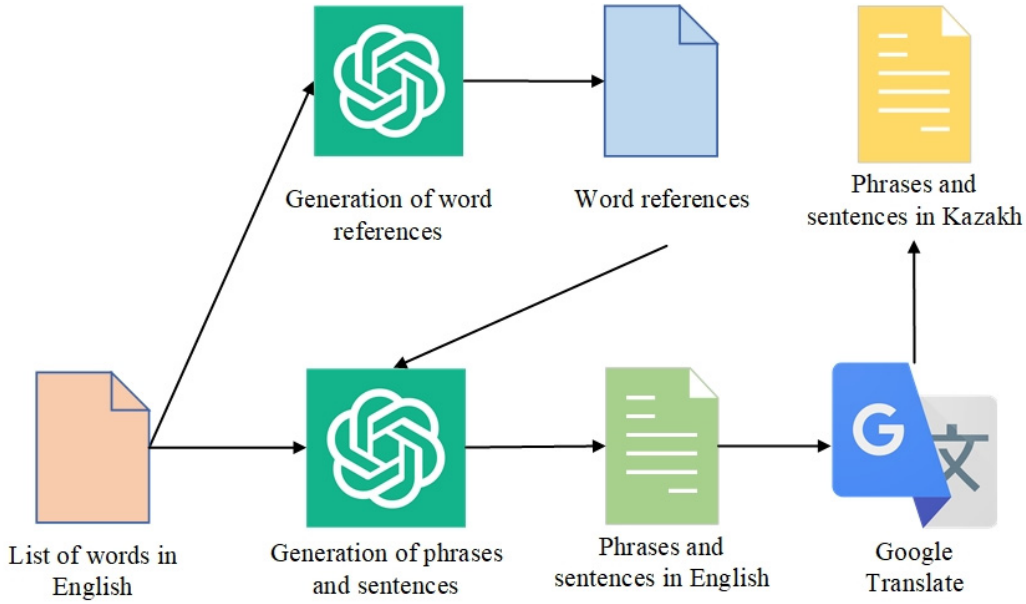

Figure 4. The system's architecture for generating phrases and sentences and translating them into Kazakh.

The translated phrases and sentences are then analyzed and filtered using morphological analysis, as described in Section 3.3.

3.3. The Morphological Analysis of Generated Phrases and Sentences for the Children's Dictionary

In the previous stages, the reference words, phrases, and sentences were generated. The key feature of those steps is that text generation for the dictionary requires a special approach and careful consideration of the target audience's characteristics to create quality content that will be interesting and accessible to young children. Generation systems often fail to produce texts that are easily understood by children aged 3 to 5 years. When generating content, it is important to consider the age-specific characteristics of children to create texts that are accessible and understandable. To ensure texts are comprehensible to young children, it is also necessary to use simple language and visual imagery. The generation stage was conducted at the sentence level, as ChatGPT struggled to generate simple phrases for children aged 3 to 5 years. It did not account for the peculiarities of children's perception and produced complex texts and phrases that children could not understand. The generated phrases were not suitable for the vocabulary of children aged 3 to 5 as they had the complexity level of adult language proficiency.

The filtering of the thematic dictionary was carried out taking into account the following parameters:

- The structure of children's speech;
- Complexity;
- Problematic sounds of Kazakh speech in children (for example, р/л[r/l], ш/с [sh/s], ө/ұ [o/u], etc.).

The thematic dictionary will be presented in the following form:

$$\begin{gathered} \mathrm{D} = \left\{ u_i, f_{ij}, S_{jk} \right\} \\ \left\{ u_i \bigcup G \right\} \in f_{ij} \}, \\ \left\{ f_{ij} \bigcup G \right\} \in S_{jk} \}, \\ G :=< w, R_{pos} >, \\ i = 1, n \; j = 1, 5 \quad k = 1, 15 \end{gathered} \tag{5}$$

where u_i are words, f_{ij} are phrases (bigrams and trigrams) for i word, s_{jk} are sentences in the Kazakh language, w is all words in Kazakh, R_{pos} is a set of rules for part of speech sequences in Kazakh. G is a set consisting of letters w and over, which is a set of rules, and R_{pos} is carried out, which is described in Table 3.

Table 3. Patterns of bigrams and trigrams for children aged 3–5 based on the proposed simple sentence structure of the Kazakh language.

Pattern	Example	Translated Version for English-Speaking Readers	
word1<n> word2<n>	Банан ағашы	[Banana tree]	n—noun v—verb adj—adjective cnjcoo—conjunction adv—adverb num—numerical prn—pronoun
word1<n> word2<v>	Банан өседі	[Banana grows]	
word1<adv> word2<v>	Ағашта өседі	[Grows on a tree]	
word1<adj> word2<n>	Тәтті банан	[Sweet banana]	
word1<num> word2<n>	Екі банан	[Two bananas]	
word1<prn> word2<n>	Оның бананы	[His banana]	
word1<prn> word2<v>	Ол алды	[He took]	
word1<n> word2<n> word3<v>	Банан ағашы өседі	[The banana tree grows]	
word1<adj> word2<n> word3<n>	Тәтті банан ағашы	[Sweet banana tree]	
word1<n> word2<v> word3<v>	Банан қарайып жатыр	[The banana is turning black]	
Word <n> word <cnjcoo> word3<n>	Банан мен алма	[Banana and apple]	
Word <adj> word <cnjcoo> word3<adj>	Тәтті және жұмсақ	[Sweet and soft]	

After the sentence generation stage, the generated sentences were translated into Kazakh using Google Translate.

Examples of generated sentences for "мысық (cat)":

Мысықтар балық пен тауық сияқты ет жейді. *[Cats eat meat such as fish and chicken.]*

Мысықтар әдетте кішкентай және жұмсақ. *[Cats are usually small and soft.]*

Көптеген мысықтар жылы үйлерде тұрады *[Many cats live in warm houses.]*

The received sentences were further divided into bigrams and trigrams. An example of splitting a translated generated sentence in Kazakh into bigrams:

- Example of a bigram: *(*Мысықтар балық *[cats fish]) (*балық пен *[fish and]) (*пен тауық *[and chicken]) (*тауық сияқты *[such as chicken]) (*сияқты ет *[such as meat]) (*ет жейді *[eat meat])*.
- Example of a trigram: *(*Мысықтар балық пен *[cats fish and]) (*балық пен тауық *[fish and chicken]) (*пен тауық сияқты *[and such as chicken]) (*тауық сияқты ет *[meat such as chicken) (*сияқты ет жейді *[eat meat such as])*.

Next, morphological analysis was implemented for each bigram and trigram using the Apertium system. Apertium-Kaz is a morphological transducer and disambiguator for Kazakh [51]. The morphology of the Kazakh language and its morphological analyzers are described in works [52–61]. The Kazakh language is a complex language with rich morphology.

Example of morphological tagging for phrases [https://github.com/apertium/apertium-kaz, accessed on 28 September 2024]:

^Мысықтар/мысық<*n*><*pl*><*nom*>$ ^балық/балық<*n*><*nom*>$

^пен/мен<*cnjcoo*>$ ^тауық/тауық<*n*><*nom*>$

^сияқты/сияқты<*post*>$ ^ет/ет<*n*><*nom*>$

^жейді/же<*v*><*tv*><*aor*><*p3*><*sg*>$^./.<*sent*>$

[^Cats/cat<n><pl>$ ^fish/fish<n><sg>$

^and/and<cnjcoo>$ ^chicken/chicken<n><sg>$

^such as/such as<post>$ ^meat/meat<n><sg>$

^eat/eat<v><vblex><inf>>$^./.<sent>$]

In the next stage, patterns of frequently used combinations of parts of speech in the Kazakh language for children aged 3 to 5 were developed. The patterns are presented in

the table below. In the Kazakh language, there are nine parts of speech: noun, adjective, numeral, pronoun, verb, adverb, postposition, onomatopoeia, and interjection.

The simple sentence structure in the Kazakh language is the following [55]: "prn v", "prn adv v", "prn n v", "prn adj n v", "prn n n v", "prn n adj n v", "prn n adv adv v", "prn n adv v", "adv n v", "prn n v adv n v", "prn v prn n adj, adj n v", "prn adv adj, adj n v", "prn adv adj n v". This approach is based on a complete set of suffixes of the Kazakh language. The creation of the complete set was developed by Tukeyev and described in [62].

In the proposed work [63], simple sentence construction is not suitable for children aged 3 to 5 as they do not use phrases longer than three words in a sentence. Table 3 presents patterns for children aged 3 to 5 based on the proposed simple sentence structure of the Kazakh language.

Filtered bigrams and trigrams based on the Kazakh language part-of-speech combination templates with analyses are presented below (excerpt):

- б*а*лық<*n*> пен<*cnjcoo*> т*а*уық<*n*> *[fish<n> and<cnjcoo> chicken<n>]*
- ет<*n*> жейді<*v*> *[meat<n> eat*i<*v*>*]*

The resulting list of bigrams and trigrams (excerpt) for children based on the example sentences:

- Б*а*лық пен т*а*уық *[fish and chicken]*
- Ет жейді *[eat meat]*

The filtered list has been added to the phrase level in the dictionary. The thematic dictionary for children in the final result is shown in Table 4 (excerpt):

Table 4. Thematic dictionary for children (part).

Words in Kazakh	Phrases in Kazakh (for Children 3–4 Years Old)	Translated Version for English-Speaking Readers	Sentences in Kazakh (for Children 3–4 Years Old)	Translated Version for English-Speaking Readers
Мысық [Cat]	Балық пен тауық Ет жейді кішкентай және жұмсақ үй жануары сары мысық ұйықтағанды жақсы көреді ...	[Fish and chicken Eats meat small and soft pet yellow cat likes to sleep] ...	Мысықтар балық пен тауық сияқты ет жейді. Мысықтар әдетте кішкентай және жұмсақ. Көптеген мысықтар жылы үйлерде тұрады. Мысықтар далада ұйықтағанды жақсы көреді. Бізде сары мысық бар. ...	[Cats eat meat such as fish and chicken. Cats are usually small and soft. Many cats live in warm houses. Cats like to sleep outside. We have a yellow cat.] ...
Банан [Banana]	сары банан тәтті банан тропикалық жеміс тәтті және піскен . . .	yellow banana sweet banana tropical fruit sweet and ripe ...	Сары банан тәтті және піскен Тропикалық өсімдік күн сәулесінде оңай өседі Калий мен дәрумендері бар дәмді жеміс Иілген жемістер тропиктік аймақтарда өседі Бақытты балалар коктейльді жегенді жақсы көреді. ...	The yellow banana is sweet and ripe. The tropical plant grows easily in the sunlight. A delicious fruit with potassium and vitamins. Curved fruits grow in tropical regions. Happy children like to eat smoothies. ...
Қуыршақ [Doll]	қызғылт қуыршақ қуыршағым әдемі барби қуыршақ . . .	pink doll my doll is beautiful Barbie doll ...	әдемі қызғылт қуыршақ ойыншығын әперді. менің қуыршағым әдемі көрінеді. ойын уақытына арналған көне барби қуыршақ үйі киіну және таңдану үшін сүйкімді қуыршақ ...	bought a beautiful pink doll toy. my doll looks beautiful. a vintage Barbie dollhouse for playtime. a cute doll for dressing up and admiring. ...

4. Practical Results—Evaluation of the Content of the Developed Dictionary

The results of the words and phrases obtained for the thematic dictionary of the Kazakh language are presented below in Table 5. Next, it is necessary to evaluate the results obtained for the proximity of phrases to the original word using metrics such as cosine similarity, Euclidean distance, and Manhattan distance. These metrics are used in various areas, like machine learning, data analytics, pattern recognition, etc. Euclidean distance evaluates the distance between two texts represented in a vector form. Cosine similarity measures the angle between vectors, indicating how similar the two pieces of text are based on the cosine of the angle between them. A value closer to 1 implies a higher similarity. On the other hand, Manhattan distance calculates the straight-line distance between two vectors in space, indicating how far apart the two pieces of text are. Lower values represent closer proximity. However, before calculating the values of these metrics, it is necessary to convert the textual representation of the phrases into a vector representation. Several methods are applied, including Bag of Words, TF-IDF Metric, and Word Embedding Methods like Word2Vec, FastText, and BERT. These methods have proven effective in various NLP tasks. For the calculation of word vectorization, the BERT model was applied [64]. It converts words and phrases into vectors of 768 values, which allows the application of the corresponding metrics to them. For example, there are words and phrases vectorized by the BERT model.

$$\begin{aligned} word\_embedding = [&-0.12224, -0.42816, -0.70929, 0.32610, -0.20067, \\ &-0.75138, -0.48973, \ldots, 0.1356] \\ phrase\_embedding = [&-0.46193, -0.41801, 0.68839, -0.84216, 0.52520, \\ &-0.61788, 0.10261, -0.12406, \ldots, 0.29184] \end{aligned}$$

Then, the metrics that work well with vectorized data are applied to these vectors. They have the following features:

- Cosine similarity is a measure that calculates the angle between vectors in space, determining their similarity based on the cosine of the angle between them. This measure is calculated using Formula (6):

$$\cos\text{ine\_similarity}(\mathrm{A}, \mathrm{B}) = \frac{A \times B}{\parallel A \parallel \times \parallel B \parallel}, \tag{6}$$

where $A \times B$ is the dot product of vectors A and B; $\parallel A \parallel$ is the norm of vector A, calculated $\sqrt{\sum_{as\ i=1}^{n} A_i^2}$, and $\parallel B \parallel$ is the norm of vector B, calculated as $\sqrt{\sum_{i=1}^{n} B_i^2}$.

- Euclidean distance represents the direct distance between two points in space, defined as the square root of the sum of the squares of the differences in the coordinates of the points. It is calculated using Formula (7):

$$\mathrm{d}(\mathrm{A}, \mathrm{B}) = \sqrt{\sum_{i=1}^{n} (A_i - B_i)^2}, \tag{7}$$

where A and B are points in n-dimensional space.

Manhattan distance is calculated as the sum of the absolute differences between the coordinates of the points along each axis. It is computed using Formula (8):

$$d_{Manhattan}(\mathrm{A}, \mathrm{B}) = \sum_{i=1}^{n} |A_i - B_i|, \tag{8}$$

These metrics can be useful when creating a dictionary for evaluating and comparing texts or other data based on their vector representation. They are shown in Table 5.

Table 5. The results of evaluating the filtered thematic dictionary of the Kazakh language (excerpt).

Words	Cosine Similarity	Translated Version for English-Speaking Readers	Euclidean Similarity	Translated Version for English-Speaking Readers	Manhattan Distance	Translated Version for English-Speaking Readers
Бегемот [Hippopotamus]	бегемот баяу: 0.7387	[hippopotamus slow: 0.7387]	жасыл өсімдіктерді жейді: 11.5877	[eats green plants: 11.5877]	жасыл өсімдіктерді жейді: 255.5542	[eats green plants: 255.5542]
	күшті бегемот: 0.7100	[strong hippopotamus: 0.7100]	күшті бегемот: 7.4231	[strong hippopotamus: 7.4231	күшті бегемот: 164.1093	[strong hippopotamus: 164.1093]
	жасыл өсімдіктерді жейді: 0.3927	[eat green plants: 0.3927]	бегемот баяу: 6.8238	[hippopotamus] slow: 6.8238]	бегемот баяу: 151.3433	[hippopotamus slow: 151.3433]
Қоян [rabbit]	ақ қоян: 0.8353	[white rabbit: 0.8353]	тез жүгіреді: 11.0343	[runs fast: 11.0343]	тез жүгіреді: 241.4868	[runs fast: 241.4868]
	қоян секіреді: 0.6306	[rabbit jumps: 0.6306]	қоян секіреді: 8.7781	[rabbit jumps: 8.7781]	қоян секіреді: 194.1711	[rabbit jumps: 194.1711]
	тез жүгіреді: 0.4350	[runs fast: 0.4350]	ақ қоян: 5.8949	[white rabbit: 5.8949]	ақ қоян: 130.0948	[white rabbit: 130.0948]
Мысық [cat]	сары мысық: 0.8190	[yellow cat: 0.8190]	үй жануары: 9.9984	[pet: 9.9984]	үй жануары: 220.0396	[pet: 220.0396]
	ұйықтағанды жақсы көреді: 0.6115	[loves to sleep: 0.6115]	ұйықтағанды жақсы көреді: 8.9627	[loves to sleep: 8.9627]	ұйықтағанды жақсы көреді: 196.4853	[loves to sleep: 196.4853]
	үй жануары: 0.4968	[pet: 0.4968]	сары мысық: 6.4826	[yellow cat: 6.4826]	сары мысық: 142.3616	[yellow cat: 142.3616]
Банан [banana]	сары банан: 0.7332	[yellow banana: 0.7332]	тропикалық жеміс: 10.4304	[tropical fruit: 10.4304]	тропикалық жеміс: 229.1729	[tropical fruit: 229.1729]
	жұмсақ банан: 0.6780	[soft banana: 0.6780]	жұмсақ банан: 8.7045	[soft banana: 8.7045]	жұмсақ банан: 191.9145	[soft banana: 191.9145]
	тропикалық жеміс: 0.5293	[tropical fruit: 0.5293]	сары банан: 7.9889	[yellow banana: 7.9889	сары банан: 173.0328	[yellow banana: 173.0328]
Сәбіз [carrots]	сары сәбіз: 0.8279	[yellow carrot: 0.8279]	қоян жейді: 8.5807	[rabbit eats: 8.5807]	қоян жейді: 188.2283	[rabbit eats: 188.2283]
	сәбіз көкөніс: 0.7868	[carrot is a vegetable: 0.7868]	сәбіз көкөніс: 6.4967	[carrot is a vegetable: 6.4967]	сәбіз көкөніс: 143.0402	[carrot is a vegetable: 143.0402]
	қоян жейді: 0.6035	[rabbit eats: 0.6306]	сары сәбіз: 5.7763	[yellow carrot: 5.7763]	сары сәбіз: 123.5438	[yellow carrot: 123.5438]

The applied three metrics allow the generated phrases to be in the appropriate order for the following visualization and audio module. It is especially useful for children to pay attention to the most significant aspects of the word category. Here, every metric could be used to order word phrases, but it is better to give preference to the one where the difference between values is larger.

In addition, the average cosine similarity [65], Euclidean similarity [66], and Manhattan distance [67] metrics were calculated for every topic used, highlighting the most significant of them in the conducted experimental research. It demonstrates which topic out of the three is preferred to be shown first to the children. The average proximity score for the received thematic dictionary is presented in Table 6.

Table 6. Average proximity score by category in the thematic dictionary.

Categories	Cosine Similarity	Euclidean Similarity	Manhattan Distance
garden	0.6724	8.328	182.941
animals	0.578	9.204	202.1627
toys	0.59	9.1	200.4

As we can see from the table, the closer the cosine similarity value is to 1, the more similar the vectors are and, consequently, the phrases or texts they represent. Thus, in phrase creation, a cosine similarity closer to 1 indicates that the phrases have a higher degree of similarity with each other. When creating a thematic dictionary, the values of Euclidean similarity indicate that some phrases or keywords will have a greater influence in forming the thematic dictionary.

Table 7 provides a compilation of curated phrases suitable for children aged 3 to 5 years. The table was generated through a systematic and multi-step process involving the application of AI tools and linguistic analysis. An English word list was initially formed and categorized into specific themes, including animals, the garden, and toys. Using ChatGPT, semantically related words were generated for each entry in this list. Subsequently, phrases and sentences were constructed utilizing these semantically related words.

Table 7. Filtered phrases for children aged 3–5 years (fragment).

Category	Words, Phrases, and Sentences (Kazakh)	Translation (English)
animals	‘Қоян’: [‘қоян секіреді’, ‘тез жүгіреді’, ‘ақ қоян’], ‘Ешкі’: [‘кішкентай қозы’, ‘ешкінің сүті’, ‘мүйізді ешкі’], ‘Мысық’: [‘сары мысық’, ‘үй жануары’, ‘ұйықтағанды жақсы көреді’],	‘Rabbit’: [‘rabbit jumps’, ‘runs fast’, ‘white rabbit’], ‘Goat’: [‘small kid’, ‘goat’s milk’, ‘horned goat’], ‘Cat’: [‘yellow cat’, ‘pet’, ‘likes to sleep’],
garden	‘Банан’: [‘жұмсақ банан’, ‘сары банан’, ‘тропикалық жеміс’], ‘Сәбіз’: [‘сары сәбіз’, ‘сәбіз көкөніс’, ‘қоян жейді’], ‘Алма’: [‘жасыл алма’, ‘қызыл алма’, ‘алма ағашы’],	‘Banana’: [‘soft banana’, ‘yellow banana’, ‘tropical fruit’], ‘Carrot’: [‘yellow carrot’, ‘carrot vegetable’, ‘rabbit eats’], ‘Apple’: [‘green apple’, ‘red apple’, ‘apple tree’],
toys	Қуыршақ: [‘әдемі қуыршақ’, ‘тірі қуыршақ’, ‘барби қуыршақ үйі’, ‘миниатюралық манекен’, ‘сүйкімді қуыршақ’, ‘әдемі жасалған қуыршақ’, ‘қуыршақ үйі’] Лего: [түрлі-түсті пластик, ойыншық кірпіштері, лего конструкциясы, пластикалық бөлшек, ойнап жобалайды, ойнап құрастырады, түрлі-түсті модульдік лего, құрылыс жинағы]	Doll: [‘beautiful doll’, ‘living doll’, ‘Barbie dollhouse’, ‘miniature mannequin’, ‘cute doll’, ‘well-made doll’, ‘dollhouse’] Lego: [‘colorful plastic’, ‘toy bricks’, ‘Lego construction’, ‘plastic piece’, ‘plays and designs’, ‘plays and builds’, ‘colorful modular Lego’, ‘construction kit’]

The generated sentences were translated from English to Kazakh to accommodate the target language requirements. These sentences were divided into bigrams and trigrams following translation to facilitate detailed linguistic analysis. Morphological analysis was performed using the Apertium system, ensuring correct usage and suitability for children. Finally, a filtering process based on part-of-speech (POS) tag templates was employed to refine the bigrams and trigrams. This resulted in a comprehensive and appropriate list of phrases for the intended age group. This rigorous approach ensured the educational tool’s accuracy, relevance, and effectiveness for young learners. The general collected data for the thematic dictionary are shown in Table 8.

Table 8. The results of the collected data for children.

Categories	Number of Unigrams	Number of Bigrams	Number of Trigrams	Number of Generated Long Sentences	Number of Generated Short Sentences
garden	40	183	37	703	573
animals	35	159	33	806	895
toys	30	108	19	596	341

These key stages helped create a list of words and phrases in the Kazakh language that can be used for teaching children. Moreover, the use of morphological analysis made

the list more accurate and relevant to educational needs. Overall, this method allows for the creation of educational materials in the Kazakh language based on semantically related words and phrases in English, which can enhance the learning of the Kazakh language for children, taking their age into account.

In this research, speech therapists are drawn on their knowledge of language development and bilingualism to create content that aligns with children's cognitive and linguistic abilities. By taking into account the unique challenges and opportunities presented by learning the Kazakh language, speech therapists actively consider the contextual and age factors that shape children's language learning experiences and speech for Kazakh-speaking children to develop their communication skills.

Speech therapist teachers checked the quality and compliance of the content of the developed dictionary in three categories: corresponds (1 point), does not correspond (0 points), and partially corresponds (0.5 point). Table 9 shows children's average scores for agreement and inconsistency of words, phrases, and sentences. Based on the results of the speech therapist's assessment of the correspondence of the dictionary's content and the sentences generated for children from 3 to 5 years old, it is concluded that the generated phrases and sentences are suitable for the target age group.

Table 9. The results of a speech therapist's assessment of the dictionary content for compliance with age groups (3–5 years).

Categories	Average Percent of Correctness for Words, %	Average Percent of Bigrams and Trigrams, %	Average Percent of Correctness for Sentences, %
garden	100	96	87
animals	100	98	91
toys	92	87	83

Initially, creating wordlists and phrases in English before translating into Kazakh can lead to inaccuracies and cultural inconsistencies.

To address the issue of English-based dependency when creating wordlists and phrases in Kazakh, the following steps are taken:

1. Research the context: Before creating a wordlist, it is important to understand the context in which the words will be used. This will help avoid misunderstandings and improve the accuracy of the translation.
2. Work with native speakers: Collaborating with native Kazakh speakers or experienced translators will help you better understand the cultural and linguistic nuances, which will help avoid inaccuracies.
3. Testing and feedback: Once the list is created, it is important to test it with the target audience and collect feedback. This will help identify potential errors and improve the quality of the content.

Analysis of Dataset Completeness

To determine the completeness of the data used in the dataset consisting of words used in children's speech, it is possible to use text statistics analysis.

Text statistics visualization is a simple but very informative method.

They include:

- Word frequency analysis;
- Sentence length analysis;
- Average word length analysis;
- Others.

They really help to explore the fundamental characteristics of text data.

To do this, follow these steps:

(1) Determine the number of characters in each sentence;

(2) Determine the number of words in a sentence;
(3) Determine the average word length.

As shown in Table 8, for each category of words, there are more bigrams than trigrams. However, in terms of the number of generated words, there are more long sentences. Since the corpus is for children, using long sentences can lead to difficulty in understanding the text and speech.

Looking at the category of animals, it is possible to determine the frequency of use of words in sentences. The frequency distribution of word usage is depicted in Figure 5, while Figure 6 illustrates the distribution of the top 10 most frequent bigrams.

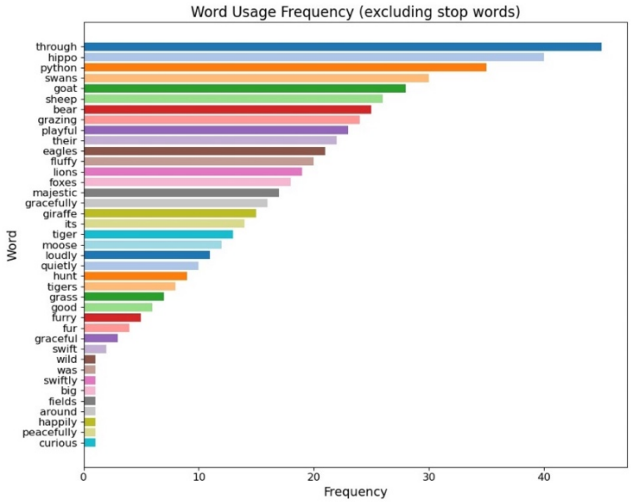

Figure 5. Word usage frequency distribution.

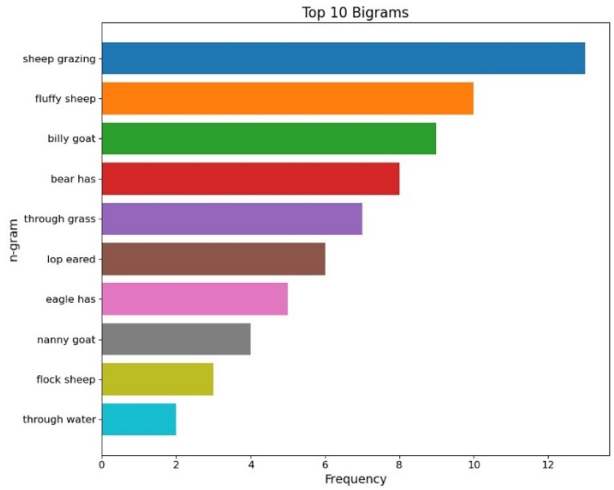

Figure 6. Top 10 bigram word frequency distribution.

Assessing the quality of the dataset is crucial to determining the overall effectiveness of the system. When assessing completeness, it is necessary to consider the needs of users in order to fully measure the quality of big data [68]. The quality assessment is demonstrated in Table 10.

Table 10. The results of a speech therapist's assessment of the dictionary content for compliance with age groups (3–5 years).

Categories	Completeness Rate, %	Missing Data Percentage, %	Weighted Completeness, %
garden	61.6	38.4	62.2
animals	74.6	25.4	75.3
toys	53.9	46.1	54.4

Completeness Rate is the percentage of non-null values in a dataset (5). Missing Data Percentage is the percentage of missing or null values in a dataset (6). Weighted Completeness is assigning weights to different data elements or words and phrases based on their importance (7) [69].

$$\text{Completeness Rate} = \left(\frac{m}{n}\right) \times 100\% \quad (9)$$

$$\text{Missing Data} = \left(\frac{v}{n}\right) \times 100\% \quad (10)$$

$$\text{Weighted Completeness} = \sum_{i=0}^{k} (\text{Completeness Rate}_i \cdot w_i) \quad (11)$$

where m is of non-null values, n is the total number of values, k is the missing values number, w is the word's weight in the dataset.

Assessing the completeness of the collected data shows that despite significant efforts to collect information, there are limitations in the accuracy and completeness of the data.

In this study, factors such as the applicability of the collected data to children were taken into account. A speech therapist checked the data for applicability to children, so the missing data does not refer to the part where words, phrases, and sentences in the Kazakh language were not selected.

There are problems with confirming the reliability of the data with the help of a speech therapist. Some categories of the dictionary may be incomplete (the category "toys"), which may lead to omissions or distortions in the analysis results. Some categories of the dictionary may be fully complete and detailed in our case with animals.

Thus, despite the existing limitations, our approach to the process of collecting and analyzing children's speech data gave holistic results and can be considered quite complete.

5. The Development of the Audio and Visualization Module for Delivering the Dictionary's Content

The main tool for developing preschool children's vocabulary is the didactic game. Didactic games are a widely used method of vocabulary work; these are educational games that can enrich children's vocabulary.

Visualization and voiceover of data can significantly influence how children perceive information. When data are presented in the form of pictures, graphs, or animations, children can better understand and remember the information, as visual materials can be more appealing and comprehensible to them.

Therefore, using visualization and voiceover can significantly improve information perception in children and contribute to their successful learning. Implementing audio and visual support in the developing system for learning new words can improve children's learning process and understanding. To simplify the task's implementation, the following module was developed using AI tools:

- Generation of images according to the algorithm of the developed children's thematic dictionary;
- Implementation of text to speech.

Study of available TTS for the Kazakh language: currently available options are KazakhTTS by ISSAI [70], Narakeet [71], Azure AI (Microsoft) [72].

An expert evaluation was conducted based on the following parameters: sound quality, generation speed, cost, ability to deploy locally, and file format. To assess sound quality, we will calculate the SNR (Signal-to-Noise Ratio).

Signal-to-Noise Ratio (SNR) is a measure used to evaluate the quality of an audio signal by comparing the power of the signal to the power of background noise or interference. SNR is measured in decibels (dB) and is typically defined as the ratio of signal power to noise power.

$$\text{SNR} = \frac{P_{signal}}{P_{noise}} = \left(\frac{U_{signal}}{U_{noise}}\right)^2, \quad (12)$$

All audio evaluation results are shown in Table 11.

Table 11. Evaluation results are based on a 45-character audio recording in the Kazakh language.

Characteristic	ISSAI KazakhTTS	Narakeet KazathTTS	Azure AI KazakhTTS
SNR, dB	22.8	21.7	25.6
Generation speed, sec	1	10	2
Free of charge	Yes	No	No
The ability to install locally	Yes	No	No
File format	wav, mp3	mp3, base64	m4a
File Size	160 kB	442 kB	740 kB

ISSAI KazakhTTS, according to the research evaluations, is the best option as it is free and can be installed on local computers. Its file size is the smallest, and the file format is convenient for application use. Although the SNR is slightly lower than that of Azure AI, it can be improved through subsequent recording processing. Since the generation speed is very low, additional processing will not significantly affect the program's performance.

To implement audio support based on our evaluation and research [73], it was decided to use KazakhTTS [70], developed by the ISSAI team in 2021. In 2022, ISSAI released the second version, increasing the size of the audio data from 90 to 271 h, which we decided to use. KazakhTTS offers five voices: Iseke, Rayya, Asel, Duman, and Gulzhanat. Using the standard phrase "Менің атым Қожа болады. Ал сіздің атыңыз кім?" ["My name is Kozha. What is your name?"], expert testing of the available voices was conducted with the requirements of moderate playback speed, soft sound, and no errors in repeated generations.

Test results:

1. Iseke: The voice has a guttural and rough sound, not suitable for our task.
2. Rayya: Playback is very fast, likely due to the audio data; this issue occurs with any text, making it unsuitable for our task.
3. Asel: There is a slight echo, and errors occur with several text-to-speech attempts. The voice is soft but not suitable for our task.
4. Duman: The sound is muted, the voice timbre is appropriate, and the playback speed is moderate, making it suitable for our task.
5. Gulzhanat: The playback speed is moderate, no errors occur with multiple text-to-speech attempts, and the voice is soft, making it suitable for our task.

For convenience, the results of this testing are published on Yandex Disk [https://disk.yandex.ru/d/JUD_QStMnREMnw, accessed on 28 September 2024]. In the final version, it was decided to use the voices of Duman and Gulzhanat.

The next step is to run KazakhTTS on a server on our local computer for a more detailed study of its capabilities. The computer has the following specifications and installed components:

- GPU: GeForce GTX 1070;
- CUDA: CUDA Toolkit 11.8;
- Torch: PyTorch Stable (2.3.0).

To optimize the program's performance, a database was created to store the recording name, file path, recording text, and usage count. Before generating a new recording, the database is checked to see if it already exists. If a matching recording is found, it is used, saving resources by avoiding the generation of a new recording. Each time a recording is used from the database, its use count is incremented by one. This was implemented to save database resources; if a recording is created but not reused within a certain period, it is deleted, which helps conserve space in the database. If the recording is needed again in the future, it will be regenerated.

After conducting experiments on short, medium, and long texts, it was observed that there were sound distortions and errors with short texts of seven characters.

For the comparative analysis of available image generation models based on text descriptions, currently there are three popular image generation models: DALL-E 3 [74], Midjourney [75], and Stable Diffusion [76].

The work [77] discusses validating the accuracy and appropriateness of illustrations produced by models such as DALL-E 3 for educational purposes. To achieve this, a comprehensive analysis of the technical foundations of the DALL-E 3 and MidJourney models is carried out, highlighting their neural network architecture and iterative improvement processes. The study reveals significant progress in generating high-quality photorealistic images from text queries, confirming the reliability and accuracy of the generated images. DALL-E 3's unique capabilities to control the image generation process through query modification allow users, including educators and librarians, unprecedented control over the creative process. This ensures that the illustrations produced are accurate and relevant to the specific educational context. The study also addresses the ethical implications of using AI-generated images in education, given potential issues such as cost and accessibility. A comprehensive approach to evaluating model performance ensures that it meets educational standards and also takes into account ethical and accessibility issues. Validation is based on detailed technical analysis, iterative improvement, query management capabilities, and ethical considerations. Thus, the article makes a compelling case for the applicability of the DALL-E 3 and MidJourney models in education and librarianship. After researching various tools, a comparative analysis was carried out. The results of the analysis are presented in Table 12.

Table 12. Comparison of available models.

Characteristic	DALL-E 3	Midjourney	Stable Diffusion
Image quality	High	Artistic	High
Generation rate	Fast	Depends on the load	Fast (locally)
Price	On request	From USD 10 to USD 600 per month	For Free
Flexibility of configuration	Limited	High	Very high
Kazakh language support	Limited; the main language is English	No, English	No, English

DALL-E 3: Developed by OpenAI, DALL-E 3 is the latest version of their model for generating images from textual descriptions. The model provides high-quality images and can generate photorealistic details.

Midjourney: This independent model focuses on creating highly artistic and stylized images. Users can control the process using specialized commands to adjust styles.

Stable Diffusion: An open model developed by Stability AI that allows users to generate images locally. It offers greater flexibility in modifying and using the model.

Figure 7 shows the generated images based on the children's thematic dictionary in Kazakh using the Midjourney program.

Figure 7. Generated drawings from the thematic dictionary.

Figure 8 shows an example of the implementation of the thematic dictionary in a mobile application. For learning purposes, the word itself is presented along with an image of the word and its pronunciation. Additionally, in the "Description of Word" section, an explanation of the word is provided depending on the child's age, using the developed approach. The educational textual data are accompanied by audio in the Kazakh language. When the page loads, the server is accessed to request the WAV file for the pronunciation of the word and its description. These recordings can be played by pressing the corresponding buttons shown in Figure 8.

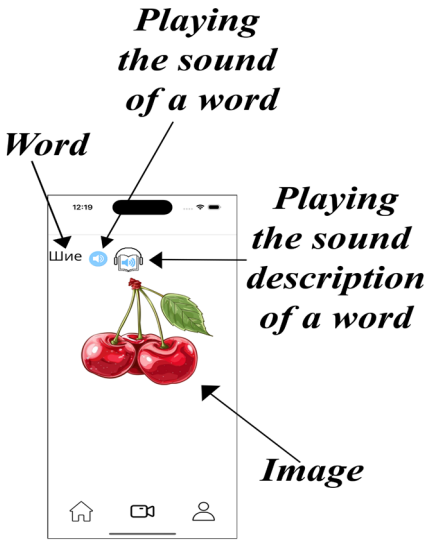

Figure 8. An example of the implementation of a thematic dictionary in a mobile application.

6. Discussion

Vocabulary is a major component of improving children's literacy as it is the basic, smallest, and most important component of language learning [78]. The dictionary was found to be recognized as an excellent medium that is critical to the development of students' literacy skills. This relates to the statements of [79], who believe that the dictionary can be called one of the most common and easy-to-use media because it is the central repository of information for language learners. The dictionary provides extensive knowledge of vocabulary, grammar, meaning, pronunciation, phrases, and parts of speech. Moreover, the results of previous research showed that vocabulary development is necessary to improve students' literacy and learning skills in language [80–82].

Developing applications and systems based on dictionaries for speech development and studying low-resource languages using modern AI technologies is very relevant. Considering that very few such means are aimed at children, we can assume that the research has further development and relevance. Existing open-source tools such as Anki [83], Duolingo [84], Rosetta Stone [85], and Babbel [86] offer polished user interfaces

and rich multimedia content. However, these tools are typically designed for older students and adults and cannot meet preschool-age children's linguistic and cognitive needs.

Additionally, the high cost associated with proprietary instruments limits their availability for widespread use in educational settings. Open-source resources for the Kazakh language are especially limited and often require additional configuration and implementation.

The developed application is based on a children's educational dictionary for a low-resource language using AI tools; it is very convenient and effective for teaching preschool children. The SUS method is often used to evaluate the usability of products and services, and it has been applied to determine the effectiveness, complexity, ease of learning, and user satisfaction of the developed application.

The SUS evaluation showed an average score of 71.3, indicating that users found the application to be user-friendly, with good visualization and voiceover of the material for children in the Kazakh language. The app's average usability score was 71.3 out of 100, indicating that users were generally satisfied with the usability level.

Based on the results of the SUS evaluation, the following measures were taken to improve the usability of the application:

- Improved navigation by adding a navigation menu and shortcut buttons to the application's main functions;
- Improving the interface by increasing the size and contrast of elements and optimizing the layout of information on the screen.

These changes were realized into the final implementation of the application, resulting in improved usability and increased user satisfaction. Figure 9 presents the outcomes of the SUS method assessment for the developed application.

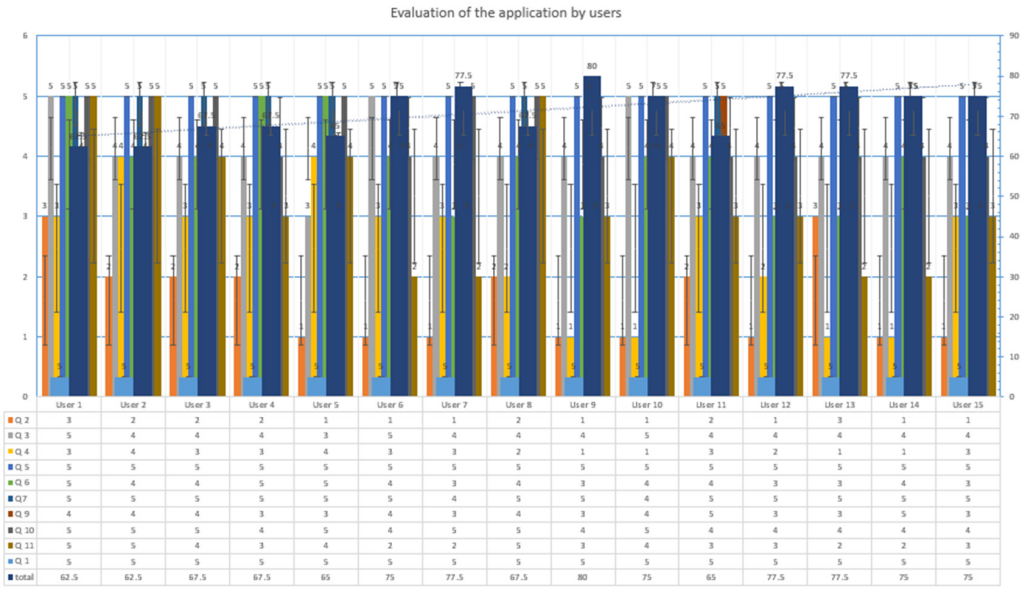

Figure 9. The result of evaluating the application of the SUS method.

The Kazakh language has few resources, so applications developed for teaching the Kazakh language are in great demand among parents and their children. The SUS method was also used to analyze and compare previously developed applications. Among the analyzed applications, it is possible to note "Qonzhyqapp" [87], "Literacy: The Talking Alphabet" [88], and "Self-speech therapist!" [89], mobile applications developed in Kazakhstan.

They contribute to the preservation and development of the mother tongue by offering children interesting and interactive ways of learning. However, these applications offer a simple way to learn the Kazakh language. That is, speaking is taught on the basis of dictionaries compiled on several topics based on animation, sound, and various exercises.

The "Qonzhyqapp", "Literacy: The Talking Alphabet", and "Self-speech therapist!" applications do not use AI tools. They contain a dictionary of 800–1200 words intended for children aged 2–5 years. "Qonzhyqapp" is designed for Android and iOS systems. Their main services are activated for a fee.

AI tools in the proposed application are more convenient and effective than the compared applications. Their evaluation is shown in Figure 10. Although there are many educational, language, and speech teaching applications, it is clearly necessary to create a new application that targets the specific needs of Kazakh-speaking children.

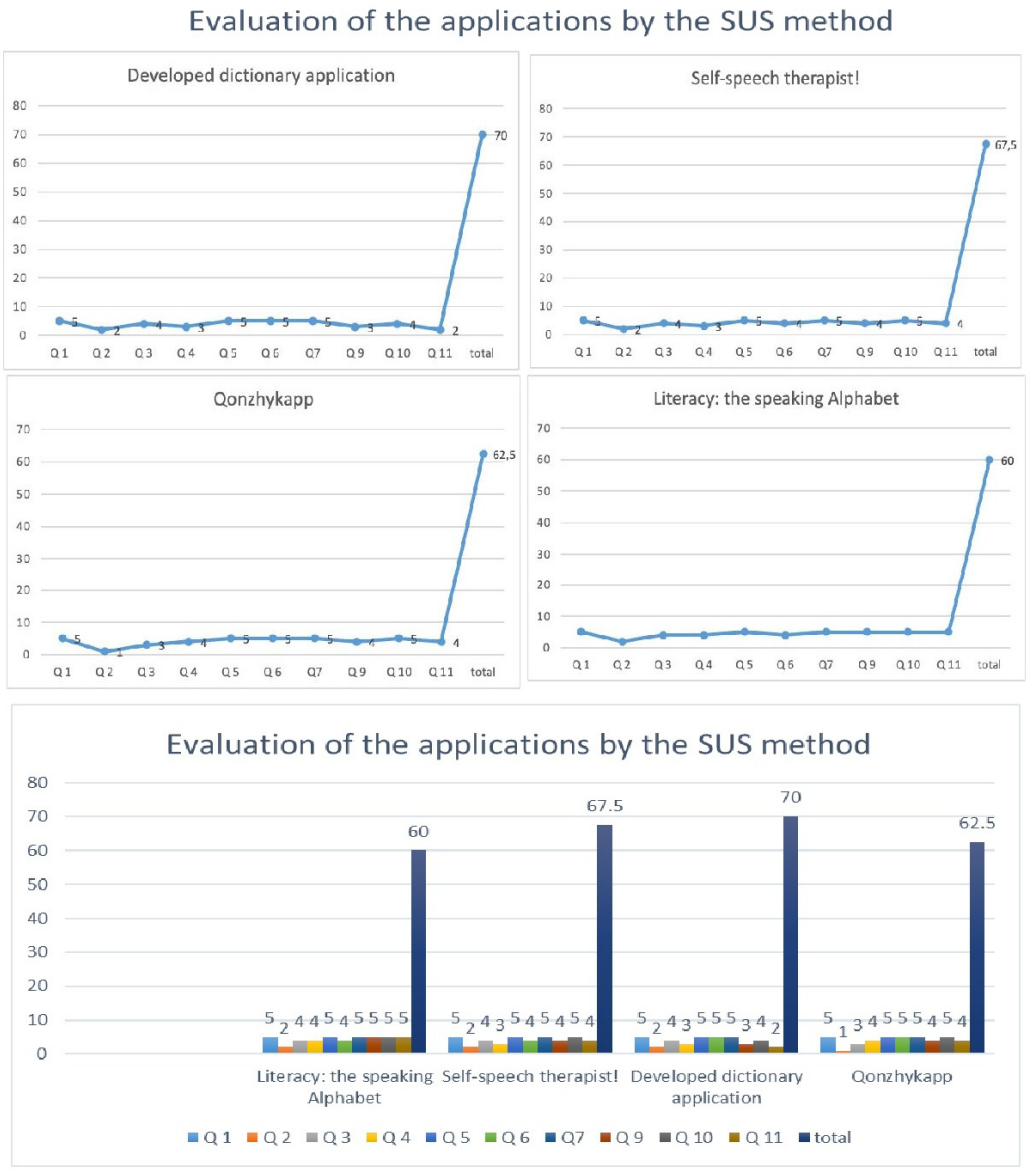

Figure 10. A questionnaire for evaluating the application of the SUS method.

The diagram compares the SUS (System Usability Scale) evaluation of four applications: "Qonzhyqapp", "Сауат ашу: сөйлейтін әліппе" ("Literacy: the speaking Alphabet"), "Өз-өзіне Логопед!" ("Self-speech therapist!"), and developed a dictionary application. The developed dictionary application has the highest SUS evaluation of 70, indicating it is the most user-friendly and effective among the compared applications. This result showcases the superior usability and quality of our dictionary, emphasizing its effectiveness in supporting children's education in a low-resource language through AI tools. The higher

SUS evaluation demonstrates our application's better design, ease of use, and overall user satisfaction compared to the other applications evaluated.

The developed dictionary has a child-friendly interface with colorful illustrations and easy navigation, making it very accessible and fun for young children. The integration of AI-generated images and text-to-speech (TTS) technology ensures content is visually appealing and accessible to children of varying reading levels. Feedback from teachers and children during testing in a preschool showed that the application was easy to use and very fun, which confirms its ease of use in an educational environment. It can also be noted that the dictionary was created on the basis of a complete explanatory dictionary [90] and a thematic dictionary developed specifically for the development of children's speech [91].

The fully developed audio and visualization application is available on the GitHub platform [92]. The rest of the information about the formed children's dictionary is shown in Appendix A.

7. Limitations and Future Directions

The limitations of this study cover the problems of confirming the reliability of the data with the help of a speech therapist. Some dictionary categories may be incomplete (the category "toys"), which may lead to omissions or distortions in the analysis results. Some dictionary categories may be fully complete and detailed, as in our case with animals.

The research covered in this work will be continued in future works. The developed system will be adapted to the children's level of academic performance and mastery of the material. It will offer them the next stage of learning and specific exercises and tools for speech development for each person individually. After fully testing the developed approach and populating the system with data, a mobile application on marketplace platforms is planned for launch. It will be part of a social project to support early childhood education development in remote regions and promote learning of low-resource languages like Kazakh.

In addition, in future works, the children's dictionary will be extended with new themes, phrases, and sentences related to them. Adding new images and audio recordings within previous and new themes will also increase the functionality of the visualization and voiceover module. Applying this approach to other Turkic languages with similar linguistic properties and dictionary data is also possible.

Within the framework of this research, the following is planned:

1. The plans to expand the thematic coverage of the dictionary will include:
    - Research interests and needs: Conducting surveys among children, parents, and teachers to identify the most relevant topics for expansion.
    - Regular content updating: Creating a mechanism for regularly updating and adding new topics depending on cultural and educational changes in preschool programs and society.
2. The plans to implement additional multimedia functions and interactive elements will include:
    - Animated explanations and video lessons: Implementing animated content simplifies complex concepts and creates engaging learning.
    - Interactive games and quizzes: Enriching the learning process through game mechanics that motivate children to participate actively.

8. Conclusions

In conclusion, it is important to note that studying children's speech development and creating a thematic dictionary for low-resource languages is significant in using IT and AI tools in modern society, where speech disorders are increasingly observed. This article presents a comprehensive approach to developing a thematic education dictionary for children aged 3 to 5 using AI technology. The approach involves creating linguistic resources through a hybrid method, including GPT-4 technologies (for English) and machine

translation, followed by post-processing based on morphological and semantic analysis in Kazakh. The study involved several key stages, from forming lists of words and sentences in English to filtering bigrams and trigrams using POS tag patterns to adapt the list for children in Kazakh. Practical research on the developed approach focused on three themes: gardens, animals, and toys. After thorough processing, the dictionary consists of 654 words, 1809 phrases, and 2105 sentences.

The experimental results were evaluated using the cosine similarity, Euclidean distance, and Manhattan distance metrics. The average cosine similarity value of 0.62 indicates high similarity between phrases. The average Euclidean similarity value of 8.9 suggests that some phrases or keywords have a greater influence in forming the thematic dictionary. The evaluation results demonstrate the approach's success in forming and presenting material for children's understanding. Using models like DALL-E 3, Midjourney, and Stable Diffusion allowed for creating visual materials that complement the dictionary content, aiding in children's more effective learning of new words. Additionally, the open-source TTS technology for the Kazakh language provided voiceovers for the dictionary content, adjusted for speed and tone to be easily perceived by children. The developed approach was tested in the educational process of a specialized preschool institution. The results show a 12.6% improvement in material comprehension among children and ease of use for staff (teachers and speech therapists). Thus, the proposed method enriches children's vocabulary and enhances language skills development within the modern educational environment. Using AI tools in educational processes for preschool children can make learning more engaging, accessible, and effective. Plans include implementing personalized learning by creating individual study plans for each child, considering their knowledge level, capabilities, and learning pace, as well as adding multimedia features such as video files, animation, and interactive pictures to the educational dictionary. The experimental results demonstrate the high efficiency of the proposed approach and the possibility of its widespread use for educational purposes.

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Data Availability Statement: This study analyzed publicly available datasets. The results obtained and datasets can be found here: https://github.com/NLP-KazNU/AP19577833-Electronic-resources-for-children-with-speech-disorders-based-on-AI-technology, accessed on 28 September 2024 [85].

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Filtered phrases for children aged 3–5 years (total).

animals	‘Бегемот’: [‘бегемот баяу’, ‘күшті бегемот’, ‘жасыл өсімдіктерді жейді’], ‘Бүркіт’: [‘жылдам аңшы’, ‘күшті тырнақтары бар’, ‘биікке ұшады’], ‘Қасқыр’: [‘қасқыр ырылдайды’, ‘қасқыр жабайы’, ‘жабайы жыртқыш’], ‘Қаз’: [‘балапандары сап түзейді’, ‘дауыстап қоныс аударады’, ‘суда жүзеді’], ‘Жираф’: [‘жирафтар табыны’, ‘мойны ұзын’, ‘дақтары бар жираф’], ‘Қоян’: [‘қоян секіреді’, ‘тез жүгіреді’, ‘ақ қоян’], ‘Ешкі’: [‘кішкентай қозы’, ‘ешкінің сүті’, ‘мүйізді ешкі’], ‘Сиыр’: [‘сиыр бұзауы’, ‘ірі қара сиыр’, ‘сиырдың сүті’], ‘мысық’: [‘сары мысық’, ‘үй жануары’, ‘ұйықтағанды жақсы көреді’], ‘Аққу’: [‘ақ аққу’, ‘аққу көлде’, ‘суда сырғиды’], ‘арыстан’: [‘аң патшасы’, ‘джунглидің патшасы’, ‘жыртқыш аң’], ‘Түлкі’: [‘қу түлкі’, ‘жыртқыш түлкі’, ‘тауық аулайды’], ‘Аю’: [‘гризли аю’, ‘ақ аю’, ‘қоңыр аю’], ‘Тышқан’: [‘кішкентай тышқан’, ‘тез жүгіреді’, ‘кеміруші жануар’], ‘Қой’: [‘қой отары’, ‘шөп жейді’, ‘жайлауда жайылады’]	‘Hippopotamus’: [‘slow hippopotamus’, ‘strong hippopotamus’, ‘eats green plants’], ‘Eagle’: [‘fast hunter’, ‘has strong talons’, ‘flies high’], ‘Wolf’: [‘wolf growls’, ‘wild wolf’, ‘wild predator’], ‘Goose’: [‘goslings march in line’, ‘migrates loudly’, ‘swims in water’], ‘Giraffe’: [‘giraffe herd’, ‘long neck’, ‘spotted giraffe’], ‘Rabbit’: [‘rabbit jumps’, ‘runs fast’, ‘white rabbit’], ‘Goat’: [‘small kid’, ‘goat’s milk’, ‘horned goat’], ‘Cow’: [‘cow calf’, ‘large cow’, ‘cow’s milk’], ‘Cat’: [‘yellow cat’, ‘pet’, ‘likes to sleep’], ‘Swan’: [‘white swan’, ‘swan on the lake’, ‘glides on water’], ‘Lion’: [‘king of the animals’, ‘king of the jungle’, ‘predator’], ‘Fox’: [‘cunning fox’, ‘predatory fox’, ‘hunts chickens’], ‘Bear’: [‘grizzly bear’, ‘polar bear’, ‘brown bear’], ‘Mouse’: [‘small mouse’, ‘runs fast’, ‘rodent’], ‘Sheep’: [‘sheep flock’, ‘eats grass’, ‘grazes in the pasture’]
garden	‘Банан’: [‘жұмсақ банан’, ‘сары банан’, ‘тропикалық жеміс’], ‘Сәбіз’: [‘сары сәбіз’, ‘сәбіз көкөніс’, ‘қоян жейді’], ‘Шие’: [‘шие ағашы’, ‘шырынды шие’, ‘қызы шие’], ‘Алма’: [‘жасыл алма’, ‘қызыл алма’, ‘алма ағашы’], ‘Ағаш’: [‘емен ағашы’, ‘жасыл жапырақ’, ‘қайын ағаш’], ‘Алмұрт’: [‘сары алмұрт’, ‘жасыл алмұрт’, ‘піскен алмұрт’], ‘Қарбыз’: [‘дөңгелек қарбыз’, ‘шырынды қарбыз’], ‘Қияр’: [‘қытырлақ қияр’, ‘жасыл қияр’, ‘маринадталған қияр’], ‘Жидек’: [‘шырынды жидек’, ‘қызыл құлпынвй’, ‘қыщқыл жидек’], ‘Қызанақ’: [‘қызыл қызанақ’, ‘дөңгелек көкөніс’, ‘қызанақ пен қияр’], ‘Бақша’: [‘шырынды жемістер’, ‘жасыл бақ’, ‘гүлдерге толы’], ‘Жеміс’: [‘тропикалық жеміс’, ‘цитрус жемістері’], ‘Өрік’: [‘қара өрік’, ‘өрік джемі’, ‘тәтті өрік’], ‘Бұрыш’: [‘жасыл бұрыш’, ‘қызыл бұрыш’, ‘қара бұрыш’], ‘Лимон’: [‘цитрус жемісі’, ‘лимон шырыны’, ‘қышқыл лимон’], ‘Қызылша’: [‘күлгін қызылша’, ‘піскен қызылша’, ‘қант қызылшасы’], ‘Көкөніс’: [‘бақша көкөністері’, ‘дәмді көкөністер’, ‘жасыл өсімдік’], ‘Асқабақ’: [‘асқабақ пирогы’, ‘қызғылт сары асқабақ’, ‘асқабақ тұқымы’]	‘Banana’: [‘soft banana’, ‘yellow banana’, ‘tropical fruit’], ‘Carrot’: [‘yellow carrot’, ‘carrot vegetable’, ‘rabbit eats’], ‘Cherry’: [‘cherry tree’, ‘juicy cherry’, ‘red cherry’], ‘Apple’: [‘green apple’, ‘red apple’, ‘apple tree’], ‘Tree’: [‘oak tree’, ‘green leaf’, ‘birch tree’], ‘Pear’: [‘yellow pear’, ‘green pear’, ‘ripe pear’], ‘Watermelon’: [‘round watermelon’, ‘juicy watermelon’], ‘Cucumber’: [‘crispy cucumber’, ‘green cucumber’, ‘pickled cucumber’], ‘Berry’: [‘juicy berry’, ‘red strawberry’, ‘sour berry’], ‘Tomato’: [‘red tomato’, ‘round vegetable’, ‘tomato and cucumber’], ‘Garden’: [‘juicy fruits’, ‘green garden’, ‘full of flowers’], ‘Fruit’: [‘tropical fruit’, ‘citrus fruits’], ‘Apricot’: [‘black apricot’, ‘apricot jam’, ‘sweet apricot’], ‘Pepper’: [‘green pepper’, ‘red pepper’, ‘black pepper’], ‘Lemon’: [‘citrus fruit’, ‘lemon juice’, ‘sour lemon’], ‘Beetroot’: [‘purple beetroot’, ‘ripe beetroot’, ‘sugar beet’], ‘Vegetable’: [‘garden vegetables’, ‘tasty vegetables’, ‘green plant’], ‘Pumpkin’: [‘pumpkin pie’, ‘orange pumpkin’, ‘pumpkin seeds’]

Table A1. *Cont.*

toys	Қуыршақ: [‘әдемі қуыршақ’, ‘тірі қуыршақ’, ‘барби қуыршақ үйі’, ‘миниатюралық манекен’, ‘сүйкімді қуыршақ’, ‘әдемі жасалған қуыршақ’, ‘қуыршақ үйі’] Көлік: [‘ашық қызыл’, ‘ойыншық машина’, ‘жарыс вагоны’, ‘кішкентай көк көлік’, ‘ойыншық автомобиль’, ‘жолда жарысады’, ‘сары жүк көлік’, ‘шағын мотоцикл’, ‘пластмассадан жасалған арба’, ‘ойыншық гараж’, ‘миниатюралық лимузин’, ‘жасыл джип’, ‘фургондарды ойнау’, ‘әдемі ойыншық машина’, ‘жылдам ойыншық автомобиль’, ‘ойыншық автомобиль’] Пойыз: ‘түрлі-түсті ойыншық пойыз’, ‘теміржол жолы’, ‘локомотив қозғалтқышы’, ‘түрлі-түсті теміржол’, ‘оқу ойыншық пойыз’ тікұшақ: [‘Кішкентай пластик ойыншық’, ‘тікұшақ ұшады’, ‘түрлі-түсті миниатюралық ойыншық’, ‘жылдам ұшады’, ‘ашық ауада ұшады’, ‘тікұшақтарды басқаруды жақсы көреді’, ‘ойнағанды жақсы көреді’] ойыншық жануарлар: [құшақтауға арналған, жұмсақ түкті серіктер, сүйкімді тұлыптар, ерке аю, икемді күшіктер, үлпілдек қоян ойыншық, сүйкімді мысық, сүйкімді қуыршақ] Роботтар: [‘пластиктен жасалған’, ‘кішкентай қызыл робот’, ‘робот ойыншық’, ‘электронды автомат’, ‘көк роботты машина’, ‘кішкентай роботтар’, ‘роботты ойыншықтар’, ‘көңілді робот ойыншық’, ‘қызыл автомат’] Лего: [түрлі-түсті пластик, ойыншық кірпіштері, лего конструкциясы, пластикалық бөлшек, ойнап жобалайды, ойнап құрастырады, түрлі-түсті модульдік лего, құрылыс жинағы] Ниндзя тасбақалары: [‘ниндзя тасбақа’, ‘зұлым адамдармен күреседі’, ‘ниндзя қаруымен шайқасады’, ‘мутант тасбақа’, ‘батыл ниндзя жауынгер’]	Doll: [‘beautiful doll’, ‘living doll’, ‘Barbie dollhouse’, ‘miniature mannequin’, ‘cute doll’, ‘well-made doll’, ‘dollhouse’] Vehicle: [‘bright red’, ‘toy car’, ‘racing wagon’, ‘small blue car’, ‘toy automobile’, ‘races on the road’, ‘yellow truck’, ‘small motorcycle’, ‘plastic cart’, ‘toy garage’, ‘miniature limousine’, ‘green jeep’, ‘playing with vans’, ‘beautiful toy car’, ‘fast toy automobile’, ‘toy automobile’] Train: [‘colorful toy train’, ‘railroad track’, ‘locomotive engine’, ‘colorful railway’, ‘educational toy train’] Helicopter: [‘small plastic toy’, ‘helicopter flies’, ‘colorful miniature toy’, ‘flies fast’, ‘flies outdoors’, ‘loves controlling helicopters’, ‘loves playing’] Toy animals: [‘for hugging’, ‘soft furry companions’, ‘cute plush toys’, ‘playful bear’, ‘flexible puppies’, ‘fluffy bunny toy’, ‘cute cat’, ‘cute doll’] Robots: [‘made of plastic’, ‘small red robot’, ‘robot toy’, ‘electronic automaton’, ‘blue robot machine’, ‘small robots’, ‘robot toys’, ‘fun robot toy’, ‘red automaton’] Lego: [‘colorful plastic’, ‘toy bricks’, ‘Lego construction’, ‘plastic piece’, ‘plays and designs’, ‘plays and builds’, ‘colorful modular Lego’, ‘construction kit’] Ninja Turtles: [‘ninja turtle’, ‘fights evil people’, ‘battles with ninja weapons’, ‘mutant turtle’, ‘brave ninja warrior’]

Questions	points, 1-5 (choose only 1 from 1 to 5 points in each row)				
Was it easy for your child to figure out how to use the basic functions of the app?	5	4	3	2	1
How comfortable was your child using the feedback or support feature in the app?	5	4	3	2	1
How easy was it for your child to find and launch the app?	5	4	3	2	1
How will your child appreciate the personalization and customization options of the app?	5	4	3	2	1
Was the app interesting and engaging for your	5	4	3	2	1
How clear were the instructions and tips in the app for your child?	5	4	3	2	1
How will your child appreciate the design and layout of the application?	5	4	3	2	1
How quickly did the app load and run on your child's device?	5	4	3	2	1
How convenient was it to use the application menu?	5	4	3	2	1
How easy was it for your child to find the information they needed in the app?	5	4	3	2	1

Figure A1. An example of a questionnaire for evaluating the application of the SUS method.

Table A2. Abbreviations based on the document content.

Abbreviation	Full Term
AI	Artificial Intelligence
TTS	Text to Speech
IRN	International Research Number
AP	Advanced Placement
NLP	Natural Language Processing
Kazakh TTS	Kazakh Text to Speech
SNR	Signal-to-Noise Ratio
ISSAI	Institute of Information Systems and Artificial Intelligence
POS	Part of Speech
BERT	Bidirectional Encoder Representations from Transformers
SUS	System Usability Scale
DALL-E	A deep learning model developed by OpenAI to generate images from textual descriptions
ChatGPT	Chat Generative Pre-trained Transformer
MATEC	International Conference on Materials and Technology

Table A3. Evaluation Questionnaire.

Column Name	Drop-Down List Options
User ID	Predefined list of user IDs
Age Group	Dropdown with age ranges (e.g., 3–4, 4–5, etc.)
Rating (1–5)	Dropdown with numerical ratings from 1 to 5
Comments	Text field for user comments
Date of Evaluation	Date picker

References

1. Brodin, J.; Hollerer, L.; Renblad, K.; Stancheva-Popkostadinova, V. Preschool teachers' understanding of quality in preschool: A comparative study in three European countries. *Early Child Dev. Care* **2015**, *185*, 968–981. [CrossRef]
2. Ziolkowski, R.; Goldstein, H. Effects of an Embedded Phonological Awareness Intervention During Repeated Book Reading on Preschool Children with Language Delays. *J. Early Interv.* **2008**, *31*, 67–90. [CrossRef]
3. Grabmeier, J. Preschoolers' Reading Skills Benefit from One Modest Change by Teachers. *Educ. Dig. Essent. Read. Condens. Quick Rev.* **2012**, *78*, 63–64.
4. Lennox, S. Interactive Read-Alouds—An Avenue for Enhancing Children's Language for Thinking and Understanding: A Review of Recent Research. *Early Child. Educ. J.* **2013**, *41*, 381–389. [CrossRef]
5. Wilson, P. Why Invest in the Pre-School Years? In *Thinking Ahead. Why We Need to Improve Children's Mental Health and Wellbeing*; Jolley, R., Ed.; Faculty of Public Health (FPH): London, UK, 2011; pp. 1–9.
6. Hargrave, A.C.; Sénéchal, M. A Book Reading Intervention with Preschool Children Who Have Limited Vocabularies: The Benefits of Regular Reading and Dialogic Reading. *Early Child. Res. Q.* **2000**, *15*, 75–90. [CrossRef]
7. Skolverket. *Läroplan för Förskolan Lpfö 98*, Ny rev. ed.; Skolverket: Stockholm, Sweden, 2010.
8. Ministry of Education and Science of the Republic of Kazakhstan, National Scientific and Practical Center of Correctional Pedagogy, Laboratory of Special Education for Children with Special Educational Needs. Analysis of the Study of the Problem of Forming the Native Language System during the Speech Ontogenesis of Children of Early and Preschool Age (Analytical reference). 2019, p. 24. Available online: https://special-edu.kz/analitspr/%D0%90%D0%BD%D0%B0%D0%BB.%D1%81%D0%BF%D1%80%D0%B0%D0%B2%D0%BA%D0%B0%20%D0%BA%D0%B0%D0%B7%D0%BB%D0%B0%D0%B1.pdf (accessed on 28 March 2024).
9. Verburg, M. The Making of My First Van Dale: A Preschool Dictionary. In Proceedings of the Euralex Conference, Torino, Italy, 6–9 September 2006; pp. 357–362.
10. Nkomo, D. An African User-Perspective on English Children's and School Dictionaries. *Int. J. Lexicogr.* **2016**, *29*, 31–54. [CrossRef]
11. Bekmanova, G.; Sharipbay, A.; Kabdylova, D.; Amangeldy, N.; Sairanbekova, A.; Omarbekova, A.; Zulkhazhav, A. Development of an electronic dictionary of terminology for school textbooks. *J. Electr. Syst.* **2024**, *20–24s*, 904–911. [CrossRef]
12. Zhao, D.; Xu, H. Improving the Compilation of English–Chinese Children's Dictionaries: A Children's Cognitive Perspective. *Lexikos* **2022**, *32*, 49–65. [CrossRef]
13. Liu, X.; Lyu, J.; Zheng, D. For a Better Dictionary: Revisiting Ecolexicography as a New Paradigm. *Lexikos* **2021**, *3*, 182–207. [CrossRef]
14. Li, Q.; Russell, M. An Analysis of the Causes of Increased Error Rates in Children's Speech Recognition. In Proceedings of the 7th International Conference on Spoken Language Processing (ICSLP 2002), Denver, CO, USA, 16–20 September 2002; pp. 366–369.

15. Callaghan, T.; Reich, S. Tools for evaluating educational apps for young children: A systematic review of the literature. *Interact. Technol. Smart Educ.* **2018**, *18*, 18–49.
16. Hirsh-Pasek, K.; Zosh, J.M.; Golinkoff, R.M.; Gray, J.H.; Robb, M.B.; Kaufman, J. Putting Education in "Educational" Apps: Lessons from the Science of Learning. *Psychol. Sci. Public Interest* **2015**, *16*, 3–34. [CrossRef] [PubMed]
17. Kolak, J.; Norgate, S.H.; Monaghan, P.; Taylor, G. Developing Evaluation Tools for Assessing the Educational Potential of Apps for Preschool Children in the UK. *J. Child. Media* **2021**, *15*, 410–430. [CrossRef]
18. Rideout, V.; Robb, M.B. The Common Sense Census: Media Use by Kids Age Zero to Eight, 2020: Common Sense Media. Common Sense Media: Ratings, Reviews, and Advice, 17 November 2020. Available online: https://www.commonsensemedia.org (accessed on 28 April 2024).
19. Kervin, L. Powerful and Playful Literacy Learning with Digital Technologies. *Aust. J. Lang. Lit.* **2016**, *39*, 64–73. [CrossRef]
20. Arnold, A. A Randomized Controlled Trial of an Educational App to Improve Preschoolers' Emergent Literacy Skills. *J. Child. Media* **2021**, *15*, 457–475. [CrossRef]
21. Dore, R.A. Education in the App Store: Using a Mobile Game to Support U.S. Preschoolers' Vocabulary Learning. *J. Child. Media* **2019**, *13*, 452–471. [CrossRef]
22. Kirkorian, H.L.; Choi, K.; Pempek, T.A. Toddlers' Word Learning from Contingent and Non-Contingent Video on Touchscreens. *Child Dev.* **2016**, *87*, 405–413. [CrossRef]
23. Russo-Johnson, C. All Tapped Out: Touchscreen Interactivity and Young Children's Word Learning. *Front. Psychol.* **2017**, *8*, 578. [CrossRef]
24. Parmawati, L.; Ratminingsih, N.M.; Budasi, I.G. The Development of a Multilingual Thematic Digital Dictionary for Elementary School Students. *E-Link J.* **2022**, *9*, 60–75. [CrossRef]
25. Cheng, J.; Wang, H.; Lu, S. Context-Aware Learning for Sentence-Level Sentiment Analysis with Posterior Regularization. In Proceedings of the 43rd International ACM SIGIR Conference on Research and Development in Information Retrieval, Xi'an, China, 25–30 July 2020; pp. 555–564.
26. Why Does a Child's Tongue Come Out Late? *Speech Therapist Tips for Parents.* Available online: https://informburo.kz/kaz/bala-tl-nege-kesh-shyady-logopedt-ata-analara-keester.html (accessed on 5 April 2024).
27. Speech Retardation in a Child. Available online: https://daryn.online/article/2919# (accessed on 9 April 2024).
28. Mamyrbayev, O.; Alimhan, K.; Oralbekova, D.; Bekarystankyzy, A.; Zhumazhanov, B. Identifying the Influence of Transfer Learning Method in Developing an End-to-End Automatic Speech Recognition System with a Low Data Level. *East.-Eur. J. Enterp. Technol.* **2022**, *1*, 84–92. [CrossRef]
29. Mussakhojayeva, S.; Dauletbek, K.; Yeshpanov, R.; Varol, H.A. Multilingual Speech Recognition for Turkic Languages. *Information* **2023**, *14*, 74. [CrossRef]
30. Rakhimova, D.; Matanov, N.; Rzagaziyeva, A. Development of a Dictionary for Preschool Children with Weak Speech Skills Based on the Word2Vec Method. In Proceedings of the ICCCI, Budapest, Hungary, 27–29 September 2023; pp. 191–202.
31. Łukasik, M. Corpus Linguistics and Generative AI Tools in Term Extraction: A Case of Kashubian—A Low-Resource Language. *Appl. Linguist. Pap.* **2024**, *39*, 34–45. Available online: http://alp.uw.edu.pl/wp-content/uploads/sites/315/2024/02/5-ALP_Lukasik-Marek.pdf (accessed on 8 April 2024). [CrossRef]
32. Ponnusamy, R. Tamil Text Generation using ChatGPT-3 Models. In Proceedings of the International Conference on Tamil Computing, Mangaluru, India, 13–14 October 2023; p. 30.
33. Oranga, J. Benefits of Artificial Intelligence (ChatGPT) in Education and Learning: Is Chat GPT Helpful? *Int. Rev. Pract. Innov. Technol. Green Energy (IRPITAGE)* **2023**, *3*, 46–50.
34. Pisarev, I.A. Methods for Automated Thesauri Development of Thematic Corpora in the Learning Process Support Systems. In Proceedings of the IEEE Conference on Soft Computing and Measurements, St. Petersburg, Russia, 25–27 May 2016; pp. 39–40.
35. Yelibayeva, G.; Sharipbay, A.; Bekmanova, G.; Omarbekova, A. Ontology-Based Extraction of Kazakh Language Word Combinations in Natural Language Processing. In Proceedings of the International Conference on Data Science, E-learning and Information Systems 2021 (DATA'21), Petra, Jordan, 5–7 April 2021; pp. 60–75.
36. Piaget, J. *The Origins of Intelligence in Children*; International Universities Press: New York, NY, USA, 1952.
37. Vygotsky, L.S. *Mind in Society: The Development of Higher Psychological Processes*; Harvard University Press: Cambridge, MA, USA, 1978.
38. Verhallen, M.J.; Bus, A.G. Multimedia stories for kindergarten children: The effects of modality and narration style on comprehension and vocabulary acquisition. *J. Educ. Psychol.* **2010**, *102*, 652–660.
39. Pane, J.F.; Griffin, B.A.; McCaffrey, D.F.; Karam, R. *Effectiveness of Personalized Learning: Findings from a Study of Four Charter Schools*; RAND Corporation: Santa Monica, CA, USA, 2017.
40. Wood, S.G.; Moxley, J.H.; Tighe, E.L.; Wagner, R.K. Does use of text-to-speech and related read-aloud tools improve reading comprehension for students with reading disabilities? A meta-analysis. *J. Learn. Disabil.* **2005**, *41*, 75–84. [CrossRef]
41. Sunder, P. The Effectiveness of Audio-Visual Aids in Teaching-Learning Process. *Int. J. Creat. Res. Thoughts* **2018**, *6*, 1509–1515.
42. Sundqvist, A.; Barr, R.; Heimann, M.; Birberg-Thornberg, U.; Koch, F.-S. A longitudinal study of the relationship between children's exposure to screen media and vocabulary development. *Acta Paediatr.* **2023**, *113*, 517–522. [CrossRef]
43. Online Nation Report 2019 (OFCOM). Available online: https://www.gov.uk/find-digital-market-research/online-nation-report-2019-ofcom (accessed on 10 September 2024).

44. Ronniger, P.; Rennecke, L.; Petermann, F.; Melzer, J. Differenzierungsfähigkeit des Sprachstandserhebungstest für Kinder im Alter zwischen 3 und 5 Jahren. *Monatsschr Kinderheilkd* **2022**, *170*, 422–429. [CrossRef]
45. Jablonski, S. Inhibitory control and literacy development among 3- to 5-year-old children. *L1-Educ. Stud. Lang. Lit.* **2014**, *14*, 1–25. [CrossRef]
46. Schebesta, A.; Kunter, G. Constituent durations in English NNN compounds: A case of strategic speaker behavior? *J. Phon.* **2022**, *94*, 101164. [CrossRef]
47. Vania, C.; Lopez, A. From Characters to Words to in Between: Do We Capture Morphology? In Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers), Vancouver, BC, Canada, 30 July–4 August 2017; Association for Computational Linguistics: Vancouver, BC, Canada, 2017; pp. 2016–2027.
48. Roseberry, S.; Hirsh-Pasek, K.; Golinkoff, R.M. Skype me! Socially contingent interactions help toddlers learn language. *Child Dev.* **2014**, *85*, 956–970. [CrossRef]
49. Allen, L.; Kelly, B.B. *Committee on the Science of Children Birth to Age 8: Deepening and Broadening the Foundation for Success; Board on Children, Youth, and Families*; Institute of Medicine; National Research Council. Transforming the Workforce for Children Birth Through Age 8: A Unifying Foundation; National Academies Press (US): Washington, DC, USA, 2015. [PubMed]
50. Septiyana, L.; Aneka, A.; Mandasari, B.; Ramadhan, F.S.S. Development of A Trilingual E-Dictionary for Early Childhood; Indonesia-English-Lampung. *Tapis: J. Penelit. Ilm.* **2023**, *7*, 160–172. Available online: https://e-journal.ejournal.metrouniv.ac.id/index.php/tapis/article/view/810 (accessed on 10 July 2024). [CrossRef]
51. Apertium. Apertium-Kaz. Available online: https://github.com/apertium/apertium-kaz (accessed on 15 March 2024).
52. Kessikbayeva, G.; Cicekli, I. Rule Based Morphological Analyzer of Kazakh Language. *Linguist. Lit. Stud.* **2014**, *4*, 46–54.
53. Makhambetov, O.; Makazhanov, A.; Sabyrgaliyev, I.; Yessenbayev, Z. Data-Driven Morphological Analysis and Disambiguation for Kazakh. In *Computational Linguistics and Intelligent Text Processing*; Springer International Publishing: Berlin/Heidelberg, Germany, 2015; pp. 1–13.
54. Makhambetov, O.; Makazhanov, A.; Yessenbayev, Z.; Sabyrgaliyev, I. Towards a Data-driven Morphological Analysis of Kazakh Language. In Proceedings of the 2nd International Conference on Turkic Languages Processing, Rouen, France, 3–5 September 2014; pp. 69–74.
55. Bekmanova, G.; Sharipbay, A.; Altenbek, G.; Adalı, E.; Zhetkenbay, L.; Kamanur, U.; Zulkhazhav, A. A Uniform Morphological Analyzer for the Kazakh and Turkish Languages. In Proceedings of the Sixth International Conference on Analysis of Images, Social Networks, and Texts (AIST 2017), Moscow, Russia, 27–29 July 2017; pp. 1–11.
56. Assylbekov, Z.; Washington, J.; Tyers, F.; Nurkas, A.; Sundetova, A.; Karibayeva, A.; Abduali, B.; Amirova, D. A Free/Open-Source Hybrid Morphological Disambiguation Tool for Kazakh. In Proceedings of the TurCLing 2016, Turkey, Konya, 3–9 April 2016; pp. 18–26.
57. Rakhimova, D.; Karibayeva, A.; Turarbek, A. The Task of Post-Editing Machine Translation for the Low-Resource Language. *Appl. Sci.* **2024**, *14*, 486. [CrossRef]
58. Bekbulatov, E.; Kartbayev, A. A Study of Certain Morphological Structures of Kazakh and Their Impact on the Machine Translation Quality. In Proceedings of the 8th International Conference on Application of Information and Communication Technologies (AICT), Astana, Kazakhstan, 15–17 October 2014; pp. 1–5.
59. Kalimoldayev, M.N.; Musabayev, R.R.; Mamyrbayev, O.J. The Algorithm of Morphological Analysis of the Kazakh Words. In Proceedings of the 10th International Conference, Hyogo, Japan, 27 December 2012; pp. 121–124.
60. Toleu, A.; Tolegen, G.; Makazhanov, A. Character-Based Deep Learning Models for Token and Sentence Segmentation. In *Proceedings of the 5th International Conference on Computer Processing of Turkic Languages (TurkLang 2017)*; Association for Computational Linguistics: Stroudsburg, PA, USA, 2017; pp. 67–71.
61. Tukeyev, U. Automaton Models of the Morphology Analysis and the Completeness of the Endings of the Kazakh Language. In Proceedings of the International Conference "Turkic Languages Processing" TURKLANG-2015, Kazan, Russia, 17–19 September 2015; pp. 91–100.
62. Tukeyev, U.; Sundetova, A.; Abduali, B.; Akhmadiyeva, Z.; Zhanbussunov, N. Inferring of the Morphological Chunk Transfer Rules on the Base of Complete Set of Kazakh Endings. In Proceedings of the Computational Collective Intelligence, ICCCI 2016, Lecture Notes in Computer Science, Halkidiki, Greece, 28–30 September 2016; Volume 9876, pp. 563–574.
63. Tukeyev, U.; Karibayeva, A.; Abduali, B. Neural Machine Translation System for the Kazakh Language Based on Synthetic Corpora. In Proceedings of the MATEC Web of Conferences, Sibiu, Romania, 5–7 June 2019; pp. 1–6.
64. Jothi, S.A.; Pandeeswari, N. Enriched Glove of Word Embedding and BERT of Contextual Embedding in Sarcasm Detection with AdaGrad Optimization Technique. In Proceedings of the 2023 3rd International Conference on Innovative Mechanisms for Industry Applications (ICIMIA), Bengaluru, India, 3–5 March 2023.
65. McElroy, E.; Wood, T.; Bond, R.; Mulvenna, M.; Shevlin, M.; Ploubidis, G.B.; Hoffmann, M.S.; Moltrecht, B. Using natural language processing to facilitate the harmonisation of mental health questionnaires: A validation study using real-world data. *BMC Psychiatry* **2024**, *24*, 530. [CrossRef]
66. Abrar Jahin, M.; Talapatra, S. A Natural Language Processing-Based Classification and Mode-Based Ranking of Musculoskeletal Disorder Risk Factors. *Decis. Anal. J.* **2024**, *11*, 100464. [CrossRef]
67. Shirude, S.B.; Kolhe, S.R. Agent-Based Architecture for Developing Recommender System in Libraries. In *Knowledge Computing and its Applications*; Margret Anouncia, S., Wiil, U., Eds.; Springer: Berlin/Heidelberg, Germany, 2018; pp. 157–181.

68. Li, Y.; Song, H.; Xu, Y. Studies on Data Quality Evaluation Index System for Internet Plus Government Services in Big Data Era. *Information* **2020**, *11*, 123.
69. Youdi, G.; Guangzhen, L.; Yunzhi, X.; Rui, L.; Lingzhong, M. A survey on dataset quality in machine learning. *Inf. Softw. Technol.* **2023**, *162*, 107268.
70. Institute of Smart Systems and Artificial Intelligence. KazakhTTS. Available online: https://issai.nu.edu.kz/ru/tts2-rus/ (accessed on 10 July 2024).
71. Narakeet. Kazakh Text-to-Speech. Available online: https://www.narakeet.com/languages/kazakh-text-to-speech/ (accessed on 10 July 2024).
72. Microsoft Azure. Speech Service. Available online: https://learn.microsoft.com/en-us/azure/ai-services/speech-service/ (accessed on 10 July 2024).
73. Balabekova, T.; Kairatuly, B.; Tukeyev, U. Kazakh-Uzbek Speech Cascade Machine Translation on Complete Set of Endings. *Adv. Comput. Collect. Intell.* **2023**, *1864*, 430–442.
74. OpenAI. DALL-E 3. Available online: https://openai.com/dall-e-3/ (accessed on 10 July 2024).
75. Midjourney. Home. Available online: https://www.midjourney.com/home (accessed on 10 July 2024).
76. Stable Diffusion. Available online: https://stablediffusionweb.com/ (accessed on 10 July 2024).
77. Adetayo, A.J. Reimagining Learning through AI Art: The Promise of DALL-E and MidJourney for Education and Libraries. Library Hi Tech News. 2024. Available online: https://www.emerald.com/insight/content/doi/10.1108/LHTN-01-2024-0005/full/html (accessed on 10 July 2024).
78. Suniyasih, N.W.; Adnyani, L.D.S.; Marhaeni, A.A.I.N.; Suastra, I.M.; Putra, N.P.W. The Development of a Multilingual Thematic Picture Dictionary in Supporting the Literacy of Fifth Grade Elementary School Students. *J. Pendidik. Bhs. Ingg. Undiksha* **2020**, *8*, 29–39.
79. Rohmatillah, R. A Study on Students' Difficulties in Learning Vocabulary. *Engl. Educ. J. Tadris Bah. Ing.* **2014**, *6*, 75–93.
80. Adnyani, N.K.P.; Ratminingsih, N.M.; Budasi, I.G. A Multilingual Thematic Picture Dictionary for Assisting Sixth Grade Elementary School Students' Literacy. *J. Pendidik. Bhs. Ingg. Undiksha* **2021**, *9*, 1–8. [CrossRef]
81. Widhiastari, M.R.; Ratminingsih, N.M.; Budasi, I.G. The Effect of Digital Multilingual Thematic Dictionary Toward the Fifth Grade Students' Literacy Skill. *Linguist. Engl. Educ. Art (LEEA) J.* **2023**, *6*, 315–325. [CrossRef]
82. Wulandari, P.D.M.; Tantra, D.K.; Santosa, M.H. Teacher's Preparation of Lesson Plan and Constraints in English as a Foreign Language During the Pandemic Outbreak in the Junior High School. *J. Pendidik. Bhs. Ingg. Undiksha* **2021**, *9*, 43–50. [CrossRef]
83. Anki. Wikipedia. Available online: https://ru.wikipedia.org/wiki/Anki (accessed on 10 July 2024).
84. Duolingo. Available online: https://www.duolingo.com/ (accessed on 10 July 2024).
85. Rosetta Stone. Learn Turkish. Available online: https://www.rosettastone.com/buy/learn-turkish/ (accessed on 10 July 2024).
86. Babbel. Available online: https://uk.babbel.com/ (accessed on 10 July 2024).
87. Qonzhyq App. Mobile Application. Available online: https://play.google.com/store/apps/details?id=com.mariomobile&hl=en_US (accessed on 10 July 2024).
88. Сауат ашу: сөйлейтін әліппе. Mobile Application. Available online: https://play.google.com/store/apps/details?id=kz.qazdevelopment.sauatashu&hl=en_US (accessed on 10 July 2024).
89. Өз-өзіне Логопед! Mobile Application. Available online: https://play.google.com/store/apps/details?id=kz.logoped (accessed on 10 July 2024).
90. Uali, N.; Kurmanbayuly, S.; Malbakov, M.; Shoibekov, R.; Kuderinova, K.; Zhubayeva, O.; Zhanabekova, A.; Fazylzhanova, A.; Isayeva, Z.; Uderbayev, A. *Unique Large Explanatory Dictionary of the Kazakh Language*; Dauir Publishing House: Almaty, Kazakhstan, 2013; 1488p.
91. Yesenzholova, G.Z. *Speech Development in Early Childhood*; Methodological Recommendations for Parents; Ulagat Publishing House: Almaty, Kazakhstan, 2014; 88p.
92. NLP-KazNU. AP19577833-Application-for-Children-with-Speech-Disorders-Based-on-AI-Technology. GitHub. Available online: https://github.com/NLP-KazNU/AP19577833-Application-for-children-with-speech-disorders-based-on-AI-technology (accessed on 10 July 2024).