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# Developing Foreign Language Communicative Competence in Future Natural Science Teachers with Online Speech Simulators: The Kazakhstan Experience

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**Abstract.** Improving the quality of education and training for future specialists in Kazakhstan requires the integration of digital tools to overcome barriers in foreign language learning, particularly for students in the natural sciences. This study investigates the development of foreign language communicative competence (FLCC) among first-year university students majoring in biology, chemistry, and physics through online speech simulators created on the Tilda platform. A quasi-experimental design with criterion-based sampling was used to form experimental and control groups (n=84) at South Kazakhstan Pedagogical University in 2024. Data were collected using pre- and post-tests assessing five key FLCC components: linguistic, speech, sociocultural, compensatory, and educational and cognitive. Platforms such as Quizizz and Tilda were integrated into the intervention. Statistical analysis included the Cramer-Welch test, Chi-square test, and Kendall's Tau coefficient. Results showed significant improvement in FLCC, especially in the sociocultural component (+21%), with 32 students in the experimental group progressing from medium to high FLCC levels. The study highlights the potential of technology-enhanced learning in language proficiency and teacher preparation in Kazakhstan's natural science education, recommending the integration of speech simulators into pre-service teacher training programs and the

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adaptation of national educational standards to include digital tools for developing foreign language communicative competence.

**Keywords**: communicative competence; foreign language; natural science teachers; speech simulator; technology-enhanced learning

## 1. Introduction

Foreign language communicative competence (FLCC) and its development have always been a priority for countries where English is studied as a foreign language (FL). Globally, FLCC is grounded in theories such as Canale and Swain's (1980) model of communicative competence and the Common European Framework of Reference for Languages (CEFR) (Council of Europe, 2001), both of which emphasize the integration of linguistic, sociolinguistic, and strategic components. Numerous empirical studies across Europe and Asia have confirmed that targeted development of FLCC enhances learners' intercultural readiness and professional mobility (Byram, 1997; Huang, 2021). In the Central Asian region, however, practical application remains limited, and Kazakhstan faces unique challenges in adapting these global models to its educational and cultural context (Sarmurzin et al., 2023; Zakirova & Zhandaeva, 2020).

In Kazakhstan, educational policy mandates that by 2024, pedagogical higher education institutions must graduate biology, chemistry, and physics teachers proficient enough in English to teach their subjects. While such teachers are being prepared, many still lack the practical language skills required for effective classroom communication (Gonzales, 2025).

Kazakhstan ranks 103rd out of 116 countries in the 2025 English Proficiency Index (EF EPI, 2025), highlighting the need for systemic educational reform. Foreign language teaching must prioritize communicative competence, especially for future science teachers expected to use English confidently in the classroom. This calls for aligning teacher education with labor market demands.
Additionally, knowledge of the language enables teachers to stay informed about global educational trends, advance in the field of science, and participate in scientific conferences and seminars. It helps develop career and personal achievements (Ali et al., 2016).

Communicative competence, tied to native language proficiency, is key to FLCC development. Students majoring in natural sciences frequently encounter difficulties in acquiring FLCC, largely due to the dominant emphasis in their academic training on cognitive mastery of subject-specific scientific content rather than on language development (Borshchovetska et al., 2024).

To improve motivation and outcomes, foreign language teaching in Kazakhstan's trilingual system must be practical and engaging. Science teachers instructing in English face challenges like aligning vocabulary, selecting key terms, ensuring accurate translation, and teaching units. Developing FLCC alongside subject knowledge enables future teachers to effectively deliver content and immerse students in a foreign language environment (Ma, 2024).

With developed FLCC, teachers can deliver subject content without language barriers. Kazakhstan's foreign language education concept (Gerfanova, 2018) emphasizes internationally recognized proficiency, including mastery of terminology, authentic texts, strategies, and discussion skills. Communicative competence also involves understanding cues, pauses, style, tone, and content.

While prior studies on FLCC development (Moydinova, 2024; Shykun, 2023) have largely focused on Content and Language Integrated Learning (CLIL) and English for Specific Purposes approaches in European and East Asian contexts (Bolton & Jenks, 2022), there remains a lack of empirical research addressing the integration of digital tools for communicative competence development among pre-service science teachers in Central Asia (Naser & Liza, 2023). This study is the first in Kazakhstan to apply online speech simulators in training pre-service science teachers, using a criterion-based approach via the Tilda platform. It also offers a novel perspective by integrating culturally relevant digital tasks and assessment into a multilingual, subject-specific teacher education context.

The development of FLCC equips future teachers not only to deliver subject content effectively in English but also to participate in international scientific discourse, access global resources, and develop intercultural competence (André-Das Dores et al., 2025). It enhances teaching quality, builds learner confidence, and meets the growing demand for trilingual education in Kazakhstan (Mehisto et al., 2022).

This study aims to develop FLCC through speech simulators, focusing on the following research questions:
RQ1: What changes in FLCC development levels can be observed in students majoring in natural sciences after using online speech simulators, given the limited research on digital interventions in FLCC training?
RQ2: Which components of FLCC are developed most effectively through the use of speech simulators among future natural science teachers in Kazakhstan?

Based on the above, this study hypothesizes that the use of structured online speech simulators will significantly improve the FLCC of pre-service natural science teachers across its core components.

## 2. Literature review

### 2.1. FLCC and its components

Researchers and educators worldwide use various digital tools to support FLCC development. These include online platforms, interactive whiteboards, video lessons, and webinars. In addition, they apply methods such as stimulating speech activity and enhancing cognitive engagement. Taiwanese researchers have proven that explicit instruction in English as a foreign language contributes to the development of FLCC (Huang, 2021). Thai scientists (Poolsawad et al., 2015) insist on diagnosing the strengths and weaknesses of the learner and then determining the tools for teaching FL and developing FLCC. In the United Kingdom, there is an ongoing discussion about artificial intelligence tools for teachers and students in developing FLCC (McCallum, 2024). An Iranian study (Zarrinabadi et al., 2021) showed that linguistic thinking is cultivated in the classroom and depends on the autonomy provided by the teacher, that is, the opportunity to express one's opinion in FL.

The purpose of acquiring communicative competencies in FL is to prepare students for adequate and successful actions in real-life situations in FL (Reid, 2015). FLCC refers to the student’s ability to engage in both receptive and productive speech activities in a foreign language, involving verbal and non-verbal communication (Sergeeva, 2014). FLCC consists of a number of components, and the composition and opinions of different scientists range from three to six, according to the literature review of Poolsawad et al. (2015).

FLCC comprises various competencies: linguistic (grammatical), discourse, sociolinguistic, formulaic, and interactional (Canale & Swain, 1980); or organizational (grammatical, textual) and pragmatic (functional, sociolinguistic) knowledge (Bachman & Palmer, 1996). Fulcher (2003) further categorizes it into language (phonology, accuracy, fluency), textual (structure of talk), pragmatic (appropriacy, implicature, expressing), and sociolinguistic (situational, topical, cultural) knowledge. Our study focuses on five FLCC components: speech, language, sociocultural, compensatory, educational and cognitive.

The selection of these five components—is based on their relevance to the professional context of future natural science teachers in Kazakhstan. Unlike classical models (e.g., Canale & Swain, 1980; Bachman & Palmer, 1996), this framework addresses not only linguistic and pragmatic aspects but also emphasizes compensatory strategies and educational and cognitive skills, which are essential for non-linguistic majors. These components more fully capture the interdisciplinary and pedagogical demands placed on FL learners within the national educational context.

The first component is speech. Its development includes the main types of speech activity: reading and writing as forms of written speech and speaking and listening as an oral form of communication (Astorga, 2015). When describing written and oral communication, it is important to consider the purpose of the content being conveyed. In any speech activity—speaking, listening, reading, or writing—the student pursues a communicative goal: to convey, explain, convince, or inquire. Motivation drives this activity through the goal–result link. Speech competence develops when tasks include thinking components, and fluency depends on this development (Khau et al., 2022).

The second component of FLCC is language. It is often referred to as linguistic competence (Bataineh et al., 2017). It includes knowledge, skills, and abilities in using language's phonetic, spelling, lexical, and grammatical aspects and performing communicative tasks (ter Wal et al., 2023), which require expressing thoughts on the topic of conversation.

Language competence can also be considered from the perspective of the native language. This refers to the application of accumulated speech experience alongside acquired knowledge, skills, and competencies gained during the educational process (Karimova, 2020).

When developing the third component – sociocultural - a real communicative situation of culturally conditioned language units is constructed. Often, these are idioms and set expressions that are typical in the use of a foreign language. A person is simultaneously a native speaker of both the language and the culture. Incorporating well-structured cultural content in foreign language classes connects foreign and native cultures, enhancing the sociocultural component of foreign language communicative competence.

Rakhimova (2017) identifies two areas of modern sociocultural competence: 1. Knowledge as a means of communication in a FL; 2. Classes that immerse learners in the culture of the target language country. We include the need for learners to share their native cultural foundations as part of the second trend.Insufficient development of the sociocultural component leads to miscommunication and a lack of cultural integration. Mastering sociocultural competence enables effective oral and written communication and appropriate selection of speech behaviors.

Compensatory component: Achieving native-language level fluency in a foreign language is challenging and requires mastery of vocabulary, word formation, sentence structure, tense usage, and strategies such as inferring meaning and simplification. Compensatory competence supports communication when language resources are limited. Strategies like prediction, simplification, and argumentation help overcome barriers and hesitations, promoting fluency and confidence (Ishonkulov, 2024).

The next component of FLCC is educational and cognitive. This competence reflects the learning process as a purposeful cognitive activity, outcomes of which are specified in educational programs. Developing educational and cognitive competence in students involves independent study using information and communication technologies, understanding search algorithms, and addressing cognitive needs (Abakumova et al., 2016). This fosters meta-subject skills and supports students' independent learning.

Integrating FLCC into STEM teacher training is essential for CLIL strategies and participation in global academic discourse (Mehisto et al., 2008; Marsh, 2012). In Kazakhstan, trilingual education increased the demand for English among science teachers, though motivation and relevance remain low (Sarmurzin et al., 2023). Scientific communication requires disciplinary discourse competence (Hyland, 2004), which general FL courses lack. Studies highlight the need for subject-specific language support in English-Medium Instruction contexts (Airey, 2011; Costa, 2012). This study explores how online speech simulators can foster FLCC among future science teachers.

**2.2 Online speech simulators**

Educational technology has become an indispensable aspect of higher education, crucial in affecting student engagement (Teng & Wang, 2021). The use of digital technologies increases Kazakhstani universities' competitiveness in the international educational services market (Zarubina et al., 2024). Therefore, an online speech simulator (SS) can be regarded a didactic tool designed for partial or complete automation of the learning process. The attractiveness, effectiveness, and usefulness of digital tools can positively influence motivation, as Wei (2022) noted. Our study uses the "Speech simulator" combination as a set of exercises for learning FL. This program or application can consist of various exercises and help users improve their pronunciation skills, intonation, listening comprehension in another language, and, most importantly, develop FLCC. SS facilitates the learning process and makes it more interactive.

While digital tools in language education have been explored (Wei, 2022; Pradana et al., 2022), few studies focus on their effectiveness in developing foreign language communicative competence among natural science students in Kazakhstan. Most existing research addresses general English as a Foreign Language contexts or humanities majors, neglecting the specific needs of STEM-oriented teacher training. Moreover, they often lack empirical evidence, validated instructional models, or analysis of pedagogical challenges in multilingual education (Lee et al., 2023; Koleini et al., 2024). This study addresses these gaps by designing and testing a discipline-specific SS for future biology, chemistry, and physics teachers.

In Table 1, we reviewed variations of online speech simulators (applications and services), an example of a task when working on it, and which component of the FLCC can be developed through this exercise.

**Table 1: Types of speech simulators**

| Speech simulator | Example of work on the simulator | Development of FLCC and its components |
|---|---|---|
| Rosetta Stone (Online platform) | The student views several photographs, then listens to an audio and text description of one. They must select the matching photo or, in another version, complete the description themselves (Rosetta Stone, 2024). | Speech component (listening, reading, writing); Educational and cognitive component (correctness of using the instructions for the task) |
| Duolingo (Mobile application) | Listen to a word or phrase in the target language (e.g., English) and then speak it in a microphone (Duolingo, 2025). | Speech component (listening, speaking) |
| Pronunciation Power (Software) | A waveform is displayed to help learners visually compare their pronunciation of a target sound with the correct model, aiding in phonetic accuracy (Son, 2016). | Language component (phonetics) |

| | | |
|---|---|---|
| Speechling (Online platform) | Listening to a female and male voice pronouncing a sentence and repeating it. You can also answer a question or describe an image (Speechling», n.d.). | Speech component (listening, speaking) |
| Elsa Speak (Online platform) | Read a phrase aloud, record it using the program, and analyze pronunciation errors for improvement (ELSA Speak, n.d.). | Speech component (reading, speaking) |
| Pimsleur (Audio course) | Listen to a dialogue or short phrases in a foreign language with explanations and translations. Then, actively repeat what you heard to reinforce learning (Pimsleur, n.d.). | Speech component (listening, speaking), language component (vocabulary, phonetics) |

Whatever the SS, it always meets the basic needs of FL learners: independent work on it, accessibility for any level of knowledge, real-time feedback, and the primary function of Computer-assisted language learning (Pradana et al., 2022). Developing our SS required technological pedagogical knowledge and skills for integrating digital tools into the educational process (Zhang, 2022).

The development of our online SS via the Tilda platform followed several research-informed stages:

- Selection of key and grammar topics for each lesson, reflecting Fang et al. (2018) on the importance of grammar practice;
- Identification of specialized terminology, supporting Koleini et al. (2024) on the value of online tools in teaching technical vocabulary.
- Design of articulation and practice-oriented FL tasks for FLCC development (Lee et al., 2023);
- Creation and recording of grammar-focused videos (Zhao et al., 2025);
- Final testing of the SS.

## 3. Research Methodology

### 3.1 Participants and study contexts

This study employed a quasi-experimental quantitative design (Creswell, 2014) to examine the impact of structured online speech simulators on the development of FLCC in pre-service natural science teachers in Kazakhstan. The research involved two groups: an experimental group (EG) that participated in a structured speech simulation course, and a control group (CG) that did not receive the intervention. Both groups completed pre-tests and post-tests designed to assess various components of FLCC, allowing for a comparative analysis of changes across competence levels.

A non-probability, criterion-based sampling technique was used to form two comparable groups of first-year students majoring in biology, chemistry, and physics at South Kazakhstan Pedagogical University named after O. Zhanibekov, Shymkent. The selection was based on academic program, year of study, and specialization in natural sciences to ensure group comparability. All participants were pre-service teachers enrolled in biology, chemistry, or physics programs. The groups were formed from the same institutional context and had similar demographic and academic backgrounds, which helped to maintain baseline equivalence for the quasi-experimental design. The final sample consisted of 84 students: an EG (n = 42), which studied using a digital course based on speech simulators, and a CG (n = 42), which followed the standard curriculum (see Table 2). Both groups completed pre- and post-tests assessing five components of FLCC: speech, language, sociocultural, compensatory, and educational and cognitive. A total of 84 participants (42 per group) was considered sufficient, as this sample size met the conventional criteria for statistical power (α = 0.05; power = 0.80) for detecting medium effect sizes in quasi-experimental designs.

**Table 2: The experimental design: control and experimental groups**

| Group | Number of students in each training program | N | pre-test | "Foreign language communicative competence and its development" course | post-test |
|---|---|---|---|---|---|
| Experimental | Biology (12) | 42 | 42 | 42 | 42 |
| | Chemistry (15) | | | | |
| | Physics (15) | | | | |
| Control | Biology (13) | 42 | 42 | - | 42 |
| | Chemistry (14) | | | | |
| | Physics (15) | | | | |

The intervention lasted eight weeks, with two 50-minute in-class sessions per week (16 sessions total). Each session included structured tasks using an online SS on the Tilda platform. Students practiced articulation, subject-specific vocabulary, and situational speech, receiving digital feedback. The CG followed the standard of English as a Foreign Language curriculum without simulators.

### 3.2 Research design and procedure

The eight-week experiment used a blended learning approach with the course "Foreign Language Communicative Competence and Its Development" on the Tilda platform, combining in-class and autonomous learning. Designed for future biology, chemistry, and physics teachers, the course aimed to develop FLCC and its components. Students accessed speech simulators in class via mobile phones and university Wi-Fi, under teacher supervision. Before starting, students unfamiliar with Tilda registered using their Google accounts through a teacher-provided link.

After mastering SS, the teacher remotely assessed tasks and gave feedback. The SS course was integrated into the "Foreign Language" syllabus, a mandatory subject in Kazakhstani universities' first and second terms. Figure 1 illustrates the research design and experimental framework.

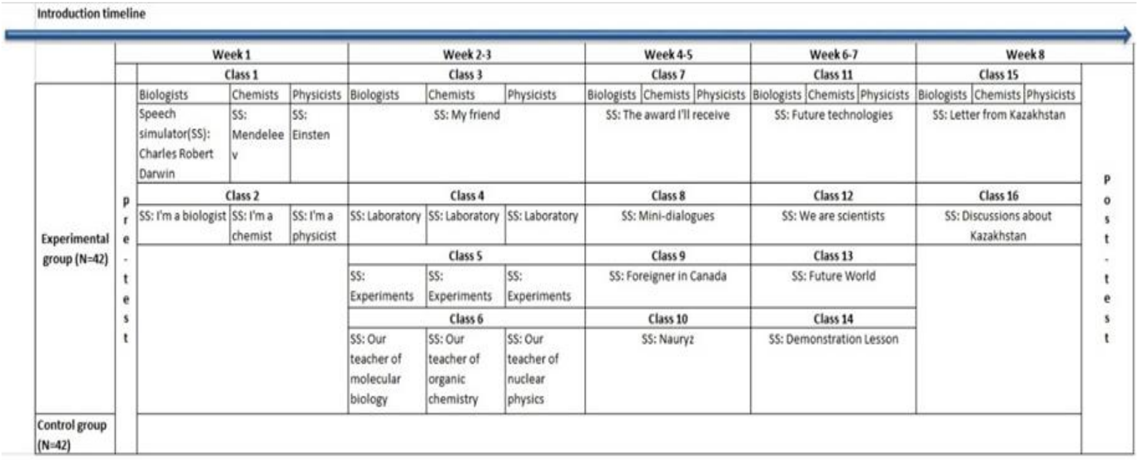

**Figure 1: Experimental process in this study**

Before the experiment, the experimental and control groups took a FLCC test on Quizziz. The 60-question test, to be completed in 55 minutes, included 5 questions per FLCC criterion (see Table 3). Each criterion had 3 simple questions (1 point each) and 2 complex questions (2 points each), with a maximum total score of 84 points (100%).

**Table 3: Components and their Criteria**

| Components of FLCC | | Amount of criteria | Criteria | Q1 | Q2 | Q 3 | Q 4 | Q 5 | Band |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Speech | 1 | listening | 2 | 1 | 1 | 1 | 2 | 7 |
| | | 2 | speaking | 1 | 1 | 2 | 2 | 1 | 7 |
| | | 3 | writing | 1 | 1 | 1 | 2 | 2 | 7 |
| | | 4 | reading | 1 | 2 | 1 | 2 | 1 | 7 |
| | | | | | | | | | 28 |
| 2 | Language | 1 | Expressing thoughts on the topic of conversation | 2 | 2 | 1 | 1 | 1 | 7 |
| | | 2 | phonetics | 2 | 2 | 1 | 1 | 1 | 7 |
| | | 3 | orthography | 1 | 1 | 2 | 1 | 2 | 7 |
| | | 4 | vocabulary | 2 | 2 | 1 | 1 | 1 | 7 |
| | | 5 | grammar | 1 | 2 | 1 | 1 | 2 | 7 |
| | | | | | | | | | 35 |
| 3 | Sociocultural | 1 | The ability to conduct a conversation about the country, capital, hometown | 1 | 2 | 1 | 1 | 2 | 7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4 | Compensatory | 1 | The ability to convey a thought in a structured manner: the ability to paraphrase | 1 | 1 | 2 | 1 | 2 | 7 |
| 5 | Educational and cognitive | 1 | Learning to navigate and correctly use the instructions for the task | 1 | 2 | 1 | 2 | 1 | 7 |
| | | 12 | Total Score | | | | | | 84 |

Note. The development of FLCC was assessed using a criterion-based scoring rubric specifically developed for this study. The rubric was informed by established frameworks for communicative competence evaluation (e.g., Bachman & Palmer, 1996; CEFR descriptors) and adapted to the context of pre-service science teacher training.

The test was based on the five-component FLCC model and aligned with CEFR A1–B2 descriptors (Council of Europe, 2001), applying principles of Communicative Language Teaching (Sato & Kleinsasser, 1999). Task design adhered to Bachman and Palmer's (1996) framework to ensure construct validity and authenticity.

To ensure validity, the FLCC rubric was reviewed by 31 experts: 11 schoolteachers from the Turkistan Region and 20 university instructors from South Kazakhstan Pedagogical University (Antontseva et al., 2024a). heir teaching experience ranged from 1 to 26 years. Pilot testing was conducted with 11 second-year students from group 1703–12zh, with sessions held weekly from February 13 to March 20, 2024, at the same university where the main study took place (Antontseva et al., 2024b).

Kendall's τ correlation coefficient across 12 criteria was 1.000 in the pre-test and 0.554 in the post-test, indicating a more differentiated development of FLCC. These results demonstrate the instrument's construct validity and moderate reliability.

The speech simulator consists of five stages: preparatory (Stage 1), training (Stages 2 and 3), and self-test (Stages 4 and 5) (see Table 4).

**Table 4: The example of the structure of Speech Simulator 1 for physicists**

| Stages of work on the SS | Speech Simulator 1 | Development of FLCC components | Supporting Sources |
|---|---|---|---|
| 1 | Enhancing Articulatory Skills: The /ai/ Sound – Rules and Exercises | Language | «Grammarway», n.d. |
| | Repeat the tongue twister multiple times by clicking on the link: "Ron dropped a rock on his watch." | | Hancock, 2012. |
| | Grammar Topic: "To Be" – Am/Is/Are | | Murphy, 2019. |
| 2 | SS: Einstein<br>Translate the text into English in writing. Pay attention to the prepared vocabulary | Language, Speech, Compensatory | Mukhametkaliyeva et al., 2008. |
| 3 | Let's exercise:<br>Check your answer with the Einstein Key and correct any errors.<br>If there are mistakes, go back and practice the grammar topic "To be: Am/Is/Are" again<br>2. LISTEN to the audio recording<br>3. Listen to the audio recording and REPEAT each phrase after the speaker without looking at the text<br>4. TRANSLATE the text aloud from your native language into English, ensuring clear and active articulation<br>5. Translate the text orally from your native language into English IN a WISPER<br>6. Translate the text orally from your native language into English SLOWLY and LOUDLY<br>7. Translate the text orally from your native language into English at your usual pace but very CLEARLY | Speech | Vinay & Darbelnet, 1995. |
| 4 | Practice:<br>1.1 Turn on the audio and record phrases in English<br>1.2 Write a translation of the phrases in English<br>1.3 Listen to the audio and insert the missing words<br>1.4 Read the text and answer the questions below<br>1.5 Continue the sentences on the grammar topic 1.6 Find the extra word<br>1.7 Replace the phrase with one word<br>1.8 Record a video in English (~5 sentences) and attach a link to it by answering the question:<br>What do you know about Einstein: what is he interested in, crazy about, glad for, angry with and what is he certain of? | Speech, Language, Compensatory, Educational and cognitive | Tuyakbayev et al., 2020. |
| 5 | Answers to the practical class | | |

In Stage 4 of Exercise 1.8, students submitted video responses via MP4 links or platforms like YouTube and Boomstream, sometimes adding supporting text. Assigned as homework, this task aimed to develop SS and communication skills. Teachers assessed submissions (1–10 scale) and provided feedback on Tilda. In Week 8, both groups took a post-test to evaluate FLCC development.

### 3.3 Data collection

The score ranges for FLCC levels were determined based on a maximum total of 84 points and reflect varying degrees of language proficiency. These levels correspond approximately to the CEFR scale, which classifies language ability from beginner (A1) to upper-intermediate (B2). Our ranges were set as follows: Optimal (84–70 points), High (69–53 points), Medium (52–36 points), and Low (35–19 points), aligning with the progressive development of communicative competence described in the CEFR framework.

Data collection and measurement followed an established procedure, allowing for an evaluation of results. Appendix 1 categorizes changes, tracks progress from low to optimal levels based on CEFR standards (EF SET», n.d.), outlines expected student skills and specifies the data collection tool (Quizizz).

Data analysis was conducted using descriptive statistics and a two-way repeated measures ANOVA to assess both within-group and between-group effects over time. Percentages of correct answers were calculated for each component of foreign language communicative competence (speech, language, compensatory, sociocultural, and educational and cognitive) in both the CG and EG.

To compare group means in cases of unequal variances, Welch's t-test ($t_{crit}$ = 1.96) was employed. Differences in the distribution of categorical data between groups were assessed using the Chi-square test for homogeneity ($\chi^2$_crit= 7.815, df = X), where X represents the degrees of freedom based on the contingency table structure.

## 4. Results and Analysis

Appendix 2 presents the results of measuring knowledge levels in the control and experimental groups before and after the experiment. It shows the number of points scored (a maximum of 84 points), the percentage of completed tasks (60 questions), and the number of correct answers.

The Cramer–Welch T-test was applied to determine whether the experimental and control groups differed significantly, and to test the null or alternative hypotheses (Derrick et al., 2016). The empirical value of this criterion is calculated based on information about the sample sizes of two groups, x and y, sample means $\bar{x}$ and $\bar{y}$, and sample variances $D_x$ and $D_y$ of the compared samples.

Table 5 contains the average value of numerical data (M - mean) for the number of points scored before and after the experiment in the control and experimental groups for all components of the FLCC in total. It displays the sample variance in each group, showing the degree of data scatter relative to the mean value ($S^2$). These data were necessary to determine the empirical value ($T_{emp}$) at a significance level of $\alpha = 0.05$. The critical value of the criterion for a significance level of 0.05 was $t_{crit} = 1.96$.

**Table 5: The pre-course and post-course assessment descriptive statistics for control and experimental groups**

| | CG before the experiment (n=42) | EG before the experiment (n=42) | CG after the experiment (n=42) | EG after the experiment (n=42) |
|---|---|---|---|---|
| M | 42.47 | 44.79 | 48.23 | 61.9 |
| SD | 10.44 | 7.95 | 9.23 | 5.73 |
| $S^2$ | 108.93 | 63.16 | 85.21 | 32.89 |
| $T_{emp}$ | 1.15 | | 8.15 | |

Note. CG = Control Group; EG = Experimental Group; M = Mean; SD = Standard Deviation; $S^2$ = Variance; $T_{emp}$ = Empirical t-test value. The table shows pre- and post-course statistics (n = 42 per group). The EG's higher post-test mean (M = 61.9 vs. 48.23) confirms the intervention's effectiveness.

Thus, since $T_{emp} = 8.15 > t_{crit} = 1.96$ at the 0.05 significance level, the alternative hypothesis ($H_1$) was accepted, indicating a statistically significant advantage of the experimental learning method. The reliability of the differences between the control and experimental groups after the experiment is 95%. Before the experiment, $T_{emp} = 1.15 < 1.96$, so the null hypothesis was accepted, confirming that both groups were initially equivalent. Therefore, the observed changes can be attributed to the experimental teaching method.

RQ1: What changes in FLCC development levels can be observed in students majoring in natural sciences after using online speech simulators, given the limited research on digital interventions in FLCC training?
Based on test results, students' FLCC development was categorized into four levels: (1) Optimal (≥70 points), (2) High (>53–70), (3) Medium (>36–52), and (4) Low (>19–36). Table 6 (Microsoft Excel 2019) shows the number and percentage of students in each category within their group.

**Table 6: Results of knowledge level measurements in the control and experimental groups before and after the experiment**

| Level | Max points | CG before the experiment | | EG before the experiment | | CG after the experiment | | EG after the experiment | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number of respondents (people) | % | Number of respondents (people) | % | Number of respondents (people) | % | Number of responden ts (people) | % |
| Optimal (1) | 70-84 | 0 | **0.00** | 1 | **2.38** | 0 | **0.00** | 5 | **11.90** |
| High (2) | 53-69 | 8 | **19.05** | 5 | **11.90** | 14 | **33.33** | 35 | **83.33** |
| Medium (3) | 36-52 | 25 | **59.52** | 32 | **76.19** | 26 | **61.90** | 2 | **4.76** |
| Low (4) | 19-35 | 9 | **21.43** | 4 | **9.52** | 2 | **4.76** | 0 | **0.00** |

Note. CG = Control Group; EG = Experimental Group. The table shows the distribution of respondents across four knowledge levels (Optimal, High, Medium, and Low) based on test scores before and after the experiment.

Visualizing the obtained data and comparing it (See Figure 2). While the CG experienced moderate improvements—particularly at High and Medium levels—the EG exhibited marked progress, especially at the High level. In the EG, the proportion of students at the High level increased dramatically from 11.90% to 83.33%, while those at the medium level dropped sharply from 76.19% to just 4.76%. Notably, the percentage of students at the Low level fell to zero. Furthermore, 11.9% of students reached the Optimal level after the experiment—compared to only 2.38% before—indicating that a subset of learners achieved near-maximal proficiency gains.

In contrast, the CG showed only moderate improvement: the percentage of students at the High level rose from 19.05% to 33.33%, and no participants achieved the Optimal level. The proportion of students in the Low category decreased slightly (from 21.43% to 4.76%), while the majority remained at the medium level (61.90% after the course).

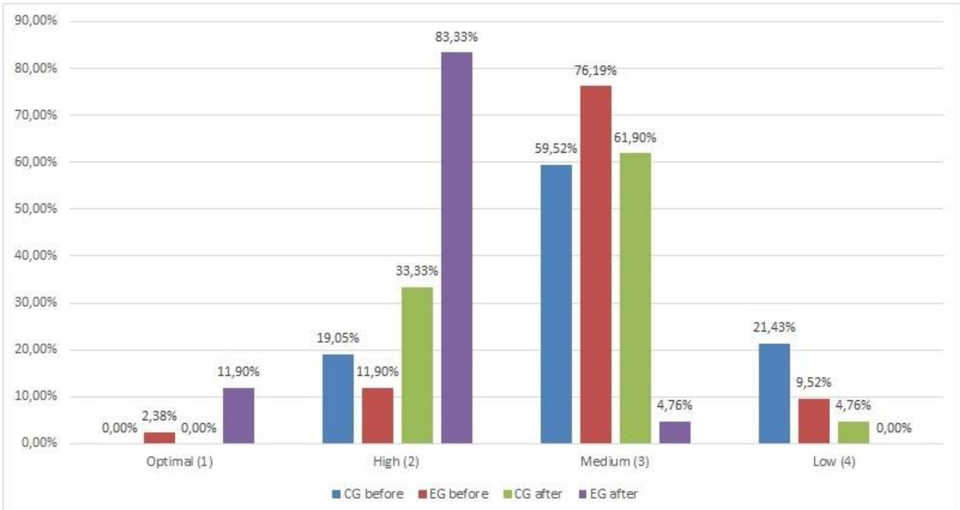


**Figure 2: Comparison of the levels of FLCC development before and after the experiment**

For the data from Table 6, measured in the ordinal scale, we used the basic test for checking the relationship between categorical variables - the criterion of homogeneity $\chi^2$, which helps to determine the reliability of coincidences and differences for experimental data. The following formula calculates the empirical value of $\chi^2_{emp}$:

$$\chi^2_{emp} = N * M * \sum_{i=l}^{L} \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)^2}{n_i + m_i}$$

Where:

- $\chi^2_{emp}$ – empirical value of the Chi-square statistic.
- $N$ – total number of students in the EG.

- M – total number of students in the CG.
- $n_i$ – number of students in the EG falling into category $i$;
- $m_i$ – number of students in the CG falling into category $i$;
- $L$ – total number of categories (e.g., levels of knowledge: low, medium, high, optimal);
- The term $\left(\frac{n_i}{N} - \frac{m_i}{M}\right)^2$ captures the squared difference in relative frequencies between groups for each category.
- The denominator $n_i + m_i$ normalizes the difference by the joint frequency in that category.

For example, the parameters of the EG (N = 42) after the end of the experiment: $n_1 = 0$, $n_2 = 2$, $n_3 = 35$, $n_4 = 5$ (that is, none of the students showed a "low" level of knowledge, 2 students showed "medium" and 35 – "high", 5 students "optimal"), the CG (M = 42): $m_1 = 2$, $m_2 = 26$, $m_3 = 14$, $m_4 = 0$. We compared the obtained values after calculations in Table 7.

**Table 7: Empirical values of the $\chi^2$ criterion for the data from Table 6**

| | CG before the experiment | EG before the experiment | CG after the experiment | EG after the experiment |
|---|---|---|---|---|
| CG before the experiment | 0 | **4,47** | 6,11 | 50,54 |
| EG before the experiment | 4,47 | 0 | 6,55 | 55,63 |
| CG after the experiment | 6,11 | 6,55 | 0 | **36,57** |
| EG after the experiment | 50,54 | 55,53 | 36,57 | 0 |

In our study, four knowledge levels were identified (low, medium, high, optimal), so the degrees of freedom (df) = 3. At a 0.05 significance level, the critical $\chi^2$ value is 7.815. As shown in Table 7, the empirical $\chi^2$ values before the experiment was below this threshold, indicating no significant difference between the control and experimental groups ($H_0$ accepted). However, after the experiment, the $\chi^2$ value rose to 36.6 (> 7.815), leading to the rejection of $H_0$ and confirming significant differences. This is also illustrated in Figure 3, where the empirical value falls into the critical region (right tail).

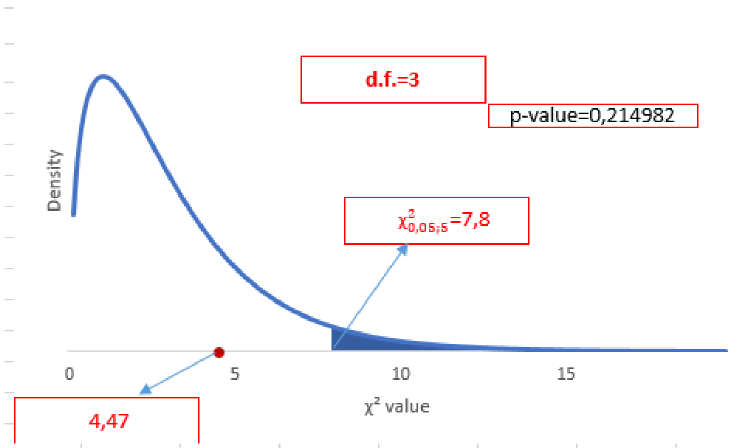


**Figure 3: Chi-square distribution ($\chi^2$)**

RQ2: Which components of FLCC are developed most effectively through the use of speech simulators among future natural science teachers in Kazakhstan?
Competence development across 12 criteria was analyzed using repeated measures; correct answer rates were compared between control and experimental groups. Descriptive statistics are presented in Table 8.
Moreover, the two-way analysis of variance with repetitions showed that the differences between the experimental and control groups were significant since p = 0.02, which was less than 0.05. This is confirmed by the fact that F = 7.65 is greater than the critical value of 4.96. Also, the differences between the components of the FLCC (1, 2, 3, 4, 5) were significant since p = 0.01, which was less than 0.05, and F = 6.68 was greater than the critical value of 3.48.

**Table 8: The comparison of pre-course and post-course assessment results of Experimental and Control groups on the basis of FLCC components**

| Scales | N of Q | EG | | Change | CG | | Change |
|---|---|---|---|---|---|---|---|
| | | Pre-course M (SD) | Post-course M (SD) | | Pre-course M (SD) | Post-course M (SD) | |
| **Speech component** | 20 | **0.49 (0.25)** | **0.67 (0.21)** | 0.18 | **0.43 (0.25)** | **0.51 (0.26)** | 0.08 |
| listening | 5 | 0.64 (0.26) | 0.68 (0.26) | 0.04 | 0.60 (0.20) | 0.58 (0.16) | -0.02 |
| speaking | 5 | 0.49 (0.17) | 0.65 (0.16) | 0.16 | 0.37 (0.16) | 0.60 (0.13) | 0.23 |
| writing | 5 | 0.30 (0.20) | 0.57 (0.21) | 0.27 | 0.25 (0.22) | 0.34 (0.38) | 0.09 |
| reading | 5 | 0.52 (0.30) | 0.77 (0.23) | 0.25 | 0.51 (0.32) | 0.52 (0.27) | -0.05 |
| **Language component** | 25 | **0.56 (0.27)** | **0.74 (0.24)** | 0.18 | **0.54 (0.26)** | **0.63 (0.25)** | 0.09 |
| Expressing thoughts on the topic of conversation | 5 | 0.64 (0.26) | 0.81 (0.22) | 0.17 | 0.59 (0.25) | 0.74 (0.19) | 0.15 |
| phonetics | 5 | 0.72 | 0.76 | 0.04 | 0.66 | 0.75 | 0.09 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | (0.23) | (0.18) | | (0.19) | (0.08) | |
| orthography | 5 | 0.45 (0.27) | 0.71 (0.26) | 0.26 | 0.48 (0.26) | 0.55 (0.26) | 0.07 |
| vocabulary | 5 | 0.57 (0.34) | 0.76 (0.40) | 0.19 | 0.54 (0.32) | 0.61 (0.35) | 0.07 |
| grammar | 5 | 0.44 (0.26) | 0.66 (0.18) | 0.22 | 0.43 (0.31) | 0.52 (0.26) | 0.09 |
| **Sociocultural**<br>The ability to conduct a conversation about the country, capital, hometown | 5 | **0.63 (0.24)** | **0.84 (0.21)** | 0.21 | **0.61 (0.14)** | **0.74 (0.20)** | 0.13 |
| **Compensatory**<br>The ability to convey a thought in a structured manner: the ability to paraphrase | 5 | **0.49 (0.29)** | **0.67 (0.39)** | 0.18 | **0.49 (0.29)** | **0.63 (0.36)** | 0.14 |
| **Educational and cognitive**<br>Learning to navigate and correctly use the instructions for the task | 5 | **0.69 (0.16)** | **0.88 (0.13)** | 0.19 | **0.64 (0.12)** | **0.74 (0.16)** | 0.1 |

Based on the data in Table 8, the EG shows a more significant improvement in most parameters compared to the CG (Parameter—Changes). The most notable gains were in writing (+0.27), reading (+0.25), orthography (+0.26), grammar (+0.22), and sociocultural competence (+0.21). In most cases, the improvements were statistically significant ($p < 0.05$), indicating the effectiveness of the method.

The CG showed smaller and most insignificant improvements. The largest gain was in speaking (+0.23), while other components showed minimal or no substantial change. In some areas (e.g., listening and reading), there was virtually no progress.

A comparative analysis of changes between the components revealed relative (percentage) changes in the development of each component relative to their initial values (See Figure 4). The greatest increase was observed in sociocultural competence (+27.8%). This means that the experimental course of simulators helped the participants master the sociocultural aspects of communication.

Educational and cognitive competence also increased significantly (+18.6%), which indicates better mastery of the educational material. Speech and compensatory competencies increased almost equally (+18.1% and +18%, respectively), which indicates improved speaking skills and the ability to formulate thoughts. Language competence increased by 12.6%, confirming the technique's effectiveness, but its growth is less pronounced than other components. On average, students' FLCC improved ($\bar{K} = \frac{(K^1 + K^2 + K^3 + K^4 + K^5)}{5}$) by 19.0%.

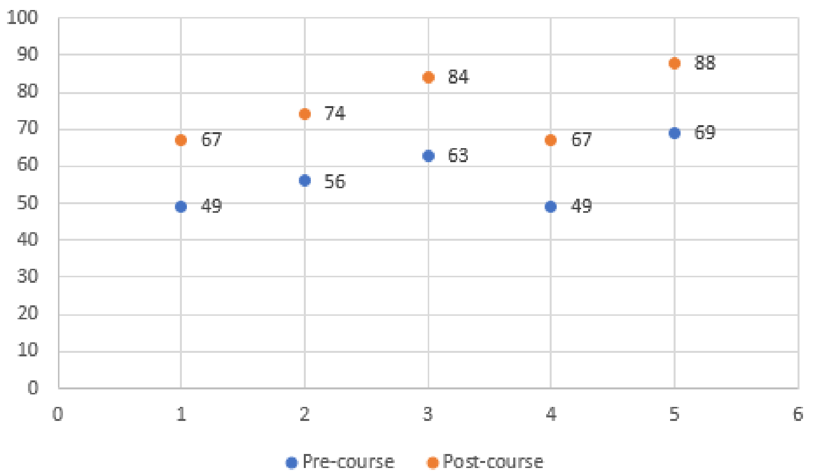


**Figure 4: Development of FLCC components in the Experimental Group (%)**

Speech simulators strengthen FLCC in science teacher training, addressing limitations of content-focused instruction. Aligned with CEFR standards, the study shows significant gains in sociocultural, speech, compensatory, and cognitive components, while language competence improved less due to limited grammar and phonetics focus. Despite technical challenges, students gained digital and learning autonomy. The study underscores digital tools' value for FLCC development in under-researched regions.

## 5. Discussion

The results of the study demonstrate a significant positive impact of online SS on the development of FLCC among first-year students majoring in natural sciences. The rejection of the null hypothesis confirmed that the EG, which used the SS-based digital course, achieved statistically higher FLCC levels compared to the CG. While the CG showed moderate improvements—primarily at High and Medium levels—the EG exhibited substantial improvement, particularly in the High category. Additionally, there was a marked reduction in the number of participants with Low and Medium FLCC levels in the EG, supporting the effectiveness of the SS methodology. These findings align with previous research emphasizing the pedagogical potential of digital simulations in fostering communicative competence (Zarrinabadi et al., 2021; Wei, 2022).

Among the components of FLCC, sociocultural competence showed the most substantial improvement (+27.8%). This outcome is closely attributed to the integration of culturally rich modules—such as "Letter from Kazakhstan" and "Nauryz"—which were specifically designed to encourage personal reflection in English. These findings support Rakhimova (2017), who demonstrated that embedding elements of learners' native culture into foreign language tasks enhances engagement and fosters intercultural sensitivity. In contrast to traditional CLIL approaches (Costa, 2012), which primarily emphasize subject content, this method utilized national culture as a communicative bridge, generating emotionally resonant and contextually meaningful tasks. The observed improvements align with a growing body of literature advocating for the integration of national identity in English as a Foreign Language education (Sulkarnayeva, 2017).

Language competence—including grammar, vocabulary, and phonetics—showed the smallest relative improvement (+12.6%), supporting Fulcher's (2003) view that linguistic accuracy develops gradually and requires sustained, form-focused instruction. Although SS provided rich input and output opportunities, it lacked explicit grammar teaching and systematic feedback. This aligns with Ishonkulov's (2024) findings in similar contexts. The results highlight the need for hybrid models that combine simulations with targeted grammar instruction or AI tools for pronunciation and syntax correction.

In contrast, compensatory competence improved (+18%) by the use of inference, paraphrasing, and simplification strategies. These are key to communicative resilience and align with the findings of Poolsawad et al. (2015), who emphasized compensatory strategies as essential for learners with limited vocabulary. The open-ended nature of SS tasks appears to have lowered the affective filter, encouraging risk-taking without fear of formal assessment (Teng & Wang, 2021). This contrasts with more test-oriented environments, where error avoidance is common.

Likewise, educational and cognitive competence also improved (+18,6%), reflecting enhanced learner autonomy and metacognitive control. Students independently followed SS prompts and engaged with digital feedback, demonstrating better task management and digital literacy. These observations confirm findings by Zarrinabadi et al. (2021), who argued that digital learning environments enhance learner agency. This supports the view that educational technology can foster both language acquisition and the development of 21st-century skills.

The stronger performance in speech competence (+18,1%) —speaking, listening, reading, and writing—emphasizes the role of speech activities as core tools of cognition, expression, and communication, reinforcing the value of active language use within digital simulations.

Potential biases such as the novelty effect and elevated motivation in the EG might have influenced the positive results. For example, students could have been more engaged simply because the online speech simulators were new and interactive, or because they felt more confident and supported by digital feedback. Differences in prior interest in technology or personal goals to improve English might also have boosted motivation. Future research should control for these factors to confirm the lasting impact of SS.

Greater gains in sociocultural and compensatory components likely result from engaging, culturally relevant content and open-ended tasks that encourage strategic language use and reduce fear of mistakes.

Taken together, these findings suggest that well-designed digital simulations can effectively support the development of communicative competence while simultaneously fostering intercultural awareness, learner autonomy, and strategic language use. The principal contribution of this study lies in its focus on pre-service science teachers operating within a trilingual education system—an underrepresented demographic in previous research. Furthermore, the study demonstrates that culturally contextualized simulations can significantly enhance FLCC even within the scope of short-term interventions.

## 6. Implications and Limitations

This study offers practical insights for foreign language pedagogy, educational policy, and teacher training in multilingual contexts. The proven effectiveness of SS highlights their potential for integration into national FL education standards, especially for non-linguistic majors. In Kazakhstan and similar settings, incorporating digital speech training into pre-service teacher programs could help future biology, chemistry, and physics teachers develop both subject knowledge and the skills to communicate it in English.

This study provides a replicable instructional model using accessible platforms (e.g., Tilda) for SS design. Educators in resource-limited settings can implement similar tools to foster FLCC development, especially where opportunities for live communication are scarce. The stepwise task format—incorporating articulation, vocabulary, grammar, listening, speaking, and video production—can serve as a template for designing digital communicative tasks that mirror real-world academic and professional discourse. The five-component assessment rubric for FLCC also offers a holistic tool for diagnosing communicative strengths and gaps in multilingual pre-service education.

Significant FLCC improvements—especially in sociocultural and speech competencies—open new research avenues on digital simulations' roles in intercultural sensitivity and cognitive engagement. Future studies could examine long-term retention, effects on STEM communication, and comparisons of digital tools (e.g., SS vs. VR or AI tutors). The link between speech competence gains and grammar acquisition also merits exploration, possibly via hybrid models. Although limited to natural science majors, the study examined differences in FLCC gains by initial performance levels and competence areas. Future research could expand this by comparing outcomes across disciplines and broader learner profiles.

This study is limited by a modest sample size and a single institutional context, which restricts the generalizability of findings. Technical barriers such as inconsistent internet access and digital literacy affected learner engagement. Furthermore, although significant gains were observed in FLCC, the relatively modest improvement in core language competence indicates the need for complementary approaches—particularly in explicit grammar instruction and writing practice.

## 7. Conclusion

This study explored the effectiveness of online speech simulators as a digital didactic tool for developing FLCC among pre-service teachers of natural sciences in Kazakhstan. Quantitative results confirmed significant gains across all five FLCC components—language, speech, compensatory, sociocultural, educational and cognitive—indicating that structured digital speech practice can effectively address the communicative needs of students in non-linguistic majors.

The findings have clear practical implications. Educational policymakers in Kazakhstan and similar multilingual contexts should consider formally integrating SS into pre-service teacher training curricula, particularly within trilingual education systems. The stepwise SS structure—focusing on articulation, vocabulary, grammar, and authentic speech—offers a replicable model for institutions with limited access to native speakers or live communication.

Cultural contextualization played a pivotal role in learning outcomes. Tasks incorporating Kazakh traditions (e.g., Nauryz) not only promoted engagement but also enhanced sociocultural competence. These results show that embedding national identity in foreign language tasks fosters emotional resonance and intercultural awareness—especially relevant for post-Soviet education, balancing global integration and cultural preservation.

When compared to traditional methods (e.g., grammar-based instruction, textbook dialogues), SS demonstrated greater effectiveness in promoting functional and strategic language use, while conventional formats still play a vital role in developing grammatical accuracy. This highlights the potential of hybrid instructional models that integrate digital simulation with explicit language teaching. Grounded in communicative language teaching and CEFR principles, the study's findings further suggest expanding the theoretical framework to embrace digital mediation, learner agency, and culturally responsive pedagogy.

In this view, FLCC is conceptualized as a multi-dimensional construct shaped by the interplay of technology, content, and culture—an interrelation that offers a productive direction for future research. To validate and extend this model, further studies should examine its applicability across diverse academic disciplines and learner populations, including humanities majors, thereby assessing the transferability and comparative effectiveness of SS-based instruction.

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## Appendix 1

**Students' skills in determining the level and types of tasks**

| Category | Optimal level | CEFR | High level | CEFR | Medium level | CEFR | Low level | CEFR | Task type |
|---|---|---|---|---|---|---|---|---|---|
| Speech component | Understands complex conversations and lectures; communicates confidently on diverse topics; writes structured essays, reports, and business letters; comprehends complex texts like scientific articles. | B2 Upper-intermediate | Understands conversations on familiar topics; can sustain discussions using more complex expressions; writing is clear despite some grammar errors; reading may struggle with unfamiliar words but grasps the overall meaning. | B1 Intermediate | Understands individual words or phrases; struggles to express complex ideas; makes basic grammar and spelling errors; reads and comprehends simple texts. | A2 Pre-intermediate | limited speech comprehension; can say a few simple phrases or sentences; writes simple phrases and sentences with errors; reads without understanding the details | A1 Elementary | Multiple Choice: Watch the video and answer; Video response; Audio response; Fill in the Blank; Reorder; Drop Down |
| Language component | Expresses ideas and maintains conversations on various topics; adapts pronunciation to different accents; generally accurate spelling with rare errors in complex words; wide vocabulary; uses complex grammar. | | Expresses thoughts on various topics with limited complexity; rare pronunciation errors; occasional mistakes in complex words and spelling; difficulty using advanced vocabulary; knows and correctly uses basic grammar. | | Speaks in simple sentences with limited vocabulary; often struggles to maintain conversation. Pronunciation is sometimes incorrect; relies on basic words and repeats expressions. Has difficulty using synonyms and complex terms; makes errors in sentence structure and grammar. | | Limited idea expression; frequent accent and pronunciation errors, especially in complex words; many spelling mistakes; limited vocabulary; incorrect word order and misuse of irregular verbs and nouns. | | Multiple Choice; Categorize; Match; Audio Response; Fill in the Blank; Drag and Drop; Drop Down; Reorder |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sociocultural component | Can confidently discuss their country, capital, and hometown, providing detailed information about culture, history, landmarks, and events. | | Can talk about their country, capital, and hometown, describing basic facts (e.g., climate, landmarks) and mentioning cultural features. | | It has difficulty explaining detailed information like culture, history, or landmarks. | | Describes basic facts such as country name, capital, and hometown. | | Multiple Choice; Video Respons e; Multiple Choice |
| Compensatory component | Expresses thoughts clearly and logically, confidently using diverse grammar and vocabulary. Accurately rephrases ideas without changing their meaning. | | Expresses thoughts more clearly and logically, using some complex phrases. Paraphrases simple ideas with some limitations. | | Paraphrase simple constructions; express one idea in different words. | | It has difficulty expressing thoughts clearly and logically; uses simple phrases and often repeats the same expressions. | | Multiple Choice; Fill in the Blank; Match |
| Educational and cognitive | Easily follow all instructions, including complex or multi-step tasks; quickly understand and accurately applies them. | | Easily navigates instructions, accurately interprets and applies them; recognizes all task stages, understands nuances, and follows directions precisely. | | Reads and understands instructions generally; follows main task steps but may struggle with complex expressions or specific details. | | Understands instructions with difficulty; recognizes keywords or phrases but may not grasp the overall meaning. | | Labeling ; Match; Hotspot; Audio Respons e |

# Appendix 2

**Test results before and after the experiment in the Control and Experimental group**

| Respondents | CG before the experiment | | | EG before the experiment | | | CG after the experiment | | | EG after the experiment | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total points | Completed tasks (100 %) | Correct answers | Total points | Completed tasks (100 %) | Correct answers | Total points | Completed tasks (100 %) | Correct answers | Total points | Completed tasks (100 %) | Correct answers |
| 1 | 57.5 | 68 | 40 | 40.1 | 48 | 22 | 59 | 70 | 39 | 65 | 77 | 49 |
| 2 | 57.2 | 68 | 35 | 42.9 | 51 | 22 | 47 | 56 | 29 | 61.7 | 73 | 42 |
| 3 | 53.4 | 64 | 30 | 47.6 | 57 | 28 | 63 | 75 | 39 | 72 | 86 | 45 |
| 4 | 51.4 | 61 | 31 | 41 | 49 | 21 | 55.2 | 66 | 33 | 65 | 77 | 47 |
| 5 | 41.6 | 50 | 22 | 34.1 | 41 | 19 | 42 | 50 | 31 | 61.6 | 73 | 42 |
| 6 | 40.8 | 49 | 25 | 34.5 | 41 | 18 | 34.5 | 41 | 21 | 62.5 | 74 | 39 |
| 7 | 36.8 | 44 | 23 | 53.9 | 64 | 35 | 46 | 55 | 32 | 65 | 77 | 43 |
| 8 | 28.2 | 34 | 13 | 30.4 | 36 | 19 | 42.8 | 51 | 24 | 63.4 | 75 | 42 |
| 9 | 27 | 32 | 11 | 39.1 | 47 | 20 | 43.5 | 52 | 30 | 54.4 | 65 | 36 |
| 10 | 19.1 | 23 | 12 | 35.7 | 43 | 24 | 44 | 52 | 30 | 54.1 | 64 | 32 |
| 11 | 53.6 | 64 | 31 | 45.4 | 54 | 25 | 58 | 69 | 38 | 63 | 75 | 41 |
| 12 | 40.9 | 49 | 28 | 41.5 | 49 | 21 | 44.8 | 53 | 31 | 65 | 77 | 44 |
| 13 | 34.5 | 41 | 18 | 53.1 | 63 | 34 | 42.5 | 51 | 29 | 68 | 81 | 47 |
| 14 | 57.2 | 68 | 34 | 48.4 | 58 | 31 | 56.9 | 68 | 35 | 62.2 | 74 | 40 |
| 15 | 51.9 | 62 | 30 | 73.2 | 87 | 46 | 54 | 64 | 33 | 73.2 | 87 | 46 |
| 16 | 42.9 | 51 | 25 | 36.3 | 43 | 24 | 41 | 49 | 23 | 54.4 | 65 | 38 |
| 17 | 41.9 | 50 | 26 | 56.2 | 67 | 38 | 45.5 | 54 | 28 | 73 | 87 | 48 |
| 18 | 41.5 | 49 | 29 | 50.8 | 60 | 36 | 40 | 48 | 24 | 54.9 | 65 | 35 |
| 19 | 40 | 48 | 24 | 36.4 | 43 | 23 | 41.5 | 49 | 29 | 59.5 | 71 | 38 |
| 20 | 39.5 | 47 | 21 | 41.6 | 50 | 25 | 61.2 | 73 | 37 | 59.5 | 71 | 36 |
| 21 | 35.2 | 42 | 20 | 38.4 | 46 | 24 | 43 | 51 | 27 | 53.5 | 64 | 33 |
| 22 | 29.1 | 35 | 15 | 42.5 | 51 | 27 | 38.3 | 46 | 18 | 64 | 76 | 42 |
| 23 | 23 | 27 | 14 | 46 | 55 | 31 | 48.1 | 57 | 26 | 71 | 85 | 44 |
| 24 | 50.8 | 60 | 36 | 44.4 | 53 | 28 | 52.7 | 63 | 37 | 53.6 | 64 | 33 |
| 25 | 45.6 | 54 | 29 | 50.5 | 60 | 36 | 43.1 | 51 | 30 | 55.5 | 66 | 38 |
| 26 | 36.2 | 43 | 25 | 45 | 54 | 28 | 39.8 | 47 | 28 | 61.8 | 74 | 39 |
| 27 | 42.5 | 51 | 26 | 47.7 | 57 | 29 | 49.5 | 59 | 32 | 62.4 | 74 | 42 |
| 28 | 60.3 | 72 | 36 | 53.1 | 63 | 37 | 63.2 | 75 | 41 | 72.6 | 86 | 46 |
| 29 | 53.8 | 64 | 32 | 43.3 | 52 | 24 | 59.2 | 70 | 40 | 64.8 | 77 | 42 |
| 30 | 53.3 | 63 | 30 | 52.7 | 63 | 31 | 61.4 | 73 | 41 | 54.7 | 65 | 38 |
| 31 | 50.5 | 60 | 36 | 49.1 | 58 | 33 | 48.4 | 58 | 31 | 65.6 | 78 | 41 |
| 32 | 50.1 | 60 | 32 | 45.7 | 54 | 31 | 55.2 | 66 | 36 | 69.2 | 82 | 45 |
| 33 | 50 | 60 | 32 | 50 | 60 | 33 | 58.2 | 69 | 39 | 58.1 | 69 | 35 |
| 34 | 49.4 | 59 | 33 | 42.6 | 51 | 28 | 64.2 | 76 | 42 | 62.1 | 74 | 38 |
| 35 | 45.4 | 54 | 29 | 46 | 55 | 28 | 51.8 | 62 | 33 | 60.6 | 72 | 38 |
| 36 | 39 | 46 | 29 | 40.6 | 48 | 28 | 42.5 | 51 | 27 | 62.6 | 75 | 43 |
| 37 | 38 | 45 | 20 | 39.2 | 47 | 27 | 36.7 | 44 | 17 | 52.2 | 62 | 34 |
| 38 | 37.2 | 44 | 26 | 49.1 | 58 | 35 | 54.6 | 65 | 40 | 61.6 | 73 | 38 |
| 39 | 36.7 | 44 | 17 | 39.8 | 47 | 25 | 37.1 | 44 | 19 | 62.2 | 74 | 38 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 33.5 | 40 | 22 | 36.1 | 43 | 22 | 44.1 | 53 | 28 | 54.6 | 65 | 34 |
| 41 | 19 | 25 | 13 | 38 | 45 | 24 | 22 | 26 | 16 | 59.8 | 71 | 36 |
| 42 | 48.3 | 57 | 33 | 59.2 | 70 | 41 | 50.2 | 60 | 36 | 60 | 71 | 36 |