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# A Longitudinal Study on NLP-Enhanced Bilingual Pedagogy for Non-Linguistic Majors

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**Received:** 2 December 2025; **Revised:** 23 January 2026; **Accepted:** 5 February 2026; **Published:** 28 February 2026

**Abstract:** Persistent dissatisfaction with the outcomes of conventional English instruction in bilingual classroom settings has highlighted the need for more effective pedagogical models for non-linguistic majors in regional universities. These challenges are particularly pronounced in small, instructor-led groups taught primarily by non-native English-speaking lecturers under constrained institutional conditions. The study aimed to design, implement, and evaluate a bilingual teaching model enhanced by emerging natural language processing (NLP) tools in order to improve learner engagement, motivation, and language proficiency among non-linguistic majors. It also sought to examine how technological support could mitigate external and institutional factors that limit the effectiveness of traditional instruction. A longitudinal research design was employed, covering the period from 2008 to 2017. The study combined qualitative analysis of institutional and instructional conditions with the implementation of an integrated foreign-language environment that embedded NLP tools into classroom activities, feedback mechanisms, and assessment practices. Student progress was monitored through a hybrid system integrating conventional assessment instruments with NLP-supported data tracking. The findings demonstrate that the NLP-enhanced bilingual model significantly increased student motivation and produced measurable gains in English proficiency over time. The novelty of the study lies in its early and systematic integration of NLP applications into bilingual pedagogy within non-linguistic programs, offering empirically grounded insights into technology-supported language instruction and providing a transferable framework for institutions operating in comparable educational contexts.

**Keywords:** Academic Communication; Assessment Monitoring; Bilingual Education; Curriculum Development; Integrated Language Environment; Technology-Enhanced Learning

## 1. Introduction

English occupies a remarkable position today as the primary language of global science, advanced technologies, international collaboration, and major sectors of the world economy. Nearly 80% of the world's information resources are available in English, and more than half of all internet domains function predominantly in this language [1]. Scientific communication reflects a similar concentration: as much as 70% of academic publications, including nearly all research in the natural sciences, are published in English [2,3]. By 2016, the number of individuals bilingual in their native language and English was estimated to surpass the population of native English speakers by a significant margin, highlighting the language's increasingly international reach [4].

Despite these global trends, proficiency in English varies widely across countries. According to the EF English

Proficiency Index, many nations remain in the lower tiers, with research in these contexts pointing to a lack of motivation and limited practical need for foreign language study among large segments of the population [5,6]. This pattern extends even to university students, where interest in advanced English training is not universal. For example, surveys conducted among non-linguistic majors at Petrozavodsk State University indicate that only a minority expect to use English for academic or professional purposes [7–9].

Concerns regarding students' insufficient language preparation are frequently voiced by scholars and university administrators. Observers have highlighted the weak communicative abilities of graduates from mass higher education institutions, noting that such proficiency levels increasingly fall short of the demands of contemporary scientific and professional environments [8,9]. Beyond gaps in linguistic competence, students also encounter significant psychological and cultural barriers that limit their confidence in communicating in English [10–12].

National educational policy emphasizes the necessity of modernizing higher education and enhancing the quality of its content and instructional technologies [13]. Universities are tasked with preparing graduates capable of engaging effectively in international academic and professional discourse, which requires a level of English proficiency higher than that commonly observed [13,14]. Nevertheless, the typical conditions under which English is taught to non-linguistic majors, small, instructor-led classes functioning in a largely artificial bilingual environment, pose persistent challenges [15,16]. Past efforts to revise methodological approaches have produced limited gains, indicating that a more holistic reconsideration of foreign language instruction is needed [17,18].

Within this context, the present study examines the complex extralinguistic factors influencing English acquisition in classroom settings and evaluates the preliminary outcomes of a pedagogical model built around a unified foreign language environment augmented with natural language processing tools [18]. Implemented over an extended period, the model was designed not only to enhance students' linguistic skills but also to foster deeper engagement with academic and professional English through more active forms of language socialization [19]. By incorporating NLP-assisted feedback and assessment into the bilingual classroom, this study aims to provide evidence-based insights to support the ongoing search for more effective approaches to teaching English to non-linguistic majors [19].

## **2. Literature Review**

Extralinguistic determinants of foreign language acquisition among non-linguistic majors demonstrate considerable variation across national and institutional contexts [20]. Analysis of conditions characteristic of regional universities suggests that these determinants intersect with instructional practices in ways that directly shape learning outcomes [21]. Foreign language teaching has traditionally relied on lecture-based formats supplemented by individual textbook study and limited use of technical aids [22]. Within domestic scholarship, this instructional paradigm is commonly described as didactocentric, positioning the instructor as the primary agent of knowledge transmission while assigning students a largely receptive role [22]. Although such an approach ensures structural coherence and systematic content delivery, it frequently leads to repetitive classroom routines, constrained learner participation, and insufficient differentiation according to individual needs [23].

In response, numerous scholars have argued that conventional instructional models no longer align with the expectations or learning behaviors of contemporary university students [23]. This critique has fueled growing interest in learner-centered approaches that foreground student agency and instructional personalization [24]. However, the implementation of these models is not without difficulty, particularly in contexts where non-native instructors are expected to mediate communicative norms originally developed for native-speaker environments [24]. Even when communicative practice is emphasized, balanced development across linguistic subsystems often remains elusive [25]. These constraints have contributed to the emergence of hybrid instructional models that combine elements of traditional and learner-centered pedagogy [25]. In recent years, such integrative frameworks have increasingly incorporated digital technologies, including natural language processing tools designed to support feedback provision, pronunciation training, and written production [26].

Beyond pedagogical methodology, foreign language instruction for non-linguistic students is shaped by broader structural and institutional conditions [26]. In many universities, responsibility for language teaching lies with interfaculty departments rather than specialized linguistic units [26]. Course duration varies substantially from three to twenty-six credit units, often without institution-wide proficiency benchmarks [26]. Students typically remain with a single instructor throughout their program, and opportunities for interaction in the target language are largely confined to small groups led by non-native teachers [26]. Instructional content frequently reflects indi-

vidual pedagogical preferences rather than standardized curricula, while assessment practices differ markedly in the absence of externally moderated final examinations [26].

Instructors working within these interfaculty settings are generally experienced practitioners, though many lack advanced academic qualifications [27]. International studies indicate that a substantial proportion of such instructors are over fifty years of age [27]. While professional experience represents a valuable resource, it is often accompanied by a preference for established teaching routines and a cautious stance toward the adoption of emerging technologies, including NLP-based instructional tools [28]. This conservatism extends to assessment practices, which frequently remain unchanged despite the availability of digital alternatives capable of enhancing diagnostic accuracy and feedback quality [28].

The sociolinguistic configuration of the classroom further influences language development. When students are exposed almost exclusively to the speech of a single non-native instructor within a closed group, that instructor's language use effectively becomes the dominant linguistic model [28]. Empirical studies conducted at Petrozavodsk State University provide clear evidence of this phenomenon. Analysis of student pronunciation revealed a direct correlation between instructor accent strength and student phonetic outcomes. Groups taught by instructors with pronounced foreign accents displayed corresponding features in their own speech, whereas students instructed by teachers with more accurate pronunciation exhibited fewer accent-related deviations [28]. In cases where the instructor lacked linguistic authority, students tended to develop group-specific pronunciation patterns that diverged from standard English norms.

These observations were corroborated during a second experimental stage involving native English-speaking instructors. Student accent strength consistently reflected both instructor pronunciation and pedagogical approach. Small, stable groups consisting of ten to twelve learners proved particularly susceptible to the emergence of shared pronunciation habits, especially when the instructor's linguistic authority was perceived as limited.

Taken together, these dynamics, combined with the structural constraints outlined above, create conditions that impede effective foreign language socialization [29]. Over time, learners may develop persistent phonetic, cultural, and psychological barriers that restrict their ability to communicate confidently with native speakers and other bilingual users of English [29]. The strategic integration of NLP-based tools offers a potential means of addressing these challenges by providing stable pronunciation benchmarks, individualized corrective feedback, and exposure to more authentic linguistic input. Nevertheless, the pedagogical value of such tools depends on their sustained and systematic incorporation into instructional practice, supported by broader institutional commitment.

Longitudinal investigations conducted within English-medium instruction (EMI) settings further demonstrate that these variables evolve dynamically throughout university study and exert a statistically significant influence on academic performance, underscoring the importance of non-linguistic determinants in language acquisition [29]. These findings extend earlier models of language socialization by situating linguistic development within a comprehensive psychosocial framework.

Closely aligned with motivational constructs, recent research has emphasized the predictive role of foreign language enjoyment (FLE) and willingness to communicate (WTC) in higher education EFL contexts. Empirical evidence suggests that positive emotional engagement mediates learner participation and persistence, particularly among students whose primary academic focus lies outside linguistics or philology [29]. This body of work highlights the necessity of addressing affective and motivational dimensions alongside instructional design.

Concurrently, the rapid advancement of artificial intelligence and natural language processing technologies has transformed contemporary foreign language pedagogy. A growing corpus of research documents the instructional potential of AI-driven feedback systems, adaptive learning platforms, and automated writing evaluation tools in fostering learner autonomy and individualized learning pathways [30]. These innovations are especially pertinent in institutional environments characterized by limited contact hours and heterogeneous proficiency levels.

Finally, systematic reviews published within the last five years indicate that digitally mediated learning environments exert a measurable influence on learners' affective states, including reductions in anxiety and increases in motivation. Studies incorporating gamification, virtual reality, and conversational agents report gains in learner confidence and engagement, suggesting that technology-enhanced instruction may partially mitigate sociolinguistic constraints inherent in non-native instructional contexts [30]. From a sociocultural perspective, research informed by Vygotskian theory argues that digitally enriched instructional ecosystems expand opportunities for meaningful interaction and scaffolded learning. In particular, AI-supported collaborative platforms facilitate access to diverse

linguistic input and pragmatic norms beyond the instructor’s individual speech model, thereby reducing the risk of group-specific linguistic fossilization observed in small, closed classroom communities [30].

### Model of a Unified Foreign Language Environment

The notion of a Unified Foreign Language Environment (UFLE) corresponds closely with recent educational reforms that prioritize immersive learning, communicative interaction, and the strategic use of digital technologies in language education. Contemporary pedagogical research increasingly recognizes the importance of authentic communicative situations, particularly those in which neither interlocutors nor evaluators are predetermined, as a means of encouraging spontaneous language production and learner autonomy [30]. By approximating real-world interactional conditions, such environments foster the development of sociolinguistic competence while reducing dependence on predictable, instructor-centered instructional patterns.

Recent studies further demonstrate that advanced artificial intelligence and natural language processing (NLP) technologies can be meaningfully embedded within foreign language environments to support adaptive, individualized learning trajectories and timely formative feedback that complements authentic communicative practice. In particular, AI-mediated chatbots and conversational agents have been shown to sustain learner interaction and motivation by enabling extended dialogic engagement beyond the temporal and spatial limits of the traditional classroom [30]. When integrated into a unified instructional environment, these tools allow learners to practice language under conditions of communicative unpredictability that more closely resemble natural conversation.

At the systemic level, the role of generative artificial intelligence in foreign language education has been framed as part of a broader sociotechnical transformation, in which institutional structures, pedagogical strategies, and learner affordances interact dynamically to influence instructional effectiveness [30]. Within such frameworks, the incorporation of AI-driven feedback mechanisms, adaptive assessment tools, and interactive language applications is understood to expand opportunities for authentic practice while supporting sustained learner engagement over time.

Empirical findings also suggest that AI-supported learning environments positively influence key affective variables, including enjoyment, engagement, and willingness to communicate factors that are central to successful language socialization. The emotional and motivational benefits associated with technology-enhanced instruction have been linked to greater persistence in communicative activities and reduced performance-related anxiety, underscoring the pedagogical value of immersive language settings comparable to the UFLE model [30].

### 3. Research Methodology and Materials

The pilot implementation of the UFLE model and the accompanying monitoring and assessment system was carried out at the Department of Foreign Languages for Humanities at Petrozavodsk State University across a ten-year period, from 2008 to 2017. A total of 1600 individuals took part, including 1580 undergraduates, graduate, and postgraduate students, and 20 instructors. The student cohort consisted of 1027 women (65%) and 553 men (35%) aged 17 to 24. **Table 1** outlines the project stages, associated research methods, and participant numbers.

**Table 1.** Core Components for Designing a Unified Foreign Language Environment.

Phase	Methods	Participants
Phase I (2008–2017): Development and pilot implementation of the UFLE model	Surveys; content analysis	1572 students and 20 instructors
Phase II (2009–2017): Pilot testing of the alternative monitoring and assessment system (MAS)	Integration of the model into curricula	Same as above
Phase III (2016–2017): Evaluation of the UFLE and MAS	Expert error analysis at three speech levels	28 students and 4 expert instructors from the initial cohort

Source: Author development.

To examine the effectiveness of the UFLE model particularly in combination with developing NLP-supported tools, both subjective and objective analytical procedures were used. Subjective methods included student surveys and content analysis of qualitative responses. Objective evaluation relied on expert assessment of speech errors at three linguistic levels, enabling a consistent comparison of performance across the project’s phases.

### 3.1. Project Implementation: Modeling a Unified Foreign Language Environment

#### 3.1.1. Stage I: Pilot Testing of the UFLE Model

The UFLE model was built on several theoretical and methodological foundations:

##### Sociolinguistic Research on Speech Behavior and Language Personality

The model draws on classical work by A. D. Shveitser, Yu. N. Karaulov, L. P. Krysin, W. Labov, E. Sapir, L. Milroy, K. Scherer, P. Trudgill, and others. Their insights into language variation and identity were used to shape communicative scenarios and evaluate the linguistic roles adopted by students. Integration of communicative, competence-based, and activity-oriented approaches was also informed by contemporary interpretations of foreign language pedagogy and intercultural competence [11,12,15].

The model synthesizes concepts from E. I. Passov, I. A. Zimnyaya, A. V. Khutorskoy, V. A. Bolotov, and L. S. Vygotsky, among many others. Activity-oriented methods helped structure tasks that moved from guided practice to independent speech production, while competence-based principles informed the sequencing of learning outcomes [13,14]. Anthropocentric and technology-supported instruction [15]. A wide range of learner-centered methods, including interactive, problem-based, and contextual learning, were incorporated, drawing on practices developed by COIL, Richards & Rodgers, Docking, Ellis, Nunan, and others. For the purposes of the present study, these activities were complemented with emerging NLP-based tools that provided automated feedback on academic writing, pronunciation, and vocabulary usage [20,21,24,26]. Project-based tasks, digital portfolios, and collaborative online activities formed an integral part of classroom instruction.

##### Curriculum Structure and Content

Academic English formed the core of the curriculum, as it supports communication across all fields of study. Alongside it, specialized forms of English business, legal, and discipline-specific varieties were introduced to prepare students for professional interaction outside the university. To support independent work, instructors prepared detailed methodological guides written in students' native language. These guides explained how to write business letters, prepare abstracts for research publications, design academic presentations, and even produce short films in English. The UFLE model is organized into two blocks: academic and professionally oriented, each combining individual and group tasks that gradually increase in complexity.

##### Professional Block: Pedagogical Innovation and Student Engagement

Within the professional component, competition-based pedagogical technologies played a central role. Students participated in individual and team competitions that involved presenting their work in English before large audiences of unfamiliar listeners, sometimes exceeding 150 participants. This approach exposed students to authentic communicative pressure and enabled them to compare their performance with that of peers from other groups and disciplines.

The department also introduced interdisciplinary examinations conducted in the form of academic conferences. Students presented research findings publicly, responded to questions, and defended their decisions. These experiences helped develop self-regulation, stress management, and rapid decision-making skills, all of which are essential for successful socialization in a foreign language environment. In the context of this longitudinal study, such activities also served as practical settings for testing the effectiveness of NLP-enhanced tools used to support preparation, feedback, and performance evaluation (Table 2).

**Table 2.** Model of an NLP-Enhanced Unified Foreign Language Environment.

	Professionally Oriented Discourse	Academic Discourse
Objective	Foreign-language socialization in professional communication through NLP-supported speech and performance tasks	Foreign-language socialization in academic communication reinforced by automated text-processing and feedback tools
Program Components and Participant Profile	<ul style="list-style-type: none"> <li>Dramatization Contest (Original Play Production)—1st-year undergraduates</li> </ul>	<ul style="list-style-type: none"> <li>Digital Storytelling Presentation Contest —2nd–3rd-year undergraduates</li> </ul>

Table 2. Cont.

	Professionally Oriented Discourse	Academic Discourse
• Film Festival—1st–4th-year undergraduates and Master’s students	• Development of academic and professional documents (CVs, cover letters, grant proposals) supported by NLP-based drafting tools	
• Academic writing (abstracts and research articles) with automated discourse-structure feedback		
• Oral research presentations at interdisciplinary conferences		
Target groups: undergraduate, graduate, and postgraduate students		
Technologies	Project-based, problem-based, and contextual learning methods combined with NLP-driven speech-recognition tools for formative feedback	Project-based, problem-based, and contextual learning supported by corpus-based analysis and automated writing evaluation
Types of Activities	Speaking, reading, listening, writing	Writing, reading, speaking, listening
Developed Competencies	• Effective oral and written communication in Russian and English	
• Professional communication skills and coherent idea formulation		
• Critical analysis and information synthesis		
• Ability to prepare research-related texts (reviews, annotations, abstracts)	Same as in the professional block, with emphasis on academic reasoning, argumentation, and discipline-specific discourse norms	

### 3.1.2. Stage II: Pilot Testing of the NLP-Enhanced Unified Control and Assessment System

The Education Development Program for 2016–2020 highlights the need for a reliable and transparent nationwide mechanism for evaluating educational quality. Within this project, the Unified Control and Assessment System (UCAS) was re-designed to incorporate a combination of traditional assessment practices and NLP-based analytical tools. As part of the broader bilingual instructional model, UCAS played a central role in ensuring that students’ English-language progress was measured objectively rather than according to the expectations of a familiar instructor.

A major aim of the system was to increase students’ motivation by making evaluations more impartial and by allowing learners to track their own progress with the help of automated tools. Alongside regular tests and oral questioning, the system included self-assessment and peer-assessment supported by NLP-assisted speech-recognition and automated error-flagging. The language portfolio was positioned as a form of authentic assessment, documenting work produced across the semester and analyzed through a blend of expert review and automated feedback. Portfolios varied by level, but typically included a CV, grant application materials, abstracts of research articles, translations, and oral presentation scripts. Access to departmental examinations required successful completion of the portfolio. The assessment structure consisted of four weighted components:

1. Tests and quizzes—20%;
2. Class participation and homework—30%;
3. Language portfolio—20%;
4. Departmental examination—30%.

This assessment structure outlines the examination sequence all students were required to complete, beginning with project-based tasks and culminating in an interdisciplinary research presentation.

### 3.2. Content of Departmental Interdisciplinary Examinations

One of the central project events was an interdisciplinary film festival, where students presented their own educational films in English. These projects typically extended across an entire semester and were accompanied by detailed documentation, including scripts, role descriptions, and workflow records. NLP-based transcription and timing tools were used during rehearsals to help students identify problematic pronunciation, pacing, and segment boundaries.

The departmental examination itself followed the format of an academic conference. Students delivered interim or final research results in English, demonstrating their ability to structure a talk, maintain eye contact, manage gestures, and speak without lengthy pauses. Admission to the exam required a complete individual portfolio containing the presentation abstract, full speech text, transcription, and annotated intonation patterns, some of which were prepared or verified using speech-processing software.

#### 4. Results

The effectiveness of the bilingual pedagogical model was examined using an independent error analysis conducted by external experts. A total of 28 students participated in this stage:

- 7 Pre-Intermediate and 7 Advanced learners taught through traditional methods (Control Groups C1 and C2).
- 7 Pre-Intermediate and 7 Advanced learners taught within the UFLE model enhanced by NLP-based tools (Experimental Groups E1 and E2).

Group assignment was based on preliminary standardized tests, and all groups were taught by the same instructor to avoid instructional bias. Students prepared five-minute audio recordings on academic or professional topics in the Digital Story format. The recordings were evaluated for communication-impeding errors. Only mistakes that hindered comprehension or altered meaning were counted, including:

- Phoneme substitution errors affecting meaning;
- Incorrect pause placement is disrupting the syntagmatic structure;
- Misuse of tenses, word order violations, and lexical inaccuracies;
- Deviations from expected academic discourse organization.

**Figure 1** summarizes communication-hindering errors among the traditional-training control groups. Group C1 produced 633 errors (average 90.43 per student), while Group C2 produced 299 errors (average 42.71). These findings provided a baseline against which the performance of the NLP-supported experimental groups was later compared.

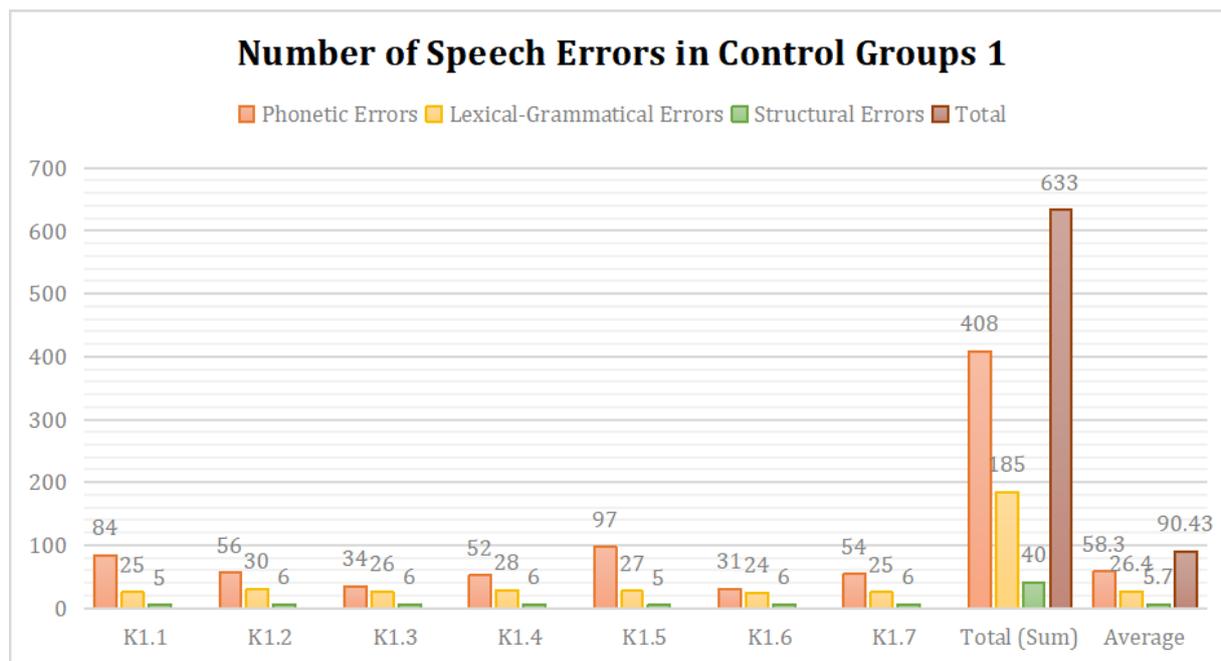


Figure 1. Cont.

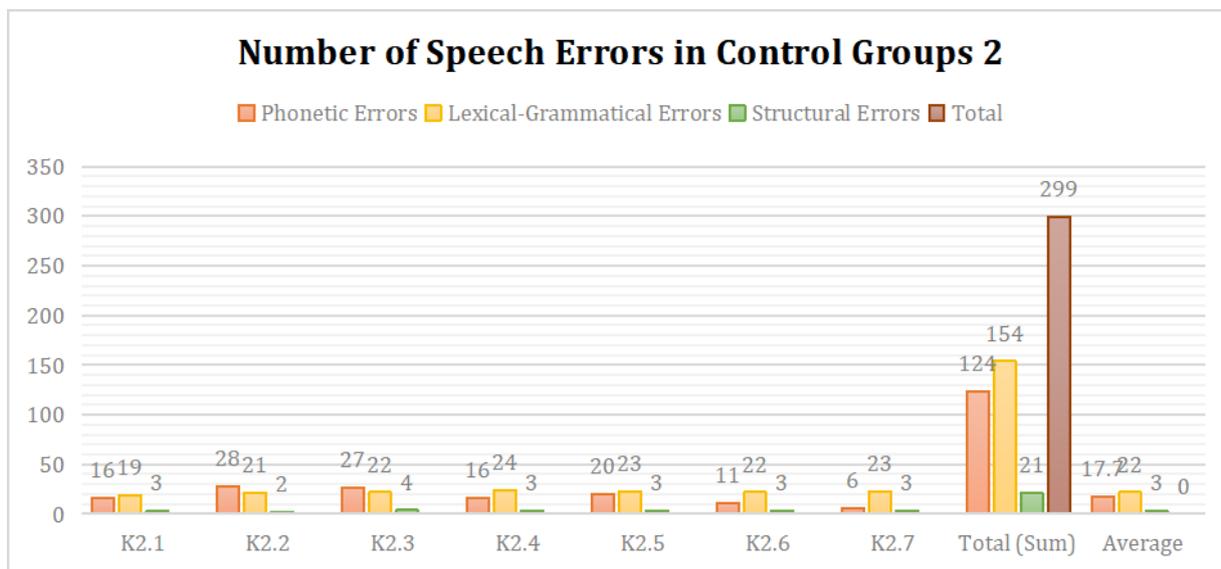


Figure 1. Number of Speech Errors in Control Groups.

Source: Author development.

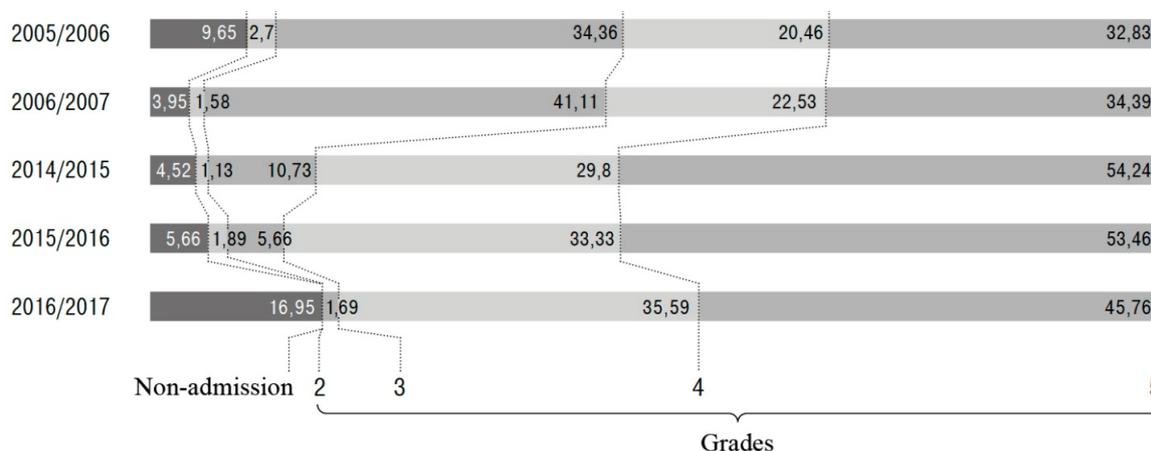
The data presented in **Table 3** show a clear contrast between the performance of the experimental groups and that of the control groups. Students in the NLP-supported bilingual program produced far fewer errors that interfered with meaningful communication. In group E1, students made 383 such errors (an average of 54.71 per student), while group E2 produced only 155 errors (an average of 22.14). To determine the reliability of these differences, a Student’s *t*-test was applied. The resulting values 3.05 for the lower-proficiency groups and 5.03 for the higher-proficiency groups exceeded the critical threshold ( $t_{crit} = 2.179$ ,  $df = 12$ ,  $p = 0.05$ ). These numbers confirm that the differences between the traditional instruction groups and the groups taught through the NLP-enhanced model are statistically significant ( $p < 0.05$ ). When compared with their counterparts in the conventional program, both experimental groups demonstrated a far lower number of errors that hindered clear and effective English communication. The gap was most noticeable between groups E1 and C1, which suggests that the NLP-supported bilingual approach is particularly helpful for students who begin their studies with limited or moderate proficiency.

Table 3. Number of Speech Errors in Experimental Groups with Low (E1) and High (E2) Levels of Foreign Language Proficiency.

Error Type	Group E1 (Low Level of Foreign Language Proficiency)							Total (Sum)	Average
	E1.1	E1.2	E1.3	E1.4	E1.5	E1.6	E1.7		
Phonetic Errors	18	24	43	34	31	30	16	196	28
Lexical-Grammatical Errors	20	20	28	29	27	25	23	172	23.1
Structural Errors	2	6	6	3	2	3	3	25	3.5
	Total							393	54.71
Error Type	Group E2 (High Level of Foreign Language Proficiency)							Total (Sum)	Average
	E2.1	E2.2	E2.3	E2.4	E2.5	E2.6	E2.7		
Phonetic Errors	3	9	7	14	13	5	7	58	8.3
Lexical-Grammatical Errors	10	10	13	15	17	16	7	88	12.6
Structural Errors	3	1	2	1	1	1	0	9	1.3
	Total							155	22.14

These findings indicate that integrating NLP tools and bilingual methods into English language instruction can substantially improve learning outcomes for students in non-linguistic fields. This conclusion is reinforced by long-term academic performance data for students who studied before (2005–2007) and after (2014–2017) the introduction of the new instructional model (see **Figure 2**). Over this period, the share of the lowest passing grades (“3”) fell significantly, while higher grades (“4” and “5”) became more common. At the same time, the number of

students not admitted to exams increased, which is likely tied to heightened academic requirements and a stronger sense of responsibility among students.



**Figure 2.** Academic Performance Indicators in Foreign Language Courses Among Non-Linguistic Students for the Periods 2005–2007 and 2014–2017 (% of Total Student Population).

## 5. Discussion

The overall upward shift in academic results points to a rise in learner motivation. A survey of 1600 students taught within the enhanced bilingual environment confirms this trend. Almost all respondents (98%) supported the combined use of traditional and innovative assessment methods. Many students reported feeling less anxious when speaking English during interdisciplinary conference-style exams compared to standard examinations (78%). Others stated that they became more accepting of bilingual speakers who use non-native English (34%) and more attentive to clarity and listener comprehension in their own speech (46%).

A major outcome of the project is the higher level of foreign-language socialization achieved by students, which extends beyond classroom interactions and includes deeper engagement with global English-speaking communities.

The long-term study also prompted a reassessment of the role of non-native instructors in an NLP-enhanced bilingual environment. Teaching in this format requires a broader professional profile: familiarity with digital and NLP-based tools, understanding of psychological and sociocultural factors that shape language learning, and the ability to guide students through complex, interactive tasks. Within this model, the instructor no longer functions primarily as the sole source of linguistic authority but instead takes on the roles of facilitator, mentor, and academic adviser. Those who adapt to this shift tend to achieve strong results, especially when working with students whose initial proficiency is modest. However, the pilot study also showed that not all instructors feel comfortable with external evaluation and the increased transparency that comes with portfolio-based and automated assessment. Students generally demonstrate greater openness to these changes than some instructors. Faculty members who have already developed strong professional identities tend to adapt more successfully and, in turn, help students achieve stronger learning outcomes even in large groups typical of graduate programs.

Despite growing classroom loads and reductions in teaching staff across many institutions, the NLP-enhanced bilingual model offers a promising alternative. Although at first glance it may appear to impose additional demands on instructors, this impression does not fully reflect the changing expectations placed on higher-education professionals. The Professional Standard for Higher Education Teachers, implemented in 2017, already requires educators to be versatile and capable of integrating digital tools into instruction. Moreover, modern labor markets increasingly value specialists who can multitask, think creatively, and collaborate effectively. The bilingual model supported by NLP systems aligns with these broader educational and societal expectations.

By integrating authentic communicative tasks, interdisciplinary conferences, digital storytelling projects, and automated assessment tools, the model supports both linguistic competence and essential academic skills. It enables students to move beyond rote learning and engage in meaningful communication within both academic and

professional domains. As a result, learners develop stronger confidence, greater autonomy, and more refined strategies for interacting in global English-speaking environments.

## **6. Conclusion**

The introduction of the NLP-enhanced Unified Foreign Language Environment (UFLE) and its accompanying Unified Control and Assessment System (UCAS) marks an important step in improving English language instruction for non-linguistic majors studying in bilingual settings. Traditional models, often dominated by lecture-based instruction, fail to meet the communicative demands faced by today's university students. The UFLE and UCAS address these shortcomings through a sociolinguistically informed and practice-oriented framework that blends bilingual pedagogy with NLP-driven support tools.

The findings of the longitudinal study demonstrate clear improvements in learners' proficiency, particularly among students with lower initial competence. The combination of project-based tasks, interdisciplinary presentations, and automated linguistic analysis encourages students to participate more actively in communication and reduces the psychological barriers commonly associated with foreign-language use. The revised assessment system, which incorporates both traditional testing and authentic performance-based evaluation, provides a more objective picture of students' communicative abilities and motivates sustained engagement with the language.

The research also underlines the central role of instructors. Successful implementation of the model requires educators who are flexible, digitally proficient, and ready to reshape their teaching practices. While some resistance remains, particularly among instructors who are hesitant to accept external monitoring, the overall results suggest that those who adopt the approach can significantly improve learning outcomes.

In sum, the NLP-enhanced bilingual model addresses long-standing extralinguistic challenges such as low motivation, anxiety, and limited exposure to authentic communication by establishing a dynamic and interactive learning environment. Its potential for scaling within mass higher education makes it a promising tool for preparing globally competent graduates capable of participating fully in international academic and professional communities.

## **Author Contributions**

Conceptualization, S.I. and Z.P.; methodology, U.T.; software, N.A.; validation, S.K., D.K., and M.K.; formal analysis, D.N.; investigation, Z.K.; resources, K.Z.; data curation, U.T.; writing—original draft preparation, S.I.; writing—review and editing, Z.P.; visualization, N.A.; supervision, S.I.; project administration, Z.P.; funding acquisition, K.Z. All authors have read and agreed to the published version of the manuscript.

## **Funding**

This research received no external funding. The authors covered all publication and article processing charges independently.

## **Institutional Review Board Statement**

Not applicable.

## **Informed Consent Statement**

Not applicable.

## **Data Availability Statement**

All available data will be provided on request.

## **Acknowledgments**

The authors would like to acknowledge the academic and administrative support provided by the Department of Foreign Languages Education, Tashkent State University of Economics, during the preparation of this manuscript.

## Conflicts of Interest

The authors declare no conflict of interest.

## AI Use Statement

Limited use of AI-based language tools was employed solely for grammar checking, sentence clarity, and improving the readability of the English text. No AI tools were used for content generation, data analysis, interpretation, or the formulation of conclusions. All intellectual and academic content was developed entirely by the authors. The authors take full responsibility for the originality, integrity, and accuracy of the manuscript, and confirm that AI-assisted language editing did not influence the scientific content of the work.

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