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Mobile applications in the context of personalized foreign language learning

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ABSTRACT

The purpose of the study is to determine the effectiveness of mobile applications in the context of personalized foreign language learning. The study uses a quasi-experimental design with control and experimental groups. The experiment lasted 12 weeks (the experimental group used Duolingo, Busuu, and LingQ). The study involved 300 students from 5 higher education institutions, for whom a foreign language has become a mandatory component of the educational program. A standardized language test, a scale of learning motivation (intrinsic, extrinsic motivation, and amotivation), and a questionnaire of learning autonomy and self-regulated learning were used to collect data. The study's results indicated a positive impact of personalized mobile learning on the overall outcomes of foreign language acquisition and on all analyzed components of foreign language competence. In particular, the study indicated a differentiated effect of different mobile applications. The Duolingo and Busuu programs were effective in developing lexical and grammatical skills. LingQ became important for the development of reading and listening skills. Thus, personalized mobile learning has become an effective tool for enhancing the quality of students' foreign-language training and for developing their motivation and self-regulation.

Keywords: Personalized mobile learning; Foreign language learning; Mobile applications; Learning outcomes; Learning motivation; Learning autonomy; Self-regulated learning

1. Introduction

Mobile applications, which play an important role in creating an effective learning environment, have transformed approaches to learning foreign languages. In particular, the concept of mobile-assisted language learning (MALL) has combined various capabilities of smartphones, cloud services and interactive platforms with modern teaching methods. Such a synthesis has influenced the implementation of access to various educational materials, instant feedback and support for autonomous learning. Recent studies have indicated that mobile applications can increase motivation and intensify speaking and listening practice. In addition, the authors have indicated that they are important for the development of self-regulated learning skills when they are integrated into a well-thought-out pedagogical model.

However, given current scientific trends, personalized learning, based on the individual needs of learners, the level of preparation, the pace of assimilation, and the learning styles of a particular learner, has gained significant attention in modern linguistic didactics. Thus, the combination of mobile applications with personalized trajectories can open significant potential for more precise selection of language content, adaptive task complexity, variability in interaction forms (text, audio, video, interactive exercises), and the use of mobile learning algorithms and intelligent recommendations [1]. Recent studies in the field of AI-enhanced personalized foreign language learning have indicated improvements in language competence, albeit in

vocabulary, grammatical accuracy, and pronunciation, compared to traditional approaches [2]. However, despite the significant number of commercial language applications, scientific studies identify several problems. Some scientists have noted that the predominance of technical and gamification aspects over pedagogically balanced personalization affects the limited consideration of individual educational goals [3]. In addition, the impact of specially designed mobile applications for personalized learning remains insufficiently studied [4]. It is also important to assess this impact on mastering a foreign language, motivation, and a sense of control over the learning process in specific educational conditions [5]. This determined the study's scientific problem: to identify the effectiveness of mobile applications in implementing personalized foreign language learning. Therefore, the purpose of the article is to determine the effectiveness of mobile applications in the context of implementing personalized foreign language learning. To achieve the goal, the following research tasks are provided: 1. To investigate the impact of personalized mobile learning on overall foreign language learning outcomes. 2. To analyze the impact of personalized mobile learning on specific components of foreign language competence (lexical and grammatical skills, reading and listening). Comparing the effectiveness of different types of personalized mobile applications (Duolingo, Busuu and LingQ) in terms of learning success. 4. To determine the impact of personalized mobile learning on motivational and self-regulatory factors.

1.1. Mobile-assisted language learning: potential and limitations

Mobile-assisted language learning (MALL) is currently an important area of linguistics, in which the smartphone is considered a central tool for organizing language learning. Current theoretical articles and systematic reviews have indicated that mobile applications allow improving individual components of foreign language competence - in particular vocabulary, grammar, listening and speaking [6]. This is realized based on high frequency of practice, multimodality of exercises and the ability to learn in "micro-intervals" of time [7]. Current empirical studies of various platforms (in particular, Babbel, Duolingo and Busuu) have indicated noticeable increases in vocabulary, grammatical accuracy and receptive skills, provided that the applications are used regularly for several weeks or months [8]. However, based on a critical analysis of MALL studies, several methodological limitations can be noted. First, much of the work is based on short-term interventions (2–6 weeks) with small samples. This has made it difficult to generalize the results and draw conclusions about sustainable effects. On the other hand, there is a noticeable emphasis on studies focused on individual skills. Scientists have analyzed the impact of technology on vocabulary or pronunciation [9], [10]. Therefore, it is precisely the integrated impact of mobile applications on foreign language competence that has been insufficiently studied. Finally, despite technical progress, several systematic reviews of Duolingo and other popular applications have emphasized that the design of most products is determined primarily by commercial logic, gamification and user retention, and not by a clearly formed pedagogical model [11]. For this reason, there is currently no transparent didactic concept. Tasks may not always correspond to the level and needs of a specific target group, the role of the teacher and the place of the application in the course structure remain peripheral. Research involving teachers has also indicated a notable gap between the potential of mobile applications and their actual use in formal education [12], [13]. The authors indicated that this gap occurred due to doubts about the quality of content, the lack of clear assessment tools and integration into the curriculum [14].

In addition, as demonstrated in numerous studies, MALL practice is often characterized by fragmentation. The authors indicated that students used the applications episodically, in a self-study mode, without systematic support from the teacher [15], [16]. Such use limits the effects on motivation and long-term retention of knowledge. In addition, other scholars have indicated that mobile learning can be vulnerable to distractions, interruptions, and a rapid decrease in the intensity of classes [17]. As indicated in other works, a well-built, well-thought-out pedagogical framework affects the effectiveness of mobile learning [18]. Thus, the effectiveness of mobile applications in the development of individual language skills has generally been proven; however, the question of their effectiveness in the context of targeted integration into a foreign language course with clear educational goals, assessment criteria, and teacher participation remains unresolved.

1.2. Personalized and adaptive mobile learning of foreign languages

At the same time, in parallel with the development of MALL in pedagogical science, the concept of personalized and adaptive learning has become relevant. Within the framework of this approach, the educational system involves adjusting to the individual characteristics of the student. As proven in theoretical works, such characteristics as the level of preparation, pace of advancement, learning style, motivational profile, and specific goals are important [19]. The authors also pointed out that personalized adaptive platforms can increase

academic results, engagement, and satisfaction with learning based on dynamic content customization [20]. Directly in the system of learning foreign languages, the authors formed and analyzed a number of mobile systems that use adaptation algorithms, in particular, spaced repetition and optimization of vocabulary acquisition. In this sense, the study of machine learning models that allow adjusting the pace and complexity of exercises in accordance with the current student performance is also important. At the same time, the authors indicated that current MALL solutions provided higher vocabulary gains and better engagement compared to "hard" courses without personalization [21]. These data are also important for the theoretical basis of this article. Important for the analysis are studies related to the analysis of the features of the use of artificial intelligence. In particular, the authors justified the involvement of large language models and chatbots to create personalized language trajectories [22]. It is proven that AI-enhanced mobile applications affect the generation of tasks according to the level and goals of the user [23]. In addition, the authors pointed to the instant feedback of these programs and the modeling of "student-virtual tutor" dialogues [24], [25]. Accordingly, as indicated in the scientific literature, commercial platforms and technology giants position AI-oriented personalization as an important and competitive advantage of language applications.

However, the literature review indicated that gaps remain in the field of personalized mobile foreign language learning. In particular, many studies focus on the description of technological solutions. The authors paid attention to such technological aspects as algorithm architecture, interface, and task types. However, the direct pedagogical principles of personalization (individual goals, context of use, the role of the teacher in setting trajectories) are still insufficiently developed. On the other hand, the current empirical base on the impact of personalized mobile applications on learning outcomes (development of language competence, motivation, autonomy) in formal higher education courses is limited. It is noticeable that pilot studies without control groups, with small samples, or with a focus on only one dimension dominate the current scientific discourse. In addition, there are few works devoted to mobile learning in the countries of Central and Eastern Europe, which combine specific educational conditions, digital infrastructure and requests for the development of foreign language competence in higher education. Thus, modern scientists have pointed out the significant potential of mobile applications in foreign language teaching and have shown the prospects of personalized and adaptive approaches. At the same time, several gaps are revealed, which are associated with the lack of experimental studies with clear control, insufficient attention to the analysis of performance dimensions (combining language competence, motivation, learning autonomy and self-regulated learning in one study). In addition, it is noticeable that the pedagogical model of integrating personalized mobile applications into the structure of the university course is poorly developed. Therefore, overcoming these gaps based on developing and experimentally testing a model of using mobile applications in the system of personalized foreign language learning will constitute a scientific contribution to this study.

1.3. Hypothesis

Hypothesis 1 (motivation to learn a language).
The use of a personalized mobile application in the process of learning a foreign language will increase students' learning motivation: after the experiment, the level of intrinsic motivation to learn a foreign language in the experimental group will be higher than in the control group.
Hypothesis 2 (autonomy).
Involving students in personalized mobile learning of a foreign language will lead to an increase in the level of learning autonomy and self-regulated learning. It is predicted that the indicators of conscious planning, control and reflection of one's own learning in the experimental group after the intervention will be higher than in the control group.

2. Research method

2.1. Research design

The study was a quasi-experimental study using a "control-experimental group" scheme and pre- and post-testing. The intervention factor was the use of personalized mobile applications in the process of learning a foreign language.
The experimental group studied according to an updated course model, within which the mobile application is used as a key personalization tool (adaptation of the level of complexity, pace, set of exercises, types of feedback). The control group works according to the traditional course methodology without the systematic use of mobile applications (or with its minimal/episodic use, which is not personalized in nature).

This design made it possible to determine the impact of personalized mobile learning on the results of mastering a foreign language. The duration of the experiment was one semester (12 weeks of active work with the application).

2.2. Participants

The study involved 300 students from higher education institutions (60 from each of five universities). For these students, a foreign language is a mandatory part of the educational program. All authors of the article represented different educational institutions and were responsible for organizing the experiment in their institutions.

Two groups were formed in each institution:

Experimental group - 30 people who studied according to the updated course model with the systematic use of a personalized mobile application;

Control group - 30 students who worked according to the traditional methodology without targeted personalization

Thus, the total sample was 300 people (approximately 150 in the control and 150 in the experimental groups) (See Appendices 1-4). The distribution into groups was based on existing academic groups at each institution (quasi-experimental design), while ensuring the maximum possible equivalence of the groups.

Students who had constant access to a smartphone or tablet were involved; regularly used mobile applications in educational and extracurricular activities (for experimental groups); provided informed consent to participate in the study and generalization of anonymized data.

The multi-site nature of the sample (five institutions) made it possible to test the reproducibility of the effect of personalized mobile learning in different institutional spaces and reduce the risk of linking the results to the specifics of one university or individual teacher.

Table 1. Demographic characteristics of the participants (N = 300)

Variable	Category	Total n (%)	Control groups n = 150	Experimental groups n = 150
Gender	Female	216 (72.0)	110 (73.3)	106 (70.7)
	Male	80 (26.7)	38 (25.3)	42 (28.0)
	Not reported / other	4 (1.3)	2 (1.4)	2 (1.3)
Age	M (SD), years	19.4 (1.2)	19.5 (1.3)	19.4 (1.1)
Year of study	1st year	182 (60.7)	91 (60.7)	91 (60.7)
	2nd year	118 (39.3)	59 (39.3)	59 (39.3)
Field of study	Teacher education programmes	128 (42.7)	64 (42.7)	64 (42.7)
	Other humanities and social sciences	102 (34.0)	50 (33.3)	52 (34.7)
	Natural sciences and technical programmes	70 (23.3)	36 (24.0)	34 (22.6)
Education institution	University 1	60 (20.0)	30 (20.0)	30 (20.0)
	University 2	60 (20.0)	30 (20.0)	30 (20.0)
	University 3	60 (20.0)	30 (20.0)	30 (20.0)
	University 4	60 (20.0)	30 (20.0)	30 (20.0)
	University 5	60 (20.0)	30 (20.0)	30 (20.0)

2.3. Instruments and Measurements

The study used various instruments and methods to measure the results of learning a foreign language, the level of motivation and learning autonomy. A standardized (and previously approved) language test was used to determine the level of foreign language proficiency, which included the following components: 1. vocabulary and grammar (closed and open-ended tasks); 2. reading (understanding texts of varying complexity); 3. listening (if technically possible). The test also included simple tasks for oral and written speech, which were assessed according to unified criteria (rubricated scales). The test was administered twice - before the beginning (pretest) and after the end of the experimental intervention (post-test). For each participant, the following were calculated: the integral score for the test, subscales (vocabulary/grammar, reading, listening).

These indicators were considered as the main dependent variables reflecting learning outcomes.

An important tool was the use of the scale of educational motivation for learning a foreign language. The level of motivation for learning a foreign language was measured using an adapted motivation scale based on modern models of L2 motivation. The questionnaire contained statements grouped into three subscales: intrinsic motivation (interest, satisfaction with the learning process); extrinsic motivation (orientation on grades, certificates, program requirements); amotivation (lack of perceived reasons to learn). Responses were recorded on a Likert scale (from 1 to 5). The internal consistency of the subscales was tested based on Cronbach's α and in this sample was $\alpha = 0.86$ for intrinsic motivation, $\alpha = 0.82$ for extrinsic motivation and $\alpha = 0.80$ for the motivation scale. To assess learning autonomy and self-regulated learning, a questionnaire was used that covered the following aspects: the ability to plan one's own learning (setting goals, planning time and workload); the ability to control task performance, using reflection strategies, and self-assessment. Respondents rated the statements on a Likert scale. The questionnaire was also filled out twice - at the ascertaining and control stages.

A questionnaire on the experience of using mobile applications was created for the participants of the experimental groups, which contained both closed and open questions. It allowed recording: the frequency and duration of using the application (number of sessions per week, approximate working time); types of tasks performed (vocabulary, grammar, dialogues, listening, reading texts); subjective assessment of the usefulness of personalization (availability of adaptive levels, recommendations, feedback); problems and barriers (technical difficulties, task overload, distractions, etc.) (See appendices 5-7).

Besides, 3 mobile applications for learning a foreign language were used in the experiment:

1. Duolingo – an adaptive gamified application, focused primarily on vocabulary and grammar practice.
2. Busuu – an application with clearly structured courses, built according to CEFR levels (A1–B2).
3. LingQ – a content-oriented application, which was based on individualized reading and listening to authentic texts.

The experimental groups worked with different applications. This made it possible to compare different types of personalized mobile solutions. The study identified the following groups of variables:

1. Independent variables: type of learning organization (traditional / using a personalized mobile application); type of mobile application within the experimental groups (Duolingo, Busuu, LingQ).
2. Dependent variables: foreign language results (integral score of the language test and subscales); level of motivation to learn a foreign language (intrinsic, extrinsic motivation, amotivation); indicators of learning autonomy / self-regulated learning (planning, control, reflection).
3. Control variables: initial level of foreign language proficiency (pre-test scores), higher education institution, course of study, field of study, basic experience in using mobile applications and digital technologies.

2.4. Procedure

At the initial stage, the selection and configuration of three mobile applications (Duolingo, Busuu, LingQ) was carried out. These applications were chosen because they are popular in the educational space of Ukraine and have various personalization capabilities. Next, a model for integrating each application into a foreign language course was developed (a list of topics and activities supported by the application, formats of classroom and extracurricular work, assessment methods). Separate instructions were prepared for teachers of experimental groups regarding lesson planning and the volume of tasks in the application.

At the ascertaining stage, all participants (control and experimental groups in five institutions) took a language test that determined the initial level of foreign language proficiency; a scale of learning motivation; a scale of learning autonomy / self-regulation. Additionally, basic information was collected about previous experience using mobile applications for language learning and the general level of digital skills. The results of the pretest were used as baseline values and as a control variable in further analysis.

At the formative stage, which lasted for one semester (12 weeks), the organization of learning differed in the control and experimental groups. In particular, the experimental groups regularly worked with mobile applications (Duolingo, Busuu or LingQ) according to the developed algorithm (on average 3–4 sessions per week for 15–20 minutes). These students also received personalized trajectories: the system automatically adapted the level of difficulty of tasks, the sequence of modules and the repetition of material. In addition, part of the homework was completed through the application. Teachers were also able to track students' progress, adjusting individual goals and the volume of tasks if necessary. At the same time, students from the control group studied according to the traditional course model: using a textbook, workbook, printed and/or standard online materials without advanced personalization. Teachers of all groups adhered to a common thematic plan. This made it possible to minimize the impact of content differences on the results.

After completing the formative stage, all participants re-took: a language test (with comparison of results with the pre-test); a motivation scale; the learning autonomy/self-regulation scale. Students in the experimental groups additionally completed a questionnaire on their experience using mobile applications.

2.5. Data analysis

Data analysis was performed using SPSS 28 statistical software and standard parametric statistical procedures. At the first stage, data completeness and primary descriptive statistics (means, medians, standard deviations, minimum and maximum values, asymmetry and kurtosis indices) were checked. Internal consistency indices were calculated for the motivation and learning autonomy scales. In this sample, the Cronbach's α coefficient was, for example, $\alpha = 0.82$ for the intrinsic motivation subscale, $\alpha = -0.81$ for extrinsic motivation, $\alpha = 0.80$ for amotivation. For the learning autonomy scale, $\alpha = 0.83$.

Before conducting the main analyses, the assumptions of parametric tests and homogeneity of variances (Lieven's criterion) were checked. The equivalence of the control and experimental groups at the start of the experiment was checked using independent t-tests to compare pretest scores on the language test, motivation, and autonomy.

The main analysis was aimed at testing three hypotheses regarding the impact of personalized mobile learning on: (1) foreign language results, (2) motivation, (3) learning autonomy. To assess the overall effectiveness of mobile learning (regardless of the specific application), mixed variance analyses were carried out according to the scheme: the factor "time" – 2 levels (pretest, posttest) – internal factor; the factor "type of learning" – 2 levels (traditional learning / learning using a mobile application) – between-group factor. Such analyses were conducted separately for: the integral score of the language test (and, if necessary, for its subscales); indicators of intrinsic and extrinsic motivation, amotivation; indicators of learning autonomy.

The key interest was the interaction "time × type of learning": a statistically significant interaction with higher gains in the mobile learning groups was interpreted as confirmation of the hypotheses about the effectiveness of personalized mobile applications. For participants in the experimental groups, additional analyses were carried out to compare the effectiveness of the three applications (Duolingo, Busuu, LingQ). The study also used the method of correlation analysis. Pearson correlation coefficients were established between the intensity of application use (frequency of sessions, total working time, number of exercises completed) and gains in language competence, motivation and autonomy. Multivariate linear regression models were also used, in which the dependent variable was the increase in the language test and the predictors: type of learning (traditional / mobile); type of application (Duolingo, Busuu, LingQ).

3. Results and discussion

3.1. Conceptual model of personalized mobile foreign language learning

Uncontrolled input conditions included higher education institutions (five universities), the type of foreign language course, and student characteristics such as initial language proficiency (measured by a pretest), basic digital skills, and prior experience with mobile applications.

The pedagogical course design emphasized the teacher's role in selecting and integrating mobile applications into the learning process. This involved planning how applications support specific topics and language skills, determining which tasks are carried out in the classroom versus in the mobile environment, and defining how results obtained through applications are incorporated back into classroom activities (e.g., discussions, role-playing, and reflection). The teacher's functions included setting learning goals, monitoring student progress, supporting motivation, and guiding students in choosing effective strategies for using the applications.

Mobile applications served as the foundation for personalized learning. In Model 3, different types of personalization were implemented through specific applications: Duolingo provided adaptive practice combined with gamification, offering level-appropriate tasks, short vocabulary and grammar exercises, and motivational features such as points, streaks, and reminders. Busuu followed a structured CEFR-based course design, including initial assessment, individualized learning plans, and interactive mini-lessons with opportunities for feedback. LingQ focused on content-based personalization, allowing learners to select topics, genres, and text complexity levels according to their interests and proficiency.

Students' learning activities in the mobile environment included regular short practice sessions, completion of personalized tasks (with adjusted difficulty, repetition, and recommendations), and receiving immediate feedback on performance (accuracy, errors, progress tracking, and reminders). Reflection was also an essential component, encouraging students to evaluate what strategies and task formats were effective or ineffective.

The model assumes that personalized mobile learning influences both knowledge acquisition and psychological mechanisms. These include intrinsic motivation (interest and enjoyment), extrinsic motivation (grades, certificates, and external requirements), and amotivation (lack of interest or perceived meaning). It also promotes learning autonomy and self-regulation, particularly the ability to plan learning in terms of goals, time management, and priorities.

Learning outcomes were measured through initial indicators such as overall language competence (total test scores and subscales including vocabulary, grammar, reading, and listening), changes in motivation before and after the intervention, and the development of learner autonomy and self-regulation.

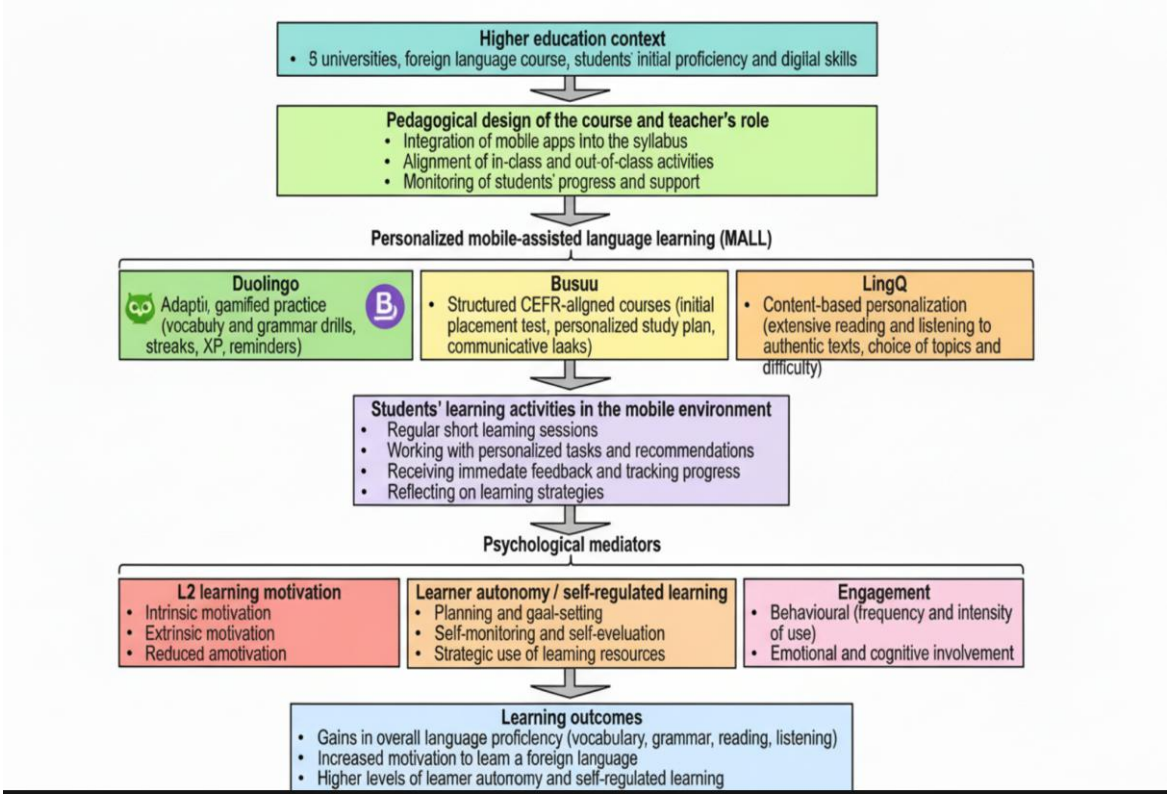

Figure 1. Mobile applications as the core of personalization (Model)

3.2. The impact of personalized mobile learning on foreign language learning outcomes

The basic dependent variable of the study was the results of foreign language acquisition, measured using a standardized language test. The analysis covered the integral score of the test, as well as individual components:

lexical and grammatical skills, reading and listening. To assess the impact of personalized mobile learning, a mixed analysis of variance with repeated measures (mixed ANOVA) was used with the following factors: time (pre-test / post-test) – a within-group factor; type of learning (traditional/personalized mobile) – a between-group factor. A statistically significant interaction of "time × type of learning" for the integral score of the language test was noticeable ($F(1, 298) = 36.42$, $p < 0.001$, partial $\eta^2 = 0.109$). This indicated the existence of different rates of growth of results in the control and experimental groups.

In the control group, a moderate increase in the average test score was observed. This can be interpreted as a natural effect of learning during the semester. At the same time, a higher increase in results was recorded in the experimental group. This indicated an additional effect of the implementation of personalized learning (See Table 2).

Table 2. Dynamics of the integral score of the language test (0–100)

Group	Pre-test M (SD)	Post-test M (SD)	Gain score	t (paired)	p	Cohen's d
Control (n = 150)	61.8 (8.9)	66.1 (9.1)	+4.3	5.21	<0.001	0.42
Experimental (n = 150)	61.1 (9.1)	74.6 (8.7)	+13.5	12.84	<0.001	1.05

Thus, the increase in the integral score in the experimental group was three times higher than in the control group. Separate analysis of the data on the vocabulary and grammar subscales also showed a statistically significant interaction: ($F(1, 298) = 29.18$, $p < 0.001$, partial $\eta^2 = 0.089$). Thus, the increase in the integral score in the experimental group was three times. Therefore, personalized mobile applications, in particular Duolingo and Busuu, which provided the use of adaptive lexical and grammatical exercises, influenced the improvement of this component of language competence. (See Table 3).

Table 3. Vocabulary and grammar test results (0–40)

Group	Pre-test M (SD)	Post-test M (SD)	Gain score	p
Control	24.6 (4.8)	27.2 (4.9)	+2.6	< 0.001
Experimental	24.4 (4.7)	32.1 (4.5)	+7.7	<0.001

At the same time, a significant interaction was also found for reading indicators: ($F(1, 298) = 18.76$, $p < 0.001$, partial $\eta^2 = 0.059$) (See Table 4).

Table 4. Reading test results (0–30)

Group	Pre-test M (SD)	Post-test M (SD)	Gain score	p
Control	18.9 (3.6)	21.1 (3.7)	+2.2	0.002
Experimental	18.7 (3.5)	24.6 (3.3)	+5.9	< 0.001

Therefore, the largest increase in this subscale was observed among students who worked with the LingQ application. This indicated the effectiveness of content-based personalization in developing reading skills. At the same time, the data from the listening test also revealed a significant interaction: ($F(1, 298) = 16.04$, $p < 0.001$, partial $\eta^2 = 0.051$) (See Table 5).

Table 5. Listening test results (0–30)

Group	Pre-test M (SD)	Post-test M (SD)	Gain score	p
Control	18.3 (3.8)	20.0 (3.9)	+1.7	0.011
Experimental	18.0 (3.7)	23.5 (3.6)	+5.5	< 0.001

Therefore, regular work with audio materials in mobile applications (primarily in LingQ and Busuu) has improved listening skills.

3.3. The impact of mobile applications Duolingo, Busuu and LingQ on foreign language learning outcomes

To determine the impact of different types of personalized mobile solutions, a comparison of the effectiveness of three mobile applications that were used in the experimental groups was conducted: Duolingo, Busuu, and LingQ. Each of the applications implemented personalized learning according to different didactic principles.

The analysis used gain scores, calculated as the difference between posttest and pretest indicators. Further analysis was carried out using one-way analysis of variance (ANOVA) with the factor mobile application type (3 levels: Duolingo, Busuu, LingQ). In case of statistically significant effects, Bonferroni post-hoc tests were used. Accordingly, the data from one-way ANOVA indicated significant differences between the three applications in terms of the gain in the integral score of the language test

($F(2, 147) = 8.94$, $p < 0.001$, $\eta^2 = 0.108$) (See Figure 2).

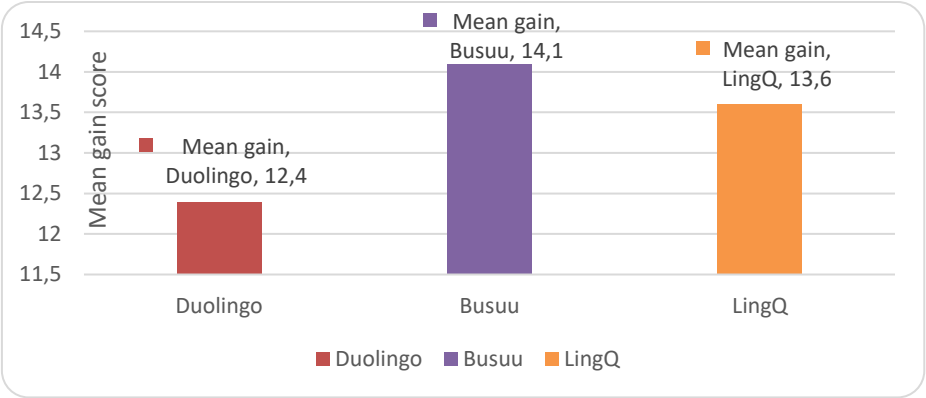

Figure 2. Integral language test gain

Post hoc analysis indicated that the increase in scores in the Busuu group was significantly higher compared to the Duolingo group ($p = 0.004$). The differences between the Busuu and LingQ groups, as well as between LingQ and Duolingo, did not reach statistical significance ($p > 0.05$). Thus, Busuu demonstrated the highest overall effectiveness on the integral indicator of language competence.

The gains on the vocabulary and grammar subscales also had significant between-group differences: ($F(2, 147) = 15.27$, $p < 0.001$, $\eta^2 = 0.172$) (See Fig. 3). Post hoc comparisons also indicated that gains in the Duolingo and Busuu groups were statistically significantly higher than those in the LingQ group ($p < 0.001$). The differences between Duolingo and Busuu did not reach statistical significance ($p = 0.214$).

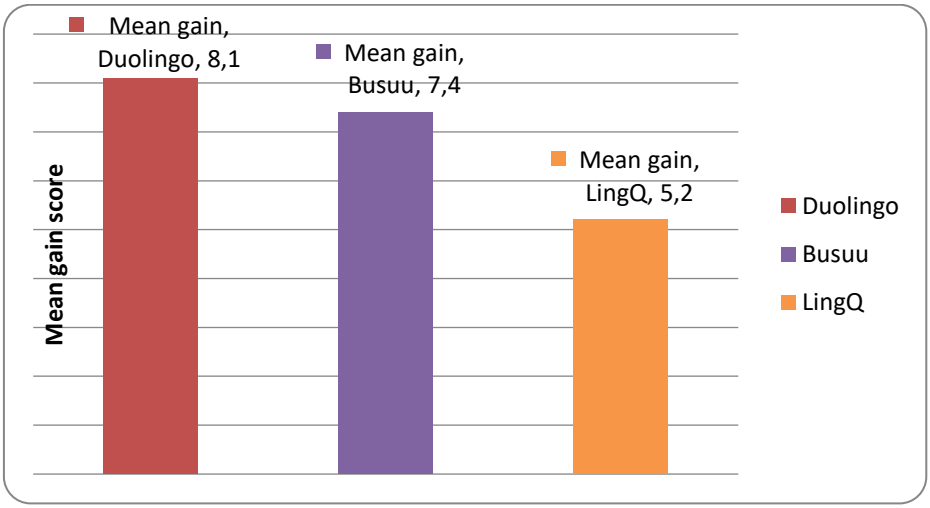

Figure 3. Vocabulary and Grammar gain

Statistically significant differences between applications were also found for gains in the reading subscale ($F(2, 147) = 12.03$, $p < 0.001$, $\eta^2 = 0.141$) (See Figure 4). Post hoc analysis showed that the LingQ group had better gains in reading compared to Duolingo ($p < 0.001$) and Busuu ($p = 0.002$).

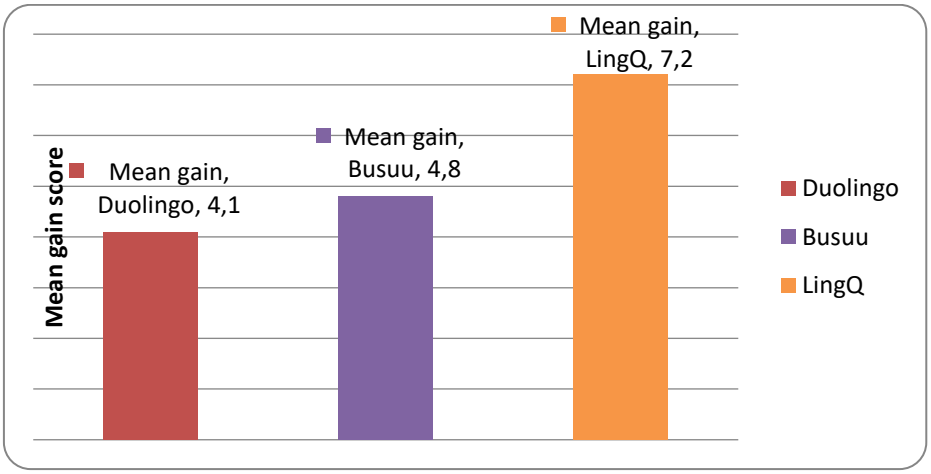

Figure 4. Reading gain

The differences between Duolingo and Busuu were not statistically significant. This confirms the effectiveness of content-based personalization. At the same time, the listening data also had statistically significant between-group differences ($F(2, 147) = 9.68$, $p < 0.001$, $\eta^2 = 0.116$) (See Figure 5).

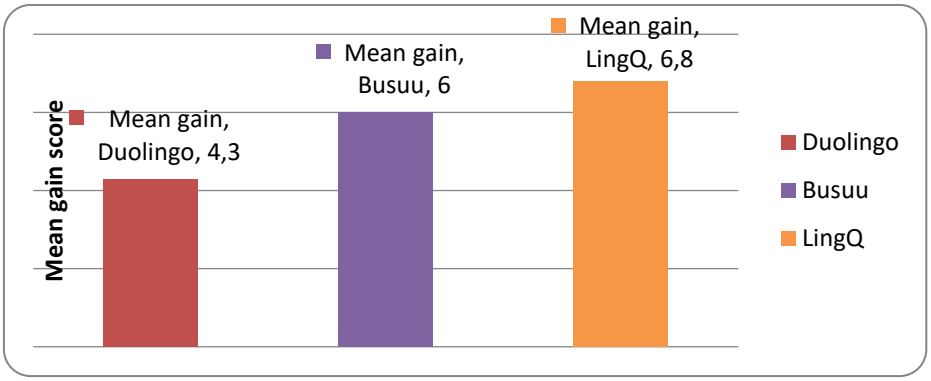

Figure 5. Listening gain

Post hoc tests showed that the gains in the LingQ and Busuu groups were statistically significantly higher than in the Duolingo group ($p < 0.01$). The differences between LingQ and Busuu did not reach statistical significance.

Thus, the comparison of the three mobile applications indicated the different effects of these personalization models on the components of foreign language competence. Duolingo was most effective for the development of lexical and grammatical skills. At the same time, Busuu achieved the highest overall gains in the integral indicator of language competence. Besides, LingQ was effective for the development of reading and listening skills. Fig. 6 presents the overall mean achievement scores (post-test minus pretest) for students who had used different mobile apps.

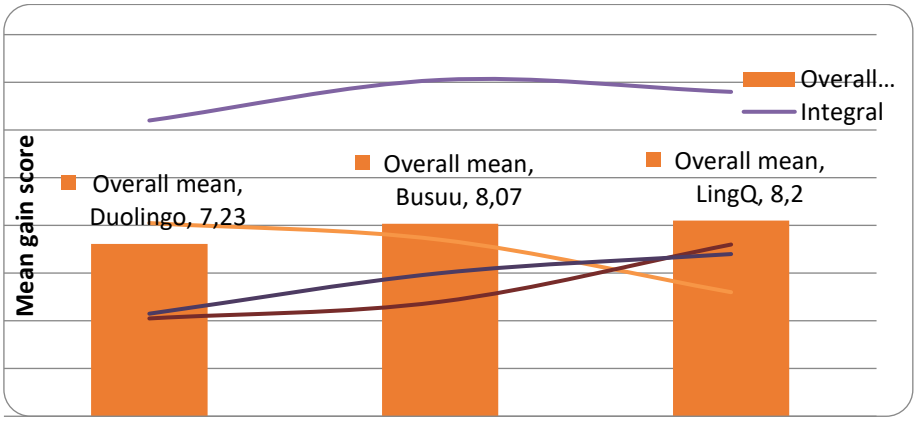

Figure 6. Comparison of overall average learning progress in mobile applications.

3.4. The impact of personalized mobile learning on motivation to learn a foreign language

Hypothesis 1 predicted that the use of personalized mobile applications in the process of learning a foreign language would lead to an increase in the level of learning motivation. Accordingly, the study analyzed changes in the indicators of intrinsic motivation, extrinsic motivation and amotivation, measured before and after the experiment, using a mixed analysis of variance with repeated measures (mixed ANOVA).

At the initial stage of the experiment, no significant differences were found between the control and experimental groups on any of the motivational subscales ($p > 0.05$). However, the results of the mixed ANOVA indicated a significant interaction "time × type of learning" for the indicator of intrinsic motivation

($F(1, 298) = 24.86$, $p < 0.001$, partial $\eta^2 = 0.077$). Therefore, changes in the level of intrinsic motivation over the semester were different in the control and experimental groups (See Table 6).

Table 6. Changes in intrinsic motivation indicators (1–5)

Group	Pre-test M (SD)	Post-test M (SD)	Gain score	p
Control	3.42 (0.63)	3.51 (0.66)	+0.09	0.118
Experimental	3.39 (0.65)	3.92 (0.61)	+0.53	< 0.001

Thus, in the control group, a slight increase in intrinsic motivation was observed. In contrast, in the experimental group, a significant increase in intrinsic motivation was recorded. At the same time, the analysis of extrinsic motivation indicators revealed a statistically significant main effect of time (See Table 7). ($F(1, 298) = 6.14$, $p = 0.014$). However, the interaction "time × type of training" did not reach statistical significance ($F(1, 298) = 2.03$, $p = 0.156$).

Table 7. Changes in extrinsic motivation indicators (1–5)

Group	Pre-test M (SD)	Post-test M (SD)	Gain score
Control	3.68 (0.59)	3.71 (0.61)	+0.03
Experimental	3.70 (0.62)	3.78 (0.60)	+0.08

Therefore, the use of mobile applications did not have a decisive impact on extrinsic motivation, which probably remains more stable and determined by institutional factors (assessment, curriculum requirements). At the same time, a significant interaction "time × type of learning" was found for the amotivation indicator ($F(1, 298) = 19.37$, $p < 0.001$, partial $\eta^2 = 0.061$) (See Table 8).

Table 8. Changes in amotivation indicators (1–5)

Group	Pre-test M (SD)	Post-test M (SD)	Gain score	p
Control	2.11 (0.72)	2.04 (0.75)	−0.07	0.214
Experimental	2.14 (0.70)	1.68 (0.66)	−0.46	< 0.001

Thus, a significant decrease in the level of amotivation was observed in the students of experimental groups. However, in the control group, these changes were not significant.

3.5. The impact of personalized mobile learning on learning autonomy

Hypothesis 2 predicted that students' involvement in personalized mobile learning of a foreign language would contribute to an increase in the level of learning autonomy and self-regulated learning. To this end, changes in learning autonomy indicators measured before and after the experiment were determined using a mixed analysis of variance with repeated measures (mixed ANOVA). At the stage of the ascertaining experiment, statistically significant differences between the control and experimental groups were not found for any of the indicators of learning autonomy. The results of the mixed ANOVA revealed a statistically significant interaction "time × type of learning" for the general index of learning autonomy ($F(1, 298) = 31.58$, $p < 0.001$, partial $\eta^2 = 0.096$). A slight increase in autonomy was noticeable in the control group. On the other hand, a significant increase in the general level of learning autonomy was recorded in the experimental group. For the indicator of planning educational activities, a statistically significant interaction was found ($F(1, 298) = 27.44$, $p < 0.001$, partial $\eta^2 = 0.084$). Thus, regular work with mobile applications that provide goal setting, progress tracking, and planning

of educational sessions influenced the development of planning skills. For the subscale of monitoring the implementation of educational tasks, a statistically significant interaction was also found.

Personalized feedback, instant error indication, and the possibility of repeating tasks influenced the development of self-control and responsibility skills. At the same time, the data indicated that the use of mobile applications with visualization of progress and history of task completion stimulated reflective processes and awareness of one's own educational activities (See Table 9).

Table 9. Changes in learning autonomy and self-regulated learning indicators

Indicator	Group	Pre-test M (SD)	Post-test M (SD)	Gain score	Time × Group interaction
Overall learning autonomy	Control (n = 150)	3.21 (0.58)	3.30 (0.61)	+0.09	
	Experimental (n = 150)	3.19 (0.60)	3.78 (0.57)	+0.59	**$F(1,298)=31.58$, $p<0.001$, $\eta^2=.096$**
Planning of learning activities	Control	3.08 (0.64)	3.17 (0.67)	+0.09	
	Experimental	3.05 (0.66)	3.72 (0.62)	+0.67	**$F(1,298)=27.44$, $p<0.001$, $\eta^2=.084$**
Monitoring and self-control	Control	3.25 (0.59)	3.33 (0.61)	+0.08	
	Experimental	3.22 (0.61)	3.74 (0.58)	+0.52	**$F(1,298)=22.19$, $p<0.001$, $\eta^2=.069$**
Reflection and self-evaluation	Control	3.31 (0.62)	3.38 (0.65)	+0.07	
	Experimental	3.29 (0.63)	3.69 (0.60)		

3.6. Discussion

The purpose of this study was to determine the effectiveness of using personalized mobile applications in the process of learning a foreign language. The results obtained made it possible to determine the impact of mobile personalized learning in accordance with the formulated research tasks.

The first research task was aimed at analyzing the impact of personalized mobile learning on the overall results of mastering a foreign language. The data obtained indicated that students in the experimental groups had higher increases in the integral score of the language test compared to the control group. This indicated that the formation of personalization of the educational process based on the use of mobile applications has a significant impact on the additional educational effect. This effect, as proven in other works [26], can exceed the natural progress caused by traditional learning during the semester. Accordingly, the results obtained were consistent with the data of other authors who indicated the role of adaptive technologies in increasing the effectiveness of learning material. In particular, the authors indicated that individualization of the pace, complexity and sequence of tasks allows for better coordination of educational requirements with students' capabilities [27], [28]. As a result, this can have a positive effect on overall learning outcomes.

The second research task was aimed at determining the impact of mobile personalized learning on individual components of foreign language competence. The results obtained showed that personalized mobile applications have different effects on the development of these components. A significant increase in lexical and grammatical indicators in students of the experimental groups confirms the effectiveness of applications focused on training exercises. These results are consistent with studies that indicate the importance of regular repetition, instant feedback, and automatic adjustment of task complexity for the formation of language skills [29], [30].

At the same time, the results of reading and listening indicated the advantages of content-oriented personalization. This type of personalization is based on working with authentic texts and audio materials. Similar conclusions can be traced in the works of other authors [31], [32]. Modern scientists have indicated that immersion in a content-rich language environment allows the development of receptive language skills [33].

The next task was aimed at comparing the effectiveness of different types of personalized mobile applications. The results of the analysis showed that each of the applications had its own didactic advantages. For example, the application known in the educational space, Duolingo, was effective for the development of lexical and

grammatical skills. At the same time, the Busuu application had the highest overall gains in the integral indicator of language competence. However, LingQ was especially effective for the development of reading and listening skills. Other scientists also indicated that the effectiveness of mobile learning largely depends on the fact of using the application and on the type of personalization implemented in it [34], [35].

The last research task concerned the analysis of the impact of personalized mobile learning on students' motivation and learning autonomy. The results of the study confirmed the hypothesis of the positive impact of mobile applications on intrinsic motivation to learn a foreign language. In particular, it was indicated that the growth of interest and satisfaction from the learning process is associated with interactivity, instant feedback and the ability to see one's own progress.

However, the noticeable lack of changes in the level of extrinsic motivation indicated its relative stability, which depends on institutional factors. Such opinions are generally consistent with the results of previous studies in the field of educational didactics [36, 37]. At the same time, the data from the study confirmed the hypothesis of its growth in the experimental groups [38]. The most pronounced changes were observed in the indicators of planning educational activities, self-control and reflection. Thus, as shown in other works [39], mobile learning improves educational outcomes and contributes to the formation of key skills of self-regulated learning [40], [41].

Thus, the results obtained complemented modern theoretical approaches to mobile and adaptive learning and indicated the differentiated impact of different personalization models on individual components of language competence [42], [43]. At the same time, the practical significance of the study lies in the possibility of using its results in the process of designing foreign language courses in higher education institutions. The data obtained should be used by teachers for a well-founded choice of mobile applications depending on the educational goals (development of lexical and grammatical skills, reading or listening). However, studying has its limitations. It was conducted in a quasi-experimental design. This, in turn, limited the possibility of full control of all external factors. Secondly, the duration of the experiment was limited to one semester. Thus, the study does not draw conclusions about the long-term impact of personalized mobile learning. Therefore, the following analysis should be directed to studying the long-term effects of mobile personalized learning and expanding the sample of applications.

4. Conclusions

Therefore, personalized mobile learning has had a practically significant impact on the results of studying a foreign language by students of higher education institutions. The use of mobile applications as personalization tools made it possible to obtain higher rates of growth in language competence compared to the traditional organization of the educational process.

Analysis of the integral indicator of language training indicated an increase in results in the experimental groups, which was significantly higher than in the control groups. This indicated an additional effect of the personalized approach. The study of individual components of foreign language competence indicated that personalized mobile learning had a positive effect on all analyzed components - lexical and grammatical skills, reading and listening, however, the nature and strength of this impact was differential. Duolingo and Busuu turned out to be the most effective for the development of lexical and grammatical skills. as LingQ showed advantages in the formation of reading and listening skills. In addition, the data indicated that the use of personalized mobile applications allows to increase intrinsic motivation to learn a foreign language and reduce the level of amotivation. At the same time, the impact on extrinsic motivation was limited.

This indicated its dependence on institutional and programmatic factors. Thus, personalized mobile applications have become an important tool for improving the quality of foreign language training, if they are purposefully integrated into the educational process.

Declaration of competing interest

The authors declare that they have no any known financial or non-financial competing interests in any material discussed in this paper.

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Author contribution

The contribution to the paper is as follows: Oksana Boiko, Kateryna Shykhnenko: study conception and design; Kateryna Shykhnenko, Olga Ustymenko: data collection; Nataliia Khmil, Dmytro Marieiev. Nataliia Khmil: analysis and interpretation of results; Oksana Boiko, Dmytro Marieiev: draft preparation. All authors approved the final version of the manuscript.

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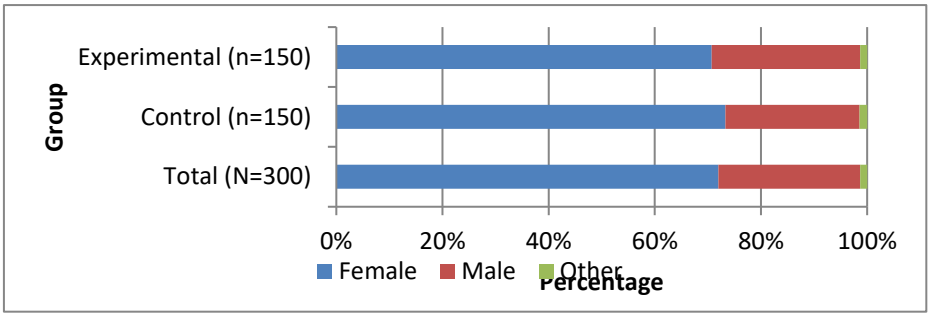
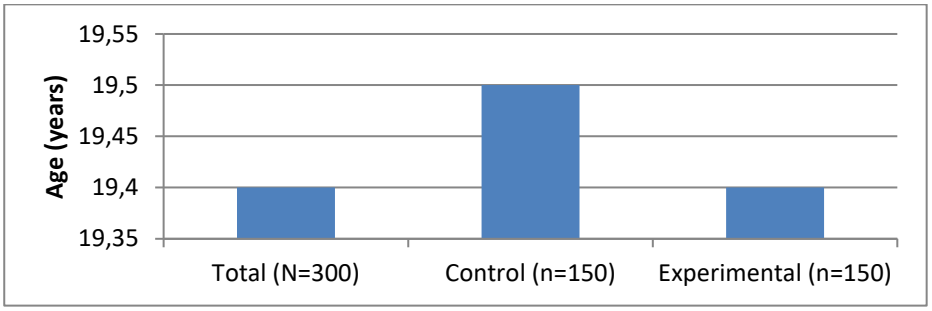
Appendices

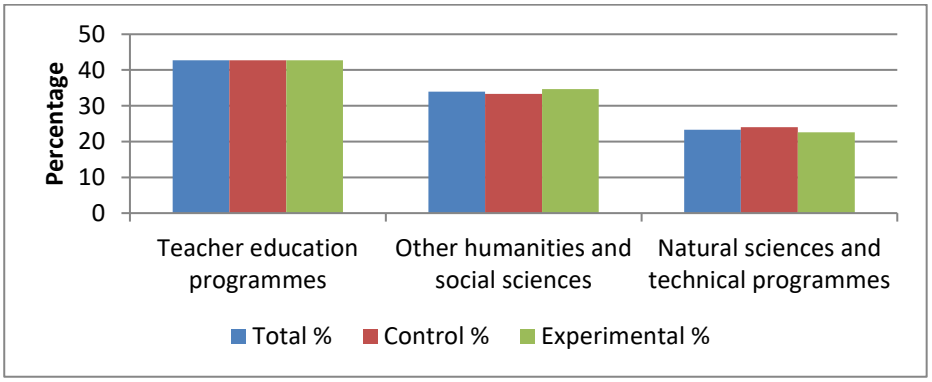
Appendix 1. Gender Distribution of Participants (in %)



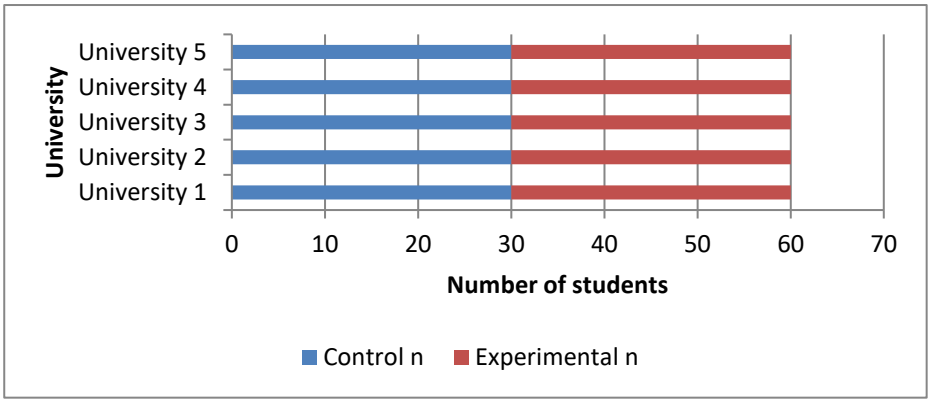
Appendix 2. Age of Participants



Appendix 3. Field of Study



Appendix 4. Higher Education Institution



Appendix 5. Structure of the standardized language test

A1. Lexical and grammatical component (0–40 points)
Included closed and open tasks aimed at testing:
knowledge of basic and thematic vocabulary and various grammatical constructions
A2. Reading (0–30 points)
Tasks for understanding written texts of varying difficulty
general understanding of the content;
the ability to find specific information;
interpretation of the content of the text.
A3. Listening (0–30 points)
Tasks for listening to short dialogues and monologues.
The integral score of the language test (0–100) was calculated as the sum of the results for all components.

Appendix 6. Scale of motivation for learning a foreign language

The questionnaire included three subscales:
B1. Internal motivation ($\alpha = 0.86$)
"I am interested in learning a foreign language."
"I enjoy the process of learning a language."
B2. Extrinsic motivation ($\alpha = 0.82$)
"I learn a foreign language to get good grades."
"Knowledge of a foreign language is a requirement of the educational program."
B3. Amotivation ($\alpha = 0.80$)
"I do not see any real benefit in learning a foreign language."
"It is difficult for me to understand why I need a foreign language."
The assessment was carried out on a 5-point Likert scale (1 – completely disagree, 5 – completely agree).

Appendix 7. Scale of learning autonomy and self-regulated learning

C1. Planning of learning activities ($\alpha = 0.83$)
"I plan time in advance for learning a foreign language."
"I set clear learning goals for myself."
C2. Control and self-control ($\alpha = 0.81$)
"I monitor how well I am doing my learning tasks."
"I try to correct my mistakes on my own."
C3. Reflection and self-evaluation ($\alpha = 0.79$)
"I analyze my successes and difficulties in learning the language."
"I can evaluate my own progress in learning."