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The effectiveness of speech technologies in building students' linguistic competence during practical classes

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A eficácia das tecnologias de fala na construção da competência linguística dos alunos durante as aulas práticas

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La efectividad de las tecnologías del habla en la construcción de la competencia lingüística de los estudiantes durante las clases prácticas

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Abstract: *Modern language education requires the use of innovative approaches making the educational process more effective. The aim of the article is to analyse the effectiveness of speech technologies (neuro-linguistic programming, NLP) in the development of students' linguistic competence during practical classes. The research employed the following methods: survey, testing, methods of mathematical statistics. The results showed the effectiveness of the course, as evidenced by a significant improvement in performance in both groups. Group 1 demonstrated a mean pre-test score of approximately 76.04, which increased to 80.25 at post-test, indicating moderate improvement. Group 2 started with a lower mean pre-test score of around 73.55. However, they showed more significant improvement, achieving an average test score of 80.21. The assessment of psycholinguistic factors among the participants revealed a positive effect on motivation, cognitive processes and language processing mechanisms. The algorithm gave satisfactory results in identifying influential elements of cognitive processing, despite the differences associated with individual characteristics among students. The error range between the analytical value obtained using a traditional NLP algorithm and the actual value varied from 0.008 to 0.012. Research prospects include examining the long-term effects of speech technology on students' linguistic competence.*

Keywords: *Linguistic competence. Neurolinguistic programming. Practical training. Speech. Technologies.*

Resumo: O ensino de línguas moderno requer o uso de abordagens inovadoras que tornem o processo educativo mais eficaz. O objetivo do artigo é analisar a eficácia das tecnologias da fala (programação neurolinguística, PNL) no desenvolvimento da competência linguística dos alunos durante as aulas práticas. A pesquisa empregou os seguintes métodos: levantamento, testes, métodos de estatística matemática. Os resultados mostraram a eficácia do curso, evidenciada por uma melhoria significativa no desempenho em ambos os grupos. O Grupo 1 demonstrou pontuação média no pré-teste de aproximadamente 76,04, que aumentou para 80,25 no pós-teste, indicando melhora moderada. O Grupo 2 começou com uma pontuação

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média inferior no pré-teste, em torno de 73,55. Porém, apresentaram melhora mais significativa, alcançando nota média no teste de 80,21. A avaliação dos fatores psicolinguísticos entre os participantes revelou um efeito positivo na motivação, nos processos cognitivos e nos mecanismos de processamento da linguagem. O algoritmo apresentou resultados satisfatórios na identificação de elementos influentes no processamento cognitivo, apesar das diferenças associadas às características individuais entre os alunos. A faixa de erro entre o valor analítico obtido por meio de um algoritmo de PNL tradicional e o valor real variou de 0,008 a 0,012.

Palavras-chave: Competência linguística. Discurso. Programação neurolinguística. Tecnologias. Treino prático.

Resumen: *El objetivo del artículo es analizar la eficacia de las tecnologías del habla (programación neurolingüística, PNL) en el desarrollo de la competencia lingüística de los estudiantes durante las clases prácticas. La investigación empleó los siguientes métodos: encuesta, pruebas, métodos de estadística matemática. Los resultados mostraron la efectividad del curso, como lo demuestra una mejora significativa en el rendimiento en ambos grupos. El grupo 1 demostró una puntuación media previa a la prueba de aproximadamente 76,04, que aumentó a 80,25 en la prueba posterior, lo que indica una mejora moderada. El grupo 2 comenzó con una puntuación media previa a la prueba más baja, de alrededor de 73,55. Sin embargo, mostraron una mejora más significativa, logrando una puntuación promedio en la prueba de 80,21. La evaluación de los factores psicolingüísticos entre los participantes reveló un efecto positivo sobre la motivación, los procesos cognitivos y los mecanismos de procesamiento del lenguaje. El algoritmo dio resultados satisfactorios en la identificación de elementos influyentes del procesamiento cognitivo, a pesar de las diferencias asociadas con las características individuales entre los estudiantes. El rango de error entre el valor analítico obtenido utilizando un algoritmo de PNL tradicional y el valor real varió de 0,008 a 0,012.*

Palabras-chave: *Competencia linguistica. Discurso. Entrenamiento practico. Programación neurolingüistica. Tecnologías.*

1 INTRODUCTION

Language learning is a complex cognitive process that involves the development of various competencies, including auditory perception and speech. The development of auditory and language competencies is closely related to neural network technologies (Geng, 2021; Chen, 2021). They play a key role in the development of advanced systems that can understand and process auditory signals, recognize speech patterns, and generate human-like speech output (Yin, 2020). Neural network technologies have gained widespread popularity in various fields, including language processing, image recognition, and predictive analytics (Dong, Tsai, 2021). They revolutionized the field of language learning by offering innovative teaching approaches (Hui, Aiyuan, 2021).

Neural network technologies are a type of artificial intelligence (AI), which aims to imitate the structure and functions of the human brain for information processing and learning (LI, 2021). They consist of interconnected nodes or “neurons” organized in layers, analysing complex data. Neural networks are trained on large data sets to recognize patterns, identify relationships, and make data-based predictions. In the context of language learning, neural networks are used to improve speech recognition, language translation, and personalized learning (Liu, 2023).

The development of deep learning and machine learning technologies based on neural networks has become the main driving force behind the automation of work over knowledge (Lauriola, Lavelli, Aiolli, 2022). These technologies have revolutionized various industries by automating tasks that were previously considered to require human intelligence (WANG, 2023). The psycholinguistic aspect of using neural network technologies in language learning emphasizes the importance of accounting for cognitive processes (Chernovaty, Kovalchuk, 2021).

The aim of the research is to study the effectiveness of the integration of natural language processing (NLP) technologies into the English learning programme aimed at the development of listening and speaking competencies.

Research objectives: a) Develop a model of a programme for learning English based on

NLP applications and test its effectiveness; b) Analyse their influence on the development of students' listening and speaking skills; c) Study the impact of the experiment on psycholinguistic factors: motivation, cognitive processes, and language processing mechanisms.

2 LITERATURE REVIEW

The continuous development of computer technology entails constantly evolvement of AI algorithms, and constant improvement of the accuracy of computer classification. Most studies focus on the mathematical analysis, as an artificial neural network is a mathematical model of distributed parallel information processing (Mijwel, 2021; He, 2021).

Research has shown that these systems enable machines to interpret and respond to spoken language, expanding communication capabilities and enabling more natural interactions between humans and computers (Chen, 2021; Zhao, Li, Feng, 2022). Virtual tutors, speech recognition exercises, and speaking practice tools were designed to create a dynamic and interactive learning environment (Zhang, 2023).

One study demonstrated how deep learning algorithms can analyse large data sets (Wang, 2020). Research has shown that these interfaces allow users to interact with computers and devices using natural forms of communication such as language commands and hand gestures (GENG, 2021).

In view of the peculiarities of the English language, one study experimentally designed and developed word learning software (Songkram, Chootongchai, 2022). AI based on a cloud platform is one of the current research issues. The large data processing capabilities of the cloud platform were used to introduce AI translation (Liu, 2021).

The main problem of psycholinguistic research is to study the course of various mental processes that occur in the speaker's brain, which lead to the articulation of speech sounds (Lumentut, Lengkoan, 2021). According to Levelt's sequential model, the pronunciation of words involves several consecutive mental processes with different localization in the brain (ROGTI, 2024). So, psycholinguistic research has shown that language perception involves the interpretation of auditory and visual information, as well as the integration of speech signals with contextual information (Minavandchal, Salimi, 2021).

There is a need for further research into speech technologies, as they still have a number of shortcomings that may have a negative impact on language learning. Implementation of neural network-based language learning systems requires technical expertise and computing resources that may not be available to educators and institutions with limited budgets or technical capabilities (Chang, 2021).

3 METHODS AND MATERIALS

3.1 RESEARCH DESIGN

Empirical research was conducted in 4 stages:

> *The first stage involved application selection and experiment design. This provided for determining learning outcomes, selecting appropriate learning materials and resources, and organizing content into sequential units or modules.*
> *The second stage was the selection of the pedagogical approach and teaching methods that will be used in the language course (choice of learning strategies, methods and activities in the classroom that promote active participation, interaction and meaningful use of language among students).*

The third stage was the delivery of training students according to the developed programme. Assessment methods were then developed to measure student progress, knowledge levels, and achievement of learning outcomes. The evaluation process can be divided into three stages:

> *– first — listening to the test voice;*
> *– second — the test voice is compared with the reference voice, the differences between them at all levels are revealed;*
> *– third — the differences of each level are*

summarized and the overall assessment of the test language is given. Such assessment was carried out during pre- and post-tests.

The *fourth stage* involved data analysis.

The two applications were chosen to meet the research objectives and target students' listening and speaking competencies. Both programmes use NLP.

Speechace, an online platform that uses neural network models to assess and improve spoken English, was used for speaking practice. It is a speaking practice tool that enables users to record their own English sentences, which are then analysed for errors in pronunciation, stress, and intonation (Appendix 1). The application consists of several levels, which are divided into lessons (Appendix 2).

The second programme, Rosetta Stone, is an immersive language learning platform. The application's main focus is on vocabulary, grammar and speaking, but it also offers features that can help to improve listening skills. The programme provides interactive lessons that make extensive use of audio components (Appendix 3).

The course was developed on the basis of the capabilities of the selected programmes. The students took this course to evaluate its effectiveness in developing listening and speaking skills. The training took place through practical interactive classes, practical exercises and immersive experiences provided by NLP applications. The course model is presented in Appendix 4.

3.2 SAMPLE

The empirical study involved 180 students aged 16 to 26 majoring in English Philology and Translation who studied at Kyiv National Linguistic University. They were randomly selected from all first- and second-year undergraduate students. The participants were invited by e-mail, however, 180 consent responses were received out of 300 students. Those students who did not give their consent to participate were excluded from the study. This sample size is explained by the goal to ensure a sufficient statistical significance and reliability of the results, as well as the opportunity to obtain representative data to generalize the conclusions. Only first-year and second-year students were selected for the experiment, as they were at the initial stage of their studies. The introduction of neural network at the beginning of students' studies provides support in language learning. Observing the results of such students, the study could evaluate the effectiveness of neural network technologies in the development of listening and speaking competencies from the very beginning of their foreign language learning experience. Sampling criteria: level of language proficiency (beginner, intermediate, advanced), major, year of study, age. The sample included both students with experience using speech technologies and those who had not used them before. The choice of only one educational institution for conducting the study is explained by the need to ensure the homogeneity of the educational environment and focus on the specifics of speech technologies in the context of intensive language learning. This avoids the variability associated with different educational approaches and programmes existing in different institutions. The training was conducted by 2 teachers of the Linguistic University. Students were divided into two groups (90 participants each) to optimize work with two teachers in small groups.

3.3 RESEARCH METHODS

The research methodology is based on the development and testing of the effectiveness of neural network technologies in language learning. A mixed-methods approach was used for data analysis, combining statistical data analysis with qualitative interviews and testing. This made it possible to determine the psycholinguistic factors (cognitive processes and language processing mechanisms) involved in learning English. This approach contributed to a comprehensive understanding of the impact of neural network technologies on the development of auditory and speech competencies.

One of the methods was a two-part test designed to assess students' listening and speak-

ing skills. The first part included listening, the tasks for which were selected from Oxford Online English (https://www.oxfordonlineenglish.com/english-level-test/listening). The second part evaluated the speaking skills, pronunciation accuracy, intonation and speaking speed of the participants in the classroom. For this purpose, students were offered to present one of the randomly distributed topics (Appendix 5). The students were limited in time (15 minutes per answer) and their answers were recorded on a voice recorder. The teachers evaluated the participants with two different grades for each part of the test.

A structured survey was also developed to collect information from participants about their experience using speech technologies, which provided results to identify psycholinguistic factors in the context of the proposed learning model (Appendix 6). It consisted of sections to assess motivation, cognitive processes, language processing mechanisms and general feedback. The participants were asked to rate the statements on a scale from 1 to 5, where 1 means "strongly disagree" and 5 means "strongly agree".

3.4 INSTRUMENTS

Test reliability was verified using Cronbach's alpha. Cronbach's alpha values in the pre- and post-test were 0.88 and 0.90, respectively, suggesting acceptable internal consistency.

The data on the performance of language learning platforms based on neural networks were analysed using statistical methods (t-test of independent samples). Correlation analysis compared the means of two independent groups to determine whether there was a statistically significant difference between them. The Pearson correlation coefficient included a comparison of the mean post-test scores in Group 1 and Group 2 to determine whether the difference in improvement was statistically significant at a certain level of confidence (e.g., $p<0.05$). The error range between the analytical value obtained using the traditional NLP algorithm and the actual value was also calculated.

4 RESULTS

Students' listening and speaking skills were assessed before and after the course. The results showed that group 1 demonstrated a mean pre-test score of approximately 76.04, which increased to 80.25 at the post-test, indicating moderate improvement (Table 1).

Table 1- Results of data before and after the test

Group	Number of participants	Pre-test average scores	Post-test average scores	Rate of increase
1	90	76.0417	80.25	5.53 %
2	90	73.5517	80.2069	9.05%

Source: Developed by the author on the basis of the data collected on the participants in the experiment (2024).

The rate of increase in Group 1 scores was calculated to be approximately 5.53%. In contrast, Group 2 started with a lower mean pre-test score of around 73.55. However, they showed more significant improvement, achieving an average test score of 80.21. The rate of increase in scores for Group 2 was significantly higher at approximately 9.05%. These results suggest that both groups experienced improvements in their mean scores after the experiment. However, Group 2 showed a greater increase in scores compared to Group 1, indicating that the experiment was effective for this group.

The critical value for a two-tailed test with a significance level (α) of 0.05 and 178 degrees of freedom is approximately ±1.972 (obtained from a t-distribution table). The null hypothesis was rejected as the absolute value of the calculated t-test ($|t|=9.129$) ex-

ceeds the critical value (1.972). This means that there is a statistically significant difference between the improvement in scores in Group 1 and Group 2. So, the intervention had a significantly different effect on the two groups.

The results of the assessment of psycholinguistic factors according to 4 parameters showed the following data (Table 2):

Psycholinguistic Aspect	Average Score	Participants
Motivation		
Continued motivation to learn English	4.3	155
Enhanced motivation due to NLP applications	4.4	160
Importance of English improvement for personal/professional goals	4.3	150
Cognitive Processes		
Improved ability to understand and analyse complex language structures	4.2	145
Improved confidence в remembering and recalling English vocabulary/ grammar	4.3	165
Course activities challenged critical thinking/problem-solving in English	4.0	140
Language Processing Mechanisms		
Improved pronunciation and speaking fluency with NLP applications	4.2	155
Enhanced listening comprehension skills with NLP applications	4.1	150
Better English grammar and syntax with NLP applications	4.0	140
Improved acquisition and retention with NLP applications	4.1	145
Overall Feedback		
Beneficial course materials and activities	4.2	155
Encountered challenges hindering learning progress	3.8	130
Suggestions for enhancing future iterations of the course	4.2	150

Table 2 - Survey results (assessment of psycholinguistic aspects)

Source: developed by the author on the basis of the data collected on the participants in the experiment (2024).

Motivation: the participants generally expressed a high level of motivation to continue learning English after the experiment. Mean ratings for motivational statements ranged from 4.2 to 4.5, indicating a strong positive response.

Cognitive processes: the participants reported improvements in cognitive processes related to language learning, although responses varied slightly. Average scores of cognitive processes ranged from 4.0 to 4.4.

Language processing mechanisms: the responses regarding the language processing mechanisms indicate a positive experience of using NLP applications in the course. Average grades ranged from 4.0 to 4.3. A total of 155 participants felt that NLP applications improved their pronunciation and speaking speed, resulting in an average rating of 4.3. Overall, 150 participants agreed that NLP applications improved their listening comprehension skills with an average score of 4.2.

Overall feedback: the participants provided constructive feedback on the overall course experience, indicating both strengths and areas for improvement. Average scores ranged from 3.8 to 4.3.

The data show that the traditional neural network algorithm was effective in analysing the cognitive processing factors of the survey data. The algorithm gave satisfactory results in identifying influential elements of cognitive processing, despite the differences associated with students' individual characteristics. The error range between the analytical value obtained by the traditional NLP algorithm and

the actual value varied from 0.008 to 0.012. This means that the predictions of the algorithm exactly correspond to the actual values of cognitive processing factors with minimal error. The smallest range of errors indicates a higher level of accuracy of the algorithm's predictions. The results show that an NLP-based experience effectively promoted the development of English listening and speaking competencies, emphasizing the potential of technology-based approaches to language learning in education.

5 DISCUSSION

Neural networks are experiencing a new surge of innovation because of the advances in education technology. This progress has led to significant development in speech recognition technology, which continues to evolve every day (Saletta, 2019). The results emphasize the importance of incorporating NLP into language learning processes. The results of our study also emphasize the importance of using NLP and demonstrate their potential for further improvement based on student feedback, which correlates with Saletta's findings about the importance of continuous development and adaptation of speech technologies.

Another study determined the individual neurophysiological mechanisms of students in the process of perceiving educational information, and cases of students' deviant behaviour were identified by reconstructing their verbal and non-verbal behaviour (Bovolenta, Marsden, 2023). Our research also focuses on individual aspects of students' perception of educational information.

Earlier study builds an intelligent English language learning system based on an improved neural network with regard to the needs of intelligent English language learning and teaching (Khan, Abid, Abid, 2020). In our study, the model included a course aimed at improving listening and speaking skills in English through interactive classes and NLP applications integrated into the programme.

The results of another study show that a system built using the audio-visual fusion method based on the Convolutional Neural Network (CNN) can achieve significant performance improvement, and the recognition error rate is relatively reduced by about 15% (Zhang, Zhang, Politzer-Ahles, Pan, Huang, Wang, Peng, Zeng, 2022). A similar study uses a recurrent neural network and a convolutional neural network to comprehensively recognize English tone and tone colour in order to accurately teach English culture and language, and explores the optimal number of layers and neural nodes when the recognition accuracy is the highest (Le Glaz, Haralambous, Kim-Dufor, Lenca, Billot, Ryan, Marsh, Devylder, Walter, Berrouiguet, Lemey 2021). In our study, the analysis of cognitive processing factors using traditional neural network algorithms yielded accurate predictions with minimal error, indicating the effectiveness of the algorithm in assessing key elements related to language learning. The obtained results confirm the achievement of the determined aim and set objectives of the research. It was proved that learning English based on NLP applications is highly effective in developing students' listening and speaking skills and has a positive effect on psycholinguistic factors: motivation, cognitive processes, and language processing mechanisms. The obtained results can be used to integrate NLP into the curricula of linguistic universities and other educational institutions, improving the quality of language education through the introduction of adaptive and individualized teaching methods.

6 CONCLUSIONS

Natural language processing technologies are one of the most promising tools in the field of language learning. The use of NLP technologies makes it possible to create more adaptive, individualized and effective teaching methods that meet the students' modern needs and take into account various aspects of their language competences. The results showed that both groups improved, with Group 2 showing a higher level of improvement compared to Group 1. This suggests that the intervention had a more pronounced effect on Group 2, in-

dicating its effectiveness in improving language skills. The results of the survey show positive responses from the participants, indicating an increase in motivation to learn English, an improvement in cognitive processes related to language learning, a positive experience of using NLP applications, and constructive feedback about the course experience. The significance of the research is the fact that this set of neurolinguistic techniques can be used to deactivate the students' psychocognitive abilities and improve their professional competence.

6.1 RESEARCH LIMITATIONS

Different teachers may have biases about the same test language because of the differences in the knowledge structure and experience of language experts. Furthermore, the evaluation given by the same expert with the same voice in different states can also be different.

6.2 RESEARCH PROSPECTS

a) Analysis of the long-term impact of NLP technologies: studying how the use of natural language processing technologies affects students' linguistic competence in the long run.

b) Experimental studies in different educational contexts: conducting experimental studies in different types of educational institutions to evaluate the universality and effectiveness of NLP technologies in different educational contexts.

6.3 RECOMMENDATIONS

It is recommended to actively introduce NLP technologies into educational programmes to more effectively build students' linguistic competence. Teachers should use a variety of communication technologies, including interactive programmes, automated assessment systems, and virtual simulations, to create a dynamic and motivating learning environment. It is also important to conduct regular monitoring and evaluation of the effectiveness of implemented technologies, collecting feedback from students for continuous improvement of the educational process.

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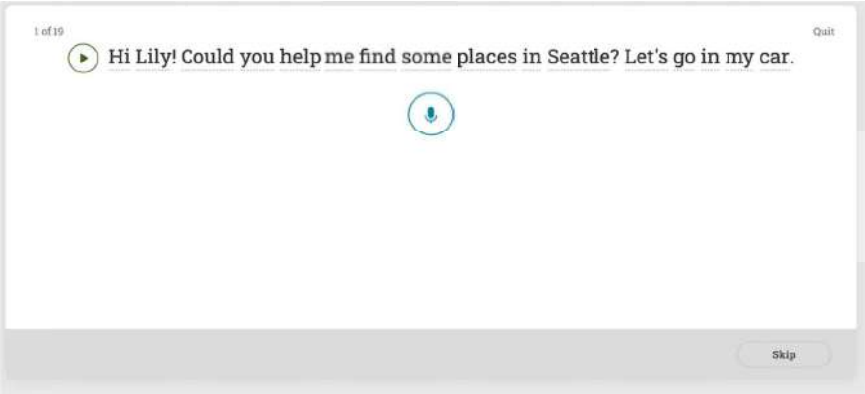
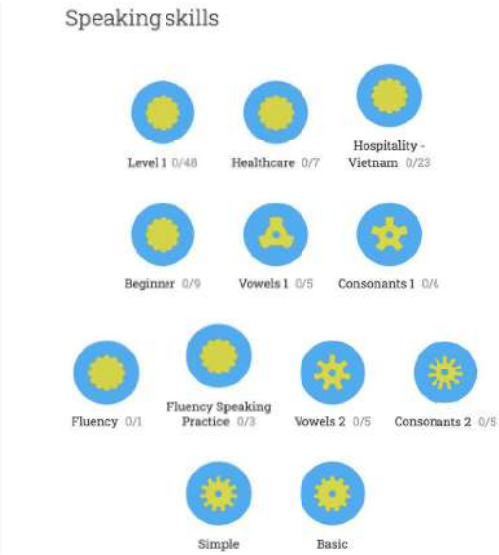
APPENDIX 1

An example of the stak from Speechace



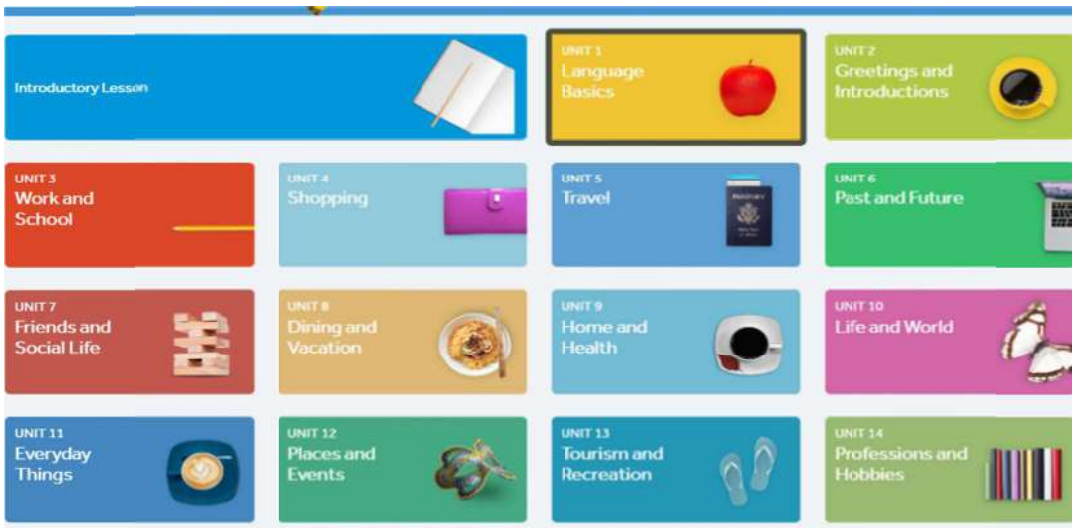
PENDIX 2

The structure of lessons in Speechace



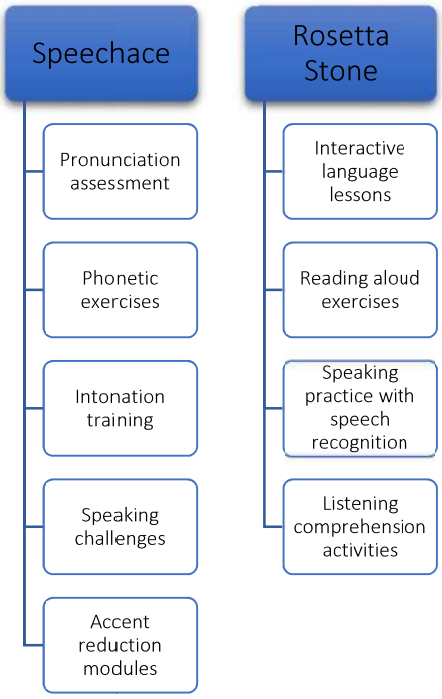
APPENDIX 3

The structure of lessons in Rosetta Stone



APPENDIX 4

Course scheme using NLP applications



APPENDIX 5

Topics

1. Your hobbies and interests
2. Studying
3. Work
4. Your home, neighbourhood and country
5. Technology and the Internet
6. Sports and leisure activities
7. Food and healthy living
8. Family
9. Your childhood
10. Shopping and fashion
11. Daily routines
12. Entertainment (music, TV and film)

APPENDIX 6

Survey

1. Motivation:

a. After participating in this course, I feel motivated to continue learning English.

b. The NLP programmes used in the course enhanced my motivation to learn English.

c. I believe that improving my English language skills is important for my personal and/or professional goals.

2. Cognitive processes:

a. Taking an English course has improved my ability to understand and analyse complex language structures.

b. After completing the course, I feel more confident in my ability to memorize and recall English vocabulary and grammar rules.

c. The lessons and exercises of the course made me think critically and solve problems in English.

3. Language processing mechanisms:

a. The NLP programmes used in the course improved my pronunciation and speaking speed.

b. I have found that NLP programmes have improved my listening comprehension skills.

c. NLP programmes helped me to better understand English grammar and syntax.

d. I have noticed an increase in my vocabulary and retention thanks to NLP applications.

4. General feedback:

a. The course materials and activities were useful for my language learning.

b. During the course, I encountered problems that hindered my academic progress.