Correction of Sensory Integration as a Prerequisite for Successful Mastering a Foreign Language

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Abstract: This article examines the education of learners with sensory impairments in an inclusive environment, focusing on foreign language learning amid wartime and social challenges. It highlights the need for effective instructional strategies that address sensory processing difficulties across visual, auditory, tactile, proprioceptive, and vestibular domains. Some learners also displayed characteristics associated with the autism spectrum. The study aimed to identify relevant theoretical frameworks and develop methods to mitigate educational losses. An experimental evaluation of a multisensory VR environment was conducted with students in grades 5-9 in Zhytomyr, Ukraine. Methods included observation, adapted Foreign Language Classroom Anxiety Scale (FLCAS) questionnaires adapted for learners with special educational needs (SEN) to assess anxiety, vocabulary testing, and a pedagogical experiment. The performance of students using a VR-based platform was compared with those taught through traditional methods. Results indicate that VR integration helps compensate for sensory deficits, improves communicative competence, boosts motivation, and reduces anxiety. The study contributes practical exercises for VR-based instruction and expands understanding of multisensory technologies in inclusive language education.

1 INTRODUCTION

At present, Ukraine is operating under extremely unstable conditions caused by the ongoing war as a profoundly destructive factor. Contemporary educational paradigm must take this key context into account and be oriented toward developing a barrier-free environment, as emphasized in fundamental state-level policy documents: the National Strategy for Creating a Barrier-Free Space in Ukraine until 2030 and the Presidential Decree No. 533/2020 “On Ensuring the Creation of a Barrier-Free Space in Ukraine” [1]. Inclusive education, particularly the search for effective tools for its organization, requires the continuous implementation of innovative approaches and the systematic identification of evidence-based methodological practices. However, this process becomes particularly complex when students with cognitive impairment resulting from sensory deficits, such as visual, auditory, or tactile impairments, learn foreign languages, as these impairments may disrupt mechanisms of information perception and processing [2]. These technologies enable the implementation of effective practices for creating multisensory learning environments. Such environments enable the activation of preserved sensory channels, for instance, visual support for learners with hearing impairments or tactile feedback, thereby facilitating the development of stable lexical and grammatical skills. A multisensory VR environment integrates visual, auditory, and kinesthetic stimuli, thereby creating new opportunities for the effective acquisition of foreign-language learning material. Despite growing global interest in immersive technologies, their adaptation to the specific context of Ukrainian inclusive classrooms remains insufficiently explored. Furthermore, the ongoing war has contributed to a significant increase in the number of learners with disabilities, which underscores the urgent need for accessible and adaptive educational solutions according to the data Data from the Ministry of Social Policy and the National Health Service of Ukraine, 2024-2025) presented in Table 1.

Table 1: Distribution of children with disabilities in Ukraine by Major Nosological Groups.

Type of impairment	Percentage contribution to the overall structure %
Congenital developmental disorders	28.2
Mental and behavioral disorders (including ASD)	20.1
Diseases of the nervous system (CNS disorders, CP)	14.7
Endocrine system disorders	10.6
Hearing impairments	5.6
Musculoskeletal disorders	4.5
Visual impairments	3.5
Other diseases and injuries	12.8

It should be noted that a significant proportion of families have children whose disability status has not been officially determined due to a range of objective factors, with estimates ranging from 40% to 60% [3].

Significance of the study logically determines its purpose, which is to provide a theoretical substantiation and experimental verification of the effectiveness of the multisensory VR platform Akelius as a compensatory tool for addressing sensory deficits in the process of foreign language learning among students in inclusive classrooms (Grades 5-9) in the city of Zhytomyr, Ukraine.

The proposed research focuses on the educational practices of general secondary education institutions in Zhytomyr. The selection of this region is determined by the active implementation of digital educational tools in local inclusive classrooms and the need for empirical evidence regarding the effectiveness of VR-based instructional solutions under conditions of limited educational resources and the ongoing wartime context. These factors contribute to increased psychological strain, particularly among students with SEN, thereby reinforcing the importance of exploring adaptive and multisensory digital learning environments.

2 THEORETICAL FOUNDATIONS OF THE STUDY

The theoretical framework of the study is grounded in contemporary concepts of global pedagogy, psychology, special education, foreign language didactics, and educational technologies. It provides a holistic understanding of the potential of multisensory VR environments in inclusive foreign language education. The study also draws upon the current legislative and regulatory framework governing inclusive and special education in Ukraine, including the Law of Ukraine “On Education”, the Law of Ukraine “On Complete General Secondary Education,” Resolution of the Cabinet of Ministers of Ukraine No. 957 “On Approval of the Procedure for Organizing Inclusive Education in General Secondary Education Institutions,” and the National Strategy for Creating a Barrier-Free Environment in Ukraine until 2030 [4]. The empirical basis of the study comprises quantitative indicators of the inclusive classroom network in the city of Zhytomyr, as well as statistical data on the number of learners who require continuous inclusive support. The research is grounded in the theory of inclusive education, which emphasizes equal access to learning, adaptation of the educational environment, and non-discrimination of individuals with sensory impairments. A key theoretical framework underpinning the study is the concept of sensory compensation and neuroplasticity, which substantiates the possibility of compensating for impaired sensory channels through the activation of alternative sensory modalities.

The theoretical and methodological framework of the study is grounded in core principles and concepts of inclusive education, emphasizing equal access to quality learning, universal design in education, and the prevention of discrimination against learners with sensory impairments through reasonable accommodations in the educational environment. Psycholinguistic theories of language learning support the appropriateness of using VR for immersive language exposure. The study also incorporates the principles of Universal Design for Learning (UDL), which ensure flexibility and accessibility of VR environments for diverse educational needs, as well as key assumptions of immersive digital technology theory, highlighting their positive impact on learner motivation and engagement. An individual-centered approach, aimed at addressing each learner's unique characteristics, is also critical. The synthesis of the outlined theoretical principles provides a solid scientific foundation for substantiating the use of multisensory VR environments as an effective tool for compensating sensory deficits in inclusive foreign language education.

2.1 Literature Review

The theoretical framework of this study is grounded in the concepts of sensory integration and neuroplasticity,heories of foreign language learning

within inclusive educational environments, the principles of Universal Design for Learning (UDL), and scholarly approaches to the use of VR in education. Multisensory input supports learners with diverse cognitive and sensory profiles [5].

The effectiveness of immersive virtual reality has also been demonstrated at the stage of second-language vocabulary acquisition in K-12 education. Virtual reality provides strong compensatory potential for learners with sensory impairments and functions as an effective multisensory tool in language education [6].

Furthermore, according to Rudling, immersive VR environments are particularly effective in vocabulary acquisition. Multisensory and embodied VR interaction enhances attentional sustainability during lexical learning and activates sensorimotor engagement in the language learning process [7].

Immersive and multisensory technologies support vocabulary acquisition, facilitate the development of pronunciation, and contribute to the formation of communicative competence. In this context, inclusive design functions as a foundational pedagogical framework. The effectiveness of VR-based learning environments in inclusive education depends on the educator's ability to differentiate approaches in accordance with the individual characteristics of learners with diverse disabilities, neurodevelopmental conditions, or educational barriers [8].

Principles of accessibility and inclusivity in immersive technologies, including VR and augmented reality (AR), contribute to the formation of a "metaverse" environment. Design strategies should prioritize support for users with sensory, motor, and cognitive impairments, with multisensory substitution and adaptive interfaces emerging as key mechanisms for compensating sensory deficits. Within this context, the authors identify several persistent barriers, notably high implementation costs and the lack of unified standards [9].

Tactile and auditory learning tools are frequently reported to support learners with SEN in mastering academic content alongside their peers, while also reducing anxiety levels [10]. A foundational framework for understanding inclusive education is provided by M. Oliver's concept of disability, which conceptualizes disability through the lens of socially constructed barriers arising from inadequacies in the environment rather than from an individual's medical condition.

Multisensory VR environments demonstrate significant potential for inclusive foreign language learning. VR-based techniques enhance learners' motivation, attention, and perceptual engagement, while positively influencing language learning outcomes. At the same time, such environments support diverse learner needs by providing flexible, immersive, and adaptive learning experiences.

3 RESEARCH METHODOLOGY

The study is grounded in inclusive, competence-based, multisensory, systemic, and learner-centred approaches. Particular emphasis is placed on mechanisms of sensory profiling, which enabled the identification of levels of auditory and visual information perception. A combination of theoretical methods (systemic analysis and a deductive approach) and empirical instruments was employed, including participant observation, interviews, and questionnaire-based surveying using the Foreign Language Classroom Anxiety Scale (FLCAS), adapted for learners with SEN.

Methods included vocabulary size testing (Vocabulary Size Test), a pedagogical experiment, and quantitative and qualitative data analysis. The results obtained using M. Lüscher's methodology revealed a statistically significant correlation between the severity of speech-related difficulties and the level of situational anxiety, as measured by the Lüscher Color Test. The study sample comprised students from inclusive classes in secondary schools (lyceums) in the city of Zhytomyr, which had well-established inclusive education infrastructure. The total sample comprised 150 students with SEN, aged 11-15 years (middle school level). The experimental group (EG) received instruction using VR-based tools, whereas the control group (CG) was taught using traditional inclusive teaching methods.

To create a multisensory learning experience, specially adapted scenarios were employed, including Akelius, Virtual Classroom, and City Tour. Learners interacted with virtual objects via tactile controllers that provided haptic feedback, enabling the compensation of perceptual deficits through the simulated mechanical sensation of "touching" virtual lexical items.

The observational method was implemented using structured observation cards with the involvement of the learners themselves to assess engagement levels (engagement rate). The study was conducted in compliance with bioethical principles, and written parental consent was obtained. VR-based instructional sessions did not exceed 15 minutes per session to prevent visual fatigue, in accordance with the sanitary regulations of Ukraine.

3.1 Research Result

The study was conducted in an inclusive educational environment involving learners with diverse sensory and cognitive impairments and was implemented in three stages:

1) Ascertaining stage. Diagnostic assessment of the levels of sensory deficits and learning barriers in foreign language (English) acquisition among students in inclusive classrooms, as well as an analysis of the content of Individual Development Programs (IDPs) and Individual Learning Plans (ILPs);
2) Formative stage. Implementation of a multisensory VR-based learning environment (using platforms such as Akelius, Virtual Classroom, City Tour, and Mondly VR) into the educational process;
3) Control stage. Analysis of changes in vocabulary acquisition, development of grammatical skills, and measurement of anxiety levels.

The study's temporal scope covered the period of students' teaching practice conducted in January-February 2025 and in November 2025. Students of Zhytomyr Polytechnic State University completed their pedagogical practice at selected lyceums in Zhytomyr. Supervision of the practice was carried out jointly by teachers at the practice bases and by academic staff of the Department of Pedagogical Technologies and Language Training, who were responsible for evaluating the practice's outcomes.

3.2 Initial (Diagnostic) Stage of the Study

The study was conducted in inclusive classrooms of Lyceums No. 3, 4, 14, 19, 20, and 21 in the city of Zhytomyr. The sample consisted of 150 students (N=150) aged 11-15 who experienced learning difficulties and required support from a teaching assistant. Data collection took place during the pedagogical practicum completed by students of Zhytomyr Polytechnic State University enrolled in the Bachelor's programme 014.021 "Secondary Education. English Language and Literature."

The distribution of students by SEN categories was based on the primary diagnostic data of the IRC, which is shown in Figure 1. The formation of the study sample (N = 150) was carried out on the basis of a preliminary study and analysis of the official conclusions of the Inclusive Resource Centers (IRC) on the comprehensive psychological and pedagogical assessment of child development. This allowed selecting participants with confirmed sensory profile features (hypo- or hypersensitivity (37%), proprioception difficulties (33%) and sensory discrimination difficulties 30%), which created barriers to mastering a foreign language. The distribution into the experimental (EG, N = 75) and control (CG, N = 75) groups was carried out using the method of stratified randomization, taking into account the specifics of sensory deficits recorded in the IRC protocols. It is worth emphasizing that the experimental group included those students who were dominated by pronounced deficits in sensory integration, while the control group included students with other features of psychophysical development, in which the sensory aspect was not critically injured or leading in the structure of the disorder. Stratification was carried out by the leading type of sensory deficit, according to the classification used in the IRC protocols. (see Fig. 1).

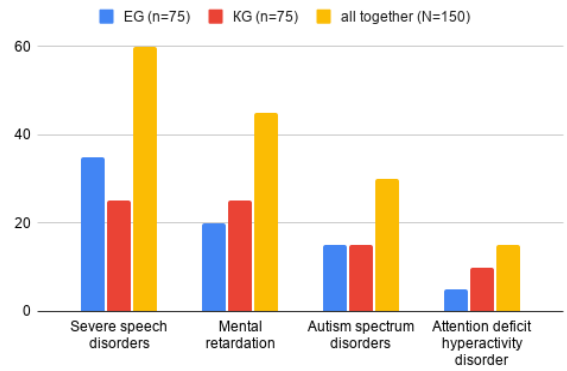

Figure 1: Categories of respondents by type of SEN.

The empirical investigation of sensory barriers employed three complementary approaches (see Fig. 2).

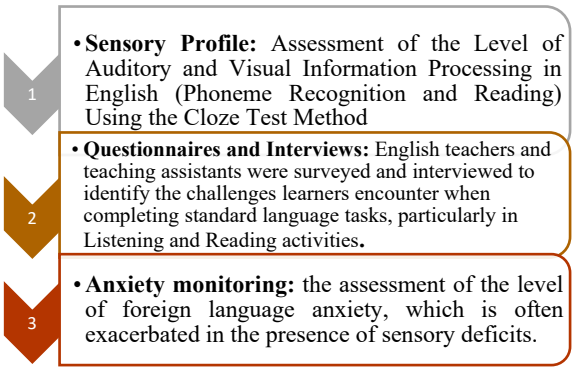

Figure 2: Mechanisms for investigating sensory barriers.

Based on the sensory profile assessment, 30% of students with SEN demonstrated effective processing of auditory and visual information, 40% experienced cognitive-related difficulties, and 30% were able to recognise phonemes but showed significant challenges in reading. The assessment focused on learners' ability to discriminate minimal pairs (e.g., ship/sheep, bad/bed). The task allows for determining whether a learner can perceive phonemic contrasts or whether the sounds are perceptually merged. 23% of participants demonstrated difficulties in grapho-motor identification, particularly in distinguishing visually similar letter pairs (e.g., b-d, p-q, n-u). These findings are significant for the further integration of VR in educational practice. A low level of phoneme recognition can be compensated through visual scaffolding, such as subtitles or three-dimensional object representations, which can be synchronously presented with auditory input in a VR environment. The aggregated results indicate that only 55 of 150 learners (36.7%) successfully completed tasks involving auditory discrimination of minimal pairs, while 45 respondents (30%) demonstrated adequate performance in visual tracking tasks. The obtained data substantiate the need to implement a systematic set of corrective interventions using virtual technologies to enhance multisensory integration.

The data obtained from the questionnaire survey and interviews can be categorized into several thematic blocks (Fig. 3).

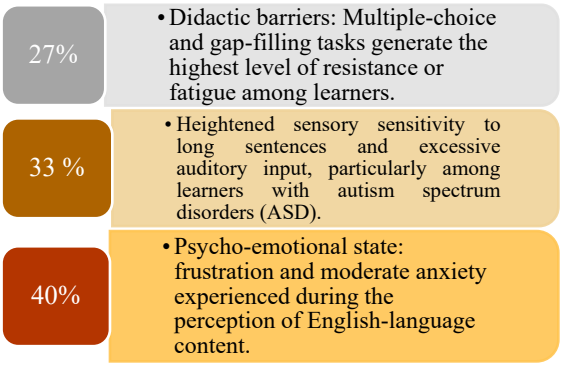

Figure 3: Qualitative indicators derived from the questionnaire survey.

The survey yielded quantitative data based on a five-point Likert scale (1-5) to assess the frequency of reported difficulties. As an Table 2, the study presents a scale of difficulties related to the differentiation of similar phonemes ([th]/[s]).

Table 2: Likert-Scale assessment of perceived difficulties.

Indicator	Never	Rarely	Often	Always
Number of students	30	47	46	27

An analysis of interviews with inclusive classroom assistants revealed that, on average, students with cognitive difficulties experience high levels of auditory fatigue after approximately 7 minutes of continuous listening. This finding correlates with the results of phonemic hearing assessments. These outcomes indicate the need to implement short iterations of auditory input supported by visual scaffolding in VR learning environments.

Anxiety levels were monitored using the Luscher Color Test before and after the English language lesson. To assess the psycho-emotional state of students with SEN, an expedited diagnostic approach was used, combining emotional pictogram cards with a simplified color-association technique. The diagnostic toolkit was based on eight standardized color stimuli (blue, green, red, yellow, violet, brown, black, and gray). This approach enabled tracing the correlation between types of learning activities (listening and reading) and students' subjective psychological comfort. The findings revealed a decrease in anxiety indicators when instruction shifted from traditional didactic materials to immersive VR simulations. This effect was evidenced by a change in students' color preferences from anxiety-associated colors (gray, dark blue) to positively active colors (yellow, green). The results clearly demonstrate that VR technologies function not merely as an engaging educational tool but also as an effective means of reducing language-learning anxiety.

The level of the affective filter (according to Krashen's Affective Filter Hypothesis) was assessed using the Foreign Language Classroom Anxiety Scale (FLCAS). This instrument enabled the measurement of foreign language anxiety as a cognitive-inhibitory factor that can hinder effective verbal communication in an inclusive classroom. The results indicated a relatively high anxiety level (43%), suggesting that the learner may possess high cognitive abilities, while their emotional state inhibits language acquisition. Foreign language anxiety was found to emerge not only as an emotional reaction but also as a consequence of insufficient sensory integration, particularly within the context of inclusive education.

3.2 Formative Stage of the Study

During their practicum in inclusive classrooms, students utilized various affordances of multisensory VR environments. The use of VR enabled learners to fully immerse themselves in the target language environment by simulating authentic, real-life communicative situations.

This study focuses on a detailed analysis of the digital learning platform Akelius, which is being implemented in the Ukrainian educational context with UNICEF support. The platform functions as a blended learning support tool and is designed for the study of twelve foreign languages. It is specifically adapted for learners with SEN, including students with dyslexia and speech and language impairments, through a flexible system of visual scaffolding and individualized learning pace. Akelius is grounded in a "learning through error" pedagogical principle and does not employ traditional grading practices, thereby reducing learners' fear of public failure and promoting a psychologically safe learning environment.

The findings indicate that the absence of directive assessment and the availability of repeated practice opportunities in the Akelius application contributed to a reduction in perfectionism-related anxiety (from 40% to 25%). This decrease is considered critically important for learners with dyslexia, as it reduces an affective barrier and promotes more sustainable engagement in language learning.

The platform employs a multimodal approach that integrates audio, visual, and textual input. For children with speech and language disorders, this multimodality provides essential instructional scaffolding. Gamification and division of learning content into micro-steps (Fig. 4) enhance learners' sense of control over the learning process. Within the scope of the empirical study, the experiment was limited to CEFR proficiency levels A1 and A2.

Akelius enables the adaptation of instructional content to learners' individual proficiency levels, thereby supporting personalized learning. Its multisensory approach is particularly effective in developing language skills, especially listening comprehension and oral communication (see Fig. 5).

Students in the experimental group (EG) demonstrated a 28% higher level of active vocabulary activation during spontaneous speech than those in the control group (CG). The use of a multisensory VR environment resulted in a 15% reduction in phonetic errors in the EG's speech, which can be attributed to the immersive "sense of presence" effect and visual support for articulation. Furthermore, the mean score on the Foreign Language Classroom Anxiety Scale (FLCAS) in the experimental group decreased from 118 points (high anxiety level) to 84 points (moderate to low anxiety level), indicating a clinically significant reduction in emotional tension. The most pronounced improvement was observed for the fear of negative evaluation, with scores decreasing by 35%, which can be attributed to the non-judgmental learning environment provided by the Akelius platform. Comparative analysis of the results showed that in the experimental group (n = 25), where VR technologies and the Akelius platform were implemented, communicative confidence increased by 22%. In contrast, in the control group (n = 25), this indicator remained within the 5-7% range, with the difference reaching statistical significance ($p < .05$).

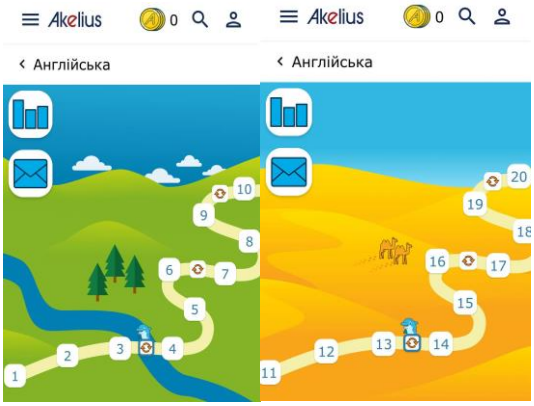

Figure 4: Screenshot of platform "Akelius".

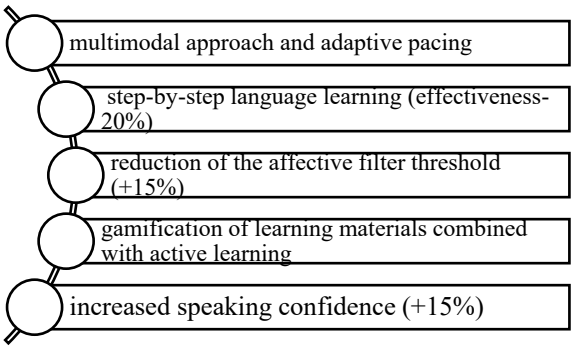

Figure 5: Key advantages of the Akelius Digital Learning Platform.

3.3 Control Stage of the Study

The implementation of a multisensory VR-based learning environment accelerated learners' development of foreign-language communicative competence, reduced anxiety levels. Statistical analysis of the experimental group revealed improvements ($p<05$) in

lexical acquisition, phonological accuracy, and speech fluency compared with the control group, which was instructed using traditional pedagogical methods (Fig. 6).

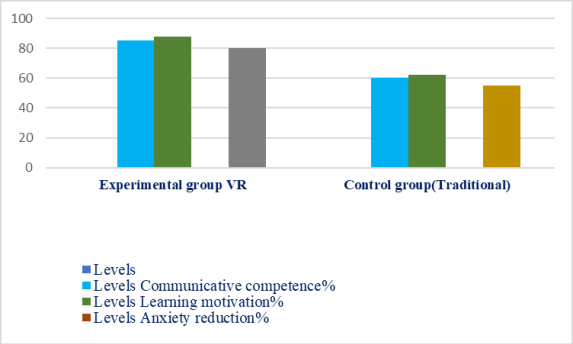

Figure 6: Impact of VR Technologies on foreign language iearning outcomes: A Comparative analysis.

The VR-based learning environment enabled individualized instruction by adapting the pace, sensory support to learner's educational needs. The implementation of virtual communicative scenarios facilitated social interaction, reduced communication barriers, and promoted more active inclusion of learners with sensory impairments in group activities.

The findings confirm the pedagogical relevance and practical effectiveness of implementing a multisensory VR environment in inclusive foreign language education, provided that appropriate methodological design and technical support are ensured. Overall, VR functions as an effective tool for compensating sensory deficits and for enhancing the quality of inclusive language education.

It is also important to highlight a range of risks and challenges encountered by learners, teachers, and pre-service teachers (Fig. 7).

First, a proportion of students experienced sensory overload (2% of learners had episodes of sensory meltdown while working on the Akelius platform), necessitating strict regulation of screen time and individualized adjustments to sensory stimuli. Second, students with significant cognitive impairments (nearly 60%) were not always able to navigate the virtual environment independently and required continuous support from a teaching assistant or a student teacher.

Among educators, a risk of insufficient methodological readiness to integrate VR into the structure of a foreign language lesson was identified (40%). A separate challenge was the equipment's technical instability, including a limited number of VR devices and software malfunctions (25%), which negatively affected the pacing of classroom instruction.

During teaching practice, students encountered difficulties in combining the roles of observer, teacher, and technical facilitator within the VR environment (30%). In addition, a psychological barrier was identified among some learners, associated with fear of making mistakes or unfamiliarity with the technology (14%).

Teachers also reported an increased workload during lesson preparation due to the need to adapt instructional materials to Individual Educational Programs (IEPs) and Individual Learning Plans (ILPs) (49%). Furthermore, uneven learning outcomes remained a significant risk, as VR effectiveness depended on the type of sensory impairment and the level of support provided.

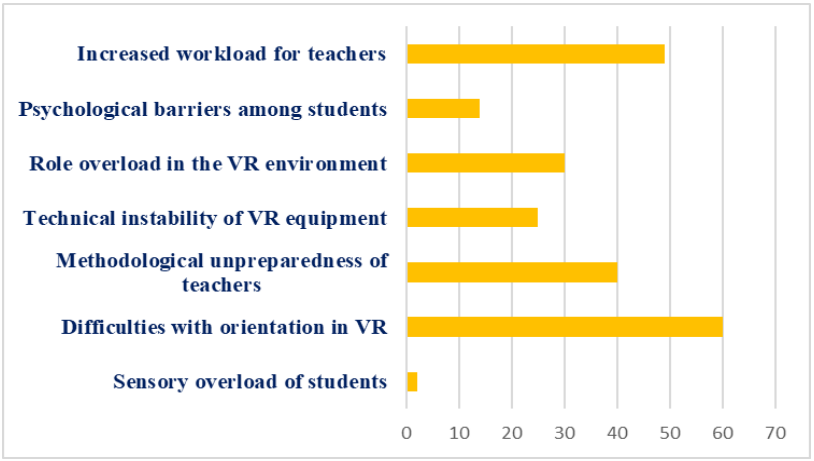

Figure 7: Identified risks in working with a virtual platform.

Akelius platform, unlike immersive VR tools (such as Mondly VR or Immerse), allows us to highlight its key advantage, in particular in working with students with sensory profile features. Unlike most commercial VR solutions, which often create excessive visual and cognitive load (visual clutter), provoking sensory overload (for example, in children with ASD), the Akelius platform is based on the principles of pedagogical minimalism and gradual sensory stimulation.

The use of Akelius in combination with virtual reality elements provides a clear structuring of audiovisual signals, which allows avoiding "sensory noise" and focusing the child's attention on articulatory praxis. Unlike applications such as Duolingo or Babbel, which are focused on passive recognition of lexemes, Akelius integrates a multisensory approach, where the visual image of the word is reinforced with specific rhythmic and intonation accompaniment. This is critically important for the formation of the articulatory base of a foreign language in children with proprioception deficits, as the platform allows for the synchronization of digital stimulus-responses with real speech therapy exercises.

4 CONCLUSIONS

Thus, the results of the comprehensive study confirm that the use of the digital platform Akelius in an inclusive educational environment serves as an effective mechanism for reducing foreign language anxiety. The data obtained using the FLCAS scale indicate a reduction in affective barriers, particularly fear of evaluation, as confirmed by positive changes in respondents' psycho-emotional state, as measured by M. Lüscher's method (a shift from anxiety-related to stabilizing color choices). In line with M.
Oliver's social model, this approach enables the transformation of the educational environment by shifting the focus from medicalized deficit perspectives of learners with dyslexia and autism spectrum conditions toward the creation of an adaptive, barrier-free learning space, where digital tools foster psychological comfort and academic achievement.

The research findings verify the hypothesis that sensory integration correction constitutes a fundamental predictor of successful foreign-language reception within an inclusive educational discourse. It has been established that a multisensory VR environment enables effective compensation for sensory deficits (visual, auditory, tactile, and proprioceptive) by stimulating neuroplasticity and activating learners' cognitive reserves. The experimental results demonstrate a statistically significant advantage for the experimental group in communicative competence and intrinsic motivation, accompanied by a substantial reduction in foreign-language anxiety (as measured by the FLCAS). Of particular scientific value is the demonstrated potential for radical individualization of instruction through the adaptive algorithms embedded in the VR environment. Consequently, multisensory VR technologies are identified as a relevant and highly effective tool in contemporary language pedagogy. Further research directions include standardizing sensory-speech correction protocols and implementing adaptive VR solutions within Ukraine's general education system, with support from international institutions, including UNICEF.

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