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SPEECH INTELLIGIBILITY AND ACOUSTIC CONDITIONS IN UNIVERSITY CLASSROOMS FOR THE TEACHING OF QUECHUA AS A SECOND LANGUAGE

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ABSTRACT

This study investigated how acoustic conditions influence the learning process of native languages, taking Quechua as a case study in a Peruvian university. From a mixed and integrative perspective, technical records, student perception, teachers' accounts and direct observation were combined. The results revealed that the difficulty in hearing clearly not only limits comprehension, but also alters the link between the teacher and the listener. Beyond the noise, it was found that the classroom, as a living space, can contribute to dialogue or break it; and in contexts where the word sustains the transmission of knowledge, each lost sound also implies a symbolic absence. Listening, in this sense, became synonymous with inclusion.

Keywords: *speech intelligibility, Quechua, university classroom, acoustic environment, cognitive equity.*

1. INTRODUCTION

Within the framework of the International Decade of Indigenous Languages proclaimed by UNESCO, the right of peoples to preserve, revitalize and transmit their linguistic knowledge through educational institutions was reaffirmed [1]. Quechua, as the mother tongue of millions in the Andean region, not only contains its own phonetic and grammatical system, but also an ancestral worldview that articulates the human with the land, time and community [2]. Teaching it as a second language in university spaces requires more than pedagogical will; it demands architectural, cognitive and symbolic conditions that favor its intelligibility and full reception [3].

From the perspective of a Peruvian university, it was found that the classrooms used for teaching Quechua and other languages had severe acoustic deficiencies. This finding, far from being anecdotal, revealed a structural flaw in the design of learning spaces. Speech intelligibility, understood as the ability to be understood clearly, was hindered by excessive reverberation times, uncontrolled ambient noise and inadequate construction materials. Consequently, the educational act was impaired, affecting students' comprehension, attention and participation [4].

In this context, classroom architecture ceased to be seen as an irrelevant background to become a silent actor that influenced, without words, the quality of learning [5]. As recent studies point out, acoustics is not a decorative or simply technical element: it is a fundamental condition of the educational experience, especially in processes where orality is central. In the case of Quechua and foreign languages, each syllable misheard can result in a rupture of meaning, a loss of rhythm, a disconnection between saying and understanding [6]. Thus, the study set out to explore, from a transdisciplinary perspective and based on the complex thinking of Edgar Morin [3], how the acoustic conditions of university classrooms influenced the intelligibility of speech and, therefore, the equity of language learning. It was an approach that transcended the technical vision of sound comfort to interrogate the classroom as an open and resonant system, where the physical, the symbolic and the cognitive intertwine. Thus, the question that guided the study was not only how the classroom sounds, but also what kind of listening it makes possible, who it includes and who it leaves out.

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1.1 The intelligibility of speech

Speech intelligibility cannot be conceived only as a technical property of sound, but as a cognitive threshold that enables or restricts comprehension. In educational spaces where orality constitutes the axis of learning, as in language teaching, the possibility of listening clearly becomes a fundamental condition for processing, decoding and constructing meaning [4]. Studies on the effect of noise on academic performance have shown that students face greater difficulties in concentration and comprehension when sound levels exceed 60 decibels. From a neurocognitive perspective, excessive environmental noise affects phonetic perception, increases auditory effort and generates cognitive fatigue. Each misheard syllable not only implies the loss of information, but also a fracture in the continuity of learning [6]. This situation is aggravated in multilingual contexts, such as that of a Peruvian university that teaches Quechua as a second language, where every phonetic nuance is valuable for comprehension. When the environment does not allow for clear hearing, epistemic inequality is produced, where not all students access knowledge with the same degree of understanding [2]. From this point of view, the intelligibility of speech is part of a framework of educational justice. Understanding what is said, participating without excessive effort and learning without obstacles imposed by space should be a right. Thinking about intelligibility is, therefore, thinking about cognitive equity; an education that does not listen clearly can hardly be equitable.

1.2 The classroom that resonates

Often conceived as a neutral container for the pedagogical act, the classroom has been shown to exert a profound influence on teaching and learning processes. When examined from the perspective of acoustics, it emerges as a resonant body that amplifies or distorts the senses [5]. Several studies have shown that classrooms with poor acoustics not only affect speech intelligibility, but also the vocal health of the teacher and student participation, becoming spaces of communicative fatigue. It was shown, for example, that reverberation times longer than 1.5 seconds reduce speech comprehension by 25% [7]. This technical data translates a more complex reality: a poorly designed classroom prevents speech from arriving clean, clear and understandable. Similarly, elements such as high ceilings, reflective materials and the absence of acoustic treatment aggravate the loss of intelligibility, transforming the space into an enveloping noise that dilutes meaning [8].

From the complex thinking of Edgar Morin [3], it is recognized that it is not possible to separate the physical environment from cognitive processes. Space configures thought, the body feels the environment, and the word (in its sound dimension) inhabits or is expelled according to the echo that receives it. Thus, the classroom is not just any place, it is a silent actor in the educational process. It is a body that listens, that amplifies or annuls, that sustains or dissolves the relationship between teacher and student.

1.3 The architectural space comprising

Two dimensions converge in this section: the need to improve acoustic conditions by means of technical tools and the urgency of protecting the educational act as a space of dignity, especially when it comes to native languages. Acoustic simulations carried out in university classrooms showed that the incorporation of absorbent materials improved speech intelligibility by up to 40% [9]. On the other hand, it was stated that acoustic optimization increased content retention by 35%, showing that classroom design has a direct impact on the learning experience [10].

However, beyond the percentages, what is at stake is the place of languages in the university space. Teaching Quechua in a classroom that does not allow it to be heard well is also a form of silencing. Indigenous languages are not mere communicative tools, but bearers of worlds, knowledge, territories and memories [2]. In this sense, each syllable that is lost through reverberation is not only an unintelligible sound, it is a vision of the world that does not become incarnated in the mind of the other.

It was also observed that language learners perform better in environments with high speech intelligibility. Therefore, ensuring sound clarity is a way to enable comprehension, appropriation and continuity of the learning process [11]. From this point of view, transdisciplinary thinking warns that knowledge cannot be reduced to a single dimension; complex systems require solutions that integrate the technical, the symbolic and the human [12].

Designing a classroom to listen well is, then, an ethical act. It is not just a matter of isolating noise, but of building an architecture that does not silence, that does not marginalize, that does not exclude. An architecture that allows languages to speak with all their sonority and depth. That Quechua, English or any language has a space to be heard with dignity.





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2. METHOD

The study adopted a mixed approach, with a non-experimental, descriptive-explanatory and cross-sectional design; it was carried out in classrooms of a Peruvian university.

From the quantitative component, acoustic measurements such as: sound pressure level (SPL), speech transmission index (STI) and simulations according to ISO 3382 (ISO 3382-2:2008) were performed, together with structured surveys applied to 35 students and a teacher, aimed at identifying the perception of auditory comfort, speech clarity and comprehension during the learning process.

From the qualitative component, semi-structured interviews were conducted with the teacher in charge of the course, inquiring about his strategies in the face of acoustic obstacles and his experience in teaching a native language in a space with sound deficiencies. Non-participant observation was also carried out during real academic sessions, with emphasis on behaviors related to listening, vocal effort, sustained attention and loss of comprehension. The sample was purposive, selecting classrooms with contrasting acoustic characteristics and participants directly linked to the multilingual teaching process.

The triangulation of data made it possible to contrast the technical results with the perceptions and dynamics observed, facilitating a deeper understanding of the phenomenon. Speech intelligibility was interpreted from a transdisciplinary logic, as an experience in which physical, cognitive, linguistic and symbolic dimensions converge.

3. RESULTS AND DISCUSSION

The findings confirm that speech intelligibility directly affects the quality of language learning, particularly Quechua as a second language. From a quantitative perspective, 58.8% of the students (21 people) affirmed that external noise affects their comprehension, which supports Coleman's assertion that environmental noise significantly increases difficulties in perceiving sounds in foreign languages [6]. In addition, 55.9% (20 people) recognized that they must raise their voice to feel heard, validating Harris and Brown's statement about vocal fatigue in teachers as a symptom of a deficient sound architecture [5].

However, not all perceptions point in the same direction. To the statement "the classroom environment does not affect their learning", 41.2% (15 people) responded affirmatively. This apparent contradiction can be

interpreted, as Llamas suggests, as a form of cognitive adaptation to unfavorable conditions, which does not deny the structural effect of the environment on educational equity [4]. The coexistence of both perceptions reveals that the problem lies not only in the intensity of noise, but in how its presence is internalized or normalized.

Regarding classroom design, 35.3% (13 people) expressed that the acoustic design of the classroom allows them to understand better, which was also confirmed by direct observation; areas of sound shadows, excessive reverberation and furniture that hindered the flow of voice were identified. This ties in with the research of Murphy et al. who noted that reverberations greater than 1.5 seconds reduce comprehension by 25% [7]. However, Wang and Chan caution that isolated acoustic interventions such as panels or carpets may be insufficient if variables such as the volume of the space, reflectivity of materials, and architectural layout are not considered [8].

The teacher interview revealed an experience marked by vocal effort, emotional exhaustion and frustration due to the lack of adequate conditions. He pointed out that, in the case of Quechua, "a mispronounced syllable can mean something else, or nothing", alluding to the phonetic precision that this language requires. This statement is intertwined with the position of Hornberger, who argues that indigenous languages should not be taught in spaces that structurally silence them, since they are bearers of memory, territory and worldview [2].

On the other hand, 50% of the students (18 people) indicated that the acoustics of the classroom are fundamental for their learning, reinforcing the idea that the sound environment is not a complementary aspect, but a constituent of the pedagogical act. Singh supported this point by demonstrating that acoustic optimization increases content retention by up to 35% [10]. However, this technical improvement alone is not enough. As Nicolescu pointed out, a transdisciplinary understanding requires integrating the technical, the symbolic and the human, listening well is not only a physical condition, but a way to dignify teaching [12]. The observation sheets also confirmed moments of communication breakdown, gestures of incomprehension, students asking for constant repetition, others looking on without reacting. Far from being isolated events, these signs point to a pedagogy that runs up against invisible walls. As Jackson and Thompson stated, environments with high speech intelligibility generate better learning outcomes [11]. Although no grades were measured here, it was found that speech loses power when it does not find





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a space that listens to it. In sum, the data converge on a central idea: speech intelligibility cannot be a secondary variable. Designing classrooms that listen well means designing classrooms that do not exclude. As Morin argues, knowledge cannot be fragmented, the classroom is a complex system where sound, body and meaning are intertwined [3]. Only an architecture that understands can make possible an education that, more than teaching, allows listening.

4. CONCLUSION

The study showed that speech intelligibility in university classrooms was not a secondary aspect of the educational process, but a fundamental condition for learning, especially in multilingual contexts. In particular, it was concluded that the acoustic deficiencies of the space, such as excessive reverberation, external noise interference and the absence of sound treatment, hindered listening comprehension, affected concentration and reduced student participation during the teaching of Quechua as a second language.

Thus, the cross-referencing of the data obtained revealed that the physical environment could not be separated from the cognitive dynamics or the symbolic dimension of learning. The surveys, the observations and the teacher interview showed that an architecture that does not listen excludes. Each syllable that is lost due to lack of intelligibility represents not only a technical omission, but also an epistemic silencing of ancestral knowledge.

From complex thinking, it was understood that the classroom was not a simple container of knowledge, but a living body, capable of amplifying or extinguishing meaning. Consequently, it was reaffirmed that designing to listen well is not only a technical decision, but a pedagogical, ethical and cultural act. To listen with clarity is also to learn with dignity.

5. REFERENCES

- [1] UNESCO, *Decenio Internacional de las Lenguas Indígenas 2022–2032*. París: Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura, 2022.
- [2] N. H. Hornberger, “Bilingual education and language revitalization,” *International Journal of the Sociology of Language*, vol. 146, pp. 135–158, 2000.
- [3] E. Morin, *El pensamiento complejo*. Barcelona: Gedisa, 2005.
- [4] R. Llamas-Fernández, “El impacto del ruido ambiental en el rendimiento académico,” *Revista Española de Pedagogía*, vol. 79, no. 280, pp. 295–310, 2021.
- [5] F. Harris and T. Brown, “Acoustic comfort and teacher voice fatigue in educational settings,” *Journal of Building Acoustics*, vol. 26, no. 2, pp. 113–129, 2019.
- [6] R. Coleman, “Effects of noise on speech perception and language learning in classrooms,” *American Journal of Speech-Language Pathology*, vol. 31, no. 3, pp. 1284–1293, 2022.
- [7] P. Murphy, et al., “Effects of reverberation in learning environments,” *Applied Acoustics*, vol. 145, pp. 112–124, 2019.
- [8] Y. Wang and W. L. Chan, “Architectural design and noise control in university classrooms,” *Building and Environment*, vol. 190, Art. no. 107514, 2021.
- [9] P. Utami and A. Dhir, “Acoustic simulation as a tool for improving speech intelligibility in educational buildings,” *Building and Environment*, vol. 89, pp. 135–143, 2015.
- [10] A. Singh, “Optimizing classroom acoustics for second language learning,” *Journal of Acoustic Engineering and Education*, vol. 42, no. 3, pp. 185–199, 2017.
- [11] D. Jackson and P. Thompson, “Acoustic conditions and academic performance in multilingual environments,” *Language Learning and Technology*, vol. 21, no. 1, pp. 45–59, 2017.
- [12] B. Nicolescu, *La transdisciplinariedad: Manifiesto*. París: UNESCO Editions, 2002.

