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Article

Ways to compensate poor acoustic characteristics of classrooms

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Abstract: The acoustic conditions of classrooms play an important role in the performance of students, especially in the acquisition of foreign languages, but at the same time, the design of classrooms according to acoustic aspects is not a proven practice, so exploring the possibilities of subsequent compensation for classrooms in inadequate condition is an important task in order to ensure quality education. In this research, technical and organizational solutions will be comprehensively examined to improve speech intelligibility in the examined primary school and university classrooms, which will be carried out by the measurement and modelling of the Speech Transmission Index (STI). We developed seven compensation scenarios and a baseline scenario for acoustic development, which are also compared from a cost-effectiveness point of view. The insulation of the back wall, the creation of an insulating false ceiling, their combined implementation, the modernization of the windows, the effect of teacher's position, the opened windows, and the increased volume are examined. The results of the research can be used in all institutions where acoustic compensation is needed, providing useful results not only for room acoustics specialists but also for institutional decision-makers and teachers. The measurement results show that in classrooms in quiet environments, in addition to technical solutions, which can be applied in all cases, organizational solutions can also be effective.

Keywords: speech transmission index; speech intelligibility; classroom noise; quality education; compensation scenarios

1. Introduction

Environmental noise surrounds us, it is present in our homes day and night, it accompanies us to school or work, and we can feel its influence everywhere. The Nobel Prize winner Robert Koch portend more than 100 years ago that "One day man will have to fight noise as fiercely as cholera and pest" [1], and today we continue this fiercely struggle, consciously and unconsciously as well. The relationship between the school performance of students and environmental noise has been confirmed a long time ago [2], as annoyance [3], in urban environment [4] or holistically [5]. The role of good speech intelligibility in language teaching is unquestionable [6]. According to a report, more than 120 million people in the European Union live in an environment exposed to road traffic noise [7]. It has been found that at a young age, noise sensitivity, more specifically a response to effects caused by poor acoustic conditions, is much more significant than in the case of adults [8]. Unfortunately, the importance of classroom acoustics is typically underestimated worldwide. Schick et al. proved, that the cause of the learning difficulties resulting in high levels of stress can be traced back to noisy classrooms, the result was supported by poorer test scores of students studying in noisy environment [9]. The number of students exposed to noise levels of 40 dB has steadily increased over the last 30 years, thus school performance has decreased during this period [10].

The understanding and comprehension of students are crucial in foreign language education, especially in listening. Classroom noise reduces teacher and student performance and productivity [11]. This is particularly important, since the UN has dedicated a separate Sustainable Development Goal [12] to quality education (SDG4), and the integration of the SDGs in language education contributes to the development of speaking, language, literacy skills and sustainability knowledge [13], thereby supporting the creation of a more sustainable future. However, the improvement of acoustic characteristics of classrooms would facilitate not only SDG4 but SDG3 (good health and well-being) and SDG9 (industry, innovation and infrastructure) as well [14].

The efficiency of spoken communication is determined not only by our lexicon and correct grammar but also by the appropriate interaction between the segmental and suprasegmental features of speech [15]. Burns states that students have a better chance to maintain effective communication if they acquire good pronunciation and intonation despite their minor grammar mistakes or vocabulary inaccuracies [16].

Speech intelligibility actually depends on many factors, such as sex of the speaker [17], rhetorical skills [18], audience age [19] and attention/fatigue [20], sentence complexity [21], etc. In this research, the possibilities of optimization through objective acoustic measures are compared, but at the same time, the inclusion of subjective acoustic elements could be a useful contribution to the planning and understanding of speech intelligibility at a higher level, to which the Speech Emotion Recognition (SER) [22], syllable-level feature extraction [23], artificial intelligence-based synthesized speech [24], distortion spectral phase exploration and structuring [25] or automatic non-intrusive system for predicting the speech intelligibility [26].

Astolfi and Pellerey established that four main factors: acoustical, thermal, indoor air and visual quality have the largest impact on education. According to their study, a beneficial, good-quality classroom can increase both teachers' and students' performance, so there is an absolute necessity for designing and building the classrooms concerning the previous factors [27]. Hagen et al. compared the qualities of acoustically renovated and non-renovated classrooms, the subjective acoustical satisfaction was clearly lower in the non-renovated rooms. They concluded that the most important consequence of the poor acoustic qualities was a decrease in concentration. Although they indicated that this upgrade is not enough to achieve maximum intelligibility, the correct sound production and behaviour of the teacher, including appropriate loudness of voice or right articulation is as significant as the suitable acoustic qualities of a certain classroom [28]. Volberg et al. imply that effective communication is influenced by on one hand, speech intelligibility. On the other hand, it is affected by the effort to understand what the speaker says, how difficult the task is, how annoying the environment and how absorbing other parallel activities are [29].

The acoustic properties are also to be evaluated in vehicles [30], churches [31], language test rooms [32], laboratories [33], commercial spaces [34], office environments [35], especially in open-plan offices, to identify the main disrupting factors [36].

Speech intelligibility can be assessed using perceptual tests such as the Phonetically Balanced Word Test (PBWT), Diagnostic Rhyme Test (DRT), and Modified Rhyme Test (MRT). Another approach is to use technical tests such as the Articulation Index (AI), Speech Transmission Index (STI), and Speech Intelligibility Index (SII) [37]. In this paper, we deal with the measurement and modelling of STI, since it is directly possible to evaluate the signal by frequencies and does not require the presence of students, thus eliminating its disturbing effect according to the IEC 60268-16 standard [38]. It should be added that the presence of students increases absorption (reduces reverberation) and generally worsens signal-to-noise ratio (SNR), thus affecting intelligibility [39], however, it is recommended to use empty rooms for planning to ensure repeatability.

However, the STI, as an objective acoustic measure, is most often used to evaluate classroom conditions [40]. The aim of the research is to show what improvements in STI values can be achieved with technical and organizational solutions in real classroom conditions.

The most common treatment method for better speech intelligibility is the installation of sound-absorbing materials, namely acoustical ceiling tiles [41], absorption and diffusive panels on the walls and ceiling [42] or individually controlled canopies [43]. Organic, inorganic and hybrid foams [44], glasswool tiles [45], honeycomb-backed MPP [46], panels from date palm waste fibers [47], loose wood chips and sawdust [48], kapok fiber, pineapple-leaf fiber and hemp fiber [49], luffa scraps and polyester fibers, can be used. Secondly, the increased volume of the speaker could be a treatment, which means the use of loudspeakers [50], headphones [51]. In this research, the effect of the implementation of inorganic foam sound-absorbing material, window replacement, and the effect of a single loudspeaker in the teacher's position are analyzed as the most common technical acoustic treatment solutions. Among the organizational solutions, opening windows and the teacher's position are examined as free alternatives to improve the acoustic comfort of the students. It is important to highlight that technical solutions can affect classroom air quality, thermal comfort [52], and impose significant investment costs on educational institutions [53]. It follows that optimal solutions must be determined by taking into account these compromises.

2. Methods

The Speech Transmission Index (STI) is expressed by the signal-to-noise ratio (SNR) and reverberation time (RT) [54], where the background noise level and speech level [55] and also their frequency dependence [56] are included [57]. STI can be identified by on-site impulse response measurements [58], with running speech measurements [59] or based on blind modelling approaches [60,61].

The STI varies between 0 and 1, nevertheless it is usually divided into 5 qualification categories, namely bad ≤ 0.30, poor 0.30–0.45, fair 0.45–0.60, good 0.60–0.75 and excellent ≥ 0.75 [62] according to ISO 9921 Standard (2003) [63]. In this paper, we used the RT and SNR to calculate the STI according to Galbrun and

Kitapci (2014) [64]. In order to demonstrate the proposed compensation scenarios, four classrooms of different sizes and types were examined, the basic properties of which are presented in **Figure 1**. All of the analyzed classrooms are located in Hungary. Empirical equations can also be used to rapidly estimate the STI [65], generally called rapid speech transmission index (RASTI) [66].

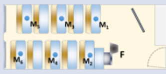
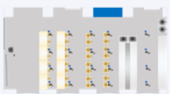
Name	Layout	Description	Volume (m^3)	Area (m^2)	Number of measurement points
Room A		• Elementary school • First floor • 20 children • Facing courtyard	7.0 x 2.7 x 3.2 = **60.48**	7.0 x 2.7 = **18.9**	6
Room B		• University • Second floor • 32 students • Facing road	9.0 x 5.0 x 3.85 = **173.25**	9.0 x 5.0 = **45.0**	8
Room C		• Elementary school • Ground floor • 18 children • Facing courtyard	8.0 x 7.0 x 5.0 = **280.0**	8.0 x 7.0 = **56.0**	16
Room D		• University • Second floor • 32 students • Facing courtyard	13.5 x 7.0 x 3.85 = **363.825**	13.5 x 7.0 = **94.5**	20

Figure 1. The basic properties and measurement points of the evaluated classrooms.

Figure 1 shows that Room A is a classroom used for the education of 20 elementary school children, which is significantly burdened by the noise of the neighbouring rooms and the courtyard. It is covered with PVC floor and it has two windows located on the back wall facing the teacher in good condition but not soundproof plastic. Room B is a small university classroom on the second floor, with a PVC floor and outdated single-layer glass windows. It is heavily burdened with traffic noise (above the limit values: the limit value for traffic noise is 60 dB [67]. During the measurements, a value of 72 dB was observed at the receiver point). Room C is a much larger room for elementary school students. It has three huge windows located on the right side of the teacher. The floor is parquet, the lower 1.5 meters of the walls are covered with wainscoting, the windows are very outdated (single-glazed windows). Room D was originally designed for laboratory demonstrations, nevertheless it is also used for regular classes. It is tiled to a height of two meters, and the floor is an epoxy concrete floor, therefore it feels extremely echoing and the windows are modern three-layer plastic. Measurements were carried out in empty classrooms, therefore the position-dependent sound absorption [68] from the human body is neglected. The effect of the students in group work is not evaluated [69], only the instructional situation, in other words, the intelligibility of the teacher's speech in different student locations.

The compensation strategies and the steps required for the analysis are summarized in **Figure 2**. The reverberation time, background noise (outdoor and indoor) and source noise were measured at the measurement points indicated in **Figure 1**. The measurements were carried out by a noise- and vibration control expert with a Sinus Messtechnik Gmbh Soundbook MK2 8-channel first accuracy class authenticated measuring instrument according to the IEC 61672-1:2013 international standard [70]. The temperature and humidity were similar during the measurements of the classrooms, so their effects were not taken into account in the propagation calculations.

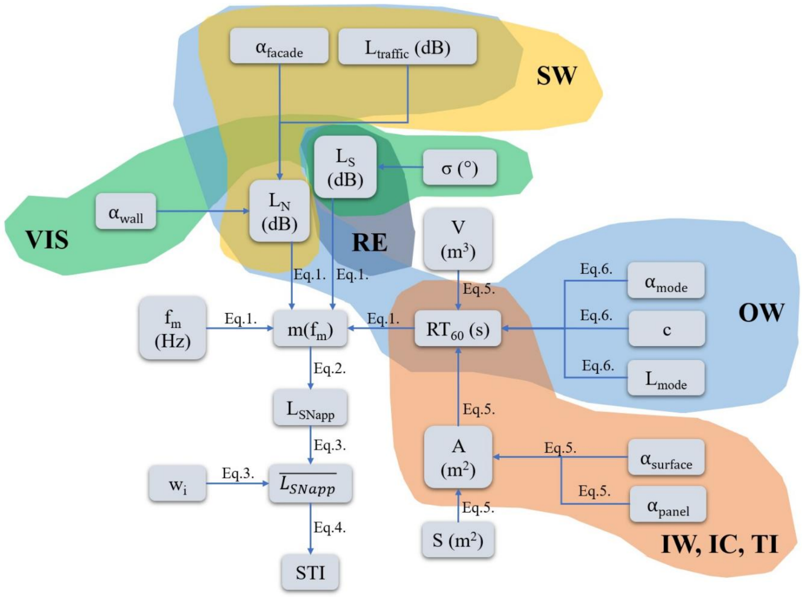


Figure 2. The workflow of the identification of acoustic characteristics of classrooms including the proposed compensation scenarios.

In **Figure 2**, the variables that are perturbed in different compensation scenarios are marked with a colored background and the equations used for the calculations are also indicated. The evaluated compensation scenarios for classrooms with poor acoustic characteristics are the following:

1. **Baseline (BASE):** No action option based on the site measurements.
2. **Back wall installation with sound-absorbing material (IW):** reduces the reverberation time and possibly the noise of the neighboring classroom.
3. **Ceiling with sound-absorbing material (IC):** reduces the reverberation time and in the case of a multi-storey building, decreases the sound propagation in structures.
4. **Sound-absorbing ceiling & back wall (TI):** the combination of Scenario 1 & 2, it means the optimal insulation of classroom with significant decrease in flanking transmission and sound propagation in structures.
5. **Soundproof windows (SW):** decrease the background noise level, especially the traffic noise, which is the main noise pollution source in urban areas.
6. **Teacher turns her/his back to the students (VIS):** improves early reflections and inhibits the visual support of the understanding of words.
7. **Opened windows (OW):** reduces the reverberation time but generally increases the background noise level.
8. **Raised voice effort (RE):** it increases the level of the signal, which can be local sound sources or an acoustically designed entire room system.

The presented compensation solutions can be divided into two main groups. One group is technical, which has a cost and can be implemented by renovating the classroom, these are the IW, IC, TI and SW scenarios, while the other group contains organizational scenarios that do not involve investment, these are the VIS, OW and RE scenarios.

At different points in the room, the modulation transfer function (MFT) was calculated with signal processing analysis theory, written as follows for non-impulse response speech intelligibility assessments [64]:

$$m\left(f_m\right)=\frac{1}{\sqrt{1+\left(2 \pi f_m \frac{RT_{60}}{13.8}\right)^2}} \cdot \frac{1}{1+10^{-0.1 L_{SN}}} \tag{1}$$

Where $m(f_m)$ denotes modulation reduction factor, L_{SN} stands for signal-to-noise level (dB), f_m refers to modulation frequency (Hz), RT is reverberation time (s). The apparent signal-to-noise ratio is written as below[64]:

$$L_{\text{SNapp}}=10 \log \frac{m\left(f_m\right)}{1-m\left(f_m\right)} \tag{2}$$

Where L_{SNapp} denotes apparent signal-to-noise ratio (dB), based on which the single weighted average apparent signal-to-noise ratio is expressed as below[64]:

$$\overline{L_{\text{SNapp}}}=\sum_{i=1}^7 w_i\left(L_{\text{SNapp}}\right) \tag{3}$$

Where w_i denotes weights for the evaluated octave bands. The Speech Transmission Index (STI) is calculated by the formula [64]:

$$\text{STI}=\overline{L_{\text{SNapp}}}+15/30 \tag{4}$$

The impact of the insulated ceiling, insulated back wall and total insulation was modelled as:

$$RT_{60}=\frac{0.161 \cdot V}{\sum_{i=1}^n \alpha_i \cdot S_i} \tag{5}$$

Where V denotes the room volume (m^3), α_i stands for the sound absorption coefficient of the $i-th$ surface (-) and S_i refers to the area of the $i-th$ surface (m^2).

The octave band values of an average (NRC = 0.85) absorption acoustic panel are used for the calculations. In the case of the surfaces to be insulated, the entire free surface of the back wall (except windows in Room A) is covered, while in the case of ceiling insulation, the panels are placed except for the two-meter strip above the teacher.

The improved reverberation time caused by the opened windows is calculated based on the following [71]:

$$RT_{60}=\left(\frac{L_{\text{mode}}}{c}\right) \frac{\ln\left(10^{-6}\right)}{\ln\left(1-\alpha_{\text{mode}}\right)}=\left(\frac{L_{\text{mode}}}{\ln\left(1-\alpha_{\text{mode}}\right)}\right) \frac{-13.82}{344\,\text{m}\cdot\text{s}^{-1}}=\frac{-0.04\, L_{\text{mode}}}{\ln\left(1-\alpha_{\text{mode}}\right)} \tag{6}$$

Where L_{mode} stands for mode path length (m), c refers to propagation velocity (m/s), α_{mode} denotes modal absorption coefficient (-). The absorption of the air is estimated based on the study of Wenmaekers et al. (2014) [72]. The increased background noise level was calculated based on the results of simultaneous indoor and outdoor noise measurements.

The cost of scenarios IW and IC are estimated based on the equations below, while the total cost of scenario (TI) can be modelled as the sum of the first two. In the feasibility assessment, the prices were determined on the basis of the average service and product fees in Hungary in 2023.

$$C_{\mathrm{bw}} = \frac{A_{\mathrm{bw}}}{A_p} \cdot p_p + \frac{A_{\mathrm{bw}}}{k_g} \cdot p_g + A_{\mathrm{bw}} \cdot p_w \tag{7}$$

Where C_{bw} denotes the total cost of the sound-absorbing material insulation of the back wall (€), A_{bw} stands for the area of the wall to be insulated (m^2), A_p refers to the area of the insulation panel (m^2), p_p is the cost of a panel (6.21 €), k_g stands for the mass of the required adhesive material (kg), p_g denotes the specific cost of adhesive material (7.27 €/kg) and p_w refers to specific labour fee (12.99 €/m^2).

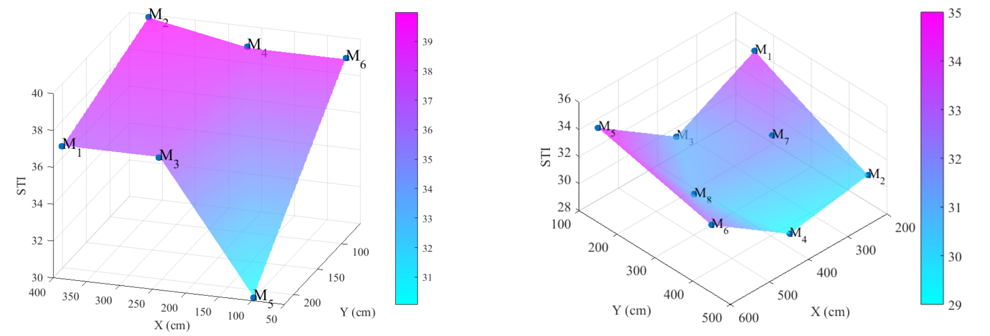
Where C_c denotes the total cost of the sound-absorbing material ceiling including the construction of a plasterboard false ceiling (€), A_c stands for the area of the ceiling (m^2), A_{pb} refers to the area of the plasterboard (m^2), p_{pb} is the cost of a plasterboard (10.98 €), l stands for the length of the room (m), w is the width of the room (m), w_{pb} is the width of the plasterboard (m), l_{CD} represents the length of the plasterboard profile (m), p_{CD} denotes the specific cost of the plasterboard profile (3.74 €), the other notations are according to the previous equation.

3. Results and discussion

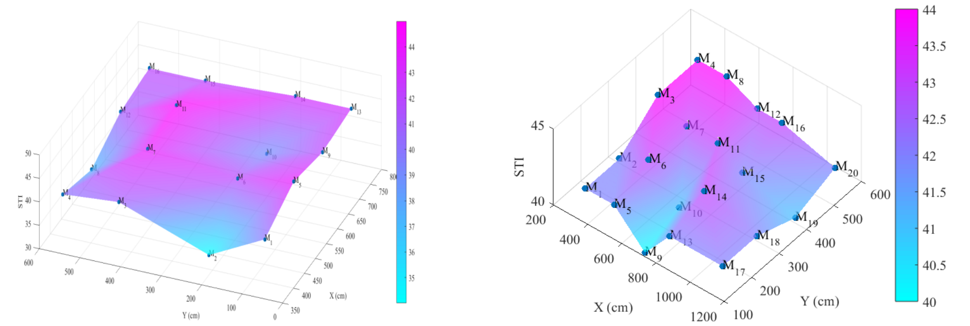
Based on the on-site measurements, the background noise, source noise and reverberation time values were determined, based on which the STI was calculated for each room as a BASELINE scenario. It is important to highlight that the variability of the STI in the rooms is also a typical acoustic characteristic, therefore the spatial pattern of the Speech Transmission Index based on the measured values is presented in **Figure 3**.

Figure 3a shows that of the six measurement points of Room A, five belong to the poor and 1 to the bad quality categories. The range of STI values is 0.1 (10%). In Room B 2 points are in the bad category, while six points are poor (**Figure 3b**) and the range of the data is 0.06 (6 %). In Room C all of the 16 measurement points belong to the poor category (**Figure 3c**) and the range is 0.11 (11 %). Room D has 20 poor points (**Figure 3d**), nevertheless the range of the STI is only 0.04 (4%). On the basis of **Figure 3**, it can be concluded that all the examined classrooms are in poor or bad quality categories in terms of speech intelligibility, so their development is essential to achieve quality education. Based on the measurement and modelling results all 7 proposed compensation scenarios were prepared for all four examined classrooms, the results of which are presented in detail for all observation points in the cluster grams in **Figure 4**.

In terms of compensation scenarios, it can generally be said that the most effective improvement can be achieved by insulating the ceiling and back wall as well. However, in the case of organizational scenarios, the result is more nuanced than this, which is why it is important to emphasize that which solution may be appropriate depends on the acoustic conditions of the given classroom.

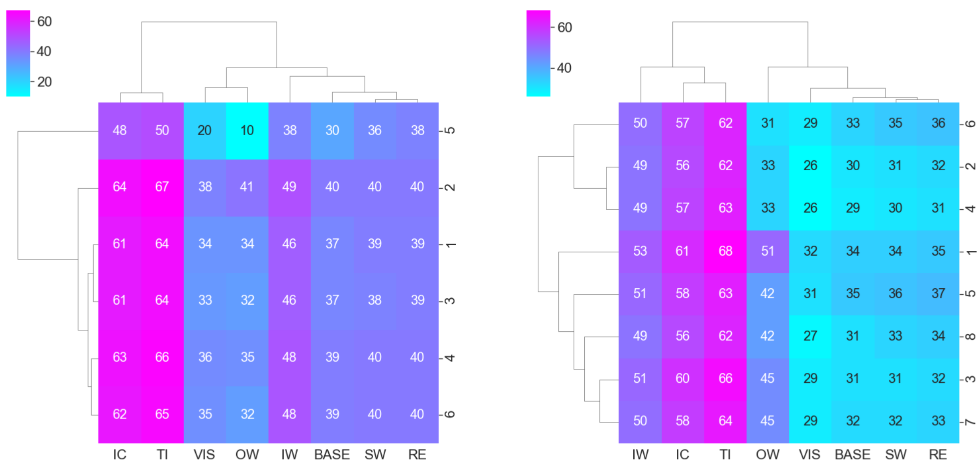


(a) Room A (STI_{max} = 0.40, STI_{min} = 0.30). **(b)** Room B (STI_{max} = 0.35, STI_{min} = 0.29).



(c) Room C (STI_{max} = 0.45, STI_{min} = 0.34). **(d)** Room D (STI_{max} = 0.44, STI_{min} = 0.40).

Figure 3. 3D representation of the spatial distribution of the STI percentages based on the measurements (BASELINE scenario): **(a)** Room A; **(b)** Room B; **(c)** Room C ; **(d)** Room D.



(a) Room A (STI_{max} = 0.67, STI_{min} = 0.10). **(b)** Room B (STI_{max} = 0.68, STI_{min} = 0.26).

Figure 4. The improvements in the STI values expressed in percentages based on the proposed compensation scenarios for: **(a)** Room A; **(b)**Room B.
Note: The abbreviations at the bottom of the subfigures correspond to the scenarios presented in the Methods Section.

In the smallest room (Room A), the measuring point M5, located at the end of the room, cannot be classified as good even with total insulation (TI), the reason being that there is a gap in the slab through which high background noise burdens the local environment of this observation point. In this case, the improvement of the building structure can help to improve the falling point M_5, the deterioration caused by the open window (OW) can also be attributed to the high background noise filtering in from outside, so among the organizational scenarios, we can recommend the frontal position and visibility (VIS) of the teacher (**Figure 4a**).

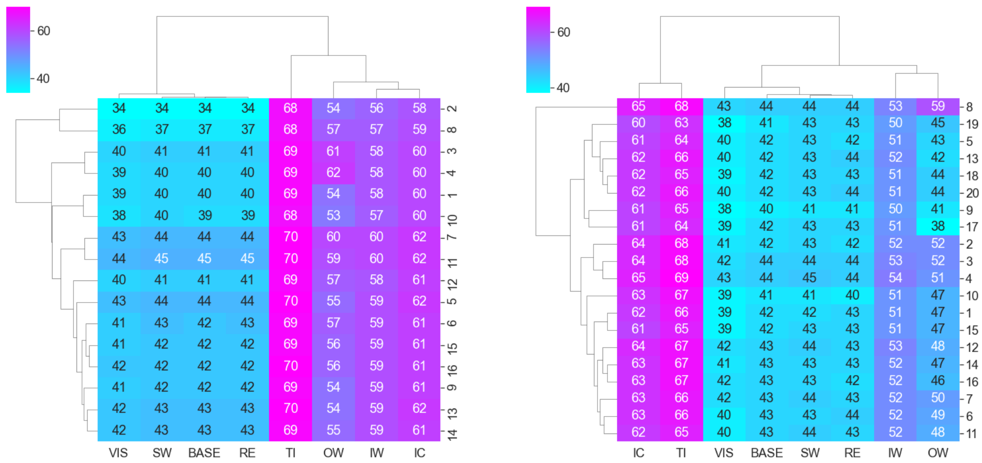
However, in the case of Room B, the open window scenario (OW) improves speech transmission at almost all points by an average of 8%, which is supported by the more favourable reverberation time. It is important to add that the increased background noise does not shift the SNR value so much that it would significantly disturb the Speech Transmission Index. In this room, with the insulation of the back wall (IW), all observation points are fair, while with total insulation (TI), all points would belong to the good STI category according to the ISO 9921:2003 classification (**Figure 4b**). The small effect of background noise is also shown by the fact that an average improvement of 1% can be achieved with soundproof windows (SW), so replacing windows is not recommended for this classroom.

The efficiency of the open windows is most striking in the case of Room C, where the STI improves by an average of 15% using this organizational scenario (OW). In this case, too, the change is due to the development of the SNR values, which is also supported by the fact that the speech transmission does not change at any observation point when the teacher's voice is raised (RE) or soundproof windows (SW) are installed. This compensation improves all points to at least the fair category, and even two points (M_3 & M_4) are to the good category (**Figure 5a**). It is important to point out that the open window compensation can only be applied if the weather conditions allow it, so this scenario can be used intermittently. During cold periods (or extremely warm periods), this solution is not possible because of the thermal comfort. With the total insulation scenario (TI), all points can be improved to the good category here as well (**Figure 5a**).

The speech transmission of the largest examined room (Room D) also changes favourably when we open the windows (OW), which corresponds to an average improvement of 5 %. At one point (M17) the acoustic characteristics deteriorate, but there are usually no students at the end of the room, so there are no seats. It follows that in the case of Room D, we recommend the use of open windows during the sessions. The insulation of the ceiling (IC) of Room D results a significant improvement in the STI (average: 21 %), so it changes to the good category in all actively used observation points (only M_{19} is fair). A further average improvement of 3 % can be achieved with the total insulation (TI) scenario (**Figure 5b**).

In addition, it is worth looking at the costs of the technical solutions, which are summarized in **Figure 6**. In this context, the costs of the different compensation scenarios can be seen in two ways, namely the specific cost of the improvement of STI value by 0.01 in euros on a logarithmic scale proportional to the length of the columns, while the total implementation costs in euros are written on the columns.

Figure 6 shows that in terms of cost-benefit, the insulation of the back wall (IW) is the most favourable scenario for all rooms, but it is important to emphasize that if the goal is a good STI category, this solution is usually not sufficient (the Speech Transmission Indices of the rooms can be improved to fair), so to achieve the good category it requires the implementation of the ceiling scenario (IC) or total insulation (TI). In general, to increase STI by 1%, replacing the windows is the least cost-effective, but this solution also has a role in reducing heating energy loss, so it is recommended to take these co-benefits into account when making a decision.



(a) Room C (STI_{max} = 0.70, STI_{min} = 0.34). **(b)** Room D (STI_{max} = 0.38, STI_{min} = 0.69).

Figure 5. The improvements in the STI values expressed in percentages based on the proposed compensation scenarios for: **(a)** Room C; **(b)** Room D.
Note: The abbreviations at the bottom of the subfigures correspond to the scenarios presented in the Methods Section.

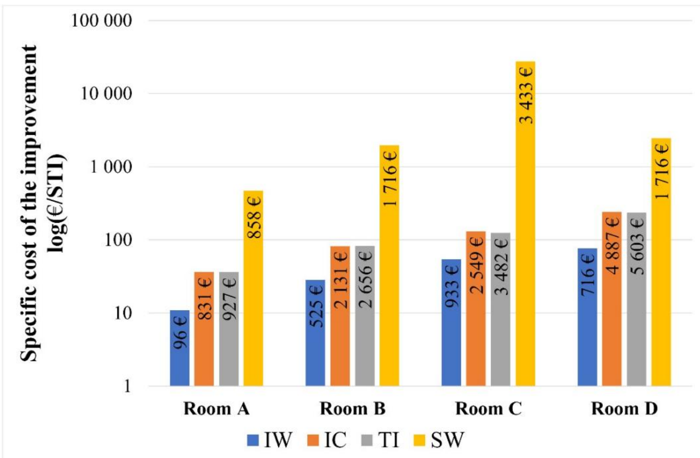


Figure 6. The specific cost (€/STI) and the total cost of the proposed compensation scenarios.

To achieve better speech intelligibility in classrooms the following suggestions can be stated:

- When designing the classrooms, an acoustic specialist should be involved.
- When renovating existing classrooms, it is beneficial to choose materials with a more favourable absorption coefficient (α).
- Tiles and hard materials with smooth surfaces that favour echoes should be avoided.
- Insulation could be an effective option for improving speech intelligibility, however, proper sizing and design is important.
- It is important to inform the teachers and to have the optimal location during the sessions.
- Organizational measures (opening windows, visual contribution, sound system) can also contribute to improving the acoustic quality of classes.

- Important exams (e.g. language exam, graduation, final exam) must be organized in rooms with the best acoustic characteristics.

The limitation of the research is that the results are based on a single-day measurement, rather than a long-time series of noise data, therefore, the weekly and seasonal characteristics of traffic noise—which is the dominant pollution source—are not taken into account. The measurements were carried out in empty classrooms, which is favorable for planning purposes, however, the effects of noise generated by students and body absorption are not taken into account. Simultaneous long-time series real-time measurements can contribute to a better understanding of speech intelligibility, the combination of these with the recording and processing of the teacher's voice with artificial intelligence algorithms could provide further opportunities for exploring the possibilities of organizational solutions, the foundations of which were laid in this research.

4. Conclusion

In most cases, the classrooms lack the integration of acoustic planning aspects, so speech intelligibility in lessons falls short of expectations. The values of the Speech Transmission Index (STI) of the examined classrooms supported the decidedly unfavorable state, to counterbalance which we proposed four technical and three organizational scenarios. It has been shown that insulation solutions are effective tools for reducing the reverberation time and STIs, and at the same time, the role of the teacher can also contribute to improving the acoustic characteristics by using open windows, adequate visibility or loudspeakers, which do not require investment. During the planning of classrooms, acoustic aspects must be enforced, and when renovating existing classrooms, efforts must be made to use coverings and materials with more favourable acoustic properties. If teachers have basic knowledge about the acoustics of speech intelligibility, they can contribute to increasing the students' class experience by properly organizing classroom design and work. The aim of the research was to explore the optimization possibilities of the objective acoustic parameters, however, an important task would also be to analyze the effect of the lessons and the components of speech, for which speech emotion recognition and pattern mining Artificial Intelligence (AI) tools provide an exciting opportunity, thus we can get a comprehensive picture of the contribution of subjective acoustic elements as well.

Author contributions: Conceptualization, VS and DS; methodology, VS, DS and ED; software, VS and ED; validation, VS and ED; formal analysis, VS; investigation, VS and DS; resources, VS and ED; data curation, VS and DS; writing---original draft preparation, VS and DS; writing---review and editing, VS, DS and ED; visualization, VS; supervision, ED; All authors reviewed the results and approved the final version of the manuscript.

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Data availability statement: The data that support the findings of this study are available from the Corresponding Author, [VS], upon reasonable request.

Conflict of interest: The authors declare no conflicts of interest to report regarding the present study.

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