DOI: 10.61782/fa.2025.0251

CONTRIBUTION TO THE MEASUREMENT AND ASSESSMENT OF INDOOR UNIVERSITY SOUNDSCAPES: A CLASSROOM EXPERIENCE

Jerónimo Vida Manzano[1*] **Rafael García-Quesada**[2] **José Antonio Almagro-Pastor**[3]
[1] Department of Applied Physics, University of Granada, Granada, Spain
[2] Higher Technical School of Architecture, University of Granada, Granada, Spain
[3] Acoustic Anechoic Chamber (CIC-UGR), University of Granada, Granada, Spain

ABSTRACT

Indoor soundscape measurement and assessment is an emerging discipline currently growing in parallel with outdoor soundscape assessment, driven equally by research adding new knowledge and standardisation harmonising methods and analysis techniques. While traditional indoor acoustic assessment has focused on the characteristics of the construction and the quality of the environment in relation to the final use of spaces, little attention has been paid to the perception of the acoustic climate by the people who occupy those spaces, i.e. the user's own opinion in context. Following the development of the ISO 12913 standard for urban soundscape assessment, great efforts are currently being made to find the best method for measuring and analysing indoor soundscapes to determine the perceived affective quality of the places where people live and work. The consideration of users' opinions in the construction and design of indoor spaces would contribute to the improvement of their own quality of life. In educational and research environments, this would also contribute to better teaching and more effective results. In this paper, we present the first results of exploring these new techniques and proposals in a university classroom over the course of a quarter.

Keywords: *indoor, soundscape, teaching acoustic climate, students' perception, context.*

[*]***Corresponding author***: jvida@ugr.es

1. INTRODUCTION

Indoor soundscape research focuses on the study of the sound environment in enclosed spaces and how it affects human well-being, behaviour and performance. This research is also closely linked to health-related studies, particularly in the fields of environmental psychology and occupational health. By studying how sound affects stress, sleep quality and general mental health, researchers can provide evidence-based recommendations to improve living and working conditions, circumstances that have contributed to increased interest in this discipline and the development of assessment methods [1-2].

The university environment is a particularly interesting place to study how sound affects academic performance, well-being and social interactions, although studies have traditionally tended to focus on the outdoor soundscape [3-4] or at the undergraduate level [5]. The evaluation of indoor soundscapes in universities is particularly appropriate for many reasons, such as the variety of indoor environments, the large and diverse student population, the possibility of longitudinal studies and control of experimental variables, the often existing access to advanced technologies that can assist in the evaluation, interdisciplinary collaborations or, most importantly, the relevance and direct impact of research results on campus design, student well-being and academic performance. By measuring and evaluating university indoor spaces, institutions can identify areas for improvement and implement strategies to reduce noise pollution and promote a more effective and enjoyable university experience understanding how sound affects activities and the overall campus environment.

In this context, indoor classroom soundscape research focuses on studying the acoustic environment of classrooms and how it affects learning, behaviour and general well-being. Given that sound plays a significant role in shaping the educational experience, this area of research has gained attention in recent years, particularly in relation to student performance, cognitive function and teacher-student interaction [6]. Following the publication of the ISO 12913 standard for the assessment of outdoor soundscapes [7-10], new approaches to the assessment of indoor acoustic environments are emerging [11-13]. The ISO12913 *Perceived Affective Quality* (PAQ) and Torresin et. al. models [9] [12] currently represent two possible ways of carrying out indoor assessments. Based on this, the research questions that motivate this work are as follows:

a) RQ1: investigate the sound levels produced by the usual sound sources in a classroom during a lesson through experimental measurements.
b) RQ2: investigate the main acoustic factors that affect how students perceive the classroom sound environment.
c) RQ3: explore the differences in the application of the ISO12913 and Torresin et al. perception models for the assessment of indoor soundscapes.

2. MATERIAL AND METHOD

2.1 General procedure

Coinciding with the start of the "Environmental Noise" course in the second year of the Environmental Sciences degree, acoustic measurements were conducted in classroom C21 of the Faculty of Science in November and December 2024 and concurrent opinion polls of the students attending the classes taught during this period, both the morning group (Group 2A) and the afternoon group (Group 2B).

Following the procedure recommended in the ISO12913-2 standard [8] for recording acoustic soundscape measurements, binaural audio recordings were made using a SQOBOLD device and noise indices and psychoacoustic parameters were estimated using Artemis software, both from HEAD acoustics. In all recordings, both during the morning and during the afternoon, the ambient temperature and humidity conditions of the classroom were kept identical by means of automatic climate control in the room.

The two access doors and the eight big rear windows in the classroom were also kept in the same position, always closed. Small upper windows on one side were just for light purposes and could not be opened (see photos). Occasionally, at the time of the lessons in classroom C21, the outside noise included sounds from teaching activities in nearby classrooms and from sporting activities taking place in nearby sports facilities on campus. When these sounds occurred, they were always sporadic, unplanned and discontinuous, and never interfered with the teaching activity. Figures 1 and 2 show a general view of the classroom and the outside. The photographs are taken from the back to preserve the identity of the students.

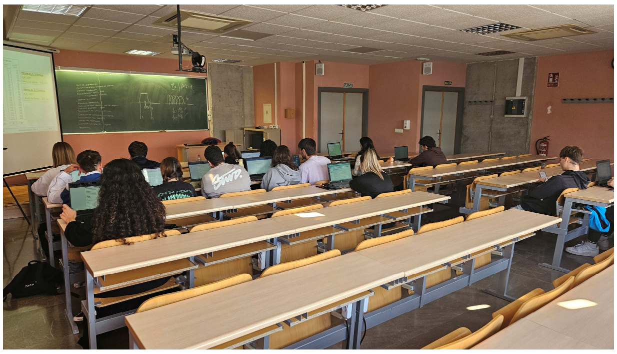

Figure 1. Rear view of classroom C21 showing closed doors, blackboard and overhead projector (photo taken the 19.11.2024, group 2A at 12.36h)

Figure 2. Closed back big windows in classroom C21 showing adjacent university sports installations (photo taken the 27.11.2024, group 2A at 12.10h)

The soundscape survey was conducted using an online questionnaire by means of Google Forms that included standardized questions following Method A and B in ISO12913-2 [7]. During the second half of the research period, in addition to the ISO12913 PAQ model, the questionnaire included an additional question using Torresin et al emotional model [12]. This was done in order to differentiate the responses using both models taking care that students had become somewhat familiar with the research objective but without noticing that they were actually being asked about the same thing but in a different way.

2.2 Participants

The participants were always the second year Environmental Science students present in the classroom and their teacher, who also carried out the evaluation as a form of motivation. The survey was conducted in the middle of the one-hour lesson, so that the students had enough time to get familiar with the environmental conditions in the classroom. The sound sources in the classroom were always the same, corresponding to the teaching activity itself: the overhead projector, the air conditioning and the teacher's oral presentation together with occasional students' interventions asking or commenting the content of the lesson being taught.

The measurement campaign was carried out over a period of 15 days, from the 4th of November to the 16^{th} of December, both in the morning group (2A) from 12-13h and in the afternoon group (2B) from 16-17h. The standard survey including the ISO12913-2 PAQ model was carried out during the first 8 days. The extended survey, including both the Torresin et al. model and the ISO12913-2 PAQ model, started the 25th of November for the last 7 days of the measuring period. A total of 336 answers were registered, 188 in group 2A (51%) and 178 in group 2B (49%) with an overall 62% and 38% of female and male participation respectively, as shown in Table 1 where ISO header means standard questionnaire and “Torresin+” the extended questionnaire as explained above.

Table 1. Summary distribution of survey participants.

2ºA	ISO		Torresin+		Σ		% total
Questionnaires	**120**	**64%**	**68**	**36%**	**188**		**51%**
Female	*76*		*38*		*114*	*61%*	
Male	*44*		*30*		*74*	*39%*	
2ºB	ISO		Torresin+		Σ		**% total**
Questionnaires	**100**	**56%**	**78**	**44%**	**178**		**49%**
Female	*63*		*51*		*114*	*64%*	
Male	*37*		*27*		*64*	*36%*	
TOTAL	ISO		Torresin+		Σ		**% total**
Questionnaires	**220**	**60%**	**146**	**40%**	**366**		**100%**
Female	*139*		*89*		*228*	*62%*	
Male	*81*		*57*		*138*	*38%*	

The participation of the students in filling in the perception questionnaires was more or less similar on all days of the experiment. Although the official number of students enrolled in the course is around 35 in each group, attendance is usually 50% at best. As completion of the survey is voluntary, the number of responses collected each day does not correspond to the number of students present in the classroom at the time of evaluation. The participation was more or less constant and stable throughout the measurement and survey period, with a similar distribution and characteristics of participants in both groups.

2.3 Questionnaire

The online questionnaire for the assessment in context was formulated on the basis of previous research on urban soundscape in the city of Granada [14]. A total of 10 questions were selected for the indoor soundscape study following a combination of Method A and B in the ISO12913-2 standard: three for sample size, sex distribution and self-reported mental well-being and seven focused on the indoor soundscape evaluation itself as follows:

Qa. Age
Qb. Sex
Qc. WHO Well Being Index (5 dimensions)
Q1. Sound source dominance (4 items)
Q2. ISO PAQ model (8 dimensions)
Q3. Overall soundscape appraisal
Q4. Overall soundscape appropriateness
Q5. How loud is present acoustic ambient
Q6. Overall soundscape tranquillity
Q7. How pleasant is present acoustic ambient

As mentioned before, from the 25^{th} of November and on the affective model proposed by Torresin et al. was added to the questionnaire as an extra eight last question:

Q8. Torresin et al. model (8 dimensions)

As both the ISO12913 PAQ and Torresin et al. models are originally formulated in English, the Soundscape Attributes Translation Project (SATP) proposal for Spanish [15-16] was used for the ISO12913 PAQ model and a free translation of the Torresin et al. model was included in the survey. Table 2 shows the eight dimensions originally formulated in English and the translation into Spanish used in this study.

Table 2. ISO12913 PAQ vs Torresin et al. Models

ISO 12913 PAQ model *(original English)*	**ISO 12913 PAQ model Spanish SATP** *(synonymous)*	**Torresin et al model** *(original English)*	**Torresin et al model Spanish** *(free trasnlation)*
1 pleasant (p)	**1 agradable *(placentero)***	1 comfortable (c)	**1 cómodo**
2 chaotic (ch)	**2 caótico *(confuso)***	2 intrusive, uncontrolled (iu)	**2 intrusivo (descontrolado)**
3 vibrant (v)	**3 estimulante *(vibrante)***	3 engaging (en)	**3 sugestivo**
4 uneventful (u)	**4 sin actividad *(estático)***	4 empty (em)	**4 sin contenido**
5 calm (ca)	**5 calmado *(tranquilo)***	5 private, controlled (pc)	**5 reservado (controlado)**
6 annoying (a)	**6 desagradable *(molesto)***	6 annoying (a)	**6 desagradable**
7 eventful (e)	**7 con actividad *(dinámico)***	7 full of content (f)	**7 lleno de contenido**
8 monotonous (m)	**8 monótono *(aburrido)***	8 detached (d)	**8 disuasivo**

2.4 Acoustic data

At the same time as the survey was being answered, three-minute acoustic measurements were registered by means of HEAD acoustic SQobold equipment. A total of 30 recordings were made in the classroom, 15 in each period (morning and afternoon). The corresponding hdf files were then analysed using HEAD acoustic's Artemis software, following the same criteria as the one used in outdoor soundscape research as recommended by ISO 12913-3 [9] to estimate the noise indices and the psychoacoustic parameters. Results are summarized in next section.

2.5 Data analysis

The responses to the perception questionnaires were processed according to the ISO12913-3 standard [9]. For the affective response, in the case of the ISO12913 PAQ model the eight dimensions (see Table 2) were used to calculate the *Pleasantness (P)* and *Eventfulness (E)* coordinates according to the following expressions:

$$P = [(p - a)+(ca - ch)x\cos 45^o+(v - m)x\cos 45^o]/9.657 \quad (1)$$

$$E = [(e - u)+(ch - ca)x\cos 45^o+(v - m)x\cos 45^o]/9.657 \quad (2)$$

In the case of the Torresin et al. model, the equivalent *Comfort (Comf)* and *Content (Cont)* coordinates were estimated from the eight dimensions (see Table 2) according to the expressions:

$$Comfort=[(c-a)+(pc-iu)x\cos 45^o+(en-d)x\cos 45^o]/9.657 \quad (3)$$

$$Content=[(f-em)+(iu-pc)x\cos 45^o+(en-d)x\cos 45^o]/9.657 \quad (4)$$

where factor 9.657 causes results to fall within [+1, -1].

Statistical description and analysis of other data, including possible associations (Pearson and Spearman correlations) and tests for differences between paired samples (Mann-Whitney U tests), was performed running the appropriate routine in Origin 2024 software.

3. RESULTS

The results obtained are presented below. The objective assessment of the classroom acoustic environment by means of sound level measurements and subsequent calculation of noise and psychoacoustic indices is presented first. The concurrent subjective assessment from the questionnaires completed in the classroom is presented later.

3.1 Sample age and gender characteristics

As mentioned above, the sample consists of 336 responses, 188 from group 2A and 178 from group 2B. The gender distribution is shown in Table 2, with an overall distribution of around 60% females and 40% males, which is common among Environmental Science students at UGR.

The mean age of group 2A is 24.5 years (*sdev=11.13, sem=0.81*) and that of group 2B 24.7 years (*sdev=11.14, sem=0.83*). This overall age and sex distribution was essentially the same during each one of the 15 days of evaluation and experimental measurements.

3.2 Acoustic measurements

The noise indices estimated from the three-minutes sound level recordings during the morning group (2A) and afternoon group (2B) lessons are presented in Tables 3 and 4 below. Again, it should be noted that different students participate in groups 2A and 2B, even from one day to the next, but the same classroom (C21) is used in both periods, so that the only change in environmental conditions is due to the date, the time of day and the normal teaching activity (sounds coming from C21 exterior, both outside and the rest of the building where it belongs) during these periods at the University of Granada. For some indices, the maximum values are marked in red and the minimum in green.

Table 3. Noise indices in dBA at C21 classroom during the morning period (2A, lessons from 12-13h)

Date	L(A)	Min(A)	Max(A)	L10(A)	L50(A)	L90(A)	L10-L90 (A)
04/11/2024	**76,7**	49,1	**91,7**	82,0	54,2	50,1	**31,9**
05/11/2024	74,9	49,9	91,0	79,3	52,9	**51,1**	28,3
06/11/2024	69,6	**44,4**	88,9	72,1	48,6	46,0	26,1
11/11/2024	64,2	47,7	79,5	69,1	50,5	48,8	**20,3**
12/11/2024	68,5	45,8	85,8	72,9	50,5	47,5	25,4
18/11/2024	69,5	45,3	88,4	73,1	48,8	46,3	26,8
19/11/2024	63,4	44,7	83,8	66,2	48,1	45,8	20,4
20/11/2024	70,6	47,2	89,0	74,7	51,8	48,8	25,9
25/11/2024	66,5	46,4	84,2	71,3	48,8	47,1	24,1
26/11/2024	64,7	44,6	90,5	68,5	47,5	**45,8**	22,7
27/11/2024	**62,9**	44,9	81,8	67,2	48,6	46,0	21,2
02/12/2024	70,7	47,9	86,6	75,8	53,3	49,3	26,5
10/12/2024	64,7	46,4	82,0	68,7	49,2	47,7	21,0
11/12/2024	69,3	44,6	85,9	74,1	50,4	45,8	28,4
16/12/2024	69,8	46,8	86,2	74,7	51,6	48,3	26,4

Table 4. Noise indices in dBA at C21 classroom during the afternoon period (2B, lessons from 16-17h)

Date	L(A)	Min(A)	Max(A)	L10(A)	L50(A)	L90(A)	L10-L90 (A)
04/11/2024	68,5	49,8	81,3	73,2	62,8	50,7	22,5
05/11/2024	74,0	52,9	89,3	78,5	55,9	**54,3**	24,2
06/11/2024	**62,1**	48,4	76,4	66,4	53,4	49,5	**16,9**
11/11/2024	65,2	47,4	79,2	70,5	50,2	48,3	22,2
12/11/2024	71,0	50,7	85,4	75,2	55,9	51,9	23,3
18/11/2024	73,1	45,7	**96,2**	77,0	50,8	47,1	**29,9**
19/11/2024	62,4	**43,7**	81,3	65,8	47,5	46,0	19,8
20/11/2024	**75,1**	51,8	95,0	79,8	55,6	53,7	26,1
25/11/2024	67,1	45,0	84,9	71,0	48,5	**46,0**	25,0
26/11/2024	66,8	49,8	83,2	71,7	53,8	51,4	20,3
27/11/2024	65,2	45,4	80,1	70,1	52,6	46,9	23,2
02/12/2024	71,6	47,0	90,6	76,0	51,9	48,3	27,7
10/12/2024	66,4	45,4	85,5	70,5	47,7	46,5	24,0
11/12/2024	71,0	46,1	85,8	75,5	51,4	47,1	28,3
16/12/2024	70,6	44,8	89,2	74,3	53,5	45,8	28,6

3.3 Psychoacoustic parameters

As previously mentioned, the psychoacoustic parameters were calculated from the three-minute recordings using the HEAD acoustic Artemis software. Summary results are presented in Tables 5 and 6 below for the morning and evening groups respectively. Sensory Pleasantness (SP) and Psychoacoustic Annoyance (PA) in Table 7 were calculated according to Zwicker and Fast method [17]

Table 5. Psychoacoustic parameters during the morning period (2A, lessons from 12-13h)

Date	N5	N95	N5/N95	S	R	F	T
		(soneGF)		(acum)	(asper)	(vacil)	(tuHMS)
04/11/2024	41,5	5,9	7,0	0,95	0,66	0,16	0,37
05/11/2024	37,2	6,0	6,2	0,89	0,58	0,11	0,27
06/11/2024	26,2	4,2	6,3	1,01	0,58	0,08	0,22
11/11/2024	21,8	5,8	3,8	0,95	0,48	0,04	0,21
12/11/2024	24,8	4,8	5,2	1,00	0,59	0,11	0,20
18/11/2024	27,3	4,4	6,2	1,04	0,53	0,09	0,22
19/11/2024	19,0	4,6	4,1	1,03	0,56	0,04	0,15
20/11/2024	28,6	5,7	5,0	1,04	0,58	0,09	0,23
25/11/2024	23,1	5,3	4,3	1,03	0,63	0,09	0,23
26/11/2024	20,1	4,8	4,2	1,12	0,59	0,07	0,17
27/11/2024	19,1	4,9	3,9	1,13	0,50	0,06	0,22
02/12/2024	29,8	5,7	5,2	1,03	0,72	0,11	0,30
10/12/2024	21,7	5,5	3,9	1,13	0,56	0,05	0,20
11/12/2024	27,1	4,6	5,8	1,02	0,75	0,13	0,27
16/12/2024	29,5	5,3	5,6	1,03	0,69	0,11	0,41

Table 6. Psychoacoustic parameters during the afternoon period (2B, lessons from 16-17h)

Date	N5	N95	N5/N95	S	R	F	T
		(soneGF)		(acum)	(asper)	(vacil)	(tuHMS)
04/11/2024	25,2	6,3	4,0	0,97	0,42	0,10	0,34
05/11/2024	36,6	7,5	4,9	0,90	0,65	0,11	0,39
06/11/2024	18,6	5,7	3,3	1,06	0,31	0,04	0,21
11/11/2024	22,3	5,3	4,2	0,98	0,65	0,08	0,28
12/11/2024	29,9	6,3	4,8	0,91	0,61	0,13	0,46
18/11/2024	34,0	4,6	7,5	1,00	0,65	0,12	0,31
19/11/2024	18,1	4,4	4,1	1,03	0,48	0,06	0,22
20/11/2024	38,5	7,8	4,9	0,95	0,60	0,11	0,37
25/11/2024	24,6	4,9	5,0	1,11	0,62	0,08	0,26
26/11/2024	25,6	6,8	3,7	1,06	0,60	0,07	0,33
27/11/2024	22,8	5,1	4,5	1,07	0,63	0,09	0,27
02/12/2024	31,2	5,3	5,9	1,06	0,69	0,10	0,29
10/12/2024	23,1	4,9	4,8	1,02	0,63	0,06	0,19
11/12/2024	29,2	5,1	5,7	0,99	0,77	0,14	0,28
16/12/2024	28,3	4,7	6,1	1,07	0,74	0,11	0,29

Table 7. Daily Sensory Pleasantness (SP) and Psychoacoustic Annoyance (PA) for 2A and 2B

Date	eval 2A	SP	PA	eval 2B	SP	PA
04/11/2024	A1	0,03	50,87	B1	0,07	29,64
05/11/2024	A2	0,03	44,70	B2	0,04	44,82
06/11/2024	A3	0,04	32,05	B3	0,07	21,16
11/11/2024	A4	0,06	25,97	B4	0,06	28,22
12/11/2024	A5	0,04	30,76	B5	0,06	36,92
18/11/2024	A6	0,04	32,94	B6	0,03	41,84
19/11/2024	A7	0,05	23,51	B7	0,07	21,91
20/11/2024	A8	0,04	34,93	B8	0,03	46,31
25/11/2024	A9	0,05	28,98	B9	0,04	30,61
26/11/2024	A10	0,04	25,17	B10	0,05	31,51
27/11/2024	A11	0,06	23,27	B11	0,05	28,65
02/12/2024	A12	0,04	37,68	B12	0,03	39,02
10/12/2024	A13	0,05	26,61	B13	0,05	28,92
11/12/2024	A14	0,04	35,00	B14	0,04	37,70
16/12/2024	A15	0,05	37,12	B15	0,04	36,24

3.4 Indoor soundscape assessment

3.4.1 Sound dominance

The analysis of the dominant sources in the classroom shows that traffic noise and natural sounds are not relevant during a lesson. However, as would be expected, human and other sources dominate. The academic activity of the teacher and students, the sound of people in the corridors outside the classroom or even the distant sound of the sports field outside contribute to this perception in different ways depending on the day (see Figure 3) but always prominently. The sound of the overhead projector and the air conditioning are included in the category 'other'.

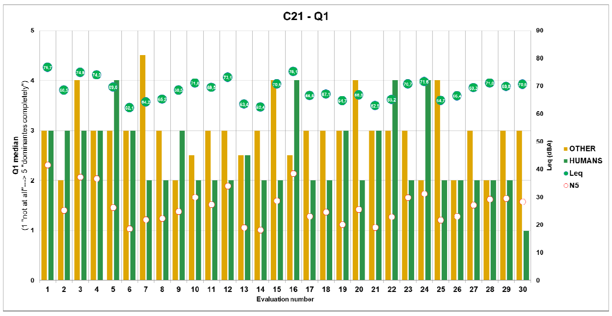

Figure 3. Median of responses to sound source dominance, noise levels (LeqA) and loudness (N5)

3.4.2 Indoor soundscape representation

The indoor acoustic environment evaluated according to the ISO12913 PAQ model shows different characteristics depending on the approach to the analysis. The affective response of each one of the 30 evaluations by means of their global (P, E) coordinates (15 at each group) can be seen in top of Figure 4. If all the individual responses are considered (188 in group 2A and 178 in group 2B, adding a total of 366), resulting (P, E) coordinates estimated with the median of all the data is shown in middle Figure 4. Under this approach, a KDE representation showing the marginal distribution of each coordinate [18], makes it easier to see in which quadrant the general perception is headed (bottom Figure 4). In this figure, solid line represents 50th percentile distribution and daily assessments as in middle Figure 4.

A similar representation of soundscape assessment using the Torresin et al. model during the last 7 days of the 15 days when measurements and surveys were made, as already explained, can be seen in Figure 5.

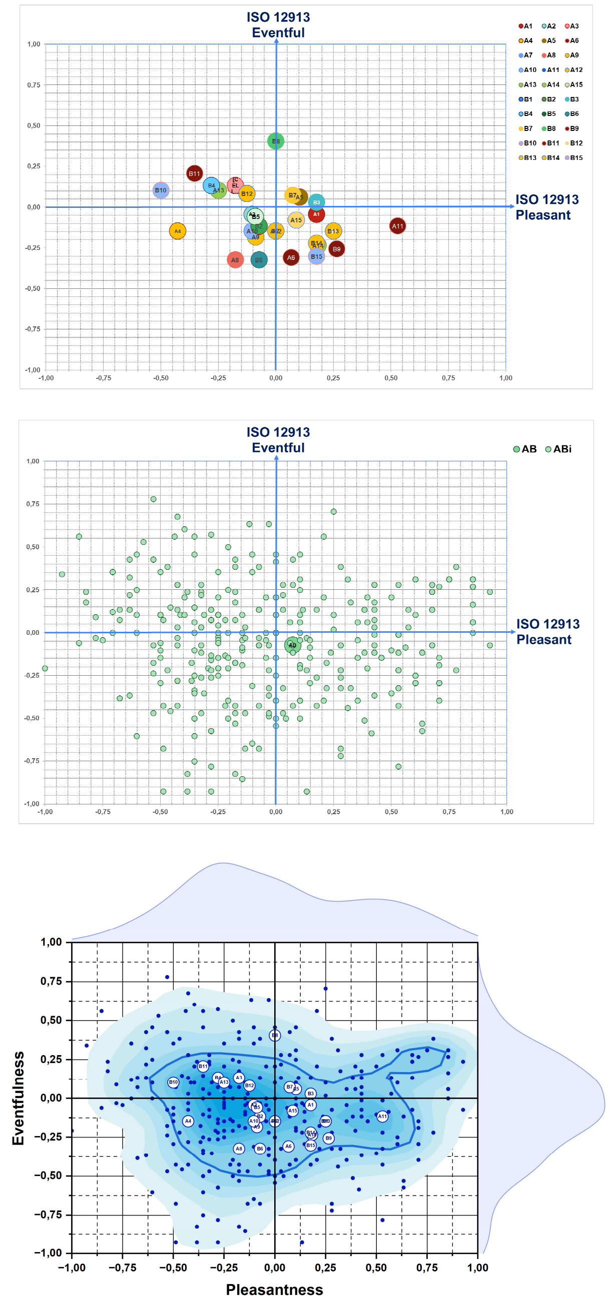

Figure 4. (top) Indoor soundscape assessment for groups 2A and 2B by means of ISO (P,E) coordinates; (middle) as in top plus the individual responses and global ISO (P,E) coordinates; (bottom) KDE scatterplot of soundscape perception by means of ISO12913 PAQ model.

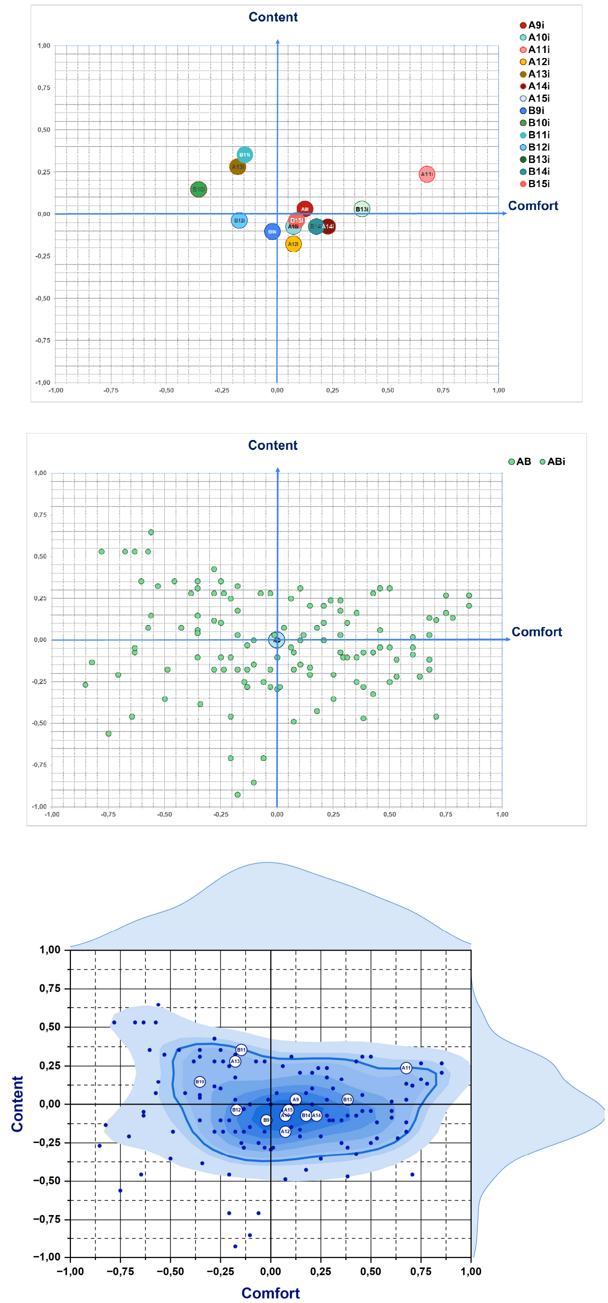

Figure 5. As in Figure 4 but assessed by Torresin et al. model: *(top)* Indoor soundscape assessment by means of (Comfort, Content) coordinates; *(middle)* including the individual responses; *(bottom)* KDE scatterplot of soundscape assessment by this model.

To better examine the differences in perceived affective quality according to the two methods, the results of the 7 days when both models were included in the questionnaire are combined in Figure 6 below.

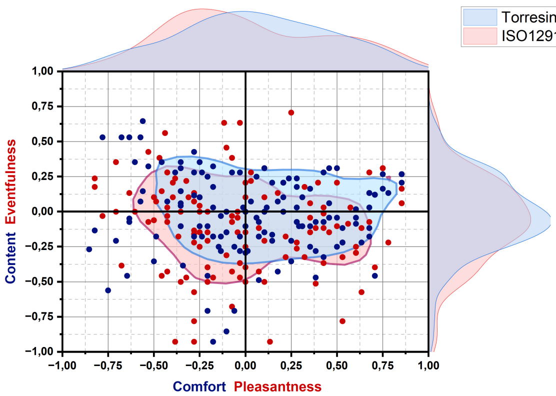

Figure 6. KDE plot of coincident assessment by means of ISO12913 and Torresin et al. models. ISO red titles, dots and surfaces, Torresin blue titles, dots and surfaces.

3.4.3 Overall appraisal and appropriateness

Figure 7 shows the variation of the overall assessment (Q3) and the appropriateness (Q4) of the classroom acoustic environment in terms of the median of all responses each day of measurement, as required by ISO 12913-3, together with the corresponding equivalent level and loudness values at the time of the assessment.

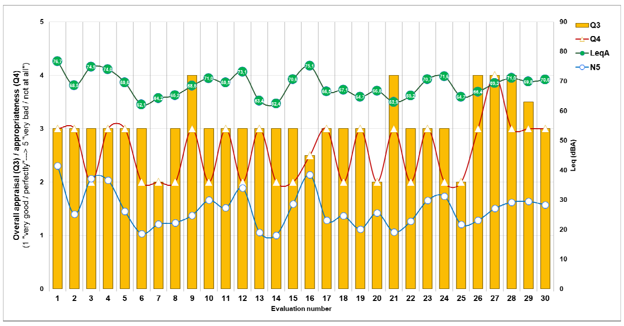

Figure 7. Median of responses about the overall appraisal and appropriateness of C21 soundscape with information on noise levels (LeqA) and loudness (N5)

4. DISCUSSION

The acoustic environment in the classroom is quite similar in the morning and in the afternoon, with very similar variations in the noise indices and magnitudes usually associated with oral communication (Tables 3 and 4). In addition, the psychoacoustic parameters do not reveal any situations of singular discomfort or pleasantness on any of the test days (Table 7). Notwithstanding the above, the daily assessment of the indoor soundscape shows changes that may indicate the influence of other factors: for example, playing football outside has a positive effect in the morning and the opposite in the afternoon (A11 and B11 dots in the upper Figure 4). Same result when applying the Torresin et al. model (A11i and B11i dots in the upper Figure 5).

As far as the global indoor soundscape assessment is concerned, the classroom lies in the middle of the emotional diagram, both with the ISO12913 and Torresin et al. models (middle, Figures 4 and 5). Individually, however, there is a large variation for each day of rehearsal and also for each of the participants (top and bottom, Figures 4 and 5). In any case, the Torresin model shows a slightly smaller spread of responses around the comfort axis, probably indicating a better assimilation of the model by the participants. Mann-Whitney U tests indicate that at the 0.05 level, coordinates [*P*] and [*Comfort*] distributions are not significantly different (U=10031, Z=-0.869) same as distributions of coordinates [*E*] and [*Content*] (U=9744, Z=-1.267) At present, this work only contributes to the use of indoor models to assess soundscapes, and has limitations related to the participation of young people and the type of test classroom, which will be addressed in future research.

5. CONCLUSIONS

The dominant sound sources during a lesson are focused on the teaching process, with much less influence from other sources on students' perception (RQ1). Keeping the physical and environmental conditions of the classroom constant, perception does not change significantly whether the class is held in the morning or in the afternoon, showing that students tend to pay more attention to the teacher's explanations than to other events (RQ2). It is possible to assess the indoor soundscape using the ISO 12913 standard, and it gives generally similar results to specific models such as that of Torresin et al. However, the Torresin evaluation seems to show a greater concentration of results, indicating an apparent better understanding of the model in this type of university spaces (RQ3).

6. ACKNOWLEDGMENTS

The authors would like to thank the students in the second year of the Environmental Sciences degree at the University of Granada for their generous and voluntary participation in this research. This research was funded by MCIN/AEI/10.13039/501100011033 and by ERDF, EU, under the ref. PID2022-141874NB-I00 project.

7. REFERENCES

[1] MR.Hossain, M.Manohare and EA.King, "Systematic review of indoor soundscape assessments: Activity-based psycho-acoustics analysis", *Building Acoustics*, vol.32, no.1, pp.123-141, 2024.

[2] Z.Al-Bayyar, PN.Dökmeci Yörükoğlu, K.Kitapci and Ö.Türker Bayrak, "Impact of indoor soundscape workshop on sound awareness of interior architecture students", *The Journal of the Acoustical Society of America*, vol.157, no.2, pp.1202-1214, 2025.

[3] S.Mancini, A.Mascolo, G.Graziuso and C.Guarnaccia, "Soundwalk, Questionnaires and Noise Measurements in a University Campus: A Soundscape Study", *Sustainability,* vol.13, no.2, pp.841, 2021.

[4] H.Touhami, D.Berkouk, T.A.K.Bouzir, S.Khelil, and M.M.Gomaa, "The Influence of Multisensory Perception on Student Outdoor Comfort in University Campus Design", *Atmosphere*, vol.16, no.2, pp.150, 2025.

[5] C.Visentin, S.Torresin, M.Pellegatti and N.Prodi, "Indoor soundscape in primary school classroom", *The Journal of the Acoustical Society of America*, vol.154, no.3, pp.1813-1826, 2023.

[6] H.Kurukose Cal, F.Aletta and J.Kang, "Association between perceived acoustic comfort and wellbeing for school teachers at work: a cross-sectional survey in the UK", in *Proc. of the Institute of Acoustics*, vol. 46, Pt 2, 2024.

[7] International Organization for Standardization. (2014). ISO 12913-1:2014 Acoustics — Soundscape — Part 1: Definition and conceptual framework. Geneva: ISO.

[8] International Organization for Standardization. (2018). ISO/TS 12913-2:2018 Acoustics — Soundscape — Part 2: Data collection and reporting requirements. Geneva: ISO.

[9] International Organization for Standardization. (2019). ISO/TS 12913-3:2019 Acoustics — Soundscape — Part 3: Data analysis. Geneva: ISO.

[10] ISO, D. ISO/TS Draft 12913-4: Acoustics — Soundscape — Part 4: Design and Intervention. (2024).

[11] S.Torresin, R.Albatici, F.Aletta, F.Babich, T.Oberman, S.Siboni and J.Kang, "Indoor soundscape assessment: A principal components model of acoustic perception in residential buildings", *Building and Environment*, vol.182, pp.1-16, 2020.

[12] S.Torresin, F.Aletta, T.Oberman, V.Vinciotti, R.Albatici and J.Kang, "Measuring, representing and analysing indoor soundscapes: A data collection campaign in residential buildings with natural and mechanical ventilation in England", *Building and Environment*, vol. 243, pp.1-17, 2023.

[13] B.West, A.Deuchars and I.Ali-MacLachlan, "Office soundscape assessment: A model of acoustic environment perception in open-plan offices", *The Journal of the Acoustical Society of America*, vol.156, no.5, pp. 2949-2959, 2024.

[14] J.Vida, J.A.Almagro, R.García-Quesada, F.Aletta, T.Oberman, A.Mitchell and J.Kang, "Urban Soundscape Assessment by Visually Impaired People: First Methodological Approach in Granada (Spain)". *Sustainability*, vol.13, no.24, pp.13867, 2021.

[15] J.Vida, J.A.Almagro, R.García-Quesada, F.Aletta, T.Oberman, A.Mitchell and J.Kang, "Soundscape attributes in Spanish: A comparison with the English version of the protocol proposed in Method A of the ISO/TS 12913–2", *Applied Acoustics*, vol.211, pp.109516, 2023.

[16] F.Aletta, A.Mitchel, T.Oberman and 54 more authors. "Soundscape descriptors in eighteen languages: translation and validation through listening experiments", *Applied Acoustics*, vol.224, pp.110109, 2024.

[17] H.Fastl and E.Zwicker. *Psycho-Acoustics Facts and Models*. Springer, New York, USA, 2017.

[18] A.Mitchell, F.Aletta and J.Kang, "How to analyse and represent quantitative soundscape data". *JASA Express Lett.*, vol.2, no.3, pp.037201, 2022.