



MADRID  
**inter.noise 2019**  
June 16 - 19

NOISE CONTROL FOR A BETTER ENVIRONMENT

## **ECONOMIC IMPACT OF ACOUSTICAL TREATMENT WITH CORK**

**Sousa, João Victor<sup>1</sup>**

**Universidad Ceuma, Campus TURU  
Avenue Luís Rei de France, 50 - Turu. São Luís MA**

**Costa, Miriany<sup>2</sup>**

**Universidad Ceuma, Campus TURU  
Avenue Luís Rei de France, 50 - Turu. São Luís MA**

**Silva, Sergio Fernando<sup>3</sup>**

**Universidad Ceuma, Campus TURU  
Avenue Luís Rei de France, 50 - Turu. São Luís MA**

### **ABSTRACT**

**This article discusses an economic comparison between the percentage of profits that an educational institution loses with the student evasion, since even in quiet spaces they only have up to 75% comprehension of every dialogued context, and the feasibility of the price of treatment implantation acoustic with cork, demonstrating the efficiency of such treatment for the growth of the institution, both economically and in educational quality and educational and business credibility. Initially, a case study was carried out, using quantitative information in percentage values lost with the students' exit, who were not exposed to acoustically adequate treatment in classrooms, and the financial result obtained with rooms within acoustic quality standards that cork provides. Thus, for this study, the institution, as well as the market consultation of the costs of the square meter necessary for the rental of cork in the internal masonry of rooms provided the institution's student tuition amounts and the amount of evasion within this period of study and research. Finally, the feasibility of this method of implantation will be shown, with the improvements economically offered to the institutions when adopting this technique of acoustic isolation.**

**Keywords:** Economic impact, application of cork, educational institution.

**I-INCE Classification of Subject Number:** 35

### **1. INTRODUCTION**

The purpose of classrooms is to meet the basic needs of sheltering students for learning, if we analyze the variables, we are in constant connection with the environment, so we must therefore wish that this environment assures us minimal circumstances of

<sup>1</sup> [eng.victorfsousa@outlook.com](mailto:eng.victorfsousa@outlook.com)

<sup>2</sup> [mirianyengenharia@gmail.com](mailto:mirianyengenharia@gmail.com)

<sup>3</sup> [sergio.silva@ceuma.br](mailto:sergio.silva@ceuma.br)

well-being so that we can perform the activities in a way that does not disturb comfort in all sensory elements.

The understanding of comfort is directly linked to the occupants' sense of comfort in the face of a particular circumstance. Second (RUAS, 1999, p.9)

The well-being of man is a broad concept that encompasses from the factors necessary to maintain his physical health, to those responsible for his feeling of satisfaction. When it comes to satisfaction with the thermal conditions of an environment, then one is dealing with thermal comfort.

The article should take into account the positive and selective exploration of the acoustic constants, as well as the reduction of harmful impacts, which cause discomfort to the individuals affecting the productivities of the tasks developed in the classroom.

In these circumstances, we emphasize the importance of the acoustic treatment for the improvement of the comfort in school buildings, because it already has a significant expression in the formation of the human being, as well as the fundamental value, both social, cultural and economic.

The non-acoustic treatment in the study environments is a problem that exceeds the aspects of knowledge absorption, also interfering in the well-being of teachers and students through poor acoustic treatment conditions. (PAIXÃO, 1998)

According to Costa, 2013, a common organism, it supports very high noise intensities, (80 to 90 Db (A)). However, the physiological reach is not useful for all types of activity. Thus for excessive activity, noise of 40 to 50 Db (A), causes a small reduction of the yield, and can then cause psychological effects, harmful to health.

In the teaching centers, there is a constant frequency of noise, for example, conversations in the corridors, movement of people, dragging of chairs, transition of cars in streets or nearby avenues, among other causes. However, the study rooms should be an environment with specific acoustic conditions, where students can study without noise (SILVA, 2013).

However, it is not only external noise, which interferes with acoustic quality within the classroom. The most relevant characteristic is the intelligibility of the words, that is, the value that the words heard can suffer interference, of the external noises, can also be affected by the internal means (SILVA, 2013).

A classroom does not only need to be quiet, it is also demanded, acoustic conditions ideal for the practice of debates between students, transforming the intelligibility of words into a condition of high importance. Usually learning is based on passing information through verbal communication between teacher and student, so that the presence of adverse acoustic conditions for conversations always end up influencing students, damaging them (SILVA, 2013)

The reverberation in large numbers in the rooms is also an obstacle of acoustic order, which affects the intelligibility of the words and the understanding of the context transmitted by the teacher. This occurrence especially influences the children, who do not have the capacity, to deduce the exposed context. (SEEP, 2002).

In this way cork is an excellent material for acoustic insulation, since it has structures described on an atomic scale up to macroscopic, which influence its sound performance. The cork granulates are substrates of the cork industry. This element is handled as aggregate in the formation of light concrete, and material with acoustic functions in the constructions. (MAIO, 2010)

The agglomerates are materials created by compacting small cork granulates, there are two types of elements from this process, being simple and composed. The simple agglomerates, in their process of creation, can be used or not binder materials, with various granulometries, pressures and temperatures, with water vapor. (MAIO, 2010)

The composite agglomerates are thus named because of combinations with other materials, such as rubber, which are obtained by pressing and agglomerating with synthetic resin. In this way cork agglomerates in particular find acoustic applications. The most widely used acoustic materials for such applicability are expanded open cell polymers, such as polyurethanes, polyethylene, polyamides and other elements. Therefore, the agglomerates of expanded cork reduce the sound levels, by capturing effect, limiting the reverberation times. (MAIO, 2010)

Thus the present article consists of presenting the economy generated in the educational institutions, using cork as material of acoustic treatment, analyzing the cost benefit in the applicability of this treatment and exposing the loss of the percentage of income with the student avoidance, validating the effectiveness of this method to progress teaching institution.

## **2. METHODOLOGY**

This article consists of a bibliographical study about the annoyances generated by the absence of acoustic treatment, decrease of the intelligibility of words, external and internal activities that influence the discomfort inside the classrooms, emphasizing the relevance of this treatment with the cork material, for the improvement of the convenience and understanding of the content presented in the classroom, for a better economic performance of the educational institution, showing, therefore, the importance of this treatment in the reduction of student drop-out, such as increase of students' classroom, while also raising the credibility and quality of teaching that can be offered.

Technical standards on acoustic comfort levels are also present both the levels that are appropriate and the levels that are acceptable for the conditions presented.

In order to verify the feasibility of the study in question, the research was returned with the courses of administration and civil engineering in classrooms with the presence of the students and professors, located in the University Ceuma, campus Turu, located in avenue Luís Rei de France, 50 - Turu. São Luís MA, 65065-470. Two types of rooms were analyzed, the first without acoustic treatment, coated only with PVA paint and the second room with 80% acoustic coating on the walls with cork plates with 3 mm thickness, 1 M base and 2,80 M height.

The classes were analyzed in 2 periods, being subdivided by bimester, where in the first two months there was no treatment and in the second it contained the following acoustic treatment.

In photo 1, it is possible to observe a traditional room, without acoustic coating or any type of treatment, using only PVA latex paint coating, the masonry present in the building are of ceramic bricks 6 holes and common glass frames with ceiling and floor of slab.



*Figure 1- Room without acoustic treatment*

In the second photo, we can see the cork boards in the masonry that have a different aesthetics of the conventional rooms, which have their standard patterns of coating, the model of this room has the same proportions and materials of photo 1, changing only the coating, to contain the acoustic treatment.



*Figure 2 Room with acoustic treatment*

In order to carry out the study, the following steps were followed: firstly, data were collected and analyzed on student performance and avoidance in the first two-semester classes, without the acoustic conditions treated, since the second two months, the same analysis was done but with a coating of cork boards for the continuation of the observation

of the same students in class, who at that moment were exposed to an environment properly treated acoustically.

Thus, with these data were also made the relation of the lost values with the evasion of the students of the first two-month school, with the following conditions presented, being in the second two-month period and the necessary expense for the coating of acoustic treatment with cork.

In order to prove the effectiveness of cork in the acoustic treatment and consequently the improvement of the students' performance in the classroom, as well as the economic impact to the institution, generated around the use of this material, it is possible to visualize below the measurement of the changes.

### TIMES OF THE BIMESTRAL AVERAGE OF TURMAS

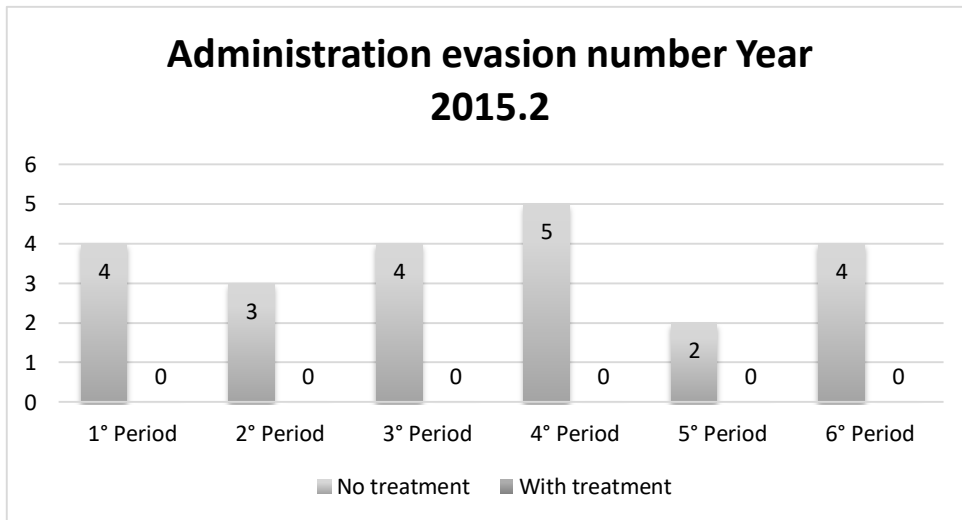
Table 1 Data of the Administration Course Afternoon 2015.2 and 2016.1

VESPERTINE ADMINISTRATION			2015.2		2016.1	
N° period	Subjects	CH	No treatment	With Treatment	Without	with
			Note	Note	Note	Note
1	ECONOMY	060	6,4	7,7	5,1	6,6
1	MATH	060	6,8	8,1	6,7	7,8
1	TGA	060	7,3	8,4	7,1	8,0
1	RIGHT PP	060	7,1	7,9	7,2	7,9
1	LPT	060	6,9	8,1	7,1	8,2
2	STATISTIC	060	6,1	7,1	6,0	7,2
2	MTP	060	6,5	7,4	6,6	7,3
2	ECON. DE COMPANIES	060	6,6	7,8	6,5	7,8
2	TCA	060	7,3	8,2	7,1	7,9
2	INT. ACCOUNTING	060	7,2	8,2	7,2	8,0
3	PSYCHOLOGY	060	7,4	8,5	7,2	7,9
3	MAT. FINANCIAL	060	6,8	8,2	6,7	8,1
3	CGC	060	6,9	8,2	7,2	8,1
3	EPO	060	7,4	8,3	7,1	7,9
3	ASI	060	7,5	8,5	7,3	8,2
4	SOCIAIS SCIENCES	060	7,6	8,5	7,4	8,3
4	ARMP	060	7,3	8,3	7,2	8,1
4	AFO I	060	7,0	8,1	7,1	7,9
4	PEOPLE'S MANAGEMENT I	060	7,5	8,4	7,3	8,2
4	ADM. MERCADOLOGICA I	060	7,4	8,4	7,1	8,3
5	ADM. MERCADOLOGICA II	060	7,0	8,3	7,2	8,0
5	BUSINESS LAW	060	7,1	8,0	6,9	8,1
5	TAX PLANNING	060	7,3	8,2	7,0	7,9
5	AFO II	060	7,2	8,3	7,1	7,9
5	PEOPLE'S MANAGEMENT II	060	7,1	8,2	7,1	8,1
6	PUBLIC ADMINISTRATION	060	7,4	8,7		
6	LOGISTICS	060	7,3	8,6		
6	ADM. STRATEGIC	060	7,5	8,7		

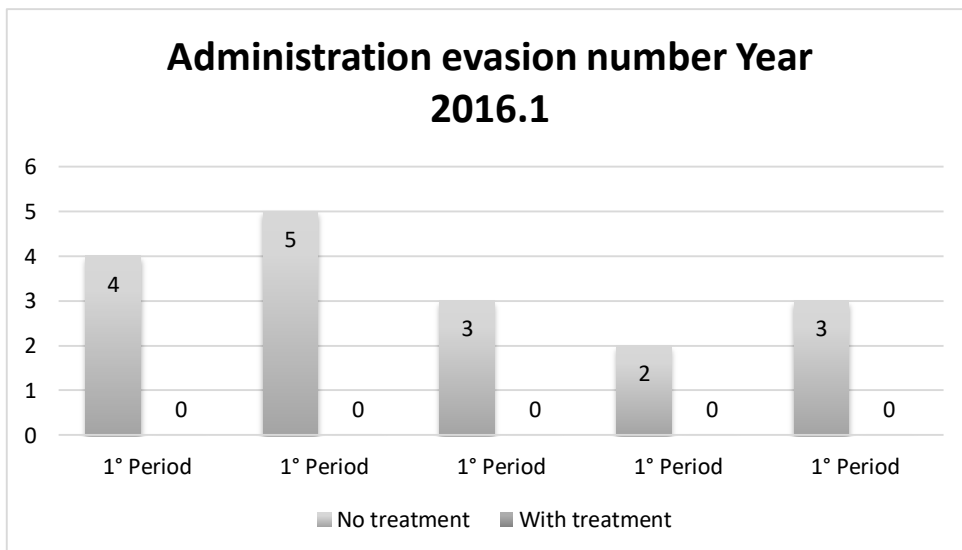
6	ADM. OF PRODUCTION	060	7,5	8,6		
6	RIGHT OF WORK	060	7,4	8,5		
	Average		7,1	8,2	6,9	7,9
	Standard deviation		0,4	0,4	0,5	0,4
	Difference in average			1,1		

1,0

In graph 1 you can see, in which the people left the course, in the graph shows a great evasion that appeared in the moments in which the classes were not in the rooms with acoustic treatment.



Graph 1 student evasion number per bimester.



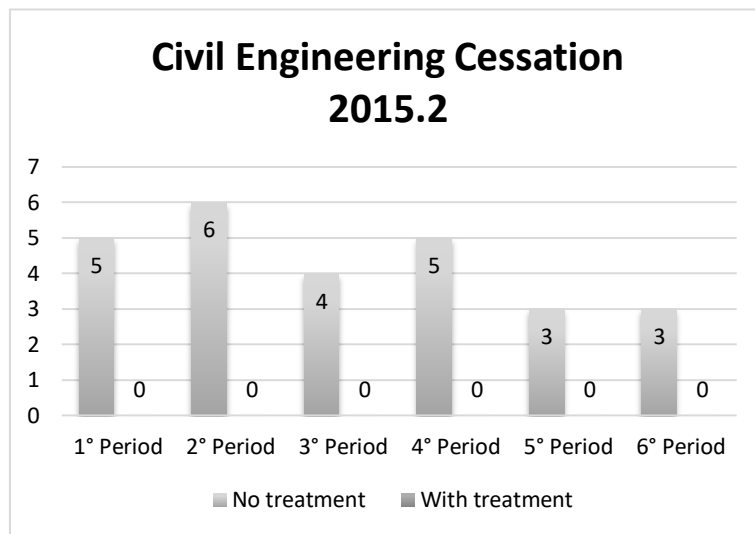
Graph 2 student evasion number per bimester.

In table 2 also shows the average data of the students who study civil engineering. In it, one can also see the variations of the students' income, where the rooms containing the acoustic treatment, the notes also improved with the new environment exposed.

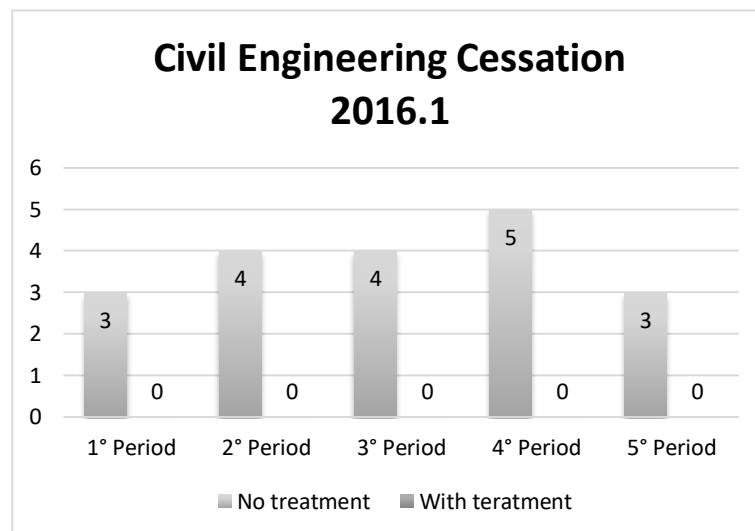
**Table 2 Data of the Civil Engineering Course Afternoon 2015.2 and 2016.1**

VESPERTINE CIVIL ENGINEERING		2015.2		2016.1		
N° period		No treatment	With Treatment	Without	with	
		Note	Note	Note	Note	
1	READING AND PROD. TEXTUAL	060	7,1	7,6	7,0	7,7
1	GENERAL CHEMISTRY	060	6,8	7,2	6,6	7,1
1	VECTOR CALCULUS	060	6,2	6,4	6,3	6,9
1	CALCULATION I	060	5,4	5,8	5,2	6,0
1	INTR. THE CIVIL ENGINEERING	060	7,2	7,8	7,0	7,6
2	COMPUTING	060	7,3	7,5	7,3	7,8
2	METHODS AND TEC. OF RESEARCH	060	6,9	7,1	6,8	7,2
2	TECHNICAL DRAWING	060	7,0	7,3	7,3	8,1
2	PHYSICS I	060	5,8	6,8	5,7	6,8
2	CALCULUS II	060	4,8	5,9	4,5	5,9
3	PHYSICS II	060	5,9	6,9	5,6	6,9
3	GENERAL MECHANICS	060	4,9	5,7	5,8	6,4
3	INFORMATION SYSTEM	060	6,7	7,3	6,8	7,2
3	SOCIAL SCIENCES	060	6,1	6,8	7,1	7,9
3	CALCULUS III	060	4,7	5,6	4,9	6,1
4	MATERIALS ENGINEERING	060	6,9	7,6	6,7	7,6
4	FUND. ADMINISTRATION	060	7,3	8,2	7,0	8,0
4	FENOM. CARRIAGE	060	6,8	7,5	6,6	7,3
4	STRENGTH OF MATERIALS	060	6,6	7,4	6,5	7,4
4	TECHNOLOGICAL CHEMISTRY	060	6,8	7,9	6,9	7,8
5	STATISTICS AND PROBABILITY	060	7,4	8,2	7,3	7,9
5	HYDRAULIC	060	7,3	7,8	7,1	7,8
5	ENG. AND SEC. OF WORK	060	7,9	8,6	7,4	8,1
5	MAT. OF CIVIL CONSTRUCTION	060	7,2	8,4	7,0	7,8
5	RESISTANCE OF MATERIALS II	060	6,8	7,9	6,5	7,4
6	TOPOGRAPHY	060	7,6	8,4		
6	INST. SANITARY HYDRAULICS	060	7,3	8,1		
6	ELECTRICAL INSTALLATIONS	060	7,4	8,2		
6	ENG. SANITARY AND ENVIRONMENTAL	060	7,7	8,3		
6	STAB. OF CONSTRUCTIONS	060	6,8	8,1		
Average			6,7	7,4	6,5	7,3
Standard deviation			0,9	0,9	0,8	0,7
Difference in average				0,7		0,8

In graphs 3 and 4 as well as in the previous graphs, shows the values of the students' output, but of the civil engineering course.



*Graph 3 student evasion number per bimester.*



*Graph 4 student evasion number per bimester.*

The rooms, without acoustic treatment, were evaluated during the period during each week, during class time, thus having teachers and students within the study environment. In the analysis of the first two months of each period, it was possible to notice the decrease and / or remaining in the students' income, as well as a large dropout rate of the students.

Already in the second two-month period, the improvement of these results is notorious, and it was observed that there was no student dropout. This happens through the new conditions that the environment with acoustic treatment with cork brings, so we can differentiate it from the rooms without this method, by 3 different senses, touch, vision and hearing.



By the touch, one can feel the change of pressure, inside the room, differentiating from the external environment. With the vision, the aesthetic character that the cork provides, is noticeable, different from the common rooms that exhibit a standard coating with painting. And by hearing, one notices the change in the intensity of sound as it propagates through the room and the way it reaches the auditory system.

Thus, we can verify the percentage of profit that the institution lost with the exit of these students in comparison to the benefit that the implantation of the cork in the rooms like acoustic treatment can bring.

According to market research, currently in Brazil, the m<sup>2</sup> of cork with the entire implantation process, costs approximately R \$ 75.00. And private educational institutions that have the degrees of Administration and Civil Engineering, have their monthly payments around R \$ 1,500.00. Thus:

The sum in values, of the evasions of the classes of Administration is equivalent to:

	<b>Sum of evasions</b>	<b>Monthly amounts</b>	<b>Total</b>
<b>2015.2</b>	22 students	R\$ 1.500	R\$ 33.000
<b>2016.1</b>	17 students	R\$ 1.500	R\$ 25.500

*Table 3 total amount of students' tuition*

In addition, the sum in values, of the evasions of the Civil Engineering classes corresponds to:

	<b>Sum of evasions</b>	<b>Monthly amounts</b>	<b>Total</b>
<b>2015.2</b>	26 students	R\$ 1.500	R\$ 39.000
<b>2016.1</b>	19 students	R\$ 1.500	R\$ 28.500

*Table 4 total amount of students' tuition*

For the implantation of the cork boards on the walls of the classrooms, was spent approximately R \$ 6,300.00 because each plate has a price relative to R \$ 75.00 and the area in m<sup>2</sup> of the masonry is approximately 84 m<sup>2</sup>.

Therefore, the total amount spent on the implementation of acoustic treatment with cork in each room is lower, compared to a monthly fee of the set of students evaded in each period. As shown in the table below:

Administration Classes

	<b>Preço implantação da cortiça por sala</b>	<b>Valores dos alunos evadidos</b>
<b>2015.2</b>	R \$ 6,300.00	R\$ 33.000

<b>2016.1</b>	R \$ 6,300.00	R\$ 25.500
---------------	---------------	------------

*Table 5 comparison of student dropout values and cork implantation*

Civil Engineering Classes

	<b>Preço implantação da cortiça por sala</b>	<b>Valores dos alunos evadidos</b>
<b>2015.2</b>	R \$ 6,300.00	R\$ 39.000
<b>2016.1</b>	R \$ 6,300.00	R\$ 28.500

*Table 6 comparison of student dropout values and cork implantation*

#### 4. CONCLUSIONS

Please Therefore, cork proved to be an excellent material, important for its acoustic insulation function. The cork as a tool for the acoustic treatment, presented to be differentiated from the common materials for coating, proving, therefore, to be a fundamental method and with great value.

In the obtained results it was verified that the application of this material gives an expressive impact to the students, offering a better quality of teaching, resulting in the improvement of the understanding of the exposed subjects, consequently the increase of the income in the period.

The approximate growth of 1 point in the bimonthly average was observed in the rooms that have the acoustic treatment in the room. This decreases the amount of student dropout because they can better understand and adapt to the contents studied.

Thus, comparing the values of the output of the students of the institution and the values of the implantation of the cork as acoustic treatment, it was seen that, it is feasible this modification in the acoustic structure for the economic growth of the educational centers.

For the investment made to install this treatment is lower than the values of the students evaded, thus making a significant and rapid profit, but not only this, but, as the increase of credibility that this institution can receive, where the students leave to escape, continuing in that environment that allows them a better quality of teaching and life.

#### 5. REFERENCES

1. COSTA, E. C. gives. Technical acoustics. São Paulo: EDGARD BLUCHER, 2003
2. MAIO, Daniela Jacinta Dolgner. DEVELOPMENT OF "INK" WITH CORK POWDER WITH OPTIMIZED ACOUSTIC PERFORMANCE. 2010. 118 f. Dissertation (Master degree) - Civil Engineering Course, Civil Engineering, Faculty of Engineering, University of Porto, Portugal, 2010. Cap. 07. Available in: <<https://repositorio-aberto.up.pt/bitstream/10216/58601/1/000147681.pdf>>. Acesso em: 25 fev. 2019.
3. PAIXÃO, D. X. et al. Environmental noise and its influence on the learning teaching process, from the health / disease relationship in first grade school students of Santa Maria's municipal public network – RS. In: CONGRESS IBEROAMERICANO DE ACÚSTICA, 1, 1998, Anais ... Florianópolis, 1998.
4. RUAS, Á. C. Thermal comfort in the work environment. São Paulo: FUNDACENTRO, 1999.
5. SEEP, B. Acústica de Salas de Aulas. Revista de Acústica e Vibrações, n. 29, julho 2002.

6. SILVA, Carlos Miguel Ferreira and. THE TIME OF REVERBERATION AND THE INTELLIGIBILITY OF THE WORD: Case Study: FEUP classrooms. 2013. 99 f. Dissertation (Master degree) - Civil Engineering, Civil Engineering, Faculty of Engineering, University of Porto, Porto, 2013. Cap. Available in: <<https://repositorio-aberto.up.pt/bitstream/10216/72582/1/000159635.pdf>> Accessed on: 21 feb. 2019.