THE ROLE OF ARCHITECTURAL ACOUSTICS COURSE ON INTERIOR ARCHITECTURE STUDENTS' PERCEPTION OF SOUND AND ACOUSTICS

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ABSTRACT

This study concentrates on investigating the impact of the 3rd-year compulsory course, 'Architectural Acoustics' offered at Çankaya University, Department of Interior Architecture, on the students' understanding of sound and acoustics. Recent studies show that there is a lack of specialized courses on acoustics and in some cases, students are introduced to acoustics only if they choose to enroll in elective courses. The knowledge of acoustics is essential in architectural education as sound is a crucial design element that directly affects spatial experience and user comfort. Students in the fields of built environment and design should be aware of acoustical concepts and gain basic acoustical knowledge throughout their undergraduate education. In this study, the pre-test/post-test method is used and applied as separate surveys to gather data from the students on; (1) noise sensitivity, (2) the importance of acoustical concepts in varying building types, and (3) familiarity with acoustical terminology. Survey results lead to detailed identifications regarding the impact of the course content on students' evaluations. Results of the statistical analysis are reported to show the topic-specific changes in the acoustical awareness levels of the students enrolled in the course.

Keywords: *architectural education, acoustics education, pre-test post-test, awareness*

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1. INTRODUCTION

Architectural acoustics has a significant impact on the user experience in the built environment, and it is an essential aspect of architecture-related disciplines. However, visual concerns are prioritized in design disciplines, and acoustics is seen as a technical subject requiring deep mathematical and physical knowledge [1-3]. Interior architecture and architecture students should be aware of acoustics concepts and gain the base acoustical knowledge throughout their undergraduate education for various reasons [4-6]. For instance, they should be aware of the consequences of their design decisions on the acoustic environment to provide a holistic experience and comfortable environment for the users. Nevertheless, they should be familiar with the terminology and have the fundamental knowledge to be able to communicate and collaborate with acousticians. Students should gain the qualifications to identify possible acoustical problems, comply with related legislations, and apply regulations and design guidelines related to noise and acoustic comfort. To equip the students with the mentioned competencies, the method of the existing acoustics courses should be further analyzed and improved. Therefore, the aim of the current study is to investigate the effectiveness of the compulsory 'Architectural Acoustics' course at Çankaya University.

Initially, it is necessary to identify the current state of architectural acoustics in interior architecture and architecture education. Studies emphasize the lack of importance given to acoustics [7-9]. In one study, the curricula of forty-two Turkish universities with architecture faculty were investigated, and it was found that thirty-two included acoustics-related subjects within other compulsory courses and attempted to deliver the subject in a time-limited to two or three weeks. Nevertheless, in ten of these universities, students were introduced to acoustics only if they chose to enroll in elective courses [7]. In another similar study, it was found that there was a significant decrease in the introduction of acoustics subjects in newer established universities [8]. In a more recent research, the compulsory courses on acoustics in interior architecture departments in Turkey were investigated. It was found that 50% of the courses were not specialized in acoustics, containing other subjects such as lighting, fire safety, and building service related topics within their scope. The limited number of specialized courses and the absence of acoustics courses with a creative design perspective parallel to design studio courses were emphasized [9]. The literature points out the need for creating awareness of acoustics and improving the method of architectural acoustics courses to create the necessary knowledge base.

Next, it is essential to discuss the current trends in teaching architectural acoustics. The recent literature indicates a tendency towards utilizing experience-based and hands-on approaches. Positive feedback was obtained from methods such as teaching the students how to use measurement devices, how to make sound recordings, and assigning them to create sound maps along with soundwalks [2, 4, 10, 11]. Sharing ongoing acoustical projects and experiences, giving real-life examples, and organizing laboratory visits were found to be effective in capturing the students' interests in the subject [11, 12]. Further trends in acoustics education are case-based and design-based approaches. It was observed that these approaches helped students better understand the practical implications of their theoretical information. Examples of the case-based approach include investigating the acoustical qualities of an existing space, taking measurements in the given space, proposing acoustic design solutions, and running acoustical simulations to test those solutions [2, 4, 11, 13]. The design-based approach, on the other hand, comprises designing spaces with the inclusion of acoustical criteria and running simulations to test and improve the designs [9, 14].

Despite being an essential component, integrating acoustics into interior architecture and architecture education has challenges. For example, acoustics is introduced to students in the later years of design education, either as part of other courses or as elective courses that are limited in number and variety [13, 15, 16]. Furthermore, technical aspects of the subject typically require laboratory settings for experiments, which are not always accessible [11]. Nevertheless, the fact that architecture students prefer learning through practice makes it even harder to captivate their attention in acoustics if taught solely through theory [4]. The mathematical and physical nature of the subject may discourage students if the relationship between social applications and observations in the real world is not emphasized [7]. Therefore, teaching acoustics to students of architecture, interior architecture, and other design fields requires a balanced approach between technical, practical, and design-related aspects of the subject.

To overcome the mentioned difficulties, the methods and outcomes of the current architectural acoustics courses should be further investigated. With this objective in mind, the aim of the current study is to investigate the effectiveness of the 3rd year compulsory course entitled ‘Architectural Acoustics’ delivered at Interior Architecture Department, Çankaya University. The changes in students’ awareness levels and knowledge were analyzed through a pre-test post-test approach questioning students'; (1) noise sensitivity levels, (2) importance ratings of acoustical concepts in varying building types, and (3) familiarity with acoustical terminology.

2. METHOD

At Çankaya University, within the 4-year Bachelor of Science education in interior architecture, the curriculum at the Department offers topic-specific building science related compulsory courses. ‘Architectural Acoustics’ is a 3-rd year compulsory course that spans over a semester of 14 weeks, following other compulsory courses such as thermal comfort, natural and artificial lighting, building services, and color theory. The acoustics compulsory course covers a wide range of acoustics concepts, providing a holistic and comprehensive understanding of the subject. Most dominantly, it focuses on sound behavior in enclosed spaces, physical principles of sound, basic concepts of acoustics and human hearing, basic principles of noise control techniques, indoor soundscape studies, and theories on architectural acoustics [17].

The current study was conducted with students participating in the ‘Architectural Acoustics’ course, at Çankaya University, in the 2020/2021 Spring Semester. The 57 participants in this study had a mean age of 22.6 (*SD* = 1.6), ranging from 20 to 28 years old. All participants confirmed beforehand not participating in any other acoustics-related compulsory or elective course.

To investigate the effects of the course, the pre-test and post-test method was utilized. The approach is commonly used in educational studies to examine the effectiveness of an educational intervention by comparing the scores of the participants before and after the intervention. In the current study, the students participated in the pre-test survey at the beginning of the semester, and the post-test survey was applied after the course was completed. The survey content and question-answer formats were kept identical to allow unbiased comparison.

The survey included questions on; (1) noise sensitivity level, (2) the importance rating of acoustical concepts in varying building types, and (3) familiarity with acoustical terminology. In the first section of the questionnaire, the Turkish translation of the Noise Sensitivity Scale Short-Form (NSS-SF) was used [18]. The next section included 14 building types with different purposes, and the participants were asked to rate the importance of acoustics in each type [19]. The final section included 30 self-evaluation questions on familiarity with acoustical terminology [7]. The items regarding acoustical terminology were selected based on the scope of the 'Architectural Acoustics' course, which covers terminologies and parameters on building acoustics, room acoustics, and soundscape in a larger context. Therefore, items in the survey were identified based on their dominance in the covered topics.

After the surveys, the data were analyzed using the IBM SPSS Statistics software (version 29.0.0.0) [20]. Median values were calculated for all variables of interest. Reliability analysis was conducted for each section using Cronbach's α. Since an ordinal scale was used in the questionnaire, the non-parametric Wilcoxon signed-rank test was applied to measure the differences between the pre-test and post-test scores. Afterward, the effect sizes were computed by *r* value [21]. In the next section, the results of the study will be presented and discussed.

3. RESULTS AND DISCUSSION

Initially, the reliability analysis was conducted. The 'importance of acoustics in various building types' subsection (pre-test Cronbach's α = .82; post-test Cronbach's α = .86) and the 'familiarity with the acoustical terminology' subsection (pre-test Cronbach's α = .93; post-test Cronbach's α = .96) had high reliabilities for both the pre-test and the post-test. Similarly, the "noise sensitivity" subscale had high reliability for the pre-test (Cronbach's α = .80); however, it had relatively low, but acceptable, reliability for the post-test (Cronbach's α = .71).

The "Noise sensitivity" subscale consisted of five questions on a six-point Likert-Scale (1=Disagree very strongly; 2=Disagree strongly; 3=Disagree; 4=Agree; 5=Agree strongly; 6=Agree very strongly). The first four questions in the questionnaire were structured, leading to a positively connoted answer, whereas the last question was the opposite. For ease of analysis, the answers to the last question were inverted (1=Agree very strongly; 2= Agree strongly; 3= Agree; 4= Disagree; 5= Disagree strongly; 6= Disagree very strongly). A significant result was obtained from the Wilcoxon signed-rank test for Question 2 (Tab. 1). However, the median scores remained the same for the pre-test and the post-test. The results obtained from the subsection indicate that there were no changes in participants' noise sensitivity levels.

Table 1. The Wilcoxon signed-rank test results of the "Noise sensitivity" subsection of the questionnaire.

Item	**Pre-test *Mdn***	**Post-test *Mdn***	***Z***	***P***	***r***
Q1. I am sensitive to noise.	5	5	-0,489	,625	-0,06
Q2. I find it hard to relax in a place that's noisy.	5	5	-2,283	,022*	-0,30
Q3. I get mad at people who make noises that keeps me from falling asleep or getting work done.	5	5	-0,083	,934	-0,01
Q4. I get annoyed when my neighbors are noisy.	5	5	-1,182	,237	-0,16
Q5. I get used to most noises without much difficulty (answers reversed)	4	4	-1,424	,155	-0,19

In a similar study, the noise sensitivity scale was evaluated through a *k*-means cluster analysis forming three clusters. Afterward, the clusters were interpreted as three levels of noise sensitivity: quite tolerant to noise, moderately sensitive to noise, and very sensitive to noise [22]. In the current study, the attempt to form three clusters resulted in unmeaningful groups. Therefore, two clusters were formed for the pre-test (Fig. 1.) and the post-test (Fig. 2.). The clusters with higher median scores were interpreted as "high noise sensitivity level" (Cluster 1), and the clusters with lower median scores as "low noise sensitivity level" (Cluster 2). The analysis shows that in the pre-test, 38 of 57 participants were in the “high noise sensitivity” cluster; in the post-test, this number lowered to 36 of 57 participants. Therefore, it may be concluded that noise sensitivity was not affected by the intervention since it may be related to other parameters.

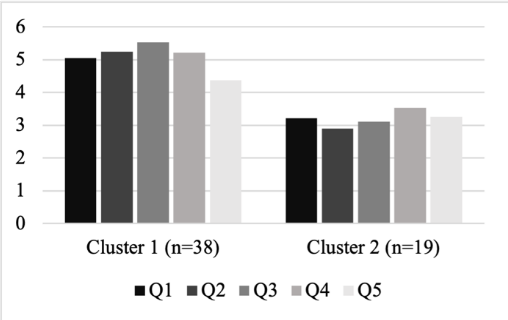

Figure 1. Pre-test “noise sensitivity” subsection, *k*-means cluster analysis.

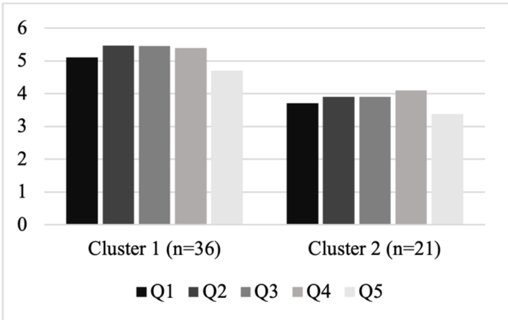

Figure 2. Post-test “noise sensitivity” subsection, *k*-means cluster analysis.

The results of the "Importance of acoustics in various building types" section are presented in Tab. 2. A statistically significant result was obtained from the “service buildings” item; however, the median values for the pre-test and post-test were the same (Mdn=4, Z= -2.428, P= 0,015, r= -0,23). The results of the remaining items showed no statistical significance, and the ratings remained the same except for one item, “recreational buildings”, which decreased by one point. Descriptive analysis of the median values of post-test scores indicated that acoustics were rated "very important" in performance buildings, educational buildings, health buildings, short-term accommodation buildings, cultural buildings, and religious buildings in both pre-test and post-test. The ‘very important’ score for Performance buildings was already expected since such buildings are classified as spaces with the primary function of acoustics [19]. Additionally, the rest of the mentioned buildings are rated as either sensitive or very sensitive to noise by the Turkish Noise Regulations [23]. It should be underlined that acoustics was not rated "not important" in any of the building types. Therefore, it can be assumed that the participants were aware of the importance of acoustics in every building type.

Table 2. The Wilcoxon signed-rank test results of the “Importance of acoustics in various building types” subsection of the questionnaire.

Item	**Pre-test *Mdn***	**Post-test *Mdn***	***Z***	***P***	***r***
Q1. Governmental Buildings	4	4	-.076	0,94	-0,01
Q2. Service Buildings	4	4	-2.428	0,015*	-0,23
Q3. Educational Buildings	5	5	-.690	0,49	-0,06
Q4. Health Buildings	5	5	-.447	0,655	-0,04
Q5. Transportation Buildings	4	4	-.563	0,574	-0,05
Q6. Cultural Buildings	5	5	-1.275	0,202	-0,12
Q7. Religious Buildings	5	5	.000	1.000	0,00
Q8. Commercial Buildings	4	4	-.704	0,481	-0,07
Q9. Recreational Buildings	5	4	-.462	0,644	-0,04
Q10. Leisure Venues	5	5	-.242	0,809	-0,02
Q11. Eating Spaces	4	4	-.149	0,881	-0,01
Q12. Industrial Buildings	4	4	-.080	0,936	-0,01
Q13. Office Buildings	4	4	-.490	0,624	-0,05
Q14. Dwellings	4	4	-.442	0,658	-0,04
Q15. Short-term Accommodation Buildings	5	5	-.068	0,946	-0,01

The Wilcoxon signed-rank test results have shown statistically significant differences in the “Familiarity with acoustical terminology” subsection (Tab. 3.). While the ratings for 23 of 30 terms have increased, the rest remained the same. The results also indicated that, in the post-test, the terms were known by the participants, with a median value of at least 3 (“I know this term”). A 2-point increase was observed in the term “Resonance”. Similar to the results obtained by Meric & Caliskan [7], in the pre-test, the participants rated the terms sound pressure level, sound absorption, and noise regulations as "I have heard this term before"; and the terms airborne sound and structure-borne sound as "I have not heard of this term before". In the post-test, the scores for the mentioned terms increased. Based on the results mentioned, it can be stated that the course has improved the awareness and knowledge of terminology.

Table 3. The Wilcoxon signed-rank test results of the "Familiarity with acoustical terminology" subsection of the questionnaire.

Item	**Pre-test *Mdn***	**Post-test *Mdn***	***Z***	***P***	***r***
Vibration	3	3	-2.739	0,006*	-0,26
Sound wave	3	3	-2.490	0,013*	-0,23
Audio Frequency	3	4	-3.792	<,001*	-0,36
Octave	2	3	-4.382	<,001*	-0,41
Hertz	3	3	-4.562	<,001*	-0,43
Tone	3	3	-3.129	0,002*	-0,29
Intensity	3	3	-2.604	0,009*	-0,24
Sound Pressure Level	2	3	-5.549	<,001*	-0,52
Decibel	3	4	-3.270	0,001*	-0,31
Hearing curve	2	3	-5.108	<,001*	-0,48
Absorption	2	3	-5.900	<,001*	-0,55
Transmission	2	3	-5.471	<,001*	-0,51
Reflection	2	3	-4.913	<,001*	-0,46
Refraction	2	3	-5.175	<,001*	-0,48
Diffraction	2	3	-5.842	<,001*	-0,55
Resonance	1	3	-6.120	<,001*	-0,57
Diffusion	2	3	-5.643	<,001*	-0,53
Anechoic chamber	2	3	-4.764	<,001*	-0,45
Reverberation	3	4	-2.661	0,008*	-0,25
Echo	3	4	-2.274	0,023*	-0,21
Sound propagation	3	3	-4.395	<,001*	-0,41
Airborne sound	1	3	-6.234	<,001*	-0,58
Structure-borne sound	1	3	-6.241	<,001*	-0,58
Impact sound	3	4	-5.102	<,001*	-0,48
Noise	4	4	-1.786	0,074	-0,17
Sound masking	2	3	-5.185	<,001*	-0,49
Auditory perception	2	3	-5.401	<,001*	-0,51
Acoustic comfort	3	4	-5.563	<,001*	-0,52
Noise annoyance	3	4	-4.222	<,001*	-0,40
Noise regulation	2	3	-5.849	<,001*	-0,55

The findings of the study suggest that the 'Architectural Acoustics' compulsory course had a significant impact on the students' familiarity with acoustical terminology. On the other hand, the non-significant results obtained from the questions on noise sensitivity and importance ratings suggest that the students only concentrated on succeeding in the course and may not have gained auditory awareness.

4. CONCLUSION

In this study, it is aimed to investigate the impact of the 'Architectural Acoustics' course on the students' perception of sound-related issues in architecture, implementing the pre-test and post-test design. Overall, the findings of the study indicate that after the course:

- The students' noise sensitivity levels remained the same,
- The importance given to acoustics in various building types did not change,
- The students' awareness and knowledge of terminology have significantly increased.

Therefore, it was found that while the 'Architectural Acoustics' course has improved the students' knowledge, it did not have a significant effect on the aspects that might be related to acoustical awareness. A possible reason could be that, to engage students with the acoustic environment, they should gain the skill of applying their theoretical knowledge in their designs, which requires practice [11]. One method of ensuring the application of the knowledge might be incorporating practical applications into the acoustics course itself. Another method might be integrating technical aspects related with indoor environmental quality into the design studios and other applied courses. Informal methods such as workshops and seminars may be included in the design studio process for students to question and understand how to use their knowledge [24].

The study had some limitations. The sample size was relatively small, and the study was conducted at only one university. Therefore, the findings may not be generalizable to other populations. In addition, further statistical tests suitable for normally distributed data sets could not be applied. Future research could address these limitations by conducting larger-scale studies in diverse settings.

Overall, the study provides valuable insights into the effectiveness of the acoustics related courses in interior architecture education and highlights the importance of incorporating such courses in the curriculum of interior architecture programs.

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