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Acoustics education for architects: Developing a base of knowledge for professional experience

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ABSTRACT

There is a dispersion of professional expertise in building industry since demand for rapid, detailed and correct information has been increased with the developing technology. According to their expertise, the actors in a project may share technical, organizational, financial information about their specific discipline or even guide other actors for the benefit of the project. Architects who combine all the information gathered from various actors should at least own basic knowledge about other disciplines to communicate with these actors. Moreover, this knowledge is also essential to take befitting decisions in every design step. Acoustics is one of the major knowledge areas in the architectural projects. University education is important to build up this knowledge. This paper will discuss the role of acoustics courses in architectural education, question a pair of teaching methods and present the outcomes of acoustics education in the professional life of architects through the case of architectural acoustics graduate courses given in Middle East Technical University Department of Architecture.

Keywords: Acoustics Education, Architectural Acoustics Education

1. INTRODUCTION

The information centred system of these days urge professionals of building sector to work together with other disciplines. Due to the excessive amount of information created and increasing demand for rapid and correct action, expertise on special subjects in various disciplines begin to be count on. According to their expertise, the actors in building industry may share technical, organizational, financial information about their specific discipline or even guide other actors for the benefit of projects. Architects, who combine all the information gathered from various actors, should at least own basic knowledge about other disciplines to communicate with these actors. Knowledge is also essential to take befitting decisions in every design phase. Acoustics is one of the major knowledge areas in the architectural projects. Acoustics education for architects is important in developing the knowledge base for professional experience. The purpose of this paper is to discuss the role of acoustics courses in architectural education, question a pair of teaching methods and present the outcomes of acoustics education in the professional life of architects through the case of architectural acoustics graduate courses given at the Department of Architecture of Middle East Technical University (METU).

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2. ACOUSTICS COURSES IN UNDERGRADUATE AND GRADUATE ARCHITECTURE EDUCATION: SYSTEM IN TURKEY

In the universities worldwide, curricula of various departments include courses that have acoustical subjects in their content or especially based on acoustics. On the other hand, it is argued by academics that acoustics courses are generally found only in graduate curriculum, and are not offered to undergraduate students as a main body of knowledge like optics taught in compulsory physics and engineering courses [1]. The same attitude is observed in architecture schools. Although acoustics is closely related with design issues and may affect the comfort conditions within the building or environment, the importance of gaining knowledge of acoustics and then integrating this knowledge to design education is not thoroughly understood in schools of architecture [2].

A survey has been conducted to reveal the facts about acoustics courses in architectural education. The curricula of the departments of architecture in the universities of Turkey were examined. The courses related with acoustics were listed according to their content, their type either as compulsory or elective, the year and semester they are offered. The examination was conducted through the web sites of universities which are referenced in the web site of Higher Education Council of Turkey [3]. The universities that have missing information about course contents were excluded from the survey group. The number of universities investigated is 42 in total.

The subjects related with acoustics are mostly integrated into building physics and/or environmental control courses in undergraduate education. These courses are mainly classified in the group of compulsory courses. Generally, the classes related with acoustics in these courses only take part in a limited period which lasts for two or three weeks. The number of the universities which have acoustics included compulsory courses is 32 out of 42.

It is also important when acoustics related subjects are introduced to students. The compulsory courses are mainly given in fourth, fifth and sixth semesters. Just in a small number of universities, these courses are in the curriculum of third, seventh and eighth semesters. Smith [4] asserts that integrating such courses related with environmental technologies such as lighting and acoustics to the curriculum of architectural education at an early stage will reinforce the scientific understanding of students which may be later used in their design efforts. On the other hand, the scientific content of the acoustics courses may be hard to understand by junior students while they are struggling to adapt the design courses. As Chen [5] argued for his research on environmentally focussed courses, it may become too early to introduce subjects related with environmental issues for architecture students in the first and second year of the curriculum when they are not so accustomed to multidisciplinary views.

Besides when the education must be given, it is also important to ponder on how the knowledge should be transferred to the students in order to create a multidisciplinary view without distracting the education of creative design thinking. It is hard to captivate the interest of the students of architecture to the theoretical subjects unless they are related with social applications and existing phenomenon that are observed in the real world [1, 6]. The teaching and learning methods play a significant role in transferring the knowledge of another discipline to the students of architecture. The possible ways of teaching and the preferred learning methods of students will be discussed later in this paper with the answers given to the related question in a questionnaire.

Twenty one universities out of 42 offer elective courses related with acoustics to their undergraduate students. The content of these courses generally focus on acoustical problems in buildings, acoustical design of halls and theatres and sound insulation in buildings. The number of universities which offer both compulsory and elective courses is 11 out of 42. In ten universities, students are introduced to acoustics only if they opt to take the elective courses.

In graduate education, the number of architecture schools that offer acoustics courses is 12 in the survey group. In many universities, acoustics courses given in graduate programs contain general information about acoustics both to recall the knowledge gained through undergraduate courses and to make an introduction to acoustics for the students that take a course about acoustics for the first time. Only few universities offer specific contents in their acoustics courses. These specific courses focus on different subjects like acoustical design of TV and broadcast studios, noise control in industrial buildings, acoustical problems engaging with typology of buildings, environmental noise and its control, acoustical design of concert halls, acoustics of open plan offices, speech intelligibility in rooms, sound measurement techniques, etc. The mentioned specific courses are not offered in every semester in these universities. Besides if the minimum number of students that should enrol a course is

not over a predetermined limit, the courses cannot be opened for that semester. Graduate students that carry their graduate studies on acoustics mostly construct their knowledge on specific subjects by self studying under the supervision of their advisors.

3. FACTS OBSERVED THROUGH THE GRADUATE ACOUSTICS COURSES OF METU

3.1 Information about the graduate acoustics courses

There are two graduate courses about acoustics in the department of architecture of Middle East Technical University. These courses are elective courses offered under the Building Science Program. One of these courses, entitled as BS 575 Acoustics in Architecture I, is offered in fall semester. This course is arranged to give students a brief introduction to acoustics then focus on room acoustics concepts. At the end of the semester, students are asked to design a concert hall in which they are required to obey some regulations and to arrange the acoustics of their designed halls proper for orchestra concerts. Meanwhile they are asked to test their design through computer simulation considering a number of acoustical parameters that are important in acoustical room design. Detailed information about the project requested as the course assignment is given in Appendix. The other course on acoustics, entitled as BS 576 Acoustics in Architecture II, is offered in spring semester. The aim of this course is to construct a knowledge base for students in order to understand the environmental noise issues and sound insulation basics within the buildings. Students are asked to prepare a written report on a special subject related with the concepts taught in the course as a term paper. In both courses the assessment of students are done with term projects, reports and exams. The detailed course content is given in Table 1.

Table 1 – Contents of graduate acoustics courses given in The Department of Architecture of METU

Acoustics in Architecture I – BS 575	Acoustics in Architecture II – BS 576
Basic Concepts (sound, amplitude, frequency, levels ...)	Introduction to Noise and Its Effects
Hearing and Perception of Sound	Review of Basic Acoustical Concepts
Introduction to Room Acoustics	Noise Parameters
Objective Acoustical Evaluation Measures	Sound Level Meters and Noise Measurement
Forms and Acoustical Design Criteria	Noise Sources and Outdoor Noise Propagation
Acoustics of Small Rooms	Turkish Noise Legislation
Modelling and Acoustic Simulation of Spaces	Reverberation Control
	Sound Transmission and Isolation

The acoustics courses given at the graduate level in the department of architecture of METU are both open to graduate and undergraduate students. The number of enrolled students to the courses is changing at every semester. The minimum number of students for a course to be active in a semester is three. The maximum number of students is 30 due to the curriculum and limited facilities. The courses have been given for more than 20 years and computer simulation has been exercised heavily since 2003. Although acoustics is in the content of a compulsory course and an elective course at the undergraduate curriculum of METU department of architecture, an introduction is given in every semester which includes basic concepts in acoustics. As it is discussed previously, not every university in Turkey offer courses that teach acoustics at the undergraduate level. Besides, there are a number of international graduate students at the department of architecture which may not have taken a course related with acoustics where they get their undergraduate degree.

3.2 Questionnaire

In order to understand the role of acoustics courses in architectural education, question a pair of teaching methods and present the outcomes of acoustics education in the professional life of architects, a questionnaire was prepared and sent to the former students that took the graduate acoustics courses BS 575 and/or BS 576. The number of questionnaire participants is 25. Some of the participants are still continuing their graduate education and the others are working professionals.

There are ten questions in the questionnaire. In the scope of this paper, only the selected questions

and the answers given to these are analyzed. The first question was about the motivation of the students to enrol the acoustics courses and the second one asked if they are Undergraduate, Master of Science or Doctorate student while taking the courses. Ten of the participants were graduate students while they were taking the courses, and the half of these participants was planning to study on subjects related with acoustics during their graduate education. The strongest motivation of undergraduate students who took these courses was an interest on subjects related with acoustics. Five of the undergraduate students also believed that course content would make a contribution to their professional life.

Another question is asked to find out the degree of awareness of students about some acoustical concepts before they took the graduate acoustics courses. The knowledge or the awareness may be formed by various ways. Students may have taken courses during their education related with acoustics either connected with their compulsory courses or elective courses. Also a special interest or a related concern may have encouraged them to learn more about acoustics. In the question, a number of concepts were listed. The options as answers are; (1) I knew the concept very well, (2) I heard about the concept but did not know thoroughly, (3) I did not know the concept. The participants were asked to choose one of the answers. Their responses to this question are shown in Table 2.

Table 2 – Awareness of students about some acoustical concepts.UG (undergraduate students), G (graduate students).

Concepts	Answer (1)		Answer (2)		Answer (3)		Total number of responses		Weighted Average (WA)		Statistical Rounding of WA	
	UG	G	UG	G	UG	G	UG	G	UG	G	UG	G
Amplitude	2	1	7	4	4	4	13	9	2.2	2.3	2	2
Frequency	7	2	6	8	1	0	14	10	1.6	1.8	2	2
Wavelength	8	1	5	8	1	0	14	9	1.5	1.9	2	2
Sound Power Level	1	2	8	4	5	4	14	10	2.3	2.2	2	2
Sound Pressure Level	1	2	8	5	5	3	14	10	2.3	2.1	2	2
Loudness	1	2	13	4	0	4	14	10	1.9	2.2	2	2
Sound Absorption	1	3	7	5	5	2	13	10	2.3	1.9	2	2
Reverberation Time	1	3	8	5	5	2	14	10	2.3	1.9	2	2
Echoes	3	2	11	8	0	0	14	10	1.8	1.8	2	2
Sound Focusing	0	1	7	4	7	4	14	9	2.5	2.3	2	2
Early Decay Time (EDT)	0	2	5	3	9	5	14	10	2.6	2.3	3	2
Early Lateral Fraction (LF)	0	2	4	3	9	5	13	10	2.7	2.3	3	2
Clarity (C)	0	2	6	3	8	5	14	10	2.6	2.3	3	2
Sound Transmission Coefficient	0	2	7	5	7	3	14	10	2.5	2.1	2	2
Transmission Loss	0	2	5	6	9	2	14	10	2.6	2.0	3	2
Air-borne and Structure-borne Sound	0	2	5	5	8	3	13	10	2.6	2.1	3	2
Environmental Noise Control Regulations	1	2	8	6	5	2	14	10	2.3	2.0	2	2

The answers of undergraduate students and graduate students were analyzed separately in order to see if there is a difference in their knowledge. As it is seen from the statistical rounding of weighted average of results, most of the undergraduate students did not know about room acoustics concepts like early decay time, lateral fraction and clarity. Also they were not aware of concepts like sound transmission loss, airborne and structure-borne sound. This may indicate us that these concepts may not have been studied before in other courses which include acoustics. The responses given to other concepts by undergraduate students were centred to the answer number two. On the other hand responses show that most of the graduate students heard about the concepts, but they did not know them thoroughly before they took the graduate acoustics courses given in The Department of

Architecture of METU. The results underline that there are some acoustical concepts which are not discussed during the undergraduate education. The contents of undergraduate and graduate curriculum are required to be discussed by the academic staff to question whether the knowledge base created in the courses is enough for the professional experience. The questionnaire in this survey is insufficient to draw a conclusion due the small number of participants and lack of some specific information. On the other hand it may inspire the staff in universities to make further investigation.

The other question in the survey is to find out what kind of teaching methods, activities and/or drivers do play significant roles in the learning process of an architecture student. The learning styles of students and their implications for teaching are broadly discussed popular subjects in the literature [7-10]. Disciplinary differences have also been taken account in the researches about education [9]. The terminology on learning and teaching methods varies in the literature according to various grouping techniques and contents. Besides, researchers are also interested in the effect of assessment methods to learning [11, 12]. The diversity and depth of the literature show us that there have been many factors affecting the learning process of students. Owing to various factors, in the related question, groups were created that may refer to a variety of teaching methods, activities and drivers. The participants of the questionnaire were asked to rank these groups according to the role in their learning as most beneficial at the top of the list and least beneficial at the bottom. The number of responses for each group is given in Table 3. It is seen from the Table 3, most of the participants choose lectures as the most beneficial group that affect their learning process and placed this group at the first rank. What is meant by lecture in the questionnaire is the traditional way of introducing a topic to students, telling about the principles and making the concept clear by illustrative exercises. The least effective group is chosen as exams. The aim of creating a group with exams is that exams urge students to rethink and organize what is learned through the lectures and this obligation plays a role in learning process [11, 12]. Case studies and simulations are placed in the second rank. Both case studies and simulations are inductive methods which enables the students to analyse real world phenomena, discover the facts themselves, and use some specific information in order to reinforce what is known or learnt. In the graduate acoustics courses of METU, simulation studies have been in the content of course program since 2003. Students assess simulation as a useful tool because they get the opportunity to use their knowledge parallel with the design process and see the possible conclusions of their choices. Groups that include guided readings, independent study/research and assignment/term paper ranked in between second and seventh group. Site visits is ranked as the sixth group by many participants. As it is perceived from the answers, this kind of ranking question is open to be incorrectly interpreted by survey participants especially when the information about groups is not stated clearly. Although there are some defects in the structure of this question, it is thought by the authors that the idea which question learning process constitute an example which may be straightened by other researchers later.

Table 3 – Results of rank order question. Percentages are given in parenthesis

Groups	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7
Lectures	13	4 (16%)	3 (12%)	1 (4%)	0 (0%)	4 (16%)	0 (0%)
Case studies and simulations	6 (24%)	7 (28%)	6 (24%)	5 (20%)	1 (4%)	0 (0%)	0 (0%)
Exams	0 (0%)	1 (4%)	1 (4%)	3 (12%)	5 (20%)	1 (4%)	14 (6%)
Guided Readings	1 (4%)	3 (12%)	2 (8%)	5 (20%)	5 (20%)	5 (20%)	4 (16%)
Independent Study/Research	0 (0%)	3 (12%)	7 (28%)	7 (28%)	5 (20%)	2 (8%)	1 (4%)
Assignments/Term Paper	2 (8%)	5 (20%)	3 (12%)	3 (12%)	6 (24%)	5 (20%)	1 (4%)
Site Visits	3 (12%)	2 (8%)	3 (12%)	1 (4%)	3 (12%)	8 (32%)	5 (20%)

A number of questions in the survey aim to find out if the knowledge gained through the acoustics courses can be used by the questionnaire participants in their professional work lives. Due the inconsistency in the answers, two participants' responses are excluded from the assessment group. The number of participants that are actively employed is 18. Five participants are not working at the time when this survey is conducted. Four of the non working participants previously worked for one or two

years before they quit their jobs. Twelve of the presently employed participants identify at what work section they are involved. Six of them work as architects at architectural offices, three of them work as architects at construction companies and the last three work at consultancy offices. All participants were asked if they have ever used their knowledge that they gained from the "Acoustics in Architecture" courses in their professional work lives. Eight participants out of 23 answered positive to this question. Two participants employed at architectural offices, one participant employed at a construction company, three participants employed at consultancy companies and two participants who do not state their work section have used their knowledge of acoustics in their professional work lives.

4. CONCLUSIONS

Integrating the environmental concerns like acoustics into design education is important. Every architecture student should receive an education on acoustics to construct a basic knowledge in order to design acoustically comfortable environments [2, 4]. The survey about the courses related with acoustics taught in the universities of Turkey and the questionnaire results received from the former students of graduate acoustics courses given in METU Department of Architecture revealed some facts and needs about acoustics education:

(a) The number of courses related with acoustics and the semesters that acoustics courses are offered display a diversified picture for the architectural departments in Turkey. There is a lack of standard approach which integrates compulsory courses that include acoustics subjects in their content.

(b) In Turkey, a few universities offer elective courses on acoustics for their undergraduate students. This is strongly related with the insufficient number of specialized staff in the departments of architecture.

(c) The acoustics courses offered to graduate students are limited and their content includes general concepts of acoustics only. Few universities offer specific content for elective acoustics courses in their graduate curriculum.

(d) The strongest motivation of students who took graduate courses at METU Department of Architecture is their interest on subjects related with acoustics.

(e) The results emphasize that there are some acoustics concepts which are not discussed during the undergraduate education. The contents of undergraduate and graduate curriculum are required to be discussed and reviewed by the academic staff in order to question whether the knowledge base created in the courses is enough for the professional experience.

(f) The learning styles of architecture students and teaching methods for acoustics courses at architecture schools should be investigated in detail in order to attract more students and impose acoustics concern to the future design professionals.

REFERENCES

- [1] I. J. Busch-Vishniac and J. E. West, "Acoustics Courses at the Undergraduate Level: How Can We Attract More Students?," *Acoustics Today*, 3(2), 28-36 (2007).
- [2] Yuksel Can, Zerhan, et al. "Experiences in noise control education in architecture," *Proceedings of INTER-NOISE 2009*, 1051-1060 (2009).
- [3] www.yok.gov.tr
- [4] D. L. Smith, "Integrating Technology Into the Architectural Curriculum," *Journal of Architectural Education*, 4-9 (1987).
- [5] P-Y. Chen, "Are We Training Architects for the 21st Century?: The Evolution of Architectural Curriculum in Taiwan under the Global Concern of Sustainability," (2008).
- [6] N. Tamer Bayazit, A. Hohman and R. Reder, "Aural architecture or acoustic architect-How to teach acoustics to architecture students," *Proceedings of INTER-NOISE 2012*, 3037-3048 (2012).
- [7] S. M. Montgomery and L. N. Groat. "Student learning styles and their implications for teaching," *CRLT Occasional Papers*, 10, 1-8 (1998)
- [8] S. Sajjad, "Effective teaching methods at higher education level," Available from Internet: <http://www.wfate.org>, (2011).
- [9] R. Neumann, "Disciplinary differences and university teaching," *Studies in Higher Education*, 26(2), 135-146 (2001).

- [10] M. J. Prince and R. M. Felder. "Inductive teaching and learning methods: Definitions, comparisons, and research bases," *Journal of Engineering Education*, 95(2), 123-138 (2006).
- [11] A. Havnes, "Examination and learning: an activity-theoretical analysis of the relationship between assessment and educational practice," *Assessment & Evaluation in Higher Education*, 29(2), 159-176, (2004).
- [12] J. Biggs, "Assessment and Classroom Learning: a role for summative assessment?," *Assessment in Education*, 5(1), 103-110, (1998).

APPENDIX

Detailed description of the project assignment requested in "BS576 – Acoustics in Architecture I" course is given in this part. Students taking BS 575 are assigned to prepare a term project covering the following features:

- The main function specified in the architectural programme is the concert use. Symphonic concerts of romantic era and baroque music are to be performed in the hall.
- Multifunctional use is an extra asset if it can be addressed in the design. In such a case, if multifunctional use is also opted, functions to be made available by the designer are to be specified.
- The design must be compatible with the fire codes and building physics essentials.
- The row spacing will be taken as 100 cm for comfort of use.
- The targeted capacity of the hall is for an audience size of 1200 people and an orchestra size of 60. Students are free to comply with this requirement with or without balcony.
- The form of the space is left to the designer's choice. However, both the form and dimensions of the hall are expected to be suited for the function(s) chosen.
- Acoustical design is to be simulated on ODEON v8.5 software.
- The project report is to include architectural design (plans and sections) and simulation results in graphical form. The material list must be also supplied along with location information on sources and receivers. The calculation parameters and number of planes should be also stated together with views of the hall in the drawings of simulation model.
- A power point presentation on findings of the project must accompany the report.
- The project report must contain the following acoustical design features:
 - Reverberation times-Global estimates, quick estimates and grid responses in 500 Hz and 1000 Hz bands,
 - Grid responses of Early Decay times in 500 Hz and 1000 Hz bands,
 - Grid responses of Clarity in 500 Hz and 1000 Hz bands,
 - Grid responses of Early Lateral Fraction in 500 Hz and 1000 Hz bands,
 - A-weighted Sound Level distribution,
 - Grid responses of STI within the hall,
 for all possible functions/architectural/acoustical programme considered in the design.
- An overall assessment of the design is required at the end of the report. Any additional information the designer thinks valuable is welcome.