Effective Course Design in Practical Room Acoustics for Students of Musicology: Conception, Didactics, Procedure

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Abstract and Introduction

In this contribution the lecturer and students present the design and procedure of the course "Practical Introduction to Room Acoustical Measuring Techniques and Analysis" held at the University of Vienna. Aim of this course was to introduce students of musicology into practical methods of measurement and analysis of room acoustical data.

The chosen format, a practical course, allowing the students to immerse themselves in the subject and to learn by doing and by experience. After a theoretical introduction into basic principles of room acoustics, measuring and analysis techniques, small groups of students carried out measurements in team-work in different room-types in Vienna (auditorium of Department of Musicology, Karlskirche, Konzerthaus, Musikverein). The self - evaluated measurement results revealed characteristic parameter values for every room. Additionally, the students designed individual research questions and drew conclusions on their own, which may lead to improvements of the rooms investigated. The course requirements thus consisted of three parts: (1) description of the experiment, (2) filling in templates for three different rooms with the collected data of the rooms, (3) answering an individual research question.

All contributions were collected in a documentation. Aura- and visualizations of collected data were made available for presentation and teaching purposes.

On a meta-level this course offered comprehensive learning experiences as a result of active and experiential learning, constructed knowledge in interaction and allowed in-depth reflective dialogues, paramount learning needs which classical teaching methods often fail to meet.

Motivation and Aims of the Course

Many students of musicology feel a lack of practice and miss direct references and experience in terms of room acoustics. Therefore, the aims were to give future musicologists practical experience with measuring techniques and room acoustics in form of a practical course, motivated by different room types and famous locations and to stimulate active contribution of the participants.

Didactic Conception

The didactic conception of the course was drawn as follows: after a theoretical introduction in the first date the participating students were invited to prepare and perform the measurements by themselves working together in small teams (to gather a sense of which steps are important, divide the tasks among the teams, change the role during the measurements) and to increase the knowledge by evaluating an individual question and three measurements each.

Preparation and Organisation

Long before the practical course started the design was developed and the activites of the course were planned in detail. After an introduction into room acoustical measurements technique at the beginning of the first block (one block is a day, the whole course took 4 days.), the students started practical measuring right away on the same day. Supplying the students with measuring equipment turned out to be crucial. Criteria for the selected equipment and procedures were:

- calibrated and exact enough to get valid results;
- intuitive, easy to understand, learn and use;
- portable and mains-independent to be able to move fast in Vienna between two locations per day, and
- using free-/shareware trial software versions.

In order to fulfill these preconditions the following procedure was developed: the students were grouped in teams of ca. 5 students, each group was equipped with a laptop containing AD/DA USB-interfaces, omni-directional pressure condenser microphones, the shareware Cool Edit 96 to record and edit acoustical measurements, the Aurora Plugin (written by A. Farina) and cheap, impulsive and intuitive sound sources. Correlation-based measurement systems were excluded beforehand due to the alienated procedure (“send out noise, get back impulse response”) in favour of the intuitive principle (“send out impulse, get back impulse response”), reducing the measurement of impulse responses to recording without the need of decorrelation. To create a compact system ready for public transport and being able to measure the impulse responses in the rooms with distances to the sources > r_H, as impulsive sound sources bursting in any situation, balloons were chosen creating “N-wave” test signals (see [1] and fig. 1: highspeed-movie made by J. Mühlhans, a participant of the course, to visualize the time behaviour of the sound source used).

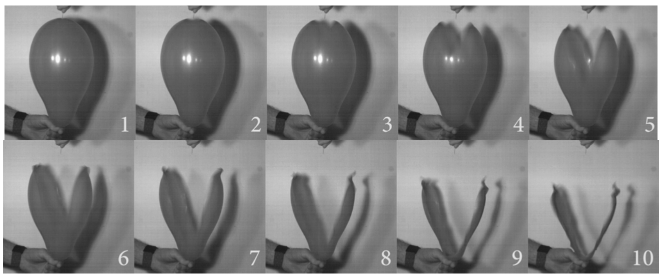

Figure 1: Balloon Burst (5.000 fps, 10 frames, i.e. 2 ms in total)

For preparation purposes the students got recommendations of introducing literature and were asked to pre-install and practise the use of the shareware on their own beforehand.

Once at a location measurements and observations as well as evaluated data were noted onto a pre-defined measurement form. All the measurements, data and photos for the subsequent individual evaluation were shared between all fellow students via an internet-cloud.

Measurement Parameters

The chosen measurement parameters were: reverberation time T_{30}, Early Decay Time EDT, center time T_{Center}, Clarity C_{80} as well as C_{50}, Deutlichkeit D50, which were available from the Aurora plugin out of the recorded room impulse responses. Additionally, using a stationary pink noise from an omni-directional point source, the decrease of sound level with distance was measured to enable the students to evaluate the strength parameter G and to compare it with values calculated with the theoretical values for rooms with a diffuse sound fields. Furthermore, the position of the source and receivers as well as the dimensions of the rooms were acquired to calculate the volumes plus the number of seats and therewith, the specific volumes of the rooms. Finally, in order to allow the students to develop a sense of the interrelations of reverberation time, early-to-late sound energy ratio and spech intelligibility, an approximation of AL_{cons}, AL_{cons}' was calculated by the students by a given approximation formula (1).

$$AL_{cons}' \approx 4\% + 0{,}66 \cdot T_{30} \cdot 10^{\frac{(L_{Rev} - L_{Dir})}{10dB}} \quad [\%] \quad (1)$$

Locations

In total, 14 different rooms in Vienna were chosen as measurement locations according to their different usages and acoustical conditions, exhibiting different room types and the maximum possible acoustical variety, which are listed in table 1 and depicted in figure 2. Among the rooms, there were two churches, two large concert halls, 3 small concert halls, an office, an atrium, and two foyers. Opera and theatre halls were planned, but could not be accessed due to tight schedules in the theater season. Due to maintenance construction works, in the Karlskirche temporarily a platform in the cupola was constructed, allowing the unique possibility to listen to and measure a focal dome echo.

Block-Date	Session Location / Room	
	Morning	Afternoon
02.03.2012	University Vienna: Auditorium HS2 (a)	Univ. Yard (b), Office, Foyer History of Arts(d)
20.04.2012	Academy of Sciences, Aula Lounge (c)	Konzerthaus: Großer Saal, Mozartsaal
25.05.2012	Church Sacred Heart, (e) Kaisermühlen	Haus der Musik, Foyer (f)
29.06.2012	Karlskirche (g)	Musikverein: Großer Saal, Kleiner Saal, Glassaal (h)
< 01.08.2012	Individual evaluation of one individual partial question + 3 measurements	

Table 1: Dates and Measurement Locations of the Course

The evaluation of acoustical parameters by the students resulted in the values shown in table 2.

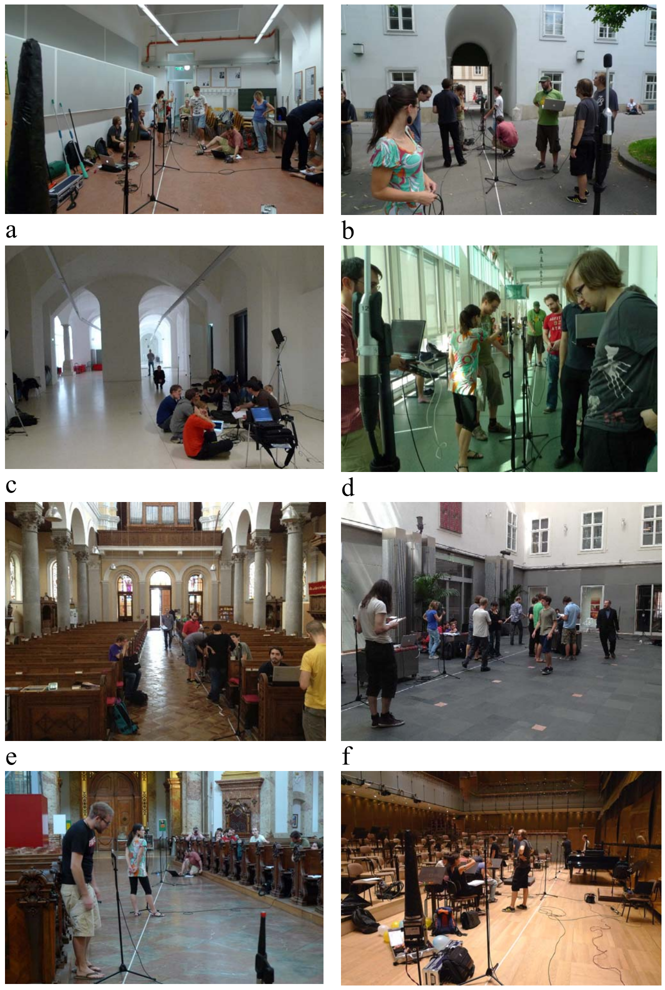

Figure 2 (a)-(h): Impressions of the Measurement/Course Sessions

Room (ca. 20 Persons)	Parameter (ca. 25 persons) > r_H				
	T_{mid} [s]	V [m^3]	G [dB]	C_{80} [dB]	AL_{cons}' [%]
University Auditorium 2	0,6	350	12	6,5	6
University Yard 9	1,4	open air	5	4	5
Foyer Kunstgeschichte	2,6	1300	19	-4	11
Aula Academy Sciences	4,4	1500	21	-6,5	21
Foyer Haus der Musik	4,5	4000	19	-4	14
Konzerthaus großer Saal	1,8	15000	6	0,2	6
Konzerthaus Mozartsaal	1,9	4600	17	0,9	5
Church Sacred Heart	3,6	8000	7	-4	11
Karlskirche	5,3	25000	9	-4	22
Musikverein Glassaal	0,9	2250	11	4	5
Musikverein großer Saal	2,9	16500	7	-1,5	7

Table 2: Resulting Parameter Values of the Measured Rooms

Didactic Analysis and Evaluation

Didactic Analysis

Learning by Deweying. Already in the first half of the 20th century John Dewey argued that learners are not blank slates but always build new information on existing knowledge gained through previous experience. Thus he put the principle of experiential learning into the centre of this thinking [3]. This was the basis for this course.

Social Constructivism. Learning is a mental process and knowledge is constructed when built into or added on to experience, competences and existing knowledge. Learning in social groups can be especially enriching [4]. The practical course described in this paper has a social constructivist basis since more experienced students supported less experienced students and balanced the different levels of knowledge. A constructivist setting, however, needs plenary explanation and clarification phases in order to collect the knowledge and assumptions of each group. For that reason, discussion rounds took place regularly.

Participatory Learning. In learning settings such as the active and interactive learning, participation of the students as well as the lecturer are a key issue for successful learning [5]. The format of the course described forced the students to involve themselves actively. Since students could suggest experiments for the course, thus design the course content, they took responsibility of and reflected on their learning process on a meta level. The learner-centred approach led to many discussions about the procedure and new measurements, and the students were responsible of whether they enjoyed learning or not.

Autonomous Learning. In the course of time the students developed a certain routine for setting up the equipment. Acting autonomously step by step was an important intention of the course design. By the end of the course the students were able to carry out measurements on their own.

Affective Learning. Being emotionally involved in the learning process is regarded as one of the core factors for motivation [6]. A strong emotional effect according to the students was the choice of the rooms which were analysed. Some rooms needed special permission to carry out measurements, other rooms were famous for their acoustic properties and thus very impressive for the students.

Practical experience. Connecting theory to the effects in reality and applying knowledge were the mayor aims of the course. Due to the practical experience gained in the course students were able to ask a great deal of concrete questions which led to a deeper understanding of the matter and contributed to the knowledge acquisition of the whole group.

Motivation to learn. Situative stimulus promote the motivation to learn [7]. Schiefele & Schaffner [8] relate the learning quality to motivation and highlight the connection of interest and answering comprehension questions (instead of fact based questions). In the course described students *wanted* to know the answers to their questions and this boosted their intrinsic motivation. What is more, the students were asked to choose their individual research focus and this fostered intrinsic motivation even more. Krapp [9] goes even further by saying that interest and motivation are a precondition for basic learning processes and influence the long term memory.

Integration of different channels of perception. Touching the measured surfaces as well as clapping in order to get a first acoustic impression accompanied the whole course. Especially the auditory channel was trained through various listening exercises.

Learning coach. The lecturer provided material and supported the students to accomplish the tasks instead of telling them what to do. As a consequence, students asked many questions when interpreting the data and received answers quickly by the lecturer.

Evaluation of the students

At the end of the course 14 students filled in a questionnaire to evaluate the course. 50 % of the students rated the course as “very good” and highlighted the practical implications of the course design based on learning by experience. The course was regarded as being challenging, they enjoyed the classes, motivation was high and they benefited in multiple ways. Key factors for extrinsic as well as intrinsic motivation were the topic itself, the format which enabled the students to have a hands-on approach, the choice of rooms and the fact that they *really* measured the rooms instead of reading papers. The course design, however, was completely new to the students, which led to the fact that they needed a lot of coaching during the process of interpreting the data and writing a report in contrast to writing a classical seminar paper. Thus, lecturers need to offer a lot of coaching and support. The learning outcomes, the test format and the learning activities need to be connected, which includes how to write a report:

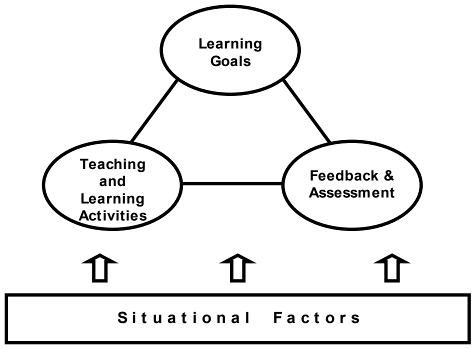

Figure 3: Key Components of Integrated Course Design

If not, satisfaction with one’s own performance decreases as was mentioned in the questionnaire.

The muddiest point is probably grading the work. Students enter a course with different levels of knowledge and competences and benefit in different ways. Neither the average person as the norm of the collective or having a completely objective standard irrespective of the students’ knowledge level suit the purpose of evaluating the learning process. The authors suggest grading the students according to their “individual norms” and the amount of the knowledge they gain throughout the course, thus the process of learning and not just the product they hand in.

Room for improvement

It is vital to have the **aims competence-oriented** (what the students will be able to *do* after completing the course) and the **grading system as transparent as possible**. This allows to structure the format and serves as a basis for communication with the students. Furthermore, making a **list of the assignments** and what the lecturer expects from each assignment in written form can be of help, as students might not be used to writing such a report. **Due dates** are crucial for certain assignments, as other students need the data for their individual research questions. Additionally, they play to deadline junkies or students suffering from procrastination. **Providing guidelines** and criteria for keeping record of the measurements (e.g. name of files, abbreviations) and for interpretation of data or having the guidelines written by the students allows to collect a homogenic pool of data. The authors suggest **conducting a sample interpretation** of the data in plenum to get a group consensus and orientation after the first measurement or measurement session. Finally, according to our experience, having a **plenary session at the end of the course** enables the group to draw a conclusion and define the quintessence of the course.

Student Perspective: Practical Reality

From a student's point of view this course was an entirely new experience. Even though room acoustics is a major topic in many lectures, we have never been so actively involved in the process of acoustic measurement. We are often taught what it is about, but never how it is actually done. First of all, we learned how to do basic acoustic measurements with affordable equipment which renders own future projects possible for us. Secondly, we achieved quite a feeling for the acoustical phenomena in general and the specific characteristics of different environments. Listening to reverb and detecting flutter echos and focal points helped us to develop a sense of acoustical problems. This provided us with a solid basic knowledge needed to work independently and was maybe the most precious experience during the course. Some of the students developed ideas and started their own acoustical projects right after the course. The use of own laptops, interfaces and especially shareware software for data processing and analysis supported our independent working behaviour. We used a free online storage with a shared public user to make all data accessible to all the students. Since room acoustic data analysis requires a great deal of knowledge in physics, it was hard for musicology students (actually part of the Arts Department) to get conclusions for the final paper. Reflecting on the course many students agreed it would be even more efficient to have an own theoretical course in the following semester just for data processing, creation of acoustic concepts and writing reports. The mode of a block course was ideal for this purpose since acoustic measurements take time for preparation and procedure especially with a lot of students. There was always some "warm up time" needed to get started so the usual course duration of 1,5 hours would have not been enough time to measure even a single location. In only four full time course units we could measure 13 rooms covering a good amount of possible room types. The missing room types (i.e. opera, theater, sports hall or recording studio) can be regarded as a future challenge for the students of this course or as an input for an upcoming practical course in room acoustics.

Summary and Conclusion

In the course presented in this paper, which was held at the University of Vienna in summer semester 2012, students of musicology were introduced into practical methods of measurement and analysis of room acoustical data by practical exercises. This allowed the students to immerse themselves in the subject and to learn by doing and by experience. Small groups of students carried out measurements in team-work in different room-types in Vienna. The measurements and the self - evaluated results revealed characteristic parameter values for every room. All contributions were collected in a documentation. Aura- and visualizations of the collected data were made available for presentation and teaching purposes. This course offered a quite new approach and, on a meta-level, comprehensive learning experiences as a result of active and experiential learning, constructed knowledge in interaction and allowed in-depth reflective dialogues, paramount learning needs which classical teaching methods often fail to meet.

The authors wish to express their thankfulness to the boards of the locations for the kind support of the course.

Figure 4: Students after Measuring Vienna Musikverein

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