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Cheap acoustics as a learning methodology

S. Dance

London South Bank University, FESBE, Borough Road, SE1 0AA London, UK
dances@lsbu.ac.uk

The Masters program in Environmental and Architectural Acoustics (MSc) from London South Bank University is taught at the Department of Urban Engineering. This was the first Masters course at the University and has been running for more than 30 years. The MSc program is based around real world problem solving in the built environment. The Masters students spend 50% of the time in the laboratory undertaken practicals, which culminates with a mini-project to create a cheap solution to an acoustic problem which may or may not meet the requisite standards for compliance. This paper will describe the successes and failures of the students through the use of case studies.

1. Introduction

The Acoustics Group have built a Master programme focused on meeting specific employers' requirements such as communication skills, professional management, and an understanding of the derived international standards which must be adhered to. As such, the Masters course in Environmental and Architectural Acoustics has been validated by Chartered Institute of Building Services Engineers for Chartered Engineering status (CEng).

We are fortunate enough to have a fully equipped and staffed acoustic laboratory with a reverberation chamber, sound proof booths and an anechoic chambers. We run the latest software packages such as CADNA, CATT, Revit:Ecotect, Google Sketchup, ARTA, and winMLS. Through info4education.co.uk the students have access to all the ISO standards on-line, although a password is required. Acoustic guides are freely available from noisevibrationresources.com.

Approximately three years ago our student feedback suggested that an independent mini-project would be of great benefit, as this would act as a trial run for the main dissertation. This idea has been developed and refined to become cheap acoustics.

2. Cheap Acoustics

Cheap acoustics runs over the entire second semester as part of the module Environmental Management. The mini-project is open ended and can be on any device or service as long as it attempts to partially meet some form of acoustic standard, legislation or guidance. It must be delivered to a panel of academic and industrial experts at the end of the semester in the form of a 15 minute oral presentation with question and answers, as well as a formal written technical report. The students having practised presentation skills in a separate semester one module.

The idea is to get the student to read around the subject of interest and to come up with their own ideas which can then be developed / tested against the given UK criteria for the product or service in a realistic ten week time frame. If ten weeks is too short then the mini-project can form the basis for the dissertation.

The reason cheap acoustics was chosen as a title was simple as traditional acoustics requires instrumentation that cost many thousands of pounds, whether it is for a microphone, a meter, an analyser, an amplifier, a loudspeaker, measurement software, modelling software, or even a sound card. So here are some recent case studies to illustrate student ingenuity.

3. Case Studies

A representative sample of six mini-projects are presented here, the target price was £200, typically an order of magnitude less than current cost of acoustic instrumentation.

3.1 Novel Personal Dosimeters

The students were taken on a field trip to the Royal Academy of Music to see how noise exposure measurements were taken. For this five Cirrus Research CR110A personal noise dosimeters were used. This led one of the students to establish if there was a suitable alternative to this particular type of acoustic instrumentation [1].

A literature review was initially undertaken to establish the requirements as defined by the relevant standards. Then a market investigation was instigated to establish the current market price of dosimeters. It was found that a Cirrus Research CR110 dosimeter cost £700, an Etymotic Research ER-200 dosimeter was available for US$99 and the Audio^3 SoundBadge was available for £200. The two cheaper devices were purchased and tested under real world conditions [2,3]; see Table 1.

3.2 The iPhone as a sound level meter

Since its introduction in 2007, Apple's iPhone has dominated the mobile phone industry. In actuality, the iPhone is a computer running a trimmed down version of the Apple's OS X operating system with a microphone and loudspeaker with an 'App Store' for downloads. These "apps" were originally targeted at the games market, but in 2008 apps became available to give the functionality of a sound level meter including real-time analysis in octaves and third-octaves (⅓), room acoustics, signal generation, dosimetry, and sound level logging and most recently speech intelligibility through STIPA measurement [4-7]

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The student presented a comparison of the measurement performance of the iPhone 3G(S), original iPhone EDGE, and several Class 1 and Class 2 sound level meters under various conditions and environments, see Figure 1 for time averaged noise measurements in a range of environments.

3.3 Room Acoustic Measurement Software

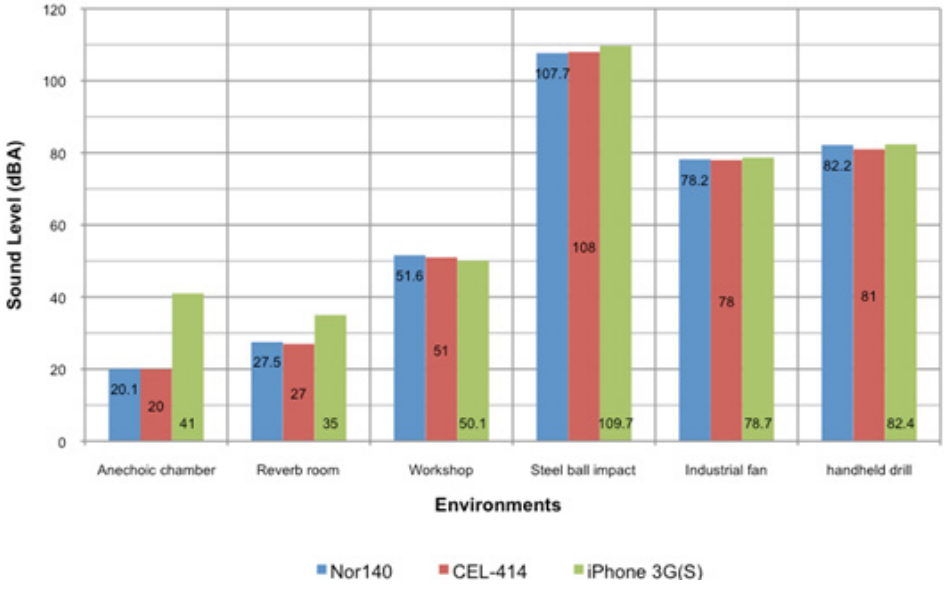
The Acoustic Group has moved from room acoustic specific instrumentation to computer based systems over the last 18 years, starting with MLSSA - a hardware/software solution then, 10 years ago, to winMLS. A student found a new measurement system, ARTA programmed by Dr Mateljan [REF]. This is a shareware program available for £150. ARTA is capable of taking impulse response measurements using pink, MLS or swept

sine signals. It can derive all room acoustic parameters, as well as undertaking sound level meter functions, such as logging or 1/3 octave band real time analysis.

Table 1: Measuerments of noise levels and noise dose percentage in different environments.

Environment	SOURCE	SLM Type	DURATION (sec)	SPL (dBA)	L_{Amax} (dBA)	$L_{EP,1h}$ (dBA)	Noise Dose %
Workshop	Metal Filing Metal	ER-200	120	-	-	-	200
		Nor 140		97.0	101.9	88.0	198.6
		Nor 132		99.0	102.7	90.0	315.2
		SoundBadge		97.7	102.3	88.7	233.4
	Cutting Plastic	ER-200		-	-	-	400
		Nor 140		97.6	101.0	88.6	228.1
		Nor 132		98.8	101.2	89.8	301.0
		SoundBadge		96.3	102.1	87.3	168.9
Reverberation	Drilling Plastic	ER-200		-	-	-	100**
		Nor 140		84.8	95.7	75.8	11.9
		Nor 132		83.9	95.4	74.9	9.6
		SoundBadge		84.6	100.7	75.6	11.3
	Sanding Wood	ER-200		-	-	-	100
		Nor 140		89.8	92.9	80.8	37.6
		Nor 132		90.0	93.4	81.0	39.4
		SoundBadge		87.1	95.1	78.1	20.2
	Hammering Metal	ER-200		-	-	-	100
		Nor 140		88.4	93.2	79.4	27.2
		Nor 132		89.0	94.9	80.0	31.3
		SoundBadge		91.0	102.0	82.0	49.6
Anechoic	Hammering Metal	ER-200		-	-	-	100
		Nor 140		89.5	99.6	80.5	35.1
		Nor 132		90.1	97.0	81.1	40.3
		SoundBadge		89.4	97.6	80.4	34.3
All	Through All	Nor 140	720	92.4	101.9	76.4	13.8
		Nor 132	720	93.5	102.7	77.5	17.6
		SoundBadge	720	92.5	102.3	76.3	13.3
		CR110A	1758	87.8	121.1	75.7	11.5
		ER-200	-	-	-	-	N/A

Figure 1 – Sound level meters and iPhone measured L_{Aeq} in a number of different environments



The student wanted to verify the accuracy of the reverberation time measurements by comparison with winMLS using exactly the same high quality equipment under identical conditions, see Figure 2, to the same international standard, in this case ISO 354:2003, the RT results are given in Figure 3. In addition the real-time analyser functions were tested and compared to those measured by a class 1 sound meter, Norsonic 140, see Figure 4.

Figure 2 Reverberation and sound level measurements

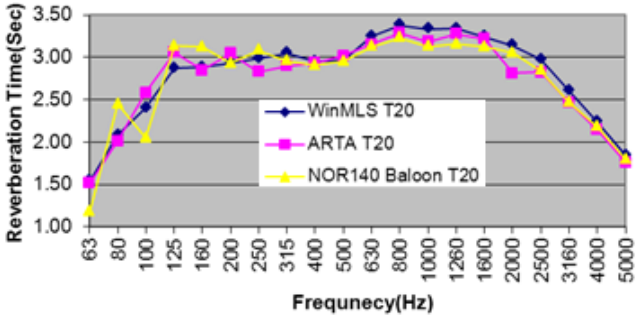


Figure 3. Reverberation as measured using three systems

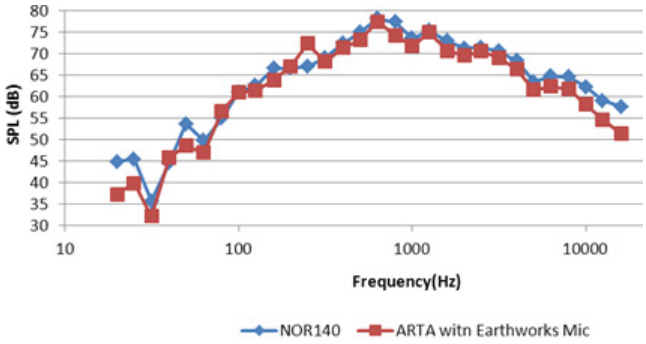


Figure 4. 1/3 octave levels as measured using two systems

3.4 Suitable Sound cards for Computer based Room Acoustic Measurement

For this project the Digigram VX Pocket sound card, £500, was compared to that integrated in a netbook connected through a Zoom 4HN A/D to acquire an acoustic signal – pink, brown and white noise in an anechoic environment,.

The comparison was then repeated against a class 1 sound level meter, Figure 8. It can be clearly seen that the low frequency performance of the Dell Mini/Zoom configuration was clearly deficient.

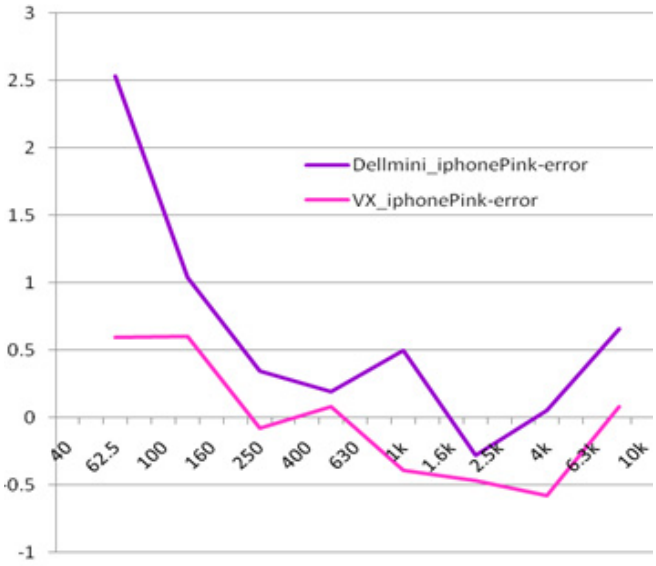


Figure 5. Comparison of the Dell Mini and Digigram card

3.5 XLR Microphone Performance

As computer measurements systems are now common the Acoustics Group had to standardise on a XLR microphone, we chose the Earthwork M30BX, see Figure 6, which illustrates the setup for the IEC 60268-4 substitution method. However, there are now a range of cheaper options available, in particular the Behringer ECM8000 and the dBX RTA-M 1/4" microphones. A microphone performance comparison was undertaken based on frequency response, see Figure 7, and a comparison to the class 1 criteria , see Figure 8, and class 2 criteria, see Figure 9. Additional, the microphone noise floor was determined.

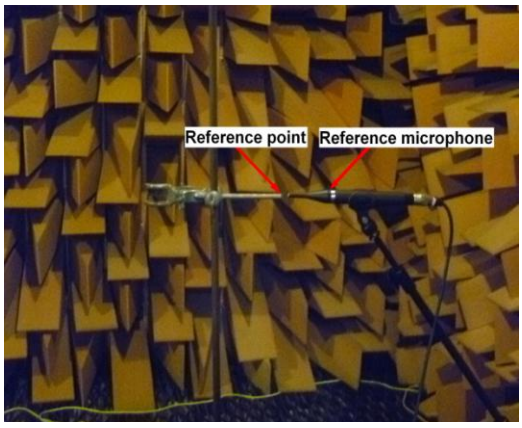


Figure 6. Substitution method of measurement.

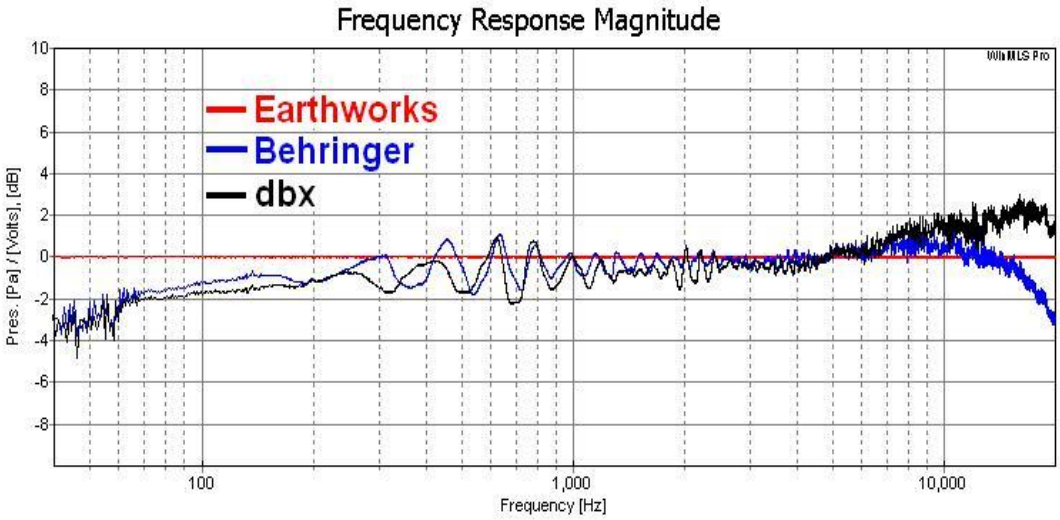


Figure 7. Microphone frequency response relative to Earthwork M30BX

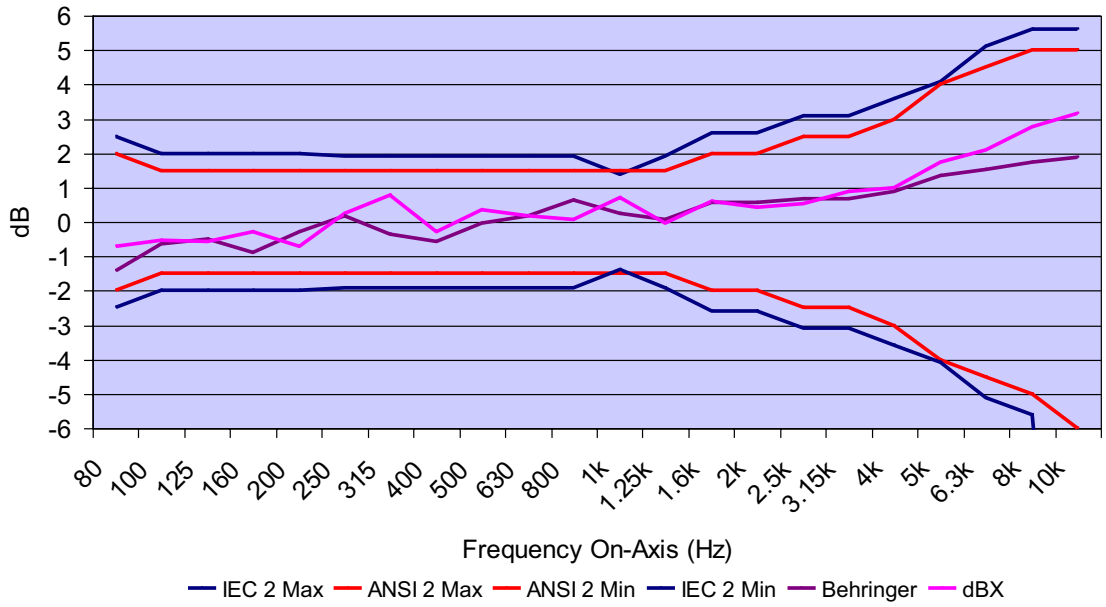


Figure 8. Pink noise frequency response referenced to Earthworks M30BX. IEC and ANSI Class 2 criteria 80 - 10000 Hz.

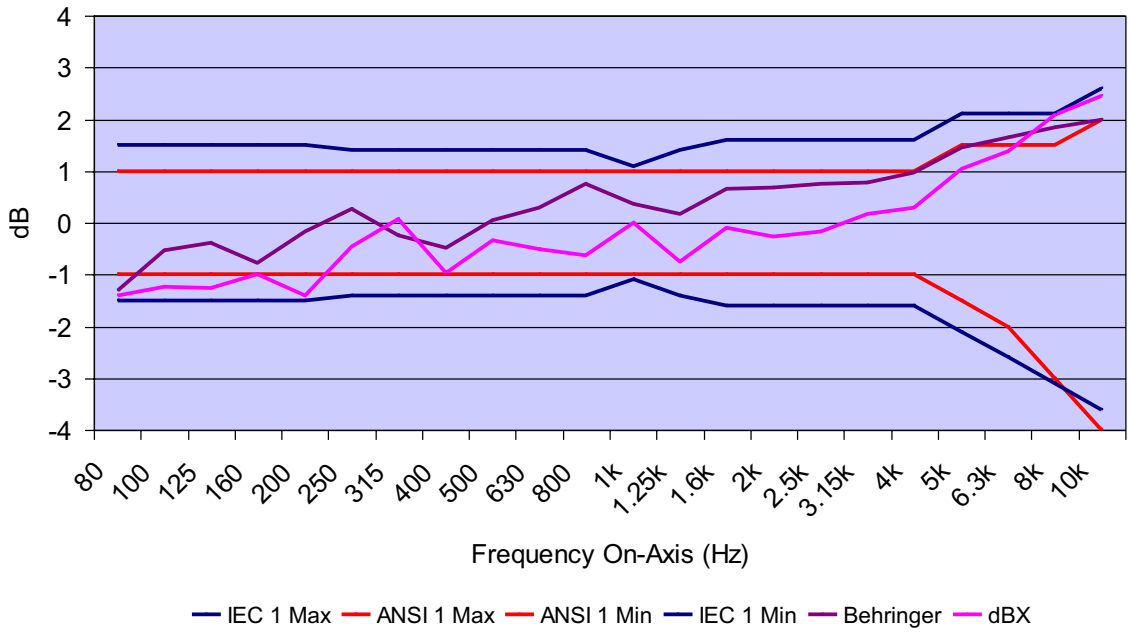


Figure 9. Pink noise frequency response referenced to Earthworks M30BX. IEC and ANSI Class 1 criteria 80 - 10000 Hz

3.6 Omni-directional Sound Source

One of the students thought the price of a dodecahedron sound source was excessively high. He also thought that by using a class D amplifier he could make an all in one design which would also be lighter and more convenient than those currently commercially available. The Acoustic Group uses ANV and Norsonics omni-directional sources, both of which are externally powered by an amplifier.

Using 12 ZX5 co-axial 150mm drivers and a fibreglass spherical garden plant pot and a lot of precise cutting an omni-directional sound source was created for £250, see Figure 15. For another £250 a class D amplifier was installed in the centre of the sound source. This system has the following specification 480 Watts RMS of sound power at 4 ohms with a linear response from 80 Hz to 20 kHz, according to the manufacturer's data sheet.

The problem came when positioning the speaker drivers. An icosahedron is circumscribed by a sphere; each of its 12 vertices then touches the surface of the sphere and gives you 12 points to position the speakers. Significant time was spent trying to line up the middle of each of the dodecahedron's pentagonal faces!

Figure 10. Plant Pot Dodecahedron Sound Source

4. Conclusions

London South Bank University's Master of Science Program in Acoustics is based around real world problems. The cheap acoustics assignment as a learning methodology in 2008 has been a great success. The students enjoy the freedom thought in the pursuit of a lower cost or alternative acoustics solution. In addition, this places a great deal of responsibility on the students, but teaches them the skills necessary to complete their main dissertation. Each year the students demonstrate ingenuity as the case studies presented are only a fraction of those undertaken.

Acknowledgements

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References

1. IEC 61252:2002-03. Electroacoustics - Specification for personal sound exposure meters. Geneva, Switzerland International Electrotechnical Commission.
2. S. Dance, B. Backus, E. Bukhary, Novel Personal Noise Dosimeters, Proc. 11th International Congress on Noise as a Public Health Issue (ICBEN), London, 2011.
3. E. Bukhary, MSc Thesis, Personal sound exposure meters – an assessment 2011, London South Bank University, 2011.
4. J. Zeman, S. Dance, D. Abraham. Acoustic uses for the iPhone. Proc IoA 32(3), Ghent 2010.
5. www.studiosixdigital.com [accessed 21/7/2011
6. www.faberacoustical.com [accessed 21/7/2011]
7. www.embeddedacoustics.com [accessed 21/7/2011]
8. www.fesb.hr/~mateljan/arta/ [accessed 21/7/2011]