Proceedings of Meetings on Acoustics

Volume 11, 2010 http://acousticalsociety.org/

160th Meeting
Acoustical Society of America
Cancun, Mexico
15 - 19 November 2010
Session 2aED: Education in Acoustics

2aED3. The current state of acoustics education at Brigham Young University

Kent L. Gee*, Scott D. Sommerfeldt and Tracianne B. Neilsen

***Corresponding author's address: Physics and Astronomy, Brigham Young University, N283, Provo, UT 84602, kentgee@byu.edu**

The current acoustics program at Brigham Young University reflects efforts intended to better prepare students for jobs in industry, research, and academia. In the classroom, ongoing modifications to courses are intended to provide students with a solid foundation in core acoustics principles and practices. A new advanced undergraduate course has been developed to provide students with formal training in acoustics prior to the graduate level and prepare them for research, internships, and entry-level acoustics positions. In the laboratory, graduate students not only carry out research of significance, but often serve as peer mentors to undergraduate students new to the group. This permits undergraduate students greater opportunity to participate meaningfully in research activities and has resulted in an increase in undergraduate-authored presentations and publications.

Published by the Acoustical Society of America through the American Institute of Physics

 [DOI: 10.1121/1.4770081]
Received 2 Nov 2012; published 21 Nov 2012
Proceedings of Meetings on Acoustics, Vol. 11, 025002 (2012)

1. Introduction

This paper presents an overview of the current acoustics program at Brigham Young University (BYU), and reflects efforts intended to better prepare students for positions in industry, research, and academia. This paper was originally presented in November 2010 in the "Teaching Acoustics in the Americas I" session at the 161st Meeting of the Acoustical Society of America and the 2nd Pan-American/Iberian Meeting on Acoustics held in Cancún, Mexico. Although the principal scope of this paper is unchanged, some content has been updated to reflect ongoing changes and growth in the program since 2010.

2. BYU Acoustics Research Group Overview

Although research in acoustics at BYU dates back to the late 1920's with Carl Eyring, for which the BYU physics building is named, his collaborators were principally external to his university. During his tenure at BYU, he published papers on room absorption, jungle acoustics, and reverberation in the sea. He passed away in 1951 from cancer while serving as the vice president of the Acoustical Society of America (ASA). Harvey Fletcher rejoined the faculty in 1952 after a brief stint at Columbia University following retirement from his remarkable career at Bell Laboratories. He received an NSF grant in 1959 for $9200, which was used to convert Eyring's planned reverberation chamber into an anechoic chamber. This led to the first publication [1] with student coauthors in 1962, and seems to mark the formation of an acoustics "group." Bill Strong joined the faculty in 1967 and kept the group going while mentoring students in the areas of musical and speech acoustics. The group began to expand to other areas beginning with Scott Sommerfeldt's hire in 1995 and has since published works in a myriad of ASA technical committees including noise, structural acoustics, underwater acoustics, physical acoustics, engineering acoustics, and signal processing.

The BYU Acoustics Research Group (ARG) is an interdisciplinary venture, primarily between physics and mechanical engineering. At the time of writing, it consists of five full-time, one visiting, one part-time, and one emeritus faculty member. There are typically 10-12 graduate students in the group and 15-20 undergraduates that participate actively. Most of these students come from physics and mechanical and electrical engineering backgrounds. Photographs of the group in 2005 and 2009 are shown in Figure 1 and Figure 2.

Figure 1. ARG photograph in 2005 in the anechoic chamber prior to its renovation.

Figure 2. Photograph of the BYU ARG in October 2009.

3. Curriculum Improvements

ARG students earn degrees in their respective programs, but there are several courses that are tied directly to the acoustics faculty. These include an introductory, descriptive class that students with a budding interest in acoustics take, [2-4] and until recently, several graduate courses in Physics and Mechanical Engineering. Because many enthusiastic undergraduate students were taking graduate courses for which they were not fully prepared, ARG faculty recognized a need to develop a course specifically for advanced undergraduate students. [3,5,6]

This was taught for the first time in 2008 and has evolved into a permanent course taught once per year. Average enrollment is approximately 10-12 students.

Physics 461, as it is called, is primarily intended for undergraduate students but is taught such that incoming graduate students from other universities can take it concurrently with their other graduate courses. The course emphasis is on using mathematical and physical models to explore real-world problems. The level of the course is consistent with the text by Kinsler *et al*. [7] but is supplemented with more applications that, e.g., acoustical consultants might encounter. Laboratory exercises include community noise measurements, room criteria and reverberation time, ground impedance analysis, and loudspeaker directivity. The course is still very much under development, including the incorporation of active-learning methods [3, 6], but the response has been very enthusiastic by the students. Some of the benefits we see as faculty are as follows.

- It provides formal training in acoustics for advanced undergraduate students, which provides them tangible skills for internships and entry-level positions
- It is allowing us to revise and raise the level of our graduate curriculum
- It helps identify students interested in acoustics research and helps to prepare them with skills necessary for research

4. Facility Improvements

Brigham Young University's current outstanding facilities are largely due to the design expertise of one of its faculty members, Tim Leishman. Figure 1 showed the original anechoic chamber with handmade wedges built by Harvey Fletcher and his students circa 1960. Safety concerns prompted an extensive renovation of the facility in 2006-2007. The updated chamber with several automated motion and measurement systems is displayed in Figure 3, along with a smaller ultrasound-capable chamber, completed in 2009. [8]

Figure 3. Left: BYU fully anechoic chamber renovated with perforated metal wedges. Right: A smaller, recently built fully anechoic chamber with foam wedges that can be used for ultrasonic measurements.

Three other dedicated measurement facilities, all constructed in the last decade, exist. First, a variable acoustics room with removable wedge panels is shown in Figure 4. Also shown in Figure 4 is one of the two coupled reverberation chambers that can be used in sound power and sound transmission studies. In addition to these excellent facilities, ARG benefits from well designed control rooms, extensive multichannel data acquisition systems, more than 100 Type 1 microphones and accelerometers, and last but not least, scanning laser Doppler vibrometry systems. The infrastructure provided by these facilities has greatly impacted ARG capabilities and productivity during the past several years.

Figure 4. Left: variable acoustics room. Right: One of two coupled reverberation chambers

5. Group Productivity

One simple chart can be used to summarize the growth in productivity from the ARG, that of publications per year, since Eyring's first paper in 1933. The chart shown in Figure 5 includes data through September 2012. The exponentially increasing trend is, of course, not sustainable (!), but shows a remarkable change in scholarly productivity. Much of this rapid growth is attributable to a) the longevity and a foundation of excellence within the program, b) the support of the university in hiring faculty members with expertise in acoustics, c) the outstanding facilities previously mentioned, and d) perhaps, most importantly, the essential role students play in the research and publication process.

Student involvement can also be summarized succinctly. Because BYU focuses primarily on undergraduate learning, ARG faculty members have tried to meaningfully involve undergraduate students in research, often in a peer-mentoring relationship with a graduate student. The literal explosion in undergraduate involvement in scholarly activity is shown in Figure 6, with significant numbers of journal articles lagging the increase in conference presentations by only a few years. Many of these journal articles are *first-authored* by the undergraduate student with, of course, significant mentorship by the advisor. This helps to show the unique nature of the acoustics research program going on at BYU.

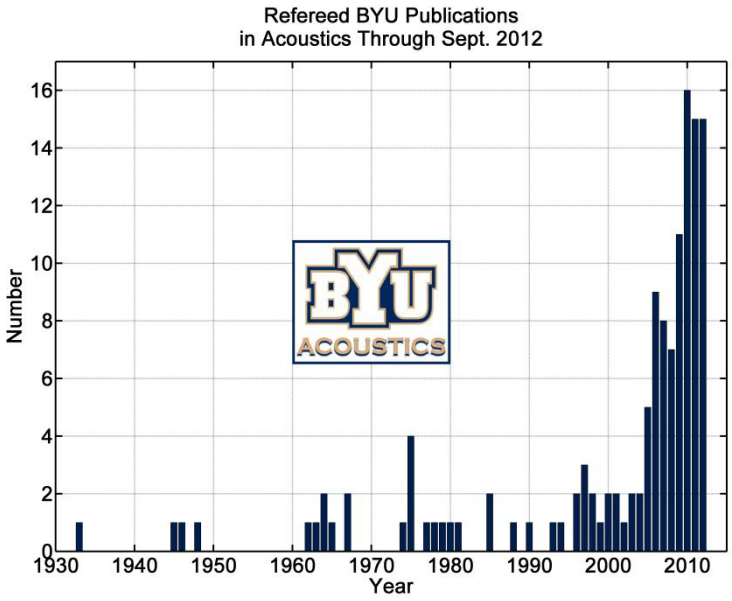

Figure 5. Number of refereed publications in acoustics per year by ARG faculty since 1933.

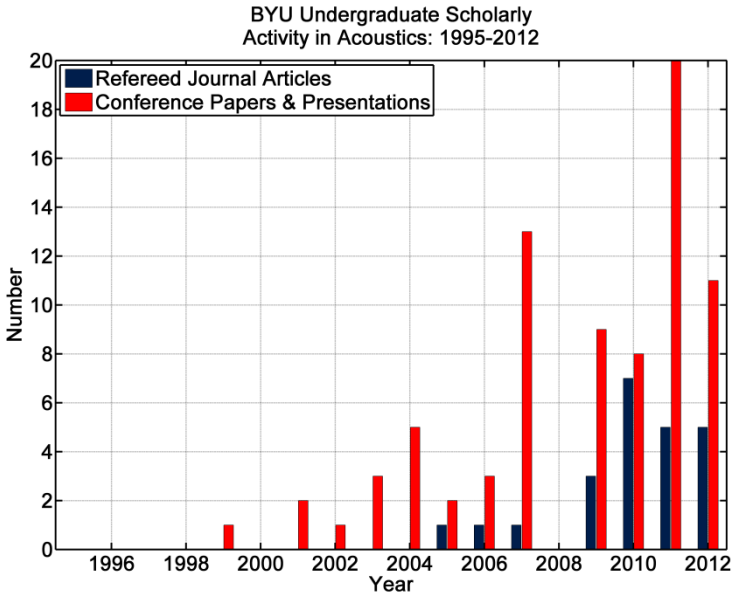

Figure 6. Summary of ARG undergraduate involvement in scholarly activities.

6. Summary

From the feedback we have received, we recognize the critical role our undergraduate program plays in feeding top graduate programs in acoustics around the country, including our own. We feel that the students leave our program having had a significant research and technical writing experience, having received formal academic training in acoustics, and with the vast majority having given a presentation at a national or international acoustics conference. At a recent ASA

meeting in Seattle where BYU brought two van loads of students, a faculty member from another institution referred to it as the "BYU invasion." Ultimately, we hope to continue to build on the long-standing foundation of excellence and continue to provide outstanding educational opportunities for the students of today and tomorrow.

References

1. H. Fletcher, E. D. Blackham, and R. Stratton, "Quality of piano tones," J. Acoust. Soc. Am. **34**, 749-761 (1962).
2. T. B. Neilsen, W. J. Strong, B. E. Anderson, K. L. Gee, S. D. Sommerfeldt, and T. W. Leishman, "Creating an active-learning environment in an introductory acoustics course," J. Acoust. Soc. Am. **131**, 2500-2509 (2012).
3. T. B. Neilsen and K. L. Gee, "Application of active-learning techniques to enhance student-based learning objectives," Proc. Mtgs. Acoust. **14**, 025001 (2012).
4. T. B. Neilsen and K. L. Gee, "Use of a Just-in-Time Teaching technique in an introductory acoustics class," submitted to Proc. Mtgs. Acoust. (2012).
5. K. L. Gee, S. D. Sommerfeldt, T. W. Leishman, B. E. Anderson, and J. D. Blotter, "Improving undergraduate noise control education at Brigham Young University," Proc. Internoise 2009, paper 10521.
6. K. L. Gee and T. B. Neilsen, "Application of Just-in-Time Teaching to advanced acoustics courses," submitted to Proc. Mtgs. Acoust. (2012).
7. L. E. Kinsler, A. R. Frey, A. B. Coppens, and J. V. Sanders, *Fundamentals of Acoustics*, 4th ed. (Wiley & Sons, New York, 2000).
8. T. Jenny and B. E. Anderson, "Ultrasonic anechoic chamber qualification: Accounting for atmospheric absorption and transducer directivity," J. Acoust. Soc. Am. **130**, EL69-EL75 (2011).