Proceedings of Meetings on Acoustics

Volume 18, 2012 http://acousticalsociety.org/

164th Meeting of the Acoustical Society of America
Kansas City, Missouri
22 - 26 October 2012
Session 2aED: Education in Acoustics

2aED6. Application of Just-in-Time Teaching to advanced acoustics courses

Kent L. Gee* and Tracianne B. Neilsen

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

Classroom instruction can be inefficient or ineffective when students do not come to class prepared. One strategy to engage students prior to class is the use of pre-class quizzes. Pre-class "Just-in-Time Teaching" quizzes or learning activities have been used with great success in the general education acoustics course at Brigham Young University (BYU). However, the pedagogical methods developed for introductory courses are not often applied at the advanced undergraduate and graduate levels. This paper reviews some of the findings from the introductory course efforts and then describes implementation of pre-class quizzes for two advanced acoustics courses at BYU. Described are examples and lessons learned, including 1) the questions must be carefully constructed so that the instructor can gauge student understanding, and 2) the quizzes can provide an effective framework for a class discussion of a topic, rather than a lecture with little to no participation.

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

Received 26 Oct 2012; published 21 Nov 2012

1. Introduction

Pedagogy has been shifting toward helping students achieve learning outcomes, which can only be met if the students engage in the learning process. Investment by students in their educational progression is more likely if the instructor fosters an active-learning environment. To accomplish this, the instructor must think carefully about how to structure activities both inside and outside of class to encourage student engagement and to improve the learning process.

One of the proven techniques for active learning in physics classrooms is referred to as "Just-in-Time-Teaching" [1]. JiTT is a learning strategy based on pre-class, web-based study assignments and active learning in the classroom. The students respond to web-based assignments that are due shortly before class (typically 1-2 hrs). The instructor reviews student responses and adjusts the focus and/or flow of the classroom lesson to suit student needs. The goal is to maximize efficacy of the classroom time when an instructor is present by helping the students engage in the material prior to coming to class and helping the instructor identify both misconceptions and depth of understanding [2]. This paper covers the use of JiTT in acoustics courses at Brigham Young University by briefly mentioning its use in an introductory course and then by focusing on its application to advanced courses.

2. JiTT in an Introductory Course: Pre-class Learning Activities

"Descriptive Acoustics," which has the course number of Physics 167, is a general education course at Brigham Young University. The course has recently undergone significant implementation changes to create a more active-learning environment for students. Many of the changes are described by Neilsen *et al*. [3] and by Neilsen and Gee [4]. One of the changes has been a shift away from multiple-choice pre-class reading quizzes, which were primarily vocabulary-based, towards JiTT-based pre-class learning activities. These activities require the students to spend 5-10 minutes performing a simple at-home experiment or exploring an interactive online simulation and then to write a paragraph about their experiences using key vocabulary from the chapter. Implementation of these activities and use in the classroom instruction is discussed by Neilsen and Gee [4,5]. However, to summarize benefits we have seen:

- Students come to class more enthusiastic, often seeking answers to questions they have already asked.
- Students are more willing to participate in class because of their familiarity with and *prior meaningful use* of the vocabulary.
- Classroom discussions are immediately made more effective and often can be taken farther because of the students' increased participation and preparation.

Overall, we have been extremely pleased with how implementing JiTT has improved the use of class time in this introductory course.

3. Application of JiTT to Advanced Courses

The bulk of physics education research related to active learning has been focused on helping students that struggle in introductory classes. Upper division undergraduate and graduate courses still rely far more on the traditional lecture approach, despite the fact that these advanced students still share many of the same misconceptions as their classmates in the introductory courses. Furthermore, the greater mathematical rigor forces more time to be spent on derivation of important equations, which may not result in greater understanding of the physical principles and does not often force the students to think critically during class. As instructors, we assume that the resulting equation translates into greater physical insight, but this is not always the case if the students do not practice learning to read and to interpret the mathematics.

To aid in these challenges, the use of JiTT seems relatively promising. Rather than students ignoring or skimming a reading assignment while their eyes glaze over, JiTT can help the class engage in the material and the instructor evaluate their level of understanding before they walk into the classroom. JiTT has been applied to two advanced acoustics courses thus far. Physics 461 is an advanced undergraduate course that typically has 10-15 physics and engineering majors. It uses the text by Kinsler *et al*. [6] but is heavily supplemented with practical examples and other resources. Students generally report difficulty understanding the reading assignments. Physics 662 is a graduate course that covers both active noise control (ANC) and sound-structure interaction. It uses the text by Fahy and Gardonio [7] and in-house notes on ANC that are similar in level as the Nelson and Elliot book [8]. During the latest offering (winter semester 2012), it was taken by eight graduate students in physics and mechanical engineering.

In implementing JiTT, responses are graded by completeness of response only, not correctness. There are usually 3-5 question per quiz with the average response length ranging 2-3 sentences. The quizzes count toward approximately 5% of the overall grade. The types of questions typically asked can be grouped into the following categories:

- Conceptual
- Mini-experiment or exploration
- Physical interpretation of mathematics
- Graph interpretation
- “Muddiest point,” questions, running course feedback

As an example of the variety of responses that are received, consider the following question from Physics 461 that involves interpretation of the relationships between pressure, particle velocity, and the acoustic condensation, written as

$$\boldsymbol{u}_{\pm} = \pm\boldsymbol{p}_{\pm}/\rho_0 c$$

and

$$\boldsymbol{s}_{\pm} = \boldsymbol{p}_{\pm}/\rho_0 c^{\mathbf{2}}.$$

The above equations show that acoustic pressure, particle velocity, and density can be related through constants for a harmonic plane wave. What does this mean about the phase relationships between these variables?

Answers to this question range from the very concise to the point of wondering if the students really understand, to regurgitation of statements from the text that use terms like “phase” and “variables” without really addressing the question, to the insightful. For example, an actual student response was

Since the vector quantities equal each other when multiplied by these constants, this means the phases of the variables are the same or exactly 180 degrees out of phase (if one is a negative quantity compared to a positive quantity).

This represents excellent understanding of the student prior to coming to class and is a response the instructor can build upon in the class discussion to quickly move to more complicated topics, such as the specific acoustic impedance of spherical waves, where both resistive and reactive components are present.

A notable example of a conceptual question from Physics 461 is

The time average of a sinusoidal pressure plane wave is zero. Is this true for the energy density and intensity? Explain.

The students often assume that because the time average of pressure is zero and, by Euler’s equation, the time average of velocity is zero, the energy density and intensity should therefore also be zero. This motivates a meaningful discussion of mean-square quantities and situations when the time averages of energy-like quantities are and are not zero.

From Physics 662, a conceptual question involving the below diagram is used. In considering ANC in a one-dimensional, infinite duct with a planar source located at $z = 0$, it is desired that total pressure cancellation be achieved in the downstream direction beyond the location of the secondary source at $z = L$. In the notes, the secondary source pressure required to produce this cancellation condition is found, and then it is noted that the secondary source does not radiate any power. The question asked of the students is

On slide 11, a seemingly outrageous statement is made. How can cancellation occur if the secondary source radiates no power? Explain.

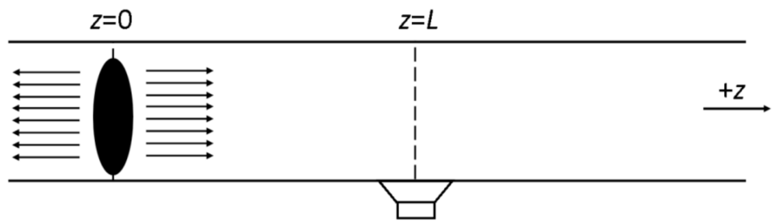

Figure 1. Active control scenario in a one-dimensional duct.

This presents a conceptual conundrum to the students as they are forced to think about how a source can produce a pressure wave without radiating any power. The fact that they are likely still wrestling with this concept when they come to class helps facilitate a lively, meaningful discussion.

Mini-experiments allow the students to tangibly experience some of the concepts from the classes. In Physics 461, an example of a mini-experiment is the exploration of axial, tangential, and oblique modes in rooms through the use of an online applet [9]. In Physics 662, the students were asked to relate changes in bending stiffness for a corrugated plate to the folding of a piece of paper in various fashions, including like a fan. Although this may seem somewhat juvenile for a graduate level class, it reinforced the idea that students' conceptual understanding can be reinforced by simple demonstrations.

For mathematical interpretation questions, students can be asked to examine assumptions, describe what variables or portions of expressions mean in words, or to perform dimensional analysis. Learning to interpret and explain graphs helps students not only in their reading, but also in their ability to orally present technical material to their peers. In essence, these questions serve as a practice forum for their roles as budding researchers.

The final category of question is that of the "muddiest point," where students can talk about the aspect from a previous class or from the reading that they really do not understand. Alternatively, this question can be used as a space for students to ask other questions or express concerns, and for the instructor to solicit feedback on the course. Although this can be humbling, it provides a chance for students to voice concerns in what they view as a non-threatening forum.

4. Observations

Above all, we have noticed an enormous difference in the classroom dynamics between the days when students have prepared by taking a JiTT quiz and the days that no quiz is offered. On the days no quiz is required, the students are less prepared and more time is spent on concepts and misconceptions that could have been covered in the pre-class quiz.

Additional observations regarding the JiTT quizzes can be made. First, because the responses are graded only by completeness, students do not find these onerous and still take them seriously. They also appreciate the guided reading approach and the feedback to their responses in class. Second, students value consistency. Because we are still developing the approach, and the curriculum to some extent, it is difficult to offer a quiz every single class, which is sometimes frustrating to the students as they are uncertain if one will be required. Finally, as faculty, we recognize the difficulty in crafting questions to help probe student understanding. Poor questions involve those that a) are too easy or leading and require no real thought, b) are too difficult and go beyond the ability of the students to even engage in meaningful thought, c) are too vague.

In summary, JiTT quizzes have been used successfully in two advanced acoustics courses. There are a few items that help ensure the success of this technique. It is important for the instructor to evaluate the questions such that they guide the student's initial exposure to the material. However, *any* quiz is better than none because it forces the students to at least think and engage in the material before class, which offers the instructor a foundation to build upon. By reviewing the student's responses, the professor gains insights into their understanding and can approach the JiTT goal of maximizing class-time efficacy. For this reason, we plan to continue to develop and improve our implementation of JiTT in advanced acoustics courses.

References

1. G. Novak, E. T. Patterson, A. D. Gavrin, and W. Christian, "Just-in-time teaching", Am. J. Phys. **67**, 937-938 (1999).
2. http://jittdl.physics.iupui.edu/jitt/, viewed 10/25/2012.
3. 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).
4. T. B. Neilsen and K. L. Gee, "Application of active-learning techniques to enhance student-based learning objectives," Proc. Mtgs. Acoust. **14**, 025001 (2012).
5. T. B. Neilsen and K. L. Gee, "Use of Just-in-Time Teaching in an introductory acoustics class," Proc. Mtgs. Acoust., submitted 2012.
6. L. E. Kinsler, A. R. Frey, A. B. Coppens, and J. V. Sanders, *Fundamentals of Acoustics*, 4th ed. (Wiley & Sons, New York, 2000).
7. F. Fahy and P. Gardonio, *Sound and Structural Vibration: Radiation, Transmission, and Response, 2nd ed.* (Academic Press, Oxford, UK, 2007).
8. P. A. Nelson and S. J. Elliott, *Active control of Sound* (Academic Press, San Diego, CA, 1992).
9. P. Falstad, "Education math and physics applets," found at http://falstad.com/mathphysics.html, viewed on 10/25/2012.