Students' understanding and perceptions of the content of a lecture

Zdeslav Hrepic, Dean Zollman and Sanjay Rebello
Physics Department, Kansas State University, Manhattan, KS 66506
zhrepic@phys.ksu.edu; dzollman@phys.ksu.edu; srebello@phys.ksu.edu

Abstract: In spite of advances in physics pedagogy, the lecture is by far the most widely used instructional format. We investigated students' understanding and perceptions of the content delivered during a physics lecture. Students participating in our study responded to a written conceptual survey on sound propagation. Next, they looked for answers to the survey questions in a videotaped lecture by a nationally known teacher. As they viewed the lecture, they indicated instances, if any, in which the survey questions were answered during the lecture. A group of experts (physics instructors) also participated in our study. We discuss students' and experts' responses to the survey questions.

Introduction

The lecture is perhaps the oldest instructional format that is commonly used today. Researchers' interest in issues related to classroom teaching has resulted in a variety of findings significant for improvements in instruction.[1] However, educators are still concerned with how students learn in a traditional lecture.[2, 3] Although many novel instructional methods have been developed, it is unlikely that the lecture will soon be replaced as the most commonly used format. This is why the lecture deserves our attention.

Motivation

During our recent study on students' understanding of sound propagation [4] we noticed a considerable mismatch between the students' and experts' perceptions of the content of the lecture. In earlier research we interviewed students before and after lecture-based instruction using the same protocol. An observation of the lecture by one of the authors indicated that the instructor had explicitly answered many of the interview questions during the lecture. However, several interviewees stated that they were unable to find answers to the interview questions in the lecture even though they specifically looked for them.

Goals

Our research questions were:

- What kind of questions do students perceive as being answered in a lecture?
- How are students' perceptions related to their knowledge prior to the lecture?
- How do students' perceptions of the content of a lecture compare with those of experts?

Methodology

We interviewed 18 students in a conceptual physics class at Kansas State University. Over half of the students had taken high school physics. Students received extra credit worth 2% of the course grade for their participation. Sound propagation was the topic of the experimental lecture and the study was conducted within a few weeks after students had completed their lectures and taken an in-class exam on this topic.

In the experiment students viewed a videotaped lecture on the chosen topic. For this purpose we used a segment of a commercially available video lecture [5] on sound propagation by the author of the class text, [6] so the students were exposed to a lecture different from the one that they had heard in class. The fact that the lecture was given by a nationally known teacher was deemed to improve the possibility that students would find the lecture understandable. The duration of the experimental lecture was about 14 min, i.e. less than a third of the normal class time. Both the lecturer and the students were native English speakers. Students had full control over the video and there were not any typical classroom distractions such as noise, etc. Therefore, the experimental situation had several important advantages compared to a typical classroom.

Before students viewed the video, they responded to a written survey on sound propagation. The survey questions were open-ended and ranged from those addressed explicitly in the video to those not addressed at all. The survey enabled us to gauge students' initial understanding of sound propagation. It also provided specific questions for which students were subsequently asked to find answers in the video.

The following questions were on the survey:

Q1. Describe the nature/mechanism of sound propagation in air? [Answer: Sound is the propagation of the (longitudinal) vibration of medium particles. Or, sound is a pressure wave.]

Q2. Does the speed of the sound in air depend on temperature? [Answer: Yes. Sound propagates faster if the temperature is higher.]

Q3. Does the speed of propagation of sound depend on the motion of the source? [Answer: No. It depends only on medium properties.]

Q4. Does the speed of propagation of sound depend upon the medium? If so, how does the speed of sound generally compare between solids, liquids and gases. [Answer: Yes. Generally it is faster in solids than in liquids and faster in liquids than in gases.]

Q5. Does sound propagate in a vacuum? [Answer: No. It needs a medium.]

Q6. Does sound affect a dust particle floating in front of the loudspeaker? If so, how? [Answer: Yes. It will vibrate longitudinally.]

While watching the video, students were asked to record the answer as they perceived it being given in the video to each survey question. They were also asked to indicate, on a Likert scale, the extent to which the question was answered: 1 (hint of the answer) to 5 (answered completely).

After viewing the video completely, each participant was asked to record whether any further answers could be inferred from the video lecture. This task aimed to determine questions whose answers the student perceived as being indirectly addressed, although not explicitly answered in the video. Besides students, we also surveyed a group of nine experts using the same protocol. For this study experts were defined as M.S. or Ph.D. degree holders in physics who also clearly held the wave model as their mental model for the propagation of sound. Four of the experts were non-native English speakers. We also asked the videotaped instructor, Paul Hewitt, to participate in the study.

Data Analysis

Data were analyzed to determine the frequency, completeness and correctness of the answers that students and experts recorded. Due to the complexity of answers to Q1, we classified participants' answers in terms of their mental models of sound propagation.[4] In order to give a qualitative picture of the issues that students have in understanding the lecture, we listed a set of traits observed in students' answers.

Results and Discussion

In discussion of the results we use responses from Dr. Hewitt as a reference point:

Q1: Answered	(rated 4/5)
Q2: Answered completely	(rated 5/5)
Q3: Not answered	
Q4: Answered	(rated 4/5)
Q5: Not answered	
Q6: Partially answered	(rated 2/5)

Similarly to the instructor, both students and experts perceived Q1, Q2 and Q4 as answered in the lecture as shown in Table 1. However, the experts perceived them as being addressed about twice as often as the students did. Although the whole lecture segment was related to sound propagation, three students believed that Q1 was not addressed at all. One student recorded the answer to Q1 artificially, without addressing the nature of sound propagation. Only three students "upgraded" their models: Two of them from an incorrect to a less incorrect model and only one from an incorrect model to the correct model. For three students we could not determine with certainty the mental model that they used, but their responses were clearly inconsistent with the wave model. The remaining seven students retained their initial (incorrect) model after the lecture.

With respect to the correctness of students' answers, there are only two questions (Q2 and Q4) for which the number of correct answers after the lecture is substantially larger than before the lecture. Unlike others, these two questions were addressed explicitly and multiple times in the lecture. Unlike students, (and also unlike the instructor) experts perceived Q5 and Q6 as being answered in the lecture. The reason for the mismatch between experts and students can be found in the distribution of inferences (instances in which the participants decided after completely viewing the video that an answer to a question could be inferred from the video). Experts on average made twice as many inferences as students did and all of the experts' inferences were related to Q5 and Q6. Unlike students, experts believed that based on the explanation of the sound propagation through the air, the dynamics of dust particles and (non)propagation in a vacuum can be inferred. Another important result related to the inferences is that correct inferences were made only by participants (students and experts) who knew the correct answer prior to the study. Contrary to Q5 and Q6, Q3 was perceived as being addressed by five students though not by a single expert. There is no apparent reason for this students' belief because nothing in the lecture was even remotely related to Q3. Table 1 finally shows that the experts rated nearly all questions as being more completely answered than the students did.

		Frequency of the answers as recorded by participants			**Perceived completeness of the instructor's answers**			**Correctness of the recorded answers**		**Inferences made**	
Question	**Viewers group**	**Question seen as address (directly or as an inference) by**	**Average number of times addressed**	**Mode of times addressed**	**Participants that rated completeness**	**Average completeness**	**Mode of completeness**	**Answered correctly and with relevance**	**Answered correctly also before the video**	**Correct answer given only as an inference**	**Total number of inferences**
1	**Students (N=18)**	**15 (83%)**	**1.2**	**1**	**13**	**3.8**	**5**	**2**	**1**	**0**	**3**
	Experts (N=9)	**9 (100%)**	**2.1**	**1**	**8**	**4.5**	**5**	**9**	**9**	**0**	**0**
2	**Students (N=18)**	**18 (100%)**	**1.3**	**1**	**17**	**4.8**	**5**	**17**	**8**	**0**	**0**
	Experts (N=9)	**9 (100%)**	**2.4**	**2**	**8**	**4.7**	**5**	**9**	**8**	**0**	**0**
3	**Students (N=18)**	**5 (27.8%)**	**1**	**1**	**3**	**2**	**N/A**	**1**	**1**	**1**	**3**
	Experts (N=9)	**0 (0%)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
4	**Students (N=18)**	**18 (100%)**	**1.4**	**1**	**16**	**4.1**	**5**	**17**	**12**	**0**	**0**
	Experts (N=9)	**9 (100%)**	**3**	**3**	**8**	**4.8**	**5**	**9**	**8**	**0**	**0**
5	**Students (N=18)**	**3 (16.7%)**	**1**	**1**	**2**	**2.6**	**N/A**	**2**	**2**	**2**	**3**
	Experts (N=9)	**7 (77.8%)**	**1**	**1**	**1**	**3**	**N/A**	**7**	**7**	**7**	**7**
6	**Students (N=18)**	**3 (16.7%)**	**1**	**1**	**4**	**2**	**2**	**2**	**1**	**1**	**2**
	Experts (N=9)	**7 (77.8%)**	**1**	**1**	**5**	**2.2**	**1**	**6**	**6**	**3**	**4**

Table 1: Results from students and experts

Another result of this study that complements the previously reported data, in a qualitative manner is observation of a collection of undesirable traits related to students' answers and their ways of understanding of the lecture. Students may tend to...

1. *concentrate on details* in the instructor's statements while overlooking the big picture. In addition they may *record details incorrectly*. (e.g. "Sound travels four times faster in steel and about two times faster in water [than in air].")
2. perceive the *incorrect answer when no answer* is given to the question. (e.g. "If the source is moving fast… you'll hear it faster.")
3. *...hear "what makes sense" and overlook what was actually stated.* (e.g. "[The dust] particle vibrates up and down," (the same answer as given before the interview). Follow-up by Interviewer: "So what did he [instructor] say about the direction of vibration? Do you remember?" Student: (Pause) What do you mean?" Interviewer: How did you conclude that they will vibrate up and down?" Student: (Pause) Just…it wouldn't…it wouldn't make sense to vibrate…They couldn't vibrate sideways.")
4. hear/understand exactly the *opposite* of what the instructor said. (e.g. "Sound propagates faster in cold air. Slower in warm air.")

5. hear what was *not said*. (e.g. “The *sound molecules* vibrate back and forth.”)
6. make *inappropriate generalizations*. (e.g. “In a liquid… sound would move four times faster than when it is not in a liquid.”)
7. create *false positive* answers. (e.g. “Sound bounces back and forth …so the dust particle will move back and forth.”
8. correctly *repeat instructor’s statements but not make sense* of them. (e.g. “He [the instructor] was just talking about the way the sound moves. When molecules start moving, they’re vibrating back and forth and they hit the next one and the next one ... [Sound is] just traveling with those, I guess. I don’t know. It’s just traveling with that. Like being carried with each vibrating molecule. ... I’m just in the dark with this whole sound thing.”)
9. *correctly repeat the instructor’s statement without realizing that it does not make sense to them.* (e.g. “Molecules hit one another until they reach the person.” Interviewer: How is sound related to these molecules hitting each other? ... Student: “What do you mean? ...I don’t know. I mean I don’t think every molecule just kind of transfers…I don’t know. I didn’t think about that.”)
10. *correctly repeat the instructor’s statements but interpret them differently than intended*. (e.g. The students understood statements about vibration of molecules when given an example of a room full of vibrating ping pong balls so that sound is an autonomous entity which is different from the medium that moves by using vibration of medium molecules.)

We now discuss the effect of earlier answers on student understanding of the lecture content, which was another of our research questions. With respect to their earlier answers students may...

1. retain their previous ideas although they change a specific answer.
2. keep their initial (incorrect) model in identical form.
3. inappropriately incorporate new information into the existing (incorrect) model.
4. use the same terminology as experts do (both before and after the lecture) but with a very different meaning attached to it.
5. be confused more after than before the lecture.

Conclusions

In general, we conclude that students correctly notice answers that are explicitly stated, preferably multiple times. Otherwise, they may try to make sense of things in ways not intended by the instructor. In addition, students by default make incorrect inferences. Finally, experts tend to believe that more answers were given (explicitly or implicitly) in the lecture and that they were addressed more frequently and more completely than students or even the lecturer believed.

Although some of the traits in students reasoning that we showed can be expected based on our current understanding of conceptual change and some have been observed in the past, this study provides conclusive evidence that these issues persist in a lecture even under idealized circumstances, and therefore reinforces the importance of attempting other non-traditional instructional formats that might be more effective.

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