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Cite as: Phys. Teach. **58**, 90 (2020); https://doi.org/10.1119/1.5144786
Published Online: 23 January 2020

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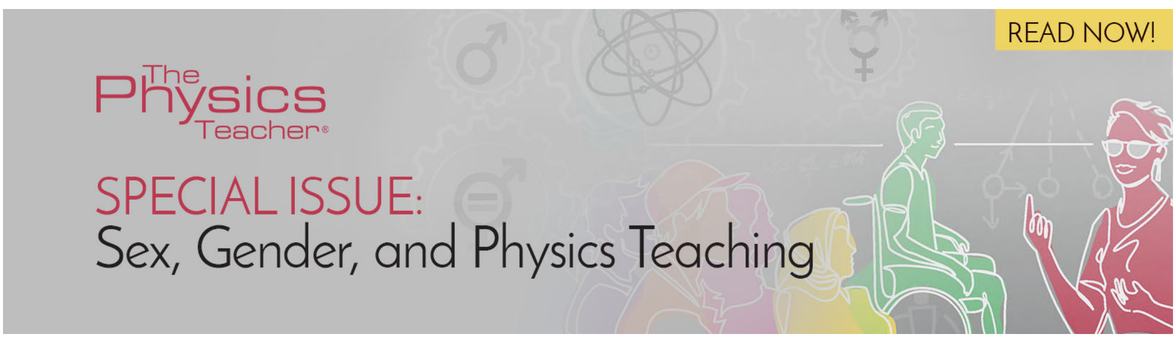

Best Practices for Administering Attitudes and Beliefs Surveys in Physics

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Physics faculty care about their students learning physics content. In addition, they usually hope that their students will learn some deeper lessons about thinking critically and scientifically. They hope that as a result of taking a physics class, students will come to appreciate physics as a coherent and logical method of understanding the world, and recognize that they can use reason and experimentation to figure things out about the world. Physics education researchers have created several surveys to assess one important aspect of thinking like a physicist: what students believe that learning physics is all about. In this article, we introduce attitudes and beliefs surveys and give advice on how to choose, administer, and score them in your classes. This article is a companion to "Best Practices for Administering Concept Inventories,"[1] which introduces and answers common questions around concept inventories, which are research-based assessments of physics content topics.

Introduction to attitudes and beliefs surveys in physics

What is an attitudes and beliefs survey, as commonly used in physics courses?

Attitudes and beliefs surveys that are commonly used in physics courses (listed below) are about how students perceive the discipline of physics or their particular physics course. These surveys measure students' self-reported beliefs about physics and their physics courses and how closely these beliefs about physics align with experts' beliefs. They ask students questions about how they learn physics, how physics is related to their everyday lives, and how they think about the discipline of physics. For example, students may be asked whether they agree or disagree with statements such as:

- I study physics to learn knowledge that will be useful in my life outside of school.
- A significant problem in learning physics is being able to memorize all the information I need to know.

Examples of these types of surveys include[2]:

- Colorado Learning Attitudes about Science Survey (CLASS)[3]
- Maryland Physics Expectations Survey (MPEX)[4]
- Epistemological Beliefs About Physics Survey (EBAPS)[4,5]
- Views About Science Survey (VASS)[6,7]
- Colorado Learning about Science Survey for Experimental Physics (E-CLASS)[8]

Most of these surveys ask students to rank statements using a five-point Likert scale from strongly agree to strongly disagree. The most common way to score these surveys is to collapse students' responses into two categories depending on whether they are the same as an expert physicist would give (called "percent expertlike response" or "percent favorable response"). They are usually given as a pre- and post-test to measure the "shift," or change in students' beliefs over the course of the term. These surveys are intended to measure how different teaching practices impact students' beliefs and attitudes by looking at, on average, the change in these beliefs and attitudes during the course. They are not meant to help you understand the beliefs and attitudes of individual students (they should be used to look at your students' beliefs in aggregate).

Each of these surveys has a slightly different focus. Pick the survey that best matches the aspects of your students' beliefs and attitudes that you want to know about. In the case that you find several surveys focus on the same aspect of students' beliefs, choose the survey with the strongest research validation and the survey that is most popular among physics faculty in general, and/or those in your department, so that you can compare your results to others. See our Resource Letter (RBAI-2)[2] for a full discussion and comparison of these different attitudes and beliefs surveys, recommendations for when to use each, and an explanation of the levels of research validation. You can get more details about each of these beliefs and attitudes surveys on PhysPort.org/assessments.

Why should I use an attitudes and beliefs survey in my physics course?

You should use an attitudes and beliefs survey in your physics course to assess the shifts in your students' attitudes and beliefs about physics as a result of your course. If your shifts are negative or zero (or weakly positive), you can make changes to your teaching to help develop your students' beliefs to be more expertlike. Research has shown that courses with an explicit focus on modeling or developing students' expertlike beliefs have significantly greater positive shifts in attitudes and beliefs scores (on the CLASS and MPEX) than courses with some focus on developing expertlike beliefs or ordinary courses.[9] Further, standard physics courses often have a negative impact on students' attitudes and beliefs, where after taking a physics course students' beliefs are less expertlike.

Improving your shifts on attitudes and beliefs surveys is not the goal in and of itself. These survey results are a measurement of how your students think about the discipline of physics, and learning physics. What students' believe about physics can influence the way that they approach learning in their physics course.[10] For example, if students believe that learning physics is about memorizing formulas, they will approach it much differently than if they believe that learning physics is about understanding how you model the physical

 DOI: 10.1119/1.5144786

world to understand it and make predictions about it. So, improving your students' attitudes and beliefs about physics can actually help them more successfully learn physics content and help develop their ability to think like a physicist.

What goes into the development of an attitudes and beliefs survey?

Research-validated attitudes and beliefs surveys have gone through a thorough development and testing process to make sure the survey is valid, reliable, the wording of the questions makes sense to students, and the content being surveyed is valuable according to experts. This process usually involves the following steps:

1. Develop questions based on taxonomy of topics to be surveyed, experts' views of important topics, and/or questions from previous surveys.
2. Test questions in think-aloud interviews with students. Revise questions.
3. Test written version with large numbers of students. Gather expert responses to survey questions to determine expertlike answers.
4. Complete appropriate statistical analyses (checking reliability, establishing groups of questions using factor analysis, etc.). Revise again.

On PhysPort we have developed a system for determining the level of research validation for research-based assessment instruments based on these common steps for survey development. For more information on the research validation levels, see our Resource Letter (RBAI-2).[2]

How are attitudes and beliefs surveys different from conceptual multiple-choice tests?

Conceptual multiple-choice tests of physics content usually only have one correct answer, and students get a point for getting it correct and no points for answering incorrectly. On attitudes and beliefs surveys, there is no "correct" answer, per se, but instead an expertlike (also called favorable) answer, which is determined by asking a group of physics experts to answer the survey questions and choosing the expertlike answer to be the one that most (but not necessarily all) experts agree on. For example, if experts disagree with a statement that physics is about memorizing information, then students who also disagree may earn one point, while students who agree with that statement do not. The overall score on an attitudes and beliefs survey is a measure of how much students agree with physicists, whereas the overall score on a conceptual multiple-choice test is a measure of how much physics content students understand. On attitudes and beliefs surveys, to track changes over a term, we look at "shifts" in students' scores, which is simply the difference between the pre- and post-test scores. On conceptual multiple-choice surveys, to track changes over time, it is common to look at normalized gain, which looks at the amount learned divided by the amount they could have learned.[1]

Limitations of attitudes and beliefs surveys

Because this is self-report data, we can't know how well the beliefs students report correspond to the ways they actually think about physics. For example, a student might say and really believe "When I am solving a physics problem, I try to decide what would be a reasonable value for the answer," but not do that in real life. Alternately, a student might agree with "A significant problem in learning physics is being able to memorize all the information I need to know" because they are thinking about the structure of the course they are enrolled in, not the practice of learning physics more broadly.

Administering attitudes and beliefs surveys

How do I administer an attitudes and beliefs survey?

– General best practices for administering attitudes and beliefs surveys

- When talking to your students about an attitudes and beliefs survey, stress that this assessment is designed to help you, their instructor, learn about how your course influences the way they think about physics. It is not meant to evaluate individual students; you are looking at what the class as a whole believes about learning physics. Also emphasize that there is no right answer. They should answer based on what they personally believe.
- Make it clear that their results will not influence their course grade. Let them know you would like to know about how they think about these questions so they should answer the questions according to what they really believe, not what they think you want them to say.
- Give students the recommended time to take the survey. You can find this on the PhysPort by searching for your specific assessment on the "Assessment" tab.[11]
- If you want to make comparisons with other classes the most meaningful, give the survey in its entirety and with the original wording and question order.

– In class or out of class

You can give the attitudes and beliefs surveys in class or outside of class. Because this is a survey of students' beliefs about physics, maintaining the security of the survey is not important in the same way it is with concept inventories, which measure physics content. Giving the survey in class usually results in a higher completion rate than if students take the survey outside of class.

– Online or paper and pencil?

Taking the survey online outside of class doesn't require class time, and the electronic format means that results can be automatically tabulated, saving valuable time. Paper-and-pencil versions of the survey require more time to tabulate results, but this time can be decreased by the use of Scantron tests or other similar tabulation systems. You can also upload a spreadsheet of survey results to the PhysPort Data Explorer[12] where they will be automatically analyzed and visualized. Some surveys are available to be taken online[13] or can be entered into your course management system (e.g., Blackboard, Canvas); the details of this administration vary by survey. Further, online surveys also allow you to make responses required, which can help decrease mistakes in filling in a paper-and-pencil bubble sheet.

–When should I give the survey?

As a general rule of thumb, give the survey as a pre-test in the first week of the term and again as a post-test in the last week of the term. You are trying to capture the change in your students' beliefs during your course, so you want to ensure the pre-test is given close to the beginning of the term, and the post-test is given close to the end of the term. That said, there might be practical concerns in your local context, such as students adding your course after the first week or high stress around the final exam, where it may make sense to give the survey outside the first and last week of the course.

– Best practices for administering attitudes and beliefs surveys online

After some experimentation, Adams et al.[3] recommend the following steps for administering an attitudes and beliefs survey online to maximize the number of responses:

1. Announce the survey both in class and by email.
2. Give a short (three- to seven-day) time period for taking the survey.
3. Include a timer for surveys administered online. If students take substantially less time to complete the survey than their peers, consider discarding their answers. To do this, determine how long it takes a fast reader to read all the survey statements, and discard surveys that are answered in less time than this.
4. Provide a follow-up email reminder to students who still need to take the survey. This will increase your response rate.

For the CLASS, it is typical to get a 90% pre-test response rate and 85% post-test response rate online.[3]

–Best practices for administering attitudes and beliefs surveys in class, with paper and pencil

Give the survey during any course meeting, e.g., lecture, recitation, or lab. To make scoring more efficient, use a Scantron test or another similar tabulation system. Especially if you have multiple sections or plan to give the same survey again in future years, print the survey and the answer page separately. That way you can reuse the survey from section to section.

What incentives should I give my students for taking the survey?

Some instructors have found that giving a small amount of course credit for completing the survey helps increase the completion rate of the survey. You could also choose not to give any credit for completing the survey. In this case, the way you talk about the survey can help motivate your students to complete it.

What about test security?

Attitudes and beliefs surveys are asking students to self-report their own perceptions of physics. You do not have to worry about students using outside resources since there is no right answer on these kinds of surveys. You can encourage your students to complete the survey independently, as you want to learn about their own personal beliefs and attitudes.

Scoring and interpreting my results

How do I interpret my scores?

– Overall percent favorable/expertlike vs. unfavorable/novicelike scores

To give you a sense of how one scores an attitudes and beliefs survey, we describe the scoring for the most commonly used attitudes and beliefs surveys in physics, the CLASS and MPEX. On these surveys, scores are usually calculated as the percentage of questions that students answer as the same way as an expert in physics (called "percent favorable" or "expertlike") or the percentage that they answer in the opposite way as an expert physicist (called "percent unfavorable" or "novicelike"). The percent favorable and unfavorable scores don't always add up to 100% because students can pick "neutral" as an answer choice, which counts as neither favorable nor unfavorable. Both percent favorable and unfavorable give you complementary information. It is much more common to use percent favorable scores to gauge students' beliefs about learning physics. The ECLASS, EBAPS, AAPS, VASS, and APSS also all assign scores based on how expertlike students' answers are, though the details of the scores on these assessments vary slightly from the MPEX and CLASS. For more details about the scoring for each of the assessments mentioned here, search for that assessment on PhysPort.org/assessment.

–Shift in favorable/expertlike scores from pre- to post-test

The "shift" in percent favorable responses is calculated by subtracting the pre-test class average percent favorable from the post-test class average percent favorable. This metric tells you how students' expertlike/favorable beliefs about physics changed from the start to end of their physics course. We hope that this shift would be positive, indicating students' beliefs improved over the course of their physics class, though in many traditional and even reformed intro physics classes there is a negative shift in percent favorable scores.

Many instructors who teach the same course several times find it extremely useful to document changes they made to their teaching and compare the shifts in students' beliefs over time to determine how the changes they made influenced their students' beliefs about physics. You can also look at specific categories of questions to learn about how changes in teaching influence these different aspects of attitudes and beliefs about physics.

To better understand how your course and/or broader educational environment may be unevenly supporting different groups of students in developing expertlike beliefs, you can look at differences in attitudes and beliefs based on student demographics. Gender differences have been found on the

CLASS in several categories,[3] where men outperformed women on some categories and women outperformed men on other categories, suggesting that these physics classes may not be impacting all students in the same ways. (Differences in scores on the other attitudes and beliefs surveys discussed in this paper have not been studied.) We caution against overgeneralizing your results. For example, if you find that *in general* women have less expertlike beliefs on certain categories of questions, this does not necessarily mean that all women in your class have these same beliefs. If you do find differences in attitudes and beliefs scores based on demographics, we encourage you to look for ways to support your students more equitably.

–Effect size of shift from pre- to post-test

To get a sense of how important the difference between your pre- and post-test scores are, you can calculate the effect size of the change. A large effect size means the difference is important; small effect sizes mean the difference is unimportant. Effect size normalizes the average raw shift in a population by the standard deviation in individuals' raw scores, giving you a measure of how substantially the pre- and post-test scores differ. There are several different measures for effect size depending on the size of your class. For more information on calculating effect size, see our expert recommendation about it on PhysPort.[14]

Are students really reporting their own beliefs, and not what they think I want them to say?

Most likely, yes. Gray et al.[15] gave students the CLASS and asked them to answer two questions for each statement, "What would a physicist say?" and "What do YOU think?" They found a rather large difference between students' personal answer and the answer they believe a physicist would give, with students' personal answer being less expertlike. The "personal" scores were similar to CLASS results from the same courses when the CLASS was given with the standard single answer format. So, this study suggests that when students complete the standard single answer format of the CLASS, they are answering based on their own personal beliefs, although they do know what a physicist would say. The other attitudes and beliefs surveys have not been studied in this way.

How can I quickly and easily analyze my results using the PhysPort Data Explorer?

PhysPort offers a powerful assessment Data Explorer[12] that makes analyzing and interpreting your attitudes and beliefs survey results quick and easy. This online tool allows you to upload your students' results and visualize them in a variety of ways. You can use the Data Explorer to calculate the percent favorable/unfavorable scores and shifts in your scores quickly, and compare your own assessment results over time as you make changes to your course. You can use the Data Explorer to look at how your students performed on individual questions or clusters[16] of post-test questions to get a coarse-grained sense of the categories where your students had more expertlike attitudes and beliefs. You can then reflect on the way you supported these expertlike attitudes and look for ways to improve your teaching.

Additionally, you can download a report of your results and comparisons that you can use to talk to your colleagues about your course, include in tenure documents, accreditation reports, etc. The system has robust security measures to ensure that your students' assessment data and your and your students' identities are protected. To use the Data Explorer go to www.physport.org/dataexplorer.

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