PhysPort Implementation Guide: Colorado Learning Attitudes about Science Survey (CLASS)
Version 3

PhysPort
Supporting physics teaching with research-based resources

Implementation Guide by Adrian Madsen

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Implementation

Purpose of the CLASS

To measure students' self-reported beliefs about physics and their physics courses and how closely these beliefs about physics align with experts' beliefs. The questions are NOT about how much students like physics, but about how they learn physics, how physics is related to their everyday lives, and how they think about the discipline of physics.

Course Level: What kinds of courses is it appropriate for?

Upper-level, Intermediate, Intro college, and High school

Content: What does it assess?

Beliefs / Attitudes (epistemological beliefs)

Timing: How long should I give students to take it?

8-10 minutes

Example Questions

Sample questions from the CLASS:

A significant problem in learning physics is being able to memorize all the information I need to know.

Strongly Disagree 1 2 3 4 5 Strongly Agree

Knowledge in physics consists of many disconnected topics.

Strongly Disagree 1 2 3 4 5 Strongly Agree

Access: Where do I get the assessment?

Download the assessment from physport at www.physport.org/assessments/CLASS.

Versions and Variations: Which version of the assessment should I use?

The latest version of the CLASS for Physics, released in 2004, is version 3. There are also variations of the CLASS for chemistry, biology, astronomy and math, which are available at https://www.colorado.edu/sei/class. The German translation of the CLASS is missing questions that don't make sense in a German engineering context, so there has 6 fewer questions than the English CLASS.

Administering: How do I give the assessment?

- Give it as both a pre- and post-test. This measures how your class shifts student thinking.
  - Give the pre-test at the beginning of the term.
  - Give the post-test at the end of the term.
- Use the whole test, with the original wording and question order. This makes comparisons with other classes meaningful.
- Make the test required, and give credit for completing the test (but not correctness). This ensures maximum participation from your students.
- Tell your students that the test is designed to evaluate the course (not them), and that knowing how they think will help you teach better. Tell them that correctness will not affect their grades (only participation). This helps alleviate student anxiety.
- For more details, read the **PhysPort Guides** on implementation:
  - **PhysPort Expert Recommendation on Best Practices for Administering Belief Surveys** (www.physport.org/expert/AdministeringBeliefSurveys/)

Scoring: How do I calculate my students' scores?

- Download the answer key from PhysPort (www.physport.org/key/CLASS)
- The "percent favorable score" is the percentage of questions where a student agrees with the expert response. (Dis)agree

and strongly (dis)agree are counted as equivalent responses. Some questions do not have an expert response and are not counted. For instructions on scoring the CLASS, see below

- See the **PhysPort Expert Recommendation on Best Practices for Administering Belief Surveys** for instructions on calculating shift and effect size (www.physport.org/expert/AdministeringBeliefSurveys/)
- Use the **PhysPort Assessment Data Explorer** for analysis and visualization of your students' responses (www.physport.org/explore/CLASS)

Detailed Instructions for Scoring the CLASS:

Organize survey data: Discard the responses of students who did not take the survey seriously and include only students who took the survey at the beginning and end of the course. To do this:

1. Eliminate responses from students who randomly choose answers: Statement 31 on the CLASS, "We use this statement to discard the survey of people who are not reading the statements. Please select agree (not strongly agree) for this statement", is meant to help instructors identify students who are not taking the survey seriously. Determine which students did not answer this question correctly and discard their responses. You can also look for students who answered all the questions with the same answer or who skipped a large portion of the survey. The survey authors also recommended using a timer for online surveys and discarding responses if the students take less than three minutes to answer the survey. A common pre-course response rate is 90% and a post-course response rate is 85%. Of these responses, approximately 10–15 % are dropped because the students did not answer statement 31 correctly, chose the same answer for essentially all the statements, or simply did not answer most of the statements.
2. Match pre- and post-course responses: Its important only to include students who completed the CLASS at the beginning and end of the course ("matched data"). This will ensure that the shifts you calculate in beliefs from pre to post are differences in the way students are thinking and not a difference in the students who took the survey. This matched data set typically includes about 65–70 % of the students enrolled in the course.

Calculate Class Average Percent Favorable or Percent Unfavorable Score: Follow this same process for the pre- and post-test results.

1. Collapse all "strongly agree" and "agree" responses together. Do the same for "strongly disagree" and "disagree" responses. This is because students' interpretations of agree vs. strongly agree are not consistent; the same conviction of belief may not result in the same selection such that one student may respond with strongly agree while another responds with agree.
2. For each student, determine the average number of questions (out of 40) that they answered in the same way as an expert physicist ("percent favorable responses"). There are two questions that are not scored, questions 7 and 41 because there is a not an expert answer If students left questions blank, calculate the average percent favorable out of the number of questions that they answered.
3. Average these individual average percent favorable scores to find the class average percent favorable.
4. You can repeat the same process to find the class average percent unfavorable score. For this measure, use the number of questions in which students do not answer in the same way as an expert physicist.

Calculate Shift in Percent Favorable Score From Pre- to Post-test:

Calculate the "shift" in percent favorable responses by subtracting the pretest class average percent favorable from the posttest class average percent favorable. This metric tells you how students' 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 theirs physics class.

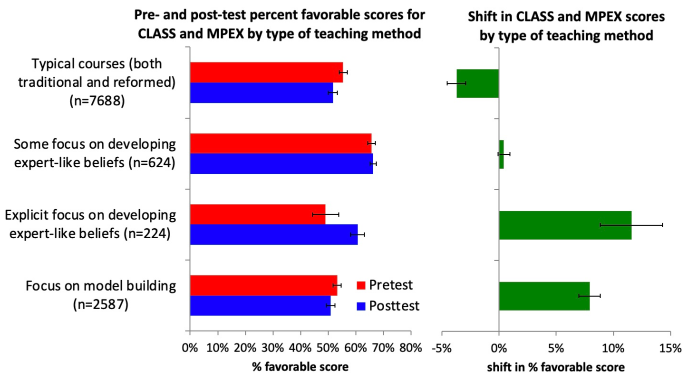
Clusters: Does this assessment include clusters of questions by topic?

Clusters of questions on the CLASS from Adams et al., 2006:

Categories	Statements comprising category
Real World Connection	28, 30, 35, 37
Personal Interest	3, 11, 14, 25, 28, 30
Sense Making/Effort	11, 23, 24, 32, 36, 39, 42
Conceptual Connections	1, 5, 6, 13, 21, 32
Applied Conceptual Understanding	1, 5, 6, 8, 21, 22, 40
Problem Solving General	13, 15, 16, 25, 26, 34, 40, 42
Problem Solving Confidence	15, 16, 34, 40
Problem Solving Sophistication	5, 21, 22, 25, 34, 40
Not Scored	4, 7, 9, 31, 33, 41

Typical Results: What scores are usually achieved?

In typical physics classes, students' beliefs usually deteriorate or at best stay the same. There are a few types of interventions, including an explicit focus on model-building and/or developing expert-like beliefs that appear to lead to significant improvements in beliefs. Small courses and those for elementary education and non-science majors also result in improved beliefs. However, because the available data oversamples certain types of classes, it is unclear what leads to these improvements. This figure from Madsen et. al 2015 shows CLASS (n=9296) and MPEX (n=1316) pre- and post-test scores and shifts for a variety of teaching methods. The CLASS and MPEX are similar in the way they measure students' beliefs about physics and learning physics, so the scores for these tests have been combined.



Interpretation: How do I interpret my students' scores in light of typical results?

Look at the shift between pre- and post-test

Your CLASS results are especially useful for comparing shifts in students' beliefs (favorable or unfavorable) before and after you have made a change to your teaching, for example, trying teaching methods that explicitly focus on model- building and/or developing expert-like beliefs. You can compare the shifts in percent favorable or unfavorable beliefs before and after you try new teaching techniques as one measure to gauge the effectiveness of the techniques.

Look at the effect size of the change

This tells you how substantially your pre- and post-test scores differ. Compare your effect size to the ranges given below to find out how substantial the change from pre- to post-test was. For more details, read the **PhysPort Expert Recommendation on Effect Size** (www.physport.org/expert/effectsize)

Effect Size	Cohen's d
Large	~0.8
Medium	~0.5
Small	0.2-0.3

Look at clusters of questions

You can also gain insight into what areas of your students' beliefs are being improved through your course by looking at their shifts in favorable or unfavorable beliefs by cluster.

Resources

Where can I learn more about this assessment?

W. Adams, K. Perkins, N. Podolefsky, M. Dubson, N. Finkelstein, and C. Wieman, New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey, Phys. Rev. ST Phys. Educ. Res. **2** (1), (2006).

Translations: Where can I find translations of this assessment in other languages?

You can download translations of this assessment in the following languages from PhysPort:

- **Arabic** translated by H. Alhadlaq, F. Alshaya, and S. Alabdulkareem
- **Chinese** translated by Lin Ding and Ping Zhang
- **English**
- **Finnish** translated by Mervi Asikainen
- **French** translated by Vincent Sicotte
- **German** translated by Christian Kautz, Hanno Holzhüter, and Felix Lehmann (This version is designed for an intro engineering class. Questions that don't make sense in a German engineering context have been removed.)
- **Indonesian** translated by Mutmainna Kadir
- **Japanese** translated by Michi Ishimoto and Hideo Nitta
- **Portuguese** translated by Eduardo Gama and Marta F. Barroso, Federal University of Rio de Janeiro
- **Spanish** translated by Genaro Zavala, Hugo Alarcon, and Angeles Domínguez
- **Swedish** translated by Johan Henriksson
- **Turkish** translated by Derya Kaltakci

If you know of a translation that we don't have yet, or if you would like to translate this assessment, please contact us!

Background

Similar Assessments

The CLASS is most similar to the MPEX. The MPEX asks more questions about students beliefs about the physics course whereas the CLASS focuses more on beliefs about the discipline of physics. Several items are the same on both tests. The CLASS is also similar to the EBAPS, though less so than the MPEX.

Research: What research has been done to create and validate the assessment?

Research Validation: Gold Star ★

This is the highest level of research validation, corresponding to all seven of the validation categories below.

- ☑ Based on research into **student thinking**
- ☑ Studied using **student interviews**
- ☑ Studied using **expert review**
- ☑ Studied using **appropriate statistical analysis**
- ☑ Research conducted **at multiple institutions**
- ☑ Research conducted **by multiple research groups**
- ☑ **Peer-reviewed publication**

Research Overview

Questions from the MPEX and VASS were taken as the starting point for the CLASS and modified then tested in student interviews. Questions were further revised with expert interviews. The “expert” answer to each question was determined by 16 physicists with extensive teaching experience who agreed to the answers for nearly all questions. Categories were created using reduced-basis factor analysis, where raw statistical categories and categories predetermined by researchers were combined iteratively. The CLASS was given to thousands of students and those with more experience in physics, had more expert-like beliefs. The CLASS has high reliability. CLASS scores were also correlated with other measures of learning. The CLASS has been administered at over 20 institutions with over 9000 students enrolled in many different course levels taught with differing teaching methods. Results have been published in over 45 peer-reviewed publications.

Developer: Who developed this assessment?

W. K. Adams, K. K. Perkins, N. S. Podolefsky, M. Dubson, N. D. Finkelstein, and C. E. Wieman

References

- W. Adams, K. Perkins, M. Dubson, N. Finkelstein, and C. Wieman, The Design and Validation of the Colorado Learning Attitudes about Science Survey , presented at the Physics Education Research Conference 2004, Sacramento, California, 2004.
- W. Adams, K. Perkins, N. Podolefsky, M. Dubson, N. Finkelstein, and C. Wieman, New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey, Phys. Rev. ST Phys. Educ. Res. **2** (1), (2006).
- W. Adams, C. Wieman, K. Perkins, and J. Barbera, Modifying and Validating the Colorado Learning Attitudes about Science Survey for Use in Chemistry , J. Chem. Educ. **85** (10), 1435 (2008).
- H. Alhadlaq, F. Alshaya, S. Alabdulkareem, K. Perkins, W. Adams, and C. Wieman, Measuring Students' Beliefs about Physics in Saudi Arabia, presented at the Physics Education Research Conference 2009, Ann Arbor, Michigan, 2009.
- S. Bates, R. Galloway, C. Loptson, and K. Slaughter, How attitudes and beliefs about physics change from high school to faculty , Phys. Rev. ST Phys. Educ. Res. **7** (2), 020114 (2011).
- M. Bodin and M. Winberg, Role of beliefs and emotions in numerical problem solving in university physics education, Phys. Rev. ST Phys. Educ. Res. **8** (1), 010108 (2012).
- E. Brewe, L. Kramer, and G. O'Brien, Modeling instruction: Positive attitudinal shifts in introductory physics measured with CLASS, Phys. Rev. ST Phys. Educ. Res. **5** (1), 013102 (2009).
- E. Brewe, L. Kramer, and G. O'Brien, CLASS Shifts in Modeling Instruction, presented at the Physics Education Research Conference 2008, Edmonton, Canada, 2008.
- E. Brewe, A. Traxler, J. de la Garza, and L. Kramer, Extending positive CLASS results across multiple instructors and multiple classes of Modeling Instruction, Phys. Rev. ST Phys. Educ. Res. **9** (2), 020116 (2013).
- L. Chen, S. Xu, H. Xiao, and S. Zhou, Variations in students' epistemological beliefs towards physics learning across majors, genders, and university tiers, Phys. Rev. Phys. Educ. Res. **15** (1), 010106 (2019).
- J. de la Garza and H. Alarcon, Assessing Students' Attitudes In A College Physics Course In Mexico, presented at the Physics Education Research Conference 2010, Portland, Oregon, 2010.
- C. De Leone, C. Ishikawa, and R. Marion, Adaptation and Implementation of a Radically Reformed Introductory Physics Course for Biological Science Majors: Assessing Success and Prospects for Future Implementation, presented at the Physics Education Research Conference 2006, Syracuse, New York, 2006.
- L. Ding, A comparative study of middle school and high school students' views about physics and learning physics, presented at the Physics Education Research Conference 2012, Philadelphia, PA, 2012.
- K. Douglas, M. Yale, D. Bennett, M. Haugan, and L. Bryan, Evaluation of Colorado Learning Attitudes about Science Survey, Phys. Rev. ST Phys. Educ. Res. **10** (2), 020128 (2014).
- G. Duda and K. Garrett, Blogging in the physics classroom: A research-based approach to shaping students' attitudes toward physics , Am. J. Phys. **76** (11), 1054 (2008).
- N. Finkelstein and S. Pollock, Replicating and understanding successful innovations: Implementing tutorials in introductory physics, Phys. Rev. ST Phys. Educ. Res. **1** (1), (2005).
- S. Garcia, A. Hankins, and H. Sadaghiani, The Impact of the History of Physics on Student Attitude and Conceptual Understanding of Physics, presented at the Physics Education Research Conference 2010, Portland, Oregon, 2010.
- E. Gire, E. Price, and B. Jones, Characterizing the Epistemological Development of Physics Majors, presented at the Physics Education Research Conference 2006, Syracuse, New York, 2006.
- F. Goldberg, E. Price, D. Harlow, S. Robinson, R. Kruse, and M. McKean, Development and evaluation of large-enrollment, active-learning physical science curriculum, presented at the Physics Education Research Conference 2010, Portland, Oregon, 2010.
- K. Gray, W. Adams, C. Wieman, and K. Perkins, Students know what physicists believe, but they don't agree: A study using the CLASS survey, Phys. Rev. ST Phys. Educ. Res. **4** (2), 020106 (2008).
- D. Harlow, L. Swanson, H. Dwyer, and J. Bianchini, Learning Pedagogy in Physics, presented at the Physics Education Research Conference 2010, Portland, Oregon, 2010.
- Z. Hrepic, P. Adams, J. Zeller, N. Talbott, G. Taggart, and L. Young, Developing an Inquiry-Based Physical Science Course For Preservice Elementary Teachers, presented at the Physics Education Research Conference 2005, Salt Lake City, Utah, 2005.
- P. Kohl and V. Kuo, Chronicling a successful secondary implementation of Studio Physics, Am. J. Phys. **80** (9), 832 (2012).
- L. Kost, S. Pollock, and N. Finkelstein, The Persistence of the Gender Gap in Introductory Physics, presented at the Physics Education Research Conference 2008, Edmonton, Canada, 2008.
- L. Kost, S. Pollock, and N. Finkelstein, Characterizing the gender gap in introductory physics, Phys. Rev. ST Phys. Educ. Res. **5** (1), 010101 (2009).
- L. Kost-Smith, S. Pollock, and N. Finkelstein, Gender disparities in second-semester college physics: The incremental effects of a "smog of bias", Phys. Rev. ST Phys. Educ. Res. **6** (2), 020112 (2010).

- B. Lindsey, L. Hsu, H. Sadaghiani, J. Taylor, and K. Cummings, Positive attitudinal shifts with the Physics by Inquiry curriculum across multiple implementations , Phys. Rev. ST Phys. Educ. Res. **8** (1), 010102 (2012).
- A. Madsen, S. McKagan, and E. Sayre, How physics instruction impacts students' beliefs about learning physics: A meta-analysis of 24 studies, Phys. Rev. ST Phys. Educ. Res. **11** (1), 010115 (2015).
- J. Martins and W. Lindsay, Evaluation of high school student responses to the Colorado Learning Attitudes about Science Survey , Phys. Rev. Phys. Educ. Res. **18** (1), 010132 (2022).
- M. Marušic and J. Sliško, Effects of two different types of physics learning on the results of CLASS test, Phys. Rev. ST Phys. Educ. Res. **8** (1), 010107 (2012).
- S. McKagan, K. Perkins, and C. Wieman, Reforming a large lecture modern physics course for engineering majors using a PER-based design, presented at the Physics Education Research Conference 2006, Syracuse, New York, 2006.
- P. Miller, J. Carver, A. Shinde, B. Ratcliff, and A. Murphy, Initial Replication Results Of Learning Assistants In University Physics, presented at the Physics Education Research Conference 2012, Philadelphia, PA, 2012.
- M. Milner-Bolotin, T. Antimirova, A. Noack, and A. Petrov, Attitudes about science and conceptual physics learning in university introductory physics courses, Phys. Rev. ST Phys. Educ. Res. **7** (2), 020107 (2011).
- V. Otero and K. Gray, Attitudinal gains across multiple universities using the Physics and Everyday Thinking curriculum, Phys. Rev. ST Phys. Educ. Res. **4** (2), 020104 (2008).
- V. Otero and K. Gray, Learning to Think Like Scientists with the PET Curriculum, presented at the Physics Education Research Conference 2007, Greensboro, NC, 2007.
- V. Otero, S. Pollock, and N. Finkelstein, A physics department's role in preparing physics teachers: The Colorado Learning Assistant model, Am. J. Phys. **78** (11), 1218 (2010).
- A. Pawl, A. Barrantes, and D. Pritchard, Modeling Applied to Problem Solving, presented at the Physics Education Research Conference 2009, Ann Arbor, Michigan, 2009.
- A. Pawl, A. Barrantes, D. Pritchard, and R. Mitchell, What do Seniors Remember from Freshman Physics?, Phys. Rev. ST Phys. Educ. Res. **8** (2), 020118 (2012).
- K. Perkins, W. Adams, S. Pollock, N. Finkelstein, and C. Wieman, Correlating Student Beliefs with Student Learning Using the Colorado Learning Attitudes about Science Survey, presented at the Physics Education Research Conference 2004, Sacramento, California, 2004.
- K. Perkins, J. Barbera, W. Adams, and C. Wieman, Chemistry vs. Physics: A Comparison of How Biology Majors View Each Discipline , presented at the Physics Education Research Conference 2006, Syracuse, New York, 2006.
- K. Perkins and M. Gratny, Who Becomes a Physics Major? A Long-term Longitudinal Study Examining the Roles of Pre-college Beliefs about Physics and Learning Physics, Interest, and Academic Achievement, presented at the Physics Education Research Conference 2010, Portland, Oregon, 2010.
- K. Perkins, M. Gratny, W. Adams, N. Finkelstein, and C. Wieman, Towards characterizing the relationship between students' interest in and their beliefs about physics, presented at the Physics Education Research Conference 2005, Salt Lake City, Utah, 2005.
- K. Perkins and C. Wieman, The Surprising Impact of Seat Location on Student Performance, Phys. Teach. **43** (1), 30 (2005).
- S. Pollock, No Single Cause: Learning Gains, Student Attitudes, and the Impacts of Multiple Effective Reforms, presented at the Physics Education Research Conference 2004, Sacramento, California, 2004.
- S. Pollock and N. Finkelstein, Sustaining Change: Instructor Effects in Transformed Large Lecture Courses, presented at the Physics Education Research Conference 2006, Syracuse, New York, 2006.
- S. Pollock, R. Pepper, and A. Marino, Issues and Progress in Transforming a Middle-division Classical Mechanics/Math Methods Course , presented at the Physics Education Research Conference 2011, Omaha, Nebraska, 2011.
- V. Sawtelle, E. Brewe, and L. Kramer, Validation study of the Colorado Learning Attitudes about Science Survey at a Hispanic-serving institution , Phys. Rev. ST Phys. Educ. Res. **5** (2), 023101 (2009).
- K. Slaughter, S. Bates, and R. Galloway, A longitudinal study of the development of attitudes and beliefs towards physics, presented at the Physics Education Research Conference 2011, Omaha, Nebraska, 2011.
- A. Traxler and E. Brewe, Equity investigation of attitudinal shifts in introductory physics, Phys. Rev. Phys. Educ. Res. **11** (020132), (2015).
- B. Van Dusen and J. Nissen, Criteria for collapsing rating scale responses: A case study of the CLASS, presented at the Physics Education Research Conference 2019, Provo, UT, 2019.
- U. Wutchana, N. Emarat, and E. Etkina, Are Students' Responses and Behaviors Consistent?, presented at the Physics Education Research Conference 2009, Ann Arbor, Michigan, 2009.
- P. Zhang and L. Ding, Large-scale survey of Chinese precollege students' epistemological beliefs about physics: A progression or a regression?, Phys. Rev. ST Phys. Educ. Res. **9** (1), 010110 (2013).