PhysPort Implementation Guide: Physics Lab Inventory of Critical Thinking (PLIC)

Version 1

PhysPort
Supporting physics teaching with research-based resources

Implementation Guide by Natasha Holmes and Adrian Madsen

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Implementation

Purpose of the PLIC

To assess how students critically evaluate experimental methods, data, and models.

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

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

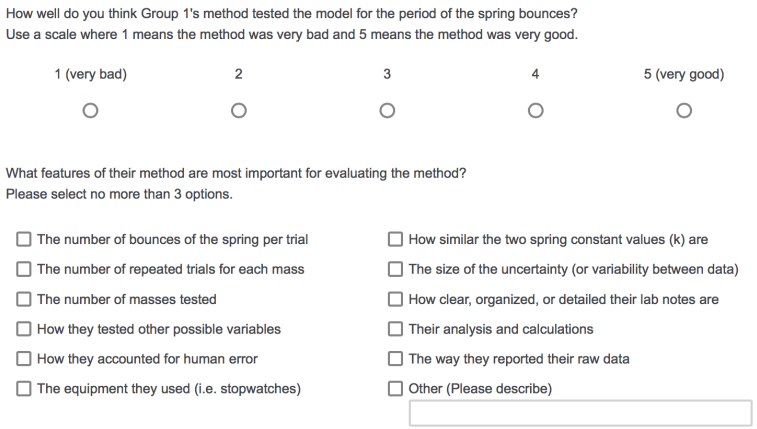
Content: What does it test?

Lab skills (designing and evaluating experimental methods, comparing measurements with uncertainty, evaluating data fitted to a model, generating and evaluating conclusions based on data)

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

average is 20 min, no more than 30 minutes

Example Questions



Access: Where do I get the test?

Instructors can fill out an instructor survey and get automatically generated links to the PLIC for their classes here:
https://cornell.qualtrics.com/jfe/form/SV_5ouHoTGEF5FBqxD

Instructors can respond to the PLIC themselves here:
https://cornell.qualtrics.com/jfe/form/SV_byziKLjBBPTIX9b

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

The latest version of the PLIC, developed in 2017, is version 1.

Administering: How do I give the test?

- Give it as both a pre- and post-test. This measures how your class shifts student thinking.
  - Give the pre-test before you cover relevant course material.
  - Give the post-test at the end of the term.
- Since the test is administered online, you can have students take it in class (e.g. in a computer lab) or out of class on their own. Research shows you will get a better response rate if you give the test in class.
- Limit the amount of time your students spend on the test to 30 minutes.
- 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 Concept Inventories** (www.physport.org/expert/AdministeringConceptInventories/)

Scoring: How do I calculate my students' scores?

- Only reasoning questions on the PLIC are included in the total score (sub-questions B, D and E). The questions about how well the data agree, how well did the group's test method work and which group did better are NOT included in the total score.
- There are anywhere from 5-10 options per reasoning question, and students are limited to selecting no more than three of the options. Responses from experts have identified a category of 'consensus expert-responses' for each question, a category of 'consensus appropriate responses', and 'novice responses'. Per question, a student can achieve:
  - 4 points if they select an option within the 'consensus expert-responses' category and no 'novice responses'.
  - 3 points if they select an option within the 'consensus expert-responses' category and a 'novice response'.
  - 2 points if they select an option within the 'consensus appropriate responses' and no 'novice responses'.
  - 1 point if they select an option within the 'consensus appropriate responses' and a 'novice response'.
  - 0 if they select 'novice responses' or other responses or no responses.
  - Responses that do not fall in either category receive no points.
- The total score is the sum of the points earned for each question.
- The "shift" in students' scores from pre- to post-test is the difference in their total score between the pre- and post-test.

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

There are currently no clusters of questions for the PLIC. It is under development and the developers are working to use factor analysis to determine clusters of questions.

Typical Results: What scores are usually achieved?

There are currently no published results for the PLIC, as it is under development. When you give the PLIC to your students using the developers online system, you will receive a report back with overall and question by question comparison data from other classes similar to yours.

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

- Look at the shift in your students' total scores from pre- to post-test to understand how your course is influencing students' critical thinking ability around experimental physics.
- You can also look at the shift in students' score on each individual question as well as the questions that students selected more frequently on the pre- and post-test, to get a sense of your students' specific strengths and weaknesses.
- If you give the PLIC using the developers online system, you will receive a report containing your students results and results from others' similar courses. You can compare your results to those from similar courses to get a sense of what kinds of gains are possible in other courses.

Resources

Where can I learn more about this test?

C. Walsh, K. Quinn, C. Wieman, and N. Holmes, Quantifying critical thinking: Development and validation of the physics lab inventory of critical thinking, Phys. Rev. Phys. Educ. Res. **15** (1), 010135 (2019).

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

Background

Similar Tests

The CDPA evaluates students' understanding of data analysis skills, which may have some overlap with content in the PLIC, but the PLIC does not assess those skills uniquely. The PLIC covers more advanced and more physics-specific scientific reasoning skills than the Lawson Test of Scientific Reasoning. The PMQ evaluates student understanding of uncertainty and whether students use

uncertainties when comparing measurements - these ideas are probed in few questions on the PLIC.

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

Research Validation: Silver

This is the second highest level of research validation, corresponding to at least 5 of the validation categories below.

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

Research Overview

The questions on the PLIC came from an experiment conducted in an introductory physics lab, initially based on the series of questions an expert posed to themselves when conducting the experiment. These were then refined several times through think-aloud interviews with introductory and upper-division physics students (majors and non-majors), as well as through open-response question responses. The PLIC is still under development.

Developer: Who developed this test?

N.G. Holmes, C.E. Weiman, K.N.Quinn, C.J. Walsh & the Cornell Physics Education Research Lab

References

- N. Holmes and C. Wieman, Preliminary development and validation of a diagnostic of critical thinking for introductory physics labs, presented at the Physics Education Research Conference 2016, Sacramento, CA, 2016.
- K. Quinn, C. Wieman, and N. Holmes, Interview Validation of the Physics Lab Inventory of Critical thinking (PLIC), presented at the Physics Education Research Conference 2017, Cincinnati, OH, 2017.
- C. Walsh, K. Quinn, C. Wieman, and N. Holmes, Quantifying critical thinking: Development and validation of the physics lab inventory of critical thinking, Phys. Rev. Phys. Educ. Res. **15** (1), 010135 (2019).