

# Attitudes Toward Problem Solving as Predictors of Student Success

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**Abstract:** The survey of attitudes towards, and views of, problem solving that is presented here is still under development. It is part of a larger project to develop an assessment of student problem solving ability in introductory physics. The survey is intended for use in a manner similar to the Maryland Physics Expectation Survey (MPEX).[1] That is, it is given to students pre- and post-instruction. Student responses are evaluated in comparison to the answers given by “experts”. Post-instruction movement of student responses toward those given by the “experts” is considered to be improvement. This paper presents the survey questions, expert responses and discusses responses of several hundred students at three different institutions. Correlations between student survey results and grades, conceptual survey scores and instructor evaluation of student problem solving ability are presented. The goal is to begin to probe whether student attitudes toward problem solving are correlated to success on other metrics.

## **Introduction**

Expertise in quantitative introductory physics problem solving is characterized by more than just the ability to generate a correct answer. Instructors and other “experts” display certain characteristics. For example, experts have confidence in their ability to solve problems. They have both the ability and tendency to evaluate their process and progress. They have well established and acknowledged procedures for solving standard types of problems (for example, “conservation of energy” problems). For expert introductory physics problem solvers, the conceptual basis of a problem overrides any distracting surface features or mathematical tasks.[2]

A survey of these views and attitudes is presented below. Many of the questions are taken directly from the Maryland Physics Expectations Survey (MPEX).[1] Others are modified MPEX questions and still others are original questions written to probe the attitudes known to be common amongst experts in solving introductory physics problems. The questions below are worded exactly as they were on a survey distributed to experts and students during 2002/2003. Several of the questions will be revised and improved based on the feedback provided by the expert respondents.

## **The Survey**

**To what extent do you agree with each of the following statements?**

**Answer with a single letter as follows:**

- A) Strongly Agree
- B) Agree Somewhat
- C) Neutral or Don't Know
- D) Disagree Somewhat
- E) Strongly Disagree

1. If I'm not sure about the right way to start a problem, I'm stuck. There is nothing I can do with that problem except to go see the teacher or a friend for help.
2. It is never alright to make approximations when solving textbook problems in introductory physics.
3. There are often several very different ways to correctly solve a given textbook problem in introductory physics.
4. In solving problems in physics, being able to handle the mathematics is the most important part of the process.
5. In solving textbook problems in introductory physics, identifying the physical principles in-

involved in the problem is the most important part of the process.

6. "Problem solving" in physics basically means matching problems with the correct equations and then substituting values to get a number.[1]

7. In solving textbook problems in introductory physics, I can often tell when my work and/or answer is wrong, even without looking at the answer in the back of the book or talking to someone else about it.

8. In solving textbook problems in introductory physics, I often find it helpful if I can look at the answer to the problem first, and then work backward.

9. To be able to use an equation in a problem (particularly in a problem that I haven't seen before), I need to know more than what each term in the equation represents. [1]

10. There is usually only one correct way to solve a given textbook problem in introductory physics.

11. I have a general approach that I apply in solving all problems that are solvable using conservation of linear momentum.

12. I don't like it when I solve a textbook problem in introductory physics and the answer is not in the back of the book because then there is no way for me to evaluate whether my answer is incorrect.

13. I am comfortable trying to solving a problem even when I'm not sure whether or not the approach I'm using will lead to a solution.

14. Equations are not things that one understands in an intuitive sense; they are just givens that one can use to calculate numerical answers. [1]

15. Solving problems in physics involves many pieces of information each of which applies primarily to a specific situation. [1]

16. In doing a physics problem, if my calculation gives a result that differs significantly from what I expect, I'd have to trust the calculation. [1]

17. If I came up with two different approaches to a problem and they gave different answers, I would not worry about it; I would just choose the answer

that seemed most reasonable. (Assume the answer is not in the back of the book.) [1]

18. When I solve most exam or homework problems, I explicitly think about the concepts that underlie the problem.

19. Suppose you are given two problems. One problem is about two masses attached by a string that passes over a pulley. One of the masses is sliding across a horizontal table and the other mass hangs off the end of the table, falling straight downward. The other problem is about a person swinging on a rope. You are told that both problems can be solved using the concepts of net force and acceleration (Newton's second law). Which of the following statements do you MOST agree with? Chose only one answer.

A) The two problems can be solved using very similar methods

B) The two problems can be solved using somewhat similar methods

C) The two problems must be solved using quite different methods

D) The two problems must be solved using very different methods

E) There is not enough information given to know how the problems will be solved.

20. Suppose you are given two problems. One is about a box sliding down an inclined plane. There is friction between the incline and the box. The other is about a person swinging on a rope. There is air resistance between the person and the air molecules. You are told that both problems can be solved using the concept of conservation of energy. Which of the following statements do you MOST agree with? Chose only one answer.

A) The two problems can be solved using very similar methods

B) The two problems can be solved using Somewhat similar methods

C) The two problems must be solved using quite different methods

D) The two problems must be solved using very different methods

E) There is not enough information given to know how the problems will be solved.

### Expert Responses

Copies of this survey were mailed to everyone ordering the 2002 Physics Education Research Conference Proceedings. Twenty-five people returned completed surveys. This pool of experts will be expanded to include physics educators from outside the physics education research community in the near future.

In evaluating expert responses, answers of “strongly agree” were combined with “agree” and “strongly disagree” responses were combined with “disagree”. The rationale for this is concern regarding two related issues. First, a given individual may agree more or less strongly depending on timing, state of mind and the context in which the question is asked. Second, the *degree* of agreement associated with “agree” or “strongly agree” is not necessarily comparable between individuals. In addition, combining responses in this way simplifies data presentation.

A summary of the expert response to each survey question above is shown in Table 1 below.

Question	1	2	3	4	5	6
Expert Answer	D	D	A	D	A	D
% Dissenting	0	16	8	12	8	0

Question	7	8	9	10	11	12	13
Expert Answer	A	D	A	D	A	D	A
% Dissenting	4	20	0	12	12	20	4

Question	14	15	16	17	18	19	20
Expert Answer	D	D	D	D	A	A	A
% Dissenting	0	0	16	12	4	12	4

**Table 1:** Expert consensus answers to the survey questions. “A” denotes agree (including strongly agree) and “D” denotes disagree (including strongly disagree). The percentage of experts giving dissenting opinions is noted.

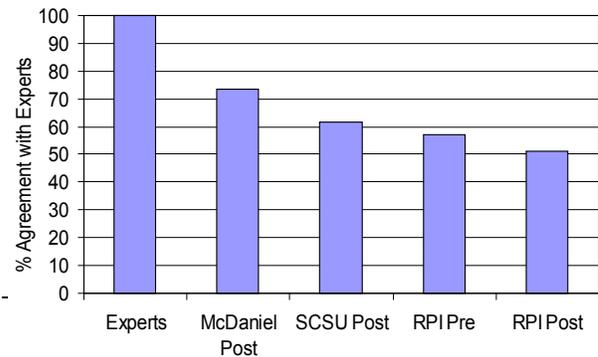
### Comparing Student Populations

To date, three groups of students have taken the survey. Approximately 275 students in the first semester of Rensselaer Polytechnic Institute’s

(RPI) calculus-based Studio Physics course were given the survey both pre- and post instruction during the fall of 2002. In addition, about 20 students in a two-semester algebra-based course at a small liberal arts college (McDaniel College) were given the survey post-instruction at the end of the second term. About 20 students at a medium sized, urban, state university (Southern Connecticut State University) were given the survey post-instruction following a one-semester, algebra-based course.

The McDaniel College course was taught by Dr. Jeff Marx, a physics education researcher. The Southern Connecticut State course was taught by Karen Cummings, an author on this study. None of the Studio Physics instructors are associated with this study, the survey or the “assessing problem solving ability” project.

Comparisons between the survey scores for these groups is shown in Figure 1.



**Figure 1:** Agreement with expert answers by group. Note that it is common for MPEX scores to decline as a result of introductory physics instruction. Hence, the decline in RPI scores is not totally unexpected.

### Calculating A Student’s Survey Score

In order to allow a comparison between student performance on the entire survey and other assessments of knowledge and skills, a scoring rubric has been developed. To calculate a total student “score” on the survey, each student answer to a question that matches the expert consensus answer shown in Table 1 is awarded one point. The sum of points awarded is the student’s score. Based on this score, correlations can be made between performance on the survey and other assessments. Several such correlations are shown in Table 2.

Correlation Between Total Survey Score and	N	R
Exam Average (RPI)	272	0.28
Force and Motion Conceptual Exam (FMCE) Post-test (RPI)	272	0.35
Instructor Assessment of Problem Solving Ability (McDaniel)	17	0.34
Instructor Assessment of Problem Solving Ability (SCSU)	20	0.48

**Table 2:** Correlation coefficients (*R*) between a total survey score and other assessments are shown for groups of (*N*) students in the various populations.

### Average Student Response on Single Questions

Another interesting comparison is “average student response” on individual survey questions among various groups of students. The following rubric was used to calculate “average student response” to a given question: Assigning a value of +1 for agree/strongly agree answers in a group, -1 for disagree/strongly disagree answers and 0 for neutral answers. The student answers within the group can then be averaged.

This process turned out to be quite valuable in probing which questions on the survey are most closely correlated with success on other assessments. For example, the group of Rensselaer students can be broken into three groups (top, middle

and bottom) based on Force and Motion Conceptual Exam (FMCE) post-test score. [3] When divided by FMCE score, the top third was more “expert like” than the bottom third on every survey question. Alternatively, when divided in thirds based on numerical final course grade, the top third was more “expert like” than the bottom on eighteen of twenty questions.

### Conclusions

This study indicates that an assessment of student problem solving ability will benefit from the inclusion of attitudinal questions. The most promising questions in terms of their ability to differentiate between the “top” and “bottom” students (using the FMCE and course grades as the metrics) are listed in Table 3.

### References

- [1] Redish, E. F., Saul, J. M., & Steinberg, R. N. Student expectations in introductory physics, *American Journal of Physics*, **66**, 212-224. (1997).
- [2] Chi, M.T.H., Feltovich, P., Glaser, R. “Categorization and representation of physics problems by experts and novices,” *Cog. Sci.* **5**, 121-152 (1981).
- [3] Thornton, R. and Sokoloff, D., “Assessing student learning of Newton’s Laws: The FMCE ” *Am. J. Phys.* **66** (4), 338-352 (1998).

Question	17	1	7	14	4	20	6	16	11	9	18	2	5	10	13
<b>Grade</b>															
<i>Diff t-b</i>	0.57	0.40	0.40	0.24	0.19	0.24	0.31	0.15	0.21	0.15	0.22	0.09	0.12	0.08	0.18
<i>t-b corr</i>	y	y	y	y	y	y	y	y	y	y	y	y	y		y
<i>t-m-b corr</i>	y	y	y		y	y		y	y		y				
<b>FMCE</b>															
<i>Diff t-b</i>	0.52	0.37	0.29	0.43	0.44	0.34	0.26	0.26	0.18	0.23	0.16	0.20	0.16	0.17	0.05
<i>t-b corr</i>	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
<i>t-m-b corr</i>	y	y	y	y		y	y		y		y	y	y	y	

**Table 3:** The fifteen most promising questions on the survey. These questions produced the largest average score differences between the top third and bottom third of Rensselaer students (*Diff t-b*). This difference in average score is shown for groupings based on final numerical course average (*Grade*) and Force and Motion Conceptual Exam (FMCE) post-test score. Questions for which the top third (*t*) answered more “expert like” than did the bottom third (*b*) have a “y” in the (*t-b corr*) row. Questions for which the top third answered more “expert like” than did the middle third (*m*) AND the middle third answered more “expert like” than did the lowest third have a “y” in the (*t-m-b corr*) row.