Investigating the Validity of the MPEX Survey

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Abstract. The Maryland Physics Expectations Test (MPEX) is a Likert-scale survey used to study students' attitudes toward learning physics. Student responses are categorized as either favorable or unfavorable as determined by the prevalent responses given by an expert control group.[1] We investigated the possibility of false negative or positive responses on the student surveys by asking students to elaborate on their responses to some of the statements. While the majority (more than 95%) of explanations were consistent with the corresponding Likert choice, a few questions generated multiple student responses that deserved further review. Several of these "interesting" student responses were compiled and sent to physics experts who gauged the favorability of each entire response. Here we present our analysis of the questions that generated the highest number of inconsistent responses.

[1] Edward F. Redish, Jeffery M. Saul, and Richard N. Steinberg, "Student Expectations in Introductory Physics," *Am. J. Phys.* **66** (3), 212-224 (1998).

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INTRODUCTION

Since its introduction in 1998, the Maryland Physics Expectations Survey (MPEX) [1] has been used at many institutions to gauge students' attitudes about physics and their expectations of physics courses. This survey was developed using accepted research techniques, including interviews to ascertain the validity of students' multiple-choice responses. As has been pointed out throughout physics education research (PER) literature, however, "One needs to take care with the interpretation of [standardized assessment] results since multiple choice tests or surveys give very limited views of complex situations" [2]. After anecdotal evidence was discussed at a PER conference [3], we decided to investigate the validity of the MPEX in a large class, using the calculus-based introductory course at Grove City as our sample.

METHODOLOGY

Students taking the MPEX are asked to rate their agreement with various statements using a 5-option Likert scale, ranging from strongly disagree to strongly agree. The choices are classified as either "favorable" or "unfavorable" by comparing them with the prevalent responses given by an expert control group [1]. For example, item 5 on the survey states, "Learning physics made me change some of my ideas about how the physical world works." Experts agree with this statement, so agreeing or strongly agreeing would be favorable student responses.

On the traditional MPEX survey, students are asked simply to circle or bubble in the Likert choices indicating their levels of agreement. Yet the possibility exists that students may pick a "favorable" Likert response for a less-than-favorable reason or vice-versa. In particular, Wittmann [3] discovered such inconsistent responses during interviews with upper-level physics students following the students' taking of the MPEX. Our study investigates the frequency of such inconsistent responses when the survey is given to a large group of students.

Clinical interviews undoubtedly provide the deepest insight into student reasoning, but conducting individual student interviews with every member of a large-enrollment course is not feasible. We settled for giving a modified version of the MPEX, in which students were asked to explain, in writing, their Likert choice. Students were asked to answer all 34 MPEX questions and to provide an explanation on 12 of those 34. Students in the three laboratory sections were asked to explain different sets of twelve items, so all 34 items were probed in our study. It was hoped that by asking students to expand upon their choices for only one third of the questions, the students would give detailed explanations, yet not feel that completing the survey was a tedious task.

Our sample consists of all students taking Physics 101 at Grove City College in the fall of 2002. Physics 101 is the first of three semesters of our calculus-based introductory physics course. A breakdown of the majors of the students completing the pre-instruction survey is shown in Table 1.

TABLE 1. Majors of Students Taking the Pre-Survey

Major	% of Class
Engineering	61%
Math and/or Computer	17%
Physics	10%
Industrial Management	6%
Biochemistry, Biology, Chemistry Education, and Undeclared	6%

The modified version of the survey was given to 143 students at the beginning of the semester in the fall of 2002, to 129 of those students at the end of that semester, and to 4 students at the start of the following semester. Note that each of the individual pre- and post-tests can be considered an individual data point, since we are examining the test itself, not the change of individual students over the course. Our data support this merging, since the ratio of "interesting" responses (defined below) to total responses is not significantly different between the pre- and post-test data sets (3.3% vs. 2.7%). Not all students provided every requested explanation; we ended up with between 36 and 88 explanations for all but one survey item. (Item 22, for which explanations were asked of all students, generated 175 explanations.)

To look at the validity of an individual question, we tallied student explanations and determined whether they were "related" to the accompanying Likert choices and, if so, whether they were consistent with those choices. We considered both unrelated and inconsistent explanations to be "interesting" and worthy of further study. We applied conservative criteria in our flagging of inconsistent explanations. If the explanation could be interpreted to be consistent, we did not flag it. Thus our number of inconsistent responses is most likely a lower limit.

We next compiled a questionnaire including many of the interesting responses and distributed it to faculty members at several different institutions. The questionnaire asked the professors to look at the Likert choice and explanation and to judge whether the response as a whole indicates a favorable or unfavorable attitude toward science and learning science. Professors were also invited to comment on their rating and on the student responses. Six faculty members, representing five different institutions, returned the survey. Most of these participating professors were not familiar with the specifics of the MPEX, allowing us an unbiased pool of experts.

FINDINGS

Table 2 provides the statements corresponding to the survey items discussed in this paper, listed in numerical order; our data for these items are found in Table 3. One example of an unrelated explanation was in response to MPEX item 14. A student explained his choice of Disagree by writing, "Imagination is necessary to understand limits (I'm not sure I answered the questions)." We could not relate this explanation to the MPEX item and thus could not check for consistency. Other unrelated explanations connected to the item in question but still did not determine consistency. For example, a student Agreed with item 33, then wrote, "Memorization is easy; it's understanding that's hard."

TABLE 2. Referenced MPEX Items

Item #	Statement (Favorable Response)
2	All I learn from a derivation or proof of a formula is that the formula obtained is valid and that it is OK to use it in problems. (Disagree)
5	Learning physics made me change some of my ideas about how the physical world works. (Agree)
10	Physical laws have little relation to what I experience in the real world. (Disagree)
11	A good understanding of physics is necessary for me to achieve my career goals. A good grade in this course is not enough. (Agree)
14	Learning physics is a matter of acquiring knowledge that is specifically located in the laws, principles, and equations given in class and/or in the textbook. (Disagree)
17	Only very few specially qualified people are capable of really understanding physics. (Disagree)
20	If I don't remember a particular equation needed for a problem in an exam there's nothing much I can do (legally!) to come up with it. (Disagree)
22	Physics is related to the real world and it sometimes helps to think about the connection, but it is rarely essential for what I have to do in this course. (Disagree)
23	The main skill I get out of this course is learning how to solve physics problems. (Disagree)
24	The results of an exam don't give me any useful guidance to improve my understanding of the course material. All the learning associated with an exam is the studying I do before it takes place. (Disagree)
30	The main skill I get out of this course is to learn how to reason logically about the physical world. (Agree)
33	It is possible to pass this course (get a C or better) without understanding physics very well. (Disagree)

TABLE 3. Analysis of Explanations for Referenced MPEX Items, in Order of Decreasing Inconsistancy Percentage

Item Number	**2**	**10**	**30**	**23**	**20**	**11**	**14**	**33**	**17**	**24**	**5**	**22**
Students asked to explain	87	98	91	87	87	87	98	91	98	91	87	276
Students actually explaining	66	81	40	64	72	75	84	43	88	52	63	175
Students with related explanation	64	80	40	63	72	74	83	42	87	52	63	174
Inconsistent explanations	5	5	2	3	3	2	2	1	2	1	1	0
Inconsistent divided by related (%)	7.8	6.3	5.0	4.8	4.2	2.7	2.4	2.4	2.3	1.9	1.6	0.0

This response relates to the item, but it does not specify whether one could pass without understanding.

Some explanations deemed inconsistent appeared due to a simple misreading of the question or Likert choices. See, for example, the responses to item 10 discussed below. Other inconsistencies could not be as easily explained. For example, a student Disagreed with item 5, not because physics failed to influence her ideas but because physics "didn't change my ideas but rather formed them." This student's Likert choice was unfavorable, but her explanation was favorable. Another student favorably chose Strongly Disagree for item 24, but then gave the unfavorable explanation, "I haven't really been studying."

Out of the 2300 explanations provided [4], we found only 50 inconsistent and 19 unrelated responses, for an overall inconsistency percentage (the number of inconsistent responses divided by the number of related responses) of 2.2%. Two students who apparently inverted the Likert scale account for 10 of the 69 interesting responses: nine of the inconsistent explanations and one of the unrelated explanations. The percentage of inconsistent explanations was under 5% for all but three MPEX items, with seven of the items generating no inconsistencies. Item 30's high inconsistency percentage is inflated by a low number of explanations and one of the Likert-inverting students. Thus, the MPEX seems to provide valid feedback for most items. Data for each item referenced in this paper are included in Table 3. This includes all items with inconsistency percentages greater than 4%. Below we discuss the items that warrant further review.

Item 10 generated five inconsistent responses, all of which appear to be due to the students overlooking the word "little" in the statement. One particular student Strongly Agreed to the statement, and then explained, "That is only true for ignorant people." Unless the student considers himself ignorant, he misread the statement. Another student responded to item 10 by Agreeing, and commenting that "I see physics everyday." The other three inconsistent results were similar. Rewording of the statement by eliminating its negative qualifier may lead to more accurate results for this statement. As one professor stated on his questionnaire, "There is a problem with putting a negative (little) in the statement."

Item 2 seems to be one of the most nebulous on the survey, as students can interpret the item on many different levels of understanding. Like item 10, item 2 generated five inconsistent responses, but none for item 2 was obviously attributable to students misreading the survey. Three were false positives, students who disagreed with the statement but for unfavorable reasons. Two of these students essentially restated the problem in their explanation: "It explains how it is valid," and, "A derivation can also show you the reason why the formula works." The third was more clearly a false positive, since he Strongly Disagreed because, "I don't really care where they come from." The authors of the MPEX attributed most inconsistencies raised in their interviews to the "students' ill-defined understanding of the nature of physics" rather than a shortcoming of the survey [1]. The interesting responses to item 2 might be so explained, but the presence of unavoidable inconsistencies suggests one reconsider the value of this item.

Item 20's inconsistent responses can also be attributed more to a lack of sophistication of the respondents than to a flaw in the survey item. Three students Agreed with the statement, then claimed in the explanation that they could possibly derive the needed equation. They are either misjudging the validity of deriving equations on their own or perhaps lacking confidence in their ability to do the derivation.

Item 11 highlights a possible drawback in determining favorability by comparison with expert responses. Agreement with this statement is deemed favorable, since physics experts would (hopefully) acknowledge the connection between their careers and understanding physics. Introductory physics students, however, will pursue a variety of careers. Disavowing a need for physics knowledge in one's chosen career of, *e.g.*, tax preparation, does not preclude a positive attitude toward learning physics.

One student in our study strongly disagreed with item 11, and followed by explaining, "I want to be a chef." Another explained his disagreement with the statement by writing, "I don't know what my career goals are. I do enjoy physics and it is relevant to my major." Every expert filling out our questionnaire agreed that the latter student exhibits a positive attitude toward learning physics, yet the accompanying Likert response would label his attitude "unfavorable."

The chef's response, and two other similar responses, generated significant disagreement among professors filling out our questionnaire. Most catego-

rized the chef's response as "unfavorable" and thus consistent with the Likert choice, since the chef "has not made connections" between her career and physics. Two professors, however, refused to categorize the answer because, as one put it, "[I] can't evaluate [her] attitude since the student honestly answered the question based on a career goal of becoming a chef."

Item 11 also serves as an example of how items with two statements can generate inconsistencies. Both inconsistent responses to this question are by students who Disagreed with item 11 because they desired good grades as well as an understanding. The inconsistency is due to the students' not distinguishing precisely what they were disagreeing with – an occurrence seen in other two-statement items as well.

Item 17 includes three vague qualifiers ("few," "specially," and "really"), leading to two inconsistencies and an unrelated explanation critiquing the statement. All three interesting explanations accompanied Likert choices of Agree. One student explained, "Many people can understand with enough effort," seemingly in direct contrast with his Likert choice. Another restated (and changed) what he was agreeing with: "Only a few take the time and have the right type of mind to gain a true and confident understanding." The student who critiqued the statement asked, "What is your definition of really? Really understanding it like Einstein? Newton? Kepler?" As one professor summarized, "This is a poorly worded statement. There is a negative (the word 'only') and it is vague (the word 'really')."

Item 23 runs into similar linguistic difficulties with the phrase "main skill." One student who Disagreed explained, "I learn more about the world." This is indeed a true positive. Another student Agreed with the statement, and then said, "I learned more general things." These students had differing choices on the Likert scale, yet they both seem to say that they learned conceptual material in this course. Likert choices for this item appear to depend upon the student's definition of "main," not necessarily what he or she takes from the class.

CONCLUSIONS

We found most items on the MPEX to be valid in a calculus-based introductory course, as would be expected from the testing the MPEX underwent (also with calculus-based courses) during its creation. The number of apparent inconsistent explanations is, for the most part, insignificant. Many of the inconsistent responses we saw, such as the responses by the two students who reversed the Likert scale, are due to inescapable student carelessness. We agree with the survey's authors that some interesting student responses can be attributed to "ill-defined understanding," but we believe that other inconsistencies might be avoided with editing of the survey. After all, several survey items were not misread by any of our students, while other items were similarly misread by several students.

In general, it seems as if avoiding negative statements (such as in item 10) and/or vague phrases (items 17 and 23) would help students in interpreting the survey items. Item 2 appears prone to false positives and thus may need revision or elimination. Additional student difficulties could be avoided by eliminating or clarifying the two-statement survey items such as item 11. Disagreeing with one statement and agreeing with the other can leave students in a quandary. These findings and suggestions are in keeping with standard assessment development guidelines, such as those found in references [5,6].

Finally, we would like to comment on our analysis of item 11. Just because favorability of response may not be uniformly interpreted does not mean the item should be eliminated. We can imagine many scenarios in which an instructor would want to know whether his or her students make a connection between their chosen careers and physics. Our analysis of this item merely reinforces the warning that instructors should carefully examine assessment instruments and their rubrics before interpreting the results.

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4. Table 3 illustrates variations in the response rate (number of students actually explaining over asked to explain) from question to question. This rate is 69% overall and does not vary with pre- versus post-test, MPEX question "categories," such as "Reality Link" [1], or any other factor we could determine.
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