

# Towards characterizing the relationship between students' self-reported interest in and their surveyed beliefs about physics

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**Abstract.** We examine the relationships between students' self-reported interest and their responses to a physics beliefs survey. Results from the Colorado Learning Attitudes about Science Survey (CLASS v3), collected in a large calculus-based introductory mechanics course (N=391), were used to characterize students' beliefs at the beginning and end of the semester. Additionally students were asked at the end of the semester to rate their interest in physics, how it has changed, and why. We find substantial correlation ( $R=0.65$ ) between students' 'Overall' CLASS belief score and their self-rated interest at the end of the term. An analysis of students' reasons for why their interest changed showed that a sizable fraction of students cited reasons tied to beliefs about physics or learning physics as probed by the CLASS survey. The leading reason for increased interest was the connection between physics and the real world.

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## INTRODUCTION

Measurements of students' beliefs about physics and learning physics have shown that students' beliefs typically degrade – that is become more novice-like – over the course of most introductory physics classes. In this paper, we begin to examine the relationship between students' beliefs and their self-reported interest in physics and the respective changes over a semester.

For many years educators have examined and characterized student interest in physics [1, 2]. Early work has examined the relation between student interest and future career prospects, retention, and student beliefs [1]. In a survey of students, Briggs found that their positive interest in physics was associated more strongly with future pursuits in physics, whereas negative interest was attributed to factors of course implementation. Our research builds on these prior efforts as well as our own work characterizing students' beliefs about physics and learning physics [3].

Ultimately, we seek to understand the relationship between students' interest (as they define it) and students' beliefs about physics and learning physics and to determine if a relationship exists whereby beliefs influence interest. This information would add to the existing evidence for the importance of designing

teaching practices and curriculum that effectively develop expert-like beliefs in students.

## STUDY DESIGN

Over the past year, we used the Colorado Learning Attitudes about Science Survey (CLASS v3) [3] to measure student beliefs both at the start (pre) and end (post) of a variety of introductory physics courses. The CLASS survey consists of 42 statements to which students respond using a 5-point Likert scale. Thirty-six of these statements have a consistent expert response and are used to determine the student's 'Overall' % favorable belief score – the percentage of statements for which his/her response agrees with that of an expert physicist. The belief categories listed in Table 1 are scored using groupings of 4 to 8 statements. The details of the design, categorization, and validation of the CLASS are reported by Adams et al. [3].

While students took the CLASS survey both at the start and the end of the term, it was only on the end-of-term survey that we included supplementary questions intended to monitor students' level of interest in physics. These questions<sup>1</sup> included:

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<sup>1</sup> Notably these questions followed 42 questions on the CLASS survey, as well as asking students to project their level of interest back to the beginning of term. Future studies will alter this format.

*At the start of the term, what was your level of interest in physics?*

(very low, low, moderate, high, very high)

*Currently, what is your level of interest in physics?*

(very low, low, moderate, high, very high)

*During the semester, my interest in physics...*

(increased, decreased, stayed the same)

This last question was followed with a free response question asking students to explain ‘Why?’ We chose to use questions that are purposely vague as opposed to questions that are more specific measures of interest such as whether students would like to learn more physics. This approach was taken in an effort to measure students’ composite affective response towards physics, how that has been changed over the term, and to what they attribute that change. The student’s answer naturally depends upon the range of factors relevant to how they personally identify what makes something interesting to them

This paper focuses on data from a calculus-based Physics I course in Fall 2004. This course was a large lecture course (over 500 enrolled) and taught by a pair of faculty who are somewhat familiar with research findings in PER and rated on student evaluations to be in the upper half of faculty in the department. Lecture was moderately interactive, using concept tests but with limited student-student discussion; the course textbook was Randy Knight’s PER-influenced book *Physics for Scientists and Engineers* [5]; weekly homework used the Mastering Physics [6] web-based system; and recitations involved group work on Knight’s accompanying workbook activities for about half of the term, after which time the TAs were given full freedom in choosing recitation activities and formats. Of the students enrolled in this course, 391 completed both the pre- and post-surveys. All analyses are conducted on this matched dataset.

## RESULTS AND DISCUSSION

**Students’ beliefs, interests, and their correlation.** In Table 1 and Figure 1, we summarize the results of the CLASS beliefs survey and the self-rated interest question for the calculus-based Physics I course in Fall 2004. The CLASS survey results show that this population of mostly engineering students has a relatively broad distribution of beliefs about physics, including a sizeable number of students (16% pre and 29% post) whose beliefs are quite consistently novice (agreeing with the expert on less than 50% of the statements) as well as an equally sizeable number of students (22% pre and 16% post) whose beliefs are quite consistently expert (agreeing with the expert on more than 80% of the statements). The averages of the % favorable score for the CLASS survey ‘Overall’ are 66% (pre) and 59% (post), with standard deviations of 16% and 19%

respectively. This ‘Overall’ score and the scores for the belief categories shown in Table 1 are typical for a course where the student population is dominated by engineering majors. We see a pre-to-post shift in beliefs of -7% to -15% across all categories. This degradation of students’ beliefs over the course of the term – where the students leave the course with more novice-like beliefs about physics and learning physics – is typical for introductory courses where the pedagogy and curriculum does not explicitly target development of expert-like beliefs [3,4].

The students’ self-rated change in level of interest in physics (Table 1B) also decreases over the course of the term. While approximately 50% of the students rated their interest in physics as ‘high’ or ‘very high’ when reflecting back to the start of the term, about 30% rated their current (post) interest as ‘high’ or ‘very high’. There is a corresponding growth (from 16% to 34%) in the number of students rating their interest as ‘low’ or ‘very low’. In addition, 45% of the students reported a decrease in interest and only 19% reported an increase.

The correlation coefficient between CLASS Overall belief score and self-rated interest is relatively strong ( $R=0.65$ ), meaning that the relationship accounts for 43% of the variability in the observed data. The correlations between the self-rated interest and the specific belief categories on the CLASS are listed in Table 1A. The ‘Personal Interest’ category has the strongest correlation as one may expect; however, all other categories have reasonably strong correlations as well. The ‘Overall’ CLASS score includes 10 questions that do not appear in the individual categories.

From Figures 1A and 1B, we see that the distributions of beliefs, as measured by the CLASS survey, for

**TABLE 1.** CLASS Survey Scores and Self-rated interest for calculus-based Phys I, Fa04 (N=391)

A. CLASS Belief Categories	% Favorable			$R^{\S}$
	Pre	Post	Shift	
Overall <sup>&amp;</sup>	66	59	-7	0.65
Personal Interest	68	57	-11	0.63
Problem Solving General	72	59	-13	0.60
Problem Solving Sophistication	61	47	-14	0.57
Senses Making / Effort	73	64	-10	0.52
Problem Solving Confidence	73	58	-15	0.51
Real World Connection	73	66	-7	0.49
Applied conceptual understanding	54	47	-7	0.49
Conceptual understanding	64	56	-8	0.48

<sup>§</sup> Correlation of post % favorable scores with self-rated interest (1-5) at the end of the term.

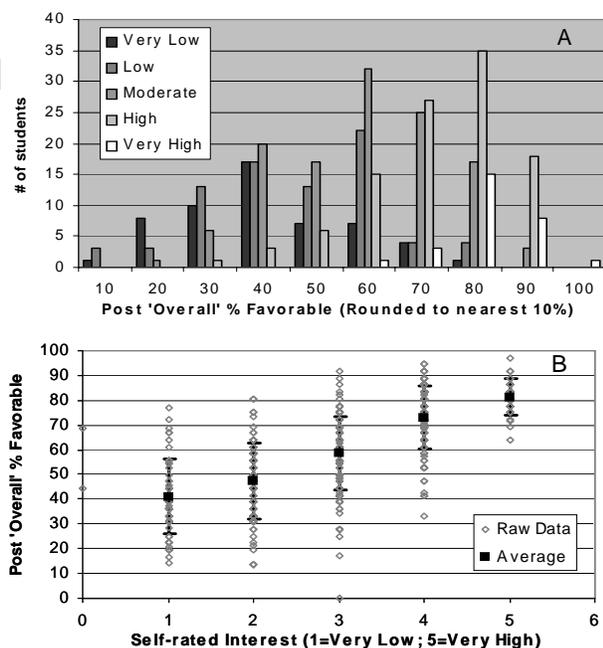
B. Self-rated Interest	Pre	Post	No. students rating interest as:		
			Increased	no change	decreased
Very Low (1)	16	55	73	144	174
Low (2)	46	79	(55)*	(102)*	(145)*
Moderate (3)	131	122			
High (4)	141	105			
Very High (5)	57	28			

\* No. of students with codeable ‘Why?’ answer.  
<sup>&</sup> The categories do not span ‘Overall’

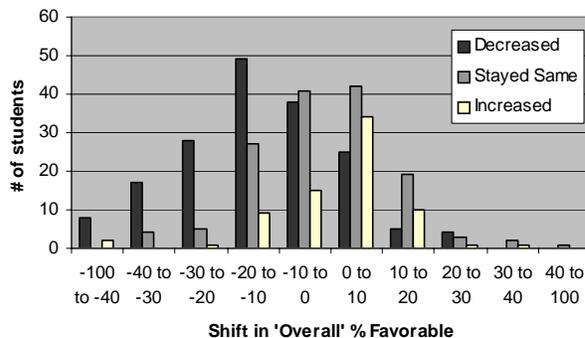
students who rate their interest as ‘high’ and ‘very high’ at the end of the course are centered around scores of 73% and 81%, respectively, with only a small fraction of these students displaying very novice-like beliefs. Conversely, the distribution of beliefs for students who rate their interest as ‘low’ and ‘very low’ are centered around scores of 47% and 41%, respectively, with very few displaying expert-like beliefs.

From Figure 2 we observe a clear relationship between students’ shift in beliefs and change in level of student self-reported interest from the beginning to end of term. Those students whose interest increased tend to have more favorable shift in beliefs than those whose interests decreased. The distribution of students who said their interest increased was centered around a shift in overall beliefs of 0.5%. The distribution of students whose interest decreased was centered around a shift in overall beliefs of -13.5% with a correlation coefficient of 0.38.

We also note there is a clear correlation between choice of major and both interest and beliefs scores as seen with prior work [3]. The 24 students intending to major in physics at the end of the course had an average ‘Overall’ belief score of 75% (st. dev. of 12%) and average interest level of 4.2 (st. dev. of 0.8) versus a class average of 59% and 2.9. As a comparison,



**FIGURE 1.** Panels A and B show two representations of the same data. Both are plots of the CLASS ‘Overall’ % favorable scores coded by students’ self-rated interest (very low to very high) for the calculus-based Phys I Fa04 course, N=391, at the end of the semester. Panel A shows the distribution by number of students, and Panel B shows the averages and standard deviations. R=0.65.



**FIGURE 2.** Distribution of observed shifts in the CLASS ‘Overall’ % favorable scores coded by students’ self-rated *change* in interest over the course of the term (increased, no change, decreased) for the calculus-based physics I Fa04 course, N=391. R=0.38.

Physics majors at the end of sophomore year, after Modern Physics, have an average ‘Overall’ belief score of 81% and average interest level of 4.0.

**‘Why’ students’ interests change.** On the end of term (post) survey, in addition to surveying students on *how* their interests changed, we gave students the option to state *why*. A surprisingly large number of students (302 of 391) answered this question. After developing a coding metric for dealing with a small class of ambiguous statements, three researchers independently coded all the answers. Evaluation consistency among the researchers was 90% or better.

After some analysis five distinct categories emerged to capture the student responses, and within each category were a number of sub-categories. The five categories are: ‘Specific Aspects of Instruction’ (52%); ‘Beliefs’ (31%); ‘Personal Success’ (24%); ‘Prior Experience’ (16%); and ‘Relation to Career Plans’ (7%). The student responses were placed into one or more sub-categories based on words or sentiments in their answer that directly reflected the specific sub-categories. (Six of the 302 responses were classified as “non-reasons,” because they did not reflect a reason for why the student’s interest changed.) For example ‘Aspects of Instruction’ included several sub-categories such as: the teacher – “I really struggled with the professor. He seems like a good guy, but his teaching style isn’t the best,” the difficulty of the course – “I’ve done poorly in test performance.” The sub-categories for the beliefs category corresponded to the categories of the CLASS survey listed in Table 1 such as ‘Personal Interest’ – “Because I saw several ways in which I may use physics in the future.”

The above examples include statements which are clearly belief or non-belief related. There were also a fair number of statements which were suggestive of beliefs but could not be considered definitive. As an experienced teacher one may recognize the following

**TABLE 2.** Categorization of 'Why' students' interests changed

	Change in self-reported interest:	
	Increased	Decreased
# of students with codeable 'Why' answers (N=302 <sup>§</sup> )	55	145
Percent of 'Why' answers related to overall beliefs probed by CLASS:		
<i>Definitive</i>	55 % (30 students)	28 % (40 students)
+ <i>Suggestive</i>	13 % (7 students)	21 % (30 students)
Top 'Why' reasons: related to belief categories: (coded definitive reasons only)	1. Connection to real world (17/55) 2. Personal interest(usefulness) (10/55) 3. Prob. Solving Confidence (8/55)	1. Conceptual Understanding (14/145) 2. Prob. Solving Confidence (14/145) 3. Prob. Solving Sophistication (14/145)
Responses related to non-belief categories:	<b>Percentage of students*</b>	
Specific Aspects of Instruction	33% (18 students)	72% (104 students)
Personal Success	18% (10 students)	33% (48 students)
Prior Experience	5% (3 students)	6% (9 students)
Relation to Career Plans	5% (3 students)	3% (5 students)

<sup>§</sup> Calculus based Physics I Fa04 N=302 with 102 neutral responses.

\* Note that each student's response could be placed into several categories.

student: "Test questions were too different from homework problems and I became frustrated." It is possible that this is an excellent student who's noted a flaw in instruction; however, more likely it's a student with weak 'Conceptual Understanding' and 'Problem Solving Confidence'. These types of responses are listed in the 'suggestive' sections of Table 2.

A summary of the results of students' responses is shown in Table 2. The top portion of the table delineates the portion of the class whose self-reported interest increased or decreased and the fraction whose reasons why were related to CLASS beliefs. The lower portion of the table lists the number of students whose responses fell into each non-belief category. A sizable fraction of the class (35% students whose interest changed, and 31% of the class overall) gave open ended responses that explicitly related to student beliefs. Furthermore, the top reasons students give for increased interest are belief related, and the top reasons for students' decreasing interest are not explicitly belief related. The top two reasons for increased interest were 'Connection to the Real World' (30% of those whose interest increased), and 'Personal Interest (Usefulness)' (18%). The top two reasons for decreased interest were 'Specific Aspects of Instruction' (72% of those whose interest decreased) and 'Personal Success', (33%). These results give some evidence of a relationship between beliefs and interest albeit this is something we want to explore further to determine if this could be a causal relationship.

## CONCLUSION AND FUTURE WORK

We observe significant correlations between students' overall beliefs about physics and learning physics with their self-rated level of interest in physics,  $R=0.65$ . As with previous research we find that students' reasons for an increased interest in physics after

a semester of instruction differ from their reasons for decreased interest. Our research shows that the dominant reasons for increased interest are belief related while dominant reasons for decreased interest are related to 'Specific Aspects of Instruction.' We expect that future studies of student beliefs and factors that influence these beliefs, such as gender or other demographics, will shed light on students' interests and how this is affected by instruction.

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