Towards characterizing the relationship between students' interest in and their 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 about physics and learning physics 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 a correlation between surveyed beliefs and self-rated interest (R=0.65). At the end of the term, students with more expert-like beliefs as measured by the 'Overall' CLASS score also rate themselves as more interested in physics. 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

Over the last decade, students' beliefs about physics and learning physics has become an active area of research within the physics education research community. Findings from the early studies showed that students' beliefs typically degrade – that is become more novice-like – over the course of most introductory physics classes.[1] More recently, studies have started looking at correlations between students' beliefs and other measures, such as content learning or choice of major.[2] In this paper, we begin to examine the relationship between students' beliefs and their self-reported interest in physics, and their respective changes over a semester.

For many years educators have examined and characterized student interest in physics [e.g.,3]. Early work examined the relation between student interest and future career prospects, retention, and student beliefs [3]. 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. Educational psychologists have also conducted extensive research in the general area of student interest and motivation.[4] Our research here builds on these prior efforts and the results represent new work that specifically examine the relationship between students' beliefs and interest in the context of undergraduate physics using PER-developed tools for measuring students' beliefs about physics.

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 and to characterize the relationship. 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) [5] 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. Complete details of the design, categorization, validation, and scoring of the CLASS are reported by Adams et al. [5]. Briefly, the student's 'Overall' % favorable belief score is equal to the percentage of statements for which his/her response agrees with that of an expert physicist. Additional belief categories, as listed in Table 1, are scored using groupings of 4 to 8 statements.

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[1] included:

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* [6]; weekly homework used the Mastering Physics [7] 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 [1, 2].

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, only 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.

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

A. CLASS Belief Categories	% Favorable Score Pre	Post	Shift	$R^{\$}$
Overall [&]	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

[$] Correlation of post % favorable scores with self-rated interest (1-5) at the end of the term. [&] The categories do not span 'Overall'

B. Self-rated Interest: % of students rating their interest as

	Pre	Post	Changed over term:	
Very Low (1)	4%	14%	Increased	19%
Low (2)	12%	20%	No change	37%
Moderate (3)	34%	31%	Decreased	45%
High (4)	36%	27%		
Very High (5)	15%	7%		

[1] 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.

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.

From Figures 1A and 1B, we see that the distributions of beliefs, as measured by the CLASS survey, for 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. Students with increased interest tended to also have more favorable shifts in beliefs than those with decreased interest. 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%. The correlation coefficient is 0.38.

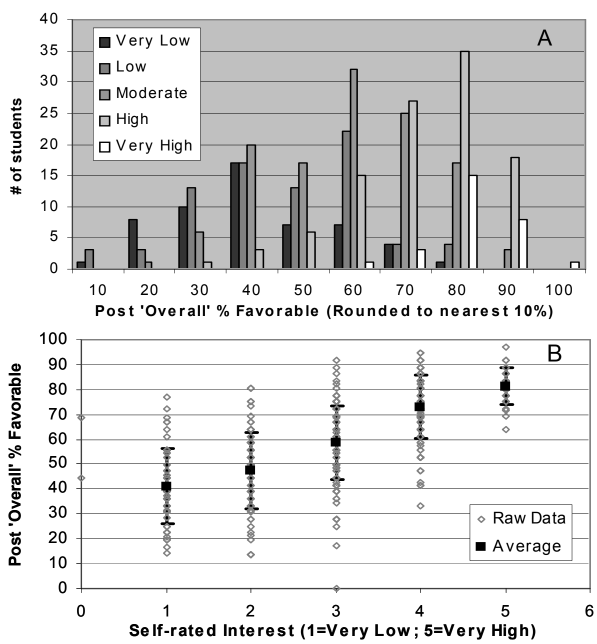

FIGURE 1. Panels A and B show two representations of the same data. Both are plots of the CLASS 'Overall' % favorable scores coded by students' self-rated interest (very low to very high) for the calculus-based Phys I Fa04 course, N=391, at the end of the semester. Panel A shows the distribution by number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

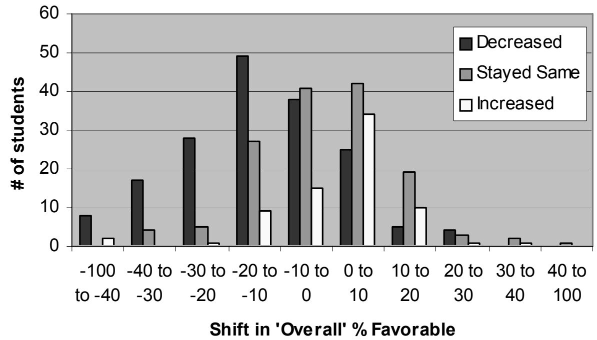

FIGURE 2. Distribution of observed shifts in the CLASS 'Overall' % favorable scores coded by students' self-rated *change* in interest over the course of the term (increased, no change, decreased) for the calculus-based Phys I Fa04 course, N=391. R=0.38.

We also note that there is a clear correlation between choice of major and beliefs scores as seen with prior work [2]. 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, respectively. As a comparison, 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. The five categories are: 'Specific Aspects of Instruction'; 'Beliefs'; 'Personal Success'; 'Prior Experience'; and 'Relation to Career Plans'. The 'Beliefs' category captures the student reasons that closely match or can be identified with items on the CLASS survey. (Six of the 302 responses were classified as "non-reasons," because they did not reflect a reason for why the student's interest changed.) Sub-categories were used to further characterize student responses. For example 'Specific Aspects of Instruction' included 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"; and the difficulty of the course – "I've done poorly in test performance." The sub-categories for the 'Beliefs' category were 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."

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

	Change in self-reported interest: Increased	Decreased
# of students with codeable 'Why' answers (N=302$^{\$}$)	55	145
Categorization of 'Why' answers:	**Percentage of students***	
Beliefs	55 % (30 students)	28 % (40 students)
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)
Top 'Why' subcategories within 'Beliefs':	1. Connection to real world (17/55)	1. Conceptual Understanding (14/145)
	2. Personal interest(usefulness) (10/55)	2. Prob. Solving Confidence (14/145)
	3. Prob. Solving Confidence (8/55)	3. Prob. Solving Sophistication (14/145)

$ Calculus based Physics I Fa04 N=302 with 102 neutral responses.
* Note that each student's response could be placed into several categories.

The above examples include statements which are clearly related to beliefs probed by the CLASS and statements which are clearly not related to beliefs. There were also some statements which were suggestive of beliefs but could not be categorized definitively into the 'Beliefs' category.[2] These responses are not considered here, but are a topic for future analyses.

A summary of the results of students' responses is shown in Table 2. The table delineates the portion of the class whose self-reported interest increased or decreased and the classification of the students' reasons for change into the 5 categories. A sizable fraction of the class (35% of 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; the top 'Beliefs' sub-categories for increased interest are 'Connection to the Real World' (30% of those whose interest increased), and 'Personal Interest (Usefulness)' (18%). By contrast, the top reasons for students' decreased interest are not explicitly belief related, but are 'Specific Aspects of Instruction' (72% of those whose interest decreased) and 'Personal Success', (33%). These results provide 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.

[2] As an experienced teacher one may recognize the following 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'.

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