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Physics Teachers' Beliefs and Their Performance in an In-service Training Program

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ABSTRACT *Research in science education identified a variety of attitudes and beliefs that shape and/or are shaped by classroom experience. The present study identified high school teachers' beliefs about Physics and learning Physics. Since the background of the forty-one teachers who participated in a six-week in-service training program was neither in Physics nor in Physics education, the training program was designed to upgrade their conceptual understanding of Physics, and their skills and competencies in teaching Physics. Using the profile obtained from the Colorado Learning Attitudes about Science Survey (CLASS) and the grades that the participants obtained in the various courses they took, the relationship between teachers' beliefs and their grade point average is presented. Implications for classroom practices are also discussed.*

KEY WORDS: *Beliefs, in-service teacher training, physics education research.*

Introduction

Strides in human development and the progress made by human society over the past half century highlight the role that science and technology play in meeting the challenges of an ever-transforming society. Nations that have set global economic standards have invested, and continue to invest, a substantial portion of their human and financial resources into science and technology, including education and training, research and development, technology acquisition and adaptation, and the development of physical infrastructures to support science and technology. The experience of industrialized nations clearly demonstrates that scientists, engineers, and technicians are needed to give the "push" towards the next stages of modernization. This socio-economic breakthrough could only be achieved with a citizenry equipped with the appropriate knowledge, skills, values, and attitudes acquired by quality education in science and technology.

The Medium Term Philippine Development Plan (MTPDP) of 1999-2004 acknowledged the important role played by science and technology in pursuing the vision of a sustainable development path anchored on growth with social equity. In achieving this vision, the MTPDP mandated the following science- and technology-related policies:

- The alignment of the content and pedagogical approaches of science and mathematics education with the national and regional thrusts for globalization.

- o The development and adaptation of appropriate productivity- and quality-enhancing technologies.
- o The development of science and technology human resources.
- o The promotion of the development and use of information technology.

There is an urgent need to develop a critical mass of scientists, researchers, engineers, and technicians who will propel our country towards socio-economic growth into the third millennium and beyond. This could only be achieved by nurturing a "culture of science" among our citizenry. In support of the vision, goals, and objectives of the Medium Term Philippine Development Plan, the Department of Science and Technology, utilizing the lessons learned from the First Science and Technology Education Plan (STEP 1) of 1994-1998 as a springboard, has embarked on the Second Science and Technology Education Plan 2001-2005 (STEP 2).

The Second Science and Technology Education Plan 2001-2005 (STEP 2), prepared by the Science Education Institute of the Department of Science and Technology, put forward the premise that "for real progress to happen and endure, three things are needed: science, technology, and education" (Department of Science and Technology, STEP 2, Chapter 1, "The Development Context," p. 1). A close look at the specific strategic thrusts for the implementation of the Second Science and Technology Education Plan reveals the significant role that teachers play in ensuring the success and sustainability of STEP 2. The strategic point on Upgrading Teacher Capabilities calls for "upgrading the capabilities of science and mathematics teachers at the in-service and pre-service levels through scholarships, grants-in-aid, and other similar schemes, for degree and non-degree programs" and "developing and implementing an induction program for science and mathematics teachers to bridge any gap between pre-service and in-service education" (Department of Science and Technology, STEP 2, Chapter 4, "Strategic Agenda," p. 23).

Educators and education researchers also highlighted the important role that teachers play in improving achievement in science and mathematics. Gonzalez (1998) stressed that the human factor is the most important factor for the success of any educational endeavor. He emphasized that "if our teachers are competent in their field of specialization, are able to communicate, and are driven by a vision and a mission, then the other problems will take care of themselves including the shortfall in textbooks and the practical absence of scientific teaching equipment"(p. 27).

The 2000 Presidential Commission on Educational Reform re-iterated that the "keystone of educational quality is first and foremost the teacher" (Presidential Commission on Educational Reform, Philippine Agenda for Educational Reform: The PCER Report, p. 14). The central role attached to teachers is also acknowledged by stating that "the most important factor underlying the quality of basic education is the quality of teachers, and this in turn, depends on the quality of teacher education" (Presidential Commission on Educational Reform, Philippine Agenda for Educational Reform: The PCER Report, 2000, p. 106).

The Research Agenda component of STEP 2 also called for a systematic process of improving science education through research-based activities. The specific action points for this research agenda include (Department of Science and

Technology, STEP 2, Chapter 4, "Strategic Agenda," 2000, p. 31):

- o Conducting research on instructional practices of teachers, on the development of process skills of teachers in higher-order thinking, and on scientific attitudes.
- o Conducting research on the teaching processes of science and mathematics teachers.

Research in math and science education suggests that "teacher beliefs about what mathematics and science is" and "what it means to know the content, do mathematical and scientific activities, and teach mathematics and the sciences" (Clark & Peterson, 1986, p. 226) may be driving forces in the instruction of science and math ideas. By challenging a teacher to explicitly state implicit beliefs, the teacher can question and critique her/his own teaching process.

The research conducted by Bernardo, Prudente, and Limjap (2003) that generated baseline data describing current teaching practices in primary- and secondary-level mathematics and science classrooms in the Philippines revealed interesting findings. The data gathered, using the survey instrument developed by the group, indicated a leaning of the teachers towards an inquiry-oriented approach to teaching mathematics and science. Classroom observation, however, painted a somewhat different picture. The teachers' questions reflected a transmissive classroom atmosphere that emphasized lower-level types of knowledge and thinking processes. The teachers, in general, tended to believe in the goals and features of an inquiry-oriented mathematics and science education, as reflected in their lessons plans, but the implementation of their lesson plans did not promote the same goals, and, as most of the time, the teachers were unable to bring the students to a higher level of thinking and understanding.

The present study investigated the beliefs held by a group of secondary school teachers who participated in a six-week in-service training program. The training program was designed to improve the teachers' content and pedagogical knowledge in Physics. More specifically, the research sought to answer the following questions: "Are there specific beliefs / attitudes towards learning Physics that can facilitate a better appreciation of Physics? Do teachers who possess a 'favorable belief' structure achieve higher learning gains than teachers who approach Physics with 'unfavorable beliefs'?"

The Role of Attitudes and Beliefs in Classroom Practice

Research in science education (Bransford, Brown, & Cocking, 2002; Hammer, 1994; Redish, Saul, & Steinberg, 1998) identified a variety of student attitudes and beliefs that shape and are shaped by classroom experience. Attitudes and beliefs are important concepts in understanding teachers' thought processes, classroom practices, openness to change, and motivation for learning to teach. Richardson (1996) reported that attitudes received considerable attention in teaching and teacher education research between the early 1950's and the early 1970's, while teacher beliefs gained prominence in research literature beginning in the 1980's.

Research (Nespor, 1987; Pajares, 1992) suggested that both attitudes and beliefs drive classroom actions and influence the teacher change process. Richardson (1996) characterized attitudes and beliefs as "a subset of a group of constructs that name, define, and describe the structure and content of mental states that are thought to drive a person's actions" (p. 111). The other constructs in this set include conceptions, perspectives, perceptions, orientations, theories, and stances.

Teacher attitudes and beliefs are also important considerations in understanding classroom practices and conducting teacher education programs that are designed to help prospective and in-service teachers towards developing their thinking skills and classroom practices.

Attitudes

Gordon Allport (1967) defined attitude as a mental and neural state of readiness, organized through experience, exerting directive or dynamic influence upon the individual's response to all objects and situations with which (s)he related. Richardson (1996) narrated that the study of teaching during the 1950's and the 1960's were focused on teachers' social attitudes towards students, other people and their cultures, learning, and the purposes of education. These studies were related to democratic and authoritarian attitudes, the relationship between attitudes, personality factors, and classroom behavior, and how attitudes affect teacher–student interactions.

As the discipline of social psychology became more cognitively oriented, there was a shift in research paradigms in both social psychology and educational psychology. This moved the study of attitudes in teaching and teacher education out of the limelight. The growing interest in cognition drew interest towards research on beliefs (Brousseau & Freeman, 1988; Brousseau, Book, & Byers, 1988; Eisenhart, Shrum, Harding, & Cuthbert, 1988; Hollingsworth, 1989; Nespor, 1987).

Beliefs

Beliefs are described as "propositions that are held to be true and are accepted as guides for assessing the future, are cited in support of decisions, or are referred to in passing judgment on the behavior of others" (Goodenough, 1963, as cited by Richardson, 1996, p. 104). Richardson (1996) made a distinction between belief, which is a psychological concept, and knowledge, which is a construct that implies epistemic warrant. Rokeach (1968) as cited by Richardson (1996) defined beliefs as "heuristic propositions that may begin with the phrase, 'I believe that ..." (p. 104). Rokeach (1968) also postulated that some beliefs are more central than others, and that central beliefs are more difficult to change.

One of the first large-scale studies of teachers' beliefs was conducted by Bussis, Chittenden, and Amarel (1976) who examined teachers' personal constructs of the curriculum and children. They suggested that these personal constructs result from an individual's interpretation of the world and they are "fore-runners" of action. They concluded that significant teacher change can only occur, if teachers are engaged in personal exploration, experimentation, and reflection.

Pomeroy (1993) compared the beliefs of scientists, secondary science teachers, and elementary school teachers, regarding the nature of science using a 50-item survey instrument consisting of statements about the nature of science held by Bacon, Kuhn, and various philosophers of science. She found that the respondents' mean score in the traditional belief cluster was rated as neutral. Taking the average score on a per group basis, the scientists held stronger logico-empiricist and logico-positivistic beliefs about the nature of science, with the elementary teachers least expressing their preference to the traditional view of the nature of science. Pomeroy (1993) suggested that this could be explained by the scientists' and secondary science teachers' stance that they are "gate-keepers" of scientific knowledge. The elementary teachers who were surveyed took the creative and intuitive view of the nature of science.

Haney, Czerniak, and Lumpe (1996) reported that teacher beliefs were a strong predictor of their intentions to implement reform-based strategies. Using a quantitative approach, they determined that the following four beliefs were most salient to teacher's intention to initiate inquiry:

- increase student enjoyment and interest in science,
- foster positive scientific attitudes and habits of mind,
- help students learn to think independently, and
- make science relevant to the students' everyday lives.

Relationship between Beliefs and Actions

Lee Shulman's classic article (1987) on teaching reform emphasized comprehension and reasoning, and transformation and reflection. He cited Fenstermacher's framework suggesting to educating "teachers to reason soundly about their teaching, as well as to perform skillfully" (p. 2). For Schulman (1987), teacher education must work with the beliefs that guide teacher actions, and with the principles and evidence that underlie the choices teachers make.

Richardson (1996) insisted that there is an interactive relationship between beliefs and actions. Beliefs are thought to drive actions; and, at the same time, experiences and reflection on action may lead to changes in and/or additions to beliefs. Pajares (1992) asserted that beliefs are "the best indicators of the decisions that individuals make throughout their lives" (p. 328).

Raymund and Santos (1995), cited Clark and Peterson's (1986) work on teachers' thought processes, where they noted the importance of understanding teachers' and pre-service teachers' implicit theories and beliefs about education, as these beliefs have an impact on classroom teaching. Nespor (1987), whose seminal work established beliefs as a theoretical construct, asserted that teachers rely on their core belief systems rather than on academic knowledge, when determining classroom actions. In addition, beliefs play a major role in teacher decision-making about curriculum and instructional tasks.

Calderhead (1996) reported that over the past two decades, research on teachers' knowledge and beliefs has progressed through three distinct stages. Initially, studies focused on teachers' decision-making. During the second phase, research was diversified to include teachers' thinking, perceptions, attributions, judgments, reflections, evaluations, and routines. The third phase of research focused on investigating the knowledge and beliefs that lay behind the practice of teaching.

There is a complex interaction between teacher beliefs, which are mental, and teacher actions, which take place in the social arena. Wallace and King (2004) view teacher actions as "representing one aspect of a teacher's beliefs and, thus, should not be perceived as separate entity from the belief system as a whole" (p. 957).

They further added that what a teacher does in the classroom is representative of his/her belief system.

Studying classroom practice, Clandinin (1986) also observed that teachers' experiences lead to the formation of images that are a part of personal practical knowledge – elements of classroom practices, such as, routines and rhythms. It has been furthermore documented that students come to teacher education programs with strong theories of teaching acquired during many years of being a student (Brookhart & Freeman, 1992). Calderhead and Robson (1991) provided evidence indicating how these theories influence the way students approach teacher education and what they learn from it.

Doing research on teacher actions, as well as their cognitively perceived beliefs, helps to understand the complexities of a belief system, as it is played out in context (Richardson, 1996). Using qualitative and quantitative analysis, the relationship between teacher beliefs, teaching practices, and gender-based student-teacher relationship was documented in a seventh-grade Biology class in Taiwan. The researcher confirmed that teacher's instructional practice reflects his/her beliefs (She, 2000). Villena (2004) also documented the beliefs and practices of elementary teachers of high- and low- performing schools in Metro Manila (Philippines). She centered on the goals of mathematics education and the nature of mathematics learning and of mathematics teaching. The study recommended that in-service training be conducted that would deliberately include opportunities for teachers to reflect on their beliefs and practices, as some teachers are not fully aware of the tradition they adhere to when teaching.

Methodology

Profile of Respondents

During the summer of 2006, the Department of Education (DepED) partnered with Department of Science and Technology (DOST) and De La Salle University, Manila (DLSU) to deliver the first of two phases of the Diploma Program in Science / Mathematics. The diploma program aimed to improve the capability of teachers who are non-majors in science by equipping them with knowledge of content, strategies in teaching, and tools for assessing learning.

The high school teachers who underwent the Diploma Program in Physics have been teaching Physics and / or will be teaching Physics even if their college preparation was not in Physics teaching. About half of the forty-one respondents (48%) had a background in secondary education with a major in Mathematics. The background of twenty-one percent (21%) of the respondents was in General Science. The rest of the group had a secondary education degree with a major in one of the following subject areas: Agricultural Education, Agronomy, Applied Electronics, Chemistry, Food Technology, Industrial Arts, Political Science, and Zoology.

The 2000 Philippine Commission on Educational Reform noted that there is a serious shortage of teachers trained in mathematics and the sciences, particularly Physics and Chemistry. Many of the high school science and math courses are handled by teachers without the necessary background. Table 1 provides evidence indicating that the percentage of teachers with a relevant background in subjects taught is low for the sciences, with only 40% of General Science teachers having a background in General Science, 41% for Biology teachers, 21% for Chemistry teachers, and 18% for Physics teachers. These figures are an improvement from the percentages cited by the 1991 report of the Philippine Congressional Commission on Education, where it was given that at the secondary level, the percentage of qualified science teachers were 34%, 30.5%, 15.4%, and 4.4% for General Science, Biology, Chemistry, and Physics, respectively.

Table 1

Percentage of Secondary Teachers with a Relevant Background in the Subject Taught

Subject Area	Academic Year 1991-1992	Academic Year 2000-2001
General Science	34.0%	40.0%
Biology	30.5%	41.0%
Chemistry	15.4%	21.0%
Physics	4.4%	18.0%

Collection of Data

The high school teachers undergoing the diploma program were administered the Colorado Learning Attitudes about Science Survey (CLASS) questionnaire during their second week into the diploma program. The teachers were from the Southern Luzon region comprising the provinces of Mindoro, Marinduque, Romblon, and Palawan. The Colorado Learning Attitudes about Science Survey [CLASS] (Adams, Perkins, Dubson, Finkelstein, & Weiman, 2006) built on work done by existing surveys. Three well-known surveys for probing student beliefs about the physical sciences are the Maryland Physics Expectations Survey (Redish, Saul, & Steinberg, 1998), the Views about Science Survey (Halloun & Hestenes, 1985), and the Epistemological Beliefs Assessment about Physical Science (Elby, 2001). CLASS was developed to make the statements as clear and concise as possible. The survey probes students' beliefs about physics and learning physics, and distinguishes the beliefs of experts from those of novices. Perkins, Adams, Pollock, Finkelstein, and Weiman (2004) examined the relationship between students' beliefs about physics and other educational outcomes, such as, conceptual learning and retention, for over 750 students in a variety of courses. The researchers identified a positive correlation between student's beliefs, measured using the Colorado Learning Attitudes about Science Survey (CLASS), and normalized conceptual learning gains, measured using two standardized conceptual inventory tests, that is, the Force Concepts Inventory (Hestenes, Wells, & Swackhamer, 1992) and the Force and Motion Conceptual Exam (Hestenes & Wells, 1992). Their analysis suggested that college-level students who come into a Physics course with more favorable beliefs are more likely to achieve higher learning gains. The data generated by the research group is consistent with the idea that beliefs are a factor influencing student learning.

Participants taking the CLASS inventory are asked to respond on a five-point Likert (agree-disagree) scale to 42 statements, such as the following:

"Learning physics changes my ideas of how the world works" (Item 28).

"If I get stuck on a physics problem on my first try, I usually try to figure out a

different way that works" (Item 15).

"Reasoning skills used to understand physics can be helpful to me in my everyday life" (Item 30).

Scoring of the Colorado Learning Attitudes about Science Survey is calculated by determining the percentage of responses for which a respondent agrees with the experts' view (tagged as "percent favorable"). The average "percent unfavorable" is also determined by taking the number of responses for which the respondent disagrees with the experts' view. The survey is scored "overall" and for the following eight categories: (a) Real World Connection, (b) Personal Interest, (c) Sense Making / Effort, (d) Conceptual Connections, (e) Applied Conceptual Understanding, (f) Problem Solving [General], (g) Problem Solving [Confidence], and (h) Problem Solving [Sophistication]. Each category consists of four to eight statements that characterize a specific aspect of thinking. Together, these categories include 27 of the 42 statements. The overall score includes these 27 statements, plus an additional nine statements, all thirty-six of which passed the validity and reliability tests conducted by the University of Colorado Physics Education Research Group (Adams, *et al.*, 2004). In the current version of the survey (version 3, available through http://CLASS.colorado.edu), six statements do not yet have an "expert" response and are not included in the analysis.

Results

The average age of the participants in the Diploma Program in Physics was 39.4 years. The youngest participant was a 23-year old male teacher; the oldest was a 58-year old female teacher. About half of the of the participants (45%) fall in the 40-49 years age range, with the number of participants in the 30-39 years age range coming in a close second (38%). The participants coming from the 20-29 years age group and from the 50-59 years age group composed 10% and 7% of the total sampler, respectively.

Over-all CLASS Results

Table 2 presents the summary of the number of favorable and unfavorable responses given for each of the categories of the Colorado Learning Attitudes about Science Survey (CLASS). The over-all profile of the 41 teachers surveyed reveals that the respondents gave a favorable response (agreement with the experts' response) in an average of 63.9% of the 36 CLASS statements. An unfavorable response was reflected in 18.5% of the statements, with the remaining 17.5% being rated as neutral (neither in agreement with nor in disagreement with the experts' response).

This over-all percent favorable profile is slightly higher than the over-all percent favorable profile for non-science majors taking up their first college Physics course. Adams, Perkins, Dubson, Finkelstein, and Weiman (2004) reported that during the fall of 2003, the seventy-six non-science students from an American state research university, who were surveyed, posted a 57% favorable profile. During the spring of 2004, the same research group surveyed 398 engineering majors taking up their first college-level Physics course. A 68% favorable (over-all) profile was reported for this specific group. A more recent survey conducted by the Physics

Table 2
Percentage Agreement (Disagreement) with Experts' Response in the Clusters of the Colorado Learning Attitudes about Science Survey (CLASS)

	Favorable Response (% agreement)	Unfavorable Response (% disagreement)
Personal Interest	81.2 %	6.1%
Real World Connection	80.5 %	11.5 %
Problem Solving (General)	66.7 %	12.9 %
Problem Solving (Confidence)	61.6%	14.6 %
Problem Solving (Sophistication)	44.3 %	25.6 %
Sense Making / Effort	78.3 %	9.1 %
Conceptual Connections	60.6 %	23.0 %
Applied Conceptual Understanding	42.3 %	35.3 %
OVER-ALL	63.9 %	18.5 %

Education Research Group at the University of Colorado (Adams et al., 2006) on 397 students, taking up a calculus-based Physics 1 course in a large state research university, indicated a 65% favorable (over-all) profile.

Personal Interest Category

This category probes whether the respondents exhibit a personal interest in or connection to the study of Physics. The teachers surveyed in the study posted the highest average percentage favorable (81%) in this category, as indicated in Table 2. This is higher than the 74% reported by Adams et al. (2004) for the Physics majors (N = 38) enrolled in a calculus-based Physics 1 course. The high school teachers reported that they "think about the Physics (they) experience in everyday life" [CLASS item # 3] and that they "study Physics to learn knowledge that will be useful in (their) life outside of school" [CLASS item # 14].

Real World Connections Category

In the real-world connections category, respondents are asked whether they think about their personal experiences and relate them to the topic being analyzed [CLASS item # 37]. The 87% favorable response for CLASS item # 28 (Learning Physics changes my ideas how the world works), and the 90% agreement with experts for CLASS item # 30 (Reasoning skills used to understand Physics can be helpful to me in my everyday life) reveal that the teachers surveyed believed that the ideas learned in a Physics class are relevant and useful in a wide variety of real contexts.

The results obtained in the present study (80.5% agreement with experts) are slightly higher than the percentage favorable responses (average of 74% agreement with experts) reported by Adams et al. (2004) for the calculus-based Physics 1 class, and the results of the most recent survey conducted by the Physics Education Research Group at the University of Colorado (Adams et al., 2006), where a 72% favorable response was noted for the real-world connections category.

Problem Solving Cluster

The Problem Solving cluster looks at three inter-related categories. The respondents are asked to state whether they enjoy solving Physics problems [CLASS item # 25] and whether they can usually figure out a way to solve Physics problems [CLASS item # 34].

The teachers surveyed in the present study reported a moderate percentage favorable (agreement with experts) in the three categories that dealt with attitudes and beliefs about problem solving in Physics, as indicated in Table 2. The group's level of sophistication when approaching problem solving in Physics is an area that can be improved further. Forty percent of the respondents reported that if they do not remember a particular equation needed to solve a problem on an exam, there is nothing else that they can do to attempt to solve the problem [CLASS item # 21].

Two items are common to the three inter-related categories. In both items, the group of teachers surveyed in the study reported a low percentage favorable response. Only 34% of the respondents reported that they can usually figure out a way to solve Physics problems [CLASS item # 34]. The majority of the respondents (56%) reported that if they get stuck on a Physics problem, there is no chance they will figure it out, which is contrary to the experts' view.

The average rating for each of the Problem Solving cluster (Problem Solving (General), 66.7% favorable response; Problem Solving (Confidence), 61.6% favorable response; and Problem Solving (Sophistication), 44.3% favorable response) reported for this study approximates the same trend noted by the Physics Education Research Group at the University of Colorado (Adams et al., 2006) for their students (N = 397) taking up a calculus-based Physics 1 course: Problem Solving (General), 58% favorable response; Problem Solving (Confidence), 58% favorable response; and Problem Solving (Sophistication), 46% favorable response.

Sense Making / Effort Sub-score

This category probes whether the learner makes the effort to use available information and make sense out of the information in learning Physics. Adams et al. (2004) reported an average of 77% favorable response on this particular category for the calculus-based Physics class. The Physics Education Research Group at the University of Colorado (Adams et al., 2006) reported a 73% favorable response for students who took a reform-oriented Physics course. In the present study, the high school teachers who were surveyed posted an average of 78.3% favorable response (agreement with experts) for the seven questions included in the category.

The respondents reported that "it is important (for them) to make sense out of formulas, before they can be used carefully" [CLASS item # 24, 78% favorable response], while they "explicitly think about which Physics ideas apply to a problem" [CLASS item # 39, 73% favorable response].

Conceptual Connections and Applied Conceptual Understanding Sub-score

Life-long learners of Physics strongly feel that students should conceptualize Physics as a coherent and consistent structure (Redish, Saul, & Steinberg, 1998). Students who emphasize science as a collection of facts fail to conceptualize the integrity and coherence of the whole structure of Physics.

The two categories discussed in this section probe how deeply students conceptualize Physics as being coherent and about drawing connections between the different ideas learned.

The conceptual connections profile of the high school teachers surveyed show a 60.6% agreement with experts. The applied conceptual understanding profile revealed a 42.3% agreement with the experts' response. Although 80% of the respondents gave an expert-like response to CLASS item # 42 (When studying Physics, I relate the important information to what I already know, rather than just memorizing it the way it is presented), 40% of the respondents reported that even "after I study a topic in Physics and feel that I understand it, I have difficulty solving problems on the same topic" [CLASS item # 5].

One-third of the total number of respondents reported that "a significant problem in learning Physics is being able to memorize all the information I need to know" [CLASS item # 1]. This reveals that a good number of the high school teachers still focus on memory work while doing Physics. A similar trend in the percentage favorable responses was found in the work done by the Physics Education Research Group at the University of Colorado (Adams et al., 2006). Students enrolled in a calculus-based Physics 1 course reported a 63% agreement with experts in the conceptual connections category, and a 53% agreement with experts for the applied conceptual understanding category.

Relationship between the Different Clusters of CLASS

The study also investigated the relationship between the beliefs held by the teachers in the different clusters of the Colorado Learning Attitudes about Science Survey (CLASS). As expected, the responses in the Problem Solving clusters – Problem Solving (General), Problem Solving (Confidence), and Problem Solving (Sophistication) – were highly and significantly correlated with each other, as indicated in Table 3.

The respondents gave a consistent response that supports their agreement (or disagreement) with the experts' response. The responses in the Conceptual Connections and Applied Conceptual Understanding clusters were highly and significantly correlated with each other ($r = 0.81$).

It is interesting to point out that the Conceptual Connections profile and Applied Conceptual Understanding profile were highly positively and significantly correlated, with the Problem Solving (Sophistication) cluster, r = 0.69 and 0.80, respectively. It seems that a respondent's level of sophistication when approaching problem solving in Physics is dependent on the level of appreciation and understanding of the various Physics concepts.

The moderate correlation between the Personal Interest cluster and with the Real World Connection ($r = 0.59$), the Problem Solving (General) ($r = 0.57$), the Problem Solving (Confidence) ($r = 0.39$), the Problem Solving (Sophistication), $r = 0.42$, and the Sense Making / Effort, $r = 0.38$, reveal that a respondent's interest in Physics is facilitated by these clusters.

Table 3
Correlation Coefficients for the CLASS Clusters and the GPA

	1	2	3	4	5	6	7	8	9
Personal Interest (1)	1.00								
Real World Connection (2)	0.59	1.00							
Problem Solving General (3)	0.57	0.36	1.00						
Problem Solving Confidence (4)	0.39	0.29	0.81	1.00					
Problem Solving Sophistication (5)	0.42	0.34	0.69	0.66	1.00				
Sense-Making / Effort (6)	0.38	0.29	0.48	0.39	0.09	1.00			
Conceptual Connections (7)	0.12	0.24	0.26	0.24	0.69	0.11	1.00		
Applied Conceptual Understanding (8)	0.13	0.21	0.21	0.38	0.80	0.08	0.81	1.00	
OVERALL (9)	0.68	0.52	0.80	0.64	0.63	0.65	0.56	0.43	1.00
Grade Point Average (10)	0.01	0.04	0.33	0.36	0.39	0.08	0.35	0.34	0.33

Relationship between the Different Clusters of CLASS and Students' GPA

The results of Perkins et al.'s (2004) study suggested that students who come into a Physics course with more favorable beliefs are more likely to achieve higher learning gains. This hypothesis for the high school teachers who participated in this study was also tested. A comparison was made between the beliefs profile of the participants obtaining the highest 25% Grade Point Average and the beliefs profile of the participants in the lower 25% Grade Point Average. The results in Table 4 reveal a statistically significant difference in the beliefs / responses of the top 25% and the bottom 25% of the class in three clusters. The participants who obtained higher Grade Point Averages reported a more expert-like thinking in the clusters of Problem Solving (General), Conceptual Connections, and Applied Conceptual Understanding.

Table 4.
Top 25% G.P.A. vs Lower 25% G.P.A.: Percentage Agreement with Experts' Response in the Clusters of the CLASS

Category	Percentage of students in Upper 25% Reporting Favorable Response	Percentage of students in Lower 25% Reporting Favorable Response
Personal Interest	78.3 %	81.7%
Real World Connection	80.0 %	77.5 %
Problem Solving (General) *	73.8 %	56.3 %
Problem Solving (Confidence)	65.0 %	50.0 %
Problem Solving (Sophistication)	45.0 %	33.3 %
Sense Making / Effort	77.1 %	74.3 %
Conceptual Connections *	68.3 %	48.3 %
Applied Conceptual Understanding *	45.7 %	30.0 %

* Statistically significant difference at .05 level of confidence

Synthesis

The high school teachers who participated in the six-week intensive program in Physics posted high agreement with experts' beliefs in the clusters of CLASS relating to personal interest [81.2%], real world connections [80.5%], and sense-making / effort [78.3%]. A moderate agreement with experts' responses was reported for the problem solving (general) [66.7%], problem solving (confidence) [61.6%], and conceptual connections [60.6%] clusters. The teachers' beliefs in the problem solving (sophistication) [44.3% favorable responses] and applied conceptual understanding [42.3% favorable responses] may be classified as novice-like thinking.

The responses in the Problem Solving clusters – Problem Solving (General), Problem Solving (Confidence), and Problem Solving (Sophistication) – were positively and significantly correlated with each other [r ranged from 0.66 to 0.81]. In a similar manner, the responses in the Conceptual Connections and Applied Conceptual Understanding clusters were also were positively and significantly correlated with each other [$r = 0.812$].

It was also noted that the Conceptual Connections profile and Applied Conceptual Understanding profile were positively and significantly correlated with the Problem Solving (Sophistication) cluster, $r = 0.69$ and 0.80, respectively. It seems that a respondent's level of sophistication when approaching problem solving in Physics is dependent on the level of appreciation and understanding of the various Physics concepts.

The moderate correlation between the Personal Interest cluster and with Real World Connection, $r = 0.59$, Problem Solving (General), $r = 0.57$, Problem Solving (Confidence), $r = 0.39$, Problem Solving (Sophistication), $r = 0.42$, and Sense Making / Effort, $r = 0.38$, reveal that a learner's interest in Physics is facilitated by these specific clusters of CLASS.

Analysis of the beliefs profile of the participants obtaining the highest Grade Point Average and the beliefs profile of the participants who obtained lower Grade Point Average revealed a significant difference in the beliefs profile of the two groups. Participants who obtained higher Grade Point Averages reported a more expert-like thinking in the Problem Solving (General), Conceptual Connections, and Applied Conceptual Understanding clusters.

The findings of this study suggest that the participants who approach learning Physics with a more favorable belief structure are more likely to achieve higher learning gains. The results of the correlation analysis reveal that providing opportunities that link concepts learned with real-world experiences could strengthen appreciation of Physics. A follow-up study should be also conducted that may document the extent to which the participants of the study modified their classroom practices. It would be interesting to relate their attitudes and beliefs to the teaching-learning atmosphere that is present in their classrooms.

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