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ABSTRACT

The status and future direction of high school physics instruction is considered in this report. The text is supported by many tables and illustrations and is organized into six chapters. Chapters discuss physics enrollments and curriculum; demographics of the physics teacher population; current teaching conditions, resources, and activities; high school physics in the larger social context; and the outlook for the future in physics teaching. (Contains 19 references.) (DDR)

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HIGH SCHOOL PHYSICS FOR A NEW MILLENNIUM

By Michael Neuschatz and Mark McFarling

AMERICAN INSTITUTE OF PHYSICS

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Maintaining Momentum: High School Physics for a New Millennium

by Michael Neuschatz and Mark McFarling

College Park, Maryland

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The findings in this report are the fruit of a collaborative effort of many individuals and organizations. Special thanks are due to the American Association of Physics Teachers and to the education administrators and school principals whose schools took part in the survey. As always, our deepest gratitude is to the physics teacher participants, whose generosity with their time and willingness to express their experiences and feelings make this study possible.

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HIGHLIGHTS

- The proportion of U.S. students who take a physics course in high school reached 28% in 1997, a post-World War II high (**Figure 1**). This translates to around 800,000 high school students taking physics each year, taught by 19,000 teachers.

- Along with the rise in enrollments, the high school physics curriculum has grown more varied, moving away from the "one-size-fits-all" course that predominated a decade ago, to encompass courses designed to accommodate students with varying mathematics backgrounds and academic aspirations. In 1997, roughly a fifth of all physics students were taught using a mathematically less intensive "conceptual" approach, while a similar fraction took an accelerated introductory course (**Figure 2**).

- An important component of this growth has been the rising participation of girls. Traditionally underrepresented, the proportion of female students taking physics is now approaching parity with male enrollments (**Figure 9**), repeating the process that occurred with high school chemistry a decade earlier. However, girls continue to be notably underrepresented in Advanced Placement physics, and women continue to comprise only one-fourth of high school physics teachers.

- The enrollment increase of the past decade has been spread relatively evenly across ethnic and racial boundaries (**Figure 10**). While this means that underrepresented minorities have not fallen further behind, it also implies that their pattern of lower exposure to high school physics remains well-entrenched. Representation of non-white teachers remains negligible.

- Another important correlate of enrollment disparities is social class. In each district or metropolitan area, schools which cater to what teachers describe as the most economically-favored students tend to have substantially higher physics enrollments, and are far more likely to offer advanced physics courses, than poorer schools from the same area (**Figures 11 & 13**).

HIGHLIGHTS (cont.)

- The last four years saw an increase in physics teacher retirements, and a concomitant jump in the recruitment of new teachers, but this influx has not led to a dilution in qualifications. Contrary to widely-circulating reports, the preparation of high school physics teachers seems to be generally, albeit slowly, improving, and cases of instructors with no physics background are rare. A third have degrees in physics or physics education, and if those with physics minors are included, the proportion approaches one-half (**Figure 3**). Virtually all the rest have a degree in mathematics or another science, or in math or science education. In the past, we have found that more than 80% had taken three or more college physics courses.

- Rising enrollment has made it easier for teachers to specialize in physics, although this is still far from the norm (**Figures 4 & 5**). Only 3% have taught physics exclusively throughout their career. More than half experienced one or more years where they were not given any physics classes to teach. And, in the current year's assignment, only 37% taught physics more than any other subject (**Figure 6**). The most common other area taught by physics teachers was chemistry, followed by math and physical science.

- Social class is also a determining factor in whether a teacher will be able to specialize in physics. Teachers in the wealthiest schools were more than twice as likely as those in the poorest schools to have specialized in physics over their careers (**Figure 14**) and were nearly six times as likely to be teaching physics exclusively during the current year (**Figure 15**).

- When asked about the obstacles that prevent them from being more effective teachers, physics instructors have consistently pointed to inadequate funding for laboratories, including facilities, equipment, and supplies (**Table 3**). Lending credence to their complaints, their median funding of $275 per physics class for equipment and supplies stands about 10% lower than it did a decade ago, even ignoring the effects of inflation. Many teachers also complained that their training in the use of computers for both labs and classroom instruction was inadequate (**Table 4**).

HIGHLIGHTS (cont.)

- Despite the widely-acknowledged importance of in-service professional development activities, only half of all physics teachers took part in even one daylong physics workshop, meeting, or course during the year prior to the survey (**Table 5**). This might explain why a third of teachers indicated that they were not adequately prepared to teach recent developments in physics (**Table 4**). However, attendance among the one-fourth of teachers who were members of the American Association of Physics Teachers (AAPT) was almost twice as high as among non-members. In general, AAPT members displayed significantly higher awareness and use of new course designs and instructional technology in their physics teaching.

- Salary levels for both starting and continuing teachers continues to rise at a rate slightly faster than inflation (**Figure 8**), although both are still substantially below pay levels for physics bachelor's and master's degree holders outside of teaching, as measured in AIP's surveys of new physics graduates and physics society members.

- Satisfaction levels among high school physics teachers remain high, with 82% asserting that they would follow the same path if they had it to do over again. The most commonly cited source of teacher satisfaction was interaction with students and the sense of gratification that came from helping them learn and grow. At the same time, many teachers, especially those in the poorest schools, continue to complain about the poor math background of students entering their classrooms (**Table 13**).

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I. INTRODUCTION

The system of public education in the United States — its governance fractured into dozens of states and thousands of local districts — is very difficult to change in a coordinated way. It requires considerable time and many different efforts to generate movement in a concerted direction. But by the same token, once movement begins, the system develops a good deal of momentum and can move steadily, albeit often slowly, towards its destination. In the past decade-and-a-half, our education system has been subject to an extraordinary number of initiatives aimed at improving the level of students' understanding of science by the time they graduate high school. Adding up the results, at least in physics, we now have clear evidence of steady progress, although there is still plainly a long way still to go.

Support for this view emerges from data compiled as part of a decade-long longitudinal study of high school physics conducted by the Education and Employment Statistics Division of the American Institute of Physics. Four times over the past decade, the principals at a representative sample of over 3,000 public and private high schools across the country have been contacted and asked to provide the names of all teachers with physics classes at their school. With virtually total cooperation each time, we have obtained the names of the roughly 3,500 physics teachers at these schools.

Teachers were then sent a detailed survey covering their backgrounds, experiences teaching physics, views on the challenges they face, and plans for the future. Response rates have consistently been around 75%, with about 10% answering a shorter version of the questionnaire this year. In 1997, incentives were used for the first time on a subset of respondents, as part of a study on the efficacy of incentives funded by the National Science Foundation. Details of that effort can be found in **Appendix B**.

The findings from the teacher survey show clearly the gains that have been made in high school physics, along with the places where there is still little to show for all the effort. **Section II** below will outline the broad picture of enrollment trends, adding descriptions of specific courses and the textbooks used. **Section III** will look at the teaching staff, focusing on their educational backgrounds and qualifications, as well as on their years of teaching experience and areas of specialization. **Section IV** examines the teachers' current assignments and circumstances, and the professional resources at their disposal. The section goes on to examine their reaction to their teaching environment, including their sense of confidence as physics teachers and their view of the major problems they face. The section also looks at recent efforts to introduce new educational resources and instructional practices, the level of teacher involvement in professional organizations, their efforts to maintain and improve professional skills, and their career satisfaction and plans for the future. **Section V** will look at the issue of the underrepresentation of women and minorities in physics, and will also consider differences in the physics enrollments and curriculum among schools populated by students of different social classes. Finally, **Section VI** will offer a summary assessment of recent reform efforts, pointing both to the successes and to the places where little progress has been realized.

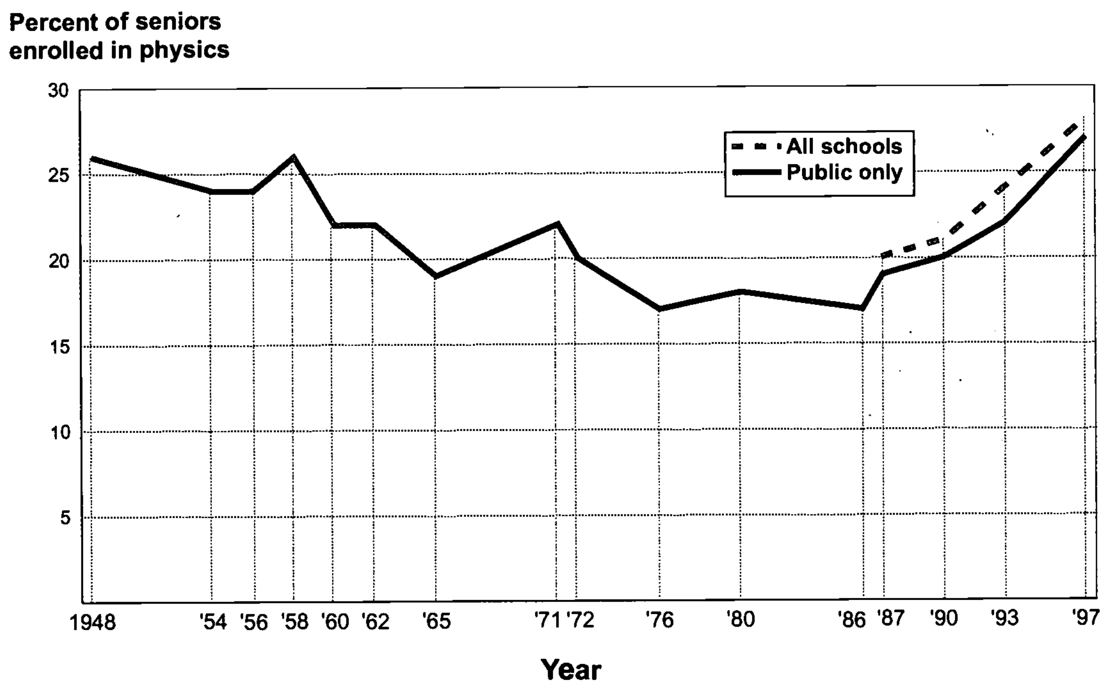
II. PHYSICS ENROLLMENTS AND CURRICULUM

As noted in earlier reports in this series, the years following the release of the Carnegie Commission report, *A Nation at Risk,* in 1983 saw a flurry of education initiatives that were expected to lead to a rapid rise in the proportion of high school students completing the basic science and mathematics sequences by graduation time. Over the following few years, virtually every state raised its high school graduation requirements in science and math. In 1989, a special conference of the nation's Governors resolved that, despite mediocre showings in global comparisons, U.S. students would become first in the world in science and mathematics by the year 2000. This exact language was later incorporated into federal legislation passed by the U.S. Congress and adopted as an official goal by the Department of Education.

Not unexpectedly, the actual gains in student achievement proved to be somewhat more elusive than the policy declarations. The first survey, conducted in 1987, showed physics enrollments at 20%, near the postwar lows of the early 1980's with only a slight increase to 21% by 1990 (see **Figure 1**). But the two most recent studies give evidence of a sustained upturn, bringing the enrollment percentage up to 28%, the highest point in the post-World War II period. While there is no simple way to tie the enrollment increases directly to the policy initiatives, nor to ascertain which of the many reform efforts might have been the most effective, it is reasonable to conclude that the programs taken across a broad front of educational institutions may finally be showing results.

One thing that is clear is that the gains are not simply the result of physics being made more widely available. As has been shown in earlier reports in this series, physics has long been part of the curriculum in virtually all high schools, public and private, across the nation. The only

Figure 1. Physics enrollment in U.S. high schools, 1948-1997



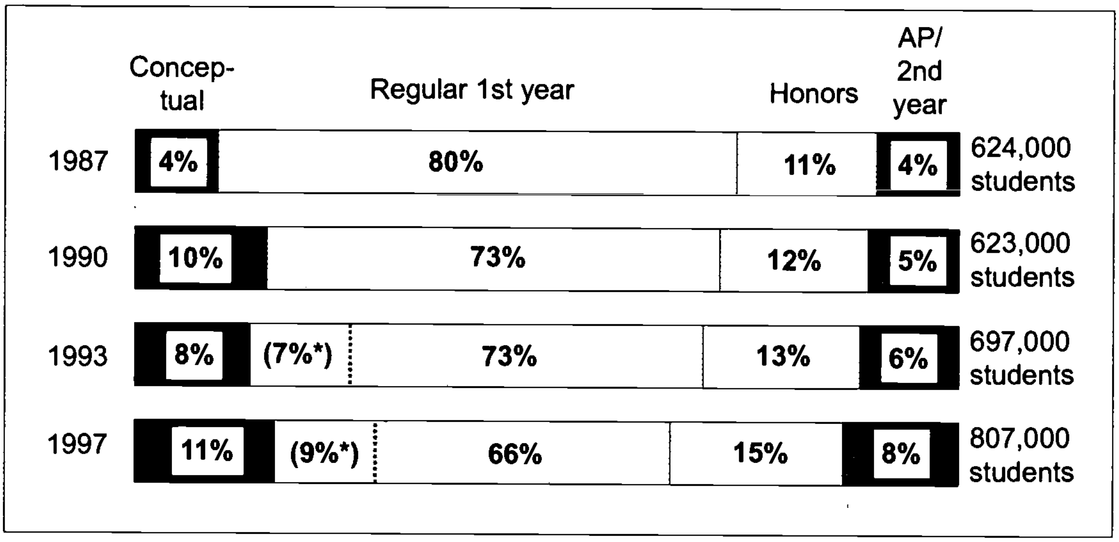
Sources: 1986-87, 1989-90, 1992-93 & 1996-97 AIP High School Physics Teacher Surveys; AIP (1964); Pallrand et al. (1985); Dept. of Educ., Nat'l Center for Educ. Statistics (Various years)

exceptions are small private schools, especially fundamentalist religious academies, and a few small, rural public schools. It was thus not availability, but rather the manner in which physics was traditionally taught — as an advanced elective for college-bound seniors especially those who were science-oriented — that limited its accessibility for many students.

However, as **Figure 2** shows, the high school physics curriculum has grown steadily more varied in the past decade, although the traditional introductory course, which assumes that students have a working knowledge of algebra and often basic trigonometry, still accounts for two-thirds of all enrollments. Over the past decade, the fastest growing alternative has been what is widely referred to as the conceptual approach, which uses little algebra or trigonometry, but rather tries to explain basic physics concepts in non-mathematical terms. While much of the growth has been explicit, in clearly-designated courses, some of the increase has also involved the incorporation of materials using the conceptual approach into courses still labeled as traditional introductory physics.

On the other end of the scale, there has also been modest growth in "honors physics," which uses algebra and trigonometry but proceeds at a more accelerated pace and tries to present material in greater depth and breadth than the regular first-year course typically does. Finally, over the past ten years, there has

Figure 2. High school physics courses: enrollment distribution



* Percent of students in regular first-year physics courses that use conceptual physics textbooks.

Sources: 1986-87, 1989-90, 1992-93 & 1996-97 AIP High School Physics Teacher Surveys

been a doubling of enrollments in Advanced Placement (AP) physics, of both the algebra and trigonometry-based (AP-B) and the calculus-based (AP-C) variety. While not all of the students enrolled in AP physics actually sit for the placement exam at the end of the year (the fraction is generally around two-thirds), a high proportion of those who do so, especially students taking the calculus-based course, typically score well enough to earn college credit in the subject.

Table 1 presents a decade's worth of data on the physics textbooks most commonly used in these courses, along with the collective evaluation of physics teachers for each text used. The most graphic changes have been the emergence of the Merrill/Glencoe book, *Physics: Principles and Problems*, as the dominant text for introductory physics, and the parallel decline of the Holt, Rinehart and Winston book, *Modern Physics*, over the same period. (Indeed, the latter book has since gone out of print, and Holt has introduced a new high school physics text.) Other notable findings include the continued dominance of *Conceptual Physics* by Paul Hewitt in physics courses aimed primarily at non-science students (and its growing use in regular introductory classes, as well), and the popularity and high ratings of the current edition of the classic Halliday and Resnick text for calculus-based AP physics after some three decades of use.

Table 1. Most widely used textbooks

	Percent of teachers using this text in: '97	'93	'90	'87	Percent rating text high in quality**
Regular first year physics	%	%	%	%	%
1. *Physics: Principles & Problems* (publ. Merrill/Glencoe)	53	44	42	33	57
2. *Modern Physics* (publ. Holt, Rinehart & Winston)	20	23	32	36	56
3. *Conceptual Physics* (Hewitt)	15	9	*	*	64
Physics for non-science students					
1. *Conceptual Physics* (Hewitt)	84	79	75	27	80
2. *Physics: Principles & Problems* (publ. Merrill/Glencoe)	7	8	7	28	33
Honors physics					
1. *Physics: Principles & Problems* (publ. Merrill Glencoe)	25	18	*	*	48
2. *Physics* (Giancoli)	19	14	10	7	68
3. *Modern Physics* (publ. Holt, Rinehart & Winston)	15	20	27	28	51
Advanced Placement B					
1. *Physics* (Giancoli)	27	28	—	—	78
2. *College Physics* (Serway & Faughn)	24	10	—	—	79
3. *Physics* (Cutnell & Johnson)	9	—	—	—	81
Advanced Placement C					
1. *Fundamentals of Physics* (Halliday, Resnick & Walker)	41	39	—	—	89
2. *University Physics* (Sears et al.)	19	23	—	—	86
3. *College Physics* (Serway & Faughn)	7	—	—	—	78

Sources: 1986-87, 1989-90, 1992-93 & 1996-97 AIP High School Physics Teacher Surveys

— not separately rated

* less than 5%

** On a scale of 1 to 5, with 5 the highest quality rating, the percent rating a text as a 4 or 5.

III. WHO IS TEACHING PHYSICS?

This section looks at the characteristics of the slightly more than 19,000 teachers who were teaching physics classes at public and private high schools across the nation in the spring of 1997. The first part provides a brief demographic profile, the second part focuses on professional background, including years of teaching experience and current career stage, academic attainment and specialization, current teacher certification and credentials, and field of specialization.

Demographic Profile of High School Physics Teachers

In the past decade, there has been little improvement in the underrepresentation of women and minority groups among high school physics teachers. The proportion of women has inched up from 23% to 25%, while African-Americans, Hispanics, and Asian-Americans combined remain fixed at about 4%. Over the years there has been a great deal of concern over the underrepresentation of women and minority groups — other than Asian-Americans — among the ranks of high school physics teachers. Among other things, it was felt that the scarcity of role models discouraged students from these groups from specializing in the field, creating a vicious circle that perpetuated the underrepresentation.

However, the indications from the decade-long data series generated by the AIP surveys is that this lack of role modeling may not be as big an obstacle as is sometimes thought, at least as far as the participation of girls in physics is concerned. While the proportion of women teachers has remained relatively steady, the proportion of physics students who are female has climbed steadily over the past decade, and now stands at a level not too far from true gender balance. Putting aside role modeling, likely candidates to explain this rising presence of girls would include:

- widespread increases in high school graduation requirements in science;
- curricular reforms designed to increase physics enrollments;
- the numerous programs and initiatives aimed specifically at encouraging girls to pursue science; and
- last, but certainly not least, long-term social and cultural changes in the position of women in our society.

A more detailed discussion of the representation of women in high school physics, both as students and as teachers, appears in **Section V**.

When we turn to the representation of minority groups, however, the lack of role models cannot be so easily ruled out. Over the years that the study has been in existence, the fraction of African-American and Hispanic-American high school students taking physics has consistently been half that of white or Asian-American students. While there have been some gains recently, also documented in **Section V**, the participation of underrepresented minority students is still woefully low. Only among Asian-Americans are physics enrollments high, and the fact that these students take physics in large numbers despite the lack of Asian-American teachers suggests that other factors may carry far more weight than role modeling.

Another area of concern has centered around the aging of the corps of high school physics teachers. For many years, physics has been one of the areas of reported teacher shortage. In our own surveys over the years, around 40% of the principals looking to hire physics teachers reported having difficulty finding qualified candidates. In this environment, there had been concern that large-scale retirements could ignite a serious staffing crisis, especially at a time of rapidly rising enrollments.

However, data from the four AIP surveys suggest that these fears may have been somewhat overblown. While the median age of respondents has indeed been inching up, from 41 in 1987, to 44 in 1997, the age distribution still appears "healthy," with teachers under 35 outnumbering teachers over 55 by well over 2 to 1. Unfortunately, this age distribution pattern reflects one of those good news / bad news situations. On the one hand, it reflects the positive result of a constant influx of new teachers, but on the other hand it also shows the negative impact of high attrition rates among teachers in the first few years of their careers, as will be evident in the next section.

Professional Background

Despite the slight increase in median age, data from the survey on years of teaching experience, as shown in **Table 2**, actually reveal a noticeable decline in the high proportion found four years ago of teachers who were nearing the end of their career. This finding reflects a rise in the number of retirements of physics teachers during the interim. At the same time, the growth in the aggregate number of physics teachers nationwide (fueled in turn by the increase in student enrollments in physics), has spurred

Table 2. High school physics teachers' years of experience

	1992-93 %	1996-97 %
1 to 5 years	19	27
6 to 10 years	17	18
11 to 20 years	27	24
21+ years	37	31
	100%	100%

Sources: 1992-93 & 1996-97 AIP High School Physics Teacher Surveys an even larger jump in the number of newly-hired teachers.

While this change may trigger alarm over the loss of highly experienced teachers, the influx of new teachers may also be cause for some celebration. For one thing, the qualifications of new physics teachers seem to be improving over time. Thus, although the fraction of physics teachers in the first three years of their career who have a college degree in physics remains lower than many may wish, this percentage has steadily increased during the current decade, from 24% in 1990 to 29% in 1993 to 43% in 1997. This finding is corroborated by the results of AIP surveys of physics bachelor's degree recipients in the early and mid-1990s, which showed a rising — albeit still small — proportion of those going directly into the job market after graduation choosing high school teaching.

A related reason for optimism is that the fear expressed in previous reports that attrition seemed to be especially high among new teachers with physics degrees now appears to be unfounded. Although attrition among starting teachers remains disturbingly high (see **Section IV**), with the vantage point of a longer data series it is now clear that starting teachers with physics degrees are at least as likely to remain in physics teaching as teachers who hold degrees in other fields.

Two possible factors may account for these positive findings. First, it was argued in earlier reports that the improbability of being able to concentrate on teaching physics, a direct result of the historically low physics enrollments, was likely to discourage many new teachers from pursuing physics as their specialty. Now, with physics enrollments rising substantially, we find a small increase in the fraction of physics teachers (37% in 1997, compared to only 31% ten years earlier) reporting physics as their primary teaching assignment. The word about this greater chance to focus on physics may filter down and encourage more students with a major in physics to consider high school teaching as a career.

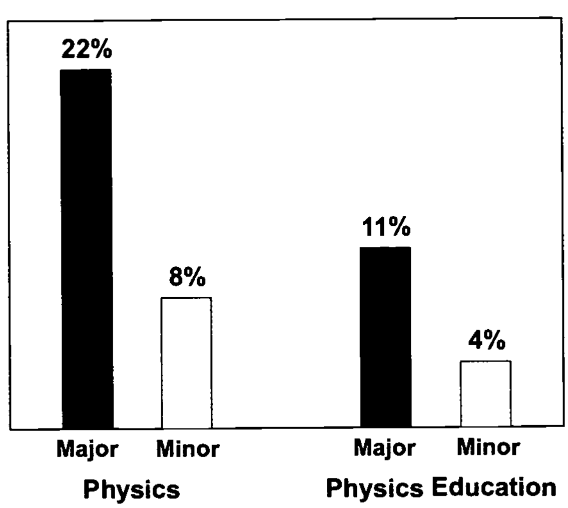
The significance of this is magnified when we appreciate the relative rarity with which those with undergraduate physics degrees get a chance to actually work specifically in the field they majored in (although many use skills they learned as physics majors). Thus, among students responding to the AIP Physics Bachelor's Recipients Survey, those who chose high school teaching were by far the most likely to describe themselves as continuing to work in physics.

The same enrollment gains that increase the chances for new teachers to specialize in physics are also likely to have an impact on teachers already well into their careers. We found that among those who had earned physics degrees, 58% taught primarily physics in 1997, compared to 48% in 1987. The greater likelihood of concentrating on physics may help to keep those with physics degrees on the job, and may actually push some of those without a strong background in physics away. The same circumstances may also motivate a few physics teachers who started teaching without a physics degree to acquire one in mid-career. Thus, of the responding teachers who began in the past decade without a physics degree and remained at their schools teaching physics, 8% had obtained one by the time of the 1997 survey.

The second potential explanation for why more physics degree holders are showing up among the ranks of high school physics teachers hinges, ironically, on the generally poor job market for physicists in the early to mid-1990s. Not only were there fewer opportunities for new physics bachelors', but also the bleak market for master's and PhD recipients discouraged many U.S. physics students from going on to graduate school in the field (Neuschatz and Mulvey, 1995, Dodge and Mulvey, 1996). The reduced prospects in industry and academia, combined with the greater opportunity to specialize in physics teaching, probably served to push physics majors in those years towards high school teaching. Unfortunately for high school physics, the now improving job market of the late 1990s (Dodge and Mulvey, 1997, Mulvey, 1998), with new opportunities and sharply rising salaries for physics graduates, may actually reduce the fraction of physics degree holders among new high school physics teachers in years to come.

The fact that only 33% of all high school physics teachers hold a degree in the field (see **Figure 3**) does not at all imply that the majority of teachers are totally unqualified. As previous reports have stressed, the oft-repeated view that physics is frequently taught by coaches, home economic teachers, and humanities specialists who have essentially no background in, or familiarity with, physics or other natural sciences is simply not true

Figure 3. Percent of physics teachers with a physics degree



Source: 1996-97 AIP High School Physics Teacher Survey

and probably never has been. We found that less than 2% of high school physics teachers had themselves never taken a college physics course. **Figure 4** shows that, in 1997, virtually all physics teachers have science or math as their field of specialization. Moreover, in terms of general level of education, 58% of physics teachers (and 67% of those who had been teaching more than 5 years) had earned a master's degree, although not surprisingly, only 4% held a PhD.

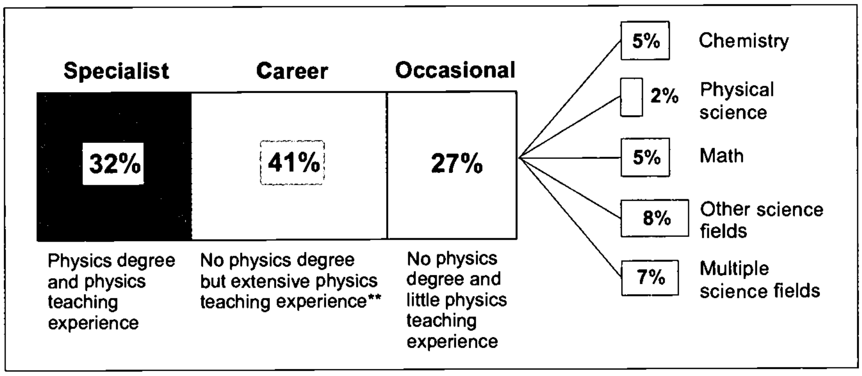
However, even with enrollment increases, it remains true that few physics teachers, even among those whose academic training specifically prepared them for teaching in that field, can expect to focus exclusively, or even primarily, on physics. As we found in earlier studies, only 3% of the 1997 physics teaching corps had taught physics exclusively in their careers, but an additional 48% had taught at least one course in physics every year or had taught physics more frequently than any other subject. (Among those with physics degrees, the percentages were 6% and 67%, respectively.) Six teachers in ten had experienced one or more years in which they were not assigned any physics at all.

Concern about teacher qualifications is often expressed in terms of certification. As in the past, we found that most public school physics teachers (this year around 60%) report having full state certification specifically in physics, with another 5% holding temporary certification in the subject. Virtually all the others have full certification in one of the other sciences or in mathematics, with less than 1% having their only certification outside of science or math, and another 1% holding no official state teaching certificate at all. Private schools teachers are excluded from this analysis, since many private schools have their own certification rules, often quite different from those that apply to public school teachers. However, even among public schools, the regulations and criteria governing credentials often vary greatly from state to state, making official certification a less effective yardstick by which to gauge teacher qualifications nationally.

As a result, we decided a decade ago to develop our own measure of physics teacher specialization, one which would take into account both academic credentials and the acquisition of practical teaching experience in the classroom. The measure developed divides teachers into three categories: specialists, who have earned a degree in physics or physics education and have taught it consistently since; career teachers, who do not have a degree in physics but have taught it regularly over the years; and occasional physics teachers, who neither have a physics degree nor consistent experience teaching it (see **Figure 4**).

The notion behind the career teacher designation is that, while experience alone is certainly no substitute for rigorous formal training, repeated years of preparing lectures and laboratory demonstrations can serve to strengthen a teacher's knowledge

Figure 4. Teacher specialization: academic training and experience*



*Teachers with physics degrees but insufficient physics teaching experience are excluded from this figure (~2%).

**Career physics teachers include those who have taught physics as much as, or more than, any other subject, or have taught it for ten or more years. The distribution of highest degree earned by career teachers was spread evenly across the sciences, with 25% in biology, 22% in math/engineering, 20% in chemistry, and 22% in other science fields.

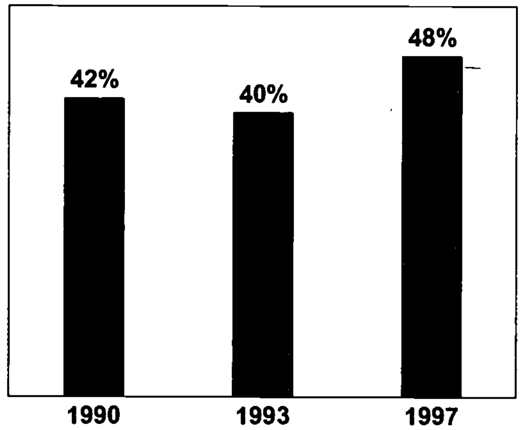
Source: 1996-97 AIP High School Physics Teacher Survey

base about the fundamental concepts and approaches of the discipline. Support for this view emerged from the 1993 AIP survey, where we found that many of the teachers without physics degrees who had initially described themselves on earlier surveys, when they were first starting out, as inadequately prepared to teach basic physics concepts, now saw themselves as adequately- or well-prepared after having several years of physics teaching under their belts.

Of course, neither formal academic training, nor repeated experience in teaching a subject, nor even a strong sense of self-confidence about one's teaching abilities guarantees effective communication of physics concepts and science methods to one's students. Unfortunately, the present study, surveying teachers only, has no independent way to gauge how adept teachers actually are at their craft. Standardized instruments to measure students' grasp of physics concepts (for example, the Force Concept Inventory) have started to emerge in recent years but until this type of information is more generally available, providing snapshots before and after courses are taken, and is supplemented by student surveys probing background variables that may interact and confound, our ability to assess the ultimate effectiveness of teachers will be incomplete at best.

Even without such measures, it is obvious from the data generated in the AIP survey that many initially poorly-qualified teachers will never get to teach consistently enough to even have a chance of developing a reasonable grounding in the discipline. This includes a significant fraction (22% in 1997) of first-time physics teachers who

Figure 5. Percent of teachers describing themselves as specializing in physics teaching



Sources: 1989-90, 1992-93 & 1996-97 AIP High School Physics Teacher Surveys

had actually been high school teachers for four or more years before they were asked to cover physics. Not surprisingly, less than one in twelve of these teachers had a physics degree, and most are destined to swell the ranks of the "occasional" physics teacher category, with their primary assignment in other areas and only sporadic experience with physics.

The overall trend, however, is mostly positive. As a result of the improvement in degree background mentioned earlier, the proportion of physics teachers who qualify for the specialist designation has been steadily climbing, while the proportion falling into the occasional teacher category has been dropping. A similar trend can be seen in teachers' self-assessment of their field of specialization, based on a question we added starting with the 1990 survey in order to supply the teachers' subjective sense of their area of expertise to our measure. This measure includes virtually all of those classified as specialists based on degree field and career-long teaching assignments, as well as some of the "career" teachers who consistently teach more physics than other subjects (see **Figure 5**).

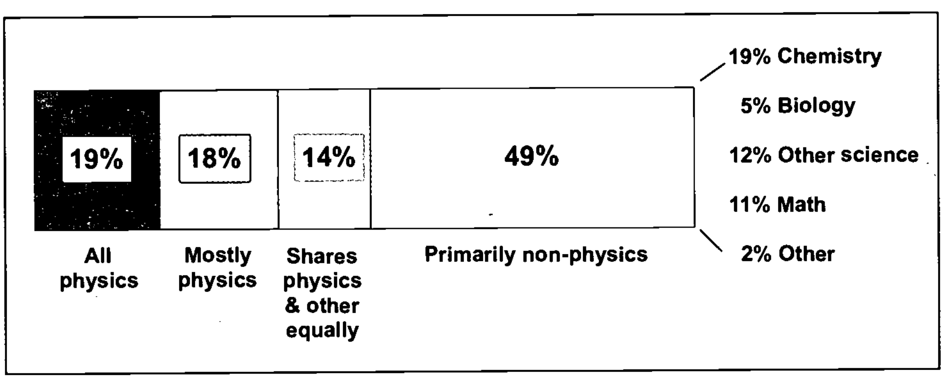
IV. CURRENT TEACHING CONDITIONS, RESOURCES, AND ACTIVITIES

Current Circumstances

The previous section looked at teacher background and opportunity to specialize in physics over the course of one's career. Here we turn our attention to the instructors' current teaching assignments. Not surprisingly, even with the progress noted in the previous section, the chance that teachers will have their primary assignment in physics in a given year remains small. In previous reports, much was made of the fact that, in the survey year, half of all those teaching physics taught only one section at a time, with only a third having their primary assignment in the subject. While rising enrollments have helped the situation, it is still the case that in the Spring term of 1997 almost half of all physics teachers taught another subject more than physics and only 37% were able to teach primarily physics, with 19% teaching exclusively physics (see **Figure 6**).

As in years past, small enrollments and the secondary place occupied by physics in many teachers' assignments contributes to a number of problems, as illustrated in **Table 3**. The level of complaints was very similar to years past, with by far the greatest lament being over inadequate funding for equipment and supplies. However, one notable surprise was that, despite the increase in enrollments which might be expected to bring in less-prepared students into physics classrooms, a significantly lower proportion of teachers cited inadequate student preparation and reading ability as a problem. Similarly, there was a slight drop in the percentage complaining that their students did not regard physics as important. In terms of teachers' own circumstances, there was a modest decline

Figure 6. Place of physics in current teaching assignment



Source: 1996-97 AIP High School Physics Teacher Survey

Table 3. Percent of physics teachers citing selected problems as serious

Insufficient funds for equipment & supplies	39%
Not enough time to prepare labs	30
Inadequate space for lab or lab facilities outmoded	26
Not enough time to plan lessons	20
Inadequate student mathematical preparation	18
Students do not think physics is important	17
Insufficient administration support or recognition	13
Difficulties in scheduling classes & labs	13
Inadequate student reading ability	11

Source: 1996-97 AIP High School Physics Teacher Survey

in the percentage of teachers bemoaning their lack of time for preparing lessons. On the other hand, a substantial number of teachers said that they had insufficient time to prepare laboratory demonstrations and exercises. But, overall, the picture was one of general, if modest, improvement, and in no case was there a significant rise in the proportion of teachers regarding any of the listed problems as a serious or even a minor complication.

The explanation for why so many physics teachers regard funding for equipment and supplies as their greatest problem is not hard to find. According to these same teachers, such funding has remained virtually stagnant for at least ten years, and has actually declined by around a third in real dollar terms over that period. Currently, physics teachers are allowed a median of $275 per physics class from all sources over the full academic year. And this has occurred at a time when the demand for more sophisticated lab equipment, including not just graphing calculators and computers but also the software and sensors needed to transform them into useful lab tools, has been rising apace.

Another area where only minor gains can be found involves the respondents' sense of confidence in their preparation to teach physics at the high school level. This is somewhat surprising, given both the improvement in teachers' academic physics background and their improved chances of specializing in physics teaching due to rising enrollments. As before, virtually all teachers see themselves as at least adequately equipped to teach the basic physics concepts in their classes. The majority also express self-assurance regarding their ability to relate those concepts to everyday life, to encompass basic concepts from the other sciences, and to demonstrate physics in the laboratory (see **Table 4**). However, the rise in credentials has not spurred a jump in the proportion of teachers describing themselves as well-prepared as against

Table 4. Teacher self-assessed level of preparation

	Percent describing themselves as:		
	Very well prepared %	Adequately prepared %	Not adequately prepared %
Basic physics knowledge	68	30	2
Other science knowledge	47	49	4
Application of physics to everyday experiences	46	46	8
Instructional laboratory design and demonstration	34	51	15
Use of computers in physics instruction and labs	19	36	45
Recent developments in physics	15	51	34

Source: 1996-97 AIP High School Physics Teacher Survey

merely adequately-prepared in these areas. And a sizable minority of teachers still feel ill equipped to cover recent developments in physics, or, in answer to a new question this year, to effectively incorporate computers in their physics teaching.

Professional Activities

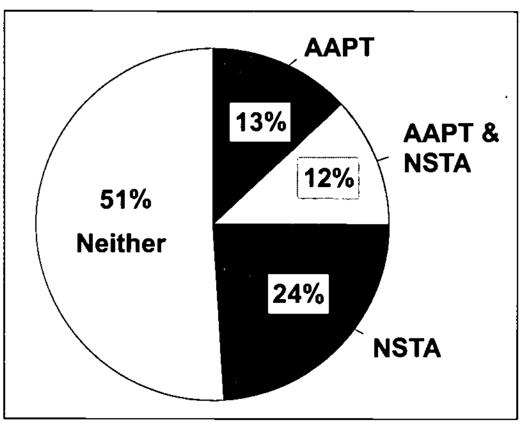
Prior surveys had shown that one of the hallmarks of specialist teachers, and an important correlate of their sense of self-confidence, was membership and activity in professional societies. This year as well, teachers who maintained professional membership seemed generally better able to keep up with new developments in physics, new instructional approaches, and techniques in physics education. And this was probably also a self-reinforcing trend, since those teachers who were better-prepared and more involved (or open to involvement) were probably more likely to be attracted to and join such groups, enriching the professional life of the community and stimulating exchanges between individual members.

The two professional societies most closely linked to high school physics are the American Association of Physics Teachers (AAPT) and the National Science Teachers Association (NSTA). In general, AAPT tends to attract teachers who specialize in teaching physics, whereas NSTA, with its broader focus, draws more of those who, while teaching physics, have their training or current assignment primarily in another science, or who focus on several science areas simultaneously.

Despite the increase in the proportion of physics teachers with physics degrees, we found little change since the last survey four years ago in the proportion belonging to either organization. As before, roughly one-fourth of all high school physics teachers maintain membership in the national AAPT organization or are affiliated with a local chapter. About 60% describe themselves as active AAPT members. Also consistent with prior findings, a somewhat larger proportion (36%) are members of the broader NSTA, with 56% calling themselves active members (see **Figure 7**).

While concern about teacher qualifications often focuses on academic background, it has been increasingly recognized in recent years that teacher preparation is a career-long issue, and that

Figure 7. Physics teacher membership in professional organizations



Source: 1996-97 AIP High School Physics Survey

in-service professional activity and growth may be as important as pre-service academic training. The survey thus asked high school physics teachers about their participation in a number of different kinds of professional activities during the prior year.

The results were fairly encouraging. Five out of six respondents reported taking part in at least one professional activity during 1996. The most common activity, as **Table 5** shows, was attendance at an education workshop, and for more than a third of all teachers that workshop focused specifically on physics. A similar fraction

Table 5. Teacher professional activities

Percent who reported attending a:	**At least once in 1996**
general education workshop	58%
physics education workshop	37
professional education association local or national meeting	37
education course at college or university	22
summer science education institute	21
physics or other science course at college or university	18
physics association local or national meeting	18

Source: 1996-97 AIP High School Physics Study reported that they had attended a local or national meeting convened by AAPT, NSTA, or one of the other professional education societies. However, far fewer participated in any of the other activities specified on the questionnaire. Only about a fifth of respondents claimed to have attended a physics meeting, signed up for a summer institute, or taken a college-level science or education course during the year. Moreover, for only about half the teachers was the professional activity specifically physics-oriented. Still, given the time pressures reported by physics teachers, these findings suggest a significant investment of free time in professional activities.

Consistent with findings in years past, we found that while membership in AAPT had only a modest impact on professional activities in general, it had a predictably stronger influence on physics-related activity. For example, just under 60% of all respondents, AAPT members and non-members alike, attended an education workshop during 1996. But when we look at workshops specifically in physics, the proportion remains near 60% for AAPT members but falls to half that for non-AAPT members. The link with meeting attendance is even more obvious, with about half the AAPT members attending a national or local physics meeting (probably of that very organization), compared to only 8% of the non-members.

The impact of AAPT membership on broader professional development activities was, as we noted, less clear. For example, while AAPT members were twice as likely as non-members to have participated in a summer science education institute in 1996, there was no difference in the proportion taking university courses, whether in physics or other subjects.

The benefits of AAPT membership in terms of increased physics-related professional activity shows up in teachers' assessments of their own preparation to teach physics. Even when we controlled for whether or not a teacher has a physics degree, modest differences could still be discerned. Thus, AAPT members were more likely to describe themselves as at least adequately prepared in recent developments in physics (76% of members as against 63% of non-members), instructional laboratory design and demonstration (93% versus 82%), and the use of computers in physics instruction and labs (69% as compared to 50%).

Curriculum Initiatives

Many current educational meetings, workshops, and professional society programs focus on the flurry of new courses, course materials, and teaching approaches that have surfaced in recent years. The extent to which some of these have been incorporated into physics teaching is shown in **Table 6**. These range from simply adding or deleting specific topics covered in the introductory course, to broadening the range of courses

Table 6. Changes to physics program	
Percent of teachers reporting that their school:	
introduced "Active Learning" techniques	44%
changed topics covered in introductory physics course	31
added a new physics course	24
introduced interdisciplinary instruction	18

Source: 1996-97 AIP High School Physics Teacher Survey

offered, to developing entirely new courses, embodying non-traditional pedagogical approaches.

As mentioned towards the beginning of this report, there has been a fairly dramatic expansion of the physics curriculum during the twelve years this study series has existed. In 1997, around one-fourth of the teachers indicated that a new course had been added to their school's physics offerings since the previous survey four years earlier. The new course most frequently mentioned was conceptual physics, followed closely by the Advanced Placement B course and then Principles of Technology. Another 18% of the teachers noted that interdisciplinary instruction had been introduced into their school's physics curriculum in recent years, with almost all reporting a beneficial impact.

Changes made within the existing menu of courses were even more widespread and equally well received. The introduction of "active learning" techniques was mentioned by almost half the respondents and favorably viewed by 90% of those. And almost a third of the respondents reported changes in the topical coverage of their introductory courses. This seems directly relevant to recent discussions about the topics covered in introductory physics courses at all levels, with complaints that either the number was too great or that the wrong ones were being included. Interestingly, the number of teachers reporting topics added equaled the number mentioning topics removed. At the same time, there were clear patterns in the specific topics mentioned, with heat and kinetic energy leading the list of topics removed and modern physics and electricity and magnetism heading the list of those added.

In addition to initiatives specific to physics, there have also been broad changes in instructional practice and school structure that have a potential impact on physics teaching. **Table 7** highlights some of these changes, which are often instituted at the state or even national level. In some cases, these actually first appeared a number of years ago, and what we are seeing now are the final stages of their impacts being played out. For example, virtually all states increased high school graduation requirements in science during the late 1980s and early 1990s. While some of these changes may still be taking effect, only 29% of the responding teachers in 1997 reported that such increases affected their schools over the last four years, although more than half of the teachers who did so viewed the impact as positive. Seven years earlier, in contrast, over half of the physics teachers reported increases in graduation requirements in science.

A more recent stimulus for curricular changes comes from the national science "standards," that were only finally formalized in the mid-1990s. One third of responding teachers reported that the standards had spurred their state or district education authorities to initiate changes. However, 60% reported that these had no significant impact on their physics teaching.

Table 7 also looks at modifications in performance assessment and grading practices. Many of these are in response to the long-term evolution of instructional practices, and the appearance of new fashions. Once again, while one-third of respondents reported recent changes in this area, only half indicated that they had a substantial impact on their physics teaching.

As **Table 8** illustrates, a much more positive reaction surfaced with regard to block scheduling, where classes are allotted a double period. This has been described as especially helpful to laboratory sciences such as physics, reducing the proportion of the instruction time dedicated to setup and cleanup. While only a quarter of the teachers reported that this arrangement had been instituted at their school, two-thirds of them saw it as having a positive impact on their physics teaching. The other innovations detailed in **Table 8** were even more widely-implemented and favorably-received. These include computer-based laboratories, instructional videos, and resources and information available through the Internet and the World Wide Web.

However, the lack of access to the necessary "hardware," including graphing calculators, microcomputers for data acquisition, computation and simulation,

Table 7. Recently implemented broader administrative changes

Percent of teachers at schools that in the last four years introduced:	Percent of teachers reporting a recent change	Of those reporting a change, percent who answered that the impact was positive
increased graduation requirements in science	29%	59%
national education standards in science	35	37
performance assessment, grading reform	35	39

Source: 1996-97 AIP High School Physics Teacher Survey

access to the Internet and the World Wide Web, and videos for instruction and demonstration, may be a limiting factor in the spread of these new approaches. Thus, as shown in **Table 9,** while many teachers indicated that graphing calculators were available to physics students at their schools, only about two-thirds of them felt the supply was adequate or that their students were generally prepared to take advantage of their features. Computers were even more widely available, present in five out of six schools, but only half the teachers felt there were a sufficient number. Even more distressing, only half the teachers said that they had any software that was specifically designed for physics instruction, and only half of those teachers said that what they had was adequate or that students were properly prepared to use the software. However, especially with regard to the integration of computers into physics instruction, AAPT members were significantly more likely to have introduced com-

Table 8. Recently implemented changes to instructional practices in physics

	Percent of teachers reporting a recent change	Of those reporting a change, percent who answered that the impact was positive
Block scheduling	26%	68%
Computer-based laboratories	48	90
Instructional videos	41	82
Student use of the Internet / WWW resources	34	69

Source: 1996-97 AIP High School Physics Teacher Survey

Table 9. Availability of equipment

Percent of teachers reporting that equipment is:	Graphing Calculators	Computers for Student Use	Specialized Physics Software
Available at school	65%	83%	48%
Where available, supply adequate	70	52	48
Where available, students are generally prepared to use	71	70	47

Source: 1996-97 AIP High School Physics Teacher Survey

puter-based labs and specialized physics software than physics teachers who were not AAPT members.

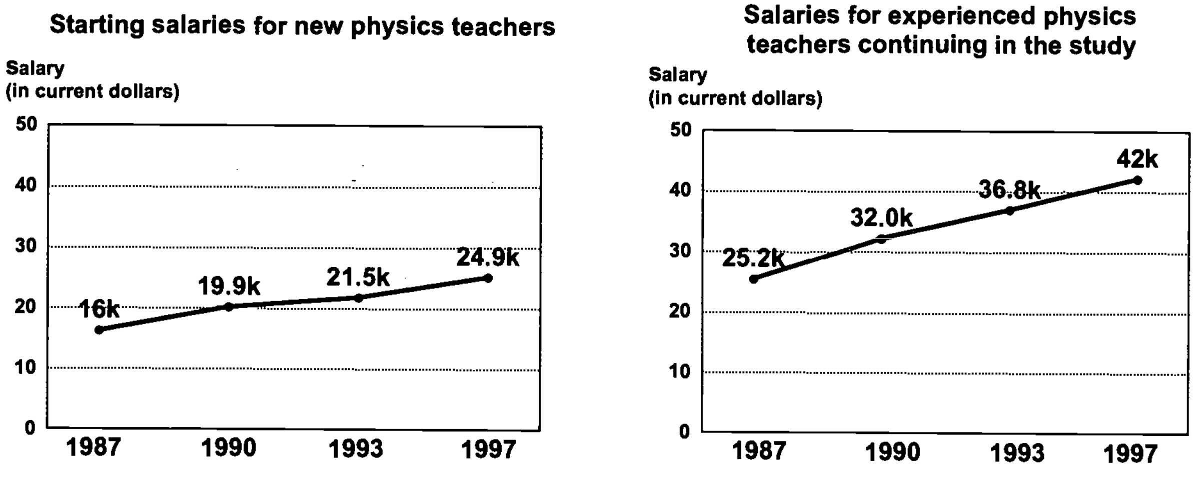
Funding and Salaries

The relative scarcity of appropriate hardware and software, despite widespread enthusiasm for the potential of computers in physics instruction, stems directly from the stagnation in funding for supplies and equipment discussed earlier. It is ironic that this decline coincides neatly with a period in which education administrators at all levels have reiterated the critical value of laboratory science in secondary education. Here again, in line with other findings, AAPT members fare a bit better than non-members, with a median funding level of $300 annually per class, as against $250 for the latter group.

As in the past, we found that physics teachers displayed high overall levels of satisfaction with their choice of career. This year, 82% of the teachers asserted that they would follow the same path if they had it to do over again, a slight gain from four years earlier. For the first time, we also asked teachers to describe in more detail what they found to be the most satisfying and least satisfying aspects of their work. By an overwhelming majority, teachers found the intrinsic aspects of the process of teaching itself, including working with eager students and watching them learn and grow, to be the greatest satisfaction. And consistent with the findings discussed just above, the greatest dissatisfaction stemmed from the poor quality of the tools and materials they had to work with, and time pressures due to competing responsibilities and inadequate opportunity to prepare for lectures and labs. Ironically, students proved to be an important source of dissatisfaction as well as satisfaction. Teachers cited the difficulties of working with recalcitrant and poorly prepared students as the second most important source of discouragement.

It is also worth noting that one of the most widely-discussed sources of teacher dissatisfaction — low salaries — barely merited a nod. Only about 2% of all teachers put down anything connected with pay, long hours, or lack of opportunity for advancement, as a major cause of discontent. And, indeed, the historical record shows less to complain about recently. After years of declining real wages, teacher salaries began to stabilize and even make up some lost ground in the mid-to-late 1980s. Among physics teachers, median starting salaries reported on the AIP surveys by respondents just beginning their teaching careers, shown in **Figure 8**, have risen at an average annual rate of about 4.5%, well above the annual average inflation rate of around 3% for that period. The salary scale across the range of career steps rose concomitantly but a bit more slowly, producing a slight compression of the salary scale.[1]

Figure 8. Median salaries for physics teachers



Sources: 1986-87, 1989-90, 1992-93 & 1996-97 AIP High School Physics Teacher Surveys

For individual teachers moving through their careers, the rising scale combines with their own regular if modest salary increases based on seniority. Teachers who had been a part of our study since its inception enjoyed an average total increase of 67% over the decade, which translates to an annual average gain of around 5.2% (see **Figure 8**). As discussed in previous reports, salaries tend to be substantially higher in the public sector than in private schools, amounting to about 20% even after controlling for the somewhat younger age profile of private school teachers.

Another indirect indicator of career satisfaction is job stability, and we found that the overwhelming majority of teachers in the study have been at the school where they are now teaching for a considerable amount of time. Thus, the median number of years teaching high school was 13, and the median number of years at the current school was 8.

Nevertheless, while teachers tend to remain at the same school, there is still a good deal of movement in and out of physics teaching. Detailed investigations using data from earlier rounds (Neuschatz and Alpert, 1994:27; 1996:25) showed that the majority of those who dropped out of the study from one round to the next remained teaching at their school but were not assigned physics classes that particular year. Another smaller group transferred to other high schools but continued to teach physics. When we further subtracted those who retired at the end of their teaching career, we found that an average of only about 4% of the teachers in the study left high school teaching each year.

Moreover, consistent with findings from the Department of Education and elsewhere, the highest attrition is among those in the early years of their career. Using data from a follow-up study we did of physics teachers who left their school between two rounds of the survey, we found that respondents in their first three years of teaching left at an average rate of around 9% a year. Among teachers who are past their fourth anniversary of entering the profession, the attrition rate (excluding those retiring at the end of their career) drops to an average of 2.5%. Similarly, when we look at future expectations of current teachers, close to 40% of those in their first 3 years expect to leave high school teaching altogether for another career, compared to only about 10% of those who have made it past their tenth anniversary.

V. HIGH SCHOOL PHYSICS IN THE LARGER SOCIAL CONTEXT

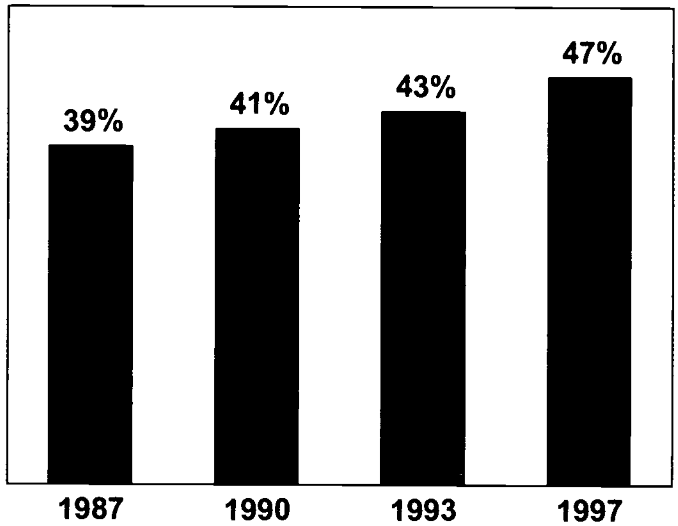
As we mentioned earlier, the current cycle in the recurring campaign to improve high school science education took root in the mid-1980s with an ambitious set of goals. The stated objective was not merely to expand overall course enrollments but also specifically to spread laboratory science instruction, especially chemistry and physics, to groups of students who previously had rarely been exposed to them at this level. In this regard, the results have been mixed, with some notable successes-in-the-making and some equally notable failures.

Women and Minorities in Physics

The clearest success involves the participation of girls in high school physics. In 1987, male students noticeably outnumbered female students in high school physics classes. Ten years later, as **Figure 9** shows, girls had almost achieved parity in overall enrollment numbers. (In chemistry enrollments, girls now slightly outnumber boys.) This is an astonishing advance over a relatively short time for such a large and fractious system. It was probably aided by broad social changes, including the fuller overall participation of women in the labor force, the opening of many professions that women were traditionally discouraged from entering, and the growing cultural acceptance of women as equally bright and capable as men. But it was also undoubtedly speeded by a concerted campaign by educators at many different levels to lower the cultural and regulatory obstacles that had prevented the fuller participation of women over many decades.

But while much progress has been made, the problem has by no means been fully resolved. Hidden beneath the overall figure is the finding noted in earlier reports (Neuschatz and Alpert, 1996:19), that girls are still seriously underrepresented in the more advanced physics classes. The

Figure 9. Girls as a percentage of total enrollment in high school physics over time



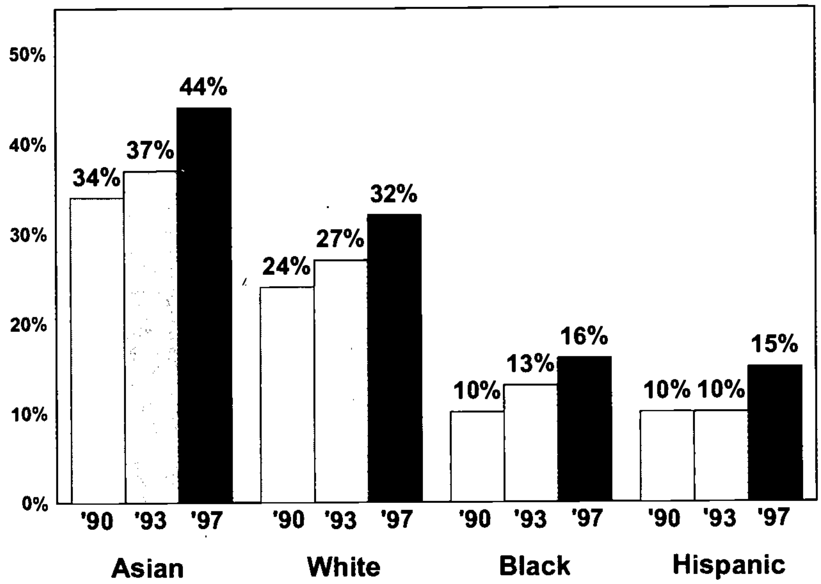
Sources: 1986-87, 1989-90, 1992-93 & 1996-97 AIP High School Physics Teacher Surveys

continued imbalance in these gateway courses helps to reinforce the persistent underrepresentation of women in physics at higher academic levels. Even after two decades of slow but steady progress, women still earn only about one-fifth of all bachelor's degrees in physics and barely an eighth of all physics doctorates.

Moreover, if modest success can be claimed for encouraging girls to enroll in high school physics across the nation, no such claim can be made for African-American or Hispanic students. While there have been gains in the participation of minority students in physics courses, **Figure 10** shows that these have only barely exceeded the general enrollment increase. Thus, the best that can be said is that the traditionally severe underrepresentation of these groups has remained more or less stable during this period of overall gains. This lack of progress also bodes ill for recent campaigns to rapidly increase the proportion of minority group members who find careers in science and engineering, including as teachers in these fields.

Indeed, it has often been argued that the historically low participation of female and minority students in high school physics was due in some measure to a vicious circle, reinforced by the parallel scarcity of members of these groups among the ranks of high school physics teachers, and the resultant lack of role models. And, in fact, we noted earlier that the fraction of women among high school physics teachers has remained stuck at around a quarter over the past decade, while the proportion of Black and Hispanic teachers continues to barely register at 1% each.

Figure 10. Percent of students in each racial group taking physics



Note: Overall school racial breakdown derived from 1993 high school data

Sources: 1989-90, 1992-93 & 1996-97 AIP High School Physics Teacher Surveys

However, as we argued in **Section III**, most of the evidence seems to point against the existence of a strong "role model effect," at least as far as gender is concerned. This is not just because of the lack of effect in aggregate terms, given the simultaneous rise in the percentage of girls taking physics at the same time as the proportion of women teachers has remained about the same. The same conclusion also seems to hold when we move from a macro to a micro focus, and look at the impact of the presence of a female as compared to a male teacher. Whether we include all classes or restrict the analysis just to the regular first-year introductory physics course (to avoid any influence from gender stereotyping in the more advanced courses), the difference in the proportion of girls in physics classes taught by women as against men is less than 4%.

Still, it would be wise not to rule out role modeling altogether, as its effects may be significant but indirect. For example, it is certainly possible that the impact does not show up until later, with a higher proportion of girls who take high school physics from a female teacher feeling encouraged to continue in physics or other science studies than those whose teacher is male. Such analysis goes beyond the capabilities of the present study.

Whether or not the absence of role models makes a significant difference, the effects of the past lower participation of girls in high school physics, and their persisting smaller presence in the advanced "gateway" courses, continue to contribute to the relatively small percentage of women who go on to earn a physics degree and eventually become physics teachers. Not only do women constitute only a quarter of these teachers, as noted in **Section III**, but they are somewhat unevenly distributed across the academic and geographical landscape. For example, as **Table 10** shows, they tend to be disproportionately concentrated in parochial schools and in public schools in the South.

When it comes to salaries, the same patterns found in earlier reports holds this time as well. At first blush, there appears to be a substantial salary difference between male and female physics teachers, on the order of 20%. But, as **Table 10** also shows, the proportion of female physics teachers drops off sharply as we move up the seniority ladder. When we take into account these differences in seniority, along with the fact that salaries in southern schools and parochial schools tend to be lower, we find that the salary differences between genders essentially disappears.

Table 10. Women as a percentage of physics teachers

Region	%
South	34
North and West	22
School type	
Public	25
Catholic	40
Other Private	19
Seniority	
1-10 years	33
11-20 years	27
21+ years	14

Source: 1996-97 AIP High School Physics Teacher Survey

When we turn to the situation of minority teachers, we find at least greater opportunity for role modeling. This is true for two reasons. First, unlike girls, who are evenly distributed across public schools, minority students are highly concentrated, a result of geographic and residence patterns, and also historical patterns of discrimination. Second, the results of our study show that minority physics teachers, especially African-Americans, are disproportionately likely to be teaching in schools where students from their minority group are enrolled. Thus, over half of all Black physics teachers teach at schools where the racial composition of the school is at least 65% Black, and over half of all Hispanic instructors are at schools that are at least 40% Hispanic.

But, despite these patterns, the possibilities for role modeling to take place are still limited. Given the number of minority physics teachers, the bulk of Black and Hispanic high school physics students study with White teachers. On the other hand, as was the case for women, the uneven distribution of minority teachers makes the potential for role modeling greater in certain areas. For example, five percent of public school teachers in the South were minorities compared to 1% elsewhere. In general, however, the numbers are so small that the overall impact is minimal.

Social Class and Physics Education

In prior surveys, it was very difficult to disentangle the effects of race from those of social class, because we had only the grossest of measures for the latter. This year, for the first time, we asked teachers directly to try to rank the aggregate socioeconomic level of the students at their school, as compared to other high schools in their area. Of course, each school contains students from a range of socioeconomic backgrounds, and a teacher's attempt to draw a composite picture could produce only a rough approximation, at best. Bearing these limitations in mind, however, we found a number of indications that the measure did a reasonable job of reflecting the socioeconomic reality at sample schools. For example, where there were multiple teachers at a school, we found a high degree of consistency in teachers' answers on this item.

Realizing that teachers would have no way of making a meaningful comparison of the relative socioeconomic profile of their school to others on a national scale, we asked them to make the comparison to other schools in their local area. Because of differences in wealth based on geographic clustering, a school that was rated by the teacher as worse off than average at the local level may actually be better off than average on a national scale and vice versa, leading to a "muddying" of the overall picture. Even so, the item accorded well with an external measure gathered by the U.S. Department of Education (the percentage of students receiving lunch subsidies), although that was available for only a subset of sample schools.[2]

In fact, we relied on the latter to investigate the relationship to whether physics was available at all, since our own social class measure came from physics teachers, and so was not available for schools where physics was not offered. The results of that analysis showed that the social class of students had no measurable impact on whether physics was offered, as long as we restricted ourselves to large schools. In such schools, physics is essentially offered universally. But over two-thirds of public schools, especially concentrated in rural areas, have fewer than 200 seniors, and a small but noticeable fraction of them do not offer physics at all, or only manage to offer it in alternate years. Here, we found that social class makes a substantial difference. Small schools where more than a third of students qualify for the federal subsidized lunch program are three times as likely to omit physics from their curriculum as smaller schools with fewer poor students. Moreover, where the poorer small schools do offer physics, it is more likely to be only in alternating years. Overall, only about half of these schools offer physics every year, compared to about 80% of the comparably-sized schools where no more than a sixth of the students qualify as poor.

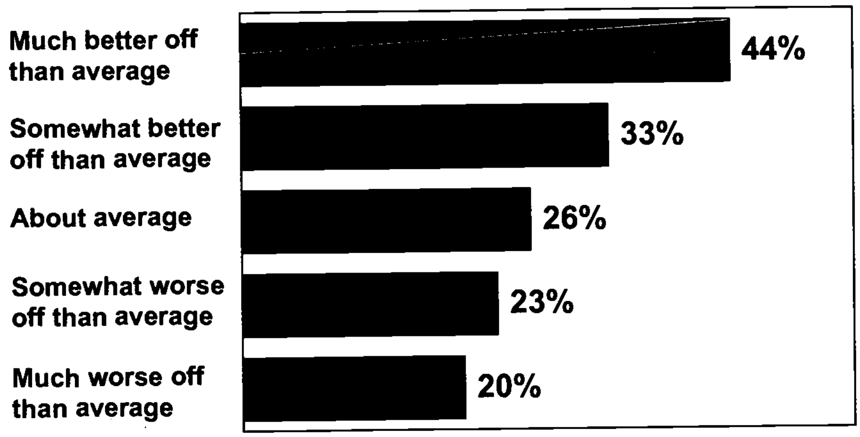
While social class affects the likelihood of offering physics only for small schools, among schools that have a physics program it has a much broader impact on the size and character of that program. To explore this relationship, we were able to turn to our own, more comprehensive data on physics courses and teacher assessments of their schools' socioeconomic circumstances, which included public schools from all the states in the Union. What we found was a direct and strong correlation between teachers' estimates of their students' social standing and a number of key characteristics of their schools' physics programs.

Before going further, we should note that these findings almost certainly understate the impact of social class, because they only reflect aggregate differences between schools. While a good deal of socioeconomic clustering by schools exists in the U.S. system of public education, each school also contains students from a range of social backgrounds. While not demonstrable with the data at hand, it is reasonable to think that, within each school, wealthier students may tend on average to have stronger course backgrounds and loftier future academic aspirations, and so are more likely to take an "elite," demanding course such as physics than are those from the lower rungs of the socioeconomic ladder. While this is in no way meant to imply that *only* the favored students in each school take physics, even a small tendency in this direction would compound with the school-to-school differences which are detailed below to yield a very strong composite impact by social class.[3]

However, the aggregate relationship comes through quite clearly by itself. Even using our rough overall school measure, we found that, among public schools, the percentage of seniors taking physics rises steadily with the rating on students economic standing, and is well over twice as high for the richest schools as for the poorest. (see **Figure 11**). This finding holds in cities, suburbs, and rural areas alike.

Moreover, these data also show that a significant part of the previously-cited difference in physics programs among schools with different racial compositions may actually reflect the substantial aggregate socioeconomic differences between racial groups. One measure of these differences was that teachers at predominantly minority schools in our sample describe their student bodies as poorer than average 67% of the time. In contrast, only 28% of the teachers at white majority schools described their school's students as poorer than average. But, where race and class *do not* overlap, it is the latter that has the greatest impact on physics. For example, physics enrollments hovered around 20% among schools rated as poorer than average by their physics teachers, and this held regardless of whether minorities

Figure 11. Percent taking physics by socioeconomic profile* of school**



*Teacher estimated ranking of school relative to others in local area

**Out of all public schools with physics programs

Source: 1996-97 AIP High School Physics Teacher Survey

comprise 5%, 45%, or 95% of the student body.

Not only do wealthier schools enroll a larger proportion of students in physics, but teachers in those schools describe their students as far better situated to profit from their study. As **Table 11** shows, the proportion of students described as poorly prepared to tackle physics in terms of math background is five times as high in the poorest schools as it is in the richest schools. The impact on teachers can be read in the comparable proportions of teachers who describe their physics students' inadequate math preparation as a serious problem (see **Table 13**, p. 34).

While none of the disparities in the other aspects of student preparation included are quite so extreme, there are substantial differences in each one. The contrast even extends to students' reading skills, despite the fact that physics students may be described as constituting a smaller and more "select" elite in poorer schools than in richer ones. And it translates in equal measure to students' enthusiasm for the subject.

Moreover, there is some indication that the gap is, if anything, growing worse. As **Figure 12** shows, at the wealthiest schools, the proportion of teachers reporting that the preparation of their entering physics students had improved over the past four years slightly exceeded the proportion saying that preparation level had declined. At the poorest schools, in contrast, the fraction saying the level had declined was almost twice the fraction who saw improvement.

The impact of students' socioeconomic circumstances is not just limited to how many students take physics or to the

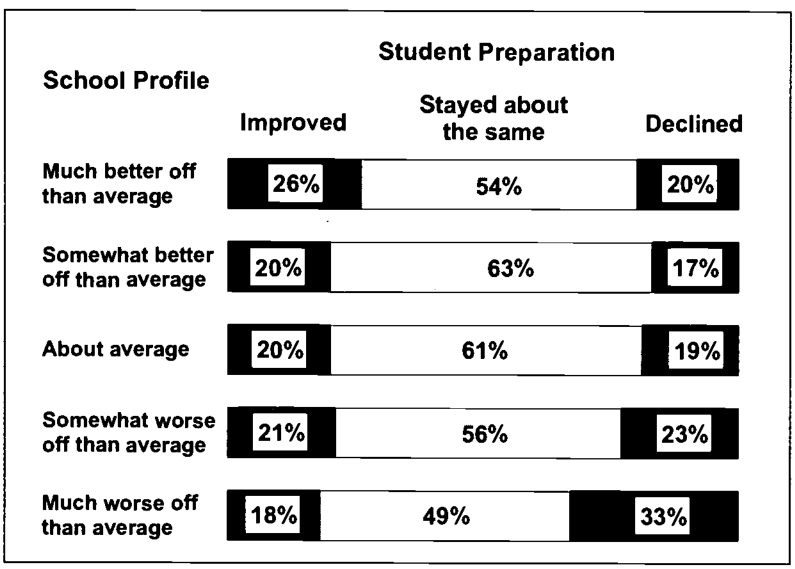
Table 11. Student preparation by socioeconomic profile of school*

Percent of teachers reporting poor student preparation in:	Socioeconomic Profile of School: Much better off than average %	Somewhat better off than average %	About average %	Somewhat worse off than average %	Much worse off than average %
use of computers in science	31	42	54	57	59
ability to think and pose questions scientifically	25	28	36	43	51
familiarity with general laboratory methods	12	12	19	26	37
physical science background	10	15	17	23	29
math background	9	11	15	25	45

*Teacher estimated ranking of school relative to others in local area

Source: 1996-97 AIP High School Physics Teacher Survey

Figure 12. Recent change in overall preparation of entering physics students by socioeconomic profile of school*



*Teacher estimated ranking of school relative to others in local area

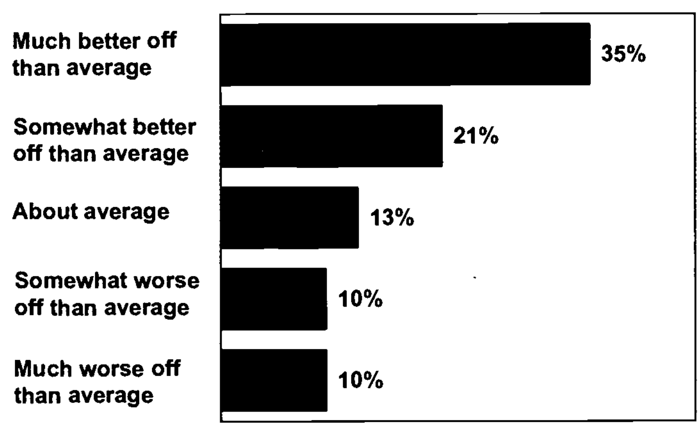
Source: 1996-97 AIP High School Physics Teacher Survey

backgrounds and attitudes they bring into the classroom. It also has an effect on the type of physics courses a school is able to offer. This can be seen most clearly in the availability of Advanced Placement physics classes, with the greatest gap separating the wealthiest schools from all the rest. Overall, AP physics is only offered by one out of seven public high schools. But, as **Figure 13** shows, schools where the student body is rated as much better off are three times as likely to offer it as schools rated average or below average in economic circumstances. Schools on the second rung are twice as likely to offer AP physics.

Students may have many reasons for taking AP physics, and may gain many benefits other than just advanced placement in college. However, only about 60% of AP physics students actually sit for the AP exam at the end of the year, and fewer than two-thirds of those get a "passing grade" of 3 or better, enhancing chances for advanced placement in college. While there is only indirect evidence available, what there is points to the likelihood that students in economically-disadvantaged schools score less well in both these respects. For example, data from the Education Testing Service, which administers the AP tests, show substantial differences in scores by racial and ethnic background.

Socioeconomic composition seemed to have less of a relationship with other facets of the curriculum, such as the introduction of new approaches to teaching and curricular reforms. Similarly, the proportion of schools incorporating active learning, interdisciplinary instruction, or computer hardware varied little by the social class standing of students. However, as **Table 12** shows, differences did appear in

Figure 13. Percent of schools* offering AP physics by socioeconomic profile of school**



*Out of all public schools with physics programs

**Teacher estimated ranking of school relative to others in local area

Source: 1996-97 AIP High School Physics Teacher Survey

Table 12. Equipment used in physics teaching by socioeconomic profile of school					
	Socioeconomic Profile of School				
	Much better off than average %	Somewhat better off than average %	About average %	Somewhat worse off than average %	Much worse off than average %
Graphing Calculators					
Available at school	71	63	66	59	55
Where available, students are generally prepared to use	81	76	66	62	52
Computers for Student Use					
Available at school	87	85	81	79	77
Where available, students are generally prepared to use	73	80	65	68	58
Specialized Physics Software					
Available at school	64	57	45	42	39
Where available, students are generally prepared to use	52	50	40	44	23

*Teacher estimated ranking of school relative to others in local area

Source: 1996-97 AIP High School Physics Teacher Survey

the availability and use of specialized physics software, graphing calculators, and computer-based labs.

This latter finding is undoubtedly linked to the strong differences that emerged regarding funding, with 64% of the teachers at the poorest schools, as against 26% of the teachers at the wealthiest schools, citing insufficient funds for equipment and supplies as a serious problem. A more objective measure of the same difference emerged when we asked teachers to indicate exactly how much funding was available to them for physics equipment and supplies for the current year. The amount fell steadily as we moved down the socioeconomic ladder, with an aggregate drop of 40% from a median of $333 per class for teachers at the most favored schools to $200 per class for teachers at the poorest schools.

Comparisons of teacher characteristics yielded a somewhat different picture. We found little difference in general teacher background, whether in age, years of teaching experience, years at the current school, or plans to remain in teaching until retirement, by the socioeconomic circumstances of the school's students. In terms of overall job satisfaction, as shown in **Table 13**, there was no steady decline in tandem with circumstances, although there was a falloff between schools rated average or better and schools described as below average. Teachers at the latter schools were also more likely to cite a lack of administration support as a serious problem than were their colleagues at more favored schools.

While general backgrounds were similar, greater differences emerged when we focused in specifically on background and current involvement. For one thing, at the wealthiest schools, teachers specializing in physics comprised about half of all physics teachers, while the "occasional" teachers, those who had neither a physics degree nor extensive experience teaching it, were 20% of the total. Those proportions steadily change as we move down the economic ladder, to the point that the ratio was essentially reversed among the poorest schools (see **Figure 14).**

Given this picture, we should not be surprised that teachers at poor schools were far more likely to describe themselves as not adequately prepared to teach physics than teachers in wealthier schools. With the exception of basic physics concepts (where virtually all teachers saw themselves as at least adequately prepared), this held for every aspect of physics teaching background that we examined, as shown in **Table 14**. And the level of professional involvement reported by the teachers did not offer much hope for equalizing those skills in the future. For example, membership in the American Association of Physics Teachers, a prime venue for publishing teaching techniques, was twice as common among physics teachers in the wealthiest schools as in the poorest.

We are thus faced with what looks like another vicious circle. The robust physics programs and well-prepared students at the wealthiest schools attract and retain the teachers with the strongest physics backgrounds, who are able to put their physics-specific training to the best use. Moreover, they enjoy strong administrative support to upgrade facilities and keep themselves up on the latest approaches. At the poorest schools, on the other hand, teachers are more likely to face poorly-maintained facilities and poorly-prepared students. At the same time, their lower enrollments limit their chances to focus much of their attention on physics, much less concentrating their energies on developing and improving their school's program.

It is here that the disparity between the situation of physics teachers at rich and poor schools can be most clearly seen, in the opportunity to concentrate on physics, rather than partitioning their energies across a number of subjects. At schools where students were rated as much better off than

Table 13. Problems in physics teaching by socioeconomic profile of school*

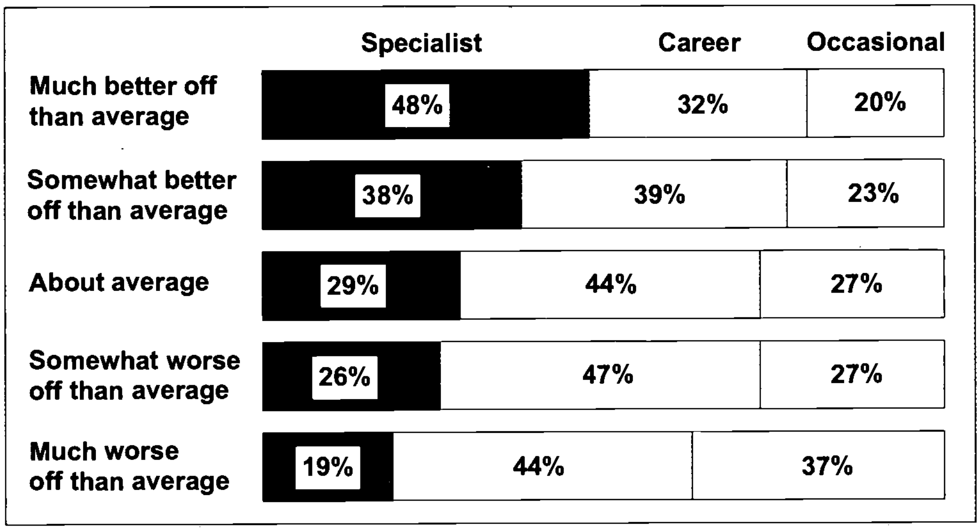
Percent of teachers citing problem as serious:	Socioeconomic Profile of School				
	Much better off than average %	Somewhat better off than average %	About average %	Somewhat worse off than average %	Much worse off than average %
Students					
inadequate student mathematical preparation	12	13	16	24	46
students do not think physics is important	9	9	17	25	44
inadequate student reading ability	7	10	10	14	31
Time Pressure					
not enough time to prepare labs	34	27	30	35	44
not enough time to plan lessons	22	18	22	25	26
difficulties in scheduling classes & labs	8	9	13	16	21
Resources and Support					
insufficient funds for equipment & supplies	26	30	42	49	64
inadequate space for lab or lab facilities outmoded	23	22	23	31	37
insufficient administration support or recognition	15	12	9	21	30

*Teacher estimated ranking of school relative to others in local area

Source: 1996-97 AIP High School Physics Teacher Survey

the average for the area, 41% of the physics teachers were able to teach physics exclusively, and for an additional 33% of the teachers, physics constituted at least half of their current teaching load. In the schools where students were described as much worse off than their counterparts in that area, only 7% of physics teachers could focus exclusively on physics, and only 14% more could count physics as their main assignment during the survey year. For the other four-fifths, the bulk of their current

Figure 14. Teacher specialization by socioeconomic profile of school*



*Teacher estimated ranking of school relative to others in local area

Source: 1996-97 AIP High School Physics Teacher Survey

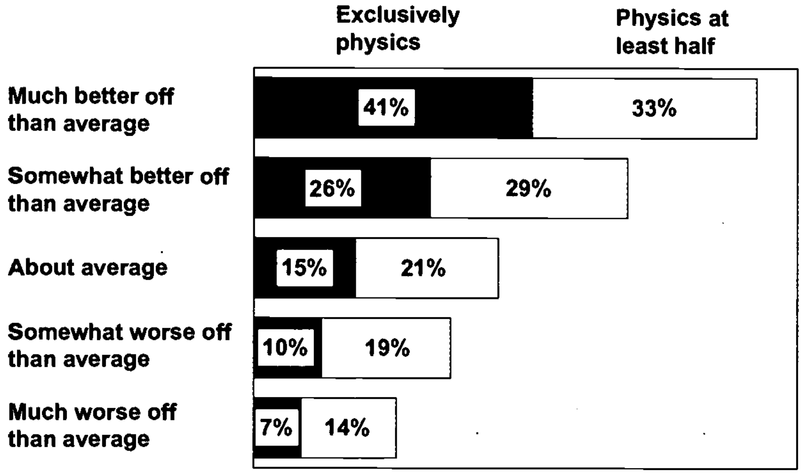
Table 14. Teacher preparation by socioeconomic profile of school*

	Socioeconomic Profile of School				
Percent of teachers describing themselves as inadequately prepared in:	**Much better off than average %**	**Somewhat better off than average %**	**About average %**	**Somewhat worse off than average %**	**Much worse off than average %**
use of computers in physics instruction and labs	30	36	49	49	52
recent developments in physics	24	32	37	37	42
instructional laboratory design & demonstration	7	9	17	18	24
other science knowledge	4	3	5	4	5
application of physics to everyday experiences	3	6	7	13	17
basic physics knowledge	1	0	3	1	4

*Teacher estimated ranking of school relative to others in local area

Source: 1996-97 AIP High School Physics Teacher Survey

Figure 15. Teacher concentration in physics for current year by socioeconomic profile of school*



*Teacher estimated ranking of school relative to others in local area

Source: 1996-97 AIP High School Physics Teacher Survey

teaching load lay outside of physics entirely (see **Figure 15**).

Clearly, these circumstances tend to make it less likely that teachers at the poorer schools would have as much time, energy, background, or inclination as their more favorably-placed colleagues to maintain or improve their physics programs. Of course, there are exceptional teachers who are able to establish and maintain outstanding programs in the face of the most daunting obstacles, to the great benefit of their students. But the conditions just described mean that, even in the relatively restricted confines of high school physics, there is essentially a two-tiered education system. The upper tier does a creditable job of offering science-oriented and academically well-prepared students an introduction to physics. The lower tier, in contrast, faces all sorts of impediments, including teachers who have less preparation specifically in physics and have far less opportunity to focus on the subject. At the same time, these teachers find themselves working in substandard facilities with less funding for labs and other supplies, all the while trying to communicate the basics of physics to students with poorer academic skills and less of a sense of the importance of the subject for their lives.

VI. OUTLOOK FOR A NEW MILLENNIUM

As the previous sections have demonstrated, the last decade of the twentieth century has witnessed undeniable progress in a number of respects towards the goal of more widespread high school physics instruction in the United States. Overall enrollments have grown by a substantial amount, with the proportion of high school students taking a physics course increasing from 20% to 28% in ten years. Growth has been especially strong at either end of the physics curriculum spectrum. Among students with the strongest mathematics background, the proportion taking advanced placement or second year physics has doubled. And among students with less-developed math skills, including many who previously would probably not have dared to attempt the traditional algebra/trigonometry-based introductory course, the increase has been even more rapid, as evidenced by the more than doubling in enrollments for "conceptual" physics classes. At the same time, the long-established disparity in the proportions of young men and women taking high school physics seems to be evaporating, with nearly equal fractions of both now enrolled in the first-year introductory course. Progress can also be seen in an array of new course designs and laboratory tools, incorporating the latest in educational technology and pedagogical research.

But these new advances do not by any means guarantee long term success. Over the years, there have been numerous and imaginative attempts to develop innovative physics courses. However, one of the biggest problems has been to sustain these new efforts to the point where teachers and education researchers can begin to discriminate between the successes and the failures based on real experience. Ironically, the pace at which initiatives have supplanted each other allows little chance for thorough comparison and real evaluation. Some responding teachers have complained that the dizzying flow of new approaches, in some cases designed by people with little high school classroom experience, has made them suspicious of any innovation, even when they feel that change is warranted. As one veteran teacher, commenting in an Internet discussion group on repeated attempts to introduce new physics courses at her school over the years, concluded: "When the funding for curriculum writing and teacher training dried up, so did the reform."

As a result, despite their intrinsic promise, all of the new approaches taken together still have a long way to go to overcome the underlying obstacles that continue to plague high school physics education in this country. Chief among these is the vicious circle set in motion by the historically low enrollment itself. Physics is still the least widely-taken of all the major high school sciences, with enrollment levels about half those of chemistry, the next most popular subject. Even more, barely more than 1% of all high school seniors take two years of physics in high school. These low enrollments help to reinforce the widely-held view that physics is an intrinsically "hard" subject, suitable only for the most academically-able students. The stronger this reputation, the more likely it serves to keep still more students from even trying physics. Given the impact of broader historical enrollment patterns and traditional stereotypes in the minds of parents, teachers, advisors, and the students themselves, this may in turn help to explain the persistent paucity of women in advanced physics classes and of minority and working class students in any type of physics course.

The pattern of low enrollment in high school physics impacts prospective teachers as well as potential students. For one thing, as noted earlier, it constrains the number of teachers who can count on concentrating in the field in their teaching assignments, which probably limits the number of teachers-in-training who are willing to specialize in the subject. Among other things, this in turn likely reduces the "clout" that the physics teacher corps at each school can muster when it comes time for allocation of funds for lab facilities, equipment, and supplies. Low enrollments also reduce the market for textbooks in the discipline, which may dampen the willingness of publishing companies to develop new materials, creating a penchant towards texts that are traditional in approach and overstuffed in content to "fit" the broadest possible market. Low enrollments also limit the variety of physics course types that any one school can offer, with the vast majority of schools fielding only the "plain vanilla" regular introductory course using algebra and a bit of trigonometry.

Fewer teachers specializing in physics means fewer teachers maintaining membership in the American Association of Physics Teachers and similar professional groups. As has been consistently demonstrated in prior AIP surveys over the past decade, this means fewer teachers plugged into the networks that help them keep up with new developments in physics and physics education. And that inability to stay current creates still more barriers to widespread implementation of new approaches and course designs.

These same low enrollments turn out to be the key for understanding another set of findings that has received tremendous attention in recent months – the apparently atrocious performance of U.S. high school seniors on the physics test administered as part of the Third International Mathematics and Science Study (TIMSS), conducted in 1995 with findings released in 1998. While many analysts have argued that these results reveal woeful lacks in our students' motivation or readiness to learn, or in the skill or competence of our teachers, data from the AIP survey suggest a very different story. The findings explored here make it clear that the real culprit is neither students nor teachers, but rather simply the extent to

Table 15. Students currently enrolled in their second year of physics

Course	Total course enrollment	% in 2nd year of physics	Number of students in 2nd-year physics
AP-B	36,000	34%	12,000
AP-C	17,000	70%	12,000
Second year non-AP	9,000	100%	9,000
			33,000†

† equals 4% of 807,000 students taking physics and 1.2% of 2,800,000 seniors

Source: 1996-97 AIP High School Physics Teacher Survey

which our nation's high school students are exposed to physics in the first place.

The explanation for this statement is related to the fact that behind the test score numbers for different countries lie major differences in educational systems and curriculum structures. As we have demonstrated elsewhere (Neuschatz, 1999), the reality is that, in many European and Asian countries, most — in some cases virtually all — secondary students take the equivalent of *at least* one full year of a course devoted to physics by the time they graduate, although this may be spread over a number of years of instruction. In this country, the comparable fraction, as shown at the outset of this report, has only recently reached one-fourth.[4]

What is even more critical to understanding the TIMSS results is that, in the countries that performed best on the TIMSS physics test, most or all of the advanced science students that took the exam had taken the equivalent of at least *two full years of physics courses* by that time. The same was true for only *one in twenty-five* of the U.S. students taking that same test (see **Table 15**). Such curricular differences have a profound impact on the test results, making them far less useful for accurately gauging comparative student performance.[5]

While these differences in the test-takers make us skeptical of the conclusions being drawn from the TIMSS physics results, we have absolutely no quarrel with the TIMSS test itself, which seems to be a well-conceived and effective instrument for measuring how well students "think in physics" and apply physics concepts in real world contexts, as opposed to how well they remember formulae or manipulate equations. Moreover, the TIMSS designers went to great pains to gather a profusion of important background data on the students, their teachers, and their school environment. It is doubly unfortunate, then, that they neglected to ask the critical question regarding how many years of secondary-level physics study the students had taken. As a result, all that can really be concluded is that, relative to test-takers from the best-performing countries, a substantial but indeterminable part of the explanation for our students' poor showing on the TIMSS physics test relates to their typically lower exposure to secondary-level physics study.[6]

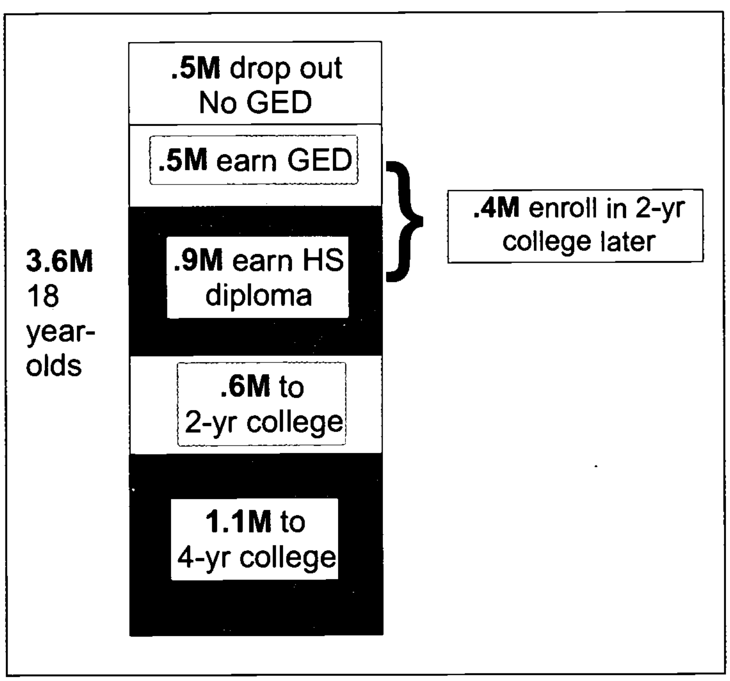
Is there any suggestion of where the U.S. would have placed in the "standings" if students with comparable physics backgrounds had been tested? While full confirmation is impossible with available data, the performance of AP physics students on the TIMSS physics test, along with the results from the prior international test conducted a decade earlier, which included only AP students in the U.S. physics sample, suggest that our students would have ranked neither at the top nor at the bottom, but rather somewhere in the middle, close to the global average. This may not be the "first in the world" showing that the President and state Governors had been seeking, but it probably would not have been depicted as shameful, either. Perhaps, then, attention in this country might have been shifted from the relatively small differences in overall averages between nations to the far more noteworthy result of how small was the percentage of students consistently that consistently answered the physics questions correctly. What was most astonishing was how low this fraction was for *any* of participating countries, even those that ranked highest. Given the apparent careful design of the questions, this raises questions about the efficacy of secondary-level physics instruction everywhere.

But most of the publicity about the TIMSS study has focused on the national standings, and, in this country, on the seemingly dismal performance of our physics students. Blame has been apportioned on all sides, focusing especially on poorly trained teachers, unmotivated and unprepared students, and badly-designed, superficial courses and textbooks. Many of these charges undoubtedly have some justification, and even an average ranking in the global standards would indicate plenty of room for improvement. But the erroneous conclusion that the various nations' performances are comparable and valid on their face has had the unfortunate effect of making many observers miss the most important factor responsible for our low standing. Our prime shortcoming is not the poor job that is done when physics is taught, but rather the fact that so few students take it, and that fewer still get beyond the basic introduction.

The fact that only a slice of our student population takes high school physics, and that only a sliver takes an intensive course sequence, leads naturally to the issue of patterns in who enrolls and who does not. As we tried to show in earlier sections, we can discern differences by race and by the average social class standing of a school's student body — although the latter reveals only the tip of the iceberg, since our data can not address relationships between social class and physics taking *within* each school. By adding in data from other AIP surveys of physics education at other levels, along with information gathered by the National Science Foundation and the U.S. Department of Education, we can begin to get a sense of the broad outlines of the system of physics education as a whole. That sense helps to clarify the differences brought out by the examination of the TIMSS results.

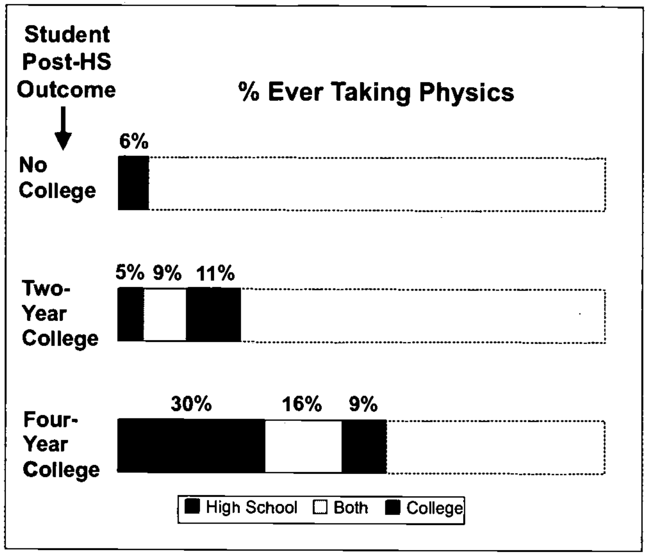
The clearest way to show these differences is to divide the high school age population into three roughly equal parts. Out of a total of roughly 3,600,000 18 year-olds in the United States in 1997, **Figure 16** identifies approximately 1,100,000 who go directly on to four-year college or university. Another 600,000 matriculate immediately into two-year colleges, eventually joined by 400,000 who did not go on immediately to college. (A far smaller group wait a year or more and then enroll as freshmen in four year schools.) Almost all of the four-year college students start out attending full-time. On the other hand, a sizable fraction of two-year college students enters as part-time students, most holding down a job in addition, with that proportion growing to a majority among those making it past the first year.

Figure 16. Immediate high school outcomes for students in the late 1990s



Sources: U.S. Department of Education- NCES, *Digest of Education Statistics*, 1996:108, 110 & 115 1997:191 & 424; NCES, National Education Longitudinal Study, Third Follow-Up, 1994:Unpublished Data; American Council on Education, *The American Freshman*, 1996:13

Figure 17. Estimated exposure to introductory physics in high school and college (by post-high school outcome)



Sources: US Department of Education - NCES, *Digest of Education Statistics*, 1996:108, 110 & 115, 1997:191 & 424; NCES, National Education Longitudinal Study, Third Follow-Up, 1994: Unpublished Data; American Council on Education, *The American Freshman*, 1996:13; 1996 AIP Two-Year College Physics Study, 1996-97 AIP High School Physics Teacher Survey, 1999 AIP Enrollments and Degrees Survey

The third group includes students who graduate with a high school diploma but do not go on to college, along with almost a million high school dropouts, half of whom eventually earn a General Equivalency Diploma in lieu of high school graduation. In **Figure 17**, we combine data from a number of sources, including decade-long longitudinal studies of student outcomes conducted by the U.S. Department of Education, to estimate the percentage of students from each group who take a physics course at some point in their academic career. Of course, combining data from different studies is a very risky business, and despite all efforts to align the measures, these must be viewed as only very rough first estimates. Bearing this in mind, the results for the four-year college entrants are not too bad — almost 50% take introductory physics in high school, and another 9% take it for the first time in college. Clearly, the U.S. educational system has achieved some success in introducing physics to its academically most successful students, although, as the preceding discussion on TIMSS makes clear, we do poorer in this regard than many other developed countries, and we do even worse at providing intensive physics study at the secondary level to the science-oriented among this college-bound group.

However, it is among the other two groups that the shortcomings of our system really emerge. In many developed European and Asian nations, students who are on a vocational/technical track, as opposed to an academic track leading to university studies, are generally given the equivalent of at least a one year's course in introductory physics as an integral part of their science curriculum. Their counterparts in our system — mostly students heading to two-year colleges — only rarely get even one year of physics in high school, and only a small fraction of students makes up for this by taking college physics at their two-year school. (A tiny additional number will take physics after transferring to a four-year program.) All told, only a fourth of these students will have had a course in physics by the time they complete their formal education. It is about this category of students that employers often complain, decrying their poor mathematics and science preparation as inadequate to the demands of the technical positions they are asked to fill.

An even more dismal picture emerges from the final group, even if we restrict it to only those students who graduate high school or earn a GED. While the math background of these students may preclude them from taking one of the more demanding physics courses, fewer than one in fifteen take even so much as a conceptual physics class in high school. Moreover, students in this category do not have the opportunity to make up for this by taking introductory physics in college.

While these students may not be headed for jobs that require an understanding of physics to succeed, this in no way means that physics will not enter their lives. There are many ways in which they have as much to gain from a basic understanding of the workings of the physical world that surrounds them as their more academically successful classmates. In addition to helping to foster better informed voters and citizens, such knowledge can aid consumers in making wiser decisions in purchasing and using tools and household equipment. Perhaps most important, it can help each individual by nourishing a greater sense of understanding and power with regard to their physical surroundings. Up until now, these benefits were enjoyed by only a small fraction of our school age population. It is here that the potential is greatest for transforming "physics for everyone" from just another slogan into a meaningful element of a forward-looking educational approach for at least the opening years of the new millennium.

END NOTES

1. 5% of teachers were removed from salary analysis because they taught part-time or received room and/or board or a "religious salary."

2. The Education Department measure was available only for public schools, and even so was missing for schools from nine states, which contained 19% of all public high schools. In our own analysis that follows we also excluded private schools, because these schools' selectivity and less well-defined neighborhood catchment areas made socioeconomic ranking far less meaningful.

3. Unfortunately, this has been very difficult to make manifest. Many previous attempts to use surveys of individual students to explore these class differences (for example, in the High School and Beyond study) have confronted daunting methodological problems, including a lack of reliable student reports on family economic circumstances.

4. Not included in any of these figures is the enrollment in the standard physical science course, combining physics, chemistry, and occasionally earth science, which is taken by most younger students both in this country and abroad.

5. While it is beyond the purview of this study, there are indications that similar considerations of non-parallel student samples limit the usefulness of comparisons based on the TIMSS advanced mathematics and 12th grade general science and mathematics literacy tests, as well. For example, only half of the U.S. students taking the advanced mathematics test were taking calculus, with the other half mainly taking pre-calculus. On the other hand, virtually all the math test takers from many of the high-performing countries that provided course information (for example, Sweden and Denmark) were enrolled in their education system's most advanced math courses which by all indications equals or exceeds an introductory calculus course. Not surprisingly, when we restrict the U.S. group to only that half taking calculus in 12th grade (or even more, to the third taking AP calculus), our country's ranking rises from the bottom of the heap to smack in the middle. (See, for example, Mid-Atlantic Eisenhower Consortium, 1998:46-47.)

When we turn to the general science and mathematics literacy test results, the biggest problem is that the average age and years of schooling for students from the top-ranked nations were notably higher than they were for the U.S. students taking the test, with the difference being substantial enough to plausibly account for much of the discrepancy in scores. Despite energetic attempts by the U.S. Commissioner of Education Statistics to minimize the issue (see Forgione,1998:1-2), even the National Center for Education Statistics is forced to acknowledge that age differences played an important role in explaining contrasts in national performances on the general science and math literacy test (NCES, 1998:Chapter 4, p. 8-9).

It is worth noting that ages were far less discrepant on the 8th, and still less on the 4th, grade tests, which, as the names implied, were tied to a specific grade level rather than to the less-precise "end of secondary education." This means that these tests offer a far more reliable basis for comparing nations, and here the U.S. showed up around the middle of the rankings, not at the bottom. By the same token, comparisons that point to the relative change in rankings from one grade level to the next are useless unless they take into account the relative years of study between the tests. Needless to say, the NCES found that countries with the greatest number of intervening years (because they extended secondary education the furthest) tended to have the greatest improvement in their rankings, while countries like the U.S. with the fewest intervening years generally had the greatest declines.

6. Even more unfortunately, as mentioned earlier, this is not information that can be reliably derived for U.S. students from items that were included in the TIMSS background questionnaire, such as the name of the most advanced physics course taken to date. Indeed, this would have still been the case even if the distinction had been made between the two levels of Advanced Placement physics courses, which the TIMSS background questionnaire also neglected to do. For as we pointed out above, even half of all AP students, and a third of those taking the calculus-based AP-C course, are taking their first course in physics.

APPENDIX A: ADDITIONAL TABLES OF FINDINGS

Table A-1. Teacher characteristics in all four survey years

	1997	1993	1990	1987
Number of physics teachers	3548	3374	3341	3301
Response rate (%)	76	73	70	75
Median age (years)	44	43	43	41
Median years teaching physics	8	11	9	8
Years teaching secondary school (%)				
1-5	27	19	19	18
6-10	18	17	15	15
11-20	24	27	33	40
21+	31	37	34	27
AAPT membership (%)	25	29	26	24
Any physics degree (%)	33	29	27	26
in physics (%)	22	18	19	—
in physics education (but not physics) (%)	11	11	8	—
Degree level (%)				
Bachelor's	42	38	38	37
Master's	54	58	58	59
Doctorate	4	4	4	4
% Female	25	23	22	23
Type of school (%)				
Public	82	81	83	82
Secular private	5	5	5	6
Mainstream religious	9	10	9	9
Fundamentalist	4	4	3	3

Source: 1986-97, 1989-90, 1992-93 & 1996-97 AIP High School Physics Teacher Survey

Table A-2. General characteristics: physics programs

	Percentage of all schools	Percentage of all enrolled students
Physics offered:		
Every year	76	94
Alternate years	16	4
Rarely or never	8	2
Schools not offering physics this year	16	4
Schools offering AP / 2nd year physics	18	29
Schools where half or more of physics teachers are specialists	33	44

Source: 1996-97 AIP High School Physics Teacher Survey

Table A-3. School characteristics and physics program by school type

	Public (79%)	**Secular Private** (5%)	**"Mainstream" religious** (8%)	**Fundamen-talist** (8%)
Median size of senior class	120	40	84	12
% physics offered:				
Every year	79	75	91	34
Alternate years	15	8	7	36
Rarely or never	6	18	2	30
% of schools with physics offering single class in physics only	51	42	35	78
% of schools with physics offering advanced physics courses	17	33	16	7
% of students taking physics	26	54	49	32
Median funds available per physics class	$250	$500	$350	$400
% where half or more teachers are physics specialists	33	46	35	24
Median salary of physics teacher	$34,500	$30,300	$28,000	$23,200

Source: 1996-97 AIP High School Physics Teacher Survey

Table A-4. Characteristics of physics program by size of senior class

	1-49	50-199	200-299	300-499	500+
% of schools offering physics:					
Every year	41	88	98	99	100
Alternating years	38	8	2	1	0
Never	21	4	0	0	0
Number of physics classes (at schools with physics in 1997)					
1	83%	55%	25%	10%	4%
2	11	23	24	17	9
3	2	10	21	16	14
4 or more	4	12	30	57	73
% of schools with physics offering advanced physics courses	7	13	25	38	55
% of students taking physics	30	27	27	28	28
% of physics students who are members of underrepresented minority groups	5	11	16	20	24
Number of physics teachers					
0	40%	8%	1%	0%	0%
1	59	85	76	61	38
2 or more	1	7	23	39	62
% of schools where half or more teachers are physics specialists	19	30	44	50	64
Median salary of physics teachers at school	$27,000	$33,000	$37,000	$39,100	$42,000

Source: 1996-97 AIP High School Physics Teacher Survey

Table A-5. Selected school characteristics by geographic region

	North-east	Middle Atlantic	South Atlantic	East north central	East south central	West north central	West south central	Moun-tain	Pacific
% of schools	5	13	13	18	7	14	13	6	11
% of schools in rural setting	43	41	42	52	59	77	61	63	35
Median seniors	127	120	145	103	90	53	60	67	116
% of students taking physics	37	37	27	30	21	26	24	24	22
% of schools with physics offering AP/2nd yr physics	28	24	26	15	11	8	19	13	18
Median salary for physics teachers ($000)	39.0	44.3	31.0	38.0	29.5	30.0	28.8	32.0	39.0

Source: 1996-97 AIP High School Physics Teacher Survey

Table A-6. School characteristics by metropolitan setting (public schools only)

	Central city of large metro area	Suburbs of large metro area	Smaller metro area	Small city/large town	Rural
% of schools	8%	13%	8%	11%	60%
Median seniors	275	285	285	225	68
% of students taking physics	26	32	25	25	22
% of physics students who are minority	39	14	16	11	6
Median salary for physics teacher	$38,500	$44,000	$38,000	$35,000	$31,500
% of schools offering physics in 1997	97	96	93	94	81
Number of physics classes offered this year (at physics offering schools)					
1	23%	13%	20%	33%	71%
2 or more	77	87	80	67	29

Source: 1996-97 AIP High School Physics Teacher Survey

Table A-7. School characteristics by metropolitan setting (private schools only)

	Central city of large metro area	Suburbs of large metro area	Smaller metro area	Small city/large town	Rural
% of schools	25	19	16	15	25
Median seniors	60	56	49	26	15
% of students taking physics	51	54	43	42	39
% of physics students who are minority	14	11	6	6	5
Median salary for physics teacher	$32,000	$29,000	$27,000	$23,200	$25,000
% of schools offering physics in 1997	85	80	83	71	64
Number of physics classes offered this year (at physics offering schools)					
1	32%	37%	42%	62%	71%
2 or more	68	63	58	38	29

Source: 1996-97 AIP High School Physics Teacher Survey

APPENDIX B. SURVEY METHODOLOGY

The 1996-97 Nationwide Survey of High School Physics Teachers is the fourth in a series of studies begun by the American Institute of Physics in the mid-1980s, in response to concern both nationwide and within the physics community over the state of physics education in our nation's schools. The initial round of the survey was undertaken during the 1986-87 school year, with subsequent surveys in 1989-90 and 1992-93. The findings of all three studies were discussed in final reports (*Physics in the High Schools I & II* and *Overcoming Inertia: High School Physics in the 1990s*) which, along with a number of shorter auxiliary reports and articles, are available from the American Institute of Physics.

For the fourth round, conducted during the 1996-97 academic year, we contacted the same stratified sample of over 3,000 high schools selected in 1986, and the names of all teachers with physics class assignments for the survey year were obtained from the school principal. That original sample had been drawn from what was felt to be the most complete listing available of all U.S. schools, both public and private, with a twelfth grade. The list, obtained from the private research firm of Quality Education Data, Inc. (QED) and containing names, addresses and background data of some 21,720 public and private schools, has been used both in the Departments of Education's 1987-88 Schools and Staffing Survey as well as in the National Science Foundation-sponsored national surveys of science and math education in 1986 and 1993.

This database was then stratified by school size and religious affiliation so that parochial and very large public schools could be oversampled and small public and private schools could be undersampled. Numerous attempts have been made to check the completeness and accuracy of that listing, as well as to compare findings with those from studies whose cases were selected from other sources. In almost all instances, we found close agreement across a broad array of measures.

Schools that had closed or consolidated during the interim were removed from the sample. (See discussion below.) The participation rate for schools remaining in the sample exceeded 99% in 1996-97 as it had in the prior two rounds. Principals were asked for the names of physics teachers at their school, along with the current number of seniors and several other questions. New to this year was a question asking whether the rules for hiring science teachers had been changed in recent years to encourage applicants with more science background but fewer education credits, and whether or not any new physics teachers had been hired under these new rules. Schools without physics programs were also probed as to why physics was not part of their curriculum.

Each physics teacher named was then sent an eight-page questionnaire designed to further explore issues investigated in previous rounds of the survey as well as to track changes in physics programs and courses since the last round. Where possible, items from earlier surveys were preserved in order to test reliability, or where appropriate, to register possible changes. Alternatively, some questions were refined in order to sharpen their focus or correct interpretation problems encountered in the earlier studies.

The longitudinal nature of the study helps clarify certain data points, as we have revisited the physics program at a high proportion of sample schools. Moreover, in the second round, the addition of chemistry teachers provided some school-level information for schools where no physics was taught or no physics teachers responded. In the third round, by asking additional questions of principals, all of whom participated in the survey, we were able to enhance our picture of all schools, including those where physics is not offered.

In the fourth round, for the first time, each teacher was asked to give the total number of students taking physics at their school, allowing a more accurate calculation of overall physics enrollments in multi-teacher schools, even if only one teacher responds. Additional questions in the most recent survey addressed student preparation to take physics, changes to the physics program, availability of recently-developed equipment and instructional technology, specific types of professional activity, and the aspects of work having the greatest impact on job satisfaction.

Sources of Error

In a study of this type there are many sources of potential error, ranging from an incomplete population list to sampling error, response bias, poorly worded questions, coding mistakes, and data entry error. While the error attributable to some of these sources can be estimated with a fairly high degree of precision, error from other sources can be estimated in only the most general way, and the magnitude of still other error components remains virtually impossible to estimate.

Problems with the List

The first source of potential error mentioned above involves the completeness and accuracy of the original list. The primary concern is that it contain every member of the target population and no other. As mentioned earlier, we began with an independently developed listing that is generally highly regarded. For a discussion of the accuracy of the list, in particular for private schools, see Appendix A of "Physics in the High Schools II."

A second source of error in studies like this one with a longitudinal component is the degradation of coverage in successive rounds. In our study, schools that closed or merged since the first round present little problem, since such closures among sample schools can be assumed to more-or-less accurately mirror events going on in the larger population. As it happens, there were 253 schools which closed between 1987 and 1992, and another 67 between 1992 and 1996, for a total of nearly 10% of the original sample.

Despite their large numbers, these closed schools tend to be concentrated among the smallest schools as well as among fundamentalist religious institutions, both groups of schools where physics is less likely to be offered. All the sample schools which closed between the first and fourth rounds of the study combined represent only about 3% of the student enrollment from our original sample. Nearly half of the schools had fewer than ten seniors in their graduating class and more than half had not offered physics classes at all. The combined proportion of seniors at closed schools where physics was known to be, or likely to be, offered is estimated at little more than 2% of the national total.

Schools newly opened since the original list was assembled are another story altogether, since these changes cannot be reflected in a sample selected in the past. In order to gauge the extent of this problem, we obtained lists of such schools from QED covering the first three-year interval, based upon QED's own annual updating of the files, and analyzed those lists to estimate our loss of coverage from 1987 to 1990. From this effort, we estimate our loss of coverage by not including those newly opened schools at less than .5% of all the seniors enrolled at the schools in our original list.

This low percentage is not surprising, considering that the three-year interval in question fell towards the end of a long period of declining high school enrollments, a time when one would expect relatively few new schools to open. Given the overhang of "excess physical capacity" and tight budgetary conditions across the country, it is likely that only localities experiencing extreme population growth would open new public schools.

Moreover, the newly-opened schools on QED's list were disproportionately concentrated among the smallest schools and among fundamentalist religious private schools, precisely the schools that are less likely to offer physics. Using our 1986-87 data as a rough guide, we therefore estimated that our actual loss of coverage of physics students due to not including newly-opened schools in the 1990 survey was even smaller, on the order of .25%. We anticipated a similar additional overage gap for the third round in 1993. Unfortunately, QED no longer separates its list of newly opened schools in a manner that would have allowed us to run similar analysis for schools opened since 1990.

1990 and 1993 demarcated the trough of the demographic "baby bust" that reduced the number of seniors in our nation's high schools. By 1997, that number had climbed significantly — almost 10% — roughly reaching the point where it had stood ten years earlier. This probably implied a significant worsening of our "coverage gap" this past round, since the pace of opening new high schools, and reorganizing old ones, is likely to have increased. Our next survey, projected for the year 2001 will be based on a new sample, but will also include a subgroup of our first sample, in part to allow us to estimate the size of our previous coverage loss.

Teacher Response Bias

One major source of error that can lead to a distorted picture in studies such as ours is response bias, resulting from systematic differences in relevant characteristics between those who responded to our survey and those who did not. Twenty-four percent (23% unweighted) of the teachers in our sample did not complete the questionnaire in 1997. We can use ancillary sources of data to gain insight into teachers who did not respond in this round, allowing us to roughly gauge the potential magnitude and effect of response bias.

Supplementary data sources, including earlier rounds of our own survey, contain information on the educational surroundings, personal background and current attitudes of many non-responding as well as responding teachers. On many school-level variables, describing the academic environment in which teachers work, we have data on virtually all sample teachers, both responders and non-responders. The information about schools was gathered from the original population database obtained from QED, as well as from teachers responding in previous rounds and from school principals.

Overall, we have heard from a substantial proportion of both our school and teacher sample, as shown in **Tables B-1** and **B-2**. While our participation rate for principals is 100%, as mentioned earlier, this provides only limited information on physics programs or physics teachers. However, due to the longitudinal character of the study, we have heard from at least one teacher at 93% of the sample schools offering physics in at least one round of our study, and these schools contain 96% of all high school students in the nation. For sample schools offering physics every year, the number we have heard from at least once rises to 98%.

When we restrict ourselves just to schools consistently offering physics, we have over the past decades heard from at least one physics teacher at 98% of them. We also have information on a high proportion of the teachers in this year's sample. While we heard from 76% this year, when we augment our 1997 responders with those who answered in at

Table B-1. Types of information available for 1997 school sample	
	% of schools with known characteristics
General characteristics of schools from QED or reported by principal	100
Description of current physics program and faculty at schools offering physics, from 1997 teacher respondents	78
Description of physics program and faculty at schools offering physics, from teacher respondents in any round	93

Source: 1996-97 AIP High School Physics Teacher Survey

Table B-2. Types of information available for 1997 physics teacher sample	
	% with known characteristics
School background information for teachers in the study:	
Characteristics of teacher's school derived from QED file or principal response	100
Current characteristics of physics program derived from 1997 responses, including from colleagues at school	82
Long-term characteristics of physics program derived from teacher responses during any round	96
Information of personal characteristics of teachers:	
Current & changeable personal characteristics, derived from 1997 response	76
Permanent or long-term personal characteristics, derived from response in any round	84
Gender, imputed from name or prior response to survey	99

Source: 1996-97 AIP High School Physics Teacher Survey

least one of the three previous rounds, we have heard at some point in the last ten years from 84% of those teaching high school physics in the U.S. in 1997. While this may not add to anything to our picture of teachers' current conditions and attitudes, it can help to fill in our knowledge of their background.

As **Table B-3** shows, a wide-ranging probe of this year's data revealed a few school-level differences between responders and non-responders. Among those that

Table B-3. Response rates for teachers by school background characteristics

	Respondents (2721)	Non-Respondents (827)
School Type †	%	%
Public	77	23
Secular Private	73	27
Mainstream religious	77	23
Fundamentalist	59	41
Setting		
Central city of large metropolitan area	71	29
Suburbs of large metropolitan area	78	22
Small metropolitan area	76	24
Small city/large town	77	23
Small town/rural	77	23
Region †		
South	72	28
North + West	77	23
Grade Range †		
Senior high	77	23
Jr/Sr high	75	25
K-12	72	28
Physics Offered †		
Every year	77	23
Alternate years	70	30
Teachers at school		
One teacher	76	24
Two or more	77	23

Source: 1996-97 AIP High School Physics Teacher Survey

† Response rates significantly different at the .05 confidence level

were found were a substantially lower response rate among teachers at fundamentalist schools and a slightly lower response from teachers at Southern schools, at schools that teach physics in alternate years, and at schools that teach kindergarten through twelfth grade. No statistically significant differences were found between respondents and non-respondents in terms of geographic setting or the number of teachers at the school.

In trying to account for the significant differences, we should note that schools offering physics in alternate years almost by definition are less likely to have a regular physics teacher. Thus, the teacher currently assigned to teach physics may feel less inclined to respond to a survey specifically devoted to that subject. A similar circumstance may account for the lower response rate at fundamentalist religious schools. Moreover, that underresponse, consistent in all four rounds, has a small impact on our overall findings, simply because of the small percentage (around 1%) of the nation's high school students attending such schools. Similarly, schools that offer kindergarten through twelfth grade and schools in the South may have a lower response because of the overrepresentation of fundamentalist and secular private schools in their ranks.

Many, but not all, of the findings displayed in **Table B-3** are consistent with response rate differences found in earlier years. In 1993, while considering school characteristics, we found lower response rates among teachers at fundamental religious schools (and at private schools in general), at Southern schools, and schools with two or more teachers. In general, given the vast array of possible differences, response rate discrepancies by school background characteristics have been few and relatively muted throughout all the rounds of this study.

Equally critical in understanding response biases are possible contrasts in individual attributes between teachers who responded and those who did not. **Table B-4** looks at response rates by personal characteristics known for the entire sample. Teachers who were new to the study had a lower response rate than those with previous survey involvement. This can be attributed to the fact that many of these teachers are not set in their careers and may not feel as "plugged in" to physics as those who have been teaching physics for several years. No significant differences in response were found by gender.

Table B-4. Response rates by personal characteristics known or imputed for entire 1997 sample

	Respondents	Non-respondents
Gender (%)		
Female	78	22
Male	76	24
Previous survey involvement † (%)		
In study before	78	22
New to study	73	27

Source: AIP 1996-97 High School Physics Teacher Survey

† Response rates significantly different at the .05 confidence level

Other personal characteristics of respondents and non-respondents were impossible to compare directly because there is no current information for non-respondents. The longitudinal character of the study does permit an indirect comparison that includes a subset of non-responders, namely those who had been in the sample and had responded in earlier rounds. Of course, there is no guarantee that findings for this subset are generalizable to all 1997 non-responders, but the analysis does provide us some critical personal data for a significant portion of this group and supports a weaker argument that those who responded some of the time have attributes that fall somewhere between those who always participated and those who never responded.

In 1993, when we performed a similar analysis of personal characteristics of teachers, we found that non-respondents who had responded in 1990 were less likely to hold graduate degrees, were less likely to be AAPT members, and were more likely to say that insufficient funding for equipment and supplies was a serious problem for them. For 1997, (see **Table B-5**) the only significant difference we could find was in the percentage of teachers who had previously said that insufficient funding for

Table B-5. Comparison of respondents and non-respondents in 1997 on the basis of personal information supplied in 1993

	Respondents (1232)	**Non-Respondents** (210)
Median years teaching	18	14
Median years at school	10	10
Median years teaching physics	10	8
Median age	44	44
Median salary	$33,000	$30,000
Median % of seniors who take physics at school	26	25
% who would not again choose teaching as a career	21	24
% female	20	17
% with graduate degrees	64	59
% with physics or physics education degrees	32	27
% at schools with 2 or more teachers	26	25
% who are AAPT members	32	26
% planning to stay until retirement	86	85
% who say that insufficient funding for equipment & supplies is a serious problem †	34	46
% who consider physics their specialty	45	40
% who are:		
specialists	29	24
career teachers	43	46
occasional teachers	28	30

Source: 1992-93 & 1996-97 AIP High School Physics Teacher Survey

† Percentages significantly different at the .05 confidence level

equipment and supplies was a serious problem.

The hardest group to examine comprises the teachers who are new to the sample and who decline to respond, since we have no reservoir of prior information about them. To cast more light on this group, we isolated the comparable group of teachers who were new to our study in 1993 and remained in the sample in 1997. We found that nearly two-thirds of those original non-responders did respond on their second chance three years later.

Of course, these responses tell us little about such teachers' circumstances when they were just starting out. And as before, findings for this subset may not be generalizable to the entire group of new teachers who do not respond. Still, it gives us background data for a substantial portion of the group, and we can again resort to the argument by analogy which suggests that, to the extent that response biases are present along given dimensions, those responding some of the time fall somewhere between those who consistently responded and those who never responded. As presented in **Table B-6**, we find no significant differences between the new teachers in 1993 who responded and those who did not.

Overall, there were fewer indications of response bias in this round than in previous rounds, and the few that appeared were quite weak. Coupled with the relatively high response rates, and data for some 1997 non-responders derived from earlier rounds, we would argue that the findings discussed in this report provide a reasonably accurate picture of our sample. However the suggestions of response bias that *were* found, coupled with sampling, poor question wording, and other sources of potential inaccuracies, require that the findings still be interpreted with some caution, and dictate that our results continue to be scrutinized for inconsistencies and compared where possible with findings from similar studies.

Sampling Error

One further source of error which is typically described in great detail is sampling error, the extent to which the sample as selected does not accurately reflect the characteristics of the population from which it was drawn. Despite all the attention usually devoted to it (undoubtedly because of the relative precision with which it can be estimated), sampling error in a large study like this one tends to be only a modest contributor to overall error, compared to other error sources that are more difficult to measure but potentially far more threatening. Nevertheless, especially when considering and comparing smaller subgroups of the sample, sampling error can potentially weigh in strongly and must be taken into account when interpreting findings.

Most of the findings discussed in this report are presented in the form of simple

Table B-6. Comparisons of respondents and non-respondents among teachers new to 1993 sample on the basis of personal information supplied in 1997

	Responded in 1993 (289)	Did not respond in 1993 (73)
Median years teaching	10	9
Median years at school	6	7
Median years teaching physics	7	7
Median age	42	42
Median salary	$32,000	$34,000
Median % of seniors who take physics at school	29	24
% who would not again choose teaching as a career	18	20
% female	26	26
% with graduate degrees	57	53
% with physics or physics education degrees	33	31
% at schools with 2 or more teachers	31	36
% who are AAPT members	30	20
% planning to stay until retirement	83	86
% who say that insufficient funding for equipment & supplies is a serious problem	37	37
% who consider physics their specialty	48	56
% who are:		
specialists	31	31
career teachers	47	53
occasional teachers	21	16

Source: 1992-93 & 1996-97 AIP High School Physics Teacher Survey

proportions of schools or teachers. The estimated size of the sampling error of a proportion for a simple random sample varies with the magnitude of the particular proportion in question and the size of the sample or sub-sample under examination, and is given by the formula:

$$S=\left(\frac{P(1-P)}{n}\right)^{1/2}$$

Where P is the proportion of the sample in a category and n is the sample size.

For example, if we had selected a simple random sample, the estimate of sampling error for our finding that 76% of our sample schools offer physics every year would be given by:

$$S=\left(\frac{.76(1-.76)}{3155}\right)^{1/2}$$

The confidence interval for this estimate is given by $\pm ZS$, where Z is the confidence coefficient. At the 95%

confidence level used in this study, $Z = 1.96$ and the confidence interval for the finding that 76% of the schools offer physics every year would be ±1.5%. In other words, if we drew repeated samples of schools and posed the same question to principals each time, we would expect that 95% of the time we would come up with a proportion offering physics every year that fell within the range of 76% ±1.5%, or 74.5 to 77.5.

The stratified random sampling procedure used here yields error estimates that will vary slightly from those generated by a simple random sampling design and described by the above formula. Stratification prior to sampling by itself generally reduces sampling error slightly, whereas disproportionate sampling of strata tends to heighten it, relative to a proportional sample of the same size (varying, of course, with the degree of disproportionality). Overall, the extent of the differences for the procedure employed here is likely to be quite small. The same holds true for findings involving means, where the 95% confidence interval is defined by $\pm 1.96s/n^{1/2}$, where s is the standard deviation of the distribution. (The finite population correction factor will be negligible due to the relatively large sample and low sampling rate, and has been omitted from the calculations above.) Finally, it should be noted that differences in proportions and means between groups (or lack of differences where large contrasts were expected) were generally made the focus of discussion in the body of the report only when they were substantial, in addition to being merely statistically significant.

The level of sampling error present in our estimates for findings derived from teacher responses is likely to be further compounded by the clustered sampling approach we employed, in which we sampled schools and then took a census of physics teachers at those schools. The increased error, relative to the levels likely if we had been able to sample from a pre-existing list of all physics teachers across the country, derives from the potential effect of a higher degree of homogeneity for many of our key variables among respondents at multi-teacher schools. Since the vast bulk of respondents were the only physics teacher at their school, the overall impact of the heightened homogeneity of responses is likely to be small, but where we focus in our analysis on multi-teacher schools, the impact may be somewhat greater. In addition, there is higher risk of contamination at these schools as well, with teachers having more opportunity to discuss the survey and responses to specific questions with colleagues.

Impact of Incentives on Survey Response Rates

For the first two mail waves, the study was conducted in the same way it had been in earlier years. Teachers were mailed a detailed eight-page questionnaire asking them to describe their personal and academic backgrounds, their teaching experience and current teaching practices and assignment, their school environment, and their attitudes and outlook for the future. For the third mailing wave, sent out in March 1997, teachers who had not yet responded were divided into two groups: an "experimental treatment" group (3a), who received a cash incentive of five dollars with their survey, and a "control group" (3b) who received only the survey with no incentive. For the fourth wave, distributed in April, those in the "control group" who had not responded were further subdivided into three groups: one (4a) receiving a shortened version of the questionnaire, approximately one-third as long as the original; a second (4b) receiving the same shortened version along with a five dollar cash incentive; and a third (4c), the "continuing control group," receiving the original-length questionnaire with no incentive. In addition, those from group 3a (the third wave incentive group) who had not responded were sent the shortened questionnaire but no additional incentive (group 4d).

Table B-7 lists the outcomes for each of the groups in terms of response rates. The response received during the two previous studies, conducted in 1990 and 1993, are also included for comparison purposes. These earlier studies were conducted in largely the same manner, except that the same long form questionnaire was used for all four waves, with a phone call placed to the school just before the final wave, requesting that a note be placed in each non-responding teacher's in-box mentioning the upcoming survey mailing and urging a response.

As can be seen from the table, the response rates for the "non-treatment groups" (1, 2 and 3b) for the first three waves were roughly comparable to what was experienced in earlier rounds of the same survey. (The response rates for the fourth wave from earlier years are not directly comparable, since these involved a phone call treatment, as outlined above.) It is evident that the cash incentive to non-respondents makes quite an impact, for example raising the response rate in the third wave from 14% (group 3b) to 41% (group 3a), an increase of almost 200%.

A strong impact can also be seen in the use of the short form of the questionnaire on the fourth wave, which raised response rates from 6% (group 4c) to 32% (group 4a), an increase of over 400% and an absolute gain of 26 points, comparable to the 27 point boost for the cash incentive noted in the preceding paragraph. Of course, the fact that the two treatments took place during different waves complicates a direct comparison. Nevertheless, given that even those in group 3a were "recalcitrant" non-respondents who had already ignored two mailings, the differences with the three-time refusers of wave four are not likely to be significant enough to invalidate comparison.

Table B-7. Response as a percentage of questionnaires mailed for each wave			
Treatment group	**1997**	**1993**	**1990**
1: Wave 1, full form (1997 N = 3541)	36%	27%	32%
2: Wave 2, full form (2185)	25%	27%	25%
3a: Wave 3, full form + $5 (1127)	41%	—	—
3b: Wave 3, full form (586)	14%	13%	22%
4a: Wave 4, short form only (132)	32%	—	—
4b: Wave 4, short form + $5 (227)	53%	—	—
4c: Wave 4, full form (146)	6%	43%*	25%*
4d: Wave 4, short form (after $5 on Wave 3) (665)	29%	—	—

*Telephone follow-up to schools conducted at the beginning of this wave.

Source: 1989-90, 1992-93 & 1996-97 AIP High School Physics Teacher Survey

Combining the two treatments by offering the incentive *and* reducing the length of the questionnaire (group 4b) produced the largest impact of all, generating a response rate of 53%, an increase over the control group response of nearly 800% and an absolute gain of 47 points. The combination exceeded the simple addition of impacts of the two component treatments, suggesting a small interactive effect from offering the two inducements simultaneously that generated extra response. Finally, offering a shortened form to the group that had already ignored the cash incentive (group 4d) also resulted in a substantial increase in response, to 29%.

Impact of Incentives on Response Bias

The end of the previous section brings up a further issue about the use of incentives on surveys. In addition to impact on response rates, there might be concerns about the impact on respondent profile (and on the parameter estimates developed as a result), if certain incentives were to have a differential impact on different groups of respondents. For example, it might be hypothesized that teachers choose to teach in private schools, where salaries are generally substantially lower, in part because they are less concerned about money, and that therefore monetary incentives would introduce a response bias that would produce an overrepresentation of public school teachers, above and beyond any pre-existing response biases. Similarly, it might be suggested that female teachers are more likely to have burdensome responsibilities at home in addition to their full-time teaching duties, and thus would be relatively more likely to respond to a shortened questionnaire than men.

By comparing the characteristics of our treatment groups to our control groups, we can get a sense of whether sample members who responded to various inducements differ from those who responded without inducements. There are two sets of characteristics for which we can make such comparisons, the set based on information provided by respondents to the questionnaire, and the set based on information derived from other sources, which we generally have for all sample members regardless of response. Each type of comparison offers a number of advantages and disadvantages.

The questionnaire data include a large array of variables. Unfortunately, the experiment was designed primarily to gauge the direct impact of incentives on response rates while trying at the same time to maximize that response. Exploring the characteristics of the respondent groups was only a secondary objective. As a result, control groups were kept relatively small, and this fact, combined with the controls' not-surprising lower response rates, limits the reliability of the distributions for these groups across the multiple categories of many of the key items. This was especially the case for the control group for the fourth and final wave, where the shortened questionnaire version was introduced, making virtually any type of finely-grained comparison inadvisable. The larger size of the third wave control group makes it more feasible to evaluate the impact of monetary incentives on respondent characteristics, but, even here, limited numbers make it prudent to use caution in drawing conclusions by comparing respondents who received incentives to those who did not.

An equally important drawback to making these comparisons is that, since comparable information is not available for non-respondents, we cannot really say, when differences are found, whether the increased response due to incentives brought us closer to the "truth," i.e. to the true distribution for the entire sample, or conversely whether biases in who responds to incentives might have even pushed us further away from the true overall distribution. All we can do is to determine whether differences exist between the two groups — that is, whether we are tapping a different group with the incentives than we are without them.

Bearing these caveats in mind, we did the comparisons for the third wave groups and found few significant differences between responders who answered after receiving a monetary incentive and those who responded without such an incentive. The dimensions along which comparisons were made and no significant differences were found were: years of teaching experience, teaching salary, membership in the American Association of Physics teachers, self-description as a physics teaching specialist, and career satisfaction expressed as a willingness to "do it all over again." In other words, incentives did not seem to bring out a different group of responders than a normal mailing devoid of incentives. Results on a sixth variable, whether the teacher had earned a graduate degree, were ambiguous, with a barely significant difference but complicated by the small size of the control group.

For variables that we were able to secure from other sources, we were, as noted above, able to take the analysis one step farther. Using the information on the entire sample, we could ask more pointedly whether the incentives, besides increasing the response rate, introduced biases that brought the respondent pool relatively closer to or farther from the actual distribution of the sample as a whole. In other words, did we end up with more accurate estimates of overall sample characteristics, or did the added responses skew our picture away from the true distribution by disproportionately including respondents who are less typical of sample members than those who responded without incentives?

To investigate this issue further, we selected the two key analytic variables mentioned earlier, gender and school type, for which we were able to obtain full information, regardless of response. For each wave, we made adjustments to take into account previous differential response, in order to provide a more accurate picture of the available "pool" of *potential* responses for each category on each survey wave.

In terms of results, we found that different forms of incentives (or for that matter the use of incentives at all) had very little impact on either the gender or school type profile of responders. There seemed to be essentially no effect at all as far as school type was concerned. While teachers at public schools were overall slightly more likely to respond than teachers at private schools, this pattern seemed to hold equally whether or not incentives were used, and regardless of whether the incentive took the form of money, a shorter questionnaire, or both together.

When it came to gender, a slight difference in response rate was noticeable. While monetary incentives seemed to have no measurable impact, women appeared slightly more likely to respond to the shorter version of the questionnaire than men. One possible explanation could be the earlier suggestion that female teachers generally find themselves more pressed for time than their male counterparts, and thus are more likely to respond to an effort to limit questionnaire length, although many alternative explanations come to mind as well. Confounding any conclusions, however, is the finding that combining the two incentives seemed to erase the differential impact, returning the gender distribution of response rates to the same proportions they exhibited when no incentives at all were used. In any event, the difference was small, and would require replication in other circumstances to verify. In all this analysis, it needs to be remembered that small sample sizes and the methodological idiosyncrasies of this particular study are likely to complicate generalization to other surveys. For example, as small a detail as the different ordering of the incentives, or their application at a different point in the study, could alter any apparent differential impact (or apparent lack of impact) found here.

Other Errors

Other sources of error are also likely to be present in the survey, and some of these may be as great or greater than the kinds of error already discussed. Such other sources include:

a) Errors arising from poorly worded questionnaire items;

b) errors from poorly constructed or unduly complex questions;

c) errors in interpretation of questions or recall of answers by teacher respondents;

d) errors due to coder carelessness or mistakes in interpretation for both closed-ended and open-ended questionnaire items; and

e) errors in data entry and in statistical computation.

Of course, every effort has been made to double check responses against independent internal and external sources of data wherever possible, and to seek additional clarification or corroboration wherever discrepancies have arisen. For example, listings of physics teachers by principals were compared to teacher reports on the number of colleagues with physics assignments at the school. Any differences prompted a check of other teachers' responses and an immediate phone call to the school. Similar follow-up was undertaken in the case of discrepancies in the estimates of total number of seniors, number of physics classes and students taught by each instructor, and for several other key variables, as well. Other safety measures to guard against error included double entry verification of data, and comparison of entered data to a scattered selection of survey instruments. These tests yielded a data entry error rate well below one-tenth of one percent.

Nevertheless, despite all such efforts, error from all the sources mentioned above is undoubtedly present in the data from which the findings were derived. In most instances, the final accuracy of the answers was impossible to cross-check. Overall error rates can thus never be determined with accuracy, and this requires that all findings be interpreted with suitable caution. While stability of findings among the 1986-87, 1989-90, and 1992-93 studies increases the sense of confidence in a number of the conclusions drawn above, it will take repeated replication in future studies to permit a more accurate measure of the overall reliability of most of the findings discussed in this report. The results of the 1996-97 study have moved us one step further in that direction.

APPENDIX C
STATES GROUPED BY GEOGRAPHIC REGION

New England
Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont

Middle Atlantic
New Jersey
New York
Pennsylvania

South Atlantic
Delaware
Florida
Georgia
Maryland
North Carolina
South Carolina
Virginia
West Virginia
District of Columbia

East North Central
Illinois
Indiana
Michigan
Ohio
Wisconsin

East South Central
Alabama
Kentucky
Mississippi
Tennessee

West North Central
Iowa
Kansas
Minnesota
Missouri
Nebraska
North Dakota

West South Central
Arkansas
Louisiana
Oklahoma
Texas

Mountain
Arizona
Colorado
Idaho
Montana
Nevada
New Mexico
Utah
Wyoming

Pacific
Alaska
California
Hawaii
Oregon
Washington

APPENDIX D: SURVEY INSTRUMENTS

1. Principal query card, sides 1 & 2

2. 8-page physics teacher questionnaire

AMERICAN INSTITUTE OF PHYSICS 1996-97 HIGH SCHOOL PRINCIPAL SURVEY

1. Does your school offer a **separate** course in high school physics this year (1996-97)? Yes ☐ No ☐

If NO, what was the primary reason why not?
☐ 1. We teach it in alternate years
☐ 2. Not an appropriate course for our school
☐ 3. Not enough students want to take it
☐ 4. Enough students, but no qualified teacher
☐ 5. Other ____________________

2. Here is the list of **PHYSICS** teachers' names you provided for us in 1992. Please indicate whether they are teaching **physics** at your school **THIS** year.

	Teaching PHYSICS this year		If NO, has this teacher		
	YES	NO	Remained on staff but not teaching physics this year	Retired	Left for some other reason
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

3. Are there any teachers with physics classes THIS YEAR who are not on the above list? If so, please note their names.

(1)____________________ (2)____________________ (3)____________________

Please turn card over ➜

4. Did your school offer a course in physics **last** year (1995-96)? YES ☐ NO ☐

5. During the last 4 years, have the rules for hiring science teachers been changed to encourage applicants with more science background but fewer education credits? YES ☐ UNSURE ☐ NO ☐

a. If yes, have you hired any physics teachers under these new rules? YES ☐ NO ☐

b. If no, are there plans to institute such changes within the next 3 years? YES ☐ NO ☐

6. How many **seniors** are there at your school this year? __________

Please update any incorrect information

Even if your school is not offering courses in physics, please return this card.

THANK YOU FOR YOUR COOPERATION.

☐ Please check here if you would like to receive a copy of the **final report** for this study.

If you have **e-mail** access at school, please list your address and those of the teachers on the other side.

(1)____________________

(2)____________________ (3)____________________ (4)____________________

AMERICAN INSTITUTE OF PHYSICS

1997 NATIONAL SURVEY OF HIGH SCHOOL TEACHERS OF PHYSICS

Dear Teacher,

Thank you for participating in the American Institute of Physics' National Survey of High School Physics Teachers. We are interested in hearing from all teachers with class assignments in physics this term, regardless of what field you may specialize in or how often in the past you may have taught physics.

If you are **NOT** teaching any physics classes this term, PLEASE CHECK HERE ☐ and return this questionnaire blank in the enclosed envelope.

Some of you will remember having filled out a similar survey questionnaire in the past. While some of the questions are the same, many of the items here cover new ground. Whether or not you completed an earlier survey form, please answer all the questions in this questionnaire booklet which apply to you.

This questionnaire consists of four sections, and should take you about 25 minutes to complete. In SECTION A, we ask you to describe your past experiences and current assignment as a teacher.

SECTION A: TEACHING EXPERIENCE AND RESPONSIBILITIES

1. How many years (counting this year) have you taught in HIGH SCHOOL? ______ years

2. How many years have you taught one or more HIGH SCHOOL courses in the following subjects?

Subject	Years teaching	Subject	Years teaching
Physics....................................	( )	9th grade level Physical Science................	( )
Chemistry..................................	( )	Mathematics/Computer Science................	( )
Biology......................................	( )	Other subject(s)	
Other HS-level Science.............	( )	(specify) ____________________	( )

3. How many years (counting this year) have you taught at THIS school? _______ years

4. What would you describe as your PRIMARY subject area of specialization in your teaching career? *(Please circle only one)*

Physics	Chemistry	Other Specific Science	General Science	Math	Other Subject
1	2	3	4	5	6

5. How many CLASSES and STUDENTS are YOU teaching this semester (Spring 1997). (Please include only the classes you yourself are teaching. Do not count labs as a separate course.)

	Number of classes you have this semester	Student enrollment in these classes
Physics	( )	( )
Chemistry	( )	( )
Biology	( )	( )
HS-level Earth Science / Astronomy	( )	( )
Applied Science / Principles of Technology	( )	( )
Other HS-level Science (specify: ________)	( )	( )
9th grade level Physical Science	( )	( )
Mathematics/Computer Science	( )	( )
All Other Subjects (specify) ________	( )	( )
TOTAL FOR ALL SUBJECTS THIS TERM	( ) Classes	( ) Students

SECTION B: PHYSICS INSTRUCTION AT YOUR SCHOOL

6. Approximately how many students are taking physics in your school this year? ________
(Please count all physics classes, including those taught by other teachers.)

7. How many other teachers (**NOT COUNTING YOURSELF**) are teaching physics at your school **THIS** term? ________

8. Approximately what percentage of the students in JUST YOUR OWN PHYSICS CLASSES this year are:

white? ____%
black? ____%
hispanic? ____%
asian? ____%
other? ____%
= 100 %

seniors? ____%
juniors? ____%
sophomores & freshmen? ____%
= 100 %

9. Approximately what percentage of all the students in your own physics classes are female? ____%

10. How many years of high school science are required for graduation at your school? ____ (years)

11. **Compared to the other high schools** in your entire metropolitan area (or county, if you are located outside a metropolitan area), how would you rank the economic circumstances, on average, of your school's student body?

- ☐ Much better off than average
- ☐ Somewhat better off than average
- ☐ About average
- ☐ Somewhat worse off than average
- ☐ Much worse off than average

(Please circle appropriate number)

12. How well-prepared are your students to take physics when they first enter the class in terms of:

	Poorly prepared	Adequately prepared	Very well prepared
Math background	1	2	3
Physical science background	1	2	3
Ability to think and pose questions scientifically	1	2	3
Familiarity with general laboratory methods	1	2	3
Use of computers in science	1	2	3

13. How has the **overall** preparation of your entering physics students changed compared to four years ago?

Improved	1
Stayed about the same	2
Declined	3

14. If you answered that it has improved or declined, to what do you attribute the change? ____________________

____

15. Now we would like to turn to the specific physics courses that you yourself are teaching this term.
Enter total number of classes and students for each type of course. (Please do not include labs as a separate course.)
Select texts from the list below, up to 2 per course, and rate your satisfaction with them, from 1=poor to 5=excellent.

Type of Physics Course	Classes	Students	Text # 1	Rating 1-5	Text # 2	Rating 1-5
A. Regular First-Year Physics	( )	( )	___	___	___	___
B. Physics for Non-Science Students/Conceptual Physics	( )	( )	___	___	___	___
C. First Year Honors/Accelerated/Gifted&Talented	( )	( )	___	___	___	___
D. Advanced Placement B	( )	( )	___	___	___	___
E. Advanced Placement C	( )	( )	___	___	___	___
F. Second Year Physics (NOT AP)	( )	( )	___	___	___	___
G. Other (Specify): ____________	( )	( )	___	___	___	___
TOTAL PHYSICS (The total number of classes and students should match your entry for the first line of question 5)	( )	( )				

Physics Textbook Codes

1. College Physics (Serway & Faughn/*Harcourt Brace*)
2. Conceptual Physics [HS] (Hewitt)
3. Conceptual Physics [College] (Hewitt)
4. Fundamentals of Physics (Martindale/*DC Heath*)
5. Fundamentals of Physics (Halliday & Resnick/*Wiley*)
6. Modern Physics *(Holt, Rinehart & Winston)*
7. Physics (Cutnell & Johnson/*Wiley*)
8. Physics: Methods & Meanings (Taffel)
9. Physics: Principles & Problems (*Merrill/Glencoe*)
10. Physics (Giancoli)
11. PSSC Physics (Haber-Schaim et al.)
12. College Physics (Sears et al.)
13. University Physics (Sears et al.)
14. Other text #1 (specify): ____________
15. Other text #2 (specify): ____________
16. Academic software ____________
17. Academic videos ____________
18. Your own materials ____________

16. Over the last *four* years, have any of the following changes been initiated by your school district or state and if so, how has your physics teaching been impacted?

	No recent changes	Yes, and the impact has been: Extremely positive	Somewhat positive	No significant impact	Somewhat negative	Extremely negative
Increased graduation requirements in science.....	0	1	2	3	4	5
National education standards in science..............	0	1	2	3	4	5
Performance assessment, grading reform...........	0	1	2	3	4	5
Other similar changes (specify)________________	0	1	2	3	4	5

17. Please use this space to elaborate on your experiences with any of the above. ________________________________

____

18. Have any of the following been introduced, by you or others, into your school's physics program in recent years and if so, what is your assessment of their impact?

	No recent changes	Yes, and the impact has been: Extremely positive	Somewhat positive	No significant impact	Somewhat negative	Extremely negative
Computer-based laboratories.........................	0	1	2	3	4	5
"Active learning" techniques...........................	0	1	2	3	4	5
Block scheduling..	0	1	2	3	4	5
Interdisciplinary instruction.............................	0	1	2	3	4	5
Instructional videos	0	1	2	3	4	5
Student use of Internet / WWW resources......	0	1	2	3	4	5

19. Please use this space to elaborate on your experiences with any of the above. ________________________________

____

20. Over the past four years, have you changed the **topics** covered in your basic introductory physics course?

☐ No ☐ Yes **If yes**, have you ☐ removed topics? (which ones) ________________

☐ added topics? (which ones) ________________

21. Over the past four years, have any new physics **courses** been introduced into your school's physics program?

☐ No ☐ Yes (please name and describe) ________________________

22. Have there been any other notable changes in your physics program in the last 4 years?

☐ No ☐ Yes (please describe) ________________________

23. How much money for physics equipment and supplies was available to you FOR JUST YOUR OWN PHYSICS CLASSES AND LABS from all school sources for the current academic year? $__________

24. Is any of the following equipment available to the students in your physics courses? If yes, how adequate is the supply, and how well-prepared are students to use it when they begin your courses?

	Available at school?		Supply adequate	Supply inadequate	Students generally prepared	Students generally unprepared
Graphing calculators	Yes	No	☐	☐	☐	☐
Computers for student use	Yes	No	☐	☐	☐	☐
Specialized physics software	Yes	No	☐	☐	☐	☐

25. Which of the following are problems that affect your physics teaching? (Please circle only one number on each line.)

	Not a problem	Minor problem	Serious problem
Inadequate space for lab or lab facilities outmoded	1	2	3
Insufficient funds for equipment & supplies	1	2	3
Difficulties in scheduling classes & labs	1	2	3
Not enough time to plan lessons	1	2	3
Not enough time to prepare labs	1	2	3
Insufficient administration support or recognition	1	2	3
Students do not think physics is important	1	2	3
Inadequate student mathematical preparation	1	2	3
Inadequate student reading ability	1	2	3

26. What aspects of your work as a high school physics teacher do you find **most** satisfying?

____

____

____

27. What aspects of your work as a high school physics teacher do you find **least** satisfying?

____

____

____

SECTION C: YOUR BACKGROUND AND EDUCATION

28. What year were you born? _______

29. Are you: Female.......... 1
Male.............. 2

30. Which racial or ethnic group do you belong to?
white........................ 1
black........................ 2
hispanic.................... 3
asian........................ 4
other (specify):_________________________ 5

31. Please indicate ALL college degrees you've earned, the year you earned each, and the code letter for your major area of study (and minor, if any) for each degree.

If you had a full double major, list as two separate degrees earned in the same year.

If you are currently pursuing a degree, please check here ☐.

	Year Earned	Major Code	Minor Code
Bachelors	19____	____	____
2nd Bachelors	19____	____	____
Masters	19____	____	____
2nd Masters	19____	____	____
Doctorate	19____	____	____

SCIENCE/MATH MAJORS

A Physics (NOT Physics Education)
B Chemistry (NOT Chemistry Education)
C Biology/Life science (NOT Biology Education)
D Other Science(Not Science Education)
(specify)_______________________
E Mathematics/Engineering

EDUCATION-RELATED MAJORS

F Physics Education
G Chemistry Education or Physical Science Education
H General or other specific Science Education
I Math Education
J Other Education/Administration/Counseling

M Other Major #1
(specify)_______________________
N Other Major #2
(specify)_______________________

32. To the best of your recollection, how many **semester** courses (not credit hours) in physics have you taken during your post-secondary academic studies. (If your college or university operated on a QUARTER system, please check here ☐)

Undergraduate ________ Graduate ________ Non-degree college courses ________

33. Many teachers are given teaching assignments in physics although their State Teaching Certificate is in another field. Please check all the boxes below which are true of your current situation.

I have
- ☐ full State Certification specifically in Physics
- ☐ temporary State Certification in Physics
- ☐ full or temporary State Certification in general high school science, math, or another science (specify)_______________________
- ☐ full or temporary State Certification in a high school subject outside of science or math (specify)_______________________
- ☐ no state high school teaching certification at present

34. How well-prepared do you feel you are in each of the following aspects of physics teaching?

	Not adequately prepared	Adequately prepared	Very well prepared
Basic physics knowledge........	1	2	3
Recent developments in physics........	1	2	3
Other science knowledge........	1	2	3
Instructional laboratory design & demonstration........	1	2	3
Use of computers in physics instruction and labs........	1	2	3
Application of physics to everyday experiences........	1	2	3

35. What is your regular teaching salary for this school year? $________________

(Please include your base salary only. Exclude any supplemental earnings or bonuses for administrative or extracurricular duties. If you are teaching part-time please check here ☐. If you are receiving room and/or board or a "religious salary", please check here ☐ .)

36. Are you a member, at either the national or the state or local level, of any professional organizations? If so, please indicate at which level(s) you belong and how active you are. (Please circle your answer.)

	Member		National	State or Local	Inactive	Active
AAPT (American Assn. of Physics Teachers).....	Yes	No	a	b	1	2
NSTA (National Science Teachers Assn.)...........	Yes	No	a	b	1	2
Other: (specify)________________	Yes	No	a	b	1	2

37. Did you attend any of the following during calendar year 1996? (Please count only those events lasting at least one full day.)

	Not in 1996	Yes, once	Yes, more than once
General education workshop........	0	1	2
Physics education workshop........	0	1	2
Professional education association local or national meeting.......	0	1	2
Physics association local or national meeting........	0	1	2
Summer science education institute........	0	1	2
Physics or other science course at college or university........	0	1	2
Education course at college or university........	0	1	2

SECTION D: YOUR PLANS FOR THE FUTURE

38. How many more years do you expect to teach high school?

This is my last year	1
1 - 5........	2
6 - 10........	3
11 - 19........	4
20 or more........	5

39. If you had it to do over again, would you still choose high school teaching as your career?

Yes... 1
No.... 2

40. Do you plan to remain in high school education until retirement or are you hoping to change careers prior to that point?

Planning to remain........ 1
Hoping to change.......... 2

41. Would you like to receive a copy of the Final Report from this survey when it is released?

☐ No ☐ Yes ☐ Send to me at school (address correction below only if our label was incorrect)
☐ Send to me at home (please provide address below)

Name/school address corrections from label or address to send report if different from label.	Name ____________________ School name (if applicable)____________________ Address____________________ City__________State_____Zip_____

42. Please indicate if you would like to receive any of the following other materials.

☐ Report on Physics in the Two-Year Colleges (available late 1997)
☐ Report on Physics Enrollments and Degrees at Four Year Colleges and Universities
☐ *Who takes Science?* (Analysis of Dept. of Education High School and Beyond Study, published in 1989)
☐ American Association of Physics Teachers (AAPT) product catalog
☐ AAPT booklet: *The Role of Laboratory Activities in High School Physics*
☐ Sample copy of the magazine *The Physics Teacher*

We would appreciate any additional comments you might have on your experience as a science teacher, as well as any comments on this or previous rounds of this survey, either general or specific. Please enter your comments below, and add additional sheets of paper if you wish.

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