The following set of white papers were prepared as background material for the 2000 AAPT Executive Board retreat that took place in Toronto, Canada, prior to the 2000 AAPT Summer Meeting in Guelph, Canada.

June 1, 2000
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Thoughts on future AAPT

There have been rather dramatic changes in the membership composition and in the national meeting programs over the past 20 years.

First, some AIP statistics. In 1981, the AAPT membership was divided as follows: Of the 83% directly in the teaching profession, 36% were in “university,” 16% in “college,” 9% in 2 year colleges, 22% in secondary schools. The matching numbers in 1998 (of the now 91% directly in the teaching profession) were 25%, 14%, 9%, 43%. While I certainly knew the direction of the drift, I had no idea it had moved so strongly towards the secondary school teacher. A matching and important statistic is the <u>fraction</u> of relevant sub-populations who are AAPT members. For secondary school teachers, data from AIP put the percentage at 39% for teachers with solid physics background, 20% for others – overall in the roughly 25% range. The matching numbers for university and college teachers are less certain. My attempts to generate comparable numbers produce some suspicious results. But it probably isn’t far off to estimate that in 1998, that <u>fraction</u> of college and university physics teachers holding APPT membership is close to the same overall 25% number. [1]

Pursuing the other obvious line of thinking which has been concerning me rather directly for some years, I dug up the program from the 1982 summer meeting in Ashland, Oregon. As you might guess, the profile of subject matter is dramatically different from a similar program of 1999.

The decrease in college and university participation in AAPT is, of course not a big surprise. We’re probably seeing another effect of the dramatic “professionalization” of physics faculties in the post-World War II era, signaled also by the scientific fragmentation of APS into its Divisions.

While the percentages of membership in the two categories – colleges & universities and secondary schools – is now roughly equal, their relationship to AAPT is quite different. For the secondary school teachers, AAPT is the primary “subject matter” or “professional” connection to the world outside their schools. For many university and a fair fraction of college teachers, APS is the primary professional organization, with AAPT in a less prominent role.

All of this, plus the observed spectrum of officers and board members over the past few years, causes one to realize that a full re-thinking of the spheres of activity of AAPT, the APS Forum on Education, the APS Committee on Education, APS in general, and perhaps other adjoining organizations, may be in order.

[1] I quote this number with some worry. A simple minded attempt to examine the geographically-based roster in the AAPT Membership Directory and comparison to rosters of physics faculty and colleges and universities located in the relevant city suggests a measurably small percentage.

My attitude towards these changes is pretty straightforward, I think. The AAPT membership trends are undoubtedly good for the improvement of secondary school physics teaching. Great! People have voted with their membership dollars, and the Association obviously should respond to the needs of its members. But it is clear that the profile of AAPT membership and the emphases in national programs has changed significantly. We should certainly take these changes importantly into account as we look ahead.

There will certainly continue to be college and university faculty folks actively engaged and productive in the traditional activities of AAPT. And AAPT has many things to offer to college and university faculty members. Examples (not intended to be a complete roster) are:

- The annual new faculty workshop

- Periodic chairs' meetings, in collaboration with APS

- Transmission of results from the many AAPT-centered efforts in such fields as PER, continuing development of new or revitalized modes of teaching such as Internet-centered "distributed learning," various active learning modes, continuing development of computer based lab and interactive lecture modes, new patterns for the physics major curriculum, etc. will be important. BUT ONLY A TINY FRACTION OF COLLEGE AND UNIVERSITY PHYSICS FACULTY WILL COME TO AAPT MEETING OR WORKSHOPS TO HEAR ABOUT THESE THING. INFORMATION ABOUT THEM HAS TO BE DISSEMINATED IN OTHER WAYS.

- AJP: The Journal is a valued by a good slice of the relevant faculty population. But it will be important, as we move into a new editorship, to reexamine the subject matter profile of the journal, to make sure that it is maximally responsive to the interest and needs of the readership (taking also into account the substantial number of non- U.S. subscribers). If we believe that is masthead position – "AJP is devoted to the instructional and cultural aspects of physical science" – remains appropriate, we need to carefully think through what that statement means as we move into the new century.

I haven't thought at any length about the long-range implications for the AAPT trajectory of the changes I summarize. If nothing else, we need to examine carefully the relationship of AAPT activities to those of the APS units - - its Education Committee and the Forum on Education. While such an idea is at the moment pure speculation, it is conceivable that one might lobby of upgrading the status of the "Forum" to that of a "Division," looking for ways to bring some the relevant work of AAPT more firmly to the attention of faculty folks at various APS meetings. (There have been efforts to "salt" APS meetings in the past, but I believe they've never be institutionalized in the way to give some permanence.)

White Paper on Increasing Access to Good Material
Alexander K. Dickison
with input from Sina Kniseley and Warren Hein
July, 2000

Introduction and background

AAPT has a history of excellent publications. The *American Journal of Physics* and *The Physics Teacher* are of high quality and popular with their readership. The *Announcer* has grown from a newsprint publication to a larger more sophisticated magazine that makes announcements, reports on society activities and publishes all the meeting information. To keep physics teachers abreast of research developments in various subjects of physics AAPT has the informative Resource Letters.

All of these publications are financially supported by membership dues and library subscriptions. This income not only supports the publications but also is the largest contributor to the support of the Executive Office.

AAPT has established a publications committee chaired by the Secretary. This committee oversees all of the official publications of AAPT. The publications previously mentioned have editors. When AAPT wants to publish an item such as a workbook or a pamphlet that does not have an editor, the Chair has it reviewed before the publications committee takes action. This insures the quality of AAPT publications.

A more recent development has been the establishment of an AAPT website. AAPT has developed a very impressive and useful website. On it is the AAPT membership list (available only to members); a description of the various programs AAPT is involved in running (TYC21, PTRA, Physics Olympics, Department Chairs Conference, Preparing Future Physics Faculty, National Task Force for Undergraduate Physics); description of AAPT committees, publications, and sections; and National Meeting Information. The website contains a job market section. This is the only part of the website that generates direct income (people do sign up for memberships at this site which is also a positive).

Finally, but definitely not the least, is the Physical Science Resource Center (PSRC). This is a place physics teachers can come to get ideas and developments in all areas of physics education. Presently this project is being funded with money raised in a large fund raising project for physics by APS several years ago. PSRC specifically and the website in general is one important area that needs to be included in AAPT's long range plans.

Challenges and Opportunities

There are four areas we will explore:

1. Administrative details.
2. What to deliver.
3. Modes of delivery.
4. Reaching underdeveloped markets.

1. Administrative Details?
   AAPT has established some formal publication procedures as well as informal "the way things are done" that directly or indirectly effect what materials are published.
   a. The Review Process
      The Secretary heads this up. Anyone seeking AAPT publication submits the work

to the Secretary. He/She then sends it out to the volunteer reviewers. Since these people are usually very busy, it sometimes takes time for the work to be reviewed. Once done, it is sent back to the author for corrections and the process repeats itself. Final approval for publication is done by the publication committee which meets twice a year. It may take one or two years before final publication approval is completed. Throughout this process, the author is not sure AAPT will eventually publish their work.

b. The Budget
Publications are not a money maker for AAPT. Traditionally publications have more expenses than income. There have been a few money makers but they have usually been a result of other businesses (Cinema Classics, Active Physics) working with AAPT. The PTRA manuals have their projects dedicated to support the PTRA program. Powerful Ideas In Physics has had an income but has not reached its potential. Maybe for this reason AAPT has never been actively involved in promoting new publications. A "joke" often heard is "the more AAPT publishes

c. AAPT has traditionally not solicited or encouraged publications. (This has changed recently in the task of updating some of the publications.) Most AAPT publications are the result of the initiative of AAPT committees, individual members, or grant projects. Most of these are excellent publications, but their content depends on the particular interests, at that time, of the authors. There is little initiative in determining what topics in physics education are "hot" and seeking publications developed in those areas.

2. What to deliver?
As mentioned earlier AAPT has many excellent publications. The question is should AAPT have more depth in the types of publications it offers? Ideally the publications would represent a cross section of the many interests in physics education. These could be categorized into:

a. Developments in physics and astronomy education research.

b. Information on the pedagogy of teaching physics and astronomy. This should include all levels from K-8 through graduate school. Topics could include new equipment, using new teaching technology, demonstrations, laboratories, curriculum, or teaching techniques.

c. Understandable reviews on current research in physics and astronomy.

d. Information on distance learning. This could include research on student learning, successful classes, laboratories, curricula, and teaching techniques.

e. Information on successful programs and on how to reach out and work with:
   i) Industry
   ii) Other departments in a school which require their students to take physics.
   iii) Schools at different levels in the same geographical area working together.

f. Guidelines that identify the support and resources that are needed at a school to offer a physics program at the K-8 level, high school level, introductory college level, and physics major level.

g. Provide information such as job openings, meetings and workshop notices/agendas, vendor advertisements, and reports concerning AAPT business.

One can find examples of all of these in AAPT publications. The question is what is the correct blend? If AAPT doesn't have a good blend, how can it or should it be achieved.

3. Modes of Delivery

Traditionally the mode of delivery of AAPT publications was printed paper. This is still the most popular. For a while AAPT had a media editor and some publications were made in slides, short films and videos. This editorial position has since been eliminated.

Over the past several years AAPT has entered the electronic publications arena. AJP went on-line two years ago. It is still too early to know its impact. The website including the job market, and PSRC has had a popular start. There is momentum to expand PSRC and put more and more on-line. If this is done, a method of how to collect income from this work has to be developed. If the idea of the electronic media is to cut down on the review and publishing time, then how can AAPT be sure of quality? Should there be an electronic media editor and committee?

Besides the two modes of electronic and print and paper, there is another mode of delivering information that is very important in physics education. This is the workshop. The workshop is very popular in physics education community. Perhaps these are popular because there is one-on-one contact. These are almost necessary to disseminate new curricula and teaching techniques. They also served at the heart of PTRA, TYC21, chairs conference, and future faculty conference. It points out the important fact that not all information can be transmitted electronically or with the print media.

4. Reaching Underdeveloped Markets

The physics education market is relatively small. This may be one of the reasons it is so hard for our publications to make any money. This does not mean that AAPT should only publish material it feels will break even. Many good publications will not make money. One way it sees a publication can become a "hit" financially is to reach other markets than the traditional physics market. Examples would be Cinema Classics and Active Physics.

Recently the Executive Board approved putting non-AAPT products in its catalog to round out the product line. This has already been implemented in several cases.
It is true that the majority of science education professors in colleges and universities are not run by traditional physics scholars or are they members of AAPT. The same can be said for middle and high school physical science teachers. Research physicists have little contact with AAPT and its product catalog. The Astronomy Society of the Pacific has a wonderful catalog and a different membership than AAPT.

Maybe AAPT should look for products that would not only be of interest to its members, but would also appeal to one of the other markets. We should then develop agreements with other vendors to handle our merchandise. This would increase income and spread the word about AAPT.

Recommended Activities

1. AAPT should strongly consider a NSF proposal to fund the Digital Library for Astronomy and Physics Education. This would be a joint project between AAS, AIP, APS, and AAPT. NSF has money budgeted for this. Working with these other organizations on a joint project is a plus. There has already been developed a good digital library for Earth Science. It could be the model. An advisory committee should be formed to explore this venture.

2. AAPT should consider increasing its emphasis on products for physics education. To do this would take additional resources and a change in AAPT structure. The products we would look for are not necessarily textbooks or research oriented products. The best sellers would probably be workbooks of classroom aides. People like hands-on kind of books that help them in their classrooms.

   To accomplish this would require more staff in the AAPT Executive Office. Present staff probably has more to do than they should at the present time. Additional staff would have time to explore underdeveloped markets.

   This means AAPT would have to make a financial commitment to take this direction. Probably the committee (next suggestion) should be formed first and their advice could determine the necessary direction and how fast we should move. The goal of providing the products is not to make money, but to provide a service to physics teachers. If AAPT breaks even or loses $20,000 a year on this venture it would be considered a success.

   The organizational structure of AAPT would also need changing. Presently the publications committee has to deal with AJP, TPT, Announcer, Resource letters, and exams. This is a full plate. Presently there is little time left for “other products.”

   The suggestion is to form a second publications committee concerned only with other products. It would be made up of well-know authors, representatives from publishers, Executive Board members, Executive Officer, and Publications Director. This group of people needs to understand publishing and marketing. They need to have contacts for reviews. The pubs director would serve a role somewhat like our journal editors. Once a product gets committee approval the pubs director is responsible for editing, publishing, and marketing.

3. PSRC has developed into an important AAPT project. It presently provides a great deal of information to physics teachers. The potential it has is even more exciting.

   The funding of PSRC is from the APS fundraising. This will run out in a few years. Funding (hopefully stable) needs to be found. Increased funding is needed for PSRC to expand. PSRC can be directly tied into the digital library for physics education mentioned earlier.

4. An advisory committee should be established to explore the possibilities of establishing a National Center for Physics Education. David Hestenes has a vision which has the support of many members. The National Center could fill the needed role of organizing conferences and workshops in physics education. The advisory committee could make recommendations on relationship of a National Center to projects already

underway: PSRC, Task Force for Undergraduate Physics Education, PTRA, etc. They would also explore the financial viability.

To Improve the K-12 Physics Curriculum

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Background

The AAPT has a long history of interest in the teaching of physics. Its committees cover the gamut from Kindergarten to post-Doctorate. The organization has been most successful in helping to establish strong physics major and graduate programs. The AAPT can be proud of success in these areas and proud also of continuing efforts to keep these programs strong and relevant to the needs of the 21st century. Graduates of these programs do well in areas that might at first glance not seem to be physics-related, but they turn out to be areas in which the tools of physics prove invaluable. Recent reports indicate that there is something in physics courses outside content that hones skills such as problem solving, communication skills, and working within a group. Another area in which the AAPT has done well is that of introductory physics courses, notably at the high school and the two-year college level, but also at the four-year college and university level. There are at present a rich collection of "introductory" courses at the conceptual, algebra-trigonometry-based, and calculus-based levels - many defined by textbooks written by AAPT members. A common feature of these books is the high level of accuracy due in part to the prompt response of colleagues to errors in new additions and printings and the close association of teachers with publishers' representatives. This is not true of science texts used in grades K-8. The notion of "author" in these texts is quite foreign to us. Of the several names listed in several textbooks none would claim to be an "author" and some did not even know that their names had been so listed. Instead of authors we have a collection of people who "checked" certain parts or aspects of the textbook. We read in **In Defense of Elitism** by William A. Henry III " ... the language difficulty of textbooks has dropped by about twenty percent during the past couple of generations. ... Perhaps the best measure of what has gone wrong is the fact, attested to by textbook authors and editors, that publishers now employ more people to censor books for content that might offend any organized lobbying group than they do to check the correctness of facts. From a business point of view, that makes sense. A book is far more apt to be struck off a purchase order because it contains terminology or vignettes that irritate the hypersensitive than because it is erroneous." AAPT is new to this level of education, having only shown interest in it as an organization since 1987. Part of the evidence in favor of establishing the Pre-High School Committee was the large number of papers by physics teachers and the many large projects run by physics teachers dealing with the elementary schools reported in our "The Physics Teacher" and "American Journal of Physics." While obviously successful in these efforts, the United States in science and mathematics surveys worldwide do very poorly. One could also describe science literacy in this country as "abysmal."

So, what is the problem and what can the AAPT do about it? When the general public thinks about "physics" they think about "the study of matter and motion and their transformations" or some such thing and "lots of mathematics required." **PSSC Physics** is a representative text of this notion. The PSSC program was and is excellent. Many of the experiments and films designed for this program are being used outside the context of PSSC courses. The problem is that it is seen as only for the "best" students. In fact, in many schools one cannot take physics until after Algebra II and Trigonometry have been completed. Physics in the elementary schools does not need mathematics and much can be learned without it. **Science: A Process Approach**, the PSNS Project, and **The Various Language: An Inquiry Approach to the Physical Sciences** by Arnold Arons clearly illustrate this. Few think of "Physics as the study of material reality" or what is known in some places as "natural philosophy" or perhaps simply, "science." **Project Physics** is an effort in this direction and we need more of this approach for all students, but most importantly for those not intending to go on in science or engineering.

When science is taught, it is often as an "add-on" and is not always required especially in small school districts. It is not integrated into the curriculum and some places (states) do not even test for science. I have often seen social studies substituted for science classes as the teachers admitted to not being able to handle the teaching of science. The AAPT needs to consider capital "P" Physics (natural philosophy) as a goal for reaching all children. Instead of a collection of physics courses that some few may take, we need a program of Physics that is a part of the education of every child in every school year. Instead of individual courses that often repeat material at a more sophisticated mathematical level we should develop a physics continuum of material. At this level there should be a clear distinction among biology, chemistry, geology, and physics as the tools and approaches of these specialties are different. By mixing everything together we get an incoherent mush. The Paideia Program is an excellent model of a way to teach this program, but when it comes to science, the Paideia Program folks need help and we can provide that help with selected readings from the masters. Teachers unaware of this approach would do well to read **Reforming Education** by Mortimer J. Adler. Reading excerpts from the **Principia** in Latin class, for example, would serve several purposes and add immeasurably to one's education. Providing examples of the use of physics in forensic detective work, automotive applications, archeology, history, sports events, medicine, around the home, on the job, dispelling pseudoscience, and so on, will show that Physics impinges on the students' daily lives and is valuable whether or not they choose a scientific field of study.

The Audience

There are approximately 46.5 million children enrolled in the public schools and approximately 5.9 million children enrolled in private and parochial schools in the U.S. in grades K-12.
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Also there are approximately 1.25 million children in the U.S. being home-schooled.

This latter group is the fastest growing group and the folks taking part have produced some excellent materials and they make use of original materials. Notable among these is the Robinson Curriculum consisting of 22 CDs laying out a K-12 curriculum being used by thousands of families. The Robinson children have done extremely well in college including graduate school and they are still coming along and doing well. While a first impression would suggest that home schooling is being done only for religious reasons, this is not always the case. In fact, lowered academic standards, inappropriate social programs being forced on children, and various other reasons have been cited. As this group is small and disparate, I will not mention it again.
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With 52.4 million children and approximately 30 children per teacher we have roughly 1.7 million teachers to think about. Most of these teachers went to school at a time when only 6% of high school graduates took physics. Even today while that number approaches 20% we still are far short of what we need. Very few teachers, including many who are currently teaching physics, have ever taken a physics course of any type. Most of those who did, often took a course, which was totally inappropriate for their subsequent teaching career.

Imagine attempting to provide workshops for these teachers! If we wish to reach all these teachers, we would need almost 71,000 workshops (There are 11,000 AAPT members.) If we were to spread the program out over ten years we would need over 14,000 workshops. Over 20 years we would need 7100 such workshops every two years. Now all we have to do is recruit all AAPT members to commit to a 20-year program!

Resources Available

We have not yet decided what would be taught in these in-service workshops; and there should also be different ones for Elementary School teachers, Middle School teachers and High School teachers. The PTRA model is an excellent one and there are also the Operation Physics model and the PEPTYC model and the Modeling Workshop model and a host of other excellent models. There is no question that successful models for making the material available to teachers already exist. There are also ample tried and tested curriculum materials available as well. For the most part, teachers are not aware of these materials. CDs from The Learning Team such as “Enhanced Science Helper” which contains the material developed mostly in the 1960s is now keyed to the NSES. “Whelmers' 41 Awesome & Easy-to Do Science Activities” and “CPU: Simulation Software for Exploring Physics” are other good examples. “Ranking Task Exercises in Physics” is another from one of the most successful series of workshops aimed at two-year college teachers, but certainly suitable at the high school level and valuable for a component of a pre-service physics course. There are many others and a bibliography of such materials would obviously be helpful to new teachers, and perhaps some old ones as well. We need to learn how to get these materials into their hands.

So, What Should AAPT Do?

1. Impact of Standards. The Standards are in place and they are being paid attention to. From our perspective they have serious faults, but we can work within them as shown by the work by John Layman mentioned below. The AAPT should make a systematic effort to improve the statement of the standards having to do with Physics and start an effort to make materials available to teachers in grades K-8 and make certain that pre-service teachers in our physics courses are made aware of these materials. These teachers do not typically have budgets that would allow purchase of materials so we will have to look into that problem as well. Having some of the material on our website might alleviate some of the cost. We need standards that are defined in terms of feasible assessments. A good start would be re-reading editorials from "The Physics Teacher" dated November 1967, April 1990, March 1991, and April 1991.

Shortly before the study that resulted in the National Science Education Standards (NSES) of the National Research Council was undertaken, the AAPT established a Standards Committee. It was short-lived as it was sidetracked into a response group of the AAPT to the various drafts of the NSES. One of the early suggestions of this group came from the Pre-High School Committee, which called for a large number of very small booklets (50-100 pages) on physics topics for elementary school teachers that could very easily be implemented in the classroom. They would be directed at areas of known misconceptions that would require hands-on experimenting. Design of the experiment and making measurements and subsequently conclusions were to be emphasized. John Layman has written **Inquiry and Learning: Realizing Science Standards in the Classroom**, which is an excellent example of such a booklet. The NSES are not to the liking of many physics teachers. They can be improved. Cliff Swartz wrote **Measure and Find Out** in three volumes many years ago. They are excellent and not only that, they illustrate what should be done in the elementary schools today. Such materials produced by AAPT members would be invaluable as in-service aids for teachers and they neither require summer courses nor night or weekend courses.

Ideally though, we would like to give more teachers appropriate physics classes. Providing more relevant courses in pre-service programs would be much better.

2. Developing High School curricula that convey our picture of the current physical Universe. We expect that only a very small fraction of the school population will become physicists. The AAPT's objective should be to present our picture of the physical world and how we came to develop that understanding throughout the K-12 curriculum, but more especially to make known to all high school students at some appropriate level the elements of Classical Mechanics, Electromagnetic Theory, the Special and General Theories of Relativity, Thermodynamics, Quantum Theory, and some details of current interest to physicists always keeping in mind that most of these students will never take another physics course. The history, philosophy, and sociology of science should be incorporated as appropriate in a fashion similar to that aimed for in Project Physics. The scientific approach to solving problems should be thoroughly integrated throughout the curriculum. The Epilogue of **Inquiry and Learning** in a few words presents us with an excellent example of what to aim for.

3. Unified Physics Program for grades K-12. As noted, we have some excellent materials to draw from. In the past, various committees have called for improved integration from one physics "level" to the next. We can't possibly present an adequate picture of physics in, say, only grade 12, regardless of the amount of mathematical sophistication of the students. It is a subject that needs time for assimilation. In recent years there has been some improvement in the presentation of physical science in the 9^{th} or 10th grade. Hewitt's **Conceptual Physics** for high school has made inroads here. There are many other efforts being field-tested that take advantage of recent findings of the PERs. A serious problem here is that of schools offering biology first followed by chemistry and then physics. Physics is the simplest science in many respects and biology is the most difficult. A good understanding of physics helps in chemistry and these two subjects make understanding biology much easier. At present biology is primarily a memorization course giving rise to two obstacles to overcome: a wrong impression of what science is about and a tendency to select biology as a second or third science course because the student already knows something about it. We do have a long history of efforts and suggestions for a unified program of physics. I have given papers on the topic. I have attended several meetings of folks who wanted to set up a Center for Physics Education (other names have been used) that would bring together all worthwhile resources in one location to serve as a place for teachers and researchers/authors to go to review what was available. Often the APS was involved and the Forum on Education perhaps even evolved from these discussions. The Database Project of the Forum certainly reflected that interest. In the past couple of weeks I have received over 50 e-mail messages encouraging me to support the proposal of David Hestenes for a National Center for Physics Education. If you have read this far you know that I will heartily endorse this project. What has been missing in the past has been the enthusiasm expressed by these messages. My paper at Beloit pointed out the problem of great efforts falling apart after the initiators moved on. The Hestenes proposal should help solve that problem. Perhaps the wheel will not be re-invented so often.

The best design that I have seen for a workshop is two weeks of highly intensive activity during two summers followed by follow-up activity in the classroom during the school year deriving from the experiences in the workshop. These activities are supplemented by required get-togethers of all group members (24 is an effective size) each fall and spring. If the get-togethers could take place at a scientific meeting, all the better. Making connections is extremely valuable. The number of physics teachers who have never heard of the AAPT is much too large.

The physics education researchers (PER) among us have provided valuable insight into how students learn physics. We need to make this information available to all teachers and much more than that. Should we promote foreign language study in the early grades because we have found that it improves later success in Physics? Does taking music lessons early really correlate well with subsequent enjoyment of science and mathematics? Why? How does humor work to improve the learning environment? See, for example, **Professors are from Mars, Students are from Snickers: How to Write and Deliver Humor in the Classroom and in Professional Presentations** by Ronald A. Berk. What mix of didactic instruction, coaching, and seminars, is most effective at the various grade levels? We know that principals (formerly known as "principal teachers") are the key to changing the school environment. We need to reach those principals and show them that integrating Physics into the curriculum, into reading and writing and mathematics classes is vital.

4. Need for more teachers with physics majors and minors. Our teachers, especially Middle School teachers, are deathly afraid of science and those that do teach are rigidly wedded to a textbook chosen by someone else. These books are uniformly poor. A reviewer of one of these books felt uncomfortable when he saw a picture of a 0.1 kg apple. He went to the grocery store and weighed apples from a dozen different varieties and the smallest green Granny Smith was more massive than that. Dozens of examples such as this along with suggested experiments that are impossible to do would discourage any student. Teachers believe the book is always right. The simple experiment with the apples would show otherwise, but they do not have the experience to question. It is very important that we inculcate the notion that nature can be questioned by all of us and when pseudoscientific notions are brought up we can see them for what they are worth. **Powerful Ideas in Physical Science** (PIPS) was developed by AAPT and AIP under an NSF grant to provide material for university teachers of pre-service teaching majors that reflected what PER folks have learned about how students learn. The idea was to influence a change in the way physics was taught to these prospective teachers so that they might use the same methods in their classrooms. We have found that it is very difficult to get university faculty to change.

The materials are excellent. We need to make the PIPS material more flexible so that courses can be offered in two-year colleges (a very high percentage of all students take their physics in two-year colleges) and subsets of the material can be integrated into traditional introductory courses in high schools and colleges. The large university physics departments historically have not emphasized the preparation of teachers. We must improve that situation. The results of the working conference on "The Role of Physics Departments in Preparing K-12 Teachers" sponsored by The University of Nebraska-Lincoln, the AIP, the APS, the AAPT, and the Nebraska EPSCoR held at UN-L should help us determine a road to travel in this regard. The traditional physics courses have served the physics community well, but we are a very small fraction of the general public that needs tools to combat science illiteracy. Teachers need more than one course, so we also need to encourage either new or changes in traditional courses that reflect a wider vision so as to make them more appealing. In this way we can attract more physics minors, majors and perhaps master's degree in physics teaching candidates.

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(Note: While much of this material has come from papers that I have given, my many years interacting with members of the Two-Year College, Pre-High school, and History & Philosophy and various temporary Committees of the AAPT have significantly contributed to these comments. Recent contact with Howard Lyon, Herb Gottlieb, Cliff Swartz, Alex Burr, and Jane Jackson helped to confirm my thinking and put these ideas together.)

WHITE PAPER ON MAINTAINING THE EFFECTIVENESS OF AAPT AS AN ORGANIZATION (MEMBERSHIP, MEETINGS, AND GOVERNANCE)

Prepared by Steven Iona utilizing many existing documents from AAPT Membership Services, AIP, data on meetings collected by Tom O'Kuma, evaluation summaries for the TYC21 project, and the many responses from the membership to open questions about the direction of AAPT in The Announcer.

A local home improvement warehouse claims to have "more of everything." The company tries to serve homeowners, contractors, those who need a small part, and those who need a house full of materials. To serve this diverse audience, the company advertises in many places and their ads cover large and small items, specialized materials, items that might appeal more to men, and items that might appeal more to women. In their store, they have many trained and knowledgeable service representatives throughout each department. The company offers specialized areas for contractors, and books for those customers who would like to learn how to construct or repair items. The store offers specialized delivery schedules and a truck that one can rent on the premises to take items home immediately. They offer individual parts and kits. They have a generous return/exchange policy, and they are open almost 24 hours/day. They offer seasonal specialties, and one can even locate items on-line. The company tries to offer "more of everything" for everyone.

AAPT may be trying to do the same thing with physics education.

The concerns and suggestions addressed in this White Paper must be considered in conjunction with those expressed in the other White Papers, since the effectiveness of AAPT is intimately linked with its attempt to foster excellent teachers, promote quality teaching, provide access to good materials, and support strong curriculum development. This paper is divided into three sections: Membership, Meetings, and Governance with each section offering some background information, a selection of data, and a section offering interpretations and responses. There is also an appendix with additional statistical information.

This paper examines issues regarding membership, meetings, and the governance structure of AAPT by addressing these goals:

- AAPT needs to increase membership in all categories.
- AAPT needs to expand its services and products for its membership and those interested in physics education.
- AAPT needs to increase attendance at AAPT sponsored meetings.
- AAPT needs to adjust its governance structure to allow for more member involvement.
- AAPT needs to encourage new, younger leaders within the organization.

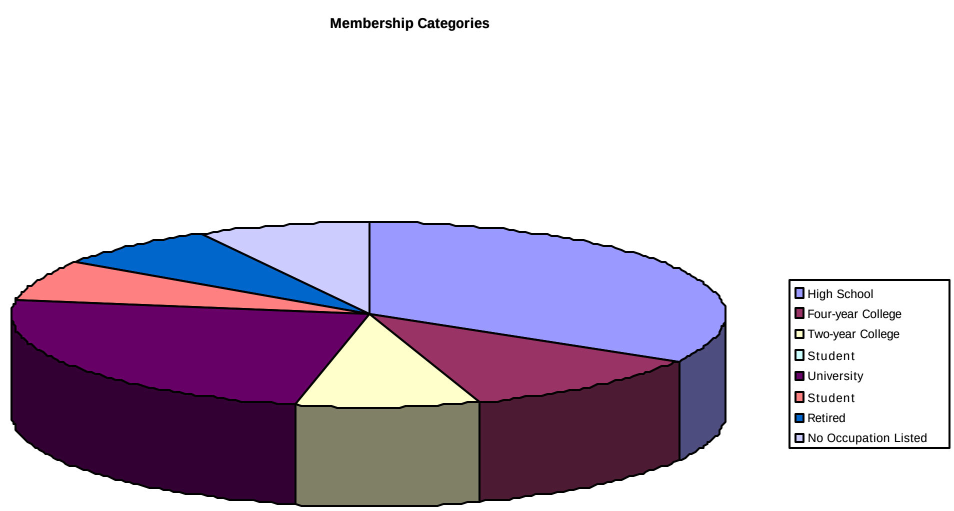
MEMBERSHIP

Background and Data

The membership of AAPT is made up of individuals who have an interest in physics education. This interest could be limited to areas such as the impact of laboratory investigations, or it could include a broad research area such as learning theory. Other areas of member interest include the impact and inclusion of minorities, informal-education activities, the impact and inclusion of technology, implications for physics education in high schools, and teaching the introductory physics course in college. This diversity is apparent in AAPT's meetings, its Area Committees, its publications, its Executive Board, its awards, and its membership. The diversity within the Association is a strength, but it can also be a weakness because groups or interests may appear to be treated unequally and it is difficult for the Association to speak adequately for all of the groups.

The overall membership in AAPT has grown about 10% in the last three years. Currently it has approximately 11,000 members.

- 8% of these members are students, about 8% are emeritus, approximately one-third are affiliated with a high school, approximately one-third are affiliated with a four-year college or university, and approximately 7% are from a two-year college.
- The data also indicate that about 7% of the membership in the database have not indicated an occupation.



- While specific age demographics are difficult to determine, it has been reported that nearly one-quarter of AAPT members are over age 60 and nearly 70% of the Four-year College/University members are over age 50.
- In general, High School members subscribe to The Physics Teacher Magazine and Four-year College/University members subscribe to The American Journal of Physics.

Using a survey of Lapsed members (non-renewing former members) and Prospective members (those who have expressed some interest in AAPT: its products, services, or meetings):

- Nearly 40% of the lapsed members are not currently physics educators. Of this group, many are retired or working in industry.
- Of the 60% of lapsed members who are currently physics educators, twice as many are from high schools versus four-year schools.
- Nearly 80% of the prospective members are currently physics educators.
- Of the prospective members who are currently physics educators, 48% are from high schools, 36% are from four-year colleges and universities, and 10% are from two-year colleges.
- Among the respondents who are currently physics educators, nearly half reported that "AAPT membership was too expensive for the value received."
- More than half of the respondents would consider joining/rejoining AAPT through an institutional membership.
- Over 50% of the lapsed members are over age 50 (25% are over age 60), and 33% of the prospective members are over age 50 (9% are over age 60).
- Nearly 70% of the lapsed members are employed (63% as full-time), and 90% of the prospective members are employed (87% as full-time).
- Over two-thirds of the lapsed and prospective members responded that they belongs to at least one professional society.
- The majority of all respondents are familiar with the AAPT Products Catalog and competitions.
- About one-third of the respondents indicated that they would join/rejoin AAPT if dues were reduced with no journal subscriptions.
- The Announcer is the least read journal by prospective members.
- The respondents attend AAPT national meetings in a higher percentage than do continuing members.
- The respondents all have access to the Internet and World Wide Web.

Data Interpretation and AAPT Response

If AAPT wishes to continue to include diverse groups within its membership, then the following could be considered:

Since the following appear to be true:	Then AAPT could respond by:
Survey respondents seem to follow the general membership groupings.	Utilize the data as representative of the larger group of lapsed and prospective members for decision making. Consider survey data as representative of the general membership for decision making.
Time and money are the major concerns regarding membership decisions.	Investigate joint memberships with other societies and associations. Investigate institutional memberships for schools or departments. Investigate memberships without journal subscriptions.
AAPT members are generally aging and aged without a corresponding influx of younger members.	Offer specialized products and services of interest to young faculty (e.g., special meetings, publications). Expand options for older members to continue membership in AAPT with reduced rates/services and with specialized products and financial opportunities of interest to them. Expand outreach to physics majors through connections with SPS. Expand outreach to physics education students. Develop an AAPT Fellowship Program to recognize members.
AAPT members are also members of other professional societies.	Work with other societies and science education groups (e.g., NSTA)
Most members have access to the Internet and the World Wide Web.	Expand AAPT presence on the web. Modify the format of The Announcer to include more of its information on the web. Expand the services and information available on the AAPT web page (e.g., newsgroups, focus on topics: politics, PER, advanced courses, laboratory). Expand the options for putting articles, journals and information on-line. Reduce restrictions on links to the AAPT web page. Expand access of information for both members and non-members on the AAPT web page.

Members and interested parties know about the AAPT products and services.	Expand the services and products
Data collection is not complete.	Determine the overlap of AAPT and APS members. Determine occupational make up of all AAPT members. Determine membership turnover rate for each membership category. Investigate other membership categories such as PER and astronomy to better target products and services
Different membership categories already have some participation options.	Consider specialized products and services for different membership categories (e.g., PER, astronomy education, new faculty, high school).
Communication is a requirement for member service.	Expand involvement of Sections in membership recruitment (e.g., establish college/university contact network, expand options for Section members to become members at the national level with reduced services)
AAPT has a history of quality service and products.	Explore options for maintaining an AAPT endorsed selection of products and services while developing connections to other services and products that may not have been developed by AAPT but are accessible in print or via the web through AAPT.

MEETINGS

Background and Data

There are two national AAPT meetings held each year. The meetings last approximately three days with several days of workshops preceding the meeting. The Winter Meeting is held in a downtown hotel in January. The Summer Meeting is held at a college or university campus in July/August. The meetings offer a collection of contributed and invited papers and several plenary physics content sessions and awards presentations and addresses. An elected officer and staff at the Executive Office coordinate the program. The abstracts for the program are printed in The Announcer.

At each national meeting, the Area Committees also meet. These committees help plan program for future meetings. These committee meetings are open to the membership, and they regularly report in The Announcer.

This portion of the White Paper addresses meeting attendance and member participation rather than the timing of the meetings, their format, or the services available at the meetings.

Reasons given by members for attending AAPT meetings include:

- Get new ideas and attend workshops
- Participate in conversations, discussions, networking, and sharing with colleagues
- Gather demonstration and teaching ideas
- Obtain technical information
- Meet people (like self) to share common concerns and problems
- Meet important people in field
- Visit with colleagues from other parts of the country
- Make job contacts
- Participate on committee meetings
- Get motivated for upcoming school year

Other data indicate the following:

- Only about 10% of the membership attends a national meeting
- Full-meeting registration at the meetings is generally tending downward.
- Recently, the meeting registration numbers have been converging for the Winter and Summer meetings at 550 full-meeting paid registrations.
- Typical expenses (without travel) are roughly twice as much for a Winter meeting than for a Summer meeting ($890 vs. $485).
- Larger proportions of Four-year College/University members attend national meetings in comparison to the membership demographics for other groups.
- Workshop attendance at the meetings has been strong and constant/session.
- Meetings do not seem to keep prospective members, yet they attend in larger proportion than do continuing members.
- Roughly half of the respondents to a national survey indicated that they would be more likely to attend a professional meeting if funding were made available, the meetings were less expensive, and if the meetings did not conflict with teaching duties.
- Meetings hold little interest for non-teaching members.
- Recently there have been supplementary meetings held in conjunction with AAPT national meetings. These have included TYC21, PTRA, and PER meetings.
- AAPT has sponsored specially funded meetings (e.g., Department Chairs and New Faculty).

Data Interpretation and AAPT Responses:

If AAPT wishes to continue to include diverse groups in its meetings, then the following could be considered:

Since the following appear to be true:	Then AAPT could respond by:
There have been supplementary meetings held in conjunction with and in addition to national meetings.	Expand opportunities for specialized and/or concurrent meetings to appeal to specific membership categories (e.g., PER, laboratory). Expand opportunities for joint meetings with other organizations/societies that would appeal to specific membership categories (e.g., astronomy, advanced courses).
Workshops offer many opportunities for attendees.	Attempt to measure the effectiveness of the workshop offerings. Expand the workshop offerings to appeal to specific membership categories.
Less than 10% of the membership attend a national meeting.	Offer letters to members recounting benefits of attending a meeting. Offer a scholarship to fund first-time attendees. Suggest required meeting attendance as part of grants. Offer letters from Section Presidents to the supervisors of prospective attendees' suggesting meeting attendance. Offer case histories of meeting attendees in a newsletter. Encourage supervisors/school systems to recommend meeting attendance. Consider a one-meeting model. Expand Executive Office support for Section or regional meetings. Expand financial support for speakers at Section or regional meetings. Expand membership involvement in Area or special committees. Expand options for members to participate in Section and/or Regional meetings.
The data collection is not complete.	Determine the attendance of AAPT members at meetings of other societies and related organizations. Determine the overlap of AAPT members at Winter and Summer meetings. Continue to collect data on attendance and paper presentation at meetings.

Prospective members attend national meetings, yet do not join AAPT.	Expand options for types of meetings of interest to members to attend including virtual meetings. Expand advertisement of plenary and awards speakers' talks and allow for more interactions of members with the speakers.

One suggestion in this section has profound implications for the Association. This is the suggestion for a one-meeting model. If AAPT met in a national meeting only once each year, there would necessarily be changes in the role of the Area Committees, Executive Office, and Sections. This would be particularly true if AAPT (with the help of Sections) then sponsored regional meetings. Such a model could address the cost, timing, and travel issues raised by members about meetings.

Likewise, holding more joint meetings with other groups could expand the visibility of AAPT and could encourage more members to attend national meetings.

Finally, the success of the workshops at meetings needs to serve as a foundation for national meeting discussions.

GOVERNANCE

Background and Data

AAPT is governed by its Constitution. This document establishes an Executive Board, Sections, committees, and Council.

The Executive Board is made up of elected members. There are officers and representatives from the Two-year College group, Four-year College/University group, the High School group, and the Section Representatives. The Board meets four times each year.

The Executive Officer is selected by the Board and heads the Executive Office.

At each national meeting, the Area Committees also meet. These committees are made up of individuals selected by the Nominating Committee and/or President to help plan program for the national meetings and deal with relevant issues to the committees. These committee meetings are open to the membership, and they regularly report in The Announcer.

The nation is divided into Sections. Each Section has a board of officers, including a Section Representative. The Section Representative serves as a link between the national AAPT and the local members. Section Representatives must be members of AAPT. The Representative is subsidized to attend the Winter meeting, and Section activities are publicized in The Announcer. The Sections do not have a uniform governance structure in that their membership, size, meetings, dues, and activities are locally determined.

The Council is another segment in the AAPT governance structure. Council is made up of the Executive Board and the Section Representatives. Council determines meeting locations and approves Sections and Affiliated Groups.

Data Interpretation and AAPT Responses:

If AAPT wishes to continue to include diverse groups in its governance, then the following could be considered:

Since the following appear to be true:	**Then AAPT could respond by:**
Area Committees help plan program.	Financially support Area Committee Chairs to help develop/plan meeting program. Develop specialized, tandem, concurrent meetings for specialized groups.
Area Committees exist to address specific issues.	Restructure responsibilities to allow Area Committees opportunities to address more issues rather than focus mainly on program planning. Expand their use by allowing them voice without Executive Board oversight (e.g., create statements on specific issues, develop specific awards programs). Expand the number of tasks assigned to Committees.
Executive Board is representative of the organization. It acts as a leadership organization and can form other leadership groups.	Develop standards for physics courses (web, non-web) and physics preparation. Provide for many opportunities for younger members and those who have participated in specialized meetings (e.g., New Faculty, PER, Department Chairs) to accept leadership roles. Expand opportunities within AAPT for diverse groups to develop and be recognized outside a formal governance structure (e.g., reduce the number of Area Committees and increase the number of other committees)
AAPT has business aspects.	The Association needs to remain financially sound.

CONCLUDING COMMENTS

The suggestions offered in the White Paper build on the idea that AAPT will continue and expand its appeal to a diverse audience. This approach is not universally accepted as an approach for AAPT to follow. Specifically from the Vision Questionnaire several members responded that they “do not wish to see AAPT break up into divisions as has APS,” and that AAPT has an imbalance of emphasis on “methodologies of teaching rather than with the subject

o address the spectrum of educational missions AAPT should “continue an emphasis on improvement of the introductory physics course as the strongest single

Diversity was a theme in the home improvement warehouse analogy at the beginning of this White Paper. To focus on attracting and serving diverse audiences, the store attempted to market its stock in a variety of ways. It did not have special products for contractors versus homeowners; instead it provided special services for the different groups. This requires many employees and a friendly, service oriented attitude throughout the store. The method breeds customer loyalty if the customer has a good experience within the store and with the materials.

If AAPT is to continue to address a diverse audience like the home improvement warehouse, it will need to loosen its governance structure and increase the ways that it markets its products, services, and meetings. This approach is possible; however, AAPT needs to maintain its name recognition on its own quality products and services. For example, publications go through a rigorous review process before they become AAPT products and the Association does not wish to loose this recognition. Yet AAPT would need to allow for dissemination of non-AAPT “endorsed” products. The marketing portion of the need to address a diverse audience would involve “selling” the meetings to different audiences, or packaging the meetings in a different fashion to appeal to different audiences. This is already being done to a limited extent in that the presentations at some of the specialized meetings overlap presentations at national meetings. Fundamentally, AAPT must learn to be made up of many constituencies, yet all interested in physics education.

The vision is for AAPT to enjoy a large, involved membership that is active in local and national affairs of concern to physics education. Also, that there are opportunities for members to share information and expand their knowledge of physics content and physics pedagogy. To facilitate this, AAPT must expand its use of and presence on the World Wide Web, AAPT must make its governance structure more flexible, AAPT must rethink its meeting structure, and AAPT must become more flexible in addressing the needs of its diverse audience.

APPENDIX

Membership

In 1999, with the assistance of Raymond Chu of the AIP Education and Employment Statistics Division and Valerie Evans and Warren Hein of AAPT, a survey of Lapsed and Prospective members of AAPT was done. The response from the survey (Response from Lapsed members N=241 or 19%, Response from Prospective members N = 191 or 19%) indicated the following trends including those listed in the Membership Section:

- Of the 60% of lapsed members who are currently physics educators 60% are from high schools, 29% are from four year colleges and universities, and 6% are from two-year colleges.
- Nearly 80% of the prospective members are currently physics educators.

Criteria	Lapsed members	Prospective Members
Belong to NSTA	15 %	29 %
Belong to regional section of AAPT	11 %	16 %
Top two predominant degree sub-fields	Physics Education, Secondary School General Physics	Education, General Science Physics Education, Secondary School
Would join/rejoin if dues were reduced with no journal subscriptions	28 %	39%
Membership is too expensive for value received	34%	44%
Read (Physics educator only)	HS Univ.	HS Univ.
Physics Today	54% 82%	37% 84%
TPT	74% 63%	70% 56%
Announcer	35% 47%	12% 8%
AJP	24% 59%	25% 44%
Attended AAPT meeting in last two years	Phys Educ 46% Not Phys Educ 50%	Phys Educ 45% Not Phys Educ 26%
Top four reasons for not attending more AAPT meetings	Work/Time conflicts High cost Limited travel budget Location	Work/Time conflicts Limited travel budget High cost Location
Other societies more relevant to my concerns	HS Univ. 11% 29%	HS Univ. 54% 82%

Journal Readership by Members

Journal Readership	High-school	Four-year Colleges/Univ.	Two-year Colleges
The Physics Teacher Magazine	38%	28%	8.7%
The American Journal of Physics	7.4%	49%	6.3%

Meetings

Tom O'Kuma in 2000 collated almost ten years of information about the Winter and Summer Meetings of AAPT including the number of paper sessions and workshops, attendance figures, and costs.
John Hubisz in 1996 chaired a taskforce to make recommendations concerning improvement of meetings. The Executive Board implemented many of these recommendations.

- The data do not indicate any clear patterns in the scheduling of the meetings since over the years, the meetings have been held in different weeks of the month and in different cities.
- There are many categories to describe attendance at national meetings including those paid for full meeting, paid attendance, and total attendance. These different categories include one-day attendance, family members, exhibitors, and special speakers.

Attendance Figures for National Meetings

Winter Mtg.	Avg.	Maximum	Minimum	Summer Mtg.	Avg.	Maximum	Minimum
Paid for Full Meeting	560	631	508	**Paid for Full Meeting**	655	763	514
All Paid	669	726	614	**All Paid**	784	920	653
Total Attend	990	1146	844	**Total Attend**	1125	1416	856

Breakdown of National Meeting Attendance by Groups

	High School	Two-year College	Four-year College / Univ.	Other
Avg. meeting participation	25%	10%	60%	5%
AAPT Membership Statistics	30%	7%	32%	31%

Using a 1997 National Survey of TYC21 Activities
Percent of Respondents Who Indicated that they Agree or Strongly Agree with Statements

Statement	Four-year College/University (N= 581)	Two-year College (N= 583)
If funding were made available to me, I would attend more professional meetings.	50%	64%
If meetings were less expensive, I would attend more professional meetings.	46%	55%
I would attend more professional meetings if they were not in conflict with my teaching duties.	50%	65%

White Paper on Maintaining the Perception of AAPT in the Science Community

Prepared by Carolyn Haas

Due to the ongoing regularly scheduled five-year review of the AAPT Executive Officer, President Howes requested that the investigation of AAPT relations with outside groups be delayed. She did, however, request recommendations based on information accumulated so far and on suggestions from members.

RECOMMENDATIONS

1. Extensive data is needed to establish AAPT's reputation and status with our traditional school, physics, and government partners and associates. The team conducting the five-year review of the Executive Officer is currently collecting and compiling this data. The team will report their findings to the Executive Board at the October Board meeting.

2. Contact with and response to requests from outside groups should be clearly assigned to appropriate staff members throughout the office and these duties should be clearly included in employee job descriptions. Completing these tasks will help prevent repeating past problems involving confusion with respect to which employee has responsibility for a particular duty or task.

3. The suggested new Associate Executive Officer position should not be created until #'s 1 and 2 are completed.

4. AAPT needs to become more visible as an important "player" in physics education policy and funding issues.

5. Alliances should be formed with non-physics groups such as NCTM, MAA, The College Board, and chemistry and engineering groups.

The Preparation of Excellent Teachers at All Levels

Lila M. Adair and Christopher J. Chiaverina
AAPT Planning Meeting
July 27-28, 2000
Toronto, Ontario, Canada

What is the status of teacher preparation in the United States today?

What makes an excellent teacher?

What is the most effective way to prepare future physics teachers?

How do we provide the very best science education for our students?

What should be the role of the physics teacher in today's schools?

Perhaps Christa McAuliffe, the NASA Teacher in Space,
who was killed in the Challenger tragedy, best summarizes
why these questions must be answered.
When asked why she wanted to be the first
teacher in space, she responded,
"Don't you understand?
Every day, through my students,
I touch the future."

To effectively touch the future, teachers must be well prepared
in content, methods, pedagogy and psychology.
AAPT has the tools, the skills and the manpower
to assure that America's physics teachers are second to none.
This white paper outlines the steps
necessary to produce excellent teachers at all levels.

The Preparation of Excellent Teachers at All Levels

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INTRODUCTION

The news is full of stories concerning the poor state of education in this country. State and national legislators are passing bills to improve the situation, all of which offer a quick fix, but no long term solutions to a major problem that has taken years to come about. Nowhere is the crisis in education more acute than in our major urban areas. To wit: faced with an under supply of teachers in certain critical-needs areas, some school districts are forced to look abroad for a solution. Last December, the Chicago Tribune reported that the Chicago Public Schools, under a special agreement with the U.S. Immigration and Naturalization Service, will receive 100 temporary work visas a year for the next five years to recruit teachers from abroad to fill critical shortages in science, mathematics and foreign languages.

The Thomas Fordham Foundation study, *State of the State Standards 2000*, indicates that in spite of a nationally accepted set of curriculum standards, many states are doing poorly on following the standards. Comparing the four major content areas, English, math, social studies and science, the study found that states are performing best in the area of science. However, overall the country receives a grade of C. Only 19 states are judged either to be following successfully the national science standards or have prepared an acceptable set of science standards of their own. Some states have no standards, and many simply have an encyclopedic list of topics with no suggested activities or laboratories. Furthermore, few state standards indicate strong relationships between math and science.

In the bigger picture, it is now clear that states cannot agree on what should be taught, how it should be taught or how teachers should be prepared to teach the material. Before any program dictating certification can be developed, there must be a clear understanding of the answers to these questions. In the Fordham study Finn and Petrilli ask: "How can we expect students to master a body of knowledge, if we fail to define what that body of knowledge is."

Has America been playing catch-up since the days of Sputnik, or is this a new problem? Everyone has a criticism, but no one seems to have a solution. Many elementary students have no science instruction during the year. Middle school students spend only small amounts of time in the lab and are often taught by teachers who have little or no science training. High school students have science teachers who are teaching out of field and spend so much time preparing them for local, state and national tests, that they never seem to quite cover the curriculum. The *Third International Mathematics and Science Study* (TIMSS) report indicates that American students fall well behind students of other nations in science knowledge. Colleges are plagued with an ever decreasing number of physics majors, and prestigious graduate fellowships are going to foreign students, passing over American students.

What is the real problem? Is it the curriculum, the quality of the American student or the preparation of the science instructor? Although all three problems need to be addressed, this paper will deal only with the preparation of teachers in America.

The Problem

The recruitment and preparation of science teachers in general, and physics teachers in particular, has been, and will continue to be, a challenge. There is no reason to believe that this situation will soon abate. The growth in elementary and high school enrollments, the acceleration of teacher retirement, and the quest for smaller class size, portend a need for over 2.5 million new teachers in the next ten years (Hauser, 1999). Meanwhile, the demand for talented college graduates in the private sector continues to attract the best and brightest. Positions in the sciences and engineering with starting salaries exceeding $40,000 are commonplace (Chicago Tribune, June19, 2000).

Presently, wealthy suburban schools are finding enough qualified instructors to satisfy their science and math needs. However, both inner-city and rural schools that do not have the wherewithal to attract qualified staff are left wanting. To illustrate the severity of the problem, 70 percent of 7th through 12th graders in the high-poverty schools are being taught by unqualified teachers. According to the National Center for Education Statistics, the figure nationwide is an alarming 56 percent (NCES, 1996).

The need for qualified science and mathematics teachers is underscored by an announcement by the U.S. Labor Department declaring a critical teacher shortage in math, science, foreign languages and bilingual education. Equally compelling is the previously mentioned decision by the Chicago Board of Education to petition The Department of Labor and the U.S. Immigration and Naturalization Service to allow the Board to use six-year work visas to attract top teachers from abroad. Will Chicago's unprecedented "Global Educators Outreach" program be the salvation of other major cities experiencing a dearth of qualified teachers in critical need areas? And perhaps more importantly, is it the way we, as a nation, want to staff our schools?

The findings of National Center for Education Information (NCEI) paint a somewhat brighter picture. The NCEI research suggests that certain areas of the country may actually have a surplus of teachers. When polled, only nine states reported that it was very likely that a fully certified, recent education major could find a teaching job now. Three states responded, "not likely" and one said "not at all." While the NCEI feels that no widespread teacher shortage has occurred, nor need occur, they do concede that fully certified science, math, and special education teachers stand the best chance of finding teaching jobs now and in the future.

We sent a questionnaire to all state science supervisors requesting information on the training and certification of K-12 teachers of science and physics. The responses indicate a great variation in certification requirements from state to state. With such disparity in teacher preparation, a question naturally arises: If we are to be held to national standards regarding science curriculum, shouldn't we need to look at national standards for teacher preparation programs? The following range of certification requirements indicates the training deemed appropriate by both the states and the National Science Teachers Association (NSTA).

The results of the questionnaire reveal that elementary school teachers are required to have from zero science courses to one year maximum. Since the elementary emphasis is on math and reading, science is a low priority in many states, and with most elementary teachers. Often no money is allocated for science equipment, and classrooms have poor lab facilities with no water or gas lines. Since the learners are still at the concrete operational level, science classes need to be hands-on and relevant to their lives. With little or no formal training in the sciences or science teaching, elementary teachers are often unable to provide meaningful, activity-based instruction.

America's elementary teacher preparation in science falls short of the mark set by the NSTA. The NSTA recommends that elementary teachers have a minimum of one college course in each of the three science areas-biology, physical science and earth science and coursework in science education. Roughly half of the elementary teachers meet this standard. According to Roman Czujko, Director, Statistical Research Center, American Institute of Physics, on average, students majoring in elementary education take the least number of science courses. This includes students majoring in the performing arts.

Clearly the future of science in America begins with elementary teachers. As Howard Voss informed the U. S. House of Representatives Committee on Science, "Science in the schools is the other end of the pipeline that feeds scientists into professional societies. Elementary school science must be taught by people who have actually learned science by experience and inquiry and who have learned about pedagogy. Studying science is not the same as studying about science by reading books or watching computer monitors do cool things." Elementary education departments must be made to see the value of quality hands-on science courses for all elementary teachers.

Recipients of the Presidential Award for Excellence in Science Teaching at the elementary level are teachers who: 1) have attended college where elementary science is a priority or, 2) have dedicated their own time and money attending conferences or workshops to learn how to teach science to elementary children. If elementary science education is to improve, the voices of these excellent role models must be heard.

State science supervisors indicate in the questionnaire that middle/junior high school teachers are required to have from 12 to 24 semester hours of science, with more hours required for those who wish to specialize in science. The NSTA recommends that middle/junior high school teachers' backgrounds should include at least two courses in each of the three science areas as well as coursework in science education. A study done by Horizon Research indicates that the majority of grade 7 - 9 (junior high) science teachers (57 percent) meet the NSTA recommendations, compared to 42 percent of grade 5 - 8 (middle school) teachers.

In junior high, just as at other grade levels, students learn best by doing. In the words of Clifford Swartz: "All that is needed is to make sure that the students learn to do things besides sitting and watching." In his March 1991 editorial, he stresses the importance of hands-on activities and the futility of rote memorization of terms. The importance of competent middle and junior high school teachers capable of providing advanced measurement and observational laboratory activities cannot be overstated. Pen and paper activities do not satisfy the curiosity of these students. In the words of Dr. Swartz: "Puberty is a terrible thing to waste."

The science supervisor questionnaire reveals that, depending on locale, high school science teachers may be required to have from zero to 12 semester hours of physics for broad field certification and from 24 to 30 semester hours of physics for the physics endorsement. Many states only offer a broad field certificate, which allows all science teachers to teach all sciences.

In contrast to their colleagues in elementary school, high school teachers, on the whole, are quite qualified to teach science. The Horizon Research report indicates that 63 percent of high school science teachers have an undergraduate major in science and 72 percent have a major in either science or science education at the undergraduate or graduate level. However, in the area of physics teaching, finding qualified teachers can be a challenge. Based on The AIP report *Maintaining Momentum: High School Physics For A New Millennium* (AIP, 1999), over the years, around 40 percent of the principals looking to hire physics teachers reported having difficulty finding qualified candidates.

The same AIP report states that only 33 percent of high school physics teachers hold a degree in physics or physics education. The report emphasizes that this does not mean that the majority of physics teachers are unqualified, however. The AIP study found that less than 2 percent of high school physics teachers had themselves never taken a college physics course and that virtually all physics teachers have science or math as their field of specialization. Especially heartening is the finding that 67 percent of the physics teachers who had been teaching for more than 5 years had earned a master's degree.

This is good news, for the demands on the high school science teacher are many. In John Layman's book *Inquiry and Learning: Realizing Science Standards in the Classroom*, a list of teacher skills is provided. Teachers are expected to plan inquiry-based science programs, facilitate student learning, assess student learning, provide an appropriate learning environment and create a community of learners. Additionally they are expected to be masters of their subject, to understand all concepts and be able to work all the problems in the book.

College instructors, although knowledgeable in their subject matter, frequently have no formal training in pedagogy. As Howard Voss states, "With some notable exceptions, scientists and mathematicians are not all that famous for expertise in pedagogy. We science types need the education types, and they need us." With the exception of the colleges and universities with strong PER groups, most instructors teach as they were taught, which often involves only lecture and problem sets. Even less skilled in the art and science of teaching, graduate students are given lab, recitation and lecture assignments.

In general, college instruction is based on the premise that teaching is an intuitive act. Since the instructors understand the material, it is just assumed that they know how to effectively share what they know with others. To make matters worse, often there is no feedback to the instructor, because there is little interaction between instructors and students except in smaller colleges or in individual study sessions.

In Leonard Jossem's article "The Teaching of Physics" and his "Resource Letter EPGA-1: The Education of Physics Graduate Students" (AJP 68:6, June 2000), he expresses his concern for the lack of pedagogical training of college professors and teaching assistants. He feels that it is the responsibility of the older, more experienced professors, to teach the new instructors by "precept, example, and friendly council". It should be noted that the AAPT is blessed with numerous exceptional college and university professors, most of whom either developed their skills through trial and error or were fortunate to have a gifted mentor on the faculty.

As college enrollment has risen from 4.7 percent of the college age students in the 1920's to 50 percent of the college age students in the 1990's, the demands on the instructor are quite different. Instructors are expected to have a thorough understanding of the subject matter, be adept at providing interesting, relevant activities in the laboratory and deal with a rapidly changing ethnic and culturally diverse set of students. In addition, the instructor is expected to tailor the instruction to the school, the subject, and the students and prepare the graduates for the world of work. Consequently, many universities are examining the need for the study and practice of modern pedagogy by their faculty members.

Current Efforts to Improve Teacher Supply and Preparation

Innovative Teacher Preparation Programs

Realizing that "the quality of schooling in America is inadequate for the times," the American Council on Education, in collaboration with the American Association of Colleges for Teacher Education, appointed a President's Task Force on Teacher Education. The mission of the Task Force is "to place the education of teachers at the center of the professional and institutional agendas of college and university presidents and their institutions". In the words of Vanderbilt Chancellor Joe Wyatt: "Our nation's future depends on high-quality public education system and a superior force of educators. There is no work more important."

The renewed interest in producing more effective teachers stems, at least in part, from a realization that in the "information age" knowledge is power. In the 21st century, our economy and the well being of our nation, perhaps more than ever before, will depend on a well-educated populace. Academe also realizes that if it is to receive well-prepared students (its lifeblood) from secondary schools, it is essential that teachers in those schools must also be well prepared.

This new sensibility has resulted in the overhauling of teacher preparation programs in over 300 colleges and universities in the last 10 years. The some times radical changes made in education departments have produced some impressive results. Trinity University, Michigan State University, University of Cincinnati, University of Connecticut, University of Virginia have been cited as producing "extraordinarily well-prepared teachers" (Darling-Hammond, 1999).

What modifications in teacher training have lead to this success? The National Commission on Teaching and America's Future found that the most successful teacher preparation programs share common characteristics. The truly outstanding programs examined in the Commission's study were found to base their teacher training on the findings from cognitive research. Among other things, this research suggests a new paradigm, one that challenges the culturally-inculcated model of teaching in which the teacher is seen as the dispenser of knowledge. Student teachers are shown the efficacy of replacing the time-honored, teacher-centered model with a student-centered, inquiry-based pedagogy. Using this approach, the teacher, serving as a guide or facilitator, creates a setting in which students can explore and solve real-world problems.

Successful programs provide a thorough grounding in subject matter (most require a disciplinary degree) and extensive clinical experience. To produce well-prepared teachers, education courses are carefully integrated with the courses on subject-matter topics. To accomplish this, in some cases teacher preparation programs are extended to five years.

Furthermore, the colleges and universities cited as having excellent programs have forged close alliances with local schools. This synergy is found to benefit both student teachers and their students. For example, in San Antonio, improvement in test scores is attributed to the collaboration of school- and university-based faculty and teachers-in-training.

The Physics Teachers Education program at Illinois State University has combined all the above elements. Considered one of the most innovative and the largest in the nation, the program prepares students to teach physics and at least one other subject at the high school level. This is accomplished by integrating a strong physics content major of 44 - 48 semester hours (s.h.) with a professional education sequence of 22 s.h. and the University's general education requirement of 45 s.h. Physics department personnel teach six of the teacher education courses. A total of one hundred-clock hours of clinical experiences is associated with required professional studies and science method courses.

A rather revolutionary feature common to many of the successful teacher-training programs is the "teacher as researcher" model. Not only do future teachers learn from the literature, but they are also taught to use their own classroom experiences to analyze the learning process and modify their teaching accordingly.

This somewhat radical approach is seen by some educational researchers as the solution to America's constant battle to improve the quality of the educational system. In *The Teaching Gap*, Stigler and Hiebert conclude that the failure of many of the reforms instituted in this country can be attributed to a " top down" approach. They argue that only by allowing teachers to apply the results of their own research will improvement in student learning be realized.

Stigler and Hiebert's thoughts on improving teaching grew from their study of the TIMSS data. Through a cross-cultural study of standard professional practices in three countries - Germany, Japan and United States - they observed how incremental change in classroom practice can lead to an improvement in student understanding.

It is interesting to note that the "teacher as researcher" model was once used in the United States with great success. According to Stigler and Hiebert, at the turn of the century, John Dewey transformed the University of Chicago laboratory school into a "hotbed of educational improvement...where teachers and researchers, through collaborative planning and experimenting, developed knowledge of effective classroom practice and fed it back into the system. The lines between teachers and researchers were blurred; all were engaged in learning about teaching and how to improve it in the context of real classrooms." The great experiment came to end when Dewey left Chicago. His replacement, Charles Judd, separated the researchers from the teachers, a situation that continues today.

Alternative Teacher Training and Certification

Over the past ten years, more than one hundred alternative teacher certification programs have been instituted in this country. Faced with the threat of teacher shortages, especially in the areas of science and mathematics, 40 states have passed legislation that encourages alternative programs for the preparation and certification of individuals who already hold a bachelor's degree and want to become teachers. Critical teacher shortages in the Southeast have caused states like Georgia to provide signing bonuses to teachers willing to go into critical fields like science and to provide full tuition for teachers willing to return to school and earn additional certification in science. As of early 1998, it was estimated that, nationwide, over 75,000 people had been granted certification through such programs.

Retirees, mid-career professionals from business and industry, ex-military personnel, and liberal arts graduates are among those seeking alternative teacher certification. The programs that have emerged to meet the demand for alternative licensing are as diverse as the clientele seeking licensure. Most alternative route programs are based at colleges and universities. They are designed to provide accelerated or post-baccalaureate training for people from various educational backgrounds and occupations. These programs all include formal classroom instruction, some form of practice teaching and mentoring.

According to Paul Vallas, CEO of the Chicago Public Schools, the Chicago system is using an increasing number of alternative certification programs to recruit talented graduate students and mid-career professionals in non-education fields to become teachers through a shortened certification process. One such program, Chicago's Golden Apple Teacher Education (GATE) program, relies on the expertise of K-12 classroom teachers who are recognized leaders in their field. Recently established by the Golden Apple Foundation in partnership with the Chicago Public Schools and Northwestern University, GATE is open to people who hold college degrees in the arts or sciences and have five-year work histories. The GATE program's reliance on award-winning classroom teachers to create and administer programs, teach courses and mentor GATE graduates is unique. A GATE program intern receives a provisional teaching certificate after completing one year of training and a four-year renewable certificate after a successful first year in the classroom.

Under the Department of Defense Troops to Teachers Program, military personnel and Department of Defense (DOD) and Energy (DOE) civilian employees affected by military "drawdown" are given the opportunity to pursue a new career in public education. One of the goals of the program is to help relieve teacher shortages, especially in the subjects of science and math.

AAPT's Efforts to Alleviate the Problem

AAPT, along with some fellow professional societies, has made a major contribution in the area of science teacher preparation. Currently AAPT is sponsoring Powerful Ideas in Physical Science, a 1000 page college curriculum designed for university faculty to instruct prospective elementary teachers and non-science majors in elementary physical science. The course provides a wide range of materials and assessment tools and incorporates innovative instructional approaches based on decades of research on physics education.

Middle school teachers have profited from Operation Physics, which is not an AAPT project but is heavily staffed with AAPT people. The program provides a series of modules covering the major topics of physics and physical science. Each module contains written material, worksheets, problems and hands-on activities written by experienced physics teachers.

High school physics teachers have benefited from the highly successful Physics Teaching Resource Agents (PTRA) program which, since its beginning in 1985, has trained approximately 900 PTRAs in content, pedagogy, methods and specific laboratory activities. These PTRAs then serve as teachers-of-teachers, providing professional development through workshops and summer institutes for thousands of teachers across the country. In 1999, PTRAs provided 85 six-hour workshops, with a total of 1545 participants, 30 percent of which were minority teachers. Participants cover a wide spectrum of teachers: 80 percent high school, 16 percent middle school, 4 percent elementary; 51 percent male, 49 percent female; 58 percent urban, 34 percent suburban, and 9 percent rural.

College instructors benefited from the Introductory University Physics Project (IUPP), a joint venture with APS which ran from 1987 to 1995 and was originally directed toward reform of the calculus-level introductory physics course. Current AAPT programs include the Physics Revitalization Conference, Two-Year Colleges in the Twenty-First Century (TYC21), Workshops for New Physics Faculty and Preparing Future Physics Faculty (PFPF).

The Physics Revitalization Conference focused on planning for and implementing and assessing change in undergraduate physics. One of the main topics of discussion was the preparation of future physics instructors. The draft report of the conference states "physics education research has shown that passive methods (such as straight lecture) are less effective than teaching methods that actively involve students in learning. Active engagement techniques have been shown to improve student's conceptual understanding, and physics education research has led to the development of instructional methods and materials that improve conceptual understanding and problem solving skills."

TYC21 was designed to improve physics education by promoting communication and interaction among two-year college faculty, who are often isolated and overlooked in their small colleges. One of their goals was to increase awareness of current developments in physics education research and innovative teaching strategies. The American Council of Education document *To Touch the Future* notes that 20 percent of all classroom teachers begin their training in two-year colleges. Two-year colleges provide the majority of our minority and multicultural teachers and teachers who come into the profession as middle career adults.

The Workshop for New Faculty was initiated to help new college and university faculty members become more effective instructors. The four workshops held thus far have addressed recent developments in physics curriculum and pedagogy.

Preparing Future Physics Faculty is part of a new NSF program designed to create a model graduate program to prepare future faculty for emerging and evolving roles in five academic disciplines: chemistry, computer science, mathematics, microbiology and physics. The program will increase knowledge, broaden perspectives and develop skills of graduate faculty members and graduate students about how to incorporate research, teaching and service components into doctoral education for aspiring faculty.

Over the years, there have been numerous alphabet soup programs, some with substantial professional development components. Many of these have all but faded from sight: NSTA Scope, Sequence and Coordination, Introductory Science Curriculum Study (ISCS), Introductory Physical Science (IPS), Physical Science Study Committee physics (PSSC), Man Made World, Harvard Project Physics, to name a few. Current programs include Principles of Technology, Active Physics, Comprehensive Conceptual Curriculum in Physics (C3P), Modeling and the new NSF joint AAPT-APS proposal PhysTec.

Recommendations

AAPT has the unique distinction of being the recognized authority in physics teaching in America. Along with that distinction goes the burden of dealing with the problems of preparation of potential physics instructors. There are five major areas where AAPT can have a strong voice in the solution to this problem.

(1) AAPT should continue to support all current programs that directly affect teacher preparation at any level.

Powerful Ideas in Physical Science…elementary school
Physics Teaching Resource Agents (PTRA)…middle and high school
PhysTec…high school and undergraduate
Workshops for New Faculty…undergraduate
Preparing Future Physics Faculty (PFPF)…graduate

(2) AAPT should work to develop new college courses and programs for the preparation of future teachers K-18.

(A) Teacher preparation courses should address content, methods, on-the-job training and observations in real classrooms. Instruction should be appropriate to the level of students who will be taught. Serious consideration should be given to providing a thorough understanding of the intellectual development of the student at each level, and appropriate hands-on activities should be designed. (Swartz, 1967, 1990, 1991) (Jossem, 2000)

(B) The physics department and the science education department should work together to design these courses, with the assistance of experienced classroom teachers. (PhysTec, 2000)

(C) Colleges should be encouraged to design a 5-year degree program, offering a B. S. in science or physics and a B.S. Ed. in science education. There are numerous colleges in America which already do this, and their graduates are far better prepared when they enter the classroom. Most foreign countries require a degree in the discipline before a prospective teacher is allowed to enter the teaching profession. (Stevenson & Stigler, 1992) (AAPT USA/Japan/China conference reports)

(3) AAPT should take the lead in developing follow-up programs for first year teachers.

Currently most American teachers never receive any formal support from the school of education of the science department from which they graduated. They are left to "sink or re often too embarrassed or overwhelmed to ask for assistance. In Japan, first-year-teachers must spend 20 hours per year in professional development, supervised by a mentor teacher. They meet on a regular basis, share lesson plans, teach each other's lessons, and evaluate the plans (Stevenson & Stigler, 1992).

Retired teachers, many of whom were actively involved in innovative programs, before leaving the classroom, could serve as mentors. The PTRA program is making extensive use of retired PTRAs to run their urban centers (Horizons Research, 1999).

This approach could also be applicable at the college level. AAPT has a large cadre of retired professors who could serve as excellent role models for new professors.

(4) AAPT should devise a plan for developing a set of national standards for the certification of science teachers to match the national science standards.

AAPT's support of the national standards indicates an acceptance of the designated science content appropriate for each level of education. It therefore follows that teachers should be trained to teach that specific content in a manner appropriate for the developmental level of the students. If we believe this to be true, then there should be a set of national standards for obtaining a teaching certificate.

(5) AAPT should take the lead in developing follow-up programs to provide life-long professional development of physics teachers at all levels.

A successful local effort along these lines is the Arizona Science and Technology Educational Partnership, which grew out of the Modeling Workshops. As was mentioned above, many good physics programs (PSSC, Harvard Project Physics, etc.) have disappeared, primarily because there was no infrastructure to keep them going. To counter this trend, perhaps a national effort should be undertaken. The Modeling Workshop authors have proposed a National Center for Physics Education (NCPE). The principal activity of the NCPE would be to organize meetings and workshops to drive science education reform and provide life-long professional development through university-high school partnerships.

Some Concluding Thoughts

In addition to their classroom responsibilities, teachers in America are expected to be counselors, surrogate parents, psychologists, and disciplinarians. Pre-college teachers are required to also attend faculty meetings, parent conferences, and professional development sessions. They have hall duty, bathroom duty, bus duty, and lunchroom duty. In many areas of the country, they are given what amounts to a subsistence wage and asked to teach subjects for which they have little or no training. In far too many situations, science teachers are asked to teach science without adequate equipment or facilities. At the same time, teachers are accused of being incompetent because they can't remedy the ills afflicting our young people, our schools and our nation.

Presidential candidates and legislators propose programs that they insist will improve the educational system in America. Efforts are made to encourage talented young people to pursue careers in teaching. Yet it seems that these attempts at educational reform rarely bring about any fundamental change in the quality of education in this country.

What can the AAPT do to improve America's educational system? First and foremost, our organization must continue to support and develop programs that improve physics instruction at all levels. This begins with improved teacher preparation and continues with professional development opportunities for teachers in the field. We must strive to insure that the brightest and best trained find their way to the front of our classrooms as well as into our nation's boardrooms and laboratories. Then, and only then, will our students have the schools they require and deserve.

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White Paper on Undergraduate Education

Prepared by J.D. Garcia, Ruth Howes, Ken Krane, Heidi Mauk, Mary Beth Monroe, Ed Neuenschwander, Dan Schroeder, Dan Smith, Judith Tavel, Stamatis Vokos

Goals:

AAPT's goals in the undergraduate arena are:

> To ensure that every person who holds either an associates degree or a bachelors degree understands the basics of physics and its methods and applications well enough to enter today's high tech workplace and to make informed decisions on personal issues and on societal and political issues.
>
> To help all students who aspire to a career related to math, science, engineering, and technology to develop conceptual and quantitative problem-solving abilities as well as scientific reasoning skills.
>
> To help physics departments to recruit talented and diverse students as physics majors and provide them with the skills they need to enter the workforce or to pursue graduate studies in physics or other fields.
>
> To promote the recruitment and in-depth preparation of K-12 teachers who teach physics and physical science as a process of inquiry (This goal is so important to AAPT that it is treated in a separate white paper.)
>
> To be a catalyst for the systematic and sustainable improvement of physics instruction in ways that are informed by results from physics education research.

Challenges and Opportunities:

There are four major trends that present challenges and opportunities for AAPT in undergraduate education.

1. The American public recognizes that higher education in technical areas is critical for those who prosper in the economy of the twenty first century.

> Physics provides students with skills they need to function in technical fields. AAPT has the opportunity to establish physics as a key element of future undergraduate curricula. However, the current physics curriculum will have to be refined and specialized to meet the needs of a wider variety of students interested in specialized technical careers or to serve as basic training for the life-long learning required for success in our changing economy. Undergraduate physics has focused strongly on preparing students for graduate school and paid less attention to the majority who enter the workforce directly from undergraduate school.

Undergraduate departments, at both two and four-year institutions, are faced with competition for funding and students from other academic departments. Many departments have tailored their offerings to fill niches where industry needs trained professionals, for example in computational physics or biophysics, and many others are following their example. A one-size curriculum does not fit all departments, nor does the upper division curriculum that has been in place for the last thirty years meet the challenges of students seeking specialized, high tech careers.

Most physics majors immediately enter the work force on graduation. The successful physics department of the future must establish collaborative undergraduate degree programs that serve a broader student audience than the traditional physics major and that offer more instantly recognizable applicability to students as well as to employers. Simultaneously, departments must preserve the integrity of the traditional physics major, which has served the community so well in preparing students for graduate study and professional careers in physics.

AIP surveys indicate that employers look for: a) ability to reason quantitatively; b) problem solving skills; and c) skills in approaching new and unknown situations. Actual physics knowledge was not high on these employers' lists of traits they consider when hiring. The good news is that physics provides strong training in these skills. However, introducing advanced topics into the upper division at the expense of experience solving lab problems and working in teams may not serve the majority of physics majors who plan to seek employment directly after graduation.

In selling graduates to employers and in the competition for funding within the university, physics departments are required to demonstrate the quality of their graduates. The development of an accreditation or certification program like that of the American Chemical Society or the Accreditation Board for Engineering and Technology provides one mechanism for doing this, but there are other considerations that should enter the discussion. Certainly, many small physics departments do an excellent job preparing their students and should not be left out of the discussion.

Most undergraduate physics departments produce few physics majors and produce the majority of their FTEs through courses for non-majors. In fact, the number of physics majors graduating per year is roughly half the number of faculty members in degree-granting departments. The most common number of physics majors graduating from undergraduate departments is zero.

Faced with such developments as the new ABET criteria which eliminate the specific requirement for a physics course, physics departments have begun to work towards improving their calculus-based and algebra-based courses. AAPT must play a role in helping departments with these introductory courses for all majors and recognizing that the majority of physicists are not familiar with the findings of physics education research and the curricula that have been developed on the basis of these findings.

A particularly important group of non-majors is the pre-service teachers whose needs are treated in a separate white paper so will not be addressed here.

2. The physics major has traditionally lacked diversity ethnically, economically and with respect to gender.

Entering students in the next five years will come from a wider set of ethnicities than their predecessors. Many of them will be older, non-traditional students and half of them will be female. These returning students often attend classes part-time. Physics courses, both for majors and non-majors, must recognize the different learning styles and needs of all students as well as the needs of students who face physical challenges.

Today's students bring a new set of skills with them when they enter college. Many are adept at the construction of web pages but have never taken a car motor apart or applied their skills to a scientific investigation. They are accustomed to obtaining information from video and computer screens, a behavior which sometimes appears to traditionally trained faculty members as the students having a short attention span. Physics departments must respond to these changes in the entering students. If physics departments are to avoid following departments of classics and geography out of the mainstream of university life, they must expand their appeal to diverse students with a variety of backgrounds who seek a variety of careers.

3. Universities and colleges will face pressure to become more commercially viable and will undoubtedly experiment with new techniques for delivering higher education.

AAPT has an opportunity to shape the higher education of the future. In particular, careful investigations of the effectiveness of delivery of courses in physics (and science generally!) by remote means are needed, particularly with regard to moving students from concrete to abstract ways of thinking.

Undergraduate physics departments grew rapidly during the post-Sputnik boom. Consequently, many departments face the imminent retirement of large numbers of faculty members. This is reflected in the increase in the average age of AAPT members (Currently our median age is 53 years and a quarter of us are over 61). AAPT has a significant opportunity to impact the preparation of the next generation of faculty members for their roles as teachers.

The fastest growing segment of undergraduate education is the two-year college. Approximately 25% of the undergraduate physics taught today is taught in two year colleges, and the students taking introductory physics in the two year colleges are likely to be female, minority and older. The NSF report, Shaping the Future, noted that two year colleges enroll the largest percentage of college undergraduates, offer the largest percentage of undergraduate science, mathematics, engineering and technology courses, and teach the largest enrollments of undergraduates of any single sector of the undergraduate community such as research universities or engineering schools. In addition, data from the NSF workshop, "Investing in Tomorrow's Teachers: held in March, 1998, indicate that 40% of pre service teachers receive their science/math training at a two year college.

During the six-year term of the AAPT program TYC21, the AAPT membership from the two-year college community has increased from about 600 members to 900 members with AAPT/TYC21 regional networks spanning the United States. The two-year college as a niche between high school and the four year college has a vantage position to implement change in our undergraduate physics programs.

AAPT is unique in its ability to integrate physics teachers at all levels. Its programs address instructional techniques and content issues that span the range from high schools through research universities. Each educational level has its own agenda, and AAPT faces a challenge in integrating these diverse constituencies to promote a common agenda leading to excellence in undergraduate physics education.

4. Over the last twenty years, research on the learning and teaching of physics has emerged as a new field of scholarly inquiry.

Systematic investigations of student understanding conducted by the physics education research (PER) community have shown that many students leave their introductory physics courses with little meaningful learning having taken place. This alarming result has been reproduced repeatedly at two- and four-year colleges and universities, those whose primary mission is teaching and those whose primary mission is research. Understanding the difficulties that students have in understanding physics concepts has allowed physics education researchers to develop instructional strategies that have been shown to be effective in improving student learning.

The sub discipline of physics education research (PER) has been accepted by the physics community as a legitimate research field for faculty members. Physics is unique among the scientific and technical disciplines first in incorporating PER within physics departments as a research sub discipline and second in the quantity of research results available to the community and the impact these research results are already having in the community.

AAPT (along with APS and AIP) has supported the emergence of PER and encouraged the use of its results in developing physics curricula. AAPT has an opportunity to extend these activities and faces the challenge of supporting an emerging subdiscipline of physics that can flourish in all institutional settings while remaining accessible to physicists whose primary interests are in other subdisciplines. PER must sustain research rigor while remaining inclusive and accessible to the broader physics community so that its results will have a significant and permanent impact throughout undergraduate physics education.

Activities for AAPT

In response to the changes in the workplace:

Support the National Task Force on Undergraduate Education in four activities currently proposed: site visit program for physics departments, a survey of undergraduate departments to see what is going on and what they need, a conference with representatives of other disciplines working on problems in undergraduate education, and preparation of new materials on careers for physics majors.

Develop guidelines and training for departments at all levels on how to interact with local industries that employ their graduates. Introduce voices from the industrial workplace at AAPT meetings. AAPT should hear from recent graduates concerning how their academic training in physics serves them in the workplace.

Provide an atmosphere of support and encouragement for those who use their physics outside the traditional academic environment, for example in public outreach or in making public policy. Work with SPS on their "hidden physicist" project and provide sections with lists of speakers whose careers have followed non-academic paths. Make AAPT members aware of existing career materials.

Work with Sigma Pi Sigma and other groups to encourage continuing fellowship among all physicists, both those in traditional careers and those in less traditional occupations.

Have a serious but open discussion within the entire community to articulate the principles, motivations, assumptions, desired results, problems, and logistics that are involved in "certification" or "accreditation." Physics may not wish or need to institute a formal accreditation bureaucracy along the lines of ABET or ACS, but some guidelines are probably in order. Certainly the subject is controversial, but AAPT needs to provide leadership in opening a discussion of these issues. ABET plans to begin accrediting applied science courses in the near future, so this process may be of immediate concern to some departments.

Convene a meeting to prepare a document describing modifications that have been made to the upper division curriculum in order to prepare graduates for a wider variety of careers (i.e. physics and business models, the paradigms model at Oregon State, the workshop model at Dickinson etc.) The resulting document should also provide evidence of the effectiveness of the modifications in achieving their goals. Stimulate proposals that support funding for real and radical change here. It may be that a conference is not the most effective way to attack issue relating to the upper division physics major, but we need to reexamine the training we are giving our students in the context of today's jobs.

Provide a web site with listings of upper division text books and reviews contributed by users following the model of reader reviews used by Amazon.com although the text book reviews should be signed.

There is a growing trend for very specialized, multidisciplinary courses to meet specific needs of industries. AAPT should take the lead in establishing guidelines by which physics departments can meet these specific needs and simultaneously retain the valuable rigor of traditional physics courses.

In response to the lack of diversity in physics:

AAPT should examine successful models established at UC Berkeley, Georgia Tech and Xavier University for increasing the representation of underrepresented groups in the sciences. What these schools have in common is a commitment to recruiting and mentoring underrepresented minorities in numbers large enough to sustain a community. This is the first step in removing the social barriers to joining the larger scientific community.

Combining physics with another major or concentration has proved effective for recruiting underrepresented minorities to physics. Even though such a course if study frequently requires more than the usual four years, the enhanced career possibilities prove to be attractive. This is consistent with some of the issues described above, but AAPT should seek ways to advertise physics careers to minority students. We should explore collaboration with the National Society of Black Physicists, the National Society of Hispanic Physicists and other minority professional societies. Awards or scholarships are often an effective tactic in recruiting majors. AAPT should work to secure appropriate funding.

Many minority students begin their careers in two-year institutions. AAPT should develop a program to encourage two-year colleges to work in partnership with four-year institutions to mentor promising minority students at two-year institutions. One model might be for two-year faculty to identify students with aptitude for physics and then work in partnership with university faculty to obtain research opportunities, academic advising and other mentoring for them as they move to the four-year department.

At both two- and four-year institutions, AAPT should work with SPS chapters and departments to ensure that minority students are paired with student and faculty mentors. Mentoring has been shown to be a critical element in student success, and AAPT should foster its development in physics departments for all undergraduates as well as members of underrepresented groups.

AAPT should work with sections to develop theme sessions at regional meetings on recruiting and retaining minority students. The sessions should specifically address learning styles, mentoring and recruitment strategies.

AAPT should form a partnership with the Society of Physics Students and get the chapters to become active in recruiting "honorary" members from local high schools. We should support the SPS campaign to form more chapters on two-year campuses. AAPT should consider developing lists of good speakers who are willing to address SPS chapters without charge if they are in easy driving distance of the chapter.

AAPT should devote increased attention to the physics course for liberal arts students since it is the only one that many students take. If we are to interest some of these students in pursuing physics majors, we must do it in this course and design major programs that will allow them to complete a physics major from a liberal arts start. One model is to introduce a one-semester course to follow introductory physics that puts the calculus in. Another is to move away from a mile-wide and inch-deep course that emphasizes algebraic manipulations to a course in which students develop robust reasoning skills with much less content covered.

In response to the changing environment in higher education:

Continue the on-going work on preparing future faculty.

Maintain an emphasis on preparing graduate teaching assistants for their critical role in introductory physics instruction and assessing their performance in the classroom. Prepare materials to train teaching assistants in the use of interactive teaching strategies.

Establish new funding for the New Faculty Conferences that have already proved successful.

Seek funding for a program to provide workshops on physics education for mid-career faculty.

Improve the teaching effectiveness of faculty by supporting visiting fellowships to institutions that play a leading role in PER.

Define ways to sustain and institutionalize within AAPT the network of two-year college faculty established under the TYC21 program. Expand the TYC21 networking program to enhance the linkages between physicists in two and four year institutions.

Develop a program to evaluate new technologies for delivering physics courses. Courses offered in unconventional formats range from web-based introductory courses to the graduate level courses offered on the physics of accelerators with a wide variety of formats in between. The quality of these courses varies widely. AAPT should develop a standard method for assessing the effectiveness of these formats in helping students to learn physics and in preparing them for their future careers.

In response to the development of physics education research:

Continue support for PER conference following the AAPT summer meeting.

Work with the PER community to establish a venue for refereed publication of the highest quality. This is essential both to inform the AAPT community of PER results and to provide publications that young faculty in the area need for tenure. The PER supplement to AJP is a start in this direction but has not yet established itself as a permanent entity.

Actively encourage funding agencies to recognize PER as a sub discipline of physics.

Develop a program through which PER results are disseminated at section meetings. The objective would be to reach faculty who otherwise would not be aware of these results.

Take a leadership role in promoting the need for assessing student learning in a course and not just student attitudes.

Provide a forum for the development of appropriate assessment strategies that can be used in different institutional settings. Provide opportunities for professional development of physics instructors in using such assessments. Devise strategies for incorporating assessment strategies in the training of graduate teaching assistants.