The Role, Education, Qualifications, and Professional Development of Secondary School Physics Teachers

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American Association of Physics Teachers

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Executive Summary

Introduction

Candidates for secondary school physics teaching positions may be drawn from a variety of sources. Some may have completed an accredited physics or physics teaching program, others may have training in other educational, science, engineering, or business disciplines. Still others may be entering the profession as an alternative or second career. The purpose of this document is to provide some guidance for administrators to gauge a candidate's qualifications to teach physics.

Knowledge of physics content

A secondary school physics teacher is expected to have a major or a minor in physics (or equivalent physics coursework). Coursework in physics should cover a wide range of topics in the areas of general physics, classical mechanics, electromagnetism, thermodynamics, wave motion, sound, optics, and modern physics. A subset of these courses should also employ inquiry-based laboratory activities. Teachers should have had a physics research experience to connect theory with practice in the discipline.

Knowledge of teaching physics

Classroom climate

The classroom of a qualified physics teacher is an active learning community where students: work in groups conducting meaningful experimental investigations; build and test scientific explanations; engage in thought provoking activities; and conduct inter-group discussions and evaluation of each other's arguments. In such a climate students are actively engaged in discussions and collaboration.

Classroom Example: Instead of explaining to students how circuits work and providing analogies, the teacher provides groups of students a light bulb, one wire and a battery. After students succeed in lighting the bulb, they describe their experiments to the class and craft an explanation as to why that particular method worked. Other groups compare their work with that group and the whole class participates in a class discussion.

Curriculum

This includes knowledge of sequences of topics that help students build understanding of new concepts or skills. These concepts or skills are built beginning with knowledge the student brings to the classroom. Sequencing choices are often supported by findings within physics education research. *Classroom Example*: When the teacher plans a lesson she/he can clearly articulate what specific lesson components build on student ideas known from research, the teacher modifies the lesson based on student responses, and the teacher avoids using terminology with which students are unfamiliar.

Knowledge of learners

This includes knowledge of ideas that students bring into the classroom (not necessarily wrong ideas) and difficulties that they might have constructing concepts or interpreting physics language that might differ from everyday language.
Classroom Example**:** When the teacher has to do a demonstration lesson she/he ascertains what students learned before and what they are expected to do next. For example, if the assignment is to teach gas pressure, the teacher might elicit student understanding of principles through concept questions or students' responses to questions on impulse and momentum. This information is then used by the teacher to modify and adjust the lesson plan.

Effective instructional strategies

This involves knowledge of multiple methods or activity sequences that lead to successful student learning of a specific concept or process skill. The teacher should be able to employ a variety of concrete and abstract representations and experimental procedures to appeal to the variety of ways students learn. The teacher should always encourage students to arrive at an answer by reasoning rather than by memorization and recall.
Classroom Example**:** The teacher: uses and encourages students to construct multiple representations of the same idea during a lesson; asks students to explain (using queries like "How?," "Why?," or "Explain") phenomena or answers; and allows students to discuss questions in groups before presenting an answer. When students have difficulty understanding a concept, a teacher suggests or encourages students to employ alternative approaches.

Assessment

This includes the ability to employ different methods to assess, both formatively and summatively, student conceptual understanding, acquisition of reasoning and problem solving skills, and science process skills. An equally important aspect of assessment is to enable students to self-assess their own work and that of their group, and to encourage and respond to constructive feedback. The ability to carry out this level of reflection is a powerful tool to enhance conceptual understanding.

Classroom Example**:** A teacher and students set and evaluate goals for activities. Students and the teacher have multiple opportunities to revise their work and improve it while they are learning a new concept. When the teacher writes a unit test (or a lab practical exam), every assignment assesses a specific goal articulated at the beginning of the unit, so that the test and the lab exam as a whole assesses most of the goals.

Acknowledgment

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The Role, Education, Qualifications, and Professional Development of Secondary School Physics Teachers

Overview

This document is the result of the work of a subcommittee of the American Association of Physics Teachers (AAPT); this subcommittee was established by the AAPT Committee on Physics in High Schools and eventually became a joint effort with the AAPT Committee on Teacher Preparation. The primary intent of the document is to provide guidance to secondary school administrators in the evaluation and professional support of physics teachers. Administrators may find the information provided in section 2 (Role of a Physics Teacher) and section 3 (Education and Qualifications) particularly valuable for this purpose. The writing committee also believes that the document will be beneficial to in-service teachers who wish to improve their teaching through professional development. In-service teachers may find information in section 4 (Professional Development) of particular interest, in addition to sections 2 and 3.

1. Introduction

The following statement from *The Role, Education, and Qualifications of the High School Physics Teacher* (AAPT Committee on Special Projects for High School Physics, 1988) describes both its focus and that of this document, which is an update of that earlier publication.

"Excellence in high school physics depends on many things: the teacher, course content, availability of apparatus for laboratory experiments, a clear philosophy and workable plan for meeting students' needs, serious dedication to learning goals, and adequate financial support. The role of the teacher, however, is the most important. Without a well-educated, strongly motivated, skilled, well-supported teacher, the arch of excellence in high school physics collapses. The teacher is the keystone of quality."

Education research has continued to show that an effective teacher is the single most important factor of student learning (Darling-Hammond, 2000; Marzano, 2007). Marzano characterizes an effective teacher as one who matches the strategies to the students.

In *Physics at the Crossroads* (Hilborn, 1996) the author argued that physics education was at a "critical juncture." Introductory physics courses were criticized because students who completed them lacked preparation for more advanced courses, an understanding of physics, and an ability to apply the ideas. The ideas expressed in this report are still a concern in physics education.

Factors that affect the actual teaching of physics have changed since publication of *The Role, Education, and Qualifications of High School Physics Teachers* (AAPT Committee on Special Projects for High School Physics, 1988). George D. Nelson describes these changes as an evolutionary framework consisting of four generations of instructional change (Nelson, 2006). He characterized the four generations as follows:

- Generation 1 was a traditional approach using textbooks with the students as passive learners. Information was presented to the students in a lecture format and assigned readings in a textbook were supplemented by demonstrations and, possibly, "cookbook" laboratory activities. Students were responsible for solving problems after the teacher showed them examples of how this type of problem was solved. After the launch of Sputnik, different ideas on teaching physics emerged. Various programs were developed, including *PSSC Physics* (PSSC Article Collections) and *Harvard Project Physics* (Holton, 1969), as a result of funding from the National Science Foundation. These programs served as a bridge to Generation 2.
- The Generation 2 ideas of teaching style changed drastically to promote student-centered learning rather than the teacher-centered model in Generation 1. Teachers needed additional professional development to employ the constructivist strategies in their classes.
- Since 1997, a Generation 3 emerged, using cognitive research-based materials to support constructivist learning. Generation 3 may incorporate technology for collecting and analyzing data and conducting simulations to compliment student development of cognitive understanding of science concepts. Formative assessment is a key factor to enable the teacher to pose questions and help guide students in their quest for understanding of scientific concepts.
- According to Nelson, Generation 4, an approach involving teacher collaborative learning communities, is the next step. These changes in the teaching of physics pose challenges for the preparation of physics teachers.

Many states have implemented a standards-based science curriculum in grades K – 12 that is often based on the *National Science Education Standards* (National Research Council, 1996). Teachers are responsible for implementing the standards-based curriculum and preparing the students for state tests in science as well as existing tests in mathematics and language arts. The effective teaching of physics includes using strategies to promote constructivist learning, conceptual understanding of physics topics, and to develop skills and methods for students to understand the process of scientific inquiry. These teaching strategies include the use of cooperative learning, technology tools, activities performed in order to collect, analyze, and report data. The teacher needs to understand the use of formative and summative assessments and techniques to create a learning environment where students share the responsibility for their own learning. As our understanding of how to more effectively engender student learning grows this altered understanding is leading to changes in teacher preparation but it also indicates the need for ongoing professional development.

In addition to our changing understanding of how people learn, physics teachers today are facing a greater variability in terms of students' academic preparation, educational expectations, epistemologies, and demographics than in years past. The need to better engage this changing population adds support to the necessity for ongoing professional support.

Science teacher education is changing. The National Science Teachers Association (NSTA) has published reports that describe standards and the revisions needed within science teacher preparation to support students achieving these standards. The standards were based on the review of professional literature and the *National Science Education Standards* (NRC, 1996), which we will reference as *(NSES),* and were designed to be a performance assessment tool at certain times during a teacher preparation program. The first three areas of the NSTA *Teacher Preparation Standards* (NSTA, 2003) deal with preparation in subject matter, the nature of science, and inquiry as a methodology for teaching and learning. The remaining seven standards deal with preparation for teaching students to become more informed about science issues, preparation to meet the needs of students, curriculum, science in the community, assessment, safety in the classroom, and professional growth. The standards offer a general outline of areas that should be included in courses and experiences for the preparation of physics teachers.

This revision of *The Role, Education, and Qualifications of the High School Physics Teacher* (AAPT Committee on Special Projects for High School Physics, 1988) is based on the perspective of the current reform in physics education. What is the role of the physics teacher in the classroom and the community? What education and qualifications will help physics teachers be effective in helping students learn physics? What are personal attributes of physics teachers that help them be successful? And finally, what types of professional development opportunities will help teachers continue to grow as teachers?

2. Role of a Physics Teacher

A good physics teacher is someone who realizes that among the most valued and significant roles of a science teacher is to help a student understand a body of information and the processes of scientific investigation. This teacher derives great pleasure when students truly comprehend a concept or principle and appreciates the role scientific inquiry had in its development.

Teacher Self-Preparation

Behind the scene work determines the level of student understanding. Quality teaching depends on what is done by the teacher before stepping into the classroom. Preparation is key:

- Set the goals in terms of conceptual and process outcomes.
- Decide what students will do in the classroom to achieve these goals.
- Decide how to assess whether the goals are achieved, including the roles of both formative and summative assessments.
- Maintain a positive outlook and be flexible.
- Prepare subject material: sequencing and correlating to standards.
- Prepare lab apparatus and equipment.

Teacher-Student Interaction

The primary role of a teacher is to establish a learning environment where all students are able to learn and are motivated to learn, an environment that is both challenging and supportive:

- Establish a learning community consisting of the teacher and the students.
- Recognize and celebrate diversity in students.
- Design or select varied instructional strategies to accommodate different learning styles.
- Establish and implement a consistent classroom management plan.
- Listen to student ideas and be prepared to address them.
- Guide students to view the place of physics in the wider scientific world.
- Encourage and support students in discovering concepts independently when possible.
- Maintain appropriate methods of communication with parents to keep them informed of student progress and attitude and address any issues that may arise.
- Make sure that student activities are challenging yet doable, and that students can track their progress.

- Make sure that students can establish connections between classroom activities and everyday experiences.
- Review safety procedures with students.
- Assess student progress both formatively and summatively.

Community Building in the Classroom

It is important for students to feel comfortable in the classroom. A good teacher should make connections with the students:

- Be authentic and genuine.
- Learn the names of all students early and speak to each student every day.
- Recognize and acknowledge students' interim successes that lead to final understanding of concepts and principles.
- Be available to provide extra help and be willing to respond to questions.
- Involve and include all students in classroom activities.
- Be fair and consistent in the treatment of each student.
- Be accurate and specific in evaluating student progress.

Scientific Literacy Development

Science does not happen only inside the classroom. Science teachers are charged with producing informed consumers of science who will be able to make decisions whenever science intersects public policy. Thus the teacher should be an informed and critical observer of science, concerned with developing scientific literacy:

- Take advantage of community resources.
- Connect with scientists outside of the classroom through speakers and field trips.
- Provide students with opportunities to learn, for choice, and for success.
- Provide meaningful applications, and manageable tasks for students to perform.
- Bring scientific news into the classroom.
- Discuss implications of new technology.
- Address real-world problems that may be interdisciplinary.
- Provide activities and opportunities for students to experience physics outside the classroom.

Additional Responsibilities

In addition to classroom responsibilities, teachers are expected to fulfill other obligations:

- Participate in division, department, and school-wide meetings.
- Support school related activities and functions.
- Contact other teachers through professional meetings and organizations.
- Pursue professional development.

3. Education and Qualifications

The professional knowledge, skills, and dispositions of physics teachers should be grounded in what their physics students will need to know and be able to do in order to contribute meaningfully to life in a democratic society. National and state goals and standards reflect these needs, and have strongly converged in recent years.

The physics teacher's knowledge base consists of three components: content knowledge, pedagogical knowledge, and pedagogical content knowledge (Shulman, 1986; Etkina, 2005). Content knowledge is knowledge of the discipline itself, and includes such things as procedural methods. Various documents define the content that students should learn, e.g., *Benchmarks for Science Literacy* (AAAS, 1993), and teacher-preparation documents, such as the *NSES* (National Research Council, 1996) describe the role and dispositions of the teacher. Pedagogical knowledge represents a "*generic* why and how to" of teaching. These, too, are addressed in national and state standards. Pedagogical content knowledge (PCK) represents a situation-specific overlap of content knowledge and pedagogical knowledge. PCK deals with the "*specific* why and how to" of teaching a given discipline. PCK is complex, and is often the result of many years of classroom experience (Wells et al., 1995). It can be described as "knowledge in context" and, according to Shulman (1986), includes knowledge of student difficulties and prior conceptions in the domain, knowledge of domain representations and instructional strategies, and domain-specific assessment methods. Others have since elaborated on the construct adding teachers' dispositions toward teaching and knowledge of curriculum (Grossman, 1991; Magnusson, Krajcik & Borko, 1999). A broader description of what a physics teacher candidate's knowledge base should be is provided in summary fashion as follows:

Content Knowledge

Physics Content: There is considerable research that indicates greater student gains in learning are associated with better-prepared teachers (Darling-Hammond, 2000). A physics teacher is a member of a learning community who has developed a broad and current understanding of the major content areas of physics and allied sciences presented here in no particular order:

- Kinematics and dynamics
- Impulse and momentum
- Work, energy, and power
- Newtonian principles and laws including engineering applications
- Conservation of mass, momentum, energy, and charge
- Physical properties of matter

- Thermodynamics and kinetic-molecular motion
- Atomic models, radioactivity, nuclear reactors, fission and fusion
- Wave theory, sound, light, the electromagnetic spectrum and optics
- Electricity and magnetism

The teacher's understanding will be at a level consistent with appropriate national and state standards, and include a familiarity of the unifying principles of science such as conservation laws, symmetry, and quantum behavior. This presupposes that the teacher possesses a general understanding of the closely allied fields of earth and space science, chemistry, and mathematics, and will be aware of the major findings of the biological and environmental sciences.

Ideally, the teacher will have learned basic content knowledge through methods of inquiry thereby acquiring closely associated procedural knowledge. The teacher should have had an opportunity to experience the processes of scientific investigation: observing, asking questions, defining a problem; hypothesizing from an evidence base; making predictions; creating an experiment; identifying and controlling variables; collecting, graphically representing, and interpreting experimental data; conducting error analyses; drawing inferences and conclusions from data; and communicating results. Knowledge so gained will help the teacher better understand science as a way of knowing. Teachers, with this kind of background, can more effectively use inquiry-based classes to guide students to understand both the power and the limitations of science.

Ideally, physics teachers will learn this content through a major in physics. Teachers who are assigned to teach physics without adequate content preparation should be provided support for developing requisite content knowledge. This includes taking one or more physics teaching methods courses through a high-quality teacher-preparation program that teaches and promotes the best practices of science instruction. In such programs, teacher candidates will have the opportunity to observe how such practices are used in physics classes, as well as planning and teaching lessons in secondary physics classes.

A careful review of the expectations for all students participating in the learning of science reveals the same set of expectations, varying in depth of expectations at various learning levels. See, for instance, the *National Science Education Standards* (National Research Council, 1996), *Science for All Americans* (AAAS, 1991) and others. It is reasonable, therefore, to expect that teachers should possess the very knowledge, skills, and dispositions that society expects their students to learn.

Nature of Science: A physics teacher has developed an understanding of the nature of science including an understanding of scientific nomenclature, intellectual process skills, rules of scientific evidence, postulates of science, scientific dispositions, major misconceptions about science, and unifying concepts and processes of science.

Making Connections: A physics teacher has developed an ability to help students understand how physics relates to their lives, the community, and society in general. Such teachers help students address science-technology-society issues in a forthright and objective manner. They help students become informed citizens who will one day need to make decisions about science related issues as they relate to environmental quality, education, and personal and community health.

Pedagogical Knowledge and Pedagogical Content Knowledge

Physics Teacher Preparation Programs

Secondary level physics teachers are prepared through a variety of programs. This includes undergraduate and graduate degree programs, including master-level programs and alternative certification programs. Science teacher education programs vary considerably because of their programmatic nature, differences in certification requirements of the fifty states, and the philosophies of faculties at universities and colleges. Some institutions will prepare specialists (a single field preparation model) whereas others will prepare generalists (broad field preparation model). Some teachers will receive specialized science methods courses within their content major whereas others will receive generalized science methods courses from a college of education.

Universities and colleges use a variety of approaches. In some colleges and universities, students complete content and education courses and during their last semester complete student teaching. Others use Professional Development School or university-school partnership models. These models often consist of collaboratives formed between teacher-education programs, content-area departments, and school districts. One advantage of partnership programs is that field experiences are more fully integrated with course work prior to student teaching, and give teacher candidates extensive opportunities to observe and apply their knowledge in “real world” situations.

All teacher-education programs should be accredited by their states. Accreditation by national agencies ensures students of the highest quality educational experience possible, and should be an important consideration for teacher candidates deciding which institution to attend or for school administrators deciding which graduates to hire.

Qualifications: Physics teachers understand what constitutes effective teaching. Physics teachers should, at a minimum, have had appropriate experiences leading to a demonstrable understanding of the following elements of pedagogical knowledge.

Curriculum—Physics teachers understand how to develop learning outcomes for science instruction that incorporate state and national standards for teaching science, and select appropriate curriculum materials to meet standards-based outcomes. They understand the logical connections between the topics of the curriculum, the need to build on each other, and to create learning progressions. They are aware of the "depth versus breadth" conundrum of science teaching, and have an understanding of how to appropriately balance transmission and constructivist approaches to teaching and learning.

Instruction—Physics teachers possess the following skills of teaching:

- Preparation—Physics teachers prepare lessons using a variety of instructional approaches, create unit plans, and deal with the broad implications of year-long curriculum planning. This includes the proper alignment between preparing objectives, designing appropriate means of achieving these objectives, and ways of assessing whether the goals are achieved.
- Instructional delivery—Physics teachers use a variety of instructional strategies to help students learn and understand the concepts of physics. These include but are not limited to interactive demonstrations, inquiry lessons and labs, reading, case study discussions, peer instruction, cooperative learning, Socratic dialogues, problem-based learning, historical studies, and the use of strategies tailored to meet the needs of diverse learners. They will effectively utilize cooperative learning strategies that involve small groups of students in roles where they share a common goal and resources in order to build interdependence.
- Student ideas—Physics teachers elicit, identify, confront, and resolve resilient preconceptions that students bring to the classroom that are derived from casual observations of the physical world. Teachers should understand the difficulties that students encounter in the formulation of scientifically acceptable explanations.
- Metacognition— Physics teachers help students self-assess and regulate their learning by reflecting critically on what they should know and be able to do.
- Inquiry teaching—Physics teachers understand and apply accepted

practices of science to help students develop knowledge on the basis of observation and experience. This includes the appropriate use of learning cycles and instructional practices such as discovery learning, interactive demonstrations, inquiry lessons, inquiry labs, and hypothetical inquiry.

- Assessment—Physics teachers assess student learning continually by effectively using diagnostic, formative, and summative practices.
- Technology - Physics teachers should be familiar with technology and the use of technology tools in physics lessons
- Learning environments—Physics teachers know how students learn and how to use instructional practices so that the learning environment is student centered, knowledge centered, assessment centered, and community centered (National Research Council, 2005, page 411). Such teachers know how to establish and maintain a respectful, supportive, and safe learning environment that is emotionally and physically conducive to learning.

In general, Education courses provide pre-service teachers an opportunity to gain a background in the history of education as well as recent educational policies and issues in public schools. Pre-service teachers learn about various styles of learning. They also gain a background in learning disabilities; assessments; how children learn; and a child's intellectual, social and personal development. As the pre-service teachers progress through the education courses, they gain insight into the actual applications of teaching strategies in methods courses and student teaching.

Personal Attributes of a Physics Teacher

Many of the personal attributes of a physics teacher mirror attributes of teachers in general. Personal attributes, such as the following, are crucially important to physics teachers performing their job effectively:

- The teacher believes in active learning. Teachers know effective instructional practices and will help their students learn science content through the processes of inquiry.
- The teacher has an interest in physics. Teachers are passionate about their subject matter and possess knowledge of the curriculum.
- The teacher has good interpersonal skills. Teachers are good communicators; good interpersonal skills are a prerequisite for good teaching.
- The teacher believes all students can learn. Teachers understand that students will learn in relation to the expectations set for each of them.
- The teacher is conscientious. Individuals who are committed to their

students and their work make the best teachers.

- The teacher is a leader. Good teachers will lead by example and encourage students to strive for excellence.

4. Professional Development

Both the teaching profession and the field of physics are in a constant state of change. Teaching strategies are emergent and not absolute therefore quality professional development is critical to the retention and improvement of any teacher in the classroom. Teachers should be encouraged to participate in peer collaboration experiences. These may occur within the department, within the school, within the district, within the community, at the state or national level. Some suggested venues for continued professional development follow:

Continuing Education

The physics teacher should be encouraged to pursue further studies in both physics and teaching pedagogy. Working towards advanced degrees can be both financially and professionally rewarding since many schools' salary structure encourages working towards a graduate degree.

Professional Organizations

There are a number of groups or associations with which the teacher can affiliate in order to keep in touch with developments in the field, effective teaching practices, and changes in resources. Membership and active involvement in professional organizations are recommended. These organizations include:

- Local sharing groups
    - In some localities, physics teachers from local schools meet several times a year. Meetings may have speakers, reports of research, classroom projects, or tours of facilities.
- State science associations
    - Sections of the American Association of Physics Teachers The local section of the AAPT is a valuable organization. It provides a clearinghouse for much information, a means to keep up with latest developments and advances in physics teaching, and a chance to become known to other physics teachers.
    - State Section of the National Science Teachers Association

The local section of the NSTA is a valuable organization. It provides a clearinghouse for much information, a means to keep up with latest developments and advances in physics teaching, and a chance to become known to other science teachers.

- National science associations
    - American Association of Physics Teachers (AAPT, http://www.aapt.org/, referenced 30 April 2009)
      The AAPT has two national meetings each year. The meetings are in different places in the country in order to make it possible for teachers (K-20) everywhere to make meetings every few years. The meetings have participant papers, plenary speakers, workshops, discussion groups, teacher sharing, vendors, exhibits, committee meetings, lunches, dinners, awards ceremonies, and opportunities to network with colleagues and meet friends.
    - National Science Teachers Association (NSTA, http://www.nsta.org/, referenced 30 April 2009)
      The NSTA has one national meeting and several regional meetings each year. All sciences are represented. The focus of these meetings is K-12.
    - American Physical Society (APS, http://www.aps.org/, referenced 30 April 2009)
      The APS runs high school teacher days at many of its divisional meetings and both of its annual national meetings. These workshops, which are free for all physics and physical science teachers, provide a networking opportunity with research physicists, and a look at contemporary physics research during APS meetings.

Workshops and Institutes

Workshops allow for networking with other teachers as well as learning new content and pedagogy. Strategies come alive when the teacher is exposed to the methodology at first hand. When teachers learn and share with fellow colleagues it reduces teacher isolation and tends to renew enthusiasm. Some of these opportunities provide stipends, continuing education credits, or graduate credits. Workshops are available through such institutions as:

- Universities
- Colleges
- Museums
- Business and Industry
- Research institutes
- Professional organizations such as AAPT, NSTA, and APS

Summer Research or Work Experience

These opportunities exist to give teachers experience with real world applications of their content area. It gives the teachers a better understanding of the nature of scientific research. Some of these opportunities provide salaries or stipends. Opportunities exist in:

- Universities
- Colleges
- Museums
- Business and industry
- Scientific and medical research facilities
- National laboratories
- Research Experiences for Teachers programs, funded by the NSF

Mentoring

Having a good, experienced mentor is essential to the growth of a physics teacher. As more physics teachers enter the profession without formal training in physics teaching, mentoring takes on an important role in the development and retention of qualified teachers. Teacher candidates and in-service teachers should be given the opportunity to work with effective, experienced teachers. It is important that the administration provides time, training, and support for mentoring experiences. This support needs to be extended to both the mentee teacher and the mentor teacher. Organizations such as the AAPT can be utilized to assist in locating mentors in the event that mentors cannot be found locally, e.g. small and or rural schools. When teachers receive this support from the administration and their mentors then the teachers will have the background to become mentors themselves. This snowball effect increases the number of qualified teachers and mentors, thus enhancing the school and student learning. Mentoring aids in both personal and professional development of both the mentee and the mentor:

- Reduces burnout
- Creates a sounding board for new ideas
- Decreases isolation

- Provides a non-threatening method of evaluation
- Provides a cheerleader for encouragement and sharing of success
- Allows for networking
- Provides opportunities to look at old things in new ways
- Encourages constant evaluation of what is done and why
- Opens dialogue on best practice and how to apply to a specific situation
- Fosters an environment of learning and sharing

Publications

Scientific knowledge is continually growing. This along with the changing nature of science education requires the teacher to keep abreast of modern developments. Professional readings will keep the physics teacher up to date, and help maintain an awareness of current topics of interest and recent developments. Suggested publications include:

- **Journals**
  - The Physics Teacher (http://scitation.aip.org/tpt/, referenced 30 April 2009)
  - American Journal of Physics (http://ojps.aip.org/ajp, referenced 30 April 2009)
  - The Science Teacher (http://www.nsta.org/highschool/?lid=pub, referenced 30 April 2009)
  - Physical Review Special Topics – Physics Education Research (http://prst.per.aps.org, referenced 30 April 2009)
- **Books**
  - *Teaching Introductory Physic* (Arons, 1997)
  - *Hands-on Physics Activities With Real-Life Applications* (Cunningham & Herr, 1994)
  - *Five Easy Lessons: Strategies for Successful Physic Teaching* (Knight, 2002)
  - *How to be an Effective Teacher: the First Days of School* (Wong, 1998)
  - *The Flying Circus of Physics* (Walker, 2007)
  - *Teaching Secondary School Science* (Trowbridge & Bybee, 1996)
  - *Teaching Introductory Physics: A Sourcebook* (Swartz & Miner, 1998)
  - *Teaching Physics for the First Time* (Mader & Winn, 2008)
  - Many more may be found through AAPT, NSTA, Association for Supervision and Curriculum Development and other organizations

- **WebPages**
    - ComPADRE (http://www.compadre.org, referenced 30 April 2009)
    - Physics Teacher Education Coalition (http://www.PTEC.org, referenced 30 April 2009)
    - Physics Education Technology Interactive Simulations (http://phet.colorado.edu/simulations/, referenced 1 May 2009)
    - BUBL physics education site (http://bubl.ac.uk/link/p/physicseducation.htm, referenced 30 April 2009)
    - websites associated with science and education publications
- **Newsletters**
    - AAPT eNNOUNCER (http://www.aapt.org/about, referenced 30 April 2009)
    - NSTA Reports (http://www.nsta.org/publications/reports.aspx, referenced 1 May 2009)
    - APS Forum on Education Newsletter (http://www.aps.org/units/fed/newsletters/, referenced 1 May 2009)
    - APS Forum on History of Physics Newsletter (http://www.aip.org/history/newsletter/, referenced 1 May 2009)
- **Listservs**
    - a variety of listservs focusing on secondary physics teaching are available including those sponsored by AAPT (http://www.aapt.org/Membership/listservs.cfm, referenced 1 May 2009))
    - Physhare (http://lists.psu.edu/cgi-bin/wa?A0=PHYSHARE, referenced 30 April 2009)
    - Physlrnr (http://listserv.boisestate.edu/cgi-bin/wa?SUPED1=physlrnr&A=1, referenced 30 April 2009)

5. Summary

The focus of physics teaching is to guide students to an understanding of physics concepts and to have the ability to apply their knowledge. This document describes the responsibilities and background of an effective secondary physics teacher. This teacher creates a positive learning environment in which the student is responsible for learning and understanding the concepts. The teacher is part of a community that extends beyond the classroom to the science department, the school, the community, and secondary physics teachers nationwide. Since the teacher is part of this community, the ideas discussed in class include the application of mathematics to physical problems, how to apply language arts to explain their findings and ideas to other students, as well as real world applications.

Preparation for secondary physics teaching requires a background in physics content, general education courses, and the ability to apply the education strategies to teaching physics. The background includes the planning and preparation of lessons and units that meet the state standards and use a variety of strategies depending on the needs of the students. The physics teacher also becomes aware of preconceptions and concept change. During field experiences the teacher may observe a safe learning environment that supports the understanding and application of physics concepts. During the student teaching experience the student teacher has the opportunity to apply the educational strategies and actually teach physics classes.

After successfully gaining the background for teaching physics classes and beginning the teaching experience, the physics teacher realizes that education is a continuing process. Professional development opportunities are available in courses offered by universities, workshops, and other types of activities.

Secondary physics teachers are rewarded for their efforts to continually improve by students' statements such as "Physics is everywhere," "Physics is fun," "I explained the physics ideas to . . .," and "having a student relate mathematics applications to physics activities." One of the best rewards may be having former physics students return for a visit and indicate they have become physics teachers.

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