Education and Qualifications

Excerpts from:
The Role, Education, Qualifications and Professional Development of Secondary School Physics Teachers
https://www.aapt.org/Resources/upload/Secondary-School-Physics-Teacher-Role_booklet.pdf

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 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.

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