# Science Education Standards: A New Approach

C. Bezergiannidou[1], A. Balouktsis[1], L. Theodoridou-Sotiriou[1]

[1]Technological Institute of Serres, 62100, Serres, Greece
*{bezergian@sch.gr, tasosb@teiser.gr, mtheod@teiser.gr}*

**Abstract:** The science education standards provide criteria for judging the performance of the components of the science education system responsible for providing schools with necessary financial and intellectual resources. In the education system, the school is the central institution for public education. The school includes many components that interact, for example, teaching, administration, and finance.
The primary function of the science education is to supply society with scientifically literate citizens. Information and resources (typically financial) energize the system. The nature of the information, the magnitude of resources, and the paths along which they flow are directed by policies that are contained in instruments such as legislation, judicial rulings, and budgets.
Components of the science education that have a major influence on teacher certification fit into four categories: (1) professional societies, (2) program-accrediting agencies, (3) government agencies, and (4) institutions of higher education operating within and across national, state, and local levels. The importance of standards does not imply that all teachers should pursue a single approach to teaching science. Teachers need to use many different strategies to develop the understandings and abilities.
This paper presents what students should understand and be able to do, how students should be taught, and means for assessing students' understandings, abilities, and dispositions in science. Also, it approaches an educational system in which all students demonstrate high levels of performance, in which teachers are empowered to make the decisions essential for effective learning, in which interlocking communities of teachers and students are focused on learning science, and in which supportive educational programs and systems nurture achievement. Finally, this paper compares features in common and standards across the countries of the EU and gives the differences between countries in terms of the intended curriculum and the assessment used.

**Keywords:** *science education, standards, educational system, certification, assessment*

## 1. INTRODUCTION

Science education standards present the need to give students the opportunity to learn science. Students cannot achieve high levels of performance without access to skilled professional teachers, adequate classroom time, a rich array of learning materials, accommodating work spaces, and the resources of the communities surrounding their schools. Responsibility for providing this support falls on all those involved with the science education system.
Standards provide criteria that people at the local and national levels can use to judge whether particular actions will serve a scientifically literate society. They bring coordination, consistency, and coherence to the improvement of science education. If people take risks in the name of improving science education, they know they will be supported by policies and procedures throughout the system.
Science literacy is important. First, an understanding of science offers personal fulfillment and excitement—benefits that should be shared by everyone. Second, people are confronted increasingly with questions in their lives that require scientific information and scientific ways of thinking for informed decision making. Science understanding and ability also will enhance the capability of all students to hold meaningful and productive jobs in the future.

The business community needs entry-level workers with the ability to learn, reason, think creatively, make decisions, and solve problems [1].

## 2. DEFINITIONS AND GOALS

### *2.1. THE TERM "STANDARD"*

The term "standard" has multiple meanings. Science education standards are criteria to judge quality: the quality of what students know and are able to do; the quality of the science programs that provide the opportunity for students to learn science; the quality of science teaching; the quality of the system that supports science teachers and programs and the quality of assessment practices and policies

Schools must have students learning science by actively engaging in inquiries that are interesting and important to them. Students thereby must establish a knowledge base for understanding science. In schools, teachers must be empowered to make decisions about what students learn, how they learn it, and how resources are allocated. Teachers and students together must be members of a community focused on learning science while being nurtured by a supportive education system. Students could not achieve satisfying science standards in most of today's schools and a sustained, long-term commitment is required to change [2].

### *2.2. THE TERM "SCIENTIFIC LITERACY"*

Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. It also includes specific types of abilities. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately[3].

### *2.3. THE TERM "SCIENCE TEACHING STANDARDS"*

Science teaching standards provide criteria for making judgments about progress on sciences; they describe what teachers of science at all grade levels should understand and be able to do. Teachers are central to education, but they must not be placed in the position of being solely responsible for it. They need to work within a collegial, organizational, and policy context that is supportive of good science teaching. In addition, students must accept and share responsibility for their own learning. Effective teachers of science create an environment in which they and students work together as active learners. While students are engaged in learning about the natural world and the scientific principles needed to understand it, teachers are working with their colleagues to expand their knowledge about science teaching. To teach science, teachers must have theoretical and practical knowledge and abilities about science, learning, and science teaching.

Standards for science teaching are grounded in:

- Science education requires changes throughout the entire system.
- What students learn is greatly influenced by how they are taught.
- The actions of teachers are deeply influenced by their perceptions of science as an enterprise and as a subject to be taught and learned.
- Student understanding is actively constructed through individual and social processes.

- Actions of teachers are deeply influenced by their understanding of and relationships with students.

A challenge to teachers of science is to balance and integrate immediate needs with the intentions of the yearlong framework of goals. Also, inquiry into authentic questions generated from student experiences is the central strategy for teaching science. Teachers focus inquiry predominantly on real phenomena, in classrooms, outdoors, or in laboratory settings, where students are given investigations or guided toward fashioning investigations that are demanding but within their capabilities. At all stages of inquiry, teachers guide, focus, challenge, and encourage student learning. Teachers who are enthusiastic, interested, and who speak of the power and beauty of scientific understanding instill in their students some of those same attitudes. Skilled teachers guide students to understand the purposes for their own learning and to formulate self-assessment strategies. Effective science teaching depends on the availability and organization of materials, equipment, media, and technology. The school science program must extend beyond the walls of the school to the resources of the community. Effective teachers design many of the activities for learning science to require group work, not simply as an exercise, but as essential to the inquiry. Although individual teachers continually make adaptations in their classrooms, the school itself must have a coherent program of science study for students [4].

## 3. ASSESSMENT IN SCIENCE EDUCATION

### *3.1. PROFESSIONAL DEVELOPMENT FOR TEACHERS OF SCIENCE*

Teachers of science are professionals responsible for their own professional development and for the maintenance of the teaching profession. Becoming an effective science teacher is a continuous process that stretches from preservice experiences in undergraduate years to the end of a professional career. Science has a rapidly changing knowledge base and expanding relevance to societal issues, and teachers will need ongoing opportunities to build their understanding and ability. Teachers also must have opportunities to develop understanding of how students with diverse interests, abilities, and experiences make sense of scientific ideas and what a teacher does to support and guide all students. And teachers require the opportunity to study and engage in research on science teaching and learning, and to share with colleagues what they have learned.

Science education requires a substantive change in how science is taught and an equally substantive change in professional development practices at all levels.

The nature of professional development experiences and about the context within which they take place frame the professional development standards are grounded in:

- Professional development for a teacher of science is a continuous, lifelong process.
- The traditional distinctions between "targets," "sources," and "supporters" of teacher development activities are artificial.
- The conventional view of professional development for teachers needs to shift from technical training for specific skills to opportunities for intellectual professional growth.
- The process of transforming schools requires that professional development opportunities be clearly and appropriately connected to teachers' work in the context of the school.

Science content increases and changes, and a teacher's understanding in science must keep pace. Knowledge about the process of learning is also continually developing, requiring that teachers remain informed. The challenge of professional development for teachers of science is to create optimal collaborative learning situations in which the best sources of expertise are linked with the experiences and current needs of the teachers. Prospective and practicing teachers must take science courses in which they learn science through inquiry, having the same opportunities as their students have to develop understanding. Teachers of science are

the representatives of the science community in their classrooms. Teachers use their knowledge to make effective decisions about learning objectives, teaching strategies, assessment tasks, and curriculum materials. When teachers have the time and opportunity to describe their own views about learning and teaching, to conduct research on their own teaching, and to compare, contrast, and revise their views, they come to understand the nature of exemplary science teaching [5].

### *3.2. ASSESSMENT STANDARDS*

Assessment standards describe the quality of assessment practices used by teachers and state agencies to measure student achievement and the opportunity provided students to learn science. Assessment standards must include [6]**;**

- Assessments must be consistent with the decisions they are designed to inform.
- Achievement and opportunity to learn science must be assessed.
- The technical quality of the data collected is well matched to the decisions and actions taken on the basis of their interpretation.
- The content and form of an assessment task must be congruent with what is supposed to be measured.
- Assessment tasks must be developmentally appropriate, must be set in contexts that are familiar to the students, must not require reading skills or vocabulary that are inappropriate to the students' grade level, and must be as free from bias as possible.
- The choice of assessment form should be consistent with what one wants to measure and to infer.
- The inferences made from assessments about student achievement and opportunity to learn must be sound.
- When teachers treat students as serious learners and serve as coaches rather than judges, students come to understand and apply standards of good scientific practice.
- Eliciting and analyzing explanations are useful ways of assessing science achievement.
- Understanding and doing inquiry are contingent on knowing concepts, principles, laws, and theories of the physical, life, and earth sciences.

### *3.3. SCIENCE CONTENT*

Three criteria influence the selection of science content. The first is an obligation to the domain of science. The subject matter in the physical, life, and earth and space science standards is central to science education and must be accurate. The second criterion is an obligation to develop content standards that appropriately represent the developmental and learning abilities of students and express meaningful links to direct student observations of the natural world. The content must be aligned with students' ages and stages of development. The third criterion is an obligation to present standards in a usable form for those who must implement the standards, e.g., curriculum developers, science supervisors, teachers, and other school personnel.

### *3.4. SCIENCE EDUCATION STANDARDS*

Science education system standards provide criteria for judging the performance of the components of the science education system responsible for providing schools with necessary financial and intellectual resources. Components of the science education system serve a variety of functions that influence the classroom practice of science education. Functions generally decided at the state level include the content of the school science curriculum, the characteristics of the science program, the nature of science teaching, and assessment practices.

Components of the science education system that have a major influence on teacher certification fit into four categories: (1) professional societies, (2) program-accrediting agencies, (3) government agencies, and (4) institutions of higher education operating within and across state and local levels [1].

- Policies that influence the practice of science education must be congruent with the program, teaching, professional development, assessment, and content standards while allowing for adaptation to local circumstances.
- Policies that influence science education should be coordinated within and across agencies, institutions, and organizations.
- Policies need to be sustained over sufficient time to provide the continuity necessary to bring about the changes required.
- Policies must be supported with resources.
- Student learning must be viewed as the primary purpose of schooling, and policies must support that purpose.
- Science education policies must be equitable.
- All policy instruments must be reviewed for possible unintended effects on the classroom practice of science education.

## 4. EDUCATIONAL SYSTEMS IN EUROPE

### *4.1. OBJECTIVES AND STRATEGIES IN SCIENCE EDUCATION*

Objectives of the science education system are to raise highly skilful, productive and creative individuals, having advanced thinking, perception and problem-solving skills and open to new ideas. Student-centered education must be carried out in all kinds and at all levels of education in line with the requirements of the time and society, that no individual is left out of the education process for any reason, and that professional development and employment conditions of the teachers are improved [7].
General strategies must be;

- Remote education methods must be developed by making maximum use of technological facilities, particularly computer technology, at all levels of education.
- Computer-assisted education must be expanded to include all levels of education and schools must be equipped with tools and equipment to meet the needs of the 21st century.
- In order to meet the teacher requirements at all levels of education, teacher training projects executed in collaboration with higher education institutions must continue besides the existing teacher training system;
- Financing opportunities must be developed and existing resources used effectively in order to improve the education institutions in terms of physical infrastructure, equipment, curriculum and teachers, all of which directly influence the quality of education.

### *4.2. COMPARISONS*

Students in Europe see a direct relationship between their performance in school and the options that will be available to them after they complete their compulsory education. The school system per se and the various career options available provide incentives to work hard in school. There is a systematic mechanism in place for moving young people into the work force with the appropriate skills as well as a good foundation for all later learning, whether it is academic or vocational. In Germany, private industry and government are jointly responsible for education and training in fields of pre-professional specialization. This educational system is found also in Austria and Switzerland with only minor variations from the Germany system, and in France, Scotland, England, and Wales with slightly greater

differences in the systems. In all cases, however, there are national standards set in cooperation with business and industry associations. The certificates obtained after training carry weight in the labor market because employers know exactly what skills the student must master to achieve the certificate and because the skills conform to those needed in that occupation at the present time.

## 5. CONCLUTIONS

Scientists, science teacher educators, state departments of education, local school boards, business and industry, governmental and nongovernmental agencies, school administrators, teachers, parents, and students all have a role to play in science education standards.

Science teachers have been involved in the development of the science education standards, because they have a central role in implementing them. But it would be a massive injustice and complete misunderstanding of the standards if science teachers were left with the full responsibility for implementation. All of the science education community—curriculum developers, superintendents, supervisors, policy makers, assessment specialists, scientists, teacher educators—must act to make standards a reality. With distributed leadership and coordinated changes in practice among all who have responsibility for science education, advances in science education can rapidly accumulate and produce recognizable improvement in the scientific literacy of all students and future citizens.

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