FRAMEWORK FOR PHILIPPINE SCIENCE TEACHER EDUCATION

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Foreword

This framework is the product of months of careful planning and discussions, with ideas coming from the best minds in the field of science, prior to the actual drafting of the manuscript. Although there may have been opposing views during the development of this framework, which is not unusual when experts meet, the final output is proof that individuals with diverse backgrounds and beliefs could be united by a common vision and goal.

The “Framework for Philippine Science Teacher Education” contains resources that will help teacher education institutions, university science professors and school administrators assess and improve the performance of science teachers using standards-based rubrics. The qualities of effective science teachers in terms of what they should know (knowledge), what they are expected to do to achieve quality learning outcomes (practice) and what they should possess to be able to embrace change and sustain professional growth (attributes) are also included. All these are anchored on the objective of raising the quality of science education.

It is hoped that this framework will be widely used and applied by the various stakeholders, and that together we will work towards achieving the desired goal of effective science teaching among our teachers.

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Director, Science Education Institute
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CHAPTER 1
Introduction

The mission of schools is to educate children to higher standards of performance by providing them with the experiences necessary to learn, define, analyze, adapt and invent. This statement was made in 1994 by Linda Darling-Hammond, Executive Director of the National Commission on Teaching and America’s Future.

Mission of Schools and Teacher Education Programs

This same mission is echoed by schools not only in the Philippines but all over the world. The Hammond Report also emphasized that teachers who will successfully carry out this mission need to be well-prepared and well-equipped. They need to be grounded deeply in subject matter, knowledge of children’s cognitive, social and personal development, and learning and motivation. In addition, they should have deep-rooted knowledge of varied approaches to teaching strategies, collaborative learning techniques, creative ways to implement the curriculum and use technology tools as well as effective assessment practices.

Raising the learning standards can be achieved through a responsive teacher preparation program and continuing professional development program for all practicing teachers.

Science Education in the Philippines: Challenges and Prospects

In the Philippines, recent efforts have been directed to improving science education, both at the basic and teacher education levels. Research shows that the
quality of science education in schools is greatly influenced by the quality of science teachers. Students’ interest in science is directly linked to the quality of teaching as well as learning interactions provided by their science teachers. Interviews with students who excelled in science reveal that they were greatly inspired by science teachers who engaged them in tasks that enabled them to inquire and solve problems.

Science has a rapidly changing knowledge base and expanding relevance to society. Teachers must pursue opportunities to build their understanding of how students with varied interests, abilities, and experiences can be supported and guided. Subsequently, students may be able to make sense clearly out of scientific ideas. These ideas can be linked to real-life situations. Furthermore, science teachers must have the chance to conduct research in regard to science teaching and learning, and to share the results of their studies with their colleagues.

Science teachers who manage to develop students’ skills in searching for answers to questions about materials and phenomena in the environment, and those who empower their students to grow to become informed decision makers in society, are considered effective teachers. These teachers are also able to evaluate their own practice and use these insights to develop challenging learner-centered experiences. In effect, a committed science teacher should be reflective, collaborative, and a lifelong learner.

There are many constraints facing science education in Philippine schools: shortage of qualified science teachers, lack of quality textbooks, inadequate equipment, large classes, lack of support from administrators, and many others. However, the Core and Technical Working Groups for this project decided that the framework for science teacher education should pay attention to problems that will address ways to improve or raise the quality of teaching practices, and personal attributes.

**Challenge 1: Shortage of qualified science teachers**

In 2004, Garcia and Tan prepared a report on Project RISE (Rescue Initiatives in Science Education). The report describes qualified teachers as follows:
1. Those who have specialization in any science discipline (e.g., biology, chemistry, physics, and general science) in their undergraduate degrees;

2. Those who have undergone in-service training programs in the varied science disciplines equivalent to a major or minor; and

3. Those with degrees in science-related professions (e.g., engineers, pharmacists, nutritionists, and nurses) who opted to go into teaching at the basic education level, took 18 units of foundation education subjects, and passed the licensure examination for teachers.

Despite these broad categories, qualified science teachers are still lacking in the country, based on a number of reasons.

Firstly, the Bachelor of Elementary Education (BEED) curriculum did not require students to specialize in any subject area. As of 2003, CMO No. 9 required BEED students to take only 6-9 units of science courses. In 2005, the New Teacher Education Curriculum was introduced (CMO No. 30). The content courses for BEED totals 57 units but only 12 units of these are in Science.

<table>
<thead>
<tr>
<th>Areas</th>
<th>BEED (units)</th>
<th>BSED (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education</td>
<td>63 (Science: 9 units)</td>
<td>63 (Science: 9 units)</td>
</tr>
<tr>
<td>Professional Education</td>
<td>54</td>
<td>51</td>
</tr>
<tr>
<td>Specialization (Content)</td>
<td>57 (Science: GE +3 units)</td>
<td>60 (Science: all 60 units)</td>
</tr>
<tr>
<td>Total</td>
<td>174</td>
<td>174</td>
</tr>
</tbody>
</table>

On the other hand, students enrolled in the Bachelor in Secondary Education (BSED) program are required to have a major and/or minor in any of the following science subjects: General Science, Biology, Chemistry, Physics, or Mathematics. In this new curriculum, students take 60 units of science subjects. However, not many teacher education institutions (TEI) in the country offer
specialization subjects in science (CHED, 2006) and the number of students majoring in science education is small (DOST, 2002). Based on personal communications with deans of colleges of education of state universities, the number of students enrolled in science education remains low.

Secondly, Project RISE (1999-2003) was discontinued due to lack of funds while the quality of training modeled in the Science and Mathematics Education Manpower Development Project (SMEMDP, 1994-1999) was not sustained as cascading models of training were implemented. Regional and district training programs were shorter in duration and, therefore, less intensive, vis-à-vis national training programs.

Thirdly, instead of specializing in science education, many science teachers tend to specialize in Administration and Supervision or Research and Evaluation. A DOST-SEI study in 2002 revealed that many classroom teachers would rather be promoted as school administrators. Ironically, the rate of principals and master teachers are within the same salary range.

Finally, the dwindling number of qualified science teachers is worsened by the brain drain phenomenon. Cortes, Tan, and Savellano (2005) reported that since 1990, more than twelve thousand science and mathematics teachers left the Philippines to seek better opportunities in the United States, Canada, and other countries. Filipinos with master’s and doctoral degrees in Science and Mathematics Education are in demand overseas. In particular, industrialized countries have been aggressive and persistent in recruiting highly qualified Filipino science and mathematics teachers.

**Challenge 2: Incongruent teaching assignments with teachers’ educational background**

Lack of qualified science teachers in many schools leads to the practice of assigning teachers to teach science subjects despite their limited background. This situation is true for both elementary and secondary schools. UP NISMED studied the profile of participants in their training programs through the years and found out that many teachers handling science subjects are nonscience majors. When asked what topics do they find difficult to teach or students have difficulty
understanding the concepts, they included electricity, chemical changes and reactions, weather, plate tectonics, and movement of heavenly bodies. These topics require a lot of visualization and use of models because the concepts are abstract. Lacking in confidence to teach these science subjects, teachers tend to focus or linger on topics they are familiar with (usually biological) and leave out the difficult ones.

One probable effect of this practice is the low performance of students in international and national assessment studies. The results of the Trends International Science and Mathematics Study (TIMSS, 1999 and 2003) and the National Achievement Test (Department of Education, 2003-2008) support this observation. Although there had been increases in the performance of students in NAT 2007 and 2008, the national mean percent score is still below mastery level.

UP NISMED reported a disturbing situation when it evaluated the impact of Bridgeit or Text-2-Teach Project which was implemented in three regions (Region 4, Region 12, and the National Capital Region) in 2004. The project, sponsored by Nokia and International Youth Foundation through SEAMEO-INNOTECH, provided interactive, easy-to-use multimedia packages to make science learning interesting and meaningful for young learners. The UP NISMED study revealed that there was no significant difference between Grades 5 and Grades 6 students in regard to what they know and can do in science. One reason that was used to account for this observation is the inadequate preparation of teachers handling science subjects. Grade 6 Science has more abstract concepts and higher order thinking skills requirement than Grade 5 Science. Thus, it can be inferred that teachers’ science content background is not enough to deal with abstract concepts in a higher grade science subject.

Most alarming is the result of the analysis of the TIMSS tests given to teachers of students who took the test in 2003. It was discovered that, on the average, the highest scoring students fared better than the teacher. The tests also revealed that many science teachers and students are incapable of assessing items that fall under conceptual understanding and analysis/reasoning, especially items under the constructed-response type. The 2003 TIMSS test covered concepts in Biology, Chemistry, Physics, Earth Sciences, Environmental Science, and the
Nature of Science while the teachers who took the test were teaching Grade 4 Science in elementary school and Biology in secondary school.

**Challenge 3: Predominance of teacher-centered classrooms and teaching practices**

Teaching science through the transmission approach is still predominant. In this approach, the teacher manages the learning and passes onto learners the knowledge and skills, treating them as ‘empty vessels which the teacher fills’.

There is evidence that transmission approach to learning, especially in elementary school, may be contributing to the lack of interest in science that is now widespread among elementary and secondary schools students across the country. The low percentage of students venturing into science-related careers in tertiary education can be attributed to the poor quality of science teaching in many Philippine secondary schools.

For many years, learner-centered classes have been found effective in developing students’ critical and creative thinking skills. The approach is based on the philosophy that students learn best when they hear, see, and manipulate variables (also referred to as interactive learning). Consequently, the method by which learning occurs is oftentimes experiential. For many years, training programszeroed in on the use of practical work approach (PWA) to teaching and learning. This approach requires science teachers to use hands-on and minds-on activities to stimulate students’ curiosity and imagination. In a learner-centered classroom, the teacher’s role is to facilitate cognitive growth by utilizing the interest and unique needs of students as a guide to meaningful learning. Students’ learning is then evaluated based on predetermined and developmentally oriented objectives.

Sadly, teacher-centered classes still prevail in many Philippine schools. Lacking in content and pedagogical skills suitable for science teaching, many science teachers turn to lecturing instead of providing students with engaging and challenging activities that enable the latter to develop creative ideas. Oftentimes, science teaching is still textbook-based and, more often than not, concepts are not
relevant to daily life or the community. According to many students, “science is boring and irrelevant” (Ogena & Tan, BESRA KRT 3 Report, 2006). Small group activities are performed by students but many teachers do not adequately process the results of these activities. Lesson plans are most often based on only one competency. The teaching and learning episodes are isolated (UP NISMED, OVCRD Report, 2010). Analysis of the competency list of DepED revealed that a group of related competencies can be developed with fewer sessions, allotting time for enrichment activities that develop in-depth understanding of content and acquisition of higher order thinking skills.

Assessment of student learning is still predominantly at the factual knowledge level. Sample tests reviewed attest to this. Use of open-ended questions is not common. The result of the assessment is not used to improve teaching. It has to be recognized that ‘what gets assessed is what gets learned’ and good assessment translates to good teaching.

**Challenge 4: Lack of quality textbooks**

In the last few years, controversies over errors and inaccuracies in many textbooks, including science books, created a lot of noise. Since textbooks may be the only reference materials used by students and teachers, science teaching in Philippine schools remains problematic. Misconceptions are being passed on from textbook to teachers and students, making them difficult to unlearn.

The process of textbook development has changed. In the past, textbook chapters and activities were written, tried out, and revised based on feedback from the end users. This process took almost two years before a commercial edition is released. The tryout ensures that the language and content are suitable to the cognitive levels of students and errors are detected. Today, textbooks do not undergo trial in schools. Many activities in the Student Manual or Workbook do not work and substantial amount of errors have been discovered.

In addition, the coverage of the textbooks and teacher guides are way beyond what elementary and secondary school students can finish in one year. Because these topics are covered by the achievement tests, teachers go hurriedly through the chapters. More often than not, teachers tend to mimic what is written
in the textbook instead of explaining the concepts in depth vis-à-vis their applications and connections to real-life situations.

**Challenge 5: The philosophy of science education at the basic education level is NOT clearly defined and reflected in the teacher education curriculum**

The current science education curriculum for basic education is still described by local and foreign science educators as overloaded, discipline-based, and more useful for the college-bound. The science curriculum puts emphasis on breadth rather than depth. Science subjects like Chemistry and Physics are taught with a sense of abstraction and a mathematical emphasis so that many students see them as unnecessarily irrelevant and difficult. This situation contradicts the needs of the large percentage of Filipino students who drop out of school in different grade or year levels (Mateo, 2006; Lapus, 2007) as well as the goal of science education at the elementary and secondary level, that is, to develop science literates and productive members of society (ICASE-UNESCO, 1993; Perth Declaration, 2007).

Over the past few years, several revisions of the Basic Education Curriculum of DepED were completed and implemented. While pilot testing had been done, results of the testing were not communicated to or shared with stakeholders. In addition, preservice students learn about the basic education curriculum only when they do practice teaching or when they have been admitted to the teaching force.

**Reforms in Science Education: What Other Countries Are Up To**

The problems and issues cited above (e.g., shortage of qualified science teachers, lack of quality textbooks, the discipline-based curriculum for basic education, and predominance of teacher-centered classrooms) necessitate educational reforms and actions that will address the compelling need for students and the larger Philippine society to be influenced strongly by science and technology.

Teaching for scientific literacy requires that science in basic education should be taught in an integrated manner. Ideally, it should not be taught by
Many studies indicate that, for all students, the purpose of science at the basic education level should be on developing scientific literacy for informed citizenry or what other science educators term as Science for Citizenship (Fensham, 2007). Many developed countries have reformed their curriculum towards this purpose (e.g., New Zealand, Australia, and Japan). A recent curriculum reform (called 21st Century Science) from York University in England introduces Foundation Science as those subjects to be taken by all students, and Additional Science an optional subject, for those students who wish to go on with disciplinary sciences in later years. Considering the demands that Science makes on citizens in increasingly S&T-influenced societies, Foundation Science trains students to become scientifically literate and equips them with scientific competencies important to real-life contexts that involve science and technology. Australia’s science curriculum for basic education (2010) focuses on inquiry teaching—the course content has been reduced to elements that are considered widely as significant to students’ lives.

A number of international meetings have released statements (e.g., Penang Declaration in 2004, Perth Declaration in 2007, and Tartu Declaration of 2010) to guide governments in revising and framing their science curriculum. In principle, the teaching of science courses should address the needs of all students. But those who are intending to pursue careers in science and its related disciplines should receive more intensive training. Statements from Penang, Perth and Tartu confirm the need for scientific knowledge to be presented in terms of its practical usefulness and exciting developments. This way, science can be seen by students as a wonderful discipline because it enables them to understand and appreciate phenomena (e.g., weather, pollution, or catching diseases) better as they are studied holistically, and not as compartmentalized applications of the different sciences.

In order for teachers to teach with scientific literacy as a primary agenda, preservice education programs should be reformed. In addition, continuing professional development program (CPD) for practicing teachers should be institutionalized. The CPD program should promote the aim of science education at the basic education level. These programs should be based on standards of performance to enable preservice and inservice teachers to enhance their professional knowledge (knowledge of science content, knowledge of how to teach
these content in more effective ways, and knowledge of the science curriculum), professional practices (ways to achieve quality learning outcomes), and professional attributes (characteristics that enable teachers to embrace change to develop and improve teaching practice as well as sustain professional growth).

In addition, the teacher education programs should include experiences in teaching science in an integrated and spiral manner. If we require students to master science concepts across disciplines, basic education teachers should also be required to do just as well. Integrated teaching provides teachers with a wide array of concepts and skills in the basic sciences. It also makes them scientifically literate.

Towards a Standards-based Science Teacher Education

In 2006, a set of National Competency-Based Teacher Standards (NCBTS) was formulated under the Basic Education Sector Reform Agenda (BESRA Report, KRT2, 2006). The standards described are applicable to all teachers, regardless of subject area. The competencies are in Appendix 1.

However, it has to be recognized that expertise in teaching is specific to particular subjects and levels. The knowledge and skills of effective science teachers differ in many respects vis-à-vis the knowledge and skills of teachers of mathematics or language. Therefore, the nature of professional development programs for science teachers must also differ from those of the other subject area teachers.

The proposed framework for science teacher education (FSTE) attempts to capture the nature of professional development required to develop effective science teachers. The framework includes a list of behaviors that serves as the criteria for making judgments about the quality of professional development opportunities that elementary and secondary school science teachers will need. These behaviors may be considered standards of performance of what an effective science teacher should know and be able to do.

The framework and its standards can serve as a guide for teachers to reflect on their current teaching practices, establish new practices, and perform self-assessment so that they can plan their professional growth. The standards will also
serve as a reference point every time teachers discuss concepts and teaching practices with colleagues and school administrators. Science teacher educators and preservice students can use the standards for clarifying areas where they can improve more.

School administrators can employ the standards for hiring, promoting, and/or supervising teachers. Professional development service providers can use the standards as basis for designing programs for continuing professional learning of teachers. Furthermore, accrediting agencies like the Philippine Regulations Commission can use the standards to develop assessment items for the Licensure Examination of Teachers. Finally, the framework can also serve as a guide for the Commission on Higher Education (CHED) in formulating appropriate legislations as well as in allocating resources to support quality science teachers’ education.
CHAPTER 2
Guiding Principles in the Development of the Framework for Science Teacher Education

Several documents were used to guide the development of the FSTE: the Proposed Science Curriculum Framework for Basic Education, the National Competency-Based Standards, the School-Based Training Standards, the Revised Policies and Standards for Undergraduate Teacher Education Curriculum, and the National Professional Standards of Highly Accomplished Teachers of Science prepared by the Australian Science Teachers Association. Relevant articles from the National Commission on Teaching and America’s Future were also referred to when formulating the guiding principles.

Reviewed Documents

The Proposed Science Curriculum Framework for Basic Education

The proposed SCFBE shows a much deloaded curriculum - focused on depth rather than on breadth. Three major areas are emphasized: content of science and its connections, inquiry skills, and scientific attitudes (Figure 1). The choice of topics/concepts is based on their relevance and applications to everyday life, arranged in a spiral manner from G1-10 to show increasing complexity of concepts based on three science areas: Life Science, Physical Science, and Earth and Space Science. The SCFBE shows how concepts within sciences and across subject areas are integrated. It highlights the thinking skills required to learn these concepts. The goal is scientific literacy for everyday life and gives emphasizes on acquiring and maintaining good health, using energy wisely and coping with changes, and protecting and conserving the environment and its natural resources.
The proposed SCFBE adapts the philosophy that science education needs of future citizens (that is, all students) are different from the science education of students who have an interest in scientific careers. Thus, the proposed G1-10 science curriculum focuses on developing students’ curiosity and wonderment of the world around them, enabling them to ask questions, and making them realize that some of these questions can be investigated scientifically. It provides students with opportunities to learn concepts and skills needed to understand and cope with materials, events and changes in everyday life while providing enrichment topics and activities for those who want to learn more. If the government later decides to add more years at the basic education levels (G11 and G12) the additional years should provide for learning “Advance Science” as it streams students along interest lines.
The three components of the SCFBE (content and context, inquiry skills, and attitudes) are integrated in the standards for effective science teachers. Teacher education programs should include upgrading of competencies of teachers in implementing the proposed content and pedagogical strategies of the basic education curriculum. Preservice educators need to fully understand the SCFBE if they are to prepare future teachers. Inservice teachers need to be updated on developments in science education if they are to be relevant.

**The National Competency-based Teacher Standards (NCBTS)**

The NCBTS defines seven domains derived from educational theories and empirical research on characteristics of learning environment and teaching practices that lead to effective student learning and documented successful practices and programs of schools, divisions, regions, and educational reform projects in different parts of the country. These domains are *social regard for learning, the learning environment, diversity of learners, the curriculum, planning, assessing and reporting, community linkages, personal growth and development* (BESRA, KRT2 Report, 2006).

While the standards under seven domains in the NCBTS are generic for all teachers, the FSTE describes specific competencies and behavior of science teachers in three categories: professional knowledge, professional practice and professional attributes. By limiting the categories into three makes the standards for science teachers more compact. Table 2 shows the alignment of the FSTE categories with the NCBTS domains.
Table 2: Alignment of FSTE Categories with NCBTS Domains

<table>
<thead>
<tr>
<th>NCBTS Domains</th>
<th>FSTE Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social regard for learning</td>
<td>Professional Knowledge</td>
</tr>
<tr>
<td>Learning environment</td>
<td></td>
</tr>
<tr>
<td>Diversity of learners</td>
<td>Professional Practice</td>
</tr>
<tr>
<td>Curriculum</td>
<td></td>
</tr>
<tr>
<td>Community linkages</td>
<td>Professional Attribute</td>
</tr>
<tr>
<td>Planning, assessing and reporting</td>
<td></td>
</tr>
<tr>
<td>Personal growth and development</td>
<td></td>
</tr>
</tbody>
</table>

The FSTE categories and the corresponding rubrics are explained in detail in Chapters 3 and 4 of this document.

**The School-based Training (SBT) Standards**

The SBT Standards are statements about what teachers should know and be able to do after an inservice training (INSET). The components are based on the guiding principle that “learners develop concepts and skills from engaging, meaningful, challenging, and relevant experiences and from teachers who encourage them to construct their own ideas.” The SBT has eight domains: training content, conduct of training, trainers’ competencies, training materials, trainers’ role, trainees’ roles, trainees’ teaching and learning materials or outputs (UP NISMED-JICA-DepED, 2007). Most, if not all the indicators in the SBT are in the FSTE.

**The Revised Policies and Standards for Undergraduate Teacher Education Curriculum (CMO 53 s 2005)**

The revised policies and standards are in accordance with the pertinent provisions of Republic Act No. 7722, otherwise known as the Higher Education Act
of 1994. Its purpose is the rationalization of the undergraduate teacher education to keep pace with the demands of global competitiveness. This document contains program specifications for BEED and BSED and their corresponding curriculum offerings. The Technical Panel for Teacher Education has been tasked to review the curriculum offerings after the first five year implementation and some of the revisions in terms of science courses are presented in Chapter 5.

**The National Professional Standards for Highly Accomplished Teachers of Science**

The Australian Science Teachers Association (ASTA) formulated standards for highly accomplished science teachers and distributed them into three categories: professional knowledge, professional practice and professional attributes. The FSTE developers were given permission by ASTA to use the three categories of standards. While ASTA only describes the behaviors under each category, the FSTE includes rubrics for each category. The behaviors of effective teachers are in Chapter 3 while the rubrics are in Chapter 4.

**The Guiding Principles in the Development of the FSTE**

The guiding principles relevant to teachers, science teaching, and science education are summarized below.

1. Teacher education is a continuum that starts at the recruitment of high school students into the teacher education institutions (TEIs) and ends sometime around retirement, or perhaps even after.

2. The qualities of good science teaching can only be defined in terms of its effects on the learner. It is important that teachers should engage all students in purposeful and successful learning.

3. The knowledge and skills of effective science teachers differ in fundamental respects across subjects and context. Hence, the need for subject-specific standards. The standards will help teachers work for deeper understanding of their subject and how to teach it. It will raise levels of commitment to working creatively and constructively with
other teachers. The standards will make them accountable for what happens in the classroom as well as for their own professional growth.

4. Upgrading the knowledge, skills, practices and attitudes of teachers is an individual decision, but this is sustained and enhanced when the efforts are collaborative and synergistic among communities of teachers.

5. Teachers are committed to extending their knowledge and improving their practice. Therefore, teacher development should be an active and reflective transformation of knowledge and skills in actual contexts. Teacher development activities should engage teachers in active, interactive, problem-oriented, hands-on, and creative group activities, instead of having teachers passively receive new inputs. These activities must also engage teachers in critical reflection on whether their current practices and beliefs actually bring about effective student learning. Finally, these teacher development activities must be contextualized and situated in environments that can support meaningful teacher growth (NCBTS, 2005).

6. Teacher-centered educational processes tend to develop low-levels of student involvement and interest in the learning process and often lead to low-levels of student learning (NCBTS, 2005).

7. Learners develop concepts and skills from engaging, meaningful, challenging, and relevant experiences and from teachers who encourage them to construct their own ideas (SBT Standards, 2005 and the SCFBE, 2010)

The major challenge in formulating and using the standards is how we can assist teachers help move students from “I know” to “I know how-to-know.”
Chapter 3
Qualities of Effective Science Teachers

The effectiveness of science teachers stems mainly from their confidence of the subject matter, how to teach it (pedagogy), and their attitude. Truly inspirational science teaching occurs when a teacher is not only enthusiastic about the science topic being taught, but also understands that topic fully in order to present it in a comprehensible and meaningful way to each learner.

The behaviors used to indicate effective science teachers have been grouped under three categories adopted from ASTA: professional knowledge, professional practice, and professional attributes. The behaviors under each category are considered standards of performance of teachers, something they can work for.

Standards are broadly stated expectations of what teachers should know and be able to do (UP NISMED, DepED-JICA, 2007). These standards provide the criteria for making judgments about the quality of professional development opportunities that elementary and high school teachers need. Figure 2 summarizes these categories and major expectations under each category.

Figure 2: Qualities of an Effective Science Teacher
The standards for effective science teachers have been presented to science teachers, faculty of colleges of education, curriculum developers, and other stakeholders in the Philippines, including the 2006-2007 Technical Panel for Teacher Education. It has also been reacted to by teachers and teacher educators in the 2007 International Conference for Teacher Education in Shanghai, China.

The standards are NOT arranged in hierarchical order. They are NOT dependent on age or length-of-teaching experience. Rather, these standards are competency-based. Some teachers can achieve many of these standards over a short time while others may take longer.

The list of standards and behaviors are by no means complete. But they are useful for professional development programs to focus on so that teachers can be helped to achieve most, if not all, of them. The text can be converted into a checklist and included in the individual portfolio of the teachers for self monitoring.

**Professional Knowledge**

Professional knowledge includes knowledge of science content, knowledge of pedagogical content, knowledge of general pedagogy, and knowledge of the science curriculum.

- **Knowledge of science content**

Content knowledge refers to the disciplinary conceptual knowledge of the teacher. Good subject knowledge involves understanding the substance, content, structure and organization of the science subject itself. It is essential for the teacher to explain not only the facts of science but more importantly the arguments for the scientific model. When it is weak, many teachers find it difficult to deal with learners’ questions and resort to teaching from a textbook to avoid having their lack of knowledge exposed.

The science teacher may have a particular area of expertise (represented by an academic degree or the equivalent), but it is essential that he or she has breadth of knowledge across several other science disciplines to become scientifically, technologically, and environmentally literate.
1. **An effective science teacher** has an extensive knowledge of basic science concepts and their applications to daily life and with other disciplines.

2. **An effective science teacher** has mastery of concepts considered important for all students and those that serve as enrichment topics for particular grade or year levels. An effective science teacher can identify and address science misconceptions of students and in textbooks.

3. **An effective science teacher** has a good grasp of the complex relationship between science and technology, that technology is not just applied science but that it is a cultural response of people to problems and opportunities that then shapes the way they live, think, and work.

4. **An effective science teacher** updates himself or herself on recent developments in scientific research and uses these knowledge to motivate learners and make science teaching interesting.

5. **An effective science teacher** knows how to connect his or her learning to what should be taught and how to incorporate new science knowledge into practice.

6. **An effective science teacher** helps learners cope with the demands of a rapidly changing society strongly influenced by S &T but realizes that science cannot answer all questions the learners might ask.

- **Knowledge of general pedagogy**

  Knowledge of general pedagogy refers to teachers' knowledge about characteristics and cognitive levels of varied learners, variety of learner-centered teaching and learning approaches including assessment and classroom management. More specifically, it includes knowledge about how learners learn, alternative conceptions that many learners hold, issues of safety, availability of appropriate resources, and the values held by various stakeholders in the education process.
1. **An effective science teacher** understands the unique characteristics of learners, their strengths and potential, talents, abilities and perspectives based on the developmental characteristics of the age groups with which he or she is working.

2. **An effective science teacher** knows how to plan and design strategies to support the intellectual, social, and personal development of each learner.

3. **An effective science teacher** understands the variety of information and communications technology (ICT) and other resources and how to incorporate them into new learning experiences.

4. **An effective science teacher** understands the nature of varied forms of assessment for both formative and summative purposes, the role of feedback to both learners and parents, and when and how to use them most effectively.

5. **An effective science teacher** knows how to deal fairly with issues that arise in classroom management and communicate techniques that generate educationally effective and safe environments.

- **Pedagogical content knowledge**

  Pedagogical content knowledge refers to knowledge that the teacher must have to be able to teach the subject matter. This type of knowledge is complex with many interacting aspects included under general pedagogy.

  1. **An effective science teacher** does not only have a strong background of his or her subject matter but also knows how to develop learners’ deeper understanding of subject matter.

  2. **An effective science teacher** is aware of suitable science goals and learning programs for his or her students, knowing that these will necessitate change over time depending on the circumstances of learners and other relevant factors.

  3. **An effective science teacher** knows a wide range of ways in which learners are likely to learn science best, building on prior knowledge and
experiences and mental constructs to introduce new experiences and ideas.

4. **An effective science teacher** knows how to engage learners in discussions so that he or she clarifies and develops their understanding of scientific concepts under investigation.

- **Knowledge of the curriculum structure and materials**

  Curricular knowledge refers to knowledge of the place of science in the basic education level, the interrelatedness of the content of science across the science discipline and with other curricular areas, and the quality materials needed to support the curriculum.

  1. **An effective science teacher** understands the philosophy and the place of science in the structure of the overall curriculum at the basic education level.

  2. **An effective science teacher** knows the content and connections of science across the different science disciplines at the basic education level and with other curricular areas.

  3. **An effective science teacher** understands that the science education needs of all students (the future citizens) are different from the science education needs of students who have an interest in scientific careers.

  4. **An effective science teacher** knows laboratory equipment, tools, and other instructional materials to be able to work with students with varying learning needs.

  5. **An effective science teacher** knows the characteristics of good science textbooks and other instructional materials that would bring about meaningful learning of students.

**Professional Practice**

This category outlines what teachers are expected to do to achieve quality learning outcomes - the objective of science education. It also expects teachers to
work with the learners, colleagues, parents and other community members to achieve this objective.

The teaching practices listed include those that are unique to science teachers (numbered items) and those desired for all teachers (presented as bullets).

Practice 1: Designs sound science teaching and learning experiences suitable for the needs and interests of varied learners

1. An effective science teacher clearly sets attainable goals to give science learning its purpose, focus, and direction.

2. An effective science teacher organizes the areas of science he or she is teaching into conceptually logical teaching and learning experiences or lessons appropriate to learners.

3. An effective science teacher demonstrates links across science disciplines and with other subject areas.

4. An effective science teacher develops series of stimulating activities related to the learning goals to engage learners to science.

5. An effective science teacher uses real-life context to make science learning more meaningful and to enable learners to make connections with their personal experiences.

6. An effective science teacher uses a wide variety of human and physical resources to enrich students’ learning of science.

7. An effective science teacher integrates ICT into teaching and learning science lessons and makes students become confident and effective users of technology.

8. An effective science teacher uses the materials and events in the immediate and natural environment to provide rich and relevant experiences for science students during field trips and excursions.

9. An effective science teacher knows where to find relevant science information and teaches students to access them.
10. **An effective science teacher** is able to evaluate the strengths and weaknesses of a range of available teaching-learning science materials and use them appropriately.

11. **An effective science teacher** makes use of students’ experiences and backgrounds in developing science concepts and ideas and recognizes that students can be teachers as well as learners.

12. **An effective science teacher** practices what effective teachers of other subject areas do:
   - initiates and implements desired change to achieve student outcomes.
   - challenges learners at the appropriate level and is alert at differences in this regard.
   - responds to the needs of learners, recognizing that these needs are affected by the learning styles and backgrounds of the learners.
   - draws on the expertise of colleagues, and relevant parents and other community members in improving the learning process.
   - is able to identify which business sectors in the community will be useful in enriching the teaching and learning of science and how to engage such sectors.

**Practice 2: Creates and maintains a learner-centered, emotionally supportive, and physically safe learning environment**

1. **An effective science teacher** clearly states what is to be learned in science at particular grades or year levels.

2. **An effective science teacher** pays careful attention to the knowledge, skills, attitudes, and beliefs that learners bring to the science classroom.

3. **An effective science teacher** allows students to ask questions, discuss possible answers to the questions, and make decisions based on independent judgment, and to reflect on the consequences of the decision.

4. **An effective science teacher** engages students in the learning process and guides them to progress from simple acquisition of factual science
knowledge and skills to conceptual understanding, to analysis and reasoning skills.

5. **An effective science teacher** creates and sustains a challenging, relevant, exciting and varied learning experience that reflects the nature of science.

6. **An effective science teacher** models the passion and interest implicit in making scientific discoveries, however simple the investigation is.

7. **An effective science teacher** allows students to pursue a diverse range of learning science activities even if they are doing the same tasks, including those that they design on their own. He or she ensures that intellectual risk taking and persistence are actively fostered when students work in new situations and undertake new experiences.

8. **An effective science teacher** practices safe and proper laboratory techniques for the preparation, storage, dispensing, supervision, and disposal of all science materials used in teaching and learning.

9. **An effective science teacher** is able to assess risks constantly and ensures that routines are established to ensure safe practice while performing science activities or when events like earthquakes, volcanic eruption or fires occur while students are in school. He or she has a classroom safety plan in place and rehearses students to ensure familiarity with its various aspects.

10. **An effective science teacher** practices what effective teachers of other subject areas do. He or she

    - designs and maintains a learning environment where all students, regardless of diversity of their backgrounds and capacities, feel valued and comfortable.

    - observes fairness and respect for the viewpoints of others and uses the diversity of learners as a learning resource to develop differing perspectives and understandings.

    - establishes a warm and supportive relationship with students, building on mutual respect, cooperative behavior, and a sense of community.
• deals with arguments and conflicts fairly and respectfully, enabling students to get involved in maintaining good behavior and establishing limits to what they are allowed to do.

Practice 3: Engages students in scientific investigations to be able to generate, construct, and test knowledge and evaluate evidence

1. **An effective science teacher** involves students in conducting varied types of scientific investigations to expose them to diverse ideas, resources and technologies.

2. **An effective science teacher** teaches and models practices that allow students to analyze knowledge and experiences critically, recognize problems, ask questions, and pose solutions.

3. **An effective science teacher** is a risk taker who is willing to live with unpredictable consequences of open-ended activities. He or she guides students to become independent learners by progressively stepping back to allow more student-directed scientific inquiry.

4. **An effective science teacher** develops students’ curiosity and openness to new ideas, the demand for reason, honesty and objectivity, and acceptance of the tentative nature of scientific knowledge.

5. **An effective science teacher** guides students in active inquiry—observing and measuring phenomena, formulating hypotheses, recording tasks, and reaching tentative conclusions consistent with data collected.

6. **An effective science teacher** guides students to reflect on the results and consider ways to refine the investigation, helps them analyze and evaluate the evidence they have collected and checks the validity of their findings. He or she makes it clear to students that, before knowledge can be accepted as scientific, reliable, and a basis for action, these data must have supporting evidence that has been or can be reproduced by others.

7. **An effective science teacher** practices what effective teachers of other subject areas do. He or she
- uses varied strategies to increase students’ ability to process information from a wide variety of sources including print, internet, discussions and media reports to be able to participate in discussions, and ask effective and appropriate questions; and

- provides students with opportunities to develop competencies in the use of technology in authentic contexts, and enables students to be in control of the technological tools, whenever possible.

**Practice 4: Finds and implements ways to extend students’ understanding of the ideas and concepts being learned**

1. **An effective science teacher** shows the connection and coherence between information acquired and their daily life applications. These connections draw on students’ everyday events, current topics, and other curricular areas to establish the relevance of science to students’ lives.

2. **An effective science teacher** is able to trace and use examples to show how science ideas evolved and change over time to ensure that students understand that science is dynamic.

3. **An effective science teacher** builds on students’ prior knowledge and understanding and incorporates these aspects into science teaching.

4. **An effective science teacher** creates environments that promote sustained high quality opportunities for all learners through purposeful discussion about scientific ideas. He or she knows that language is the gateway to learning and the teacher ensures learners that there are many opportunities to use that language to construct their own meanings and to grapple with new ideas.

5. **An effective science teacher** enables students to understand that scientists use language in particular ways where certain words have precise meanings in science and that these meanings may differ from everyday usage. He or she helps students to express and clarify their growing understanding of science concepts and communicate these using a range of forms and technologies.
6. **An effective science teacher** provides strong links to literacy, numeracy and interpersonal and communication skills and regularly pose tasks and questions to students to heighten their awareness of the different discourses in science, in science education, and in the communication of science to different audiences.

7. **An effective science teacher** utilizes successfully the unplanned learning opportunities that arise in the course of the lesson development. He or she communicates enthusiasm and interest while being able to draw out and explain relationships of science to other learning areas and make the whole coherent.

8. **An effective science teacher** practices what effective teachers of other subject areas do. He or she

   - maintains a high level of student engagement using flexible approaches, changing strategies to solve particular learning problems that arise as a group or as individuals; and
   
   - is prepared to tackle societal issues that emerge and seeks relevant parts of student experiences to elucidate what is being learned.

**Practice 5: Builds students’ confidence and capacity to use scientific knowledge and processes to make informed decisions**

1. **An effective science teacher** exposes students to varied learning situations to make them at ease with science as part of daily life, giving them opportunities to continue to learn science, engage with scientific processes and communicate about them. He or she ensures that their teaching enables students to develop/enhance their habits of mind (e.g., being critical and creative thinkers and become lifelong learners).

2. **An effective science teacher** provides learners with opportunities to identify relevant science topics and issues (including personal and social issues) and reach evidence-based decisions and make them realize that some problems often do not have one correct answer.
3. **An effective science teacher** uses strategies that develop divergent thinking and models creative and ingenious ideas in searching for evidence.

4. **An effective science teacher** explains clearly interdependent relationship between science and technology and society and the links that science has with other areas of knowledge and ways of knowing. He or she considers science and technology as interdependent human experiences with costs and benefits and emphasizes the development of their students’ understanding of both the power and limitations of science.

5. **An effective science teacher** encourages students to read newspaper articles about science, to follow TV programs on new advances in science with interest, to critique articles and reports about science, and to engage in discussions about the validity of any conclusion made. Students gather information using varied means: electronic via email and the internet and are able to critically evaluate this information for bias and accuracy.

6. **An effective science teacher** explores with students ways in which societal and cultural beliefs and values have shaped science and decisions about its applications.

7. **An effective science teacher** focuses on new and emerging ideas and technologies and the ethical issues arising from them, enabling students to exercise their skills responsibly and participate effectively in public debates.

8. **An effective science teacher** increases students’ understanding of the impact that current decisions have on future directions of Science, Technology and Society.

**Practice 6: Uses a wide variety of strategies consistent with learning goals to monitor and assess students’ learning and to provide effective feedback**

1. **An effective science teacher** uses assessment as an integral part of the teaching learning process. The assessment procedures chosen are coherent with the goals of the science learning experiences.
2. **An effective science teacher** practices what effective teachers of other subject areas do. He or she

- recognizes the different purposes of assessment, making them explicit to students along with the process and criteria for judgment.
- draws on formal and informal assessment strategies to guide in planning and developing units of work, gauge the progress of students individually and as a group, and review the nature of the teaching and learning process.
- utilizes assessment to help students reflect on their own progress and to provide summative accounts of progress made in relation to the goals that have been set.
- assists students to use self and peer assessment strategies to make them reflect on their progress and be responsible for their own learning.
- makes use of an extensive repertoire of formal and informal assessment strategies and justify why that strategy is used, recognizing that good assessment tasks are good learning experiences. The multiple methods ensure reliability and validity of assessment data and enable the teacher to explore and identify the full range of students’ understanding and capabilities.
- keeps careful and thorough records of students’ progress, uses these records of progress together with samples of work to aid two-way communication with their students and students’ families. He or she recognizes the different reporting requirement of parents, education agencies and certification authorities. He or she develops portfolios of student achievement which illustrate and exemplify what students know and can do and the progress students have made.
- uses assessment as part of the general process of evaluating the quality of their own work and identifying where improvements can be made.
Professional Attributes

Professional attributes are those characteristics that enable teachers to embrace change to develop and improve teaching practice as well as sustain professional growth. Professional attributes include modeling scientific inquiry skills and scientific attitudes. These attributes include being reflective, committed to improvement, and becoming active members of their professional community.

Attribute 1: Analyzes, evaluates, and refines teaching practices to improve student learning of science

1. An effective science teacher regularly and critically analyzes the strengths and weaknesses of his or her teaching practices, changing them if needed to improve student learning.

2. An effective science teacher reflects on the extent to which the goals for student learning have been met, recognizing patterns in student interactions, and gathering evidence about problems that students may have in learning science. Information have to be regularly collected from students and their work or from colleagues who can help evaluate the effectiveness of the teaching methods, analyzing them for their implications to future practice and acting on the implications.

3. An effective science teacher sets long term goals for his or her own professional growth, identifies areas in which improvement are needed and seeks the appropriate professional development activities to meet them.

4. An effective science teacher analyzes and reflects on his or her teaching practices using examples of students’ works and teaching methods used. He or she uses these opportunities to compare their students with relevant goals and standards for learning.

5. An effective science teacher uses a variety of means to meet his or her own goals for professional growth to include: learning from colleagues through collaboration on professional tasks and seeking advice from other teachers on matters related to teaching and learning; reading professional literature to remain up to date on issues and developments.
in science and science education, using ICT to access information and collegial interaction. He or she seeks resources and ideas from outside the school and assesses their value through reflection and professional judgment prior to and after their use and subsequent evaluation.

6. **An effective science teacher** models the development and improvement implicit in lifelong learning along with risk taking and flexibility entailed in the testing of new ideas and changes in practice.

**Attribute 2: Works with other teachers within the school and joins professional teachers and/or community organizations to improve the quality and effectiveness of science education**

1. **An effective science teacher** is an active member of professional science teacher organizations.

2. **An effective science teacher** is a team player, recognizing that the quality of science education is dependent on the strength of the professional community and on how this community facilitates frequent conversation about practices and student progress.

3. **An effective science teacher** helps in the professional growth of colleagues, keeping abreast of current science knowledge and developments in science education, actively participates in workshops and other learning activities, and passing on useful knowledge to colleagues.

4. **An effective science teacher** contributes to the development and evaluation of the science curriculum and teaching programs in school.

5. **An effective science teacher** provides accurate information about the school, teachers and the science program and offers suggestions to parents and community members on how the latter can support the children’s learning in science.

6. **An effective science teacher** conducts his/her own research on science teaching and learning and shares the results with others.

7. **An effective science teacher** practices what effective teachers of other subject areas do. He or she
- acknowledges that seeking and giving collegial advice are not signs of incompetence but rather professional action viewed as desirable to acquire new skills.

- is active in professional development in and outside of the school, helps in designing and implementing programs, gives talks and serves as resource person or trainer, writes articles in journals, develops new teaching materials, and participates in research projects.

- is able to establish effective relationships with teachers in their school and other schools, with parents and significant community members who share the same interest in improving the teaching and learning of science.
Concluding Statements

While the standards under seven domains in the NCBTS are generic for all teachers, this document presents specific competencies and behavior of science teachers in three categories: professional knowledge, professional practice and professional attributes.

The standards for science teachers demand bold, flexible professionals equipped with quality teaching practices. The standards will guide them to work towards an in-depth knowledge and pedagogical understanding of science subjects they will teach. In addition, the standards will help teachers elevate their level of commitment to the education and well being of students, regardless of sex, background, level of ability, or style of learning, increase their understanding of how students learn and develop, and assist in adapting teaching and assessment to student needs. Likewise, they will enhance teachers’ skills in classroom management, instructional methods and strategies, including technology, and use of various types of assessments to analyze student progress and plan instruction. They will build up a collaborative approach to relationships with colleagues, parents, cultural institutions and the broader community of interest in education, and step up dedication to lifelong learning and professional development.

These expectations require reflection and even redefinition of the nature of work of educators and inservice training providers to strengthen the knowledge and skills of teachers. Opportunities need to be provided to support development of these competencies before the standards enter into the evaluation of these teachers.
CHAPTER 4
Evaluating the Performance of Science Teachers Using Standards-based Rubrics

Rubrics are matrices that contain the parameters by which something can be graded on and the criteria for each level of performance. It is commonly used in scoring authentic assessment outputs.

The rubrics for effective science teachers are based on the standards for professional knowledge, professional practice, and professional attributes. While the ASTA document describes the behaviors of accomplished science teachers, the FSTE expounds levels of performance and suggests the use of rubrics to ensure objectivity and consistency in rating.

Rubrics can be used for self-rating which means that the teacher evaluates his or her own performance. It can also be used by school administrators or by an accrediting agency for promotion or retention purposes. Further, it can be used by teacher educators in rating individual students.

The rubrics contain both a numerical value and a qualitative description. The numbers and descriptions do not indicate age or years of teaching experience. Level 1 describes a Neophyte Science Teacher, Level 2 an Emerging Professional Science Teacher, Level 3 a Master Science Teacher, and Level 4 a Certified Science Mentor. It means that a Level 4 teacher can do what a Level 3, and 2, and 1 teacher can do. A teacher can be at Level 1 in knowledge of content but at Level 2 in curricular knowledge. A young teacher (young because of age and teaching experience) can be at Level 2 or 3 depending on his or her knowledge of subject matter, pedagogical skills, and professional attributes.
The proposed science curriculum for basic education advocates an integrated science curriculum based on the nature of science that spirals concepts and skills from G1-10 and, whenever appropriate, integrates concepts across science disciplines. Therefore, it is expected that all science teachers must have a clear understanding of the nature of science and to possess greater in-depth subject matter knowledge than the level at which their instruction is focused.

The rubric on knowledge of subject matter content shows a differentiated set of standards for elementary and secondary school science teachers. The criteria for general pedagogy and PCK which are not included in Table 3 are in the rubric for professional practice (Table 4).
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Certified Science Mentor</th>
<th>Master Science Teacher</th>
<th>Emerging Professional Science Teacher</th>
<th>Neophyte Science Teacher</th>
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<tbody>
<tr>
<td><strong>Knowledge of science content, their connections and applications</strong></td>
<td>Can do Levels 1, 2, &amp; 3; Can identify and explain the big ideas, essential questions, knowledge and skills, and performance indicators, in at least one science area; Detects and addresses misconceptions, including those in science textbooks and media articles</td>
<td>Is proficient on all competencies of one science area in elementary science G1-6 (<em>e.g.</em>, Life Science, Physical Science, and Earth and Space Science) or in secondary school science (<em>e.g.</em>, Integrated Science, Biology, Chemistry, and Physics).</td>
<td>Has mastery of subject matter exceeding those specified in the science curriculum of the grade level assigned; <em>e.g.</em>, for ESS: G1-2 or G3-4 or G5-6; for HSS: G7-8 or G8-9 or G9-10 or G7-10</td>
<td>Has mastery of subject matter specified in the science curriculum of the grade level he or she is assigned to teach, <em>i.e.</em>, at elementary or secondary schools; Detects and addresses misconceptions of students</td>
</tr>
<tr>
<td><strong>Pedagogical content knowledge</strong></td>
<td>Can switch his or her teaching and learning strategies, depending on the circumstances of the learners and other relevant factors</td>
<td>Identifies and implements ways to challenge and extend students’ understanding of the major ideas of science</td>
<td>Implements a variety of engaging teaching/learning and authentic assessment strategies</td>
<td>Develops learners’ deep understanding of subject matter using inquiry-based teaching</td>
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<td><strong>Curricular knowledge</strong></td>
<td>Able to argue the relationship between Science-Technology &amp; Society; Can identify the characteristics of a good science textbook and other instructional materials for meaningful learning</td>
<td>Can explain the connections of science across science disciplines at the basic education level and with other curricular areas</td>
<td>Able to differentiate the science education needs of all students from the science education needs of students who have an interest in scientific careers</td>
<td>Can explain the philosophy and the place of science in the structure of the overall curriculum at the basic education level; Able to use equipment, tools, and other instructional materials correctly</td>
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<tr>
<td><strong>P1. Designing sound science teaching &amp; learning programs suitable for varied learners</strong></td>
<td>Can do Levels 1, 2, &amp; 3;</td>
<td>Can do Levels 1 &amp; 2</td>
<td>Can do Level 1</td>
<td>Designs coherent science learning units, lessons, and activities based on attainable goals and appropriate for learners’ needs and interests</td>
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<td></td>
<td>Develops units &amp; lessons that demonstrate links across science disciplines and other subject areas</td>
<td>Makes use of a wide variety of human and physical resources and real-life context to enrich students’ learning of science</td>
<td>Evaluates strengths and weaknesses of available teaching and learning science materials; Choose and/or modify the materials to align with set goals</td>
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<td><em><em>P2. Creating &amp; maintaining a learner-centered, emotionally supportive, &amp; safe</em> learning environment</em>*</td>
<td>Allows students to pursue a diverse range of activities, including those they can design on their own</td>
<td>Creates and sustains a challenging, relevant, exciting and varied learning experiences; Prepares a unit plan (not just a day to day lesson)</td>
<td>Engages students in the learning process and guides them to progress from simple acquisition of facts to conceptual understanding to reasoning and analysis</td>
<td>Clearly states what is to be learned in science at particular grades or year levels; Pays attention to the knowledge and skills that learners bring to the classroom; Prepares lessons based on related competencies</td>
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<td>Conducts own investigations or in collaboration with other teachers</td>
<td>Guides students to engage in real-life, community-based problem solving; Develops students’ competences in using technology</td>
<td>Enables students to engage in simple open-ended investigations, learn how to process data, make conclusions based on evidence, &amp; share findings</td>
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<td><strong>P3. Engaging students in scientific investigations to generate, construct, test knowledge, &amp; evaluate evidence</strong></td>
<td>Tackles societal issues &amp; use relevant parts of students’ experiences to elucidate what is being learned</td>
<td>Exposes students to project-based learning; Enables students to learn and use the language of science correctly</td>
<td>Shows how science ideas evolve and change overtime to let students understand that science is dynamic</td>
<td>Shows the connection &amp; coherence between information acquired &amp; their daily life applications</td>
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<tr>
<td>P5. Building students’ confidence &amp; capacity to use scientific processes to make informed decisions</td>
<td>Explores with students how cultural beliefs and values have shaped science and decisions about its applications; Can discuss future directions of Science in the country</td>
<td>Enables students to exercise their skills responsibly including participation in public debates on science issues and the power &amp; limitations of science</td>
<td>Uses strategies to develop divergent thinking; Provides opportunities for students to talk about science articles and critically evaluate the information for bias and accuracy</td>
<td>Expose students to varied learning situations to make them at ease with science, engage in science processes, &amp; communicate ideas clearly</td>
</tr>
<tr>
<td>P6. Monitoring &amp; assessing students’ learning &amp; providing feedback</td>
<td>Assists students to use self and peer assessment; Conducts action research to help monitor, assess students’ learning, and provide effective feedback</td>
<td>Uses assessment for learning to track daily students’ progress (e.g., embedded assessment and developmental questions in student activities and lessons)</td>
<td>Utilizes assessment to help students reflect on their own progress individually and as a group; Provides summative accounts of progress</td>
<td>Draws on formal and informal assessment strategies to guide in planning and developing units of work, gauge performance and use these to review the teaching &amp; learning process</td>
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</table>

* Science teachers are expected to practice safe and proper laboratory techniques for the preparation, storage, and disposal of science materials used in instruction. They need to have a safety plan in case an earthquake, fire, or other disastrous events might occur. Effective science teachers observe fairness and respect for the viewpoints of others. They deal with conflicts and arguments fairly and respectfully.
Good science teaching is a complex job. The standards reflect this complexity. The standards also reflect the vision of the kind of science teaching and learning that is valued. Thus, the standards capture the essence of effective performance in three categories: professional knowledge, professional practice, and professional attributes. Teachers should meet all these standards but not at one time or separately. These standards can be demonstrated.
The standards attempt to delineate the knowledge and skills necessary for a professional and effective science teacher. The standards are more than a checklist of skills, knowledge, and experiences to be achieved, and simply possessing them will not automatically transform an individual into a professional and effective science teacher. The integration of the standards and continued reflection upon the content of and interrelationships among the standards should facilitate lifelong development in the career of a professional science teacher.

This chapter provides rubrics that reveal the levels of performance for each category. Simply, the rubrics show that a teacher can be in Level 3 in one category but may be in Level 2 in another. The important thing is that teachers know where they are and where they need to go. Teachers should understand that the shortest route to reach their goal (becoming effective teachers) is a straight line. But there are many obstacles along the way. Several pathways can be tried. To reach the goal, they have to remain focused on it!

Upgrading with respect to the three categories – professional knowledge, professional practice, and professional attributes – is an individual decision but this is sustained and enhanced when the efforts are collaborative and synergistic among communities of teachers.

Finally, the standards are not meant to represent absolute prescriptions. Instead, standards simply define knowledge, skills, experiences, attitudes, and habits of the mind in order for science teachers to teach more effectively.
CHAPTER 5
Continuing Professional Development for Science Teachers

Becoming an effective science teacher begins from preservice experiences in the undergraduate years till the end of one’s professional career. In other words, the bachelor’s degree program is only the beginning. Teachers must value the importance of continuing education to enhance their knowledge of content and pedagogical skills. Continuing education will also enable the teacher to develop new strategies vis-à-vis frequent changes in the curriculum.

Continuing professional development or continuing professional education enables teachers to improve and broaden their knowledge and skills, and develop the personal qualities required in their professional lives. It involves a commitment to structured skills enhancement and personal or professional competence. It is a conscious updating of professional knowledge and the improvement of professional competence throughout a teacher’s working life. It is a commitment to being professional, keeping up to date and continuously seeking to improve. It is the key to optimizing a teacher’s career opportunities, both today and for the future.

At the heart of professional development is the individual’s interest in lifelong learning and increasing his or her own skills and knowledge. Individuals may pursue professional development independently while the Department of Education, Commission on Higher Education and teacher professional
organizations may provide group opportunities for professional growth and development.

Professional development opportunities can range from a single workshop to a semester-long academic course, to services offered by different professional development providers. These programs vary in regard to the philosophy, content, and format of the learning experiences.

**Professional Development Programs for Practicing Teachers (INSET)**

The main purpose of professional development programs for teachers is **capacity-building**, that is, to increase their ability to achieve the goals that are set for example by DepED or CHED. Other terms used for capacity-building are capacity development, empowerment, and strengthening. Such programs advocate a **transactional model of professional development** rather than a transmission approach focused on giving information. Capacity building means providing opportunities for teachers to reflect on their learning and teaching beliefs or practices. They make changes on their practices and behavior as a result of reflection and collaboration with other teachers. They share such knowledge and skills after modifying or making adaptations to suit different clients.

Professional development programs can be described in many ways. Some are discussed below.

- **In terms of the nature and duration of training**

  **Conferences** can accommodate hundreds or even thousands of teachers. During these events, teachers sit for hours listening to a series of lectures to update them on recent breakthroughs and newer teaching strategies. Conferences provide opportunities for teachers to interact with fellow educators and gain insights as they reflect on the presentations. However, it will not enable nonmajors and nonminors in science education to learn the specific content and skills required to teach science effectively. In addition, conferences are not occasions to clarify one’s misconceptions.
Short-duration training programs that run for a week cover selected topics only. There are many concepts to clarify. Besides, inquiry-based teaching and learning require hands-on exposure to materials, events, and phenomena. If science majors took four years to finish a degree, how can nonscience majors master science concepts in a week, or even a month? Nonscience majors need continuous help in raising their level of conceptual understanding and reasoning skills. They also require help towards the improvement of their pedagogical content knowledge.

A progression type or sequential approach to training is recommended. This means that practicing teachers need to attend a series of short-duration seminar-workshops with a certain focus, to help build their subject matter content and proficiency in teaching science through inquiry. Effective training programs in science involve teachers in hands-on, minds-on, and hearts-on activities, otherwise referred to as the practical work approach (PWA). This approach veers teachers away from teacher-centered and transmission approach to learner-centered interactive teaching. Teachers are taught how to process the results of activities and students’ questions to derive concepts and learn to use higher order thinking skills. The basis for attendance in the training will be a diagnostic test. For example, a teacher can attend Level 1, or Level 2, or Level 3 training (refer to rubrics in Chapter 4). Assessment for learning and assessment of learning are integral parts of the training programs. Successful participants to the series of training can be certified by an accredited service provider.

Another professional development program for nonmajor/nonminors in science education is enrolment in a certificate degree offered by colleges of education. This will serve as a bridging program before teachers can go to post graduate studies. Those who already have a major in science education in the undergraduate level can expand their background of science as well as enrich their pedagogical content knowledge through enrolment in a Master’s or PhD program, specializing in science education. This can be done either by residential mode or distance mode.
The 21st century has seen a significant growth in online professional development. The University of the Philippines Open University offers postgraduate courses in science education via distance education.

- **In terms of the approach of the training**

  **Cascading approach** to training of teachers involves many teachers but found ineffective in upgrading teachers’ competencies because of dilution of knowledge and skills from one trainer to another. One reason is that the duration of the training is usually shortened as the level moves from the national, to regional, to division levels. The funding cost for the cascading approach to training is also a limiting factor for successful implementation.

  A **school-based training or cluster-based training** is preferred. Participants are teachers within a big school or a group of teachers from several small schools. Transportation expense is minimal and no accommodation cost is expected. The design of the training is based on expressed needs of teachers and planned by master teachers in the school or cluster of schools in consultation with classroom teachers. These are defined in the context of the schools’ peculiar situation. The training is collegial because the teachers are familiar with other teachers and resource persons/lead facilitators from nearby universities and teacher-training institutions.

  Not too many teachers are involved with the school-based approach. But teachers become more proficient with lessons and issues when these are conducted regularly. In the end, the implementation of learner-centered teaching strategies is well monitored and supported. School-based training can use the ‘progression approach’ in maximizing the potentials of science teachers.

  **Mentoring program** is a form of school-based professional development. It is a process by which one person assists another person to grow and learn in a safe and sympathetic environment. In teaching, mentoring enables a more experienced teaching staff member in guiding a member with less teaching experience (a Neophyte Teacher, if we use the rubrics in Chapter 4). Therefore, a mentoring program for teachers is an attempt to effect meaningful change.
Ultimately, teachers accelerate the development of their students until the desired level is attained. Whether the practice is to have veteran teachers within the school as mentor or external support is provided, mentoring programs have common features: an experienced and willing teachers in the same subject/content area, release time to observe the teacher, a common release time so the mentor and mentee can have one-on-one and small group conversations, and not more than three teachers with whom one mentor will work. The Master Teacher and Certified Mentor (see Chapter 4) can take charge of the mentoring program. UP NISMED has developed a mentoring guide for school-based or cluster-based program (UP NISMED-OVCRD, 2010).

- **In terms of focus**

  Besides strengthening the mastery of subject matter content, teacher professional development programs can use a combination of strategies/themes suggested below.

  **Constructivist theory-based teaching:** Each lesson considers the prior knowledge of the teachers. It also enables teachers to connect their old knowledge vis-à-vis more recent scientific developments. This teaching strategy also enables teachers to discover for themselves the concepts through experiential learning, starting with simple activities to complex ones.

  **Inquiry-based teaching:** The program enhances teachers’ use of basic science processes and integrated skills to teach science and how to develop/enhance the curiosity of students. Science content topics are introduced using daily life problems and situations that are close to the experiences of the learners.

  **Reflective teaching and learning:** This method enables teachers to process and analyze data or activity results, and to find connections between activities and the concepts they aim to develop. It also involves addressing misconceptions that arise during the discussion. This strategy allows participants to reflect on the lessons to identify strengths, weaknesses, and insights gained. Teachers also reflect on the impact of their teaching practices and depth of knowledge of science content and thinking skills on students.
Teaching resources and multimedia materials development: The lack of instructional materials and equipment in school has been used to account for the poor performance of students. Teachers need to know how to improvise and use instructional support materials, preferably made of indigenous and easily available materials, suitable for teaching science in specific grade or year level. They need to learn how to use their local environment for teaching science. All these can be used to motivate students about the lesson, develop concepts, and/or assess learning.

Linking theory and practice: Teachers equipped with innovative ideas are expected to bring enthusiasm and excitement in their teaching practices. They model the changes in teacher and learner behavior, highlighting the difference between teacher-centered and learner-centered classrooms, especially on how the teachers serve as facilitators of learning. Teachers are allowed to adapt/adopt the materials acquired and learned in the training in their own classrooms.

Assessment: The training focuses on assessment as an integral part of the teaching and learning process. Teachers develop varied items/tasks for use in formative and summative assessment. Highlighted is the use of authentic assessment that includes problem solving and project making, using rubrics to evaluate performance. It puts emphasis on both assessment for learning and assessment of learning.

Collaborative lesson and research development: This strategy maximizes the use of cooperative/collaborative learning groups in lesson planning, conducting practical work and other tasks, and in constructively critiquing each others’ work. Reflective teaching and learning are applied in this approach to lesson development. Teachers will be exposed to conducting action research to improve the teaching and learning process.

Designing a curriculum and developing instructional materials: DepED has pilot-tested a curriculum based on Understanding by Design promoted by Wiggins and McTighe. As a training program, it allows teachers to go through the three stages of curriculum planning by focusing on backward design process and the six facets of understanding.
Suggested Revisions for the BEED and BSED Program, Major in Science

The New Teacher Education Curriculum prescribes 12 units of science subjects for those who want to teach science at the elementary school and 60 units for those who want to teach at the secondary level. These are in addition to the 9 units of science (equivalent to 3 subjects) required in General Education. The idea is for preservice students to have a strong grounding of science concepts, and get exposed to more challenging activities and tasks that develop curiosity and higher order thinking skills.

- **Science Subjects for General Education (for BEED and BSED)**

  The Technical Panel for Teacher Education recommended science courses under the General Education program for all preservice students. These courses deal with concepts that are enduring; they emphasize connections and applications to daily life. Understanding these concepts will enhance teachers’ scientific, technological, and environmental literacy level and make them informed citizens and rational decision makers, whatever their area of specialization is.
Table 6: Description of Science Courses for General Education

<table>
<thead>
<tr>
<th>Science Subjects</th>
<th>Description</th>
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<tbody>
<tr>
<td>Introduction to Life Sciences (3 units)</td>
<td>The course covers topics on life science that will make students scientifically and technologically literate. These include topics and skills that will help students acquire and maintain good health. They will learn these through inquiry-based learning – asking questions and searching for answers to these questions.</td>
</tr>
<tr>
<td>Introduction to Physical Sciences (3 units)</td>
<td>The course exposes students to basic chemistry and physics concepts and their applications to daily life. These include topics about natural and processed materials, using and coping with changes brought about by energy, and living safely from natural and human-made disasters. They will learn these through inquiry-based learning. Relevant issues can be discussed.</td>
</tr>
<tr>
<td>Introduction to Earth, Environment &amp; Space Science (3 units)</td>
<td>This course will enable students to recognize and appreciate the fact that Earth is a system. When one part of the system fails, the other parts are affected. The concept of interconnectedness is the overarching principle behind the content coverage of this course. Basic concepts and thinking skills are emphasized to enable students to integrate Earth, environment &amp; space science concepts in other fields of study, thus, making the subject more contextual, relevant and meaningful. Hopefully, they can also model environment-friendly practices and attributes. This course will be inquiry-based and issue-based.</td>
</tr>
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- **BEED, Major in Integrated Science**

Many educators and observers believe that increasing the number of units in science from 6 to 12 for BEED is still not sufficient to teach science effectively and meet the needs of students who are science inclined and those in special science elementary schools. The recommendation is to require prospective elementary school science teachers to have a major. The minimum qualification should be a BEED major in Integrated Science. With this qualification, there will be no need to train new teachers for at least five years after graduation, thus minimizing the costs for inservice training programs.

- **Science Education (SciEd) Courses (for both BEED and BSED)**

For many teachers, translating science content appropriate for elementary or secondary schools is difficult. This document recommends inclusion of science
education courses for all science education students to make the integration of science content and pedagogical content knowledge more efficient. The course integrates lecture and laboratory. Students majoring in any of the science disciplines should enroll in a least one science education course.

The science education courses may be labeled SciEd-Biology, SciEd-Chemistry, SciEd-Physics, and SciEd-Earth/Environment and Space Science. It means that if a preservice student wants to teach chemistry, then she or he takes SciEd-Chemistry. If a student wants to teach Physics, then she or he enrolls in SciEd-Physics. A student enrolled in BEEd Integrated science should enroll in SciEd Earth, Environment and Space Science. A student can take more than one of these science education courses if he or she desires.

A SciEd course covers selected topics in secondary school science they are majoring in. It means that preservice students go through all or selected topics and skills to be learned and acquired by secondary school students enrolled for example in Year 3 Science (Chemistry) and address misconceptions that may arise from the interaction and/or will result from the assessment. Improvisation of equipment and how to use the environment for teaching is covered to address the problem of lack of equipment.

Similar courses have been offered in the UP College of Education in Diliman for many years and proved to be beneficial to preservice students when they do their off- and in-campus training. With this training in integrating content knowledge and pedagogical content knowledge in the undergraduate years, prospective teachers will be able to teach with confidence when they become real teachers. They will not be considered Neophyte Teachers (refer to rubrics in Chapter 4) even if they are new in the teaching profession if their knowledge of content and teaching/learning practices go beyond Level 1.

**Concluding Statements**

Raising the quality of science education requires the identification of teachers who effectively enhance student learning and demonstrate the high level of knowledge, skills and commitments. They are committed to students and their learning, know the subjects they teach and how to teach those subjects, manage and
monitor student learning, think systematically about their practice and learn from experience, and are members of learning communities. They are also competent in the areas of student assessment and integrating technology.

Darling-Hammond (1997), in Arntsen et al. (1998) stated that "teachers learn best by studying, doing, and reflecting; by collaborating with other teachers; by looking closely at students and their work and by sharing what they see." This kind of learning cannot occur in college classrooms isolated from practice or in public school classrooms isolated from knowledge about how to interpret practice. Healthy learning environments for teacher preparation deliberately shape opportunities for exploration, examination, application and reflection of teaching and learning activity. The "rub between theory and practice" (Miller & Silvernail, 1994, p. 44) becomes a meaningful and significant learning experience when problem solving, inquiry and knowledge application occur in classrooms filled with children. Linking the teaching of methods courses with preservice experience necessitates that the college faculty become more involved in the everyday activity of public schools. Teacher preparation students are more likely to realize strategies introduced in methods courses if their instructors interact regularly with them at their placement sites (Brown & Hoover, 1990). Well prepared teachers with broad, yet intense, experiences will build classrooms in which higher levels of learning may take place.

A significant number of teacher preparation institutions in the country failed to produce quality teacher candidates based on the results of the licensure examination for teachers (LET). It is recommended that teacher preparation programs that are unable to meet the rigors of the accreditation process by this date should be asked to submit plans to the Commissioner for phasing out their programs. Reforms in teacher education institutions have not been implemented intensively in Philippine public schools. Those who implement teacher education programs should be more aware of standards for teachers. Programs should be tailored to produce teacher candidates who are well-qualified and capable of realizing the new learning standards required of students.
REFERENCES

Books, Modules, and Sourcebooks


UP NISMED-OVCRD (2010). *Systems approach to teacher mentoring and urban poor student achievement, project report*. UP Diliman, Quezon City.


Downloaded Materials

Appendices

Appendix 1. National Competency-based Teacher Standards
Appendix 2. Tartu Declaration of Science and Technology
## APPENDIX 1

### National Competency-based Teacher Standards
(Department of Education)

<table>
<thead>
<tr>
<th>Domains</th>
<th>Strands</th>
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<tbody>
<tr>
<td>1. Social Regard for Learning</td>
<td>1.1 Teacher’s action demonstrates value for learning.</td>
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<tr>
<td></td>
<td>1.2 Teacher demonstrates that learning is of different kinds and comes from different sources.</td>
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<tr>
<td>2. Learning Environment</td>
<td>2.1 Creates an environment that promotes fairness.</td>
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<tr>
<td></td>
<td>2.2 Makes the classroom environment safe and conducive to learning.</td>
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<td></td>
<td>2.3 Communicates higher learning expectations.</td>
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<td></td>
<td>2.4 Establishes and maintains consistent standards of learner behaviour.</td>
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<tr>
<td></td>
<td>2.5 Creates a healthy psychological climate for learning.</td>
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<tr>
<td>3. Diversity of Learners</td>
<td>3.1 Determines, understands and accepts the learners’ diverse knowledge and experience.</td>
</tr>
<tr>
<td>4. Curriculum</td>
<td>4.1 Demonstrates mastery of the subject.</td>
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<tr>
<td></td>
<td>4.2 Communicates clear learning goals for the lessons that are appropriate for learners.</td>
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<td></td>
<td>4.3 Makes good use of allotted instructional time.</td>
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<td></td>
<td>4.4 Selects teaching methods, learning activities and instructional materials or resources appropriate to the learners and aligned to the objectives of the lesson.</td>
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<td></td>
<td>4.5 Recognizes general learning processes as well as unique processes of individual learners.</td>
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<td></td>
<td>4.6 Promotes purposive study.</td>
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<td></td>
<td>4.7 Demonstrates skills in the use of ICT in teaching and learning.</td>
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<tr>
<td>5. Planning, Assessing, and Reporting</td>
<td>5.1 Develops and utilizes creative and appropriate instructional plan.</td>
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<td></td>
<td>5.2 Develops and uses a variety of appropriate assessment strategies to monitor and evaluate learning.</td>
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<td></td>
<td>5.3 Monitors regularly and provides feedback on learners to encourage them to reflect on and monitor their own learning growth.</td>
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<tr>
<td>Domains</td>
<td>Strands</td>
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<tr>
<td>5.4 Communications</td>
<td>Communicates promptly and clearly to learners, parents and superior about learner’s progress.</td>
</tr>
<tr>
<td>6. Community Linkages</td>
<td>Establishes learning environment that responds to the aspirations of the community.</td>
</tr>
<tr>
<td>7. Personal Growth and Professional Development</td>
<td>Takes pride in the nobility of teaching as a profession.</td>
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<tr>
<td></td>
<td>Builds professional links with colleagues to enrich teaching practices.</td>
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<tr>
<td></td>
<td>Reflects on the extent of the attainment of professional development goals.</td>
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</tbody>
</table>
APPENDIX 2

Tartu Declaration on Science and Technology

The World Conference on Science and Technology Education was held in Tartu, Estonia, 28 June - 2 July 2010. We, the conference participants from 35 countries, believe that 21st century Science and Technology Education (STE) should prepare students for rapidly developing, knowledge-based societies.

Access to high quality education is a fundamental right for all in preparing for responsible global citizenship in a sustainable world. Human considerations that need to be at the forefront of thinking, planning and actions related to STE include respect for: human rights; health; peace; poverty alleviation; cultural diversity; indigenous knowledge; and gender equity.

Young people are naturally curious about their world and issues that affect them personally, locally and globally. Increasingly they indicate their interest in current science and technology.

Nurturing confident life-long learners, with skills, attitudes and capacities to thrive in complex societies is a high priority. Planning and implementing effective STE needs to take account of the moral, ethical and value-laden contexts within which science and technology is situated. Effective STE includes an emphasis on the development of life competencies such as problem-solving, decision-making, learning and working individually and collaboratively.

Increasingly, an STE teacher’s role is to provide links between students and scientific and technological expert sources. Curricula should allow students to participate in engaging, experiential, hands-on STE. This should be in a range of relevant contexts, on a need-to know basis, and build on children’s natural curiosity. Information and communication technologies, particularly the Internet, are increasingly becoming essential tools for students to interact with science and technology. Health and safety concerns are integral and important to STE.
The conference participants call upon all involved in research, policy development and practice in STE to implement this Declaration in their regions of the world, acknowledging the key roles of teachers.

We resolve that:

- innovative STE is for fundamental importance throughout life commencing at the earliest years;
- major goals for STE are active, ethical citizenship; responsible, evidence-based decision-making; and high levels of satisfaction in STE;
- STE involves students developing and applying scientific conceptual understanding to make sense of contexts in their evolving world;
- inter-disciplinary learning in relevant contexts is essential, to reflect the nature of professional science and everyday science and to allow teachers to build on students’ interests and questions;
- an integrated approach to STE needs to be implemented, because science and technology are inseparable as we move into the future;
- students’ involvement in decisions about their own STE learning is essential;
- an inquiry approach is central to STE, where students formulate scientific and technological questions, investigate those questions and build and apply conceptual understandings;
- assessment policies and practices that improve students’ professional learning support are essential in order for teachers to create rich, relevant, interesting, current and timely STE;
- STE policy and practices should be informed by evidence-based research findings and research in STE encouraged and supported.
FRAMEWORK FOR PHILIPPINE SCIENCE TEACHER EDUCATION

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