



national professional standards

for **HIGHLY ACCOMPLISHED**
TEACHERS OF SCIENCE



National Science Standards Committee

Australian Science Teachers Association Inc.

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THE ASTA STANDARDS IN SUMMARY

A. PROFESSIONAL KNOWLEDGE

Highly accomplished teachers of science have an extensive knowledge of science, science education and students.

1. They have a broad and current knowledge of science and science curricula, related to the nature of their teaching responsibilities.
2. They have a broad and current knowledge of teaching, learning and assessment in science.
3. They know their students well and they understand the influence of cultural, developmental, gender and other contextual factors on their students' learning in science.

B. PROFESSIONAL PRACTICE

Highly accomplished teachers of science work with their students to achieve high quality learning outcomes in science.

4. They design coherent learning programs appropriate for their students' needs and interests.
5. They create and maintain intellectually challenging, emotionally supportive and physically safe learning environments.
6. They engage students in generating, constructing and testing scientific knowledge by collecting, analysing and evaluating evidence.
7. They continually look for and implement ways to extend students' understanding of the major ideas of science.
8. They develop in students the confidence and ability to use scientific knowledge and processes to make informed decisions.
9. They use a wide variety of strategies, coherent with learning goals, to monitor and assess students' learning and provide effective feedback.

C. PROFESSIONAL ATTRIBUTES

Highly accomplished teachers of science are reflective, committed to improvement and active members of their professional community.

10. They analyse, evaluate and refine their teaching practice to improve student learning.
11. They work collegially, within their school community and wider professional communities to improve the quality and effectiveness of science education.

These standards should be viewed as a series of highlights in a relatively seamless description of high accomplishment in teaching science.

RATIONALE FOR PROFESSIONAL STANDARDS

The most important influence on the quality of science education in our schools is the quality of our science teachers. The standards described in this document aim to capture what it is that highly accomplished teachers of science know and do. Professional development plays a central role in enhancing this quality. An effective professional development system needs clarity about the areas in which teachers should improve and it needs to have the capacity and the incentives to engage all teachers in effective professional development. The standards presented here aim to give this clarity and provide the certification to give the incentive.

Recognition that high quality teachers are fundamental to good teaching, calls for policies and strategies that attract and retain good teachers and promote their continuing professional development towards high professional standards. Central to such strategies are improved career paths that place greater value on teachers' work and provide greater incentives for all teachers to develop towards high levels of effectiveness. There are many excellent science teachers, but mechanisms for recognising teachers who demonstrate evidence of their professional development are poorly developed.

Such reforms cannot be successful without the profession developing its own capacity to define rigorous standards and assess its members' performance. Professional standards, by definition, must be profession wide, but education authorities will play an important part in their development and public credibility. ASTA's standards aim to reflect the complexity of knowledge and pedagogical reasoning that underpins excellent teaching in science.

ASTA's work on standards and methods for assessing teacher performance provides a basis for:

- Improving the effectiveness of professional development, by clarifying the areas in which the profession expects its members to improve with experience and establishing a standards-guided system for continuing professional learning across the profession.

- Providing a basis for improving career path opportunities and pay systems for classroom teachers who attain those standards.
- Providing, thereby, stronger incentives for all teachers to engage in long term professional development focused on student learning and guided by challenging profession-defined teaching standards.
- Strengthening the contribution the profession makes to leadership in teaching, accountability and quality assurance.

Certification is an endorsement by a professional body that a teacher has attained performance standards set by the profession. ASTA's work on standards is based on the belief that Australian education will benefit considerably from the establishment of a national system for providing professional recognition and certification to teachers who can demonstrate that they have reached those standards.

Certification will support the development of more attractive career structures for prospective science teachers. Indications are that it is imperative to develop better methods for recruiting and retaining the best graduates possible into teaching. Professional certification is increasingly recognised by policy makers and education authorities as a potentially powerful strategy for educational reform.

While it is vital that the profession feels ownership for and commitment to its standards, it is equally vital that education authorities and the wider public judge the standards and assessments to be valid and credible. ASTA sees the quality of teaching as a joint responsibility of education authorities and the profession.

WHY SUBJECT-SPECIFIC TEACHING STANDARDS?

Research on the nature of expertise across many occupations shows that expertise is domain specific, not generic. In medicine, for example, researchers found that expertise in diagnosis cannot be separated from the field of medicine in which the diagnosis is being carried out. The same is true with expertise in teaching. Teachers' knowledge and expertise is largely specific to particular subject domains and levels. What accomplished teachers of science know and do is different from what accomplished teachers in other fields know and do.

If standards are valid – if they capture what good teachers know and can do - they must reflect these differences. What an expert primary teacher knows about how to help students develop their reading and writing skills is different from what a high school science teacher knows about how to engage students in a productive discussion about cloning. Reverse the settings for these two teachers and they will readily feel deskilled. The extent to which their professional capabilities differ quickly becomes apparent. If methods for assessing teacher performance against the standards are to be valid they must also be sensitive to these differences in what teachers are expected to know and be able to do in different subjects and at different levels.

Deep subject matter knowledge is a necessary, though not sufficient, condition for teachers to be effective. Expert teachers not only know their subject matter; they understand the education potential in their subject matter. They also know many ways to help someone learn that subject matter. A highly accomplished teacher of chemistry at the senior high school level not only knows about chemical equilibrium: they know several ways to help someone come to understand it more deeply; they can anticipate difficulties students will have in understanding the concept and have ways to help students overcome them; they can relate this concept in interesting ways to other important ideas and to

real world contexts. This kind of subject-specific pedagogical knowledge lies at the heart of expertise in teaching. It is a difficult task for standards committees to represent adequately the complexity of the wisdom possessed by expert practitioners, but that is what the ASTA National Science Standards Committee has tried to do.

Depth of subject matter knowledge has profound effects on the pedagogical choices open to a teacher. Pedagogy and content knowledge are interdependent. A primary teacher may use highly effective, flexible and interactive pedagogical methods in teaching social studies, yet use didactic, inflexible and ineffective methods in mathematics. A cause may be the level of confidence they have with the content to be learned and their understanding about how students learn that content. The way a teacher understands the content of what they are teaching determines whether they can see the potential in students' ideas and build on them.

Highly accomplished teachers of science do not just communicate information; they educate minds. The capacity to educate a mind into scientific ways of thinking depends in large part on a teacher's ability to promote learning through discussion, to design challenging and varied tasks appropriate to the student, and to provide frequent, timely and readily assimilable feedback that leads to deeper learning. The capacity to do these things is fundamentally dependent on the depth of knowledge a teacher has about what they are teaching.

Highly accomplished teachers of science can model the values and habits of mind inherent in what it means to do science. They can make complex ideas like inertia or energy meaningful to students. They can spark enthusiasm for science and forge commitments that may last a lifetime. Standards need to reflect the subject-specific character of professional knowledge in teaching.

WHAT IS MEANT BY 'STANDARDS'?

The ASTA Standards:

- directly reflect a vision of the kind of science teaching and learning that is valued and is effective;
- recognise the holism of and interaction between elements of teachers' work, describing highly accomplished teachers' discipline and craft knowledge, skills, attitudes and values;
- capture the essence of effective performance; and
- are demonstrable.

Good science teaching is complex work. These standards aim to reflect that complexity. The term 'standards' as used in this document does not mean competencies or criteria derived from breaking down teachers' work into its component parts with checklists of indicators. Rather the process of developing these standards began with members of the ASTA National Science Standards Committee defining what they meant by quality learning in science. The central task of the Committee was then to identify what science teachers needed to know and be able to do if they were to promote that kind of learning in their classrooms.

These standards identify the essential features of highly accomplished science teaching without prescribing one way to meet those standards. There are many ways to meet these standards. They do not specify any particular teaching style, nor do they imply standardisation of teaching methods. These standards state, for example, that highly accomplished teachers are able to engage students in scientific inquiry. That highly accomplished science teachers should be able to do this is non-negotiable, but how they achieve this with their students, in their school context, is a matter for their judgement and skill. The standards also state that good science teachers assess their students' development in understanding scientific concepts and know how to provide feedback that promotes this development. But the standards do not specify one way of doing this.

Teaching science well is something that teachers learn to do over many years. The standards presented here aim to describe that trajectory – what teachers of

science should be seeking to improve. These standards aim to describe the critical aspects of practice that distinguish highly accomplished teachers of science from novice or competent teachers.

The nature of teachers' work is constantly changing. These standards aim to capture these changing conceptions, but the Committee recognised that standards require regular review. The highly accomplished teacher envisaged here is skilled at evaluating his or her own practice. They know that the key to expertise is reflection on practice in the company of colleagues. They are not only good teachers, they can be explicit about their practice and the reasons behind their professional decisions. They are professionals who expect to be accountable to colleagues, to parents and to school managers. Members of the National Science Standards Committee believed that advanced professional certification should only be given to teachers who are active contributors to their professional community, in their schools and more widely in the profession.

Highly accomplished teachers adapt their practice successfully to suit context, but standards for professional certification aspire to be context free. While they undoubtedly have rich and deep local knowledge about their students and the school community, the purpose of professional standards is to describe what highly accomplished teachers should know and be able to do wherever they teach. Procedures for assessing whether teachers have attained the standards, however, must allow for rich descriptions of the school context and give recognition to what teachers are achieving relative to the conditions in which they teach.

Highly accomplished teachers of science will meet all of these standards — but not one at a time or separately. Reflecting the holism and interactivity of teachers' work, it is intended that all individual assessment tasks and procedures to determine high accomplishment will encompass at least several of these standards.

PURPOSES FOR TEACHING STANDARDS

Teaching standards serve several important purposes. Standards are a means by which the profession can provide professional leadership concerning issues of quality in teaching and learning. The ability to define standards for practice is one of the fundamental credentials of a professional body. ASTA's standards are set at a level that all teachers should be able to achieve, given opportunities for quality professional development.

Through the development of standards, the profession can assume greater responsibility for the purpose and nature of professional development of its members. Standards for highly accomplished practice provide a clear indication of what the profession expects most teachers learn with experience no matter where they teach – they provide directions for personal professional development over the long term. This kind of professional development is a necessary complement to that which employers provide to support implementation of their policies.

Standards form a bridge between research and practice. The task of defining standards requires a direct application of research on learning and teaching science to practice. Standards need to be

grounded in research on learning and teaching science as well as in professional experience. When incentives for teachers to implement the standards are strong, the likelihood that research will be applied to educational practice is enhanced.

Two reasons stand out to explain the poor take-up of research and innovations in teaching: the lack of clarity about what teachers should keep up with, and career structures that provide few extrinsic incentives for continuing development. Standards aim to address both.

Standards give the profession a stronger role in the definition of teachers' work. Standards also enable the profession to draw attention to the work conditions that need to be in place to enable teachers to teach as well as they can.

As outlined previously in the Rationale, the primary purpose of the ASTA standards is to provide the basis for a system of professional certification for highly accomplished teachers of science. It is envisaged that a professional certification system will provide a valuable service to employing authorities wishing to give recognition to teachers who can demonstrate they have attained those standards.

A VISION FOR THE TEACHING OF SCIENCE IN AUSTRALIAN SCHOOLS

It has always been part of the human condition to wonder at the world we live in – stars, animals, the nature of materials, the shape of the landscape – and to ask why the world should be that way. The fundamental goal of science education is to respond to and foster such curiosity and questioning, and in so doing educate about central aspects of our culture. One major part of this fundamental goal is to develop citizens who are literate about science and its applications. Our Australian society is shaped by the natural environment in which we live; the natural environment in which we live is shaped by our society. The nature of our future society is therefore dependent on the extent to which we citizens understand and appreciate these interactions. At the heart of this is students becoming engaged with science, both attitudinally and intellectually.

Effective teaching is central to this engagement and dependent upon the quality of those who teach science – on what science teachers know and can do. Highly accomplished teachers of science, have a passion for science, for learning and for growth in the knowledge and capabilities of their students. It is with the support and guidance of committed and accomplished teachers that students grow to become informed decision makers in our society and in setting and realising their own educational and life goals.

Critical thinking, manifested as speculation and inquiry, is fundamental to science. A vast domain of scientific knowledge exists. But this scientific heritage is continually confronted by revision and expansion brought about by new discoveries and their technological applications. Continual and engaged exploration through challenge and change is the hallmark of science activity and of science education.

Science is a human construct. The search for relationships for which scientists strive is a human, social process, influenced by evolving social values and the changing cultural influences. Science has a long and fascinating history of human attempts to understand, to exploit, and to live in harmony with the natural environment, from the Earth to the most distant astral bodies. This heritage is not the exclusive preserve of any particular culture but is the product of thousands of years of speculation and investigation, often paralleled by and always influenced by other social, cultural and political

movements. This cultural embeddedness means that a knowledge of this heritage, the capacity to make relevant reference to it and an awareness of the thought processes through which it evolved are necessary components of what teachers of science need to know and be able to do.

Science is dynamic and forward-looking. The challenges of science and the passion and interest of scientists are directed towards future discoveries. Highly accomplished teachers of science focus upon new and emerging ideas and technologies and help students incorporate these into their view of the world. In conjunction with these new ideas, technologies and processes, new ethical dilemmas also arise. The students of highly accomplished teachers of science are alert to the nature and prospective consequences of such issues so that they exercise their skills responsibly and are able to participate actively and effectively in public debate.

Highly accomplished teachers of science enable students to explore the world of science in constructive and exciting ways. Their students develop the skills required to engage in these activities fully, to think logically and rationally about the issues and consequences and to communicate their thinking and findings in a readily intelligible form. The research skills of science – generating hypotheses, making observations, classifying information and so on – are directly complemented by developing attitudes and values such as openness to ideas and a will to be imaginative, combined with healthy scepticism and a respect for evidence. Precision and rigour develop hand in hand with creative thought.

Our society is being continually confronted, challenged and redirected by technologies and ideas arising from scientific processes. Therefore, it is becoming increasingly important that students develop the skills and understandings that good science education can provide, and are prepared for emerging and changing careers that are becoming more dependent on a scientific and technological base. While only some will directly participate in these emerging and changing careers, all need to understand their significance for the long-term future of our society.

The development of strong, sustained teaching and learning communities is essential if the overall goals of science education are to be met. Such communities exist within a framework of safety, supportiveness and an acceptance of joint responsibility for learning in science — students bringing to this relationship their prior experiences and understandings and views about the direction of their learning, and teachers providing deep and diverse professional knowledge and expertise.

Science and science education then are of fundamental significance to our culture, present and future, in a range of ways. To have students understand the present and be prepared for the

future, learning science must be an active and engaging process that properly embeds, orders and makes sense of what is being encountered. This process is fundamentally based on the quality of relationships built in the classroom and upon the mutual trust and respect between teacher and student. The success of this collaboration depends on teachers being able to draw upon a wide range of knowledge and expertise, brighten this with their passion and place it in forms and contexts to develop agile, critical and questioning minds. Those who consistently create such science classrooms are highly accomplished teachers of science.



A. PROFESSIONAL KNOWLEDGE

Highly accomplished teachers of science have an extensive knowledge of science, science education and students.

1. Highly accomplished teachers of science have a broad and current knowledge of science and science curricula, related to the nature of their teaching responsibilities.

Highly accomplished teachers understand the place of science in the structure of the overall curriculum, and the interrelationships of the content of science with other curricular areas. They are familiar with and critically aware of curriculum documents that are directly related to their work. They understand the intended curriculum and translate it meaningfully into the implemented curriculum.

Highly accomplished teachers of science demonstrate a strong understanding of the field of science they are teaching, the relevant concepts to be taught and their interrelationships. They know, understand and are able to communicate:

- that Science is about finding underlying common features, general explanations and predictable behaviour, in what may seem like isolated natural events and observations;
- the distinctive modes of scientific inquiry, such as the establishment of hypotheses and suitable means of testing them; the processes of gathering, ordering and assessing evidence and communicating results; and the habits of mind such as being sceptical, logical and creative, which underpin these processes;
- fundamental laws, concepts and theories related to what is being learned and how these have evolved over time. This includes an understanding of and reference to the important conceptual themes of science, such as cause and effect, patterns of change, systems and interactions, structure and function. It also includes the teaching and incorporation of appropriate vocabulary and terminology which provides a common language and access to the ideas of others;

- how these concepts and laws might figure and be revealed and applied in contexts with which their students are familiar. They are able to draw suitable analogies, place science learning in current and relevant contexts and anticipate and map the learning pathways students could take through areas of the curriculum;
- the different discourses in science, in science education and in the communication of science to a range of audiences
- how science links to, and is complementary to other areas of the curriculum; and
- an awareness of the ethical, political and social issues to which scientific exploration and its technological products frequently give rise.

Highly accomplished teachers of science appreciate that there are complex relations 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 we live and work. They are sufficiently familiar with examples of the incredible variety of products of modern science and technology to use them as examples of how scientific knowledge can transform human lives.

They know about the heritage of science, its dynamic nature and emerging issues from current discoveries and development. They use their knowledge of recent developments in scientific research and understanding to inform and enliven their science teaching.

They are aware that science provides important knowledge that students want and need, but that because of its inherent limitations, science cannot answer all questions that students might ask.

2. Highly accomplished teachers of science have a broad and current knowledge of teaching, learning and assessment in science.

Highly accomplished teachers of science not only know their subject matter deeply; they know how to help others develop deeper understanding of that subject matter. Highly accomplished teachers have a rich bank of pedagogical content knowledge that allows them to make subject matter comprehensible to students. This expertise enables them to transform their content knowledge into a form that is understood by their students. It enables them to choose the analogies, examples or applications of a concept or skill that make the content accessible and interesting to a given group of students.

Highly accomplished teachers of science are able to outline various theoretical positions concerning science education and educative processes and explain how these might be used or modified in practice. They are able to place the nature of their own work in this context. They understand the purpose, structure and strategies of their teaching practice and how these continue to evolve and become refined through experience and reflection.

They know how to plan in a systematic and goal-focused way and, armed with a substantial repertoire of teaching strategies, they know how to devise and pursue a path to various destinations from a range of starting points. They know how to integrate various teaching, learning and assessment strategies for successful practice.

They know how to incorporate the processes of science consistently in the teaching and learning of science, and how to engage students in discussion so that the students clarify and develop their understanding of scientific concepts under investigation.

They know how to establish constructive interpersonal relationships and use this knowledge to build positive environments for science learning. They know how to deal fairly with issues that arise in classroom management and use a range of techniques to generate educationally effective and safe

environments. They understand the fundamental importance of communication in science education and know a wide range of strategies to achieve this effectively. They understand the importance of language in science and science learning.

Highly accomplished teachers of science understand the range of ways in which their students are likely to learn best. They can articulate some of the central theories of how children and adolescents learn and describe the implications for their science teaching. They know that all learning builds on previous experiences and mental constructs and that they must find a way of relating and meshing these constructs and experiences with those which are being introduced to their students.

In teaching science, highly accomplished teachers are aware of the conceptions and explanations of science phenomena that students are likely to hold at different stages of development. They know how to explore, review and, where necessary, challenge these conceptions, through specifically designed learning experiences.

Highly accomplished teachers of science are aware of the ways in which teaching and learning are enhanced by using Information and Communication Technologies. This includes information retrieval and communication as well as the role of emerging technologies in research, data gathering, modelling and simulation. Highly accomplished teachers of science take advantage of opportunities to incorporate these resources into learning experiences.

They understand the nature of authentic assessment of learning for both summative and formative purposes. They know how to assess students' work in a wide variety of ways, how to match the form of an assessment with its purpose and they understand the importance of feedback to both learners and parents. Highly accomplished teachers of science know the role of feedback, a range of feedback strategies and when and how these are most effectively employed.

3. Highly accomplished teachers of science know their students well and they understand the influence of cultural, developmental, gender and other contextual factors on their students' learning in science.

Highly accomplished teachers of science know their students as individuals and understand that this knowledge is one of the foundations for effective teaching and learning. While they understand the unique qualities of each student, they do so against a knowledge of the learning characteristics and developmental characteristics of the age group with which they are working.

Highly accomplished teachers of science understand their students' current knowledge of and beliefs about the science under study. They have a knowledge of their students' interests, past experiences of science, the degree of confidence demonstrated by their students and the background knowledge students have about natural and technological phenomena.

They have a clear idea about the cognitive level and capability of their students and any background factors that might be significant for planning and teaching. These factors include, for example, cultural heritage, particular interests, the home environment, a medical condition, high levels of mobility or information about the student's motivation and commitment to learning. They know how the social dynamics of groups of friends and of the class as a whole operate and how to use these to shape effectively the mood and functioning of a class.

With these factors in mind, highly accomplished teachers of science know how to establish suitable goals and learning programs for their students, knowing as well that their students and their circumstances will change over time and that this often necessitates modifications to these goals and programs.

B. PROFESSIONAL PRACTICE

Highly accomplished teachers of science work with their students to achieve high quality learning outcomes in science.

4. Highly accomplished teachers of science design coherent learning programs appropriate for their students' needs and interests.

Highly accomplished teachers of science know how to organise the areas of science they are teaching into conceptually coherent learning programs appropriate to their students. Their learning programs are built around the powerful ideas, or big generalisations of science and clearly demonstrate links with other areas and the larger framework of scientific knowledge that students will acquire.

Highly accomplished teachers of science set worthwhile goals to give learning its purpose, focus and direction. To achieve these goals, they develop coherent programs of work that are subject to review and modification and integrate feasible and fruitful teaching strategies. They know where they are taking their students educationally. Their programs contain clear links between content learned previously, the current concepts and the content to be learned in the future. For them, the science curriculum is not a pre-determined rutted path, but a landscape. They plan programs that help students learn to begin to see this landscape and to find their own way around it.

Highly accomplished teachers of science articulate the rationale for their programs. They develop sequences of stimulating activities to engage students in science that are clearly related to achieving their learning goals. Their learning programs are consistently subject to review and modification.

They make the intended learning outcomes and their implications clearly known to their students and use them as consistent reference points during the teaching of a theme, unit or topic. They also make the relationship of the outcomes to assessment processes clear to students and other partners in the learning process.

Highly accomplished teachers of science challenge students at the appropriate level. They are alert to individual variations in this regard and adjust their programs accordingly. They use real life contexts to make their students' learning meaningful and to enable students to develop connections with their own world and personal experiences.

Highly accomplished teachers of science are aware of and are responsive to the different needs of their students. They understand that these needs will be

affected by the different learning styles and backgrounds of their students. They provide flexible pathways for their students' learning and continually revise their programs in the light of student feedback.

When planning and teaching a program of work, highly accomplished teachers of science make purposeful use of a wide range of human, environmental and physical resources to further and enrich their students' education.

Highly accomplished teachers of science purposefully integrate the use of Information and Communication Technologies into their teaching and learning programs. They guide students to become confident and effective users of technology.

In planning learning programs, highly accomplished teachers of science recognise that students can be teachers as well as learners and make use of their experiences and background knowledge. They also draw on the expertise and knowledge of teaching colleagues, other school personnel, and, where relevant, parents and other community members. They are aware of and make use of science-based enterprises or businesses which rely on the application of scientific ideas to conduct their work within their community.

They see the potential of materials and events in their immediate surroundings and are opportunistic in making use of them. They explore and use the school grounds and their immediate surrounds for learning possibilities, along with other aspects and features of their local natural and built environment. They also make use of other sites which might provide rich and relevant experiences for their students through field trips and excursions.

Highly accomplished teachers of science recognise and actively encourage students to explore the stores of information and opinions that are available and relevant to their learning. They have a comprehensive knowledge of the range of available teaching materials and are able to evaluate their strengths and weaknesses. They know where to find relevant information and other useful materials and teach their students how to access them.

5. Highly accomplished teachers of science create and maintain intellectually challenging, emotionally supportive and physically safe learning environments.

The learning environments that highly accomplished teachers of science create and maintain are purposeful and learner-centred. There is a focus on the main task, however varied its features may be in practice. What is to be learned, and how, is made explicit to all students. There is a strong sense of personal efficacy, the ability and will to succeed, in teacher and students alike.

In such environments, students are engaged in learning and encouraged to move beyond the simple acquisition of factual knowledge and skills to active thought about the implications and applications of what is being learnt. There are substantial but realistic challenges for all participants to extend their knowledge and capabilities and to broaden the scope of their learning. Questioning and discussion are valued, with students encouraged to take responsibility for their own learning, to exercise independent judgement and to reflect on the meanings and consequences of those judgements. Highly accomplished teachers of science pay careful attention to the knowledge, skills, attitudes and beliefs that learners bring to the educational setting.

The learning opportunities that highly accomplished teachers of science create and maintain are relevant, vital, exciting and varied, reflecting the nature of science itself. Whatever the scale, teachers model the passion and interest implicit in making discoveries. While all students may sometimes be engaged in the same task, there will be times when students pursue a diverse range of learning activities including those of their own design. Intellectual risk-taking and persistence are actively fostered, with students supported to work in new situations and undertake new experiences.

A highly accomplished teacher of science creates and maintains a learning environment where all students, regardless of the diversity of their backgrounds and capacities, feel valued and comfortable. Fairness and respect for the viewpoints of others are central features of the classroom climate. Highly accomplished teachers use the diversity among their students as a learning resource to develop differing perspectives and understandings.

Relationships are warm and supportive and characterised by mutual respect, cooperative behaviour and a sense of community. Discipline is based on the discipline of the learning activity itself, and inappropriate behaviour is dealt with constructively in that light. Abuse and prejudiced behaviour from any quarter are not tolerated. In that respect the learning environment is secure and safe for students — both emotionally and intellectually. When problems arise, highly accomplished teachers defuse confrontations and deal with them fairly and respectfully. Students are involved in establishing and maintaining behavioural expectations and boundaries.

The physical environment is stimulating, but also secure and safe. Highly accomplished teachers of science assess risk constantly and ensure that routines are established to ensure safe practices and that all occupational health and safety requirements are adhered to. A classroom safety plan is in place and rehearsed to ensure familiarity with its various aspects.

As part of the process of ensuring physical safety, these teachers are familiar with their students' fears and concerns, any special needs or considerations which might apply in individual cases and any likely behavioural responses which might put students at risk.

6. Highly accomplished teachers of science engage students in generating, constructing and testing scientific knowledge by collecting, analysing and evaluating evidence.

Highly accomplished teachers of science actively involve students in a wide range of scientific investigations and in so doing expose them to diverse ideas, resources and technologies. These first hand experiences are as important to making science authentic as they are to engaging students and captivating their interest.

Highly accomplished teachers of science both teach and model practices that allow their students to approach knowledge and experiences critically, recognise problems, ask questions and pose solutions. Their teaching reflects both the excitement and challenge of scientific endeavour and its distinctive rigour.

Highly accomplished teachers of science are risk-takers who are willing to live with the often unpredictable consequences of open-ended activities. The experiences they provide initiate students into the scientific process. Over time they help their students become independent learners by progressively stepping back to allow more student-directed inquiry.

They encourage and develop in their students' curiosity, openness to new ideas, scepticism, the demand for reason, honesty and objectivity and acceptance of the tentative nature of scientific knowledge.

Highly accomplished teachers of science guide their students in active inquiry which leads students to observe and measure phenomena, formulate hypotheses, record data and reach tentative conclusions consistent with data collected. Their students reflect on the knowledge that results and consider ways to refine the investigation. They analyse and evaluate the evidence they have collected in order to check the validity of their findings. The students understand that, before knowledge can be accepted as scientifically reliable and a basis for action, they must have supporting evidence that has been or can be reproduced by others.

Highly accomplished teachers of science use strategies that increase students' ability to assess the validity and reliability of information from a wide variety of sources including print, Internet, discussions and media reports. In developing these critical thinking skills in their students, highly accomplished teachers of science help them to understand that knowledge that is often claimed to be scientific is in fact pseudo-scientific and does not meet science's strict standards of evidence.

Technology has many applications in the teaching of science and it can both extend and enhance the learning experience for students. Highly accomplished teachers of science use scientific inquiry to allow students to develop competencies in the use of technology in authentic contexts, putting students in control of the technological tools whenever possible.

7. Highly accomplished teachers of science continually look for and implement ways to extend students' understanding of the major ideas of science.

Highly accomplished teachers of science focus on challenging and extending students' deep understandings of concepts associated with the major ideas of science. Highly accomplished teachers of science move easily between detailed information, everyday examples and larger ideas or theories. They provide connections and coherence between these levels that enable students to develop enhanced understandings. They use a variety of means to keep these big questions before their students in an exciting way so that the power and wonder of the ideas are continually emerging, thus preventing the students getting lost in the detail.

Highly accomplished teachers of science demonstrate clear knowledge and understanding of the science concepts and the major ideas that they intend their students to understand. They think about the nature of the content and how it can best be presented; they consider the range of immediate and longer term learning goals, the balance of their program and different ways in which their students learn.

Highly accomplished teachers of science select and use strategies and activities that are likely to be most effective for enhancing students' conceptual development, related to major scientific ideas. They are able to explain and justify the nature of their choices. They provide connections themselves, and use strategies that assist students make connections, between the detail of science concepts, the big ideas, and the practical implications in everyday life. They weave into their teaching examples of how the big ideas have evolved and changed over time to ensure their students understand that science is dynamic.

Highly accomplished teachers of science maintain a clear focus on the science ideas with which their students are engaged. They are keen to experiment and explore and may allow students to diversify their interests and activities, but they maintain a focus on the major science ideas being explored. Students are encouraged to take ownership of content, context, time and problem solving.

Highly accomplished teachers of science actively elicit relevant aspects of students' prior knowledge and understandings, incorporate these aspects into their teaching and shape and select the content accordingly. They assist learners to build on existing

knowledge to restructure what the students know as the result of their understanding being extended and challenged. They consistently make connections with experience and information with which their students are familiar, drawing on everyday events, current topics of discussion and debate or other curricula areas to establish the relevance of science to students' lives.

The capacity to create environments that promote sustained, high quality opportunities for all to learn through purposeful discussion about scientific ideas is a hallmark of highly accomplished teachers of science. These teachers know that language is the gateway to learning and they are skilled at ensuring that all learners have many opportunities to use language to construct their own meanings and to grapple with new ideas.

They 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. Highly accomplished teachers of science help students to express and clarify their growing understandings of science concepts and to communicate these using a range of forms and technologies. They provide strong links to literacy, numeracy and interpersonal and communication skills and regularly pose tasks and questions to their students to heighten their awareness of the different discourses in science, in science education and in the communication of science to different audiences.

Highly accomplished teachers of science are able to utilise successfully the unplanned learning opportunities that present themselves. In so doing they communicate their enthusiasm and interest, while being able to draw out and explain relationships with other learning and make the whole coherent. Their flexible approach and alertness to the climate in which they teach, enables them to maintain a high level of student engagement. They change strategies to solve particular learning problems that arise in their students as a group or as individuals. They are constantly alert to issues that emerge and canvass relevant parts of students' own experience to find illuminating examples or other productive avenues to elucidate what is being learnt.

8. Highly accomplished teachers of science develop in students the confidence and ability to use scientific knowledge and processes to make informed decisions.

Highly accomplished teachers of science encourage students to be comfortable with science as part of their lives. They have an emphasis on students becoming able and willing to continue to learn science, to engage with scientific processes and to communicate about them. Highly accomplished teachers of science give time to this aspect of science. They recognise that learning about science as a part of the world is important for all students as well as learning the concepts and skills of science. As well as being important in its own right, this aspect also leads to higher levels of interest by the students and to increased motivation to learn important concepts and skills. Highly accomplished teachers of science ensure that their teaching enables students to progress in developing the habits of mind to become life long learners.

Highly accomplished teachers of science provide opportunities for students to identify relevant issues and reach evidence-based decisions in a range of areas. They select appropriate topics and issues that are meaningful to the students, based in real life experiences and often do not have one correct answer. Students and the teacher will be asking and discussing questions like "Is there a different way of doing this?", "Is it a better way?", "How do we decide if it is a better way?". Highly accomplished teachers of science engage their students in drawing evidence-based conclusions and being able to justify these decisions taking into account societal and cultural values and environmental considerations as well as scientific information. Their students often engage in problem solving activities – recognising and defining problems and putting forward plans to address them. Students in their classes, no matter what age, weigh up evidence and ask 'what's fair?' and 'what's reasonable?'

Highly accomplished teachers of science manage teaching and learning processes where students recognise issues, consider the range of factors involved, focus on evidence rather than personal feelings, discuss their own values, debate and review. Students use relevant scientific knowledge and ways of thinking in discussing personal and social issues.

Highly accomplished teachers of science model and value creative and ingenious ideas, as well as valuing evidence. They use strategies that encourage and develop divergent thinking.

Highly accomplished teachers of science make explicit the interdependent relationship between science and technology and society and the links that science has with other areas of knowledge and ways of knowing. Their students consider the place of science and technology in the world and discuss issues related to science and technology as interdependent human enterprises with costs and benefits. Students are familiar with the natural world and changes made to it by human activity. Such teachers emphasise the development of their students' understanding of both the power and limitations of science.

Highly accomplished teachers of science provide experiences that increase students' competence and confidence with scientific and technological information. Students are encouraged 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 discussion about the validity of any conclusions drawn. Students obtain information electronically via email and the Internet and are able to critically evaluate this information for bias and accuracy.

Highly accomplished teachers of science explore with students the ways in which societal and cultural beliefs and values have shaped science and decisions about its application. They review what is being learned against the large backdrop of the history of growth of scientific knowledge and how views have evolved and have come to prominence at various times, in differing locations and cultures. They understand that each student's values and attitudes are influenced by previous experience and expose students to and engage them in debates, discourse and critiques about science and associated issues, recognising its dilemmas and limitations.

Highly accomplished teachers of science focus upon new and emerging ideas and technologies and the new ethical dilemmas arising from them. The students of highly accomplished teachers of science are alert to the nature and prospective consequences of such issues so that they exercise their skills responsibly and are able to participate actively and effectively in public debate.

Highly accomplished teachers of science increase students' understanding of the impact that current decisions have on future directions of science, technology and society. They develop in students the ability to analyse ethical and moral issues and justify their decisions as responsible citizens who shape the future.

9. Highly accomplished teachers of science use a wide variety of strategies, coherent with learning goals, to monitor and assess students' learning and provide effective feedback.

Highly accomplished teachers of science are highly skilled in assessing their students' developing understanding. They capitalise on every opportunity to provide useful feedback to students about their current and developing understandings. Often the most effective forms of feedback are immediate and derive from the teacher's capacity to assess and recognise the significance of what students already know. The capacity to provide frequent, quality feedback is characteristic of highly accomplished teachers of science and is related to the depth of a teacher's knowledge of the science content they are teaching. Their feedback focuses on understanding, not just memory.

Highly accomplished teachers of science use assessment as an integral part of the teaching and learning process, from planning onwards. The assessment procedures and tasks they select, design and use are strictly coherent with the goals of the learning experience.

Highly accomplished teachers of science recognise the different purposes of assessment. They make the purpose and nature of assessment tasks explicit to their students, along with the process and criteria for judgement.

They use ongoing formal and informal assessment strategies. Initially, assessment guides their planning and the development of units of work. Subsequently, it is to gauge the progress of students individually and as a group and as a basis for reviewing the nature of the teaching and learning program. They use assessment to help individual students understand and reflect on their own progress and to provide summative accounts of progress made in relation to the goals that have been established.

They actively assist students to understand the purposes of their learning and to formulate and use self-assessment strategies. They provide regular opportunities for student self- and peer-assessment in order to clarify and support students' perceptions of what is required as well as encouraging personal reflection on progress and responsibility by students for their own learning.

Highly accomplished teachers have an extensive repertoire of formal and informal assessment strategies from which they make choices based on the most effective means of allowing their students to demonstrate their learning. They are able to explain and justify the nature of their selections in terms of specific purposes and particular contexts and they know that good assessment tasks are good learning experiences. They use multiple methods to ensure the reliability and validity of assessment data and to explore and identify the full range of students' understanding and capabilities.

Highly accomplished teachers of science keep careful and thorough records of student progress. They use these records of progress together with samples of work, to aid two-way communication with their students and students' families. They recognise the different reporting requirements of parents, employers, education agencies and certification authorities. They may also develop portfolios of student achievement which illustrate and exemplify what students know and can do and the progress the students have made.

Importantly, they use assessment data as part of the general process of evaluating the quality of their own work and identifying where improvements can be made.

C. PROFESSIONAL ATTRIBUTES

Highly accomplished teachers of science are reflective, committed to improvement and active members of their professional community.

C.

10. Highly accomplished teachers of science analyse, evaluate and refine their teaching practice to improve student learning.

Highly accomplished teachers of science consistently, systematically and critically review all aspects of their practice to improve their students' learning. They are insightful in analysing strengths and weaknesses in their practice and can support their judgements with specific evidence from their practice. Highly accomplished teachers of science are prepared to embrace change to develop and improve their teaching practice. They not only teach well, they can justify why they teach, what they teach and articulate why they use particular teaching strategies.

Highly accomplished teachers of science are skillful in reflecting on the extent to which their goals for student learning have been met. The capacity to improvise and change course in response to student feedback is a result of their ability to reflect. They read classrooms well, recognising patterns in students interactions that others often do not see. They also use a range of methods to gather evidence about problems that their students may be having in learning science. As part of their regular practice, highly accomplished teachers of science collect information from events in their classrooms, from students and their work and from their colleagues, to evaluate the effectiveness of their teaching methods. Highly accomplished teachers of science use their professional skills and judgement to analyse the significance of the information and to draw implications for their future practice. They act on these implications.

Highly accomplished teachers of science are committed to continuing their own professional learning and development. As a result of analysing their practice, highly accomplished teachers of science are able to identify areas in which they need to improve their own knowledge and skills. They show initiative in identifying their professional development needs and finding ways to meet them. They set long term goals for their personal professional growth and identify issues around which their professional development should occur. They use professional standards to guide this process.

Highly accomplished teachers of science collaborate with colleagues in analysing and reflecting on their practice. For them, every lesson is, in a sense, an experiment. They use practice as the site for professional learning and create opportunities for reflective dialogue with colleagues focused on examples of their students' work and their teaching methods. They use these opportunities to compare their students' work with relevant goals and standards for student learning. They focus on the content and skills that students are expected to learn and they are skilled at identifying problems that their students meet in learning that content. They also use these opportunities to identify teaching strategies that they may need to develop to overcome those problems.

Highly accomplished teachers of science use a wide variety of means to meet their own goals for professional growth. They regularly learn from colleagues through collaboration on professional tasks. They seek advice from other teachers on matters related to teaching and learning. They read professional literature, ensuring that they remain up-to-date on issues and developments in science and science education both nationally and internationally. They use information and communication technologies to access the wealth of information and collegial interaction that is available. They seek new resources and ideas from outside the school, and assess their value through reflection and professional judgement prior to and after their use and subsequent evaluation.

In pursuing these tasks, highly accomplished teachers of science model the development and improvement implicit in lifelong learning, along with the risk-taking and flexibility entailed in the testing of new ideas and changes in practice.

11. Highly accomplished teachers of science work collegially, within their school community and wider professional communities to improve the quality and effectiveness of science education.

Highly accomplished teachers of science are active contributors to their professional community and contribute to the improvement of practice in a number of ways.

They promote a staff culture in which experimentation in teaching is expected and acceptable. Seeking and giving collegial advice are not signs of relative incompetence, but rather professional actions viewed as desirable, necessary and legitimate in the acquisition of new skills. They promote a view of teaching as a body of skill and knowledge that can be learned and developed over time.

They regard student achievement and well-being as both an individual and collective responsibility. To them, professionalism implies mutual accountability, not just autonomy. As team players, they recognise that their work is one element of science education and that the quality of this education is dependent on the strength of the professional community. To promote professional accountability, they facilitate frequent conversations among colleagues about practice and student progress.

They support and promote the professional growth of their colleagues. They keep abreast of current science knowledge and developments in science education through active participation in workshops and other learning activities. They pass useful professional knowledge on to colleagues. They may conduct their own research and share the results with colleagues and others. They act as mentors to less experienced teachers of science, providing ideas, advice and support and they may lead activities designed to facilitate professional growth amongst their colleagues.

Highly accomplished teachers of science contribute to the development, and evaluation of the science curriculum and teaching program in their schools. They consistently encourage and support their colleagues, collaborating in such activities as developing and testing teaching strategies, designing curriculum programs and developing methods for assessing student progress.

Highly accomplished teachers of science are active in professional communities beyond their school. They contribute through activities such as writing articles, mounting demonstrations and exhibitions, giving talks and working actively within professional associations. They may contribute to the wider professional community through designing or conducting professional development programs; through writing articles for professional journals; developing new teaching ideas and materials; or taking part in research projects or evaluating new practices. They may also be actively involved in working with scientists and scientific organisations, as a means of keeping up with developments in science relevant to their field of teaching.

Their work consistently displays an understanding of the complex partnerships that underpin effective education. Within their school communities, they establish productive relationships with teachers, parents/care providers and others, sharing views on teaching and learning in general and science education in particular — explaining, listening, advising, revising — sometimes working as an advocate, sometimes as an intermediary, sometimes as a resource, but always working for improvement in students' science education.

Highly accomplished teachers of science know that their success depends on working with parents and care givers as significant partners in the education of their students. They communicate with parents and care givers in an interactive manner on matters of teaching and learning. They provide information about their science programs and offer suggestions about how parents and care givers can support their children's learning in science.

BACKGROUND

For the past decade the Australian Science Teachers Association (ASTA) has demonstrated a growing interest in the development of professional standards for teachers. Teacher organisations generally in Australia are recognising they must demonstrate their capacity to be explicit about quality learning and teaching if the teaching profession is to be strengthened.

As long ago as 1973 the Karmel Report¹ argued that

A mark of a highly skilled occupation is that those entering it should have reached a level of preparation in accordance with standards set by the practitioners themselves, and that the continuing development of members should largely be the responsibility of the profession. In such circumstances the occupational group itself becomes the point of reference for standards and thus the source of prestige or of condemnation. (p. 123)

ASTA believes that the profession should take the primary responsibility for setting and administering professional standards. In order to ensure that such standards are implemented effectively, this responsibility must be shared with employer and teacher industrial organisations, but ownership by practising teachers is an indispensable condition of their effectiveness.

In 1994 ASTA took a lead in this area by commissioning its own study (Ingvarson, 1995)² of the latest international experiences in the establishment of teaching standards. Subsequently ASTA Council made a commitment to seek funding to support a national effort to develop professional standards for teachers of science.

For several years now the Commonwealth Minister for Education has advocated that teachers should

play a stronger role in articulating their own standards and promoting excellence in teaching and learning. Consistent with this, the 1998 Senate Inquiry into the Status of Teachers, A Class Act³, also recommended that the Commonwealth Government should facilitate the development of a national professional teaching body with responsibility, authority and resources to develop and maintain standards of professional practice. They emphasised that this body should work closely with state and territory governments and peak teacher organisations.

The Senators recognised that an effective education system needs career structures that keep good teachers close to students and provides incentives that encourage all teachers to pursue their professional development. For this reason the Senators recommended that:

"A system of professional recognition for teachers must be established which is based on the achievement of enhanced knowledge and skills and which retains teachers at the front line of student learning. Such knowledge and skills should be identified, classified and assessed according to criteria developed by expert panels drawn from the profession. Education authorities should structure remuneration accordingly (p. 7-8)."

In 1999, working in collaboration with Monash University, ASTA mounted a project jointly funded by the Australian Research Council (ARC/SPIRT) and ASTA as an industry partner to develop a national voluntary system to provide professional certification to teachers whose practice has attained high standards set by the profession. The aims of the project were:

¹ Interim Committee for the Australian Schools Commission (1973). *Schools in Australia: report of the Interim Committee for the Australian Schools Commission* (also known as the Karmel Report). Canberra: Australian Government Publishing Service.

² Ingvarson, L.C (1995). *Professional credentials: standards for primary and secondary science teaching in Australia*, Canberra; Australian Science Teachers Association.

³ Senate Employment, Education and Training References Committee (1998). *A Class Act: Inquiry into the Status of the Teaching profession*. Canberra: Commonwealth of Australia.

- to develop and validate standards for highly accomplished teaching of science in primary and secondary schools;
- to develop and validate methods for assessing the performance of highly accomplished teachers of science; and
- to build understanding and support nationally for the project among education and school authorities who will determine whether and how national certification is recognised by states and school systems.

One of the first steps taken by the ASTA Project was to establish a National Science Standards Committee. Science teachers across Australia were invited to apply for membership of the Committee. Fifteen highly regarded teachers were selected to develop the standards, representative of all states and territories, and all school systems.

The Australian Association for the Teaching of English, the Australian Literacy Educators' Association and the Australian Association of Mathematics Teachers began similar projects in 1999, also funded jointly by the associations and the Australian Research Council. These projects have proceeded independently, but in close and regular contact with each other.

At a joint workshop on professional standards in Adelaide in March 2001 members of the four associations agreed that, as professionals they were committed to:

- The recognition of quality teaching.
- Teachers being central to the process of developing, implementing and renewing standards.

- A professional development process that is informed by the standards.
- Professional Associations developing nationally agreed, discipline specific standards.
- Our disciplines being essential to high quality and inclusive education.
- Collaborative partnerships between all professional teaching associations.
- Working with other stakeholders towards strengthening the profession.

The four teacher associations also developed a core set of principles about quality teachers. They:

- Engage all students in purposeful and successful learning.
- Are enthusiastic and reflective professionals.
- Have a deep understanding of their subject and how to teach it.
- Are committed to extending their knowledge and improving their practice.
- Are committed to working creatively and constructively within a range of communities.
- Are professionally accountable.

These teaching principles reflect those that guided the work of the National Science Standards Committee. The task of the Committee was to describe what the principles meant in the context of highly accomplished teaching of science. It was recognised that the knowledge and skills of accomplished teachers differ in fundamental respects across different subjects and contexts.

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