The pre-registration test for aspiring primary teachers:

Guideline to Core Knowledge — Science

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QUEENSLAND COLLEGE OF TEACHERS

Science

Introduction

The Queensland Government response to the report of the Queensland Education Performance Review (29.06.09) requires

That all aspiring primary teachers be required to demonstrate through test performances, as a condition of registration, that they meet threshold levels of knowledge about the teaching of literacy, numeracy and science and have sound levels of content knowledge in these areas.

This document defines the core knowledge requirements for teachers to successfully design and manage learning experiences in the key areas of literacy, numeracy and science. It embodies the three constructs around which the test will be developed:

1. ***required knowledge and understanding of the content and processes*** *of* (literacy, numeracy and science)
   This construct acknowledges the need for teachers to possess content knowledge at a considerably greater depth than the level being taught. The convergence of opinion in the research literature points to a consideration of what students need to learn as the starting point for defining teacher development needs. For this reason, the definition of test content developed here is explicitly anchored to the relevant national and state curriculum frameworks, advisory and reference documents. It is important to note that this definition is not redefining curriculum for students; rather, it is a representation of what teachers need to know in order to effectively teach the curriculum for literacy, numeracy and science.
2. ***knowledge about the teaching of*** (literacy, numeracy and science)
   The sound level of content knowledge prefaced above needs then to be supported by at least threshold levels of pedagogical content knowledge which enable the emerging professional to know and understand how students' understandings in a subject typically develop, how to engage students and sequence subject matter, the kinds of misconceptions that students commonly develop, and effective ways to teach a subject. For the purposes of this definition, pedagogical content knowledge for each area will be detailed using the following foci:
   - knowledge of curriculum frameworks
   - teaching literacy/numeracy/science
   - diagnosis, monitoring and assessment.
3. **personal literacy and numeracy skills**
   The test will also require demonstration of core personal literacy and numeracy skills. These skills are a focus within the professional standards for teachers and their inclusion reflects the underpinning nature of literacy and numeracy across all curriculum areas including science. Their inclusion also recognises, differentiates and underlines the standing of science as a key curriculum area.

The table below summarises the configuration for the test:

Figure 1: Configuration for pre-registration testing in literacy, numeracy and science

1	*Required knowledge and understanding of content and processes* to teach …	literacy numeracy science
2	*Knowledge about teaching of …*	literacy numeracy science
3	Personal literacy and numeracy skills	literacy numeracy

The test will be enacted through three test instruments – one each for literacy, numeracy and science.

Further, it is critical to recognise that the performances against this testing program represent an independent source of evidence to be considered as a discrete and mandatory requirement alongside successful completion of an approved/acceptable preservice program. It is timely to remember that in being certified as completing requirements for approved preservice programs, graduands demonstrate achievement of the professional standards at graduate level. This judgement is made through a comprehensive and robust assessment program that targets all aspects of the program, including professional experience. The assessment program and its implementation is reviewed and monitored as part of the Queensland College of Teachers (QCT) program approval processes. It is not intended that this testing will or can canvass the same breadth of coverage, but will provide an additional and confirmatory source of evidence.

Science

The parameters defined here align to and represent an explicit and specific drilling down for nominated priority areas of the knowledge of 'the content, processes and skills of the areas they teach …' required by the *Professional Standards for Queensland Teachers* (at graduate level).[1]

The aim of the science curriculum is to provide students with a solid foundation in science knowledge, understanding, skills and values on which further learning and adult life can be built. In particular, the science curriculum should foster an interest in science and a curiosity and willingness to speculate about and explore the world. Students should be able to engage in communication of and about science, value evidence and scepticism, and question scientific claims made by others. They should be able to identify and investigate scientific questions, draw evidence-based conclusions and make informed decisions about their own health and wellbeing. Science is a human endeavour that students should learn to appreciate and apply to daily life. *(The Shape of the Australian Curriculum: Science, 2009)*

The aspects of the science test include the following:

- Required knowledge and conceptual understanding of the content area
- Pedagogical content knowledge.

The content of these two aspects have been anchored to both state and national curriculum frameworks for science as specified in the table below:

Required knowledge and understanding of content area
Queensland Studies Authority (QSA) http://www.qsa.qld.edu.au/learning.html • Early Years Curriculum Guidelines • Year 1 Learning Statements • Years 3, 5, 7, 9 Essential Learnings (Science) • Implementing the Essential Learnings and Standards • Planning - Using the Essential Learnings and Standards • Year 10 Guidelines (Science) • P— 9 Literacy and Numeracy Indicators Australian Curriculum Assessment and Reporting Framework (ACARA) http://www.acara.edu.au/publications.html • Shape of the Australian Curriculum: Science (May 2009) • Framing Paper Consultation Report: The Science (May 2009)
Pedagogical content knowledge
Queensland Studies Authority (QSA) http://www.qsa.qld.edu.au/learning.html • Early Years Curriculum Guidelines • Year 1 Learning Statements • Years 3, 5, 7, 9 Essential Learnings (Science) • Implementing the Essential Learnings and Standards • Planning - Using the Essential Learnings and Standards • Year 10 Guidelines (Science) • P—9 Literacy and Numeracy Indicators Australian Curriculum Assessment and Reporting Framework (ACARA) http://www.acara.edu.au/publications.html • Shape of the Australian Curriculum: Science (May 2009) • Framing Paper Consultation Report: The Sciences (May 2009)

[1] Queensland College of Teachers, *Program Approval Guidelines for Preservice Teacher Education*

Knowledge and understanding of content and processes of Science

Knowledge of the way scientists work and the science discipline conceptual knowledge and understandings which underpin the primary school science curriculum have been identified. The ways of working is an integral component of the science curriculum. It is intended that the ways of working processes are incorporated and embedded into all other organisers.

This section of the definition is organised according to the following:

- Ways of working
- Science as a human endeavour
- Earth and Beyond
- Energy and Change
- Life and Living
- Natural and Processed Materials.

Organiser	Required knowledge and understanding of content
Ways of Working	Working scientifically involves active participation, both individually and collaboratively, in genuine endeavours that help to construct personal scientific understandings. This includes: • **Investigating** o Inquiry based learning (investigating) involves the following steps: posing questions, predicting, designing and planning an investigation, collecting, working with and presenting data, analysing data, evaluation the investigation and drawing conclusions. o Inquiry based learning (investigating) underpins and is embedded in the learning in all the curriculum strand organisers. o How to use science equipment for classroom activities safely and accurately is required. Practical activities require risk assessment procedures to be known and applied. This includes knowledge of storage and use of chemicals. o Use of models, simulations and scaled replicas can be used to support learning in the ways of working strand. • **Communicating** o Science is communicated orally, in written mode and using different mediums and multimodal technologies. • **Reflecting** o Reflecting on the learning and the processes is critical for constructing and confirming current understandings and developing new concepts.
Science as a human endeavour	Science may help to influence society through the posing and responding to social and ethical issues and science research is influenced by societal challenges or social priorities. This organiser highlights the need for informed, evidence-based decision making about real-world current and future applications of science. • **Science in every day life** o Science has applications in daily life, including at home, at school, at work and in leisure time. Scientific ideas can be used to explain the development and workings of everyday items and phenomena. • **Science and ethics** o Science can help to make natural, social and built environments sustainable at a scale ranging from local to global and may influence personal human activities. o Responsible, ethical and informed decisions about real-world issues and social priorities may benefit from the application of scientific understanding. • **Contributions of the past** o Scientific knowledge including from Australia has been accumulated and refined over time, and can be used to change the way people live. o Cultures from around the world, including those of Aboriginal people and Torres Strait Islander people, have contributed to scientific understanding and scientific practice. o Immediate and long-term consequences of human activity can be predicted by considering scientific understandings of past and present events, discoveries, inventions and innovations.

Knowledge and understanding of content and processes of Science

Organiser	Required knowledge and understanding of content
Earth and Beyond	The earth and beyond knowledge organiser recognises that scientific understanding about the earth and universe can be used to model the past and make predictions. • **Key concepts** o Our lives depend on air, water and materials from the ground; the ways we live depend on landscape, weather and climate. o The Earth is composed of materials that are altered by forces within and upon its surface. o The Earth and life on Earth are part of an immense system called the universe. • **Weather and Climate** o Temperature and winds o The water cycle o The seasons o The changing atmosphere ➢ natural ➢ human impacts o Using models to make predictions • **Structure of the Earth and its atmosphere** o Features of the layers of the Earth o Tectonic plates, volcanoes, earthquakes and tsunamis o The surface of the earth changes o The atmosphere • **Using the Earth's resources** o The resources include, air, water, minerals (iron ore and coal) o Human use of resources • **The solar system, stars and galaxies** o The sun is a star and supplies light and heat energy to the earth o Planets and the solar system o The moon, tides o Using technology to investigate • **Space travel and exploration** o The new knowledge and benefits of space research and travel.
Energy and Change	This physical sciences knowledge organiser recognises forces and energy concepts. They are identified and analysed to help understand and develop technologies, and to make predictions about events in the world. • **Key concepts** o Energy is vital to our existence and our quality of life as individuals and as a society. o Interaction and change involve energy transformations and transfers; control of energy transfer enables particular changes to be achieved. o Observed change in an object or system is indicated by the form and amount of energy transferred to or from it. • **Forces** o Pushes and pulls o Weight o Buoyancy and density o Friction o Simple machines o Gravity • **Motion** o Speed o Acceleration • **Energy** o Forms and sources of energy o Energy transfer and transformation o Sustainability of energy sources • **Electricity and Magnetism** o Static electricity o Electric currents and circuits o Magnets o Motors and generators • **Light and Sound** o White light and colours o Reflection and refraction o Vibrations and sound

Knowledge and understanding of content and processes of Science

Organiser	Required knowledge and understanding of content
Life and Living	This biology based knowledge organiser recognises there is a relationship between the structure and function of living things and this is the basis for understanding life-maintaining processes. All living things in an environment are interdependent, and changing one aspect of the environment will affect other organisms. • **Key concepts** o Organisms in a particular environment are interdependent. o Living things can be understood in terms of functional units and systems. o Life on Earth has a history of change and disruption, yet continues generation to generation • **Cells** o Plant and animal cell structures o Tissues, organs and systems (respiratory and digestive) • **Life cycles** o Growth o Reproduction • **Natural selection** o Fossils o Adaptation o Classification o Natural selection/Evolution • **Ecosystems** o Living and non living environment o Food chains o Recycling of matter o Flow of Energy • **Impact of humans** o Introduction of species o Changing the environment
Natural and Processed materials	This chemistry based knowledge organiser recognises the properties, changes and uses of materials are determined by their structure and their interaction with other materials. • **Key concepts** o The properties of materials determine their uses; properties can be modified. o The substructure of materials determines their behaviour and properties. o Patterns of interaction of materials enable us to understand and control those interactions • **Particles** o Atoms, elements, compounds and mixtures o Common substances and formula (e.g. water (H_20), carbon dioxide (CO_2) and salt (NaCl) • **States of matter** o Gases, liquids and solids o The particle model • **Materials and their uses** o Properties (colour, texture, state, density, texture, heat and electrical conductivity) o New molecules (including polymers for use as drugs, building materials) • **Changes** o Physical and Chemical o Conservation of matter o Rates of reaction o Chemical reactions which impact on life (respiration and photosynthesis)

Pedagogical Content Knowledge: Science

PCK construct	Required knowledge and understanding
Knowledge of Curriculum Frameworks	• What the students need to know and be able to do at respective junctures. • The sequences of learning: how the concept progressively develops. • The curriculum standards associated with student learning. • How to judge student work with respect curriculum standards.
Teaching Science	• Use curriculum frameworks for undertaking short, medium and long-term planning for class/es. • How to select, design, plan and implement the appropriate learning experiences and teaching strategies which clearly link to what is required to be taught (*Essential Learnings*) AND to what will be assessed and how it will be assessed (using the *Standards).* • Select appropriate science contexts which: o Engage students due to identified interests or connectivity o Relate to everyday life experiences (and have implications for the application of the knowledge and skills being learnt) o Provide opportunities for hands on engagement/ investigations (underpin content strands with ways of working). • Use appropriate strategies to develop science understandings including: o Questioning and other diagnostic tools which identify current student understandings o Thinking strategies like: POE (Predict, Observe, Explain) during investigations to help student focus on the task and process o Inquiry based learning, analogies, models and simulations. o Modelling "working scientifically" and "fair testing". o Modelling appropriate ways to represent knowledge and understanding. o Develop metacognition skills so students understand how they learn. o Evaluating sources of information. • Teach students to become cooperative and collaborative learners; to understand the role each team member plays and oversees these processes including: o Gathering equipment o Conducting the investigation (sharing and assisting) o Communicating – reflecting and reporting the results (like working scientists). • Conduct risk assessment - Assess risks associated with the environment, the distribution and safe use of equipment and materials used in investigations. This includes planning for effective movement and interaction of students and equipment in a productive and safe manner and accessing children's health records where necessary. • Identify and access resources to provide relevant and appropriate learning experiences. It is essential that teachers relate the science that is done in the classroom to real life issues/ circumstances/ examples (Science is a human endeavour organiser). • Identify and explicitly teach the literacy and numeracy competencies which underpin/ support the development of science understandings. o Literacy - Science literacy text types or representations include: annotated diagrams, circuit diagrams, cross sections, cutaway diagrams, flow charts, graphs, concept maps, force arrow diagrams, maps, 3 D models, tables, Venn diagrams, science reports and science journals - Science texts aim to convince readers that explanations are authoritative, reliable and based on evidence. (As new evidence develops, understandings can change.) - Many science texts are multi modal - combine verbal, visual and, mathematical language to represent themes, concepts, relationships and explanations. - There are scientific conventions which are internationally recognised and must be followed – e.g. when naming species (*Homo sapiens*).

Pedagogical Content Knowledge: Science

PCK construct	Required knowledge and understanding
	o Numeracy - Science numeracy competencies largely relate to making sense of and manipulating data. This includes: - Appreciating the size of numbers (to rank or compare) - Measuring, including converting between units of measurement; reading scales; approximating, estimating - Manipulating data – e.g. calculating averages - Using scientific notation – e.g. 300 = 3.0×10^2 - Modelling numerical information/data; creating formulae; understanding interactions between different variables - Making sense of number problems, including non routine problems, and recognising the operations needed to solve them - Explaining and making predictions from numbers in graphs, diagrams, charts and tables - Explaining methods and reasoning using correct mathematical terms; judging whether answers are reasonable, and possessing strategies for checking them where necessary. • Work cooperatively and effectively with the school community. Use teacher aid/ support staff efficiently (e.g. preparing equipment and materials for investigations), communicate effectively with teaching colleagues, administration, parents and community members and know when to ask for help. Use information and communication technologies (ICTs) by using and modelling the use of: learning objects, excel (spreadsheet and graphing), digital interfaced equipment (microscopes, environmental probes e.g. temperature), computer modelling and simulations, Web 2.0 technologies (wikis, blogs, u tube).
Diagnosis, Monitoring and Assessment	Teachers are required to have a working knowledge of how to assess student learning. This includes knowing how to: • use authentic science **assessment strategies** for gathering information and making judgements about students' development in science: o observation of experimental investigations o reviewing students' experimental reports and science journals o listening to and analysing group discussions and student presentations o discussions with students about their progress. • use **assessment data** to evaluate student learning and review teaching and assessment practices e.g. assessment of using the scientific method should provide information about students' abilities and inform future teaching. It is collected through: o observing students performance in designing and carrying out science investigations o examining experimental reports and associated tasks to identify their correct application and understanding of the scientific method. o using student self-assessment and conferring with students about their scientific results and conclusions. • determine students' **prior learning and assess their current levels of proficiency:** o assessing prior knowledge e.g. where in the broad scope of science students' current conceptual knowledge and understanding' of science contexts lies. o developing activities to recognise and address alternative conceptions and/or misconceptions e.g. complete concept cartoons or maps.