SCIENCE

Seventh-day Adventist
Secondary Curriculum

A Curriculum Framework for Seventh-day Adventist Secondary Schools

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We in the South Pacific Division Education Department are pleased that teachers are engaged in developing science curriculum materials, and we look forward to seeing more evidence of thorough planning and professionalism in our teaching as we attempt to implement the intentions of this framework.

Yours sincerely

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WHAT IS A FRAMEWORK?

A Framework

In the Adventist secondary school context, a 'framework' is a statement of values and principles that guide curriculum development. These principles are derived from Adventist educational philosophy which states important ideas about what is real, true and good.

A framework is also a practical document intended to help teachers sequence and integrate the various elements of the planning process as they create a summary of a unit or topic.

The framework is not a syllabus.

The framework is not designed to do the job of a science textbook. Although it contains lists of science topics, skills, issues and teaching ideas, the main emphasis is on relating values and methods of thinking to teaching topics and units.

Objectives of the Framework

1. One objective of the framework is to show how valuing, thinking and other learning skills can be taught form a Christian viewpoint. The Adventist philosophy of science influences this process.

2. A second objective is to provide some examples of how this can be done. The framework is therefore organised as a resource bank of ideas for subject planning relating to ideas, issues, values and skills of thinking and learning science, so it is intended to be a useful planning guide rather than an exhaustive list of "musts".

The framework has three target audiences:-

1. All science teachers in Adventist secondary schools.

2. Principals and administrators in the Adventist educational system.

3. Government authorities who want to see that there is a distinctive Adventist curriculum emphasis.

USING THE FRAMEWORK

LAYOUT

The framework is comprised of four sections — philosophy and objectives, suggestions on how to plan, examples of topic plans and a set of lists of important ideas, values, issues, teaching strategies and other elements which are useful in building a planning summary. The nature and purposes of each section are set out below.

It is suggested that you read this page describing these four sections now before attempting to use the document for the first time.

SECTION 1 — PHILOSOPHY

Section 1 is the philosophical section. This section contains a definition of science, a philosophy of science, a rationale for teaching science, and a set of objectives which have a Christian bias.

This section is meant to help teachers refresh their memories of the Christian perspective they should teach from. They may consult this section when looking at longer-term curriculum planning, and when thinking about unit objectives. They may also consider adapting it or using it as is to form part of their science program of work.

SECTION 2 — HOW TO PLAN A UNIT

Section 2 is the "how to" section of the framework. It explains an eight step process teachers can follow when planning a topic or unit of work while thinking from a Christian perspective. It concludes with a sample summary compiled by working through the eight steps. Because it suggests an actual process for integrating ideas, values and learning processes, this section is the heart of the document.

SECTION 3 — SAMPLE UNIT PLANS

Section 3 shows practical examples of how to use the framework in topic and unit planning. It is meant to show how Section 2 can be used to produce a variety of possible approaches to teaching valuing, thinking and other learning.

SECTION 4 — PLANNING ELEMENTS

Section 4 contains the various lists of ideas, values, skills, issues and teaching strategies that teachers may consult when working their way through Section 2 of the framework. It is a kind of mini dictionary of ideas to resource the eight steps followed in Section 2.

SECTION 1

PHILOSOPHY

INDEX

WHAT IS SCIENCE?

Science is:

- The continuing search for understanding about ourselves and our changing physical, technological and biological environment. Rightly interpreted and understood, it must be consistent with ultimate truth which is embodied in God, who is as yet only glimpsed by man.

- A set of processes which facilitates the systematic acquisition and refinement of data. These processes enable us to generalise and predict.

- A way of viewing life. It involves attitudes and values and is a way of thinking about our interaction with our environment and with God.

A PHILOSOPHY OF SCIENCE

God is the source of ultimate truth. Science is the continuing search for understanding about ourselves and our changing physical and biological environment. Therefore, rightly interpreted and understood, it must be consistent with ultimate truth, which is embodied in God and glimpsed by man.

Science provides the student with an opportunity to explore and attempt to comprehend the order and perfection of the original creation. Although creation is marred by sin, men may possess a closer relationship with the Creator as they seek to understand His creation.

God created man as an intelligent being with a capacity for logical thought and creativity. Science provides scope for the utilisation of these capacities in investigating God's creation and the laws by which it is governed and maintained.

REASONS FOR TEACHING SCIENCE

We teach science for a number of reasons. Some of the most important of these are grouped in five categories below:

Search for Understanding:

Science is more than just a body of organised facts. It also represents a way of organising knowledge about our physical and biological environment. Since knowledge is continually changing, science becomes man's attempt to correctly represent knowledge. Truth can only be found in a knowledge of God, since He is the source of ultimate truth.

Development of Processes:

Scientists use many different processes — ways of doing and thinking — to investigate and generate ideas.

These processes include: observing; classifying; measuring; guessing; hypothesising; predicting; testing; experimenting; describing; communicating; interpreting data; brainstorming; inferring from data; and identifying and controlling variables. All of these are ways of exploring and discovering, and are transferable to many aspects of life.

Development of Creativity:

When students understand scientific processes they also develop imagination and creative thinking. God Himself has shown a great deal of imagination through His acts of creation. A student's creativity to ask questions, generate possible explanations, and test ideas is central to science.

Some important abilities include: visualising, combining objects and ideas in new ways; producing alternate or unusual uses for objects; solving problems and puzzles; fantasising; pretending; dreaming; designing; producing unusual and new ideas; identifying; isolating; merging; diverging; converging.

Development of Positive Attitudes:

Students bring to class a set of pre-determined attitudes to God, to themselves, to other people, and to their environment. Science teaching, especially in a Christian context, tries to address human feelings, values and decision-making skills, and to direct them along positive lines.

Examples of positive attitudes that could be developed are: willingness to explore human emotions; sensitivity to, and respect for the feelings of other people; expression of personal feelings in a positive way; making well-informed decisions about personal values and social and environmental issues; open-mindedness; curiosity; a sense of responsibility; and a willingness to test ideas and explore arguments on either side of an issue.

Personal Relevance:

Science needs to be relevant to the world of the student. Students experience science in a number of different contexts as it relates to: self, home, leisure, work, and the environment. Science includes a lot of information, and numbers of skills and attitudes that can be used in everyday life. Hopefully studying science will enable students to understand and use technology, and create new applications for technology.

SCIENCE OBJECTIVES

Science Education should provide opportunities for students to:

Attitudes

1. Recognise the value, legitimate roles and limitations of scientific and technological knowledge, and their subordination to the knowledge revealed through Divine inspiration.

2. Appreciate and respect the handiwork of the Creator, demonstrated by a respect for others, themselves and the environment.

3. Value honesty and integrity and while striving for accuracy, recognise that all observations are subject to uncertainties.

4. Recognise through the study of nature the evidence for the existence of an intelligent, powerful and orderly Creator who established natural laws through which He sustains the universe.

5. Develop attitudes of inquiry, open-mindedness and interest in current scientific issues.

6. Develop an attitude of curiosity toward the natural world and experience the excitement of discovery.

7. Utilise scientific knowledge and skills to glorify God and benefit mankind.

8. Develop responsible attitudes towards the environment and natural resources.

9. Develop confidence in using problem solving skills.

Knowledge

1. Develop and maintain an awareness of safety procedures and learn to follow safety practices.

2. Acquire scientific knowledge appropriate to the interest, needs and aspirations of the student.

3. Be informed about the impact of science and technology on society, and explore courses of action regarding science-related issues in society.

4. Learn and apply basic scientific terminology, literacy skills, and numeracy skills.

5. Understand that a large amount of scientific knowledge is theoretical and subject to change, and is therefore the best available at the present time only.

Processes

1. Design, implement and report the results of scientific investigation.

2. Recognise and use appropriate problem solving skills.

3. Develop a creative approach to formulating and testing hypotheses, planning investigations, and presenting data.

4. Develop and express powers of critical thought, recognise the need to possess evidence before making judgements, and develop the capacity to honestly evaluate evidence that may contradict current beliefs.

5. Acquire and develop manipulative skills in using apparatus (both field and laboratory), and make measurements.

6. Develop the ability to locate, retrieve, organise, interpret and evaluate stored information.

7. Develop concepts and models that help students comprehend the natural and technological world.

8. Develop skills in social interaction by communicating, cooperating, organizing and respecting other viewpoints.

Skills

1. Manipulate laboratory and field equipment.

2. Make accurate and consistent measurements.

3. Accurately observe and describe properties and changes.

4. Accurately record results.

SECTION 2

THE PLANNING PROCESS

INDEX

HOW TO PLAN A UNIT

This section of the framework explains the steps you may go through to bring important ideas, values, issues, thinking and other skills into unit and topic planning. Assuming that you have decided the approximate content area you want covered, there are eight steps you can follow, not necessarily in any particular order. They are:

1 Select the outcomes
2 Select the important ideas
3 Select the values
4 Select the issues
5 Select the value teaching activities
6 Select the inclusion of key competencies and other skills
7 Select the types and levels of thinking
8 Select the assessment tasks

These steps are now explained in reference to planning a topic on *CELLS*. Some of the examples in each step refer to numbers which correspond with particular values, issues, teaching strategies, ideas and competencies in the lists of unit planning elements in Section 4 of this framework. Some teachers may wish to use these numbers to abbreviate the write up of their planning.

STEP 1 SELECT THE OBJECTIVES AND OUTCOMES

Having chosen your content area, use your state syllabus or curriculum profile and this framework to choose and list your objectives and outcomes. The objectives of the framework are on page 8.

Example The Topic "Cells"

- Appreciate and respect the handiwork of the Creator, demonstrated by a respect for others, themselves and the environment. (Attitudes Objective 2 p 8)
- Recognise through the study of nature the evidence for the existence of an intelligent, powerful and orderly creator. (Attitudes Objective 4 p 8)
- Investigate the genetic basis of variation in living things. (NSW Draft Consultation Science K-10 Objective 6.5)

STEP 2 SELECT THE IMPORTANT IDEAS

Think of the important ideas that may influence your topic. The Christian world view and definition of science in this framework are based on a number of such ideas about what is real, true, and good. Some of these ideas are categorised under headings such as "creation", "environment" and "ethics" on pages 24-25 in Section 4 of this framework.

Example The Topic "Cells"

- Man was created with the capacity and desire to inquire and expand knowledge (Idea 1e p 24)
- All life is a sacred gift from God (Idea 11a p 26)

STEP 3 SELECT THE VALUES

Every science topic makes reference to values. Think of some of the values that you may include or emphasise in your topic. You may briefly mention some and treat others in depth. These values can be categorised in different ways — for example aesthetic, ecological, ethical etc. See pages 25-27 for a starter list of values.

Example The Topic "Cells"

- Appreciation of nature (Value A 1 p 25)
- Awareness of detail in nature (Value A 2 p 25)
- Appreciation of design (A3 p 25)
- Following directions explicitly and willingly (Value Q 6 p 26)
- Intellectual curiosity (Value R 3 p 27)
- Cooperation with others (Value S 4 p 27)

STEP 4 SELECT THE ISSUES

Think of issues the topic may suggest. Issues are a good way of raising awareness of values because they often centre on points of tension between opposing views. Some of the most common issues relating to scientific study are listed in Section 4 pages 30-34 of the framework. Examples of this range of issues are "animal rights", "ozone layer" and "pollution".

Example The Topic "Cells"

- Destroying animals to get tissue (Issue 5 p 30)

STEP 5 SELECT THE VALUE TEACHING ACTIVITIES

It is suggested that you start to think about five aspects of teaching the valuing process — identifying values, clarifying values, making value judgments, making decisions or acting out judgments, and matching the valuing process with learning experiences.

You will also need to make decisions about what types of learning activities can allow you to pursue the valuing process. For example you might explain, draw an analogy, compare, debate an issue, role play etc. See pages 35-37 of the framework for ideas.

Example The Topic "Cells"

- Analogy — likening a model of a cell to a model of a city (Strategy 1 p 35)
- Comparing — comparing design with complexity (Strategy 6 p 35)

STEP 6 CHECK THE INCLUSION OF THE KEY COMPETENCIES AND OTHER SKILLS

Because the key competencies are important life skills, it is worthwhile to think of those competencies that we may wish to emphasise.

The seven key competencies are listed here. A fuller explanation of each competency is found in Section 4 pages 41-43.

It may also be useful to look through the list of science skills on pages 41-43 in Section 4 of the framework to review the skills you may include.

The seven key competencies are:

1. Collecting, analysing and organizing information
2. Communicating ideas and information
3. Planning and organizing activities
4. Working with others and in teams
5. Using mathematical ideas and techniques
6. Solving problems
7. Using technology

Example The Topic "Cells"

- Collecting, analysing and organising information (p 38)
- Communicating ideas and information (p 38)
- Working with others and in teams (p 39)
- Using technology (p 40)

STEP 7 SELECT LEARNING AND THINKING SKILLS

In learning science, students are also learning to think at different levels. Good teaching ensures that students are thinking at levels that include and move beyond learning facts.

There are many good schemes for describing the thinking process. It is worth remembering that thinking occurs at different levels of complexity.

A sample list of thinking skills is found in Section 4 pages 44-46.

Example The Topic "Cells"

- Extending and Refining Knowledge (See p 44)

- Comparing
- Classifying
- Deducing
- Analysing

STEP 8 ASSESSMENT

The final unit and topic planning step involves listing some ways in which some aspects of the topic may be meaningfully assessed. Some suggestions on assessing values are found on pages 45-46 of this framework. Other guidelines are found in state syllabi.

Example The Topic "Cells"

- Level of drawing cells (slow and accurate or scribbled and fast)
- Participation in discussion

BUILDING THE SUMMARY

The point of working through the eight steps is that you build a topic summary which becomes the basis for your teaching. A summary may look something like the one below.

	Topic	**Unit and Branch of Science**
	Cells	**Biology — Living Things**
1.	Outcomes	• Appreciate and respect the handiwork of the Creator, demonstrated by a respect for others, themselves and the environment. [Attitudes objective 2 p 28] • Recognise through the study of nature the evidence for the existence of an intelligent, powerful and orderly creator. [Attitudes objective 4 p 8] • Investigate the genetic basis of variation in living things. [NSW Science K-10 objective 6.5]
2.	Important ideas	• Man was created with the capacity and desire to inquire and expand knowledge [Idea 1e p 24] • All life is a sacred gift from God [Idea 11a p 26]
3.	Values taught	• Appreciation of nature [Value A 1 p 28] • Awareness of detail in nature [Value A 2 p 28] • Appreciation of design [Value A 3 p 28] • Following directions explicitly and willingly [Value Q 6 p 28] • Intellectual curiosity [Value R 3 p 29] • Cooperation with others [Value S 4 p 29]
4.	Issues taught	• Destroying animals to get tissue [Issue 5 p 30]
5.	Value teaching activities	• Analogy — likening a model of a cell to a model of a city [Strategy 1 p 35] • Comparing — comparing design with complexity [Strategy 6 p 35]
6.	Teaching competencies and other skills	• Collecting, analysing and organising information [See p 38] • Communicating ideas and information [See p 38] • Working with others and in teams [See p 39] • Using technology [See p 40]
7.	Teaching learning	• Extending and Refining Knowledge [See p 44] • Comparing • Classifying • Deducing • Analysing
8.	Assessment	• Level of drawing cells (slow and accurate or scribbled and fast) • Participation in discussion

SECTION 3

SAMPLE TOPIC PLANS

INDEX

THE GREENHOUSE EFFECT

VALUES

- Environmental sensitivity
- Integrity of industry, government
- Inventiveness in seeking solutions
- Open mindedness
- Responsibilities
- Unselfishness - balancing personal wants against global needs

ISSUES

- Acid rain
- Changing technology
- Coastal ecology
- Commercial interests
- Global warming
- Individual rights
- Press dramatisation

IMPORTANT IDEAS

- The environment is fragile due to the critical interdependence of physical and biological systems.
- The consequences of man's sin cause the degradation of the environment.
- Humans have the God-given obligation to care for and conserve the environment.
- Science is a useful tool for solving some problems.
- The application of scientific knowledge does not solve all the problems of mankind.
- All life is a sacred gift from God.

VALUE TEACHING ACTIVITIES

1. Attempt an experiment to see how the greenhouse works. For example, measure the temperature inside and outside a car or model greenhouse and account for the difference.

2. Survey car port use or use of public transport to emphasize responsible fuel use, environment sensitivity, and balancing personal and global needs.

3. Determine students' pre-conceived ideas about the issue.

4. Contact the EPA or NRMA Associations for information about the greenhouse.

5. Screen a report from Beyond 2000 etc, list the issues and values, and then discuss or debate them.

6. Get students to role play to pretend they are a radio announcer to report on the issues as they see them. They can attempt to pose solutions for some problems.

7. Have students bring information about exhaust gases from tune up specialists who analyse engines. Compare gas, diesel and petrol engines. Analyse the data and suggest ways to reduce CO_2.

8. Go on to role play the car owner told to repair a catalytic converter when he knows he keeps using the car without doing so. Also, play the roles of the engineer analyst and mechanic involved.

9. Pose a hypothetical: You are a factory manager who knows the law is outdated. Should your company be more responsible than the law? What should you do?

   Also use value analysis to weigh up the consequences of the choices made, and evaluate the values that underlie the choices.

10. Record or stage a debate between a greenie and an industrialist or a minister. Class members could also stage a debate.

TEXTS

- John 14:6
- Psalms 21:1
- Psalms 8:6
- Genesis 3:15-19
- 1 Corinthians 10:31
- Romans 1:28
- Matthew 6:25-30

ASTRONOMY

PROCESSES TO BE TAUGHT

- Observing the sky
- Describing and recording observations
- Classifying observations
- Interpreting tables, diagrams and pictures
- Communicating by spoken and written word
- Researching information – book references, videos, data bases

IMPORTANT IDEAS

- Scientific information can lead one to an appreciation of the Creator
- Our creation model is an interpretation of the observable facts and Divine revelation which answers the question of origins

CONTENT TO ACHIEVE PROCESS OBJECTIVES

Looking up! – Astronomical Observations

ATTITUDES/VALUES

- Appreciation of design, magnitude, scale, development of knowledge with increased technology, creativeness of early astronomers, scepticism to new ideas
- Open-mindedness to new theories
- A recognition of the limits of science in predicting origins
- Perseverance and tenacity log of observations

SKILLS

- Observing
- Describing
- Researching information
- Collecting information
- Summarising
- Interpreting descriptions – text, tables, diagrams and pictures
- Classifying according to criteria

ISSUES

- Space exploration: the economics of satellites and political use of (including spying) pollution, space junk, nuclear devices
- International cooperation
- The origin of the earth, solar system, matter
- Life on other planets
- Space invasion for resources

INTEGRATION

Observations beyond our immediate environment lead to the consideration of the ultimate sources of energy, matter and life. The unit provides opportunity to link scientific observation, speculation and theories to a foundation of the school's philosophy. God's creation of the worlds as revealed in Scripture is supported.

SECTION 4

PLANNING ELEMENTS

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IMPORTANT IDEAS

The world view and definition of science supported in this framework are based on a number of assumptions about what is real, what is true, and what is good. Such assumptions have been already set out in the philosophy, rationale and definition of science. Some of the important ideas which relate to these assumptions are called 'underlying premises' because of their importance. They are listed here to show how aspects of science may be linked with the most prominent ideas of the framework philosophy.

1. Creation

- God is the omnipotent, omniscient, omnipresent creator of matter and intelligence.
- Creativity is a characteristic of intelligent beings.
- Our creation model is an interpretation of the observable facts and divine revelation which attempts to answer the question of origins.
- Man was created with the capacity and desire to inquire and expand knowledge.

2. Environment

- The environment is made up of physical, biological and social interactions.
- The environment is fragile due to the critical interdependence of physical and biological systems.
- The consequences of man's sin cause the degradation of the environment.
- Humans have the God-given obligation to care for and conserve the environment.
- Since ecology is the study of the interrelationships within the environment it is a significant study for man.

3. Ethics

- God, portrayed in His Word, is the absolute standard of ethics.
- Honesty, accuracy and integrity will be displayed in the collection, interpretation and reporting of information.
- All human observations and interpretation are fallible.
- Potential sources of error and their significance will be acknowledged.
- Sometimes we must choose between apparently conflicting values, and to do this we must use our God-given powers of reason.
- The benefits of developing scientific discoveries must be weighed up against the possible social and environmental consequences of doing so.

4. Human Body

- The human body is the temple of God.
- There is value in individuality and uniqueness.
- There are God-given guidelines for good health.
- The human being is created in God's image.

5. Natural Laws

- From our observations of nature, we acknowledge our changing perception of patterns and natural law.
- Natural laws are evidence of God's orderliness.
- God is a source of awesome power and the perpetuator of natural laws. He is the sustaining force behind the maintenance of the universe.
- Miracles are instances where perceived natural laws are overridden.

6. Nature of Science

- Science is one means of understanding and manipulating the environment.
- Science is a useful tool for solving some problems.
- Scientific knowledge has limitations. These limitations are found in sensory experience, human assumptions and the ability to interpret information.
- The application of scientific knowledge does not solve all the problems of mankind.

7. Relationships

- Appreciation for the beauty, order, complexity and interdependence of creation leads us to love, reverence and honour God.
- Human relationships are based on respect for the rights and preferences of others and our responsibility to them.
- Social interaction is an aspect of learning science.

8. Safe Practices

- Safe practices are an integral part of the investigative process.
- The potential damaging effect of ignoring safe practices should be demonstrated.
- Safety practices are learnt from people in authority as well as personal experience and observation.
- Routines, forethought and alertness are essential elements of safe practice.

9. Science and Religion

- Scientific information can lead one to an appreciation of the Creator.
- Scientific information is interpreted by some as denying the existence of a loving Creator.
- In some areas of science, there is potential for conflict between observations, or some interpretation of them, and our understanding of Divine revelation. These areas need sensitive treatment.
- Although science is studied by using the senses, Christians allow the possibility that unknown laws and relationships, extra sensory events and the supernatural are also part of reality.
- Christians need to be open minded about issues for which there are alternative explanations which seem plausible.

10. Sources of Knowledge

- God is the source of all true knowledge.
- Divine revelation is the vehicle for communicating some true knowledge to man.
- Accepting the discoveries of others is a way of gaining knowledge.
- Individual independent research is a way of exploring knowledge.
- The observation of nature is a source of knowledge.
- The scientific method is a procedure for the effective investigation of the physical and biological world, but it is inappropriate to apply this method to events that cannot be replicated or which exist outside the physical world.
- Reliability, validity and relevance to our objectives are important considerations in determining the value and use of knowledge.

11. Value of Life

- All life is a sacred gift from God.
- Each person is of inestimable value to God.
- Because of its great worth, life is to guarded and maintained as long as possible.
- Because only God can give life, humans need to guard the life they have.

12. The Reporting of Research

- Part of Christians' mission is to share their scientific perspectives with others.
- When investigating, we should be prepared to share our results for the benefit of others.

BIBLICAL REFERENCES FOR IMPORTANT IDEAS

The following list of Biblical references is provided to give more information about some of the values listed in this framework. **The list is not exhaustive,** and can be added to in future. It is intended that teachers refer to the list to increase their consciousness of the possible place of Scripture in their subject content.

Creation:

Genesis 1	• In the beginning God created
Isaiah 45:18	• God has made the earth
Psalm 33:6-9	• By word of God everything was made
Isaiah 45:12	• God formed earth to be inhabited
John 1:1	• Jesus of New Testament is the Creator God

The Environment:

God's Ownership:

Psalm 24:1	• Earth is the Lord's and the fullness thereof
Genesis 9:11-16	• God has made a covenant that the earth will not again by destroyed by water

Man's Dominion:

Genesis 1:26	• Man made by God to have dominion over fish, fowl of air, cattle and over all the earth
Genesis 1:28	• Be fruitful and multiply, replenish the earth, and subdue it; and have dominion
Psalm 8:6	• Man made to have dominion
Genesis 3:15-19	• Because of sin the quality of life changed for the worse
Genesis 6-9	• World-wide flood brought further deterioration to the quality of life for man and the extent of his dominion

Ethics:

Isaiah 43:11-15	• God is; there is none equal
Isaiah 45:5-8	• None beside God
John 3:16	• God loved the world and valued the people in it
2 Corinthians 13:7	• Do that which is honest
Hebrews 13:18	• In all things be willing to live honestly
Joshua 24:15	• Choice is offered to all
Romans 14:12	• All are accountable to God
Psalm 8:3-6	• Man is inferior to God and the angels, yet he is of value in God's sight
Jeremiah 10:2	• Learn not the way of the heathen

Human Body:

Psalm 139:14	• We are fearfully and wonderfully made
1 Corinthians 6:19, 20	• Body belongs to God and we are responsible to God for what we do
1 Corinthians 10:31	• Whatever we eat or drink or do it is to be done to the glory of God

Natural Laws:

Psalm 19	• Nature reveals God's ways and His laws
Revelation 19:1	• Glory, honour, and power belong to God
Nahum 1:3	• God is great in power

Sources of Knowledge:

Colossians 2:3	• In God we find all the treasures of wisdom and knowledge
1 Samuel 2:3	• The Lord is the God of knowledge
2 Chronicles 1:10	• Wisdom and knowledge are a gift of God to man
Job 37:16	• God is perfect in knowledge
Proverbs 2:6	• Knowledge and understanding come from God
Proverbs 1:7	• The fear of the Lord is the beginning of knowledge
Psalm 19:1	• Natural world reveals the knowledge of God
Romans 1:28	• Leaving God out of our knowledge leads to confusion and error
Job 38	• God challenges the mind by asking us to consider the natural world
Luke 24:25-31	• Questioning and reasoning are the preferred processes to establish knowledge rather than miracles
Ecclesiastes 1 & 2	• Seeking out, observing, experiencing, proving, and contemplating are all desirable forms of attaining knowledge
1 Thessalonians 5:21	• Prove all things, accept and hold to that which is good

Value of Life:

John 8:1-11	• Even those despised by others are of value to God
Matthew 6:25-30	• Man's value is greater than that of animals and plant life

CATEGORISED VALUES

EXAMPLES OF VALUES GROUPED ACCORDING TO TYPES OF VALUE JUDGMENTS MADE IN SCIENCE

An important part of teaching science is to develop worthwhile scientific attitudes and values. The list is set out below to remind teachers of how important attitudes and values can be emphasised continually, both in formal teaching, and when interacting with students.

Aesthetic

A1 Appreciation of nature
A2 Awareness of detail in nature
A3 Appreciation of design

Ecological

E1 Environmental sensitivity
E2 Conservation of materials and environmental resources
E3 Stewardship: the disposition to preserve and account for natural resources including animals
E4 Sensitivity to the needs of living things
E5 Enjoyment of nature as a leisure source
E6 Compassion for wildlife

Moral/Ethical

M1 Work ethic: the value of getting things done
M2 Truth: disposition to seek truth
M3 Responsibility for one's own actions
M4 Respect for authority
M5 Awareness of consequences of values and procedures
M6 Responsibilities for conclusions and reporting
M6 Honesty and integrity in carrying out and reporting experimental work

Faith (belief and trust in God)

F1 Self-worth: positive assessment of self as part of creation
F2 Giving glory to God by the development of one's abilities
F3 Belief in God's Word in the face of apparently contradictory conclusions
F4 Confidence in the reliability of God

Health and Personal Development

H1 Balance: appreciation of the need for balance between activity and rest
H2 Safety awareness for procedures and issues

Management

Resource use/economic

M1 time
M3 Work ethic: the value of getting things done
M4 Time awareness: appreciation of time as a limited resource
M5 Punctuality

Organisation

M6 Orderliness in practical and theoretical work

Quality of Scientific Procedure

Q1 Unselfishness in sharing findings
Q2 Self-criticism and a willingness to evaluate and be evaluated by others
Q3 Rationality in thinking
Q4 Logic in thinking
Q5 Following directions explicitly and willingly
Q6 Appreciation that most issues and problems can be approached from a variety of perspectives
Q7 Scepticism of unsupported research
Q8 Tenacity in problem solving
Q9 Tentativeness about the nature of theories
Q10 Tolerance of competing ideas and theories
Q11 Willingness to predict, speculate and take 'intellectual risks'
Q12 Reliability of assertions
Q13 Orderliness in practical and theoretical work
Q14 Enthusiasm for science and science-related interests
Q15 Creativity in problem solving
Q16 Discrimination between data sets
Q17 Informed and healthy scepticism based on recognition of the limitations of science. This would include the capacity to resist claims unsupported by evidence or theory
Q18 Accuracy in calculations and thought
Q19 Acceptance of scientific inquiry as a legitimate way of thinking about issues and problems
Q20 Perseverance and tenacity in the face of difficulties

Social

S1 Unselfishness in sharing findings
S2 Tolerance and respect for others' views, rights, needs and opinions
S3 Respect for authority
S4 Cooperation with others, consisting of carrying out tasks together and a willingness to pool data and ideas
S5 Courage: standing for one's convictions in relation to social and environmental issues
S6 Empathy with others
S7 Appreciation of the role of science and technology in shaping society and in enhancing the quality of life derived from the increased range and availability of consumer goods

Readiness to learn

R1 Self-motivation in pursuing knowledge
R2 Acceptance of responsibility for one's own learning
R3 Intellectual curiosity, curiosity about the world
R4 Independence of thought, self-confidence and self-respect
R5 Sense of adventure: disposition to attempt new and challenging things
R6 Open-mindedness: willingness to change one's mind in the light of new evidence; willingness to suspend judgement if there is insufficient evidence
R7 Inventiveness in seeking solutions

ISSUES IN SCIENCE

In science we continually focus on issues which affect our lives. Some of the most common issues relating to scientific study are listed below. As you consult this list before teaching units of work, you may save time and enable yourself to think of related issues and resources that go with them.

Animal Rights:

1. Pharmaceuticals
2. Physiology and biochemistry research
3. Pesticides
4. Vivisection
5. Manipulation of animals - caging of birds, reptiles, amphibians, mammals, fish
6. Extinction of species
7. Conservation of animals - national parks

Biotechnology:

8. Genetic engineering
9. Genetic counselling
10. Tissue culture
11. Use of hormones - growth hormones
12. Use of antibiotics

Changing technology and employment:

13. Labour saving machinery replacing human labour - robotization
14. Artificial intelligence

Conservation expenditure:

15. Wetlands
16. Rainforests
17. Mangroves

Drugs:

18. Use and abuse
19. Socially acceptable
20. Costs - economic and health
21. Legal

Effective use of resources:

22. Mining, mining ocean, Antarctica, moon
23. Mining wastes
24. Finite nature of resources

Electrical Supply:

25. Effects of EMR from power lines, computer screens, fluorescent lights
26. Interference of machines in power supply.

Engines:

27. Orbital engine - place of manufacture
28. Superconductors

Epidemiology:

29. AIDS
30. Hepatitis B
31. Ross River Fever
32. Malaria
33. Dysentery

Finite carrying capacity of earth:

34. Population density.
35. Food supplies.
36. Birth control

Flood Model of Creation - Evolution:

37. Speciation
38. Geological column
39. Age of earth
40. Fossil gaps
41. Rates of change
42. Continental drift
43. Sceptics' society

Food additives:

44. Effects
45. Preservatives
46. Synthetic food - square eggs

Fuels - energy sources:

47. Renewable or alternative
48. Non-renewable or fossil
49. Nuclear
50. Waste disposal
51. Irradiation of food - medical, laboratory research
52. Research

53. Alternative energy resources - wind, wave, and solar
54. Politics of changing from fossil fuels

Geological Catastrophe:

55. Earthquakes
56. Volcanic eruptions
57. Tidal waves

Greenhouse Effect:

58. Global warming
59. Ice cap melting
60. Press dramatisation
61. Means of bringing world unity
62. Different hopes of different countries

Life - Preservation of:

63. Euthanasia
64. Improving the quality if life
65. Transplants
66. Cryogenics

Lifestyle - Diet/health/fitness:

67. Costs to industry
68. Diseases
69. Junk food
70. Vitamins
71. Cost to community
72. Personal costs

Ozone Layer:

73. Ozone depletion
74. Skin cancer
75. Cfc's
76. Nitrogen oxides

Plastics:

77. Production from fossil fuel
78. Disposal
79. The use of oil for plastics or petrol
80. The problems of degradable or biodegradable plastics
81. LPG burnt off at refinery - waste

Politics, Industry and Science:

82. Industry laws
83. Government monitoring and regulation
84. Rights of protest - MFP land grab in Brisbane
85. Waste laws
86. Mutual interdependence of government and industry
87. Rate of law change
88. Commonwealth versus state laws
89. Problems of reporting discoveries eg cold fusion

Pollution:

90. Atmosphere
91. Waterways
92. Rubbish disposal
93. Pesticides
94. Fertilizers
95. Herbicides
96. Noise - industry - industrial deafness
97. Moral pollution - effects of television

Recycling - resource management:

98. Organic garbage
99. Glass
100. Paper
101. Metals
102. Plastic
103. Keeping recycled materials high in cost

Reproductive Technology Issues:

104. Abortion
105. IVF
106. Surrogacy
107. Cloning
108. Narrowing of genetic base of food crops
109. Embryo experimentation
110. Genetic counselling
111. Sex determination
112. New reproductive technologies
113. Genetic engineering
114. Contraception
115. Gene splicing
116. Ownership of embryos

Resource Usage - Economics and Science:

117. Helping AIDS victims versus joint replacement
118. Choosing patients to help
119. Waiting lists for major operations

Retaining Scientists:

120. Brain drain

River control:

121. Flood mitigation
122. Damming

Road Toll:

123. Speed
124. Accidents
125. Alcohol
126. Seat belts and child restraints
127. Cost of medical work
128. Road costs versus medical research
129. Investigation costs

Siting of industries:

130. Waste disposal
131. Environmental concerns

Soil Conservation:

132. Salination
133. Economic loss - loss of topsoil
134. Extraction of ground water

Space exploration:

135. Economics
136. Space junk
137. Nuclear devises in space - power plants of satellites
138. Spying
139. Satellites
140. Supersonic travel
141. Giving high technology to political rivals

Warfare:

142. Chemical weapons
143. Biological weapons
144. Nuclear weapons

STRATEGIES FOR TEACHING VALUING

This section of the framework briefly outlines some types of possible teacher tactics for introducing and emphasizing values.

1. Analogies

An example is titration, where one drop makes a very large change in colour.

2. Analysing Values

For example, we may look at the alternatives for fossil fuels. Look at long range consequences such as cost, and support industries.

3. Application of Values

This tactic involves putting values into action. An example would be conserving power in the home.

4. Building Support for a Position

For this tactic, we would show how to support a case both for and against a position. For example, we would support a case for a universal flood by building up arguments.

5. Classroom Organisation and Procedures

We can teach values such as orderliness, organisation, attention to detail, and good preparation by insisting on them in day to day classroom organisation.

6. Comparing and Contrasting

We can draw out values by comparing opposing views on topics such as creationism. We can also contrast values such as scientific logic and personal bias.

7. Debate

By debating issues such as loggers versus greenies in rainforests, we can draw out a range of values.

8. Demonstration

We are constantly demonstrating values in the classroom. For example, we may demonstrate safe procedures with acids and bases.

9. Experiments

Scientific experiments can show values such as safety, accuracy, inventiveness, and creativity of design.

10. Explanation

We often have a duty to explain why we hold value positions, or why values are important to students. For example, we would explain why smoking is dangerous.

11. Field Experience

Field experiences such as biology excursions can highlight values such as duty, compassion for animals, and the place of nature in leisure.

12. Hypotheticals

We may pose hypothetical problems for students to solve. Examples are case studies about abortion or euthanasia.

13. Identifying Values

We should take opportunities to identify values in many topics we cover. For example, when talking about the ozone layer, we might identify scientific responsibility.

14. Media Stimulus

We can use media such as, news items, Quantum, and Towards 2000 programs, to raise issues and weigh them up.

15. Modelling

The teacher constantly models values such as enthusiasm, care in procedures and an attitude that science is God's book in nature.

16. Narration

We can use narration to identify and support many values. Examples of narration are sketches of the lives of Galileo, Newton and Keppler.

17. Problem Solving

We can help students weigh up values by asking them what to do next in problem situations. An example of this approach is the ABC program entitled, 'What Do We Do Next?'

18. Projects

Projects on environmental and social issues, such as the greenhouse effect and AIDS, can include a valuing component.

19. Questioning and Clarifying

We are constantly questioning students to help them identify and clarify their values. For example, we ask leading questions so that students formulate values for themselves.

20. Raising Issues

We may, for example, raise issues about animal rights to have students explore the tensions between competing values. The gains of research may involve some cruelty to animals.

21. Role Plays

When students act out roles they are forced to think about the values the role represents. For example, we could have a student act out the role of a manager of a cement company who chooses to destroy bat caves.

22. Simulation

Simulation forces students to cast themselves in life-like problem situations. For example, a student can be asked to make out he is operating a nuclear reactor, and in the process, making decisions about its use.

23. Visiting Speakers

Visiting speakers present value positions on many topics. For example, a greenie may talk on mining in Kakadu.

24. Work Experience

Students learn value by visiting work sites. For example, a visit to a museum or a pathology laboratory may illustrate numerous values in action.

THE VALUING PROCESS

1 Identify values

We may use opportunities to identify some of the values present in most learning experiences. We may do things such as:

- Take stock of what we are doing — the point of our task, the reason for a viewpoint, the value behind a reason we give etc
- Identify some of the key values in the text or learning situation
- Identify values that are unstated or assumed

2 Clarify Values

Our attempts to make good value judgments depend on the clarity of our thinking about our values. Clarifying pushes us beyond simply identifying values to:

- Question the meaning of values
- Identify criteria for choices we make.
- Name consequences of our choices
- Clarify the meaning of values or the criteria used in our judgments of worth
- Ask why others make their judgments
- Think about the type of values involved in the situation — ethical, aesthetic, quality of science etc

3 Make Value Judgments

The heart of the valuing process is making the actual judgment. When making judgments we may use many mental processes. Making judgments may lead us to :

- Evaluate the quality of decisions and choices made by others
- Evaluate criteria used in making choices — quality of reasons, quality of the authority we rely on, the type of standard etc
- Rank a set of values in a priority order
- Give sufficient reasons or weight of evidence for a judgment

4 Make Choices or Decisions to Act

Our judgments lead to choices, decisions, commitment, action, or lack of action. Our choice based on our judgment may cause us to:

- Decide on a course of action
- Change or continue a procedure
- Make commitments
- Choose an alternative
- Make a plan, state goals

TEACHING THE KEY COMPETENCIES

The teaching and learning of science develops all the key competencies. However some competencies receive more attention than others.

Students spend a good deal of time solving problems, collecting, analysing and organising information, communicating ideas, and using mathematical ideas and various forms of technology .

The seven key competencies are listed below, then briefly described:

1. Collecting, analysing and organizing information
2. Communicating ideas and information
3. Planning and organizing activities
4. Working with others and in teams
5. Using mathematical ideas and techniques
6. Solving problems
7. Using technology

Collecting, Analysing and Organising Information

This competency focuses on the **locating and processing of information**. Information can be in the form of writing, statistics, graphs, charts, tables, problems etc. Processing information includes the capacity to do the following:

- locate information
- sift and sort information
- select what information is required
- present information in a useful way
- evaluate information
- evaluate the sources and methods of obtaining information

Communicating Ideas and Information

This competency involves the capacity to **effectively use a range of types of communication**, including spoken, written, graphic and non-verbal expression. It includes the capacity to do the following:

- identify different audiences and purposes of communication and respond to these appropriately
- identify and use a range of forms and styles of communication to suit its purposes (eg speak to school visitors, write an accident report, sketch a seating plan)
- identify, use and adapt conventions appropriate to the mode of communication (eg apply rules of grammar when needed in writing, know how to modulate the voice when speaking dramatically, know how to place a diagram in a report)
- organise ideas and information so that meaning is communicated clearly
- revise and adapt communication in response to feedback

Planning and Organising Activities

This competency focuses on the ability to **plan, organise and manage one's own time and resources**. It includes the capacity to do the following:

- plan one's own work activities
- organise one's own work activities
- make good use of time and resources
- sort out priorities
- monitor one's own performance

Working With Others and in Teams

This competency focuses on **working with others**. It includes the capacity to:

- interact effectively with other people on a one to one basis (eg listen carefully, show trust, keep agreements, communicate)
- interact effectively with other people in groups (eg collaborate and cooperate, and recognise the value and contributions of others)
- understand and respond to the needs of a client (eg use questioning, listening and negotiation skills and make responses which meet mutual expectations)
- work effectively as a team member to achieve a shared goal (eg negotiate, be responsible, work towards agreed goals, give constructive feedback to the group)

Using Mathematical Ideas

This competency focuses on **using mathematical ideas and techniques for practical purposes**. It includes the capacity to:

- clarify the purposes and objectives of the activity or task (ie so that we can then identify the most appropriate mathematical ideas and techniques to use)
- select appropriate mathematical ideas and techniques for our purposes
- apply mathematical procedures and techniques with precision and accuracy
- judge levels of precision and accuracy appropriate to the situation
- interpret and explain a solution for given context, and evaluate the effectiveness and efficiency of the methods used

Solving Problems

This competency focuses on **problem solving strategies**. It includes the capacity to do the following:

- apply problem solving strategies where the solution is clearly evident
- analyse problems by identifying their similarities with previous learning
- display confidence in problem solving
- apply critical thinking and a creative approach to solving problems by doing the following:
- clarify the problem by identifying all of its relevant aspects
- apply chosen strategies and adapt them where necessary to achieve the desired outcomes
- explore possible solutions
- evaluate the effectiveness of the strategies chosen to solve the problem

Using Technology

This competency focuses on **using technology by combining physical and sensory skills** (needed to operate equipment) **with the understanding of scientific and technological principles** (needed to explore and adapt systems). It includes the capacity to do the following:

- clarify and define the purposes and objectives for the use of technology in a situation
- assess the function and suitability of materials, equipment and processes for a given task
- select and use systems, techniques, equipment and materials to achieve desired outcomes
- use equipment, materials and processes safely, with regard for safety, the rights of others, and social and environmental implications
- select or adapt equipment, materials and procedures to optimise the use of existing resources and account for the capacity of the people involved
- design, create, or hypothesise about possible technological solutions

SOME SCIENCE SKILLS

This list contains science skills which could be assessed in a written test. It is by no means finite. You may be able to add more science skills to this list as you use it.

SKILLS RELATED TO THE LABORATORY

- Identify basic laboratory apparatus
- Select the most suitable item of equipment for a stated task
- Identify hazards in the laboratory
- Suggest means to maximise safety and minimise anticipated hazards

SKILLS RELATED TO OBSERVING

- Make qualitative observations of an object or situation
- Make quantitative observations of an object or situation
- Make observations which describe change
- Make observations in correct sequence
- Discriminate between relevant and irrelevant observations
- Identify similarities and differences
- Recognise limitations of making observations unaided by mechanical devices
- Record observations accurately
- State sources of error in observation
- Explain sources of error in observations
- Explain inconsistent observations
- Repeat observations to check accuracy

SKILLS RELATED TO INFERRING

- Make inferences about an object or situation
- Distinguish between an observation and an inference
- Identify observations that support an inference
- Suggest additional observations that could support or disprove an inference
- Make logical inferences from data presented in tables or graphical form

SKILLS RELATED TO MEASURING

- Select appropriate instrument required to make a measurement
- Accurately read linear, curved or circular scales
- Compare accuracy of various instruments used for similar purposes
- Estimate readings which fall between scale divisions
- Use appropriate metric unit when recording measurements
- Convert between various metric units
- Identify sources of errors in measurements
- Record measurements at an appropriately significant level

SKILLS RELATED TO CLASSIFYING

- objects according to a predetermined set of properties
- Identify the basis on which a set of items has been grouped
- Use a classification key to identify an object (keys can be branching, dichotomous or circular)

SKILLS RELATED TO TRANSPOSING INFORMATION

- Identify the most appropriate form to present information
- Draw a diagram from a written description
- Write a description of information contained in diagrammatic, pictorial or symbolic form
- Draw a flow chart or map from written information
- Graph information presented in table or written form
- Construct a table from information presented in graphical or written form

SKILLS RELATED TO INTERPRETING DIAGRAMS

- Use title, subtitles and/or labels to extract information presented in diagram form
- Use the key to interpret symbols used in diagrams
- Identify the relationships, steps, cycles or sequence of events from diagrams
- Relate information in diagram to any accompanying prose

SKILLS RELATED TO READING MAPS

- Locate and identify compass direction displayed on a map
- Locate and interpret symbols used in a key or legend on a map
- Locate, identify and use the scale on a map
- Use grid marks (co-ordinates) on a map
- Extract information from a weather map
- Extract information from a geological map

SKILLS RELATED TO READING TABLES AND GRAPHS

- Use the title, subtitle and/or keys to interpret information in tables
- Locate and extract specific information from tables
- Use the title, subtitle, labels and/or key to interpret information in line, column or pie graphs
- Locate and extract specific information from graphs
- Compare and contrast different quantities plotted on the same grid
- Recognise trends in graphed data

CONSTRUCTING TABLES AND DRAWING GRAPHS SKILLS

- Construct appropriate cell grid for entering data
- Devise appropriate headings of columns and/or rows
- Record data in correct cell grid
- Write an appropriate heading for a table
- Recognise dependant and independent variable
- Select and label axes
- Choose a suitable scale for each axis
- Plot points
- Draw a line or curve of best fit when appropriate
- Connect plotted points with a straight line when appropriate

SKILLS RELATED TO MAKING PREDICTIONS

- Recognise patterns and trends in data
- Predict outcomes from observations of patterns or trends in data
- Interpolate information from a graph
- Extrapolate information on a graph
- Predict the consequences of changing the variables in an experiment

SKILLS RELATED TO DESIGNING AN EXPERIMENT

- Define the purpose of the experiment
- Construct a hypothesis
- State any relevant assumptions underlying the hypothesis
- Define clearly what is to be measured or observed
- Identify variables which can/cannot be controlled
- Plan adequate control of variables
- Select equipment required and plan procedure
- Suggest appropriate means to collect, record and analyse observations or measurements
- Plan repeated trials when necessary
- Recognise that variables can only be investigated once at a time

ANALYSING RESULTS AND MAKING CONCLUSIONS SKILLS

- Use simple mathematics to re-organise quantitative information eg averaging
- Recognise when data supports hypothesis or not
- Recognise trends and relationships in data
- Recognise consistencies and contradictions in data
- Make tentative conclusions on the basis on simple observations
- Make correct conclusions on the basis of multiple observation
- Identify observations that support a conclusion
- Make generalisations from analysed data
- Solve problems which require the drawings of tangents to curves in order to determine gradients
- Solve problems which involve the use of the area under a curve

SKILLS RELATED TO EVALUATING AND APPLYING

- Evaluate conclusions
- Evaluate experiments in terms of stated purpose
- Recognise interpretations which are over generalisations
- Identify criteria when making judgement
- Judge the validity of interpretations of data
- Evaluate solutions to problems in terms of outcomes which might affect individuals or groups
- Distinguish between evidence, hypothesis and opinion
- Modify hypothesis in the light of non-supporting observations
- Apply the results of an experiment to make inferences about another situation
- Apply the information with a map to make reasonable and consistent conclusions
- Use models to explain phenomena

SKILLS RELATED TO CRITICAL THINKING

- Formulate cause-effect relationships
- Recognise ambiguity
- Give reasons
- Defend a point of view
- Use analogies
- Suspend judgement in the absence of evidence
- Make appropriate decisions based on the results of experiments
- Accept a ‘no conclusion’ result if evidence in inconclusive
- Apply a critical approach to all thinking tasks
- Disclaim the validity of non-scientific and pseudo-scientific arguments

SKILLS RELATED TO PROBLEM-SOLVING

- Use a ‘scientific approach’ to problem solving
- Identify parts of the scientific method
- Isolate the single major idea of a problem
- State problems as a definite, concise questions
- Recognise the difficulty in clearly defining some problems
- State sub-problems or hypothesis related to the main problem
- Categorise the nature of the problem (moral, political, social or scientific etc)
- Distinguish between problems which can and cannot be solved by science
- Identify the relevant variables in a problem
- State methods of collecting evidence on problems (direct observation, interviewing, research, experimenting)
- Recognise causes of problems eg new technology
- Apply existing knowledge in formulating possible solutions to the problems
- Make recommendations as to the best solution to a problem

TEACHING HOW TO LEARN

A Summary of the Dimensions of Learning by Robert Marzano

The following summary overviews one attempt to help teaching reflect the best of current knowledge about the learning process. The model of instruction on which it is based assumes that the process of learning involves the interaction of five types of thinking, called here the dimensions of learning.

The dimensions of learning are loose metaphors for how the mind works during learning. Because learning is complex, these processes are not indpendent, but interact to help bring about learning. Metaphors are useful because they open our eyes to new ways of seeing and prompt us to explore new options in teaching.

Dimension 1 Positive Attitudes and Perceptions about Learning

- Positive attitudes about the learning climate
  - -Acceptance by teacher and other students
  - -Physical comfort
  - -Order — perception of safety in the learning process
- Positive attitudes about tasks
  - -Task value
  - -Task clarity
  - -Sufficient learning resources

Dimension 2 Acquiring and Integrating Knowledge

- Declarative knowledge — understanding content such as concepts, facts, rules, values, component parts
  - -Constructing meaning through:
    - Prior learning
    - Forming concepts through examples and non examples
  - -Organising knowledge through:
    - Using physical and symbolic representations
    - Using organisational patterns
      - Descriptive patterns
      - Sequence patterns
      - Process/Cause patterns
      - Problem/Solution patterns
      - Generalisation patterns
      - Concept patterns
    - Using graphic organisers
  - -Storing declarative knowledge by:
    - Elaboration — making varied linkages between the old and the new by imagining pictures, sensations and emotions, by linking images in story fashion, and by verbal rehearsal
- Procedural knowledge — skills and processes important to a content area
  - -Constructing procedural models
    - Providing students with an analogy
    - Think aloud models
    - Flow chart models
  - -Shaping procedural knowledge — students alter the original model in learning it
    - Guided practice
  - -Internalising procedural knowledge
    - Practice to the point of performing the procedure with ease
    - Speed and accuracy goals

Dimension 3 Extending and Refining Knowledge

- Comparing: Identifying and articulating similarities and differences between things.
  - How are these things alike, different? What characteristics are alike, different?

- Classifying: Grouping things into definable categories on the basis of their attributes.
  - Into what groups could you organise these things? Defining characteristics?

- Inducing: Inferring unknown generalisations or principles from observation or analysis.
  - Based on these facts, what can you conclude? How likely is it that....will occur?

- Deducing: Inferring using unstated consequences and conditions from given principles and generalisations.
  - Based on the rule or principle, what predictions/conclusions can you make/draw?

- Analysing errors: Identifying and articulating errors in your own or others' thinking.
  - What are the errors, how is it misleading, how could it be improved?

- Constructing support: Constructing a system of support or proof for an assertion.
  - What is an argument that would support the claim? Limitations of the argument?

- Abstracting: Identifying and articulating the underlying theme or general pattern of information.
  - What is the general pattern? To what other situations does the pattern apply?

- Analysing perspectives: Identifying and articulating personal perspectives about issues.
  - Why would you consider this to be good/bad? What is your reasoning? What is an alternative perspective and what is the reasoning behind it?

Dimension 4 Using Knowledge Meaningfully

Look for the *big issues* that stand out in these processes.

- Decision making: The process of answering such questions as "What is the best way to ?
  - Is there an unresolved issue about who or what is best? About who or what has the most or least?

- Investigation: Definitional — What are the defining characteristics? Projective — What would happen if? Historical — How did this happen?
  - Is there an unresolved issue about the defining features, about how or why something happened, or about what would happen if?

- Experimental inquiry: The process we engage in when answering such questions as "How can I explain this?" and "Based on my explanation, what can I predict?"
  - Is there an unexplained phenomenon for which students could generate explanations that could be tested?

- Problem solving: Answers questions such as "How will I overcome this obstacle?" or "How will I reach my goal but still meet these conditions?"
  - Is there a situation or process that has some major constraint or limiting condition?

- Invention: The process of creating something that fills an unmet need or desire.
  - Is there a situation that can or should be improved on? Something that should be created?

Dimension 5 Productive Habits of Mind

- Self-regulated thinking and learning
  - Being aware of your own thinking
  - Planning
  - Being aware of necessary resources
  - Being sensitive to feedback
  - Evaluating the effectiveness of your actions
- Critical thinking and learning
  - Being accurate and seeking accuracy
  - Being clear and seeking clarity
  - Being open-minded
  - Resisting impulsivity
  - Taking and defending a position
  - Being sensitive to others
- Creative thinking and learning
  - Engaging intensely in tasks even when answers or solutions are not immediately apparent
  - Pushing the limits of your knowledge and ability
  - Generating, trusting, and maintaining your own standards of evaluation
  - Generating new ways of viewing situations outside the boundaries of standard convention
- Personal goals are powerful motivators
- Structured academic problems — like those met in maths, science and logic
- Socratic dialogue and debate — five types of questions to develop thinking
  - Questions of clarification
  - Questions that probe assumptions
  - Questions that probe reasons and give evidence
  - Questions about viewpoints and perspectives
  - Questions that probe implications and consequences

(Marzano, R. 1992. A Different Kind of Classroom. Alexandria. ASCD.)

ASSESSMENT

What is Assessment?

Assessment in science refers to any method teachers use to measure the performance of students in relation to the objectives of the science course.

Assessing Attitudes and Values

What are the advantages of assessing attitudes?

- Students are more likely to think that attitudes are important if they are assessed in some way.
- It provides evaluation information on different ways appropriate attitudes can be fostered amongst students in particular learning activities.
- It allows teachers to determine whether attitudes are being established.

What are the problems associated with assessing attitudes?

- Some people have ethical objections to assessing attitudes, such as:
    - Establishment of objective criteria and applying them without subjectivity;
    - Attempting judgements of students which may be subjective.

- Some students reveal their attitudes more readily than others. Quiet steady workers may have excellent attitudes, but they are rarely exposed.
- If students are aware that attitudes are being assessed in a particular session, they can easily adopt the desired attitude.
- Attitudes cannot be easily quantified, and there are educational objections to including them in a students' global mark.
- The time required to assess attitudes.

How can attitudes be assessed?

- First students need to be aware of what the desirable attitudes are, and why they are important.
- It is important to look for changes in attitudes if students attitudes are different to the intended ones early in the year.
- Assessment of attitudes needs to be primarily based on observation of students over the whole of the course, not just on isolated incidents.
- Observation of students' attitudes needs to occur in contexts where students are likely to display their attitudes, eg field trips, practicals, projects, discussions and seminars, and records kept by using rating scales and/or criteria listings.
- Observations of students' attitudes can be done by:
    - Teacher assessment - the standard method.
    - Self-assessment - here students assess themselves. Students can be surprisingly honest and perceptive about their own attitudes.
    - Peer assessment - here a student is assessed by his/her peers. This can bring out some revealing insights that may not have been apparent to the teachers. However, care must be taken here.

- Besides observations, students attitudes can be assessed by completion of questionnaires or by the expressing of their opinions in essays, eg Do we mine in the Antarctic?

How can students' attitudes be recognised and reported?

- Mark - Attitudes could be given a weighting when compiling the over all course mark (eg 10% or less). This could be as a part of a test or not.
- Profiles - A listing of desired attitudes could be listed and then either:

    - Indicate on a check list those which are observed (based on reflection or impressions over the term, or accumulated check lists);
    - Report only those observed (based on reflection or impressions over the term, or accumulated check lists);
    - Use a four or five point rating scale (based on reflection over whole term).

- Descriptive statements - Assessments could be referred to when completing reports or testimonials.