E411 SENIOR SCIENCE (YEAR 12) – 2008 - 2009

Rationale

All students in the final years of secondary education should have access to an appropriate form of science education. Science and technology are playing an increasing role in our society: space technology, lasers, communications technology and genetic engineering are but a few of the science-related areas which have changed, or will change, our society and the way we live. In a democratic society, it is increasingly important that more people take part in decision-making processes. Consequently it is essential that people be better informed about science and technology, and the impact of these on society. There is, therefore, a need for a science subject which provides some 'real world' problem-solving and 'survival skills' for those students about to leave school but for whom further formal science studies are unlikely. Senior Science (E411) caters for the interests, abilities and needs of those students. At the same time, this subject must cater for students who will continue in science-related subjects with a less traditional, more vocational orientation.

The development of the process skills of science and the engendering of appropriate scientific attitudes in students are major objectives of this subject but, of course, science content is obviously important and cannot be neglected. The major objectives of the Senior Science subject are to develop the process skills of science and engender appropriate scientific attitudes in students. The content should be chosen to suit the development of both process skills and attitudes as well as the needs, interests and abilities of the students and the opportunities offered by the environment (physical, social and cultural) of the school.

This subject takes the broadest possible view of science. Some of the areas covered may not be treated at all in more traditional school science subjects. In all cases, however, the scientific processes are as important as the content. The final decision on the balance between content and process will rest with the teacher. The following guidelines are offered to assist teachers in making these decisions.

Subject Design

This subject stipulates nine outcomes which describe the things that students are able to do as a result of studying Senior Science. The achievement of these outcomes can be assessed using the common assessment framework described below.

The subject content, the means by which the outcomes are achieved, is specified only in so far as the content should incorporate a fair sampling of the physical, biological, earth and environmental fields of science.

Within this general framework, teachers are free to choose the content and learning experiences that best suit the needs of their students and the resources available to satisfy those needs. As this subject aims to show science in the context of society as a whole, the community and the local environment should be considered as part of the learning environment. The Senior Science program should attempt to bridge the gap between the classroom and daily life. The use of the community as an extension of the school environment makes science more relevant to students.

For example, students may use their work experience in a science-related technology, business or firm to show achievement of some Senior Science outcomes. The work experience should, however, be chosen so as to satisfy the aims of Senior Science (E411).

Much of the content of Senior Science will cross traditional barriers of science to emphasise 'real world' problems connected with human and social interaction. Many topics could be drawn from the applied and/or social sciences. It is the application of science as a process and the development of positive attitudes that are important.

However, while the development of process skills is a major aim of this subject, students must also be able to show some degree of competence with regard to knowledge and understanding in the range of content areas studied.

In designing a suitable Senior Science program, teachers can adopt one of two broad approaches:

- **Thematic approach**

  Teachers select content to support a particular theme or series of themes. This approach enables teachers to develop a more detailed program within a particular field of science.

  Marine studies, science and technology, horticulture, environmental studies and food science could provide the focus for a Senior Science program. Vocationally oriented programs may develop under the thematic umbrella also, with areas of study within the theme representing an appropriate *balance* of physical, biological, environmental and earth science components.

- **Topic approach**

  Teachers may develop topics based on student interest or local needs or opportunities or choose from the topics listed in the Senior Science support document.

  Usually a minimum of four topics is studied and assessed. There is one criterion with respect to the choice of topics which is mandatory: it concerns the issue of *balance*. Teachers must ensure that the program they develop represents a fair sampling of the major fields of the disciplines:

  - biological science
  - physical science
  - environmental/earth sciences.

Teachers will be expected to be able to demonstrate that an appropriate balance of content from the above fields exists in their program. The topics studied in the first year of the subject may not be studied again in the second year of the subject. Teachers may use topics of their own devising provided the criterion concerning the balance of area of scientific content is maintained. Where possible, teachers should ensure that their students are involved in the choice of topic for study.

Finally, it is an overarching goal of this subject that students will be able to demonstrate a respect for evidence and intellectual honesty when confronting scientific issues and opinion. It is a broad outcome and not amenable to assessment. It is no less important for that. Students might demonstrate their achievement of this outcome by making considered judgements about the validity of scientific investigations and laboratory experiments that they have performed or observed, or from secondhand data provided to them and by balancing scepticism and tolerance with respect to other scientific opinions and ways of interpreting experiments or events.

Subject Outcomes

Senior Science Year 12 has the following nine outcomes. The manner of achieving these outcomes - which are generic science process skills - is at the discretion of teachers and their students. Teachers should also be aware that threaded through the outcomes and their pointers are key competencies. The evaluation of an outcome may involve simultaneous judgement about the achievement of a key competency.

Within the content of Senior Science, the student must be provided with opportunities to achieve the following nine outcomes:

Outcome 1: Demonstrate an understanding of relevant concepts, laws, procedures and conventions within real life and/or work place context, in

- biological science
- physical science
- environmental/earth science.

Outcome 2: Plan and carry out short term and extended investigations independently or within a group.

Outcome 3: Present data in a variety of forms (including oral, graphical tabular, diagrammatic and written forms) as appropriate to the task.

Outcome 4: Describe patterns and trends in data observation and make valid inferences.

Outcome 5: Use appropriate sensorimotor skills and equipment to carry out scientific procedures, make accurate observations and measurements.

Outcome 6: Communicate effectively using scientific terminology as appropriate to the audience.

Outcome 7: Perform a range of appropriate calculations using mathematical ideas, techniques and scientific units with reasonable accuracy.

Outcome 8: Demonstrate and apply safe procedures and a high level of responsibility in investigating scientific issues.

Outcome 9: Illustrate, with examples, how science has had an impact on the environment and our society.

Components of Outcomes

Outcome 1: Demonstrate an understanding of relevant concepts, laws, procedures and conventions within real life and/or work place context, in:

- biological science
- physical science
- environmental/earth science.

The following components amplify the context and meaning of the outcome. The student:

- displays a general knowledge of factual content
- applies a general knowledge of scientific laws, principles, generalisations and relationships, in everyday and work situations
- exhibits some specific knowledge of the applications of the conventions, procedures and concepts within **each** of the fields
  - biological science
  - physical science
  - environmental/earth science

Outcome 2: Plan and carry out short term and extended investigations independently or within a group.

The following components amplify the context and meaning of the outcome. The student independently:

- designs a valid procedure, setting up and manipulating simple scientific apparatus to help answer questions in a variety of fields of science
- plans and then coordinates and manages an independent line of thought, enquiry and activity to investigate a scientific problem and achieve a defined objective.

The student within a group:

- clarifies and defines the purposes and objectives to be achieved and then works with others in designing and carrying out an extended investigation
- identifies defined roles to complete a task and then works with others to achieve the agreed objectives within the agreed timelines for an extended experimental investigation
- uses initiative in drawing on a range of processes to solve problems as they arise, and achieve the objectives.

Outcome 3: Present data in a variety of forms (including oral, graphical, tabular, diagrammatic and written forms) as appropriate to the task.

The following components amplify the context and meaning of the outcome. The student:

- recognises that there are a number of ways of organising, processing and presenting data
- uses a variety of forms in presenting reports on investigations carried out in the classroom or the workplace.

Outcome 4: Describe patterns and trends in data observation and make valid inferences.

The following components amplify the context and meaning of the outcome. The student:

- applies what has been learnt to new situations to interpret and analyse unfamiliar data
- recognises patterns and makes valid inferences, both from experimental and supplied data.

Outcome 5: Use appropriate sensorimotor skills and equipment to carry out scientific procedures, make accurate observations and measurements.

The following components amplify the context and meaning of the outcome. The student:

- recognises and states a problem, constructs hypotheses, then designs and carries out simple controlled experiments using simple or complex equipment available to them in the laboratory or field
- responds to faults and difficulties as they arise and checks the accuracy of measurements
- makes accurate measurements, quickly and confidently
- makes accurate observations, records data, manipulates laboratory apparatus and follows instructions concerning experimental procedures in a variety of areas of science.

Outcome 6: Communicate effectively using scientific terminology as appropriate to the audience.

The following components amplify the context and meaning of the outcome. The student:

- uses written, oral, mathematical, graphical and diagrammatic means to effectively communicate organised data and information in a presentation to their peers
- adapts the form of the communication to the context and audience and communicates using prescribed forms and styles
- communicates clearly and coherently, having checked all data for accuracy.

Outcome 7: Perform a range of appropriate calculations using mathematical ideas, techniques and scientific units with reasonable accuracy.

The following components amplify the context and meaning of the outcome. The student:

- performs calculations applicable to an area of science, using appropriate units, reliably and efficiently
- collects, tabulates and works with numerical data as an outcome of an independently designed investigation
- judges the level of accuracy required in a calculation or measurement
- in processing data, checks that results obtained make sense in the context.

Outcome 8: Demonstrate and apply safe procedures and a high level of responsibility in investigating scientific issues.

The following components amplify the context and meaning of the outcome. The student:

- consistently demonstrates a positive attitude toward safety issues in the class or workplace environment and behaves in a manner consistent with this attitude
- takes care to properly use and maintain science equipment and hardware in the class or workplace environment
- uses procedures and equipment within the guidelines of health and safety, environmental impact and ethical practice. The student demonstrates, at all times, an awareness of and commitment to, appropriate ethical standards in the subject of investigations, particularly with respect to care of animals.

Outcome 9: Illustrate, with examples, how science has had an impact on the environment and our society.

The following components amplify the context and meaning of the outcome. The student expresses:

- an attitude of enquiry and a willingness to learn how the world is interpreted through the sciences
- a confidence in, and a desire to use, scientific procedures for seeking knowledge
- an appreciation of the impact of science on the changing environment
- a clear perception of both the positive and negative aspects of many of the changes science has wrought
- an ability to present cogent argument for (or against) a scientific enterprise that has some environmental impact.

Common Assessment Framework

The following table describes seven assessment task frameworks which will provide the common basis for evaluating achievement of the nine outcomes in Senior Science. The assessment task details give an indication of the type of assessment task to be set by the teacher. The suggested activities are pointers to that activity and set guidelines for those assessment tasks. The suggested activities are not in any way prescriptive. Teachers are encouraged to set assessment tasks within the framework parameters to suit their particular teaching program.

Each task incorporates a number of opportunities for a student to demonstrate achievement of outcomes. However, students will need to demonstrate their achievement of an outcome on at least two occasions to gain credit for that outcome.

For this reason, an assessment program incorporating tasks constructed around all seven of these framework tasks is a minimum assessment program in Senior Science.

Note:

- An assessment program must incorporate at least one task of each description.
- Group work, subject to authentication, is acceptable, and the same kind of task can be done on more than one occasion.
- Each task should be designed so that it is possible to evaluate a number of outcomes simultaneously.
- Teachers are free to vary the particular set of outcomes evaluated in a task as long as
    a) a task of each description is part of their assessment program
    b) each outcome is evaluated on at least two occasions.
- The extended investigation is to be conducted over a minimum four week time period.

Task	Outcomes	Task Description	Examples of Activities
One	For example 1, 2, 5, 7	Independently carry out and write conclusions for an experiment.	• Conduct an experiment to investigate the galvanising process. • Design and conduct an experiment to test a food for all materials studied in a study of nutrition. • Design and carry out experiments to determine: – the effect of caffeine on respiration rate. – the most effective dish-washing liquid. – the most effective rate to apply fertiliser.
Two	For example 1, 3, 4, 6, 8	Collect information and critically report on a particular area.	• Report on the efficacy of homoeopathic or folk remedies in fringe medicine. • Conduct an analysis of water purity in a local stream and outline causes and possible solutions to any adverse findings. • Report on the effectiveness of rehabilitating an old mine site. • Describe use-patterns of a walk trail. • Suggest alternative designs for a shopping centre based on people traffic.
Three	For example 1, 3, 4, 9	Summarise and evaluate samples of popular writing on science.	• Identify fallacious or unsubstantiated claims in a written text. • Prepare a brief oral or written summary of an article in *ECOS*. • Investigate the science content of *Cosmopolitan*.

Four	For example 1, 2, 5, 7, 8	Design an experiment or product using scientific principles and conduct the experiment or test the product within appropriate guidelines.	• Design, produce and evaluate a simple water filter. • Produce a hand cream, outline ways to test it for potential allergenic effects and conduct a test within ethical and safety guidelines.
Five	For example 1, 6, 9	Present an oral report evaluating the impact of science in society.	• Present a brief oral report on the occupational health and safety issues relevant to a particular industry/occupation. • Present an account of work done as part of an extended investigation.
Six	For example 1, 2, 3, 5, 8	Design and conduct an extended investigation: (a) independently (b) within a group.	• Design and trial an exercise program for primary school students. • Design an experiment to measure changes in yield for a crop grown in a range of soil types, and trial it. • Determine mass of food consumed and mass excreted by rats and evaluate diets for these animals. • Examine phenotypes in Drosophila offspring resulting from a controlled breeding program. • Examine energy use patterns for a school.
Seven	For example 1, 4, 6, 7, 9	Test	• Multiple choice questions. • Short answer questions. • Calculations. • 'Open - book' test items. • Practical tests of laboratory skills or for certification.

Common Assessment Task Booklet

The *Common Assessment Tasks* booklet for this subject further describes each task, and defines parameters for its completion. Schools are free to determine specific assessment details within these parameters. Copies of the booklet are available from the Curriculum Council and are included with the syllabus, on the Curriculum Council website (http://www.curriculum.wa.edu.au).

Performance Criteria

Each task developed for Senior Science will incorporate a number of outcomes. Student achievement of each outcome can be evaluated using the following table.

Tasks may vary in difficulty: it is possible therefore that a relatively simple task may only allow student performance to be judged at the 'Satisfactory Achievement' level. Other, more complex tasks will enable student performance to be rated at 'High' or 'Very High' achievement level. Clearly, students must be given opportunities to achieve at the highest level.

Outcome 1: Demonstrate an understanding of relevant concepts, laws, procedures and conventions within real life and/or work place context, in

- **biological science**
- **physical science**
- **environmental/earth science.**

Satisfactory	High	Very high
Within relevant areas of each of the fields • biological science • physical science • environmental/earth science recalls ideas and applies concepts in familiar situations.	Within relevant areas of each of the fields • biological science • physical science • environmental/earth science applies scientific concepts in familiar situations and some complex tasks.	Within relevant areas of each of the fields • biological science • physical science • environmental/earth science applies scientific concepts in a range of complex tasks.

Outcome 2: Plan and carry out short term and extended investigations independently or within a group.

Satisfactory	High	Very high
Plans a simple strategy which controls most relevant variables and carries out the procedure.	Plans a strategy which controls all relevant variables and carries out the procedure.	Develops a hypothesis, plans a suitable strategy then systematically collects relevant data to test the hypothesis, using the planned procedure.

Outcome 3: Present data in a variety of forms (including oral, graphical, tabular, diagrammatic and written forms) as appropriate to the task.

Satisfactory	High	Very high
Presents data using a number of familiar forms.	Presents data in a wide variety of forms, depending on the purpose of the task.	Presents data in a range of forms to reveal patterns and relationships.

Outcome 4: Describe patterns and trends in data observations and make valid inferences.

Satisfactory	High	Very high
Describes trends in tables and graphs and makes simple inferences.	Accurately describes patterns and trends in data and makes valid inferences.	Accurately describes patterns and trends in data and makes valid inferences based on a range of such data and information.

Outcome 5: Use appropriate sensorimotor skills and equipment to carry out scientific procedures, make accurate observations and measurements.

Satisfactory	High	Very high
Uses simple and familiar apparatus such as balances and timers to make observations and measurements.	Makes efficient use of scientific equipment to make observations and measurements.	Understands and uses more complex scientific equipment effectively to make observations and measurements.

Outcome 6: Communicate effectively using scientific terminology as appropriate to the audience.

Satisfactory	High	Very high
Presents simple ideas clearly and uses more common scientific terms such as 'force' and 'energy' correctly.	Presents ideas and information clearly using appropriate scientific terminology.	Collects information, organises it logically and presents complex ideas and information clearly using less common scientific terminology appropriately.

Outcome 7: Perform a range of appropriate calculations using mathematical ideas, techniques and scientific units with reasonable accuracy.

Satisfactory	High	Very high
Performs basic calculations in an appropriate context, and specifically is able to add and subtract with 80-100% accuracy.	In addition to the preceding, the student is able to multiply, divide and use simple formulae with 80-100% accuracy and report results using correct units.	The student, in addition to the preceding, is able to calculate percentages and rearrange and apply formulae and report results using correct units and to an appropriate level of accuracy.

Outcome 8: Demonstrate and consistently apply safe procedures and a high level of responsibility in investigating scientific issues.

Satisfactory	High	Very high
Follows simple safety directions consistently.	Identifies requirements for safety and usually displays responsible behaviour.	Independently implements responsible and safe behaviour.

Outcome 9: Illustrate, with examples, how science has had an impact on the environment and our society.

Satisfactory	High	Very high
Recognises the impact of science on their life.	Discusses the impact of science on society, their life and work.	Demonstrates in discussion a high level of understanding of the impact of science on society, their life and work.

Note: ND (Not Demonstrated) will be assigned if the student does not meet the requirements of the S (Satisfactory) rating in the assessment of the outcome.

Rating Procedure

Before a final grade can be awarded, the final rating achieved for each outcome must be determined. This is done using the following process:

V is attained when at least 50% of ratings are at a **Very High** level, and at least 50% of the remainder are at a **High** level or better.

H is attained when at least 50% of ratings are at a **High** level or better, and at least 50% of the remainder are at a **Satisfactory** level or better.

S is attained when at least 50% of ratings are at a **Satisfactory** level or better.

ND is attained when more than 50% of ratings are at a **Not Demonstrated** level.

Where a student fails to achieve a final rating of S for an outcome, teachers are encouraged to provide the student with an additional opportunity to demonstrate S if:

- **the student has completed all the CATs incorporating that outcome; and**
- **the student has demonstrated S for that outcome in at least one task.**

The additional opportunity should not simply be a repetition of a task, but should be an equivalent task which reflects a change of context in which the task is done.

Professional judgment should then be used to determine whether a final rating of ND or S is appropriate in each situation.

Grading Procedure

At the completion of this subject, grades will be awarded in the following manner:

A **Very High** in at least 50% of outcomes, and **High** or better in at least 50% of the remainder.

B **High** or better in 50% of outcomes, and **Satisfactory** or better in the remainder.

C **Satisfactory** or better in all outcomes.

D **Satisfactory** or better in at least 50% of the outcomes.

E **Not Demonstrated** in more than 50% of the outcomes.

A final rating of ND for any outcome will result in a grade of D being awarded.

Specific details giving examples of the combination of V, H and S resulting in different grades can be found in the *Common Assessment Tasks* booklet.

Time Allocation

The subject has been designed to be completed through a structured education program of approximately 110 hours in any suitable contexts and series of learning experiences. Typically the subject will be studied over the period of one school year. For administrative reasons schools wishing to vary this delivery pattern (e.g. over a shorter period or over a longer period up to two school years) are required to notify the Chief Executive Officer of the Curriculum Council.

Subject Completion

Students must complete the school's structured educational and assessment program for a subject in order to be eligible to receive a grade unless there are exceptional and justifiable circumstances. In situations where the school considers that insufficient information has been gathered to justify the award of a grade for the subject, a result of U (for unfinished) should be allocated. The Curriculum Council offers the flexibility for the U to be converted to a grade after the final grades have been submitted. Further details on assessment and grading are provided in Volume I of the Syllabus Manuals.

Support Material

Support material for this subject can be ordered through the Curriculum Council Publications Catalogue and is available on the Curriculum Council website (http://www.curriculum.wa.edu.au).