Gifted and Talented Education

Differentiating the curriculum and its applicability to the science and technology syllabus

NEW SOUTH WALES
DEPARTMENT
OF EDUCATION
AND TRAINING

GAT Unit□□□
Curriculum K-12

NEALS

Introduction

How to cater for gifted students – differentiating the curriculum

The purpose of differentiating the curriculum is to provide appropriate learning opportunities for gifted and talented students. Three important characteristics of gifted students that underscore curriculum differentiation (Van Tassel-Baska, 1988) are their capacity to:

- learn at faster rates
- find, solve and act on problems more readily
- manipulate abstract ideas and make connections to an advanced degree.

Gifted students need the opportunity to work through the curriculum at a faster pace and need less time on basics and revision.

A differentiated curriculum is a program of activities that offers a variety of entry points for students who differ in abilities, knowledge and skills. In a differentiated curriculum teachers offer different approaches to *what students learn* (content), *how students learn* (process) and *how students demonstrate what they have learned* (product).

Numerous models of curriculum differentiation can be applied creatively to produce programs that provide flexibility and choice for the range of individual differences in the classroom. These models show how content, teaching and learning processes and products can be fine-tuned to meet the needs of gifted students.

This handout contains examples of how the Maker model (1982) and the Williams model (1993) can be used to modify curriculum in the *Science and Technology K-6 Syllabus.*

THE MAKER MODEL

June Maker

This model incorporates strategies for the modification of content, process, product and the learning environment.

Content needs to be adjusted to accommodate the ability of gifted students to manipulate abstract ideas and deal with complexity. Students should be pre-tested to determine their current level of knowledge and skills, e.g. level of scientific understanding and technological skills. The curriculum can then be compacted so that students have the opportunity to be challenged and achieve outcomes of a higher order.

Process involves the methods that are used by teachers to present information, the questions asked of students and the mental and physical activities expected of them. This dimension of curriculum design has received the most attention from educators and has been focussed on higher-level thinking, creative problem solving, decision making, planning and forecasting. These processes are particularly pertinent to the learning activities of investigation and design in the science and technology syllabus.

Students and teachers should also consider what types of products should be created for particular audiences. The following list of questions provides some pointers for consideration:

- What do I want to communicate?
- What is my purpose?
- What are the characteristics of the proposed audience?
- How can I communicate most effectively with the audience?
- What medium or combination of media will best communicate the message?

The following tables show the kinds of modifications that can be made in the content, process and product areas of curriculum.

THE MAKER MODEL

CONTENT MODIFICATIONS

Abstraction (The focus of discussions, presentations and reading materials should be on abstract concepts, themes and theories)	Going beyond the facts
Complexity (Complexity is determined by examining the number and difficulty of concepts and disciplines that must be understood or integrated)	Dealing with greater breadth and depth
Variety (Students can work on different aspects of a broad theme and in their areas of interest)	Exposure to new ideas or content
Organisation (Content is organised around key concepts or abstract ideas)	Selecting new arrangements of content
Study of people (Students research the lives of creative and productive individuals)	Relating content to humans
Methods of inquiry (Students study the methods of inquiry used in different disciplines)	Relating content to the methods used in a particular field

PROCESS MODIFICATIONS

Higher-order thinking skills (Instructional methods should stress the use rather than the acquisition of information)	Using questions from the analysis, synthesis and evaluation area of Bloom's taxonomy
Open–ended processing (Questions are provocative in that they stimulate further thinking and research into a topic)	Encouraging divergent thinking
Discovery (Activities stimulate inductive reasoning to find patterns and underlying principles)	Inquiry approach to determine own conclusions

Proof and reasoning (Students are required to explain the reasoning that led to their conclusions. Students learn about other students' approaches and learn to evaluate reasoning processes)	Required to give reasons, substantiate conclusions
Freedom of choice (Choice of activities can be motivating and independent learning can meet the gifted student's preference for self-regulation. Some students need support to become independent learners)	Opportunities for self-directed learning
Group interactions of like-ability peers (Structured and unstructured activities should be provided to enable both intellectual and socio-affective goals)	Group problem solving

PRODUCT MODIFICATIONS

Real–world problems (Products should address problems that are meaningful to the students)	Investigating real-life problems
Real audiences (Gifted students are not developing products that are evaluated only by the teacher)	Products for evaluation by teachers, peers, community, particular readership
Evaluations (Gifted students' products should be evaluated by appropriate audiences, their peers and themselves)	Teacher assessment & student evaluation using pre-established criteria
Transformation (Original work is produced when students are engaged in higher-order thinking)	Practical uses for what is learned

(Adapted from Gross, Sleap & Pretorius, 1999)

The following tables provide some suggestions for modifications to curriculum based on the Products and Services strand of the *Science and Technology K-6 Syllabus*.

Products and Services
CONTENT MODIFICATIONS

Abstraction	Going beyond the facts. Dealing with abstract concepts and generalisations Establish a set of criteria by which to evaluate various brands of…
Complexity	Introducing greater breadth & depth Identify trends in the use of different products
Variety	Exposure to new concepts or content beyond the curriculum

	Relate patterns of usage to technological change or to fashion
Organisation	Rearrangement of content. New synthesis of key concepts or abstract ideas Conduct an Internet search about production of a particular commodity e.g. electronics goods, motor vehicles
Study of people	Relating content to humans. Study creative and productive individuals and how they operate Research the modus operandi of key engineers, designers, researchers, inventors and their role in the production process
Methods of inquiry	Relating content to the methods used in a particular field Review industrial, safety or environmental regulations

MAKER MODEL
PROCESS MODIFICATIONS

Higher-order thinking skills	Using questions from the analysis, synthesis and evaluation area of Bloom's taxonomy What changes to current industrial practices and lifestyle would you recommend to minimise the greenhouse effect?
Open-ended processing	Encouraging divergent thinking Invent an environmentally sound product to fill a niche market
Discovery	Inquiry approach to determine own conclusions Conduct research, e.g. survey to determine customer tastes and preferences
Proof and reasoning	Required to give reasons, substantiate conclusions Produce a design brief that outlines the method of production and includes environmental considerations
Freedom of choice	Opportunities for self-directed learning Students conduct Internet search, apply information process. Have similar products been produced? From where? By whom? How environmentally sound are they?
Group interactions	Group problem solving In groups prepare a marketing strategy for …

MAKER MODEL
PRODUCT MODIFICATIONS

Real-world problems	Investigating real-life problems/asking provocative questions Global warming – causes, interest groups, conflict, predictions. How is consumption of products and services related to emission of greenhouse gases?
Real audiences	Students develop products for evaluation by various people or groups, e.g. peers, teacher, parents, Shire Council, magazine, scientific journal etc. Produce an advertisement for a new product or service Make an outline of a movie script about…
Evaluations	Teacher assessment and student evaluation using pre-established criteria How to judge the merits of student-designed products/services
Transformations	Students encouraged to suggest practical uses for what is learned Produce a graphic presentation e.g. PowerPoint presentation to communicate to a non-expert audience the value of a particular product or service

Maker (1982) recommends that the following adjustments should be made in the learning environment for gifted and talented students:

- student-centred rather than teacher-centred
- encouraging independence rather than dependence
- open rather than closed
- accepting instead of judgemental
- complex and abstract rather than simple and concrete
- of high mobility rather than low mobility.

The Cognitive – Affective Interaction Model for Enriching Gifted Programs

Frank E. Williams

This model, created by Williams (1993), is based on studies of the creative person and process. Unlike Bloom it is not a taxonomy. This model has three dimensions.
Dimension 1: This consists of subjects that make up the school curriculum. The K-12 content is the vehicle for students to think and feel about.
Dimension 2: This comprises 18 strategies to be used by the teacher to develop student thinking and creativity.
Dimension 3: This consists of eight student processes that have been shown empirically to be involved in creative thinking.

The model has been devised to give students the opportunity for creative thinking (characterised by fluency, flexibility, originality and elaboration). The teaching strategies also enable the expression of the personality factors of curiosity, imagination, risk-taking and complexity that have been identified as important for the expression of creativity.

Science is an area of endeavour that relies very much on the creative process. To model more effectively the nature and practice of science, the teaching strategies that Williams has proposed are outlined below.

Strategy 1 Paradoxes
Apparently self-contradictory statements or observations.
Paradoxes can be used to evaluate ideas and challenge students to reason and find proof.
e.g. Ask students in science to disprove old wives' tales, e.g. some people think that a Kg of lead falls faster than a Kg of feathers.

Strategy 2 Attributes
This involves the skill of analysis. Students can be asked to list the attributes or properties of something.
e.g. Analyse the nature of 'fast food' - origin, content, nutritional value, price per unit weight.

Strategy 3 Analogies
Students find the similarities between things and compare one thing to another.
e.g. Find the similarities between scientific inventions and patterns in nature. Compare birds with aeroplanes, or fish with submarines.

Strategy 4 Discrepancies
Williams is referring to the exploration of deficiencies in a person's understanding.
Ask students to discuss what is not known or understood.
e.g. Genetic engineering and cloning - how far should we go?

Strategy 5 Provocative questions
Questions that require thoughtful consideration to clarify meaning or develop new knowledge.
Many types of challenging questions can be posed to elicit higher-order thinking.
e.g. Questions that require analysis, synthesis and evaluation.

Strategy 6 Examples of change
Demonstrate the dynamic nature of things, make modifications or alterations.
e.g. Durability of products – what is planned obsolescence?

Strategy 7 Examples of habit
Teach about rigidity, fixations and habit. Teach about situations/things in science that remain unchanged because of habit, e.g. typewriter keyboard.

Strategy 8 Organised random search
Given a situation or body of knowledge, possibly from an historical context, ask students to search for other information to answer questions such as 'What would you do?' or 'What would you have done?' Justify your response.

Strategy 9 Skills of search
Search for ways something has been done before, search for the current status of something, or conduct an experimental investigation. Look for cause and effect; draw conclusions; analyse results; draw implications.
e.g. Student investigations. See the companion document to this handout *Independent Research and the K-6 Science and Technology Syllabus* at
http://curriculumsupport.nsw.edu.au/gats/index.cfm

Strategy 10 Tolerance for ambiguity
Pose open-ended situations; provide situations that puzzle. This is a good technique that leads to self-directed learning.
e.g. Which brand of paper towel is most absorbent? How would you design a fair test to investigate this?

Strategy 11 Intuitive expression
Be sensitive to inward hunches or nudges. Discuss the role that hunches have played in scientific research.

Strategy 12 Adjustment to development
Learn from mistakes and failures. Show how failure, mistakes and accidents have led to the discovery of worthwhile things (serendipity). Find out about the discoveries of Archimedes, Newton, and Alexander Fleming.

Strategy 13 Study creative people and processes
Analyse the traits and characteristics of eminently creative people through biographies.

Strategy 14 Evaluate situations
Evaluate solutions and answers in terms of their consequences and implications — pose the question 'What if?'

Strategy 15 Creative reading skills
Students generate as many ideas as possible after reading a text — this can stimulate a student to develop new ideas.

Strategy 16
The skill of generating ideas by listening.

Strategy 17 Creative writing skills
The skill of generating and communicating ideas through writing.

Strategy 18 Visualisation skills
Provide opportunities for students to perceive or visualise themselves in many contexts. e.g. Visualise nature as seen by a bird or insect.

Programs

Designing programs for gifted and talented students in science and technology involves creating activities that promote higher-order thinking and problem-solving at a developmentally appropriate level for them. An important component of programs is experimentation. The following illustrates how the scientific method can be applied in a learning activity.

Sample teaching unit

Investigating electricity

Context

Students are interested in the way that safety devices work. There has been a house fire in the area, which was thought to be due to a faulty electrical system. The students have posed the question, 'How can an electrical system be made safe?'

This set of learning activities requires different levels of scaffolding and teacher direction to enable students of varying abilities to achieve the desired outcomes. Gifted students are generally self-directed and benefit from the opportunity to engage in more complex and abstract thinking. Opportunities for students to learn about scientific methods allow them to demonstrate an advanced capacity to communicate in scientific language.

For example, an important goal for education in science and technology is an understanding of the design of a fair test of a hypothesis. To develop a fair test, students need to appreciate the meaning of the term '*variable'.* The following questions should be given to students to help them plan their test:

- What are the variables?
- Which variables will be manipulated?
- Which variables will be kept the same?
- Which will be measured?

Outcomes

Content strand PP S3.4:

- *Identifies and applies processes involved in manipulating, using and changing the form of energy.*
    - o Determines, records and reports on the conditions necessary for an electrical circuit to operate, e.g. a light bulb.
    - o Devises a fair test to find out which materials conduct electricity most effectively and shares findings.

Learning processes INV S3.7:

- *Conducts own investigations and makes judgments based on the results of observing, questioning, planning, predicting, testing, collecting, recording and analysing data and drawing conclusions.*

Learning processes UT S3.9:

- *Evaluates, selects and uses a range of equipment, computer-based technology, materials and other resources to meet the requirements and constraints of investigation and design tasks.*

Sample of lesson plans in K-6 Science and Technology

Background

Students have through teacher demonstration learned the names of circuit components and observed how to create a circuit with a battery, leads, a switch and an ammeter. Students deduce that electricity can flow through circuitry components when they are connected in particular ways. Students are then directed to group activities to perform the following segment.

Objective	**Activity**	**Outcome**
Students determine the components of an electrical circuit: a source of potential difference (battery, electricity supply), connecting wires and a load device that consumes energy (light bulb)	Students are supplied with electrical equipment and construct a circuit operating a light bulb (This activity is by trial and error. Some students will require more teacher direction than others to perform the task) Students propose ideas for why the globe lights up	Determine, record and report on the conditions necessary for an electrical circuit to operate e.g. light a bulb Students deduce that an electrical current is flowing through the circuit and that the light globe is a conductor Conducts own investigations and makes judgments based on the results of observing, questioning, planning, predicting, testing, collecting, recording, and analysing data, and drawing conclusions
Students collect and test various materials for electrical conductivity	Students design a scientific experiment to test materials for conductivity Students work in groups to complete activity. Teacher provides varying degrees of assistance to provide for individual differences in ability to complete the task	Devises a fair test to find out which materials conduct electricity most effectively and shares findings Conducts own investigations and makes judgments based on the results of observing, questioning, planning, predicting, testing, collecting, recording, and analysing data, and drawing conclusions. Evaluate, select and use a range of equipment, computer-based technology, materials and other resources to meet the requirements and constraints of investigating and designing tasks
Students determine uses	Students use the	Evaluate, select and use a

for insulators and conductors e.g. insulation, fuses, safety switches	information process (NSW Department of Education, 1989) to select, organise and evaluate information sources (use of Internet)	range of equipment, computer-based technology, materials and other resources to meet the requirements and constraints of investigating and designing tasks
Students design an experiment to test the effectiveness of a safety switch	Students prepare experimental outline of a suitable test for a safety switch. Students use the Internet to choose a safety switch for their evaluation. Students determine when the safety switch would cut out electricity and when it would not	Evaluate, select and use a range of equipment, computer-based technology, materials and other resources to meet the requirements and constraints of investigating and designing tasks

In this example students are required to devise a fair test to find out which materials conduct electricity most effectively. The questions and answers that need to be addressed in this case are as follows:

- What are the variables?

A variable is a factor that can have different values. Examples of variables in this experiment would be type of substance, electrical current (amperes), electrical resistance (ohms), electrical power (voltage)

- Which variable will be manipulated?

The variable that will be manipulated is the type of substance that is tested

- Which variables will be kept the same?

The variables that will be kept constant include electrical power (voltage) and electrical resistance (ohms)

- Which will be measured?

The variable that will be measured will be electrical current (amperes).

Opportunities for gifted and talented students to engage in independent study using the scientific method allow for the development of logical reasoning and critical thinking skills.

References

Gross, M.U.M., Sleap, B. & Pretorius, M. (1999). *Gifted students in secondary schools: Differentiating the curriculum.* Sydney: University of New South Wales, GERRIC (Gifted Education Research, Resource and Information Centre).

Maker, C.J. (1982). *Curriculum development for the gifted.* Austin, TX: Pro-Ed.

NSW Department of Education. (1989). *Information skills in the school*. Sydney.

Van Tassel-Baska, J., Feldhusen, J., Seeley, K., Wheatley, G., Silverman, L. & Foster, W. (1988). *Comprehensive curriculum for gifted learners. A comprehensive guide to planning and implementing an effective curriculum for gifted learners.* Boston: Allyn & Bacon.

Williams, F.E. (1993). The cognitive-affective interaction model for enriching gifted programs. In J.S. Renzulli (Ed.), *Systems and models for developing programs for the gifted and talented* (pp. 461-484). Highett, Vic.: Hawker Brownlow Education.

Electronic resources
The following resources were available 23 November 2004:

Australian Government, Department of Education, Science and Training & Curriculum Corporation. *ScienceLynx: Useful websites for teachers*.
http://www.curriculum.edu.au/science

BBC. *Science & nature*.
http://www.bbc.co.uk/sn/

BBC. *Sea life*.
http://www.bbc.co.uk/nature/blueplanet
Science & Nature. Animals series. Click on links to *Games* and *Quick quizzes*

BMC Biology. *The scientist*.
http://www.the-scientist.com/

CSIRO Australia. *CSIROnline: Education*.
http://www.csiro.au/index.asp?type=educationIndex

NSW Department of Education and Training. Professional Support and Curriculum. *Primary: Science and Technology*.
http://www.curriculumsupport.nsw.edu.au/primary/index.cfm?kla=Science

Powerhouse Museum & MassMedia Studios. *Eco'tude: Changing your school's ecological attitude*.
http://powerhousemuseum.com/ecotude

State Government of Victoria. *Goamazing.com*.
http://www.goamazing.com

The Jason Foundation for Education. *Welcome to JASON*.
http://www.jason.org

Topica. *Topica: Experiments: Messages*.
http://lists.topica.com/lists/krampf/read

University of Technology Sydney. *Science teacher treasures*.
http://www.ed-dev.uts.edu.au/teachered/science/k12teach.html