Mathematics Science Strand

Teaching Constructively in Science

Lecturers' guide

Lecturer Support Material

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Contents

Unit overview

This unit *Teaching Constructively: In Science, Health and Physical Education* is studied to provide students with the opportunity to engage children in science learning and teaching.

This methods unit prepares trainee teachers to understand the nature of children learning in the subject area of science. Through classroom observation and research, student teachers should become aware of the impact of prior knowledge and beliefs on learning. This understanding is applied to the planning of lessons through a constructivist teaching approach. Students should gain experience in designing and implementing lesson plans that reflect the constructivist approach.

This unit guides and prepares trainee teachers to teach effectively and critically evaluate their teaching through both peer and self-evaluation techniques.

Teaching Constructively in Science

3 credit points 36 hours

SM1: The nature of learning 15 hours

Nature of learning in science, health and physical education

- Aims of education; attitudes, processes and knowledge
- Identifying children's ideas and misconceptions
- contemporary perspectives on learning
- constructivist teaching and learning models

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SM2: Teaching strategies 9 hours

- Mapping and sequencing concepts, activities and resources
- Questioning, cooperative inquiry; teacher and text-centred teaching, activity based teaching
- catering for individual differences and gender in the science classroom

↓

SM3: Planning lessons 9 hours

- Models for lesson plans: planning lessons for science, health and physical education
- creating an efficient activity-based learning environment
- micro-teaching and peer evaluation.

General objectives

On completion of this unit you should be able to:

a) outline the aims of teaching in terms of knowledge acquisition processes;
b) describe and apply constructivist methodology to the preparation of teaching sequences;
c) plan lessons to cater for individual differences;
d) prepare and use resources for science;
e) implement teaching strategies effectively;
f) select appropriate strategies for teaching science concepts;
g) critically review your own and peers' teaching practices.

Content and sequencing

The core module is *The Nature of Learning*. The first module is studied for the first four weeks to provide a foundation for the development of strategies to cater for children with different abilities and background knowledge.

The second and third modules, contained in one booklet, focus on teaching strategies and planning that is applicable to Science. At all times, studies in professional development should be drawn upon to reinforce the principles of teaching methodology. The basic principles are applicable to all teaching.

This unit should be studied in the second year of teacher training and/or before the first major practice teaching block.

Module MS1: The nature of learning 15 hours

- **Nature of learning in science**, health and physical education; Aims of education; attitudes, processes and knowledge.
- **Identifying children's ideas and misconceptions**; contemporary perspectives on learning; constructivist teaching and learning models.

Module MS2: Teaching strategies 9 hours

- **Mapping and sequencing concepts**; selecting activities and resources.
- **Teaching strategies**: Questioning; co-operative inquiry; teacher and text centred teaching; catering for individual differences and gender in the science classroom; activity based teaching.

Module MS3: Planning lessons 9 hours

Models for lesson plans; planning lessons for science; creating an efficient activity-based learning environment; microteaching and peer evaluation.

The lesson plans should include clear objectives, logical sequencing of concepts, teaching strategies, questioning techniques, learning activities as well support materials such as teaching aids.

Generic skills

Throughout the teaching of this unit there should be an emphasis on methodologies relevant to primary teaching in PNG including application of knowledge to problem solving, the importance of language transition within the subject area, gender sensitivity and inclusive approaches to teaching and materials. There should also be provision for access by students with learning difficulties and/or physical disabilities.

Opportunities to experience and access current technological aids and instruments associated with the discipline area should also be provided wherever possible to increase technological literacy.

Approaches to teaching and learning

This unit should be presented through a course of lectures closely integrated with workshops, tutorials and teaching practice providing maximum opportunity for group discussion and peer interaction.

If at all possible this unit should be integrated with practice teaching experience. As one suggestion, the first module (SM1) may be delivered through generic lectures with students completing a concurrent individual research assignment within the content area.

The following two modules may then be presented as tutorials in conjunction with a concurrent science unit. A common assignment could then be credited to the studies in both the method unit and the content unit.

A cooperative learning environment together with independent assignments will provide opportunity for development and reinforcement of effective teaching skills in science. Students should be given opportunities to apply fundamental concepts, processes and skills to teaching.

There are a number of approaches to be taken to ensure students are practised in teaching science effectively. In some colleges this unit may be absorbed into other professional studies however, based on program 2000, it is essential that the equivalent time is given to the methods of teaching science somewhere in the Diploma course.

One approach might be to teach the first module as core and integrate the remaining two with general preparation for practice teaching through relevant professional studies or even as add-ons to science units themselves. This has been the direction chosen by some colleges.

Extra time is necessary to succeed in these studies. Students should make time to review the class work each day and to complete tutorials and other assigned exercises.

A sample teaching program may be as shown below:

Week	Lectures	Tutorials	Assignment
1	Generic lectures 2 hrs/wk Module SM1	Tutorials to assist with research assignment. 2 hr/wk	
2			
3			
4			
5	Lectures 2hrs/wk Module SM2	Tutorials on strategies and planning lessons Strategy assessment 2 hr/wk	Task 1 due week 6
6			
7	Lectures 2 hrs/wk Module SM3		Task 2 continuous assessment of strategies (teams of students)
8			
9	Independent preparation of lesson plans		
10			
11			
12			Task 3 due

Assessment strategies

The assessment program should reflect the nature of this unit and be indicative of the manner in which this unit is taught. It is important that students undertake tasks to investigate the nature of learning in science, propose teaching strategies based on their findings and plan lessons, which provide children with learning experiences. The assessment should provide opportunity for students to demonstrate a hands-on approach to the teaching of science.

Example:

Three assessment tasks should be completed for this unit. The three modules are developmental therefore the major weight of the assessment will relate to Modules MS2 and MS3. Student resource materials will include detailed criteria for each task. Students will be provided with formative feedback throughout the study of this unit. The assignment tasks are summative however students, who fail to satisfy the criteria, will be able to resubmit Assignments 1 and 2 after consultation with the lecturer. Microteaching will be assessed by lecturer, peer and self-evaluations. Self- and peer-assessment is a good way to involve students in critical review of their own and peers' teaching.

Assignment 1 (Module SM1)
Prior beliefs in concepts in science – research assignment 40%
(See sample instrument)

Assignment 2 (Module SM2)
Demonstration of a strategy micro-lesson presentation 10%

(See sample instrument)

Assignment 3 (Modules SM1, SM2 and SM3)

Preparation of teaching sequences and lesson plans
for topics from the primary Syllabus 50 %

(See sample instrument)

References

References

Hand, B. and Prain, V. (1995). *Teaching and Learning in Science*. Harcourt Brace and Company

Bidduiph, F. and Osborne, R. (1984) *Making Sense of our World* (An interactive teaching approach) University of Waikato.

J .Gerlorish, Jr. R. Martin C. Sexton and K. Wagner (1994). *Teaching Science for All Children*. Allyn & Bacon.

Deutrom, B. (1998). Science for the Pacific: A – Z of Essential Terms. Oxford:PNG. (ISBN: 0-19-554162-6. Price approx AUD13.00 available from the Co-operative Bookshop).

Cross, R. (1996). Teaching Primary Science: Empowering children for their world. Addison Wesley Longman: Melbourne. (ISBN: 0-582-80364-0. Price approx. AUD30.00).

Suggested teaching strategies

The student modules provided contain a thorough background for the lecturer as well as the student.

The lecturer needs to read some of the suggested references to fully understand the difficulties children have in understanding science concepts.

The content should be presented in a practical and contextual setting. That is, students should select topics from science modules that they are concurrently studying or have studied previously.

The topics selected should also relate to the primary syllabus. In this way students will prepare strategies and lessons that they may use in future teaching practice.

If it is possible to coordinate with the practice teaching school, in that students can find out what they will be teaching, it may even be possible to have students work on the actual lessons that they will need during their practice teaching experience. This would be even more worthwhile and meaningful.

The nature of learning

Try to begin by providing students with the opportunity to discover some of their own beliefs that may or may not be in conflict with the accepted scientific explanations.

For example, here is a set of questions about astronomy concepts and some responses from students. Try these with your own students. Exercise 3 is based on these.

Some responses to prior belief questions about the moon, sun and stars

1. What is a full moon?
Occurs after two months; completed orbit of earth; complete circle; appears at its largest; big round shape that lights up the sky; always up high; gives out plenty of light; sphere shape; seen at night; whole surface visible from earth

2. When do you see this shape (crescent moon)?

3. Where does the moon rise?
In the west (4); In the east (4); south; where the sun goes down (3); where the sun rises (2); where the sun comes up (4); opposite of the sun; where the sun comes up but in its own path

4. Can you see the moon in the daytime?

5. What does the moon look like if seen in the day?

6. Does the moon or earth move?

7. What happens to the sun at night?
Sun moves and shines somewhere else; the moon hides it (sun); it (sun) turns upside down; stays the same; other part of the earth

because earth moves (9); stays the same place all the time - only the earth moves; moon takes its (sun's) position - sun stays in its position; it (sun) gains a lot of energy; its (sun's) brightness disappears and the moon's light is seen; the sun is hidden by the earth's shadow and the shadow is provided by the light of the moon; at night the sun shines to the other part of the world …. The parts that are behind the sun experience dark and night; sun hides.

8. Where is the sun at midday (noon)?

9. Where does the sun rise and set?

10. What happens to the stars at night?
Reflect light from the sun; give off what (light) they absorb during the day; Light of the sun is too bright to see them; stars get orbit from sun; (stars) come out and give bright light at night.

Constructivism

This paper provides an insight into constuctivism for the lecturer. Before teaching any science it is important that any teacher is aware of the prior knowledge, beliefs and thinking of children or students.

Constructing knowledge in science

(John Broadfoot, QUT)

Introduction

What the students know about science is often very different to what we, as teachers, think they know or should know. Many students retain naive ideas about many natural and physical phenomena. For example many PNG students, due to limited exposure to mass media and the outside world in general, might still believe the earth is flat. Why? Everyday observations of the horizon show it to be flat! Why shouldn't students think the earth is flat?

These mistaken beliefs founded on solid observational evidence are often called **misconceptions**. However we must be careful not to label all incorrect ideas or concepts in student learning as misconceptions. Sometimes the misunderstandings are a fault of poor structuring of the learning process. Knowledge acquisition in science requires curricula and teaching strategies designed for conceptual restructuring.

Conceptual restructuring

Astronomy provides an excellent example of problems faced by students in restructuring their prior beliefs and ideas. Observational astronomy involves conceptual restructuring of prior knowledge about the shape, size movement and location of celestial objects. Students come to us with "phenomenal" experience about the nature of celestial objects. For example, students' intuitive models of the sun-earth-moon system are based on an observer-centred perception and may be very different from the accepted scientific ones

(Vosniadou, 1991). These mental models (figure 1) provide insight into the way in which students construct knowledge bases and solve problems in astronomy.

Conflicts can occur with students in their restructuring of their knowledge. Many students retain their naive or intuitive models of the universe and science with little to no influence from adult scientific models. Vosniadou (1991) identifies three kinds of mental models which may be used to explain observed phenomena. These are categorised as "intuitive, scientific and synthetic". The intuitive model is based on observational experiences of the natural world and requires little modification for accommodation of these observations. Scientific models support and agree with current scientific views whereas the synthetic models combine both intuitive and scientific views to create some kind of misrepresentation of scientific information.

The pre-Copernican or Ptolemaic belief of an earth-centred universe would rest comfortably with such a model. Observations of stars, moon, planets and the sun revolving around the earth would form an intuitive model, which is in keeping with the Ptolemaic model of the universe. However everyday observations or perceptions of celestial systems support intuitive models such as the fifteenth century "flat earth" and may contribute to the conceptual problems experienced by many students. It is true to say that most students accept the scientific model of a spherical earth but this is in direct conflict to observational perceptions.

Another common student observation that contradicts with modern science beliefs is the notion that "the sun circles the earth to give us day and night". It is very difficult to change such a belief held by students as there is no easy demonstrable way of proving to the students that "the earth is spinning on its axis and that the sun is more or less stationary". There are many students who, having studied high school physics and/or a university physics course, cannot understand the physics of motion and gravity but adhere to their earlier beliefs, which are more consistent with their everyday experiences.

After exposure to scientific views restructuring of existing knowledge may occur leading to an understanding of scientific theory or to misconceptions. These processes depend on new observational beliefs in astronomy changing and/or replacing previous beliefs. Existing mental models will also differ with each student. The implications of these ideas are important in investigating and understanding how students learn and modify their existing ideas or beliefs to become consistent with scientific ones.

Existing frameworks and experiences

The knowledge students bring to the classroom will affect their learning. Research has identified a number of important aspects in the assimilation and acceptance of new ideas and knowledge.

Students existing frameworks are very dependent on their past experiences with the outside world, everyday events, their preconceived ideas and how new ideas relate to them and others.

Students continually draw on past experiences to assimilate new ideas. They more easily assimilate new ideas, which are self, or human centred and relate to everyday experiences. Conceptions need to contain some physical reality for students.

Many scientific definitions are meaningless because they depend on contrived events and phenomena which students cannot link to their own ideas about the world.

Another conflict occurs due to the traditional nature of science, which is presented as being regular and predictable whereas children enjoy the irregular, the unpredictable and surprise. (These are elements employed by the "discovery" approach.)

Implications of existing frameworks on teaching strategies

The implications of relating new concepts or ideas, within children's existing frameworks, should be reflected in the teaching strategies we choose. The strategy chosen will depend on whether or not students already possess their own ideas and how these compare to the scientific view. Students' ideas will influence their thinking in different ways and to varying extents. The readiness of individual students to the introduction to a new concept or level of explanation should be ascertained.

We must avoid confusion created by students' sensory perceptions of the real world. A lack of one-to-one correspondence may exist between scientists' views of what is happening and what is detectable by our senses that form the basis of many intuitive ideas and predictions. It is better to relate concepts to familiar materials and changes that may be observed in the real world.

If students' intuitive ideas are not related to the theoretical ideas of a new concept, their ideas will remain unchanged. Theoretical models may remain unrelated to students' conceptions of their world, e.g. kinetic models. Teachers also need to be aware of unintended scientific reasoning that students might apply to link their non-scientific ideas to new knowledge.

As teachers our level of explanation needs to be considered in three phases commensurate with the cognitive development of each student:

(a) descriptive and functional (sensory),

(b) representative (symbolic) and

(c) explanatory (abstract).

Teaching strategies

The teaching strategy chosen to introduce a new concept will depend on a number of considerations:

I. The strategy chosen will depend on whether or not students already possess their own ideas and how these compare to the correct scientific view.

2. Students' preliminary ideas will influence their thinking to varying extents.

3. The instructor initially must identify those firmly held views, which are different from the scientific ones.

4. Strategies must be aimed at exchanging the students' different views for the correct ones held by scientists.

5. For exchange to be successful, students must accept that their present views are unsatisfactory and the alternative views must be attractive to them by being:
   - intelligible, coherent and internally consistent;
   - plausible and reconcilable with other views held; and
   - preferable to their old idea.

6. Change must be a gradual process to enable students to fully integrate and accept the scientific view as being better than that previously held by them.

7. To maximise this change a logical order of presentation is needed and alternative orders of presentation should be considered as part of curriculum development.

Summary

The steps needed to bring about constructive learning in science are:

1. Find out students' intuitive ideas and prior beliefs about the concept or topic using surveys, questions, activities and discussion before planning for instruction.
2. Clarify student views through further discussion.
3. Devise strategies to motivate and interest students in the new idea or concept and to challenge their prior intuitive ideas.
4. Design a logical and ordered presentation to achieve a shift in ideas and assimilation of the new concepts.

Appendix 1 summarises further constructivist strategies for teaching (Yager, 1991).

Glossary

In reading research on science teaching and learning, one is confronted with many terms. Some of these terms are defined.

Facts are singular occurrences that happen in the past or the future. They may have no connection to other facts.

Concepts describe common attributes or relationships between facts. Concepts are generally based on an accumulation of facts. Conceptualisation can only occur after experiencing many singular related facts.

Generalisations are broad relationships between two or more concepts. For example: "objects with more mass exert a greater force".

Meaningful learning implies that students, after instruction, are able to integrate and relate new concepts to previously acquired concepts.

Rote learning is the memorisation of concepts without understanding or relationship to prior learnings or concepts.

References

Vasniadou, S. (1991). Designing curricula for conceptual restructuring: Lessons from the study of knowledge acquisition in astronomy. *Journal of Curriculum Studies, 23*(3), 219-237.

Yager, R. (1991). The Constructivist Learning Model: Towards real reform. *The Science Teacher*, September, 1991.

Teaching strategies

Concept identification and mapping

Concept mapping is essential to establish the interdependence of concepts. It is only though concept mapping that the teacher/learner can identify the interaction of prior beliefs on learning.

There are other examples and activities on concept mapping in the student materials.

Example of a concept: BOILING

Definition: **Boiling is the change of the state of matter from a liquid to a gas**.

CRITICAL ATTRIBUTES

- liquid form decreases and gas form increases
- substance does not change its composition

VARIABLE ATTRIBUTES

- boiling point varies with atmospheric pressure
- boiling point depends on the purity of the substance

EXAMPLE OF THE CONCEPT

- boiling water

NON-EXAMPLE OF THE CONCEPT

- water evaporating

Student identification of concepts and prior beliefs

Round table discussions are useful for students to identify their own ideas and beliefs when beginning a new topic with a number of related concepts.

Quite often, through discussion, students can exchange ideas and clarify their own ideas before trying to understand the explanations of the teacher.

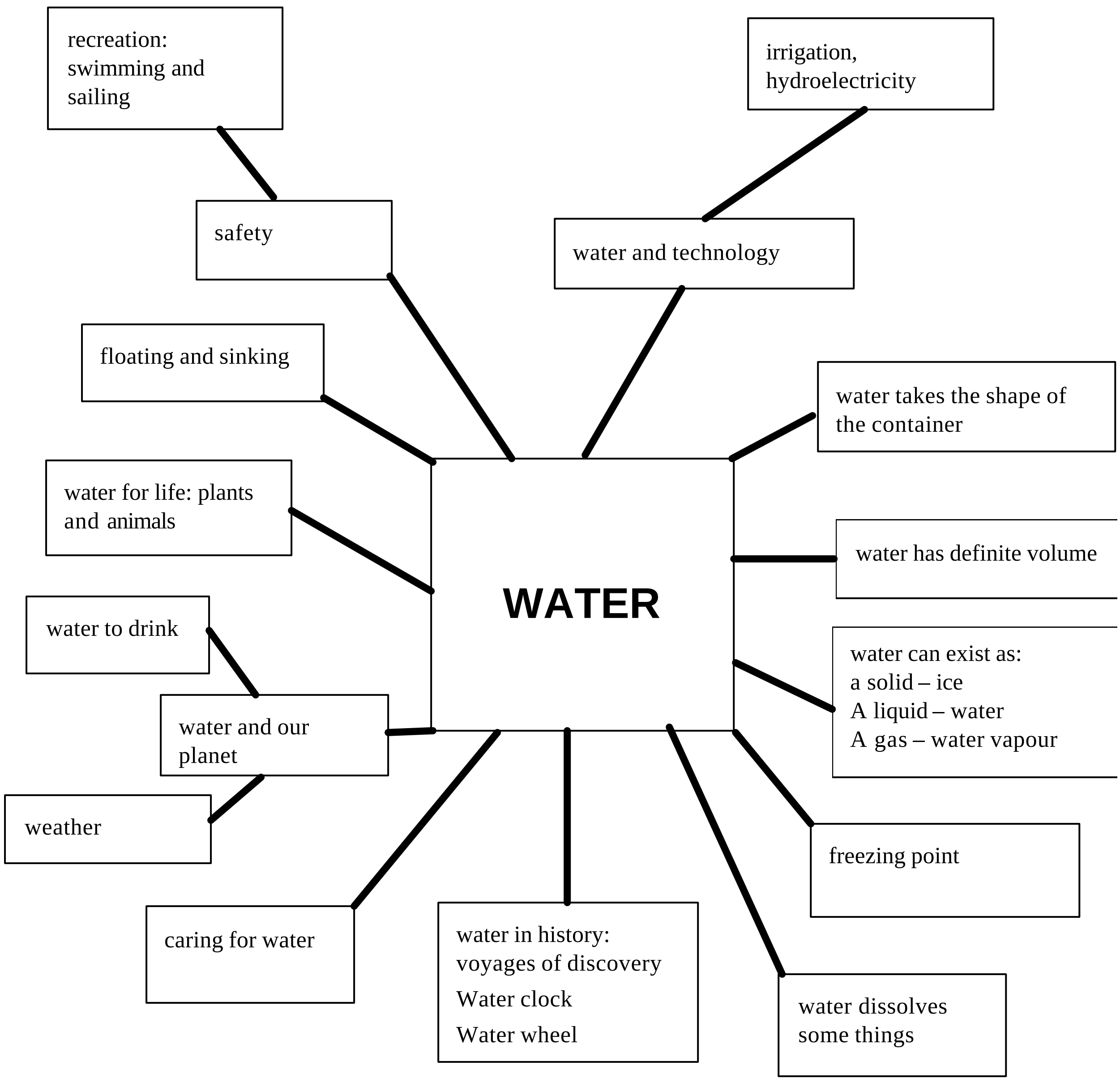
The teacher/lecturer can assist this process with a carefully designed set of focus questions to identify the critical and variable attributes of a concept or group of related concepts.

Students should also have plenty of practice at **Concept Mapping**. This will assist their own learning as well as their teaching.

Concept mapping is also essential to develop a logical and sequenced lesson plan or series of lessons for a topic in science.

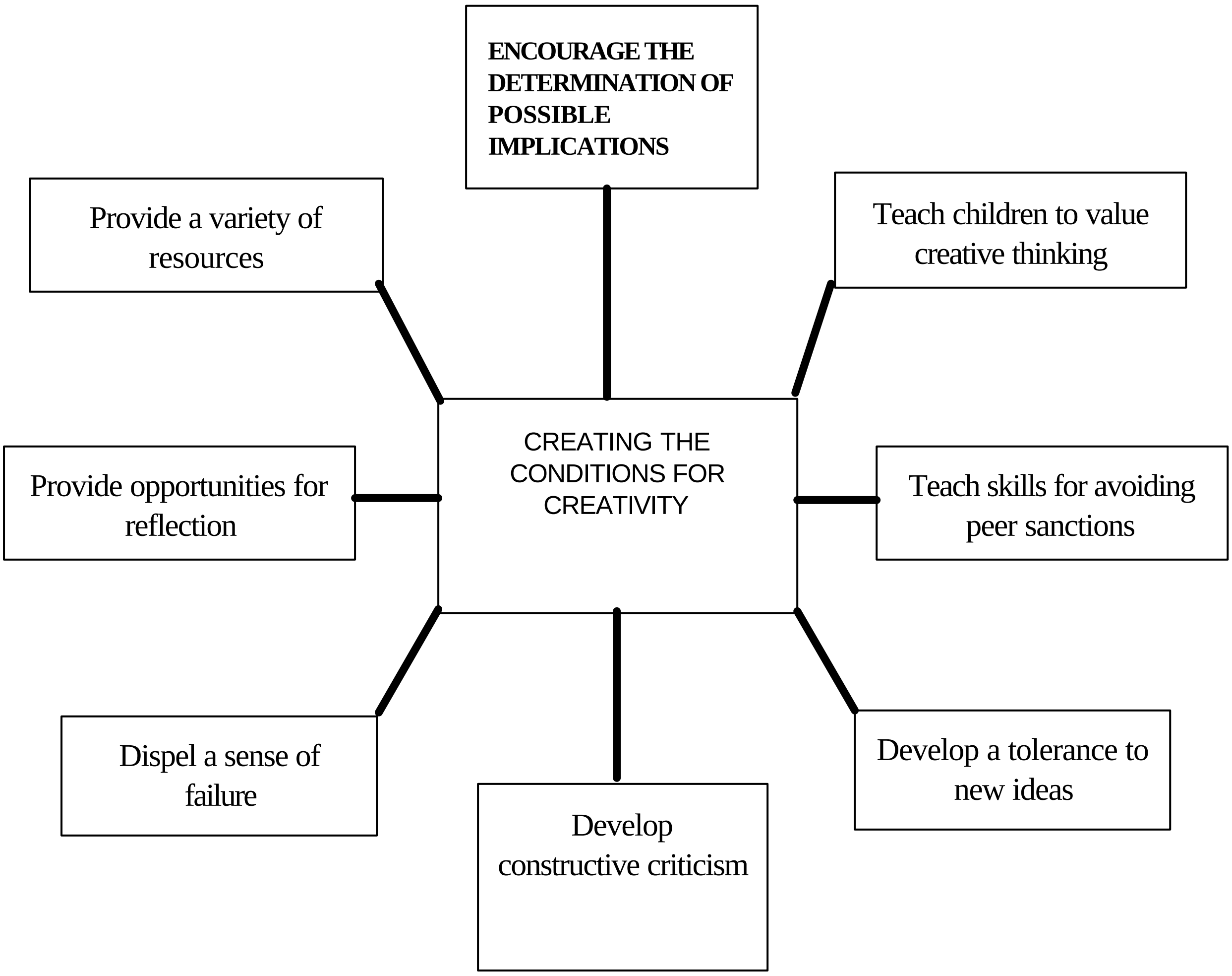
It should be stressed to students that concept mapping is the starting point for all good teaching in science.

Example of a concept map



Student activity. Practising a roundtable discussion.

Using the following diagram, discuss strategies to provide conditions for creativity in a science classroom.



Conceptual conflicts

What do we do when students have a conflict with the accepted idea or explanation of a concept? Many researchers have arrived at very similar strategies for challenging and changing students' ideas.

Some examples are given her.

From: Cross, R. (1996). Teaching Primary Science: Empowering children for their world.

Often, our task is to help children come to the conclusion that their explanations for the observations are incorrect. This has been called a 'conceptual conflict' approach. It simply means that children need to come into contact with evidence, which they accept as inconsistent with their explanation. Perhaps in the case where the boiling water producing bubbles of steam, an activity could be devised whereby some of the steam was captured, and condensed back into water.

Rosalind Driver (1988) discusses a number of teaching strategies that can be used by us to promote the modification of concepts. Here it should be remembered that the teaching strategy we choose needs to take into account of prior conceptions, and that means we must make every effort to find out what they are. Summarising these strategies:

1 **Broadening the range of application of a conception**. Using prior conceptions as a positive aid to extend the range under which the concept is held to new but applicable circumstances.

2 **Clarification of a concept.** Often the concept is ill defined, for example one concept covers both heat and temperature. We can clarify this.

3 **Building experiential bridges to a new conception.** This is done through activities that exemplify the concept in action.

4 **Unpacking a conceptual problem.** The concept under consideration may rely on other concepts and for these too the child may hold alternative frameworks. It is important to unpack the problem, and analyse the props that the child has to support a particular problem.

5 **Using a different model or analogy.** Using analogies to real life experiences is one that has been done throughout the history of science, for example, the wave theory of light. We can often develop a conception by describing it in terms of the familiar.

6 **The progressive shaping of a conception.** We should not be too alarmed if at first children's conceptions are not completely in accord with that desired; having a partial model, say for the particle theory of matter, will allow that model to be refined and developed in the future.

7 **The construction of an alternative conception**. Here the children's prior idea is incompatible with the scientific explanation. This needs to be tackled through experiential and conversational methods in order that

the child is confronted with the dilemma, that her or his conception is inadequate.

These teaching strategies are used in what is called the 'Generative Learning Model' of teaching. This is described fully in Roger Osborne and Peter Freyberg's book (1985).

Generative Learning Model

It is worth examining these three stages of the "generative Learning Model" in some detail as these will go a long way towards clarifying the constructivist approach and will put Rosalind Driver's strategies into action:

(Osborne & Freyberg, 1985, pp.109-110)

Teacher activity	Pupil activity
FOCUS	
Establishes a context. Provides motivating experiences.	Becomes familiar with the materials used to explore the concept.
Joins in, asks open-ended, personally-oriented questions.	Thinks about what is happening, asks questions related to the concept.
Interprets pupil responses.	Decides and describes what he/she knows about the events, using class and home inputs. Clarifies own view on the concept.
Interprets and elucidates pupils' views.	Presents own view to (a) group (b) class, through discussion and display.
CHALLENGE	
Facilitates exchange of views. Ensures all views are considered. Keeps discussion open.	Considers the view of (a) another pupil (b) all other pupils in class, seeking merits and defects.
Suggests demonstrative procedures, if necessary.	Tests the validity of views by seeking evidence.
Presents the evidence for the scientists' view.	Compares the scientists' view with class's view.
Accepts the tentative nature of pupils' reaction to the new view.	
Contrives problems that are most simply and elegantly solved using the accepted scientific view.	
APPLICATION	
Assists pupils to clarify the new view, asking that it be used in describing all solutions.	Solves practical problems using the concept as a basis.
Ensures students can verbally describe solutions to problems.	Presents solutions to others in class.
Teacher joins in, stimulates, and contributes to discussion on solutions.	Discusses and debates the merits of solutions; critically evaluates these solutions.
Helps in solving advanced problems; suggests places where help might be sought.	Suggests further problems arising from the solutions presented.

Constructivist strategies for teaching

It is fairly easy to identify the previous ideas of children but more difficult to change these ideas, especially if their ideas are firmly entrenched.

Therefore, in science, it is very important that the learning experiences are structured to promote a change in thinking and understanding.

It is a large task to cater for the variety of individuals in a classroom however there a number of well documented strategies that can be used in science to bring about change.

The following ideas will assist lecturers in guiding students through the activities and the development of their own defensible strategies for teaching science.

From Yager, R. (1991). The Constructivist Learning Model: Towards real reform. *The Science Teacher*, September, 1991.

The student

To cater for individual learning, the constructivist teacher should:

- Accept and encourage student ideas
- Use student interests, questions and ideas as a guide to lesson planning
- Seek out student ideas before presenting teacher ideas or textbook ideas
- Encourage use of alternative sources of information and expression, written and non-written
- Use open-ended questions which encourage students to elaborate and form own ideas
- Encourage students to test their own ideas, suggest causes for events and predict consequences
- Encourage students to challenge each other's ideas
- Use cooperative learning strategies utilising collaboration, individual and group contributions including promotion of student leadership
- Encourage self-analysis, collection of evidence to support ideas and reformation of ideas
- Give students time for reflection and analysis

The constructivist classroom

Overall, the constructivist teacher:

- uses student identification of problems with local interest and impact as the focus for lessons or topics
- uses local resources as original sources of information
- involves students in seeking information that can be applied in solving real life problems
- extends learning beyond the classroom and school
- focuses on the impact of science and technology on individuals
- does not view science as something to master for tests
- doesn't use "process" skills solely on the basis of importance to *practicing scientists*
- emphasises careers in science and technology appropriate to individuals
- provides opportunities for students to apply science and technology ideas in real life roles
- demonstrates the importance of understanding science and technology for societal reasons

Predict - Observe - Explain (POE) strategy

One of the most powerful is the **Predict - Observe - Explain strategy**.

Predict	Before an activity the teacher poses questions and asks children to predict outcomes.
Observe	The teacher may do a demonstration while children observe or children may carry out an investigation themselves.
Explain	Children reflect on their predictions and explain.

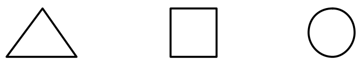
Students are challenged to predict what might happen if certain events occur or experiments are carried out. After making a **prediction** students **observe** through first-hand experience. Students try to **explain** their observations in terms of their existing knowledge.

If the observation disagrees or is in conflict with their prior knowledge, understanding or beliefs then students are challenged to change or accommodate their thinking. At this stage it is important that teachers are able to guide student thinking and support the change process with further POE incidents.

After exposure to scientific views restructuring of existing knowledge may occur leading to an understanding of scientific theory or to misconceptions. Existing mental models will also differ with each student. The implications of these ideas are important in investigating and understanding how students learn and modify their existing ideas or beliefs to become consistent with scientific ones.

TRY THIS!

Predict: Cut three different shaped holes (a triangle, a square and a circle) about 4 mm across in a piece of cardboard. If you go into the sunlight and hold the cardboard in front of you so that the sun shines through the holes onto the ground, predict what shapes you will see on the ground?



Observe: Go outside and observe what happens!

Explain: Explain what you see. (Use drawings and words to explain).

Lesson planning

A number of suggested approaches and examples have been given to assist students and lecturers with the planning of effective science lessons.

The stages of a lesson are important and a five-step plan has been presented with many examples of variations.

Students should be encouraged to select appropriate steps for the class being taught.

Appendix 1 Tutorials

Tutorial 1

Form groups of about 5 five students. Nominate a chairperson (to present the report) and a scribe (to record the group's findings).

1. Select a topic from the Primary Syllabus including Grade 7 and 8.
2. List the major science concepts within the chosen topic.
3. Discuss the prior beliefs held by the members of your own group. Do members of your own group have conflicting beliefs about the concepts?
4. List the concepts that, according to your group, could be possible sources of misunderstanding due to previous observations and knowledge (prior beliefs).
5. Explain the conflicts between the group understandings and scientific knowledge.
6. Prepare a summary report to present to the class. The main ideas are to be presented on display paper.

Appendix 2. Assessment instruments and criteria

Assignment 1 Prior beliefs and ideas 40%

(a) Select a topic from the Primary Syllabus, including Grades 7 and 8. Use a topic with which you are familiar from your previous studies. Select a single concept and devise a series of questions (at least 8) to best discover the prior beliefs or understandings of a sample of Primary students. ***(10 marks)***

Marking criteria

Introduction gives clear basis for selecting questions (2 marks)

Questions are well constructed, well worded and unambiguous (4 marks)

Questions are probing for prior knowledge relevant to the topic selected. That is the questions have focused on concepts, which are needed as prior knowledge for the topic. (4 marks)

(b) Select four (4) students of Primary school age and interview them using your questions. Record their answers and comments. They may wish to draw their ideas on paper. This would also be useful for your report. (***20 marks)***

Marking criteria

Student's (4) answers recorded satisfactorily (8 marks)

Data is well presented (e.g. a table) (4 mark)

Recording of other comments by students (e.g., sketches, any comments that are relevant such as students changing their mind part way through an answer) (8 marks)

(c) Discuss the students' answers in terms of the known scientific facts or knowledge. Explain possible reasons for differences in their ideas to the science ones. (***10 marks)***

Marking criteria

Scientific concepts presented logically (2 marks)

Data presented in a comparative form to show differences (3 marks)

Student has explained why there may be an acceptance of the student's prior knowledge or belief (5 marks)

Assignment 2 Demonstration of a strategy 10%

MARKING SHEET FOR MICROTEACHING

Name: ____________________________________

Tick the boxes as appropriate and submit the completed sheet to the lecturer.

5 = excellent; 4 = very good; 3 = good; 2 = satisfactory; 1 = unsatisfactory	*5*	*4*	*3*	*2*	*1*
1. Interest and motivation					
(a) How well was the class motivated at the start of the lesson?					
(b) How interesting was the lesson?					
(c) To what level was student interest maintained?					
(d) How would you describe lesson flow?					
2. Resources and strategies					
(a) How well were the teaching strategies varied?					
(b) How well did demonstrations/practicals reflect the objectives?					
(c) Safety precautions were taken where necessary?					
(d) What was the level of student participation?					
3. Questioning					
(a) How would you describe the structuring of questioning?					
(b) The teacher's ability to question at different levels was					
(c) Sequencing of questions was					
(d) How well did the teacher test for understanding during the lesson?					
4. Teacher					
(a) How confident is the teacher?					
(b) Teacher knowledge of subject matter was					
(c) How would you describe the teacher's ability to relate to students?					
(d) The teacher's use of suitable body language was					
5. Objectives					
(a) How well were the lesson objectives achieved?					
TOTALS (Lecturer use only)					

Assignment 3 Preparation of teaching sequences and lesson plans 50%

This assignment enables you to demonstrate your understanding and competence in applying the principles of teaching and learning to the planning of science lessons. This assignment is developmental in that it should be completed as part of and an extension to your tutorial program. In this way the topics covered in lectures and tutorials will directly assist you with your assignment as it is completed. You will be expected to present your assignment in stages during tutorials for formative feedback.

You may further develop the topic chosen for Assignment 1 or may choose to select a new topic from the Primary Syllabus and Teachers' Guides.

Criteria for marking

The criteria for marking will be based on the objectives of the unit. In completing this assignment you will be contributing to these objectives of the unit:

- describe and apply constructivist methodology to the preparation of teaching sequences; (concept map, sequence, identification of misconceptions and possible learning difficulties) (10 marks)
- plan lessons (objectives, teaching strategies, questions, catering for individual differences and gender, contributions to language development, five lesson plans) (20 marks)
- prepare and use resources for science lessons (design, suitability and practicality of activities, preparation of teaching resources including equipment, posters and models). (20 marks)

The level of competence demonstrated in your final submission will be used to assign a mark for each objective (criteria).

Evaluation of quality of student responses

This is an example of the evaluation that can be compiled from student scripts for Assignment 2. This form of evaluation is valuable in improving assessment instruments.

Assignment 2

The criteria for marking will be based on the objectives of the unit. In completing this assignment you will be contributing to these objectives of the unit:

- describe and apply constructivist methodology to the preparation of teaching sequences; (concept map, sequence, identification of misconceptions and possible learning difficulties)

This question was generally answered poorly with a lack of real understanding of sequencing. Many students did not give a separate sequence relating to the concept map. There were many cross arrows in some concept maps. There needed to be more single chain links for the basic concepts at a Primary level. Nobody identified misconceptions and possible learning difficulties.

Recommend that this assignment be redeveloped to single concept maps for each lesson.

Many lessons did not have well-developed concept maps. Students copied directly from the Government Teachers' Guides.

- plan lessons (objectives, teaching strategies, questions, catering for individual differences and gender, contributions to language development, five lesson plans)

Most students followed the format from their Professional Development studies, which did provide consistency. However there was very little innovation demonstrated in the planned teaching approaches and strategies. Many of the lesson plans were taken from Teachers' Guides.

Recommend that Topic is not related to Teachers' Guides next year and that lecturer assigns the topic. Furthermore students must demonstrate innovative strategies including practical activities.

- prepare and use resources for science lessons (design, suitability and practicality of activities, preparation of teaching resources including equipment, posters and models).

This section was very poorly done. Very few students actually produced learning aids such as posters for their lessons. However there was reference to equipment, materials and charts in the lesson notes.

Recommend that teaching aids must be constructed as a compulsory component next year.

Appendix 3. Overhead transparencies

Teaching strategies based on a constructivist methodology

1. The strategy depends on students' prior knowledge and how this compares to the scientific view.

2. Students' preliminary ideas will influence their thinking.

3. Teachers must identify firmly held views, which are different from the scientific ones.

4. Strategies must be aimed at exchanging the students' different views for the correct ones.

5. For exchange to be successful, students must accept that their present views are unsatisfactory.

6. Alternative views must be attractive to students by being:

7. Intelligible, coherent and internally consistent;

8. Plausible and reconcilable with other views held; and

9. Preferable to their old idea.

10. Change must be a gradual process.

11. A logical order of presentation is needed

12. Alternative orders of presentation should be considered as part of curriculum development.

Constructivist strategies for teaching

From Yager, R. (1991). The Constructivist Learning Model: Towards real reform. *The Science Teacher*, September, 1991.

THE STUDENT

To cater for individual learning, the constructivist teacher should

- Accept and encourage student ideas
- Use student interests, questions and ideas as a guide to lesson planning
- Seek out student ideas before presenting teacher ideas or textbook ideas
- Encourage use of alternative sources of information and expression, written and non-written
- Use open-ended questions which encourage students to elaborate and form own ideas
- Encourage students to test their own ideas, suggest causes for events and predict consequences
- Encourage students to challenge each other's ideas
- Use cooperative learning strategies utilising collaboration, individual and group contributions including promotion of student leadership
- Encourage self-analysis, collection of evidence to support ideas and reformation of ideas
- Give students time for reflection and analysis

THE CONSTRUCTIVIST CLASSROOM

Overall, the constructivist teacher:

- uses student identification of problems with local interest and impact as the focus for lessons or topics
- uses local resources as original sources of information
- involves students in seeking information that can be applied in solving real life problems
- extends learning beyond the classroom and school
- focuses on the impact of science and technology on individuals
- does not view science as something to master for tests
- doesn't use "process" skills solely on the basis of importance to *practicing scientists*
- emphasises careers in science and technology appropriate to individuals
- provides opportunities for students to apply science and technology ideas in real life roles
- demonstrates the importance of understanding science and technology for societal reasons