Mathematics Science Strand

Module
SM1

Teaching Constructively in Science

Learning in Science

Student Support Material

Acknowledgements

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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. The core module is The Nature of Learning (in science, health and physical education). The module is studied for the first five weeks to provide a foundation for the development of strategies to cater for children with different abilities and background knowledge. The basic principles are applicable to science, health and physical education. This unit should be studied in the second year of teacher training and before the first major practice teaching block.

Teaching Constructively: In science, health and physical education

3 credit points 36 hours

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

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MS2: 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

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MS3: 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.

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Why study this module?

This methods unit prepares trainee teachers to understand the nature of children learning in the subject areas of science, health and physical education. Through classroom observation and research, student teachers will become aware of the impact of prior knowledge and beliefs on learning. This understanding will be applied to the planning of lessons through a constructivist teaching approach. Students will gain experience in designing and implementing lesson plans that reflect the constructivist approach. The lesson plans will include clear objectives, logical sequencing of concepts, teaching strategies, questioning techniques, learning activities as well support materials such as teaching aids. This unit will guide and prepare trainee teachers to teach effectively and critically evaluate their teaching through both peer and self-evaluation techniques.

Aims and 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, health and physical education lessons;
e) implement lessons effectively;
f) evaluate individual lessons; and
g) critically review your own and peers' teaching practices.

Content (Modules)

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 15 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 10hours

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

Approaches to Teaching and Learning

This unit will be presented through a course of lectures closely integrated with workshops, tutorials and teaching practice providing maximum opportunity for group discussion and peer interaction. A cooperative learning environment together with independent assignments will provide opportunity for development and reinforcement of effective teaching skills in science, health and physical education. Students will be given opportunities to apply fundamental concepts, processes and skills to teaching. 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. Notes and readings will be provided for this unit.

Assessment

Three assessment tasks must 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 will be summative however students who fail to satisfy the criteria will be able to resubmit Assignments 1 and 2 after consultation with the lecturer. Micro-teaching will be assessed by lecturer, peer and self evaluations.

Assignment 1 (Module S1)
Prior beliefs in concepts in science, health and physical education 30 %

Assignment 2 (Modules S1, S2 and S3)
Preparation of teaching sequences and lesson plans for topics from the primary Syllabus 60 %

Assignment 3 (Modules S1, S2 and S3)
Strategy micro-lesson presentation 10 %

In one chosen area (evaluation and reflection)

Generic Skills

Throughout the teaching of this unit there will 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, and the 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 will also be provided wherever possible to increase technological literacy.

References

Support materials

Paullon, R. (2000). *Teaching and learning in science, health and physical education.* Student learning resources developed by PASTEP. O.L.S.H. Teachers' College - Kabaleo: ENB.

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

Module MS1: The nature of learning

What is science?

- Science is **knowledge** that teachers tell children or children look up in books.
- Science is a **way of finding answers** to problems that may be such that there is no one solution.
- Science is experimenting to find about things around you.
- Science is learning and developing **new essential skills.**

Even though science is all around us and is part of our daily lives, people have many misconceptions about it. This is expected to happen because of the number of different science images portrayed in the media and the way teachers present science concepts.

Science is old. It has undergone many changes in history. It is linked with other social activities. Any attempted definition, and there have been many, can only express more or less at some period of time (Bernal, 1969, p.30).

Fortunately our task is not so much one of defining science, but trying to clarify our understanding of modern science. A good way to begin to organise our thoughts is by asking questions such as:

- What is science's relationship to and place in society?
- Who does science and why?
- What are the objectives of science?
- What are the methods of science and are these methods appropriate for the questions that science asks?
- What is the status of knowledge that has formed gradually over years, as well as being one of the most important influences on society? (Bernal, 1969, Vol.1, p.30)

Exercise 1 What is Science?

1. *Form groups of two to four.*
2. *Brainstorm ideas about science for five minutes and list at least one idea from each person.*
3. *Rank your ideas on a scale of the most important to the least important features of science.*
4. *Share your ideas with the other groups and draw a diagram (poster) to show some of the ideas about science.*
5. *Discuss these between groups and try to arrive at a class consensus.*

The three parts of science

Whole science consists of three parts: development of children's **attitudes,** development of their **process skills** and children's construction of useful, ideas or **science products.**

Children receive a whole science experiment when they are immersed in all of science parts. The synergy among the parts makes science whole.

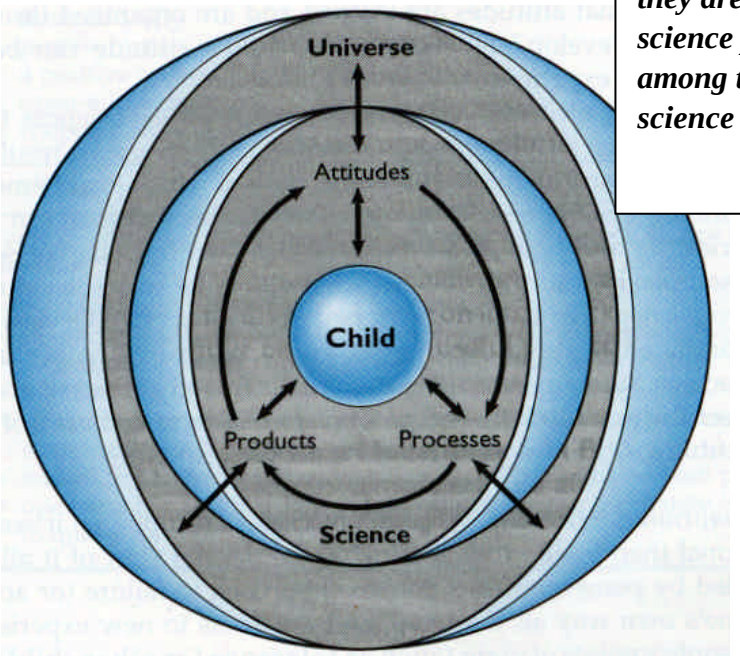


Figure 1.1. An illustration of how a child experiences the universe (from *Teaching Science to All Children.* J .Gerlorish, Jr. R. Martin C. Sexton and K. Wagner (1994).

Attitudes

What are attitudes?

Attitudes are mental predispositions toward people, objects, subjects, events and so on. Attitudes are important because of the three primary factors:

1. The child's **mental state of readiness**. Will a child perceive and construct concepts without prior knowledge?
2. The way children learn. Children's learning are organise through experiences as children develop and can change through additional experiences.
3. The dynamic results of experiences. Is the child able to make decisions, evaluate and then prioritise according to what the end result must be?

Emotional attitudes

Children's attitudes towards learning are more emotional than intellectual. It's all about what they feel about science lessons. Children can be encouraged to be:

- More curious
- Preserve
- Positive even if approaches fail
- Open-minded
- Cooperative with others

Intellectual attitudes

Attitudes based on intellectual or rational thought develop simultaneously with science processes skills and with the discovery or construction of useful science ideas.

Children can be encouraged to further develop:

- A desire for reliable sources of information
- Scepticism, a desire to be shown or to have alternative points of view prove
- Avoidance of broad generalisations when evidence is limited
- Tolerance for other opinions, explanations, or points of view
- Willingness to without judgement until all evidence or information is found or examined

- Refusal to believe in superstitions or to accept claims without proof
- Openness to changing their minds when evidence for change is given and openness to questions about their own ideas

Science Process Skills

Children use skills to solve their own problems of learning and life. **Learning how to learn is important**. Children learn how to learn by thinking critically and using information creatively. There are two types of science process skills

1. **Basic skills** are the skills children use often and are usually at hand.
    - **Observation** is the power to use the five known human senses to come up with answers.
    - **Classification** is the ability to sort or organise observations in ways that carry specific meaning.
    - **Communication** refers to the use of language (spoken, written and symbolic in many forms) to express thoughts in ways others can understand.
    - **Measurement** is done when graduated or arbitrary instruments are used to enhance thinking by adding precision to observation, classifications and communications.
    - **Estimation** is to be able to judge from estimation an amount or value.
    - Prediction refers to types of thinking that requires best guesses based on information available.
    - **Inference** is the conclusion about the cause of an observation. For children to make better inferences they need help to make observations and conclusions based on prior knowledge.

2. **Integrated science process skills** are made up of several basic skills. These skills can combine for greater power to form the tools used to solve problems.

   - **Identifying and controlling variables** requires children to identify aspects of an experiment that can affect the outcome and keep constant as many variables as possible, while manipulating only the aspects or factors (variables) that are independent.
   - **Defining operationally** occurs when children use observations and information gained through experience to describe or label an object or event.
   - **Forming hypotheses** is important for designing investigations. It is similar to prediction but more controlled and formal than an "educated guess".
   - **Experimenting** requires the use of many thinking skills to design and conduct a controlled scientific test.
   - **Graphing** makes it necessary to convert measurements into diagrams to show the relationships among and between measures.
   - **Interpreting data** requires the collection of observations and measurements in an organised way and then drawing conclusions from the information obtained by reading tables, graphics and diagrams.
   - **Forming models** requires that children create an abstract (mental) or physical (concrete) illustration of an object or event.
   - **Investigation** is the complex process skill that requires children to observe, collect and analysis data, and to draw conclusions in order to solve a problem.

Science products

Science products become important when children construct important ideas and discover much for themselves when they use the skills of science. The information and ideas of science are often referred to as products. Science products are of four types:

1. **Facts.** Facts are specific and usually verified through observation and measurement.

2. **Concepts.** Concepts are abstract ideas that are generalised for facts or specific relevant experiences.

3. **Principles.** Principals are more complex ideas based on several related concepts.

4. **Theories.** Theories consist of broadly related principles that provide an explanation from a phenomenon. The purpose of a theory is to provide a best explanation based on evidence. Theories are used to explain, relate and predict.

The knowledge of science is a product of a hierarchy of facts and ideas.

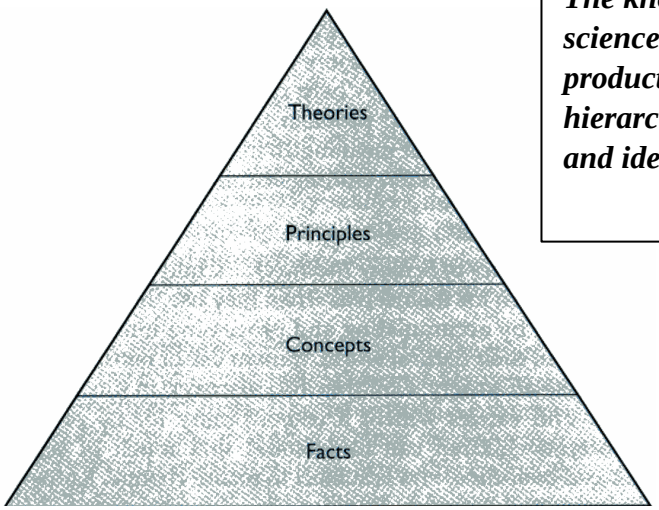


Figure 1.2. An illustration of the science products of science Diagram (from Teaching Science for all children)

2. How do children's ideas influence their learning?

Children's ideas are based on prior beliefs and knowledge. These ideas:

- are personal
- may seem contradictory
- resist change

What do children need to help them learn?

Children need to be encouraged and challenged positively. Changes occur in learning if children:

- **think** with the aid of the five senses;
- do **physical activities** that are purposeful instead of allowing children to sit for longer periods listening;
- speak common **language** so that reasoning and expressions of ideas develop through child-child and child-adult.
- **socialise** with their peers. Social development is related to academic success.
- have a positive **self-esteem** to meet the teacher's expectations. It is often not easy. Cooperation rather then competition is seen to be the best way to handle the situation.

The approaches to teaching

The following people had a great impact on learning:

- **John Dewey** was a philosopher, psychologist and theorist who exerted considerable influence on education.
- **Jerome Brunner** was an educational psychologist who encouraged induction as one way to promote active learning at the turn of the century.
- **Jean Piaget** was a biologist) who developed a theory of cognitive development.
- **David Ausubel** was an educational psychologist who provided a useful perspective on learning.

Research into learning

1 *What impact have John Dewey, Jerome Brunner, Jean Piaget and David Ausabel had on our understanding of the ways in which children learn?*

2 *Whose research into learning makes sense to you? Explain.*

Constructivist approach to learning

In recent times the **constructivist approach** to learning has been highly recommended. Constructivism emphasises the importance of children's active construction of new knowledge from prior knowledge and experiences. Figure 1.3 illustrates the processes

believed to occur during the acquisition and assimilation of new experiences into new knowledge.

Prior beliefs and/or previous experiences may be so strong that the teacher will have great difficulty in changing students' existing knowledge into the preferred understanding or scientific view.

Therefore it is very important for all teachers to ascertain the prior knowledge that each and every student has before beginning a new topic. Appropriate teaching strategies will need to be planned based on the current information collected by the teacher.

The following stages of scientific inquiry may be used to facilitate student abandonment of previous ideas that do not match the scientific viewpoint:

1. Science begins within the individual. The individual must question some event, object or phenomena in his/her mental or physical environment.
2. The individual must realise that there exists a body of knowledge that may or may not answer the question. He/she must have the skills and appropriate mental processes to retrieve that knowledge in an appropriate form.
3. If a solution cannot be found from the work of others, then the individual must be able to establish an investigation based on known knowledge using appropriate skills and mental processes to attempt to find a solution to the problem. The power of the solution will be limited by the power of the procedures used.
4. From prior knowledge and results of the investigations the individual generates new knowledge and answers the questions or at least proposes further action with this intention.
5. The individual communicates his/her findings to others.

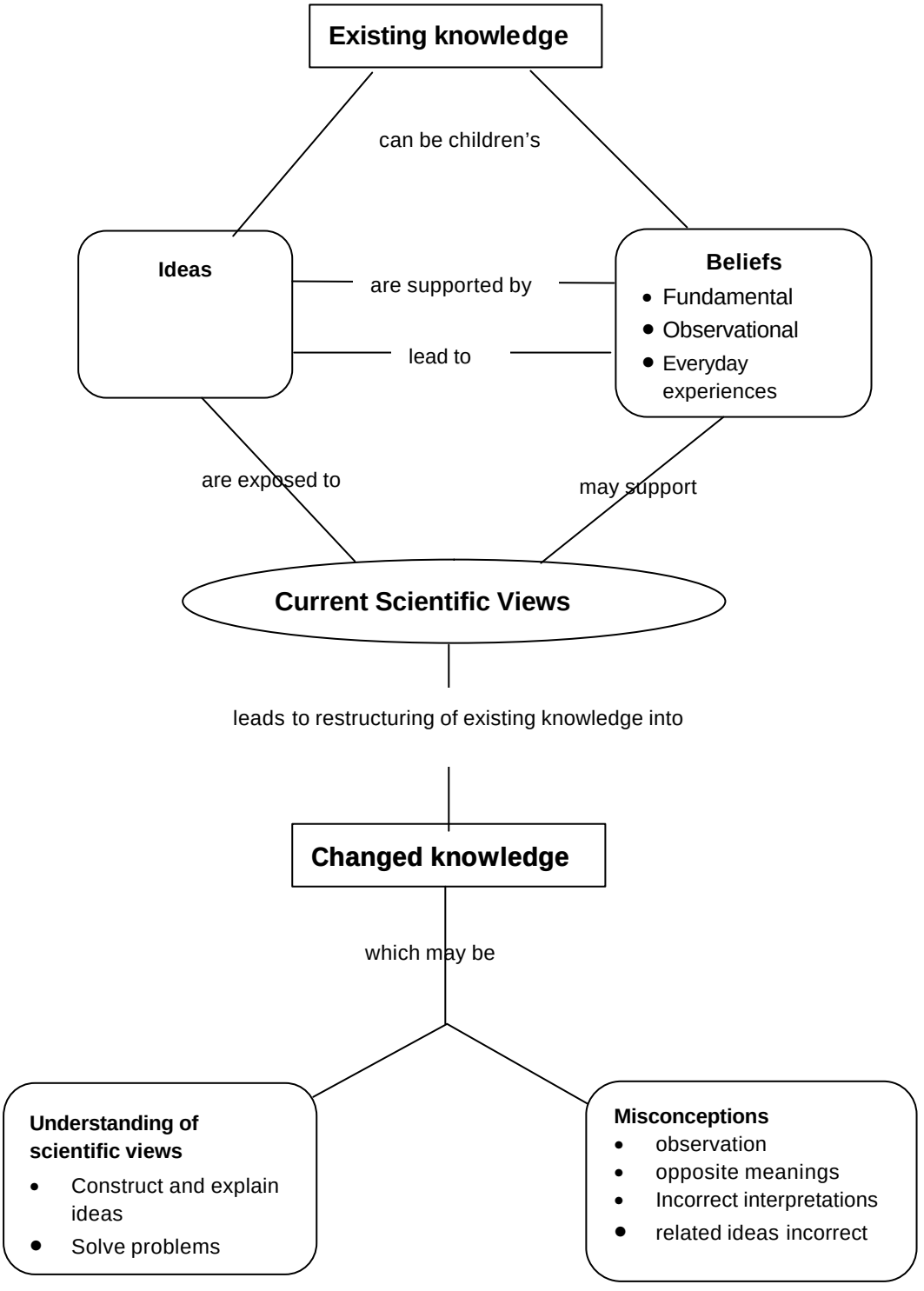


Figure 1.3 A Model of knowledge acquisition based on constructivism.

From: Broadfoot, J. (1995). *Visuo-spatial abilities among science undergraduates.* (MSc Thesis)

The Predict - Observe - Explain strategy

A teaching strategy often used to challenge children's' prior beliefs is the Predict - Observe - Explain Strategy (P.O.E.).

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.

Equipment needed

- 2 plastic funnels of different sizes
- 2 glass funnels of different sizes
- A ping-pong ball
- A ball about the same size as the ping-pong ball but heavier in weight

Procedure

1. Put a ping-pong ball into a funnel as shown.
2. What do you think will happen to the ball if air was blown into the funnel?
3. Blow air through a plastic tube into the funnel. Before the air is blown into the funnel, make sure that the funnel is pointing upwards.
4. Explain your prediction in terms of your observation?
   What really happened?
   Did you predict this? Why?
   If you didn'y, what did you think would happen?

Exercise 2. Let's think about the results!

1 *What was your prediction before and after the experiment?*

2 *Did your prediction work out the way you anticipated on?*

3 *If your answer was no then could you think of other ways to make your experiment work as predicted?*

4 *Is it easy to change the ideas you have about this experiment?*

5 *How can you change your idea?*

Exercise 3. Prior knowledge

1. Draw up a table like the one below.
2. Write down what you know about the questions tabled below.
3. Ask a friend and see what their ideas are like compared to yours.
4. Now compare your ideas with scientific knowledge
5. Explain any discrepencies.

Questions	***Your ideas***	***Scientific opinion***	***Is your answer consistent with the scientific opinion? Explain***
In which direction does the sun rise?			
Where do the stars appear to rise and set?			
Can you see the stars during the daytime?			
Do you see the moon during the daytime?			
What do you call these phases of the moon? 			

Constructivism

What is constructivism?

As stated in a report by Cook (Nov 96, p.76-81), constructivism:

- is a "theory of knowing";
- confronts questions of knowledge - what knowledge is and where it comes from;
- can be considered an **epistemology**[1] but suggests a rather different relationship with the real world.
- implies that all knowledge and experience is subjective and that no truly objective way of seeing exists.

Constructivist learning in simple terms, suggests that:

- each and every individual constructs a unique set of meanings from her/his experiences;
- individuals compare their set of meanings with those of others through language;
- learners make sense of new experiences in terms of what they already know; and
- learning takes place when the learner has constructed new meaning by integrating what is new with what is old.

Constructivist learning from the teacher's view

Teachers fall somewhere along the following continuum in their own views of the learning experiences in the classroom.

Constructivist **Receptive/ transmissive**

In different lessons, the type of learning environment may shift along the continuum between constructivist and receptive/tranmissive despite the overall view of learning held by the teacher.

[1] Epistemology comes from the Greek words episteme, which means "knowledge", and logos meaning "word" or "study". So epistemology means the study of knowledge, what it is, where it is, how we get it, and so on.

The **transmissive** theory of knowledge describes knowledge as a substance that can be transmitted from one reservoir (the teacher's mind) to another (the student's mind)". (Geelan, 1996,p.32)

Exercise 4. Students and the classroom

6 *What was your classroom like at high school?*

7 *Have you changed your views about learning since leaving school and starting teacher training?*

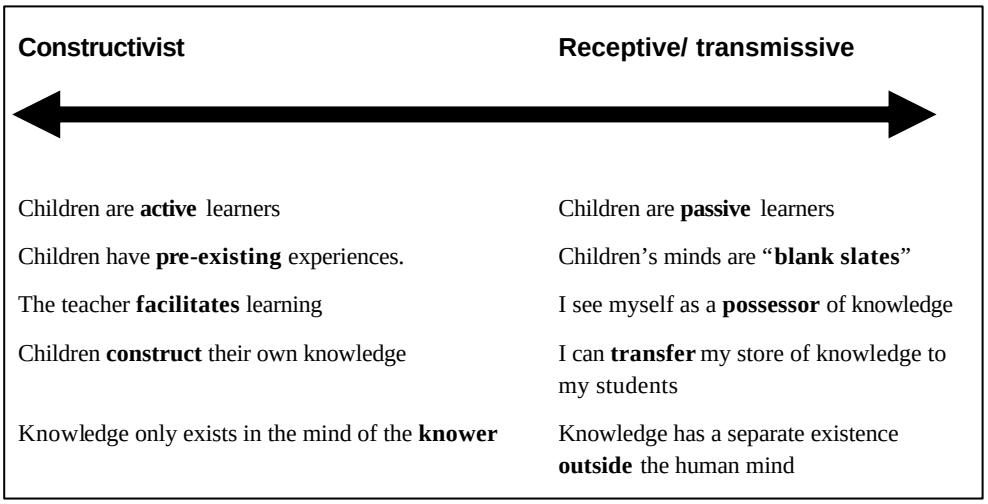
8 *Read the account below. Do you agree or disagree with this view of learning? Discuss.*

"When I began to teach, I felt I had spent years developing a store of knowledge, that I had an array of textbooks as additional knowledge stores, and that my job was to cram all of this fantastic scientific knowledge into the, presumably empty, heads of my students."

9 *Tick the descriptions which describe the way you see children in a classroom.*

- ❑ Children are **active** learners
- ❑ Children are **passive** learners.
- ❑ Children come to my class with a wealth of **preexisting** experiences.
- ❑ Children's minds are "**blank slates**" which I can fill with facts
- ❑ I see myself as a **facilitator** (helper) of learning
- ❑ I see myself as a **possessor** of knowledge
- ❑ Children **construct** (build) their own knowledge
- ❑ I can **transfer** (give) my store of knowledge to my students
- ❑ Knowledge can only exist in the mind of the **knower**.
- ❑ Knowledge has a separate existence **outside** the human mind.

Refer to the diagram below and decide what type of teacher you are - constructivist or receptive/transmissive.



10 *List five strategies that you would use that demonstrate the constructivist view of learning?*

11 *Where do you think your students would put your classroom on the continuum? Are you comfortable with that situation? What could you do to change?*

Constructivist learning from the child's viewpoint.

- From a young age children try to make sense of their world.
- A child will enter your classroom with many pre-existing ideas about any topic.
- You must help the child to adapt and build upon these pre-existing ideas to achieve new meanings.

Your student's views of your classroom may be somewhat different to your view, but they will certainly have a view about their learning situation.

12 *Read through the next table and try to see your classroom from your student's eyes. Which kind of classroom would they see?*

CONSTRUCTIVIST CLASSROOM	RECEPTON/TRANSMISSIVE CLASSROOM
We do lots of interesting and different things in lessons.	We mostly listen to the teacher.
My teacher can't be expected to know everything	My teacher knows a lot about her/his subject
My teacher helps me to learn.	My teacher is too busy to give me individual help
I learn from many sources including my teacher	I learn from my teacher or my textbook
My teacher uses many different ways to evaluate my learning	We often do tests.

Things to remember as a constructivist teacher

- Start where the learner already is. The mind is **not** a " blank slate".
- To find out where the learner is at, **ask questions**!
- Allow the learner plenty of time to **think** and then to **talk**.

A constructivist view of the curriculum

Traditionally, the curriculum has been seen as a list of knowledge and skills that have to be taught, i.e., to be transmitted to the learner. Thus the curriculum can be seen as being determined by factors outside the learning environment, i.e., by the needs of society, by the structure of subjects, etc.

From a constructivist point of view, the curriculum also needs to take into account what the learner brings to the learning situation.

The question now becomes: ***"What experiences and ideas will be effective in promoting certain learning outcomes?"*** Thus what is taught to achieve certain outcomes now becomes a focus for research and enquiry rather than a predetermined list.

The curriculum, in this view, should now be determined by considering such things as the backgrounds and interests of the learners and the learning environment.

8. What are some of the particular features of your college and your students, which should take into account when you design your curriculum?

Learning for understanding

Ausubel has defined two kinds of learning that can take place in places like classrooms. Much learning in classrooms in **not meaningful** for students because it is not taught by taking into account what the student already knows or does not know or understand. **Rote learning** is also called "**learning off by heart**". Meaningful learning is that which is understood by the learner.

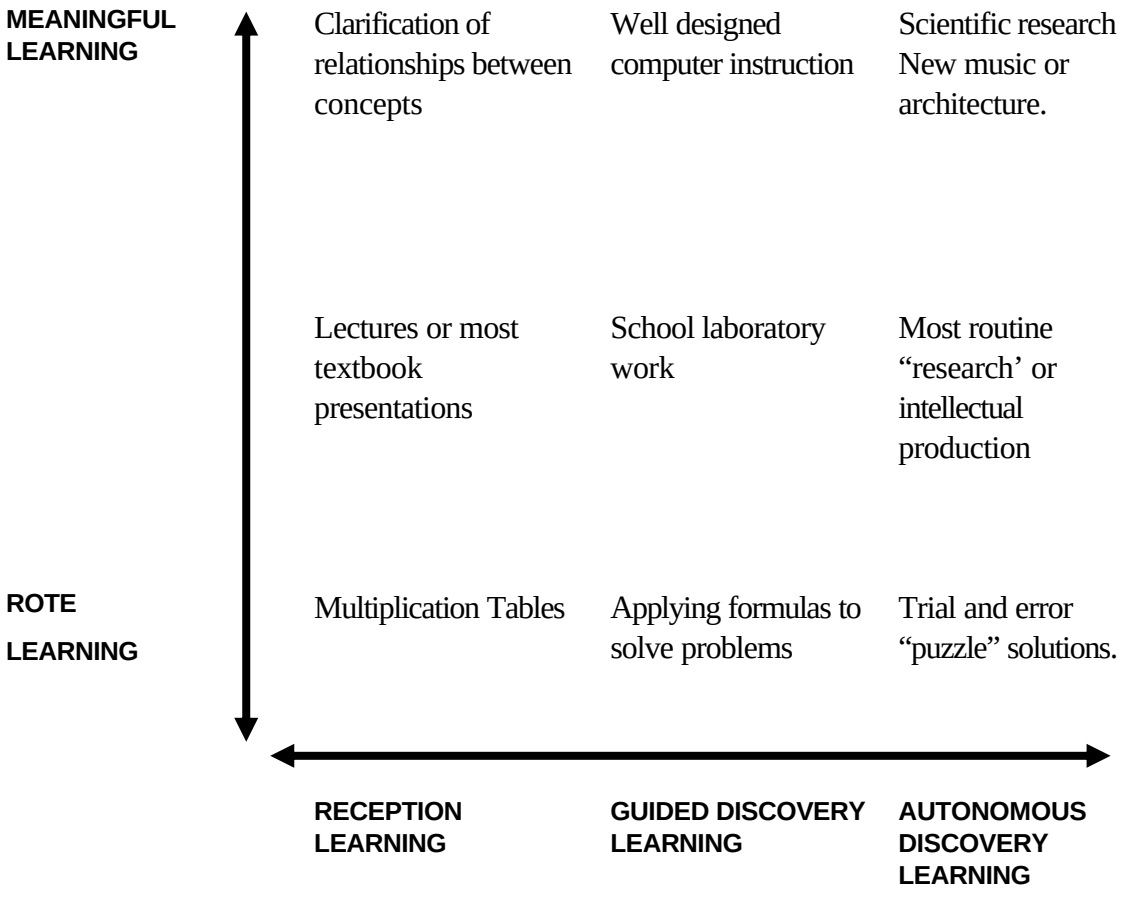


Figure 1.4 A model of learning showing the two continuums for meaningful to rote learning versus reception to autonomous learning.

9. *Where does the learning situation in your classroom fit on the above graph? The best kind of learning is in the top right hand corner. How can you make the learning in your classroom more meaningful*?

Teaching for understanding

A learner feels that he/she understands a concept or idea if and when he/she can do some of the following.

1. State it in their own words,
2. Give examples of it,
3. Recognise it in its various forms,
4. See connections between it and other facts or ideas,
5. Make use of it in various ways,
6. Foresee some of its consequences,
7. State its opposite or converse.

The more aware we are of the structural nature of our own ideas the more we are tempted to try to transplant this structure into the minds of children but it cannot be done. Children must do this structuring and building for themselves.

10. Think of an idea, concept or fact that you understand quite well. For that idea expand the seven steps.

11. What was one important idea or concept that you taught in the last class you took? Do you think your students could do most of the seven things listed above for that idea? How would you know if they could not? How could you find out?

Making links - helping students understand ideas or concepts

The idea of "making links" is to relate new ideas (concepts) to what the student already knows. The teacher can do this by:

- Providing **concrete experiences;**
- Providing **a variety of experiences;**
- Providing **relevant experiences;**
- **emphasising attributes** or characteristics of the concept;
- Giving **clear descriptions**;
- **compare and contrast** the concepts with other concepts;
- Giving examples **and non-examples;**
- Encouraging feedback **and evaluation** by getting students to:
  - interpret new information
  - describe the concept in their own words.
  - give examples.
  - discuss the usefulness of learning the concept and/or the importance of the concept.

A constructivist model is one that strives toward deeper understanding. Children can only have a deeper understanding and beliefs if the ideas they construct make sense. Not all constructive ideas are equally correct

When does a constructivist learning and teaching model become appropriate to use?

The model provides an opportunity for children to explore and be directly involved in manipulating objects, asking questions and encouraging children to ask useful and productive questions.

The activity of the teacher in the constructivist learning and teaching model can be illustrated in a flow diagram.

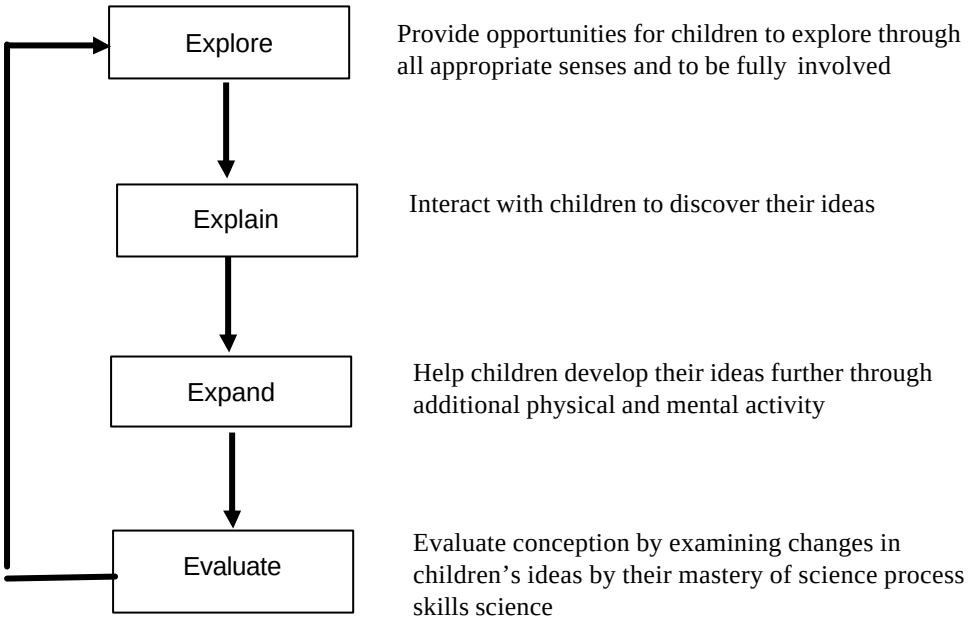


Figure 1.5 Flow diagram for teacher activity in a constructivist classroom. (from Teaching Science for All Children*)*

What are some of the roles of a classroom teacher?

For a start the teacher is not a "walking library" that knows all information. Yet the teacher can facilitate children's learning so that children have a better and deeper understanding of concepts.

Children learn better if the teacher performs the following roles:

Teacher's role	What the teacher does
Presenter	Demonstrates, models, present activities to groups of children and etc…
Questioner	Asks questions and pose problems
Environmental organiser	Organises carefully and clearly what children are to do, while allowing sufficient freedom for exploration
Public relations co-ordinator	Encourages co-operation, development of human relationship and patience with diversity in class
Documenter of learning	Displays or uses children's correct finish products to draw ideas from
Theory builder	Helps children build connections between and among their ideas and then construct meaningful patterns that represent their constructed knowledge

Teaching relationships

How children learn normally influences how the teacher plans, teaches and evaluates learning. The role the teacher plays is based on the teacher's own behaviour and learning beliefs.

Teacher type	Descriptions of the teacher in the classroom
Authoritarian Teacher	• Firm, centralised control is evident in classroom. • Makes significant decisions by doing all the planning for the class and issuing instructions • Students thinking is limited to teacher's decisions • Active while children viewed as passive. • Control is maintained and conformity is expected • Learning devoted to recall (rote learning) • Does not allow for so much flexibility
Laissez- Faire Teacher	• Does not go with the flow of a structured lesson but rather lets it happen without leadership • Children are allowed to follow their own initiative • Teacher direction-giving and planning are absent • Children may develop social skills and determine what are adequate standards.
Democratic Teacher	• Teacher becomes the leader of the group • Work is done co-operatively • Leads children into the study of important topics and problems • Atmosphere is composed of give and take • Flexibility • Compromise • All ideas are respected • Ideas are based on evidence and insight is generated through cooperation and teamwork • Children and teacher learn together • Allows for more flexibility

Exercise 5 How do you teach?

1. *Which type of teacher are you?*
2. *Which type of teacher do you prefer?*
3. *Write down the strengths and weaknesses of each type of teacher listed in the table on page 20.*