

Constructivist Instruction in Science Education

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Abstract— Knowledge is not passively received either through the senses or by way of communication, but it is actively built by cognising subject. Rather than putting fully formed knowledge into the learners' minds, teachers should guide them construct through scientifically valid approaches. As such in all systems of education, science teaching and learning should involve constructivism. This article is aimed at exploring detailed information about constructivist instruction; its approaches, processes, methods and the roles it plays in science instruction & science education in general.

Index Terms— *Constructivism, Instruction, Practical, Schema, Science education, Social constructivism*

- Constructivism; refers to a theory of knowledge that focuses on use of practical activities and experiences during instruction.
- Instruction; refers to teaching and learning.
- Practical; refers to manifestation in practice or actions. It is concerned with the actual doing rather than relying on theory or imaginations.
- Schema; refers to prior knowledge i.e. knowledge that already exists in the learner's mind.
- Science education; refers to a field concerned with sharing of science content, skills, and processes with the aim of disseminating knowledge and achieving laid down goals. In any level of schooling it involves sharing of science content, skills, and processes to learners through instruction and subsequent evaluations.
- Social constructivism; refers to an approach to constructivism that involves interactions, and sharing of ideas amongst learners.

INTRODUCTION

Constructivist instruction stems from constructivist learning theory. Jean Piaget, John Dewey, Lev Vygotsky and other educators & psychologists of the past and the present have contributed greatly to this theory. From the works of Piaget, ideas on constructivist instruction explain that, knowledge acquisition is as a result of experiences. As such learning should be experiential and involving to learners. Kaping'e and Rutto (2014), points out that the theory explains learning as being constructed through effective and purposeful hands on materials. It is based on the belief that, effective learning occurs when learners are actively involved in the process of knowledge construction, and that new knowledge is build upon schema. Generally constructivism fosters: manipulative skills, critical thinking and creates motivated & independent learners.

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CHARACTERISTICS OF CONSTRUCTIVIST INSTRUCTION

Constructivist instruction is majorly learner centred, characterized by the following:

- Active involvement of learners in knowledge construction.
- Learning is built upon schema.
- Learning activities are interactive, involving discussions and collaboration.
- Teachers only facilitate and guide learners where necessary during instruction.
- Knowledge is dynamic/changes with experiences.

APPROACHES TO CONSTRUCTIVIST INSTRUCTION

There are three major approaches to constructivist instruction as explained below:

- 1) Process approach; this approach emphasizes on guiding learners during knowledge construction, teachers serve only to assist learners where necessary during instruction. This approach is aimed at developing learners' process skills. Mechling and Oliver (1993), observers that the value of developing process skills is to make learners apply knowledge effective-

ly to science and its practice, they further explain that science teachers should put emphasis on both the processes and content of science.

2) Discovery approach; in this approach learners are given freedom to figure out things for themselves, and construct an understanding of their own. John Dewey (1933), and cognitive psychologist Jerome Bruner (1966), promoted the concept of discovery learning. Teachers are encouraged to give learners opportunities for discovery learning e.g. engaging them in activities that stimulate their natural curiosity. Discovery learning enables learners to think widely and get acquainted with skills of knowledge construction. Heuristic instructional method is an example of discovery approach. Mukwa and Too (2002), observes that in heuristic method learners are supposed to find answers to problems on their own. They further explain that the purpose of this method is to utilize the instincts of curiosity in learners hence prompt them to adapt a fact finding approach to all aspects of learning. Learners are trained to discover facts, principles/laws, and systemize the knowledge learnt to arrive at generalizations. Discovery approach is useful in science instruction as it:

- promotes hard work amongst learners
- develops scientific attitudes in learners
- Promotes self confidence and self activity in learners
- motivate learners
- stimulates learners' curiosity
- Promotes an investigative spirit in learners.

3) Inquiry/problem-solving approach; this approach emphasizes on real life problem solving. Learners are confronted with real problems and given an opportunity and freedom to solve them. It involves critical

thinking and manipulative processes, which contribute immensely to knowledge acquisition hence effective learning.

Mukwa and Too (2002), further give two methods to problem solving:

➤ Inductive method: this is whereby learners arrive at a general conclusion by establishing laws/principles or formulating generalizations through observation of particular facts.

Generalizations are arrived at, after a series of convincing processes and reasoning. For instance in fluid mechanics, by repeatedly observing the motion of a metallic object through a viscous fluid, e.g. a steel ball falling freely in a viscous liquid, learners will eventually conclude that when such objects are dropped in a viscous fluid it initially accelerates to a maximum velocity after which its velocity remains constant till it reaches the bottom of the fluid. Inductive methods are useful in instruction as it:

- ◆ promotes logical thinking
- ◆ gives an opportunity for active participation during problem solving
- ◆ enhances problem solving skills in learners
- ◆ boosts retention
- Deductive method: in this method learners proceed from general to specific. They work with already proven facts, laws/principles and formulas in solving problems, e.g. in determining the velocity of an object learners will work with the already existing formulas e.g. $v = s/t$, $v = u + at$ or any other as may be applicable. Deductive methods enhance speed and efficiency in solving problems but comes with a number of limitations as explained below:
 - ◆ Extensive use of this method will lead to blind memorization of formulas, laws/principles or facts.

- ♦ Learners may forget the formulas, laws/principles or facts making problem solving a disaster.
- ♦ Makes learners passive in knowledge construction, hence not suitable for development of cognitive and scientific skills.

ROLE OF A TEACHER IN CONSTRUCTIVIST INSTRUCTION

In a constructivist class room, instruction is majorly learner centred. David Jonassen as explained in Wikipedia gives a description of the roles of a teacher as follows:

- 1) Modeling, Jonassen identifies two types of modelling. Behavioural modelling of the overt performance and cognitive modelling of the covert performance. Behavioural modelling involves demonstrations on how to carry out instructional activities, while cognitive modelling involves learner's thinking and reasoning during these activities.
- 2) Coaching, this involves acts of analysing learner's performance, providing feedback & appropriate advice and also giving words of encouragement & appraisal. These actions are aimed at motivating learners and fostering a desirable attitude towards subject matter.
- 3) Scaffolding, this involves systematic and tangible support to the learner, focussing on the task. It provides a temporary framework to support learner's performance in tasks that seem difficulty to them or beyond their capacity.

Generally in a constructivist environment the major role of a teacher is to facilitate instruction and guide learners where necessary during the process.

CONSTRUCTIVIST INSTRUCTIONAL METHODS

Gagne, (1975), gives three aspects of teaching and learning i.e. conditions, processes and outcomes. Conditions refer to external (environmental) and

internal (mindset) factors that foster learning; processes refer to the link between the teacher and the learners, while outcomes refer to the expectations of the instructional process. In science teaching and learning constructivist based methods should be employed to enhance effective instructional processes hence achievement of instructional objectives. Bearison and Dorval, (2002), emphasize on social constructivist methods to learning. These methods explain knowledge as being mutually constructed and put emphasis on interactions and social contexts of learning. Learner Involvement creates opportunities for students to evaluate and refine their understanding as they are exposed to the views and contributions of others, science teachers are therefore encouraged to engage learners in interactive sessions during instruction.

In science instruction practical is the major constructivist instructional methodology. Practical activities are broadly categorized into three: laboratory experiments, project work and field work.

- 1) Laboratory experiments; refers to practical activities carried out in the laboratory e.g. foodtests, titration, setting up simple electric circuits etc. These experiments can be conducted as class or demonstration experiments.
 - Class experiments; constitute the following:
 - ♦ Individual student experiments, these are carried out by each learner on their own.
 - ♦ Group experiments, these are carried out by learners in groups.
 - ♦ Whole class experiments, this category of experiments are done by the class as a whole.

Generally class experiments are vital in science instruction as it: promotes open mindedness and curiosity; develops creativity; enhances acquisition of scientific inquiry methods and problem solving skills; promotes critical thinking and intellectual development.

➤ Demonstration experiments; refers to experiments performed by teachers as learners follow. They are basically meant to: illustrate a principle, proof a fact, or show how to carry out a task e.g. if a teacher is to teach about how to operate a given device by demonstration method, then he/she is expected to show his/her learners procedures for operating the device accurately and safely. Sokoloff and Thorton, (1997), argue that an effective way of helping students overcome misconception is an interactive demonstration strategy. For effective demonstration, the physical environment should be carefully arranged to ensure clear sight and audibility, all materials to be used should be within reach before the demonstration begins. During demonstration use verbal explanations effectively as you carry out the processes systematically for learners to easily follow and understand. In the course of demonstration, activities that permit interaction should be encouraged as it will enhance analysis, interpretations and drawing of conclusions. Narendera, (1977), outlined the advantages of demonstration experiments as follows:

- ◆ Saves time
- ◆ learners get one result at once
- ◆ Appropriate when apparatus/chemicals to be used are delicate/dangerous
- ◆ Appropriate when resources to be used are insufficient. Other advantages of demonstration experiments are:
 - ❖ it is effective in explaining the relationship between skills and purpose
 - ❖ It aids in linking theory to practice.

In science instruction laboratory experiments are important as they enhance the development and effective use of scientific skills e.g. observation skills, investigative skills, manipulation skills, classification skills etc. it also enhances effective knowledge construction.

2) Project work; refers to practical activities involving in-depth study and investigations of a given phenomena. It takes an extended period of time to complete, of even upto the whole term or semester/trimester as may be applicable. In this method learners are usually responsible for planning and purposing the activity. As an instructional method project work enables learners to:

- read widely and selectively
- apply scientific concepts and skills already learnt
- device, plan, and carry out the project hence foster self organization
- develop the concept of originality

In many cases project method is a complete surrender to the learners'. It seeks to offer them freedom to work on their own, as such give opportunities for individual development and self expression.

3) Fieldwork; it is a practical activity carried outside the confines of the school setting. As an instructional methodology it is important in the following ways:

- it is appropriate in developing a topic
- helps in investigating a problem
- aids in linking theory to practice i.e. what is learnt in class to real life situations e.g. learners can be taken to a manufacturing factory in order to have a real life experience of the manufacturing processes.

IMPROVISATION

Improvisation refers to the process of consciously searching for locally available materials/apparatus, and assembling them appropriately in order to be used in place of conventional ones, which may not be available. If used appropriately improvised apparatus are just as effective as the conventional ones. Therefore science teachers should at all times strive to improvise apparatus to compensate for insufficiency in their schools. This will go a long way into enhancing

constructivist instruction hence effective dissemination of knowledge.

ATTITUDE AND INSTRUCTION

Attitude refers to a consistent tendency to react in a particular way, often positively or negatively towards a situation or phenomena. Fazio and Roskes, (1994), cites attitude as a major factor in educational psychology as it strongly influences the thought process hence the way an individual processes information and acts. Attitude has a direct influence on an individual's behaviour and plays a great role in an individual's tendency towards a phenomena, concept or situation when given a choice. Eggen and Kauchak, (2001), observe that positive attitude is fundamental to effective instruction. Thus it's paramount for science teachers to help learners develop a positive attitude toward subject matter and its processes.

SUGGESTIONS FOR EFFECTIVE CONSTRUCTIVIST INSTRUCTION

Brooks and Brooks (1993), suggest the following initiatives aimed at improving the effectiveness of constructivist instruction:

- Encourage and accept student's autonomy and initiative.
- Encourage communication between the teacher and the student and also between students.
- Ask follow up questions and seek elaboration after student's initial response.
- Search out student's understanding and prior experiences about a concept.
- Encourage student's critical thinking and enquiry by asking them, thoughtful open-ended questions and encourage them to ask each other questions.
- Provide challenging ideas to learners, this will encourage discussions and sharing of ideas amongst them.
- Give enough time for students to construct their own meaning when learning something new.

- Try to use raw data and primary sources in addition to manipulative, interactive and physical materials.
- When assigning tasks to learners use terminologies that foster scientific skills and attitudes eg classify, analyze, predict, create etc.
- After posing a question, give learners enough time to think about their answers and be able to respond thoughtfully.

CONCLUSION

This article has explored a number of constructivist paradigms, all of which are geared towards encouraging and improving on constructivist instruction in science. Being a practical oriented field teachers need to employ constructivist methods in their day to day teaching and learning of science. This will go along way into improving science education in schools, hence realization of the curriculum objectives, aims and goals, in the long run fostering national development.

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