Phenomenological Primitives and Learning of Science [1]

Abstract

Phenomenological primitives play a vital role in learning science. Phenomenological primitives are primitive notions which stand without significant explanatory substructure or justification. Phenomenology makes a distinction between appearance and essence. Phenomenology is the study of essence. Phenomenology deals with question of what is the nature or meaning of something. This is different from naïve conceptions and prior knowledge. Naïve conceptions develop before students experience formal study of science. Prior knowledge is a combination of both knowledge and skills accumulated from previous experiences. However, phenomenological primitives may facilitate, interact or obstruct new learning. The aim of the present study was to shed some light on the phenomenological primitives of 11-year old students, more specifically on the concepts related to light, electricity, mass, weight and solutions. A 10-item two-tier multiple choice test was developed and administered to 414 sixth grade students of twelve schools. These schools included government, aided and unaided schools located in rural and urban areas. A few selected students were interviewed to understand their explanations of the reasoning. The results indicated that sixth grade students among several other p-prims hold that energy is associated with moving objects only. Since children's existing ideas have a major influence on learning, it is necessary that the teacher should be sensitive to his or her pupil's ideas. If teachers are aware of some possible views held by children at various age levels, then they can device appropriate methods to deal with different views held by their pupils.

Phenomenology

Phenomenological primitives are primitive notions which stand without significant explanatory substructure or justification (diSessa, 1983). Phenomenological primitives (p-prims in short) can be understood as simple abstractions which are taken as relatively primitive in the sense that they generally need no explanation (diSessa, 1988). The Phenomenological primitives are encoded as an expected event and are relatively independent of the context. The primitives (like axioms) are at the root of many explanations and justifications. The p-prims are notions not necessarily of specific experiential base. For example, an object (not seen before) made of iron may be heavier or lighter depending on the amount of metal used in its molding. However, there is a notion about its weight even in the absence of a direct prior experience with the object.

Phenomenology makes a distinction between appearance and essence. Phenomenology is the study of essence. The "essence" is derived from the Greek *ousia,* which means the inner essential nature of a thing, the true being of a thing. Essence is that what makes a thing what it is (and without which it would not be what it is). Notion of

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essence is highly complex and is not a single, fixed property by which people know something; rather, it is meaning constituted by a complex array of aspects, properties, and qualities – some or which are incidental and some of which are more critical to the being of things.

Phenomenology deals with question of what is the nature or meaning of something. Phenomenology does not produce empirical or theoretical observations or accounts. Phenomenological primitives are different from naïve conceptions and prior knowledge. There is general vagueness or lack of precision in the definition of these terms in the literature. If there is a lack of precision in the way that researchers articulate the construct, it will be reflected in the way questions are asked, and measures are developed. Therefore, it is important to develop a precise definition of naïve conceptions and prior knowledge so to have a clear understanding about the phenomenological primitives. The following sections will elaborate the terms naïve conceptions and prior knowledge as used in this paper.

Naïve Conceptions

Pupils have naïve conceptions (descriptive and explanatory systems) for scientific phenomena that develop before they experience formal study of science. Naïve conceptions that students bring with them to the classroom are persistent. Naïve theories and the distortions they engender in students' comprehension are among the principal causes of students' failure to achieve understanding in science (Champagne, Gunstone & Klopfer, 1983).

The naïve propositions such as - 'heavier objects fall faster than lighter ones' - is common among learners. This is generalized from their experience that stones fall faster than leaves. However, the 'contaminated' form as - ' heavier objects fall faster than lighter ones because gravity pulls harder on heavier objects' - is the result of information learned in science that is inappropriately liked to an existing naïve conception (Champagne, Gunstone & Klopfer, 1983).

Prior Knowledge

Prior knowledge may be defined as a combination of knowledge and skills accumulated from previous experiences (Hewson, 1986). However, there is an abundance of terminology used by researchers to refer to what seems to be the same construct – prior knowledge. These include background knowledge, pre-existing knowledge, previous knowledge and existing knowledge. In this paper prior knowledge is used to mean all these terms. The term prior knowledge denotes that the knowledge is based on some experience and not notions of reality. Prior knowledge exists not only at the level of "concepts," but also at the levels of perception, focus of attention, procedural skills and modes of reasoning.

Prior knowledge affects how students interpret instruction. It may not prevent them from carrying out procedures correctly but, it frequently leads to unconventional and unacceptable explanations. Prior knowledge is active at levels ranging from perception to conception. A large body of findings shows that learning proceeds primarily from prior knowledge, and only secondarily from the presented materials. Prior knowledge can be at odds with the presented material, and consequently, learners will distort presented material. Neglect of prior knowledge can result in students learning something opposed to the teacher's intentions, no matter how well those intentions are executed in instruction. To help people make the most of a new experience, educators need to understand how prior knowledge affects learning. To the child who does not yet understand heat and temperature, no quick explanation can possibly resolve the contradiction between the hot desert and the warm wool; it takes weeks to years for this understanding to emerge (Lewis, 1991).

Learning of Science

Phenomenological primitives serve a variety of cognitive functions such as heuristic cues and analyses in knowing. P-prims like ‘intuitive scientific knowledge’ can be highly useful despite its intrinsic limitations of precision, accuracy, and coherent generality (Reif, 1987). Phenomenological primitives that students bring to class have a major impact on developing an understanding of concepts consistent with those of scientists. Teachers of science must recognize that the existing p-prims often interfere with the concepts being developed in classrooms. To develop a foundation of concepts that will allow students to develop similar understanding to chemists, students must restructure their current understanding. Teachers must recognize the importance of students’ expression of their ideas and understandings to explain phenomena, even if these differ from scientists. For this to occur teacher will have to undergo a process of conceptual change, a restructuring of their views of teaching.

Retrieval and Processing of Information

The retrieval and processing of phenomenological primitives are comparable to that of the formal concept interpretations (Reif, 1987) though not identical. The operation of p-prim involves - - (1) natural retrieval of p-prims and (2) devising a use of the p-prim to identify or reason in the context of a particular instance. Specifics of the situation provide a notion that has no sound or experiential base. For example, springiness is not occurring to the mind of a student when seeing a bouncing ball. A person resists to see a bouncing ball as a spring. How could one convince that one should do so? The person argues that harder objects such as ball-bearings bounce so well. Therefore, what is expected to see in an instance is not seen by a learner whereas another learner sees it so quickly.

Students reading a science text or listening to a science teacher must gain understanding by relating what they are reading (hearing) to what they know, and this require active, constructive work (Carey, 1986; Rajan, 2010). Scientific understanding cannot be affected without grasping the depth and tenacity of the student's preexisting knowledge (Carey, 1986). This is true in the case of phenomenological primitives also.

Learning Difficulties

New learning is intertwined to what already exists in the learner's cognitive structure. Learners are more likely to construct an interpretation that agrees with their p-prims/naïve conceptions/prior knowledge. Learners hold a wide range of ideas about many scientific topics that often contradict the science that they will learn in schools. Teachers should not assume that their students will come to classes with out any perceived ideas about a topic. The nature of learners ideas vary across a number of dimensions. Some of the ideas appear to be quite specific, while others are more general. Some times learner's ideas are easily labile but others are very stable. Certain conceptions seem to disappear rapidly under the effect of teaching. For example, many beginners who are asked to light a bulb using a battery and wires consider that a single wire is enough to carry the current from the battery to the bulb, without the circuit needing to be closed with another wire. But this conception disappears with a single encounter with the topic (Dupin & Joshua, 1987).

The overwhelming weight of evidence has forced informed educators to fundamentally change the way science is taught. Traditionally, it has been assumed that the knowledge (p-prims, naïve conceptions, prior knowledge) that students already possess will facilitate further learning (Champagne, Gunstone & Klopfer, 1983). Emphasis was on the role of facilitative function (positive transfer) of these in learning. That is, the facilitating effect of knowing something on learning a new concept. Recent research has revealed that students' p-prims interfere with, rather than enhance learning. This has raised a new problem of identifying and confronting (if needed) with p-prims so that science knowledge presented in the instruction can be successfully learned and applied.

Learning difficulties may cause due to - - (1) a knowledge base including p-prims that is fragmented and incoherent and (2) an inability to apply knowledge appropriately after it has been retrieved (Labudde, Reif & Quinn, 1988). Scientific concepts are usually introduced by verbal and mathematical definitions. For example, Boyle's law is introduced in its mathematical form, that is, Pressure (P) is inversely proportional to Volume (V) at constant Temperature. Concepts are often introduced without taking into account students' p-prims, and without having students adequately compare and contrast unfamiliar scientific pre-existing notions. Adequate comparison of p-prim with presented knowledge is warranted for effective learning or restructuring of knowledge.

Role of a Science Teacher

A science teacher should be a diagnostician to identify Phenomenological Primitives. Since children's existing ideas have a major influence on learning, it is necessary that the teacher should be sensitive to his or her pupil's ideas. If teachers are aware of some possible views held by children at various age levels, then they can device appropriate methods to deal with different views held by their pupils. Where pupil's views are completely unknown, an awareness of the significance of pupil's views can in itself lead to a different approach in the teaching-learning process.

Recent studies have highlighted the importance of teachers' understanding how children learn. To teach children successfully, teacher requires an understanding of how children think and construct scientific knowledge as well as a thorough understanding of science (Alsop, 2003). It is usually not possible, in ordinary class interactions, to explore any one pupil's ideas in depth. However, small changes in emphasis by the teacher can assist here. For example, when an inappropriate or unexpected answer is provided by a pupil in a teacher-led discussion, a few moments can be spent attempting to find out why the pupil gave that answer. So, often in class, the inappropriate answer is ignored and the teacher moves the question on to another pupil in constant pursuit of the 'right' answer. To discover or to diagnose children's existing knowledge, teachers must provide plenty of opportunities for pupils to express their ideas, whether in small groups or in whole-class settings. However, this in itself is not enough. Teachers, need to ensure a classroom climate where children's ideas are valued and listened to. The role of teacher as listener is inherent in the role of 'teacher as a diagnostician' (Osborne & Freyberg, 1985).

Sample

A 10-item test was administered to 414 sixth grade students from twelve schools of Kottayam Distirct, taking into account the type of school - government, government aided and unaided.

Tools

There are several techniques and instruments such as - - (1) interview about instances and events, (2) prediction- observation-explanation, (3) drawings, (4) paper and pencil tests based on multiple-choice items and (5) two-tier multiple choice tests that can be used in identifying phenomenological primitives/naïve conceptions/prior knowledge. Of these approaches, two-tier multiple choice item is the most common tool that has acquired strong support. Items of the test were modeled on the work of (Pesman & Eryilmaz, 2010).

A test with a total of 10 items was administered to 414 sixth grade students. Five questions were yes or no type and five questions were two-tier multiple choice questions with diagrams. The items in two-tier multiple choice diagnostic instruments were specifically designed to identify students' p-prims. The first part of each item consists of a multiple choice content question having four choices. The second part of each item contains a set of four possible reasons for the answer to the first part. Incorrect reasons were derived from student's p-prims gathered from research, interviews, and free response tests.

For example,
5 grams sugar is dissolved in 1 litre water taken in a beaker. Of the figures given below which one depicts the sugar solution?

(_ _ _ _ _)　　(_ _ _ _ _)　　(_ _ _ _ _)　　(_ _ _ _ _)

Explain why did you select the answer?

Interviews were conducted without any predetermined set of questions and the interview was essentially exploratory (Marriam, 1988). Notes were taken down during the interview.

Results

Of the 414 sixth grade students 376 students (90.82%) hold that sugar solution is a homogeneous solution. 309 students (74.64%) agree that to complete a circuit with a cell and a bulb, two pieces of wires are required. But 70 students (16.91%) gave the response that when a cell is connected from the top (as shown in Figure 1) will cause the bulb to glow.

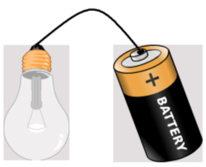

Figure 1

12 of the 414 students (2.90%) hold the view that still and moving objects possess energy. 333 of the 414 students (80.43%) have the notion that only moving vehicle and rolling ball have energy. It is surprising to note that 211 students (50.97%) agree to the proposition that a table even though at rest contains energy. It is quite intriguing that quite a few students selected that a still table possesses energy but not a still ball. The explanations to these answers and responses during interview will further help understand why they have given these answers.

Three students were interviewed about their responses/reasons to each question. Also, the explanations given by 414 students in writing as part of the test were analyzed. The results of the interview and explanations are paraphrased and given below to increase clarity and brevity.

“A moving vehicle and a rolling ball possess energy. A moving vehicle will have more energy. Without energy vehicle cannot run. If they have no energy they won’t move and roll. Only a vehicle with energy will run. A moving vehicle has energy for sure. A moving vehicle and rolling ball are working and therefore they have energy. Wheel of a vehicle is rotating and ball is also rolling, therefore, both have energy. Objects at rest have no energy. Those which are stationary possess no energy. Those which having energy travels/works. Objects which are not working have no energy.”

Another question was related to mass of an object. The question reads: An object has a mass of 10 Kg on earth, what is its mass in moon?

(i) More than 10 Kg (i i) less than 10 Kg (i i i) 10 Kg (iv) 0 Kg

49 of the 414 (11.84%) students selected the answer as 10 Kg. 250 of the 414 students (60.39%) selected that the mass in moon will be either less or more than 10Kg. Their reasons as revealed in the response and interview are given below.

“In moon the mass is less because it is far from earth. There is no air in moon and objects will fly in moon. Since there is no air there is no mass. The mass of moon is less than that of earth, therefore mass of an object in moon is less than that on the earth. Moon is a satellite of earth. It will be less than 10 Kg because moon is smaller than Earth therefore, gravitation in moon will be less than that of Earth. But an object on the surface of moon will experience more attraction since the distance from the centre is less compared to Earth. Gravity is less in moon therefore mass is less. Moon being small, the gravitational force is less.”

Discussion

The results of the exploratory study indicated that students do possess p-prims, naïve conceptions and prior knowledge about concepts in science. The existence of the p-prim that only moving objects possess energy is a p-prim as well as a naïve conception. The students’ concept regarding electric circuit may be interpreted in terms of their prior knowledge contributed by the experiential base. However, the concept of mass of an object on earth and in moon was absent which may be attributed to lack of prior knowledge and the p-prims that they possess. Moreover, the concept is not of relevance to every day life. Formal exposure to science will have to deal with these p-prims and naïve conceptions. The quality and nature of responses indicate that the p-prims, naïve conceptions and prior knowledge do unfold in the context of appropriate situations.

References

Alsop, S. (2003). Learning science. In S. Alsop & K. Hicks (Eds.). *Teaching science*. New Delhi: Kogan Page India Private Limited.

Carey, S. (1986). Cognitive science and science eduation. *American Psychologist*, 41(10), 1123-1130.

Champagne, A. B., Gunstone, R. F., & Klopfer, L. E. (1983). Naïve knowledge and science learning. *Research in Science & Technological Education*, 1(2), 173-183.

diSessa, A. A. (1983). Phenomenology and the evolution of intuition. In D. Gentner & A. L. Stevens (Eds.), Mental models (pp. 15-33). Hillsdale, New Jersey: Lawrence Earlbaum Associates, Publishers.

diSessa, A. A. (1988). Knowledge in pieces. In G. Forman & P. B. Pufall (Eds.), Constructivism in the computer age (pp. 49-70). Hillsdale, New Jersey: Lawrence Earlbaum Associates, Publishers.

Dupin, J. & Joshua, S. (1987). Conceptions of French pupils concerning electric circuits: Structure and evolution. *Journal of Research in Science Teaching*, 24(9), 791-806.

Hewson, M. G. (1986). The acquisition of scientific knowledge: Analysis and representation of student conceptions concerning density. *Science Education*, 70(2), 159-170.

Labudde, P., Reif, F., & Quinn, L. (1988). Facilitation of scientific concept learning by interpretation procedure and diagnosis. *International Journal of Science Education*, 10(1), 81-98.

Lewis, E. L. (1991). The process of scientific knowledge acquisition of middle school students learning thermodynamics. Unpublished doctoral dissertation, University of California, Berkeley.

Merriam, B. S. (1988). *Case Study research in education: A qualitative approach*. California: Jossey -Bass Inc., Publishers.

Osborne, R., & Freyberg, P. (1985). *Learning in Science*. Auckland: Heinemann Education.

Pesman, H.., & Eryilmaz, A.. (2010). Development of a Three-Tier Test to Assess Misconceptions about Simple Electric Circuits. *Journal of Educational Research*, 103(3), 208-222.

Rajan, K. M. (2010) Constructivism: An approach to classroom practice. *Pedagogics*, 8(1), 64-68.

Reif, F. (1987). Interpretation of scientific or mathematical concepts: Cognitive issues and instructional implications. *Cognitive Science*, 11, 395-416.

http:///www.phenomenologyonline.com/glossry/glossary.html.