Primary School Students' Ideas of the Day/Night Cycle and alteration of Seasons: An exploration of Inconsistencies in Students' Responses

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Abstract

Since the early 80s, a significant part of research in science education has focused on identifying students' ideas across a wide range of scientific topics and ages. This research has found that children form ideas about several physical phenomena at a very early age, before receiving any formal education, from events they experience and observe every day in the natural world. These ideas are usually in conflict with the scientific account and have thus been termed as mis-, alternative, pre-, pre-instructional, prior, naive and intuitive conceptions. Amongst the topics that have received attention is that of elementary astronomy which has been seen as a fruitful and attractive area in investigating how students, especially of younger age, combine practical observation of their own world with views that they have been taught, cultural artefacts and information, developing thus their ideas and understanding of related phenomena. The present paper presents the results of a study which investigated Greek primary school children's ideas about day/night cycle and alteration of seasons. A total number of 35 students from the fifth and sixth year of their primary education were asked to explain these two astronomical events and provide a drawing of their ideas. Their ideas and drawings revealed considerable apparent inconsistencies in terms of related concepts like the shape of Earth and its motion. For example, many of the students expressed the idea that the Earth is moving relative to the Sun to explain the day and night cycle but stated that the seasonal cycle is the result of the Sun moving relative to the Earth. A great deal of this apparent inconsistency could be explained by the Knowledge-in-Pieces (KiP) framework, according to which knowledge is viewed as a complex system composed of fundamental elements that are cued into an active state in response to a question, and its context, thus giving rise to students' ideas. The paper discusses students' ideas in these two basic astronomical events while also draws on the KiP framework and knowledge elements identified in the literature to account for the inconsistencies in students' ideas of day/night cycle and alteration of seasons. The findings of the study underscore the need to further examine the role of the knowledge students bring with them to learning events, in and outside the science classroom, and how this knowledge is likely to affect their understanding of phenomena.

Keywords: Misconceptions, P-Prims, Elementary Astronomy, Primary Students' Ideas

1. Introduction

Since the early 80s, a significant part of research in science education documented that student form ideas and reasonable, from their point of view, explanations about natural phenomena long before they enter primary education [1], [2]. These ideas are very resistant to change and are maintained until students leave compulsory education and beyond [3]. From a constructivist perspective, they are the result of students' attempts to understand the natural world around them through a personal and idiosyncratic meaning-construction of their everyday life experiences.

1.2 Students' misconceptions

A variety of terms has been used to describe these ideas and whilst their usage and definitions vary and are dependent on the philosophical positions of those using them, they could be regarded broadly as synonyms rather than referring to fundamentally different concepts [4]. Indeed, all of these terms have been used interchangeably to describe students' ideas that share some common characteristics. According to these common characteristics, students' ideas: a) are strongly held and stable as structures, b) differ from the ideas scientific experts hold, c) strongly affect students' understanding [5].

In this article the term misconception is used as a general means of describing students' ideas that share the above four characteristics. The prevailing view on misconceptions has been that these ideas are either formed prior to instruction, as has already been stated, or are the result of these prior ideas interacting with instruction (faulty or not).

These origins and properties of misconceptions have been reflected in instructional approaches that are mostly based on the classical approach to conceptual change theory [6]. The early work on this approach has been guiding research in science education for more than three decades, suggesting that science instruction involves the active and rational replacement of misconceptions with the scientifically acceptable ideas. It has, however, shown neither to be effective in terms of science instruction, nor consistent with science education research [7]. Students' ideas could not be extinguished on their entirety for scientifically acceptable ones to take their place and more often they continue to co-exist with them thus influencing their interpretation and creating hybrids – i.e., an amalgamation of prior to instruction ideas with the scientific one's students are taught [8].

1.3 Coherence vs. fragmentation of students' knowledge that give rise to misconceptions

In much of the research conducted on misconceptions, it has been maintained that students' ideas derive from a coherent and consistent knowledge [9] to which students are highly committed [10]. Amongst these approaches of viewing students' ideas as having the characteristics of theories is the coherence perspective [9] according to which students, at any time, possess a limited number of fully-developed and coherent theories. Although these theories are scientifically incorrect, they have such an explanatory power that can be used to make consistent predictions across different situations and give rise to explanations of phenomena and observations.

On the other hand, from a knowledge-in-Pieces perspective, students do not hold unitary ideas in the form of theory-like misconceptions but rather, a fragmented collection of knowledge structures which gives rise to these misconceptions and has none of either the systematicity or coherence attributed to theories. These knowledge structures consist of, but are not limited to, phenomenological primitives (p-prims for short) that are phenomenological in the sense that they are minimal abstractions derived from experiences and closely tied to familiar phenomena and primitive in that they require no further explanation [11].

1.4 Students' ideas in elementary astronomy

Some early research on students' misconceptions has focused on elementary astronomy, showing that primary school students have difficulties in understanding that the day/night cycle is caused by the Earth's axis rotation [12] and seasons by the Earth's tilted axis [13]. In the case of seasons, students usually explain the phenomenon in terms of the Sun being closer to the Earth in the summer than in winter, or that that Sun is being blocked by clouds in the winter [13]. Similarly, they believe that the Sun is being blocked by clouds at night, or that the Sun is on the other side of the Earth [12] where it is day.

This paper reports on a study which investigated students' ideas of these two elementary astronomy phenomena and discusses some of the ideas identified by drawing on the KiP framework and knowledge elements identified in the literature to account for inconsistencies in their explanations of these two phenomena.

2. Methodology

The paper presents the results of a study which investigated Greek primary school children's ideas about day/night cycle and alteration of seasons. Being a small-scale study, the sample was composed of students from two different schools with 20 from the first school in grade 6 (aged 11-12 years old) and 15 from the second in grade 5 (aged 10-11 years old).

The schools and students were selected opportunistically, and the selection was principally concerned with ensuring a typicality of Greek primary schools and, to the extent that was possible given the small study sample, "naturalistic coverage" [14, p. 75].

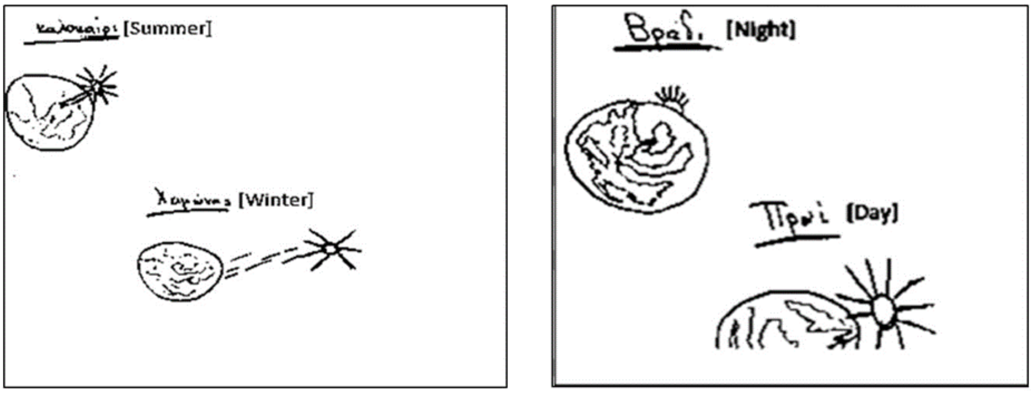
They were, therefore, selected in a way to ensure a very broad representativeness in terms of students' ability and their socio-economic background.

2.1 Materials

A paper-and-pencil questionnaire of two sections was designed and administered to the students. One section was concerned with day and night cycle and the other with seasons. In both sections, students were asked to write their explanations of these two phenomena and also provide a drawing about these explanations. Two more questions in both sections were asking students about the place of the Sun and the moon during night and daylight times, winter and summer for day/night and seasons phenomena respectively.

3. Results and Discussion

The ideas that students expressed are in agreement with those identified in other studies of similar age groups [12], [13]. For example, many of the students from both age groups explained that it gets hotter in the summer because the Sun moves closer to the Earth. Perceiving such an idea as being deriving from a theory-like knowledge would imply that it was, as a whole, part of these students' knowledge system and existed in some form in their minds prior to being questioned about why it is hotter in summer than winter in the questionnaire. In this way, the question triggered the access of that knowledge which led students to express this misconception about seasons. In the same vein, the same theory-like knowledge would have been accessed in a similar question about why it gets colder in winter with the Sun, in this case, moving away from the Earth (or the Earth from the Sun). From a coherence perspective, such a knowledge would have been part of a more fully developed theory about the Sun and Earth and their characteristics as celestial objects, like that of their shape and movements. In this sense, questions relating to other astronomical events, such as the day and night cycle that students were asked about, would have accessed relevant stored knowledge from that fully developed theory with the ideas, so derived, exhibiting consistency in terms of whether, for example, it is the Earth moving or the Sun in both phenomena. There were indeed some students who incorrectly explained that it is hotter in summer because the Sun moves away from the Earth (Figure 1a) and also explained day and night again in terms of a scientifically incorrect motion of the Sun (Figure 1b). However, there were also students who believed that the Earth moves closer to the Sun in the summer – hence it gets hotter – yet still understood the day/night cycle correctly or others who gave the same explanation for seasons but explained day and night because the Sun moves to the other side of the Earth at night.



a) b)

Fig. 1. A student's typical drawing explaining: (a) seasons by showing the Sun moving closer to the Earth in summer and further away in winter [15, p. 28] and (b) day and night cycle by showing the Sun moving relatively in front and behind the Earth [15, p. 42].

This inconsistency could be explained in terms of their ideas deriving from a KiP knowledge because it makes simultaneous reference to two incongruent explanations of the day/night cycle and seasons with respect to the relative movement of the Sun and the Earth. From a KiP perspective the explanation as to why it is hotter in summer than in winter can be understood in terms of the question activating the "closer means stronger" [5, p. 102] p-prim which connects proximity and intensity. This particular p-prim is axiomatic – i.e., needs no further explanation – and might have been abstracted from a number of phenomena students experience in their everyday life, for example, fireplaces are hotter the closer one sits to them and a light is brighter the closer one is to its source. When this p-prim is activated in situations in which there is an inverse square dissipation of energy it can lead to a scientifically correct explanation – e.g., sound gets louder the closer to a speaker. However, when activated in an inappropriate context like seasons here, it generates the misconception that it must be that the Earth is in closer proximity to the Sun in the summer raising the intensity of the heat. Similarly, the misconception of the Sun going to the other side of the Earth at night, could be perceived as being the result of an Ur-prim [16] – i.e., an even more fundamental than p-prims knowledge element – that could be activated when explaining causality and according to which “objects exist continuously in time and in space” [16, p. 414]. In this case, the cause of the day and night cycle is the movement of the Sun which, although being to the other side of the Earth at night, continuous to exist and results in being day on that side.

In concluding this paper, and although the differences between the two perspectives in terms of their relevance for instruction have been highlighted and discussed elsewhere in the literature [5], [10], it is suggested here that in terms of elementary astronomy instruction, as well as in other topics, what needs to be examined further is how these can be practically used by teachers in their attempts to challenge students' misconceptions.

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