



## ALTERNATIVE CONCEPTIONS OF ELEMENTARY SCHOOL STUDENTS IN ASTRONOMY

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### ABSTRACT

*Students do not come into formal instruction without any pre-instructional knowledge or beliefs about the phenomena and concepts to be taught in astronomy. Besides, Children develop their everyday concepts about the world based on daily observations, from text books and conversations with adults. During the process of acquisition of this knowledge, learners may view the world in the form of weird concepts which are deviant from accepted notion of knowledge, termed as alternative conceptions or alternative frameworks or misconceptions. The acquired knowledge of elementary astronomy is a part of basic scientific literacy. Alternative conceptions in astronomy are a road block to new scientific learning. If the alternative conceptions are not addressed at the elementary level, the probability of sustaining the alternative conceptions may continue at higher learning as well. Therefore, it is important for teachers to have a clear understanding of the alternative conceptions that students bring with them into the science classroom. This research paper attempts to identify alternative conceptions of elementary school students in certain astronomical topics like apparent motion of sun and moon, day and night, seasons, phases of the moon etc. The sample consists of 56 seventh grade students from a school in Hyderabad. An Astronomy test consisting of six open ended questions prepared by the researcher was administered to the students. Students' responses were analysed to elicit information about their knowledge and understanding of astronomical phenomena and to identify any alternative conceptions held by them. Results showed that students exhibited many alternative conceptions about these astronomical phenomena. Implications and recommendations were made for teachers to integrate well – constructed pedagogical design in the teaching - learning process, so that alternative conceptions in elementary astronomy could be redirected to conceptual change among learners.*

**KEY TERMS:** Science education, Astronomy, Alternative conceptions, Conceptual change

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### INTRODUCTION

Students cannot be thought of as empty containers to be loaded with the knowledge but rich with experience, knowledge and beliefs of their own understanding of the phenomena that occur in nature. Prior to beginning school, children have a wealth of experiences, and these have led them to develop a common-sense understanding of their social and natural environment. Children construct an initial understanding of the observed world based on their everyday experience from the environment, interaction with parents and friends, media, culture and socialization factors. They bring ideas that have formed from their daily experiences to their learning environment (Driver & Bell, 1986). Children synthesize (construct) their knowledge of the world based on two information sources—observations of the world and explanations given by other people (Kikas, 2003).

The Next Generation Science Standards (NGSS) are built on the notion that learning is a

developmental progression in which children continually build on and revise their knowledge and abilities, starting from their observations and initial conceptions about how the world works. They act as strong frameworks to interpret things that happen in classrooms and they help people to interact with their environment. It is these improper interpretations that are collectively known as alternative conceptions. Different researchers have labelled students' constructs that are alternative to the accepted science beliefs as misconceptions, preconceptions, children's science, alternative frameworks, non-scientific views, erroneous notions, private versions of science, synthetic mental models, unfounded beliefs, and naïve notions (e.g., Finegold & Pundak, 1990; Sneider & Ohadi, 1998; Vosniadou, 1991; Wandersee, Mintzes, & Novak, 1994). The preferred term used by many researchers is *alternative conception* because "it refers to experience-based explanations constructed by a learner to make a range of natural phenomena and objects intelligible, but it



also confers intellectual respect on the learner who holds those ideas" (Wandersee, Mintzes, & Novak, 1994, p. 178).

The term alternative conceptions refer to ideas that people have which are inconsistent with scientifically acceptable ideas. Sometimes these can be individual versions of students' understanding of concepts that have not been tested through scientific methodology. Following an extensive review of the research literature, Wandersee, Mintzes, & Novak (1994) generated "emerging" research-based claims relating to alternative conceptions in science:

*Students come to formal science instruction with a diverse set of alternative conceptions concerning natural objects and events.*

*The alternative conceptions that students bring to formal science instruction cut across age, ability, gender, and cultural boundaries.*

*Alternative conceptions are tenacious and resistant to extinction by conventional teaching strategies.*

*Alternative conceptions have their origins in a diverse set of personal experiences including direct observation and perception, peer culture, and language, as well as in teachers' explanations and instructional materials.*

*Learners' prior knowledge interacts with knowledge presented in formal instruction, resulting in a diverse variety of unintended learning outcomes. Instructional approaches that facilitate conceptual change can be effective classroom tools.*

Exploring children's misconceptions about the nature and natural phenomenon and the sources of their knowledge may strengthen the teachers' efforts to improve their teaching practices about science concepts. For meaningful learning to take place, teachers should consider what knowledge the learner already possesses. Knowing children's preconceptions will provide the teachers, information about the children's mental models that they have constructed before the instruction. "If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom" (How People Learn, Bransford, Brown & Cockling, p. 14-15).

By this way it will be possible to create instructional methods, strategies and aids that may help the students to change the wrong mental models and construct meaningful and useful ones. Therefore, teachers should be well informed about the alternative conception's children hold in order to facilitate conceptual change through effective strategies of teaching astronomy. In the course of conceptual development, the children eventually

revise these initial constraints and can acquire the scientific conceptions that is presented to them in the course of schooling (Samarpungavan et al., 1996). Therefore, this study attempts to explore children's knowledge about the basic astronomical bodies such as sun, moon and stars and astronomical phenomena such as day and night, occurrence of seasons and phases of the moon.

## SOURCES OF ALTERNATIVE CONCEPTIONS

The literature suggests that there are many reasons why students hold alternative frameworks about astronomical objects and events. A common problem is one of reconciling everyday experiences, such as observing the rising and setting sun, with abstract models, which attempt to explain why this occurs (Vosniadou, 1991). Another factor is the difficulty of interpreting two-dimensional diagrams, which attempt to represent three-dimensional space (Parker & Heywood, 1998) or from the enormous astronomical scales of size, distance, and time. Misleading diagrams and illustrations in the traditional science textbooks can encourage alternative frameworks (Ojala, 1992). Books in which text and diagrams do not correspond can also be a source of alternative frameworks (Vosniadou, 1991). A further reason child hold alternative frameworks could be that mythological beliefs of the society affect children's astronomical beliefs.

In India, children start learning rudiments of astronomy from primary classes, as a part of science or geography. Textbooks recount explanations of phenomena, but more in an informative fashion rather than as reasoned arguments. The use of diagrams is limited and not very carefully done. Consequently, even the diagrams are rote-learned and reproduced in examinations. Besides, in India many festivals and rituals are associated with astronomical phenomena. The lack of scientific temper and adherence to superstitions like astrology are found in the highest strata of society. Astrological beliefs are in direct conflict with astronomy, they hinder correct and scientific understanding of the world, promote wrong beliefs about the nature of science, and consequently hamper the development of scientific attitude. Astrological beliefs can be even more damaging, since they can lead to irrational decisions in daily life. Such beliefs are transmitted in groups by passive social influence and they do not change easily or simply in response to disconfirming evidence.

Alternative conceptions often result when new experiences are interpreted considering prior experiences, and new understandings are grafted onto prior understandings. Memories in general are retrieved by first recalling the schema and then the associated details. If a concept does not fit a pre-existing schema and is not at all that salient, it likely will be forgotten or even rejected. The origin of a



given alternative conception is often difficult if not impossible to determine. Misunderstanding, miscommunication, and even a misapplication of well-established physical principles leads to the formation of alternative conceptions. According to Neil F. Comins (1993) the following are the various sources for alternate conceptions: Factual Misinformation, Media Minimalism, Cartoons and Science Fiction, Mythical Concepts, Language Imprecision, Erroneous Personal Cosmology, Incomplete Understanding of the Scientific Process and Scientists, Incomplete Information / Reasoning, Misinterpreting Sensory Information and Inaccurate or Incomplete Observations.

### ALTERNATIVE CONCEPTIONS IN ASTRONOMY

Extensive research on children's cosmologies (primarily examining their understanding of the Earth, Sun, Moon, and stars as astronomical objects) has found that young children have constructed alternative frameworks that they use to interpret their world. Children's alternative frameworks also include their understanding of the Sun, Moon, and stars, how and why these objects move, and how they cause familiar phenomena such as the day-night cycle, seasons and phases of the Moon. According to Dunlop (2000), many children have difficulty understanding some concepts in astronomy, such as the size and shape of the Earth; the cause of day and night; the cause of seasons; and the movements of the Earth, the Sun, and the Moon. In this regard, Klein (1982) and Jones, Lynch and Reesink (1987) have found that only a few primary school pupils are able to model the relationships between the Sun, the Earth, and the Moon.

Alternative conceptions of students in these basic astronomical events that were documented in the previous research are presented here.

Children's explanations for the day-night cycle cover range of possible non-scientific mechanisms, including clouds occluding the Sun, the motion of the Sun (moving out into space, up and down on the ground, going to the other side of the Earth or going around the Earth), and that the Earth moves around the Sun (Baxter, 1989; Vosniadou & Brewer, 1994). These studies suggest that while elementary-aged children know that the Sun is involved in the switch from day to night, some may not be familiar with the apparent motion across the sky. Another prevalent alternative conception is that movement of the clouds causes day and night. Sharp (1995) examined 6-7-year-old children's conceptions of different astronomical phenomena after they had been involved in teaching activities targeting the various phenomena. The results showed that most children recognized the shape of the Earth and the Sun as spherical and indicated that the Sun is much bigger than the Earth. However, they could not provide adequate explanations for the day/night cycle.

Another common alternative conception is distance between the Earth and the Sun causes the seasons, an extension of this being that the Earth has a highly elliptical orbit, changing the distance between the Earth and the Sun (Starakis & Halkia, 2014).

Sharp (1996) in his study, found that the majority of 10-11 year-old children concluded that the Sun and the Earth resemble the shape of a sphere, but they did not know and did not readily accept that the Earth rotates around its axis. They were, furthermore, unable to relate this movement to the day/night cycle.

Children's explanations for the motion of the Moon also suggest that many children have a limited understanding of the apparent motion of the Moon. From elementary school through to college levels, the 'eclipse model' as an explanation for the phases of the Moon (in terms of the Earth blocking the light from the Sun and causing a shadow across the Moon) has been found to be the most commonly held alternative conception. (Trundle, Atwood & Christopher, 2002).

Radhakrishnan (2001) conducted a study to find the misconceptions of children in Kerala and revealed that, 95% knew that Sun rises in the East and 94% knew that Sun sets in the West. Only 25% said that Sun emits light at night also. About 75% said that Sun is the biggest star and about 55% said that we can replace Sun with Moon. About 80% said that Sun goes under the sea at night as they have seen it directly and in picture and videos. About 40% said that the position of Sunrise and Sunset changes over the year. Only 56% know that time of sunrise and sunset changes every day. Only 2% knew that sun does not come overhead every day.

Vosniadou and her colleagues conducted a series of experiments investigating children and adults' knowledge of observational astronomy. In addition to studies conducted in the USA, they collected data from children and adults in India (Samarapungavan *et al.*, 1996) and Greece (Vosniadou & Brewer, 1990). These studies have provided us with specific information on children's and adults' knowledge of the size, shape, movement, temperature, composition, and location of the Earth, Sun, Moon, and stars, and their explanations of phenomena such as the day-night cycle, the seasons, the phases of the Moon, and the eclipses of the Sun and the Moon. They showed that most children have well defined mental models (Vosniadou, 1992, Vosniadou & Brewer, 1994). They differentiated three types of models: (a) initial models that are derived from and are consistent with the observations of everyday life, (b) synthetic models that are the attempts to integrate scientific and everyday information, and (c) scientific models that agree with the accepted scientific view.

### PURPOSE OF THE STUDY

The main purpose of the study is to identify the alternative conceptions of elementary school students



about celestial bodies and basic astronomical events such as the sun, moon, seasons, day and night cycle and the phases of the moon.

### RESEARCH QUESTION

What types of alternative conceptions do elementary students' have about celestial bodies and basic astronomical events?

### METHODOLOGY

Based on the previous literature, the researcher framed a free response test consisting of five open ended questions. The following open ended questions were included in the questionnaire:

1. What is moving Sun or Earth?
2. Where did the Sun go at night?
3. What causes day and night?
4. How do seasons occur on earth?
5. What causes day and night?

This free response test was administered to a sample of 56 seventh grade students in a school at Hyderabad. The responses to this test were analysed. The main thrust of data analysis for this study is centred on the qualitative data generated from students' justifications for their answers/ responses to the open-ended questionnaire. The meanings from the statements and explanation given by the students are identified and interpreted in the following section.

### FINDINGS AND DISCUSSIONS

The study revealed that alternative conceptions do exist among students in the just mentioned astronomical concepts and phenomena. The alternative conceptions identified for each open-ended question are presented below with a discussion.

#### 1. What is moving Sun or Earth

This question was asked to find out whether students recognize that the Earth orbits around the Sun and the apparent motion of the sun. About 80% of the participants gave the correct response but without giving any supporting evidence or explanation about the apparent movement of the sun. Although all students had learned about the motions of the Earth, 20% of the participants were confused about what went around what. Some of their responses contained the following alternative conceptions:

*Sun moves around the earth once a day.*

*Sun moves around the earth, that's the reason we have day and night.*

#### 2. Where did the sun go at night

The analysis of the responses obtained to an item "where did the sun go at night" reveal that most of the students (80%) have scientifically correct understanding. Their response was "the Sun is on the

other side of the Earth during the night." Since the Earth spins on its axis once a day, sometimes we are on the side of the Earth facing the Sun, and sometimes we are on the side of the earth facing away from the Sun. Some students (12%) also expressed an idea that the 'Sun is *beneath* the Earth during night-time". Although this idea is closer to the scientific idea than some of the others, they are not thinking of the Earth as a sphere in space, but rather as an object with an absolute down direction—so that some celestial objects are above the Earth and others are beneath it. A few (8%) also expressed a flat Earth viewpoint by responding as the Sun being "below the horizon" or "over the horizon" in their explanation. The following alternative conceptions were found in their responses:

*Sun goes to the other side of the earth during the night.*

*We turn away from the sun at night and thus we cannot see the sun.*

*Sun goes beneath the earth.*

*The earth faces away from the sun due to its motion.*

#### 3. What causes day and night

This question was asked to find out if students can relate the earth shape and its spin to why we have day and night. Interestingly, children held naive views in explaining why the day and night occur. Although 43% of the students explained correctly what cause of day-night, 52% of the students have the misunderstanding and 15 % did not respond. Some of the responses of the participants clearly explain their alternative conceptions:

*Sun's moving down to the ground in the evening and coming up in the sky causes day and night.*

*Clouds move in front of the Sun and block its light.*

*It is caused by sun going around the earth once a day.*

Though some students gave the correct explanation that due to earth's rotation day and night occur but had a misconception that sun and moon are stationary at the opposite side and earth in the middle rotating. Some children explained day and night by extending their everyday experience with light. If the Sun is no longer visible, it must be hiding behind something, such as behind clouds, mountains, or the Moon. The daily usage of words such as sunset and sunrise have caused misconception in the children that sun goes up and down which causes day and night. The same findings were recorded in the study conducted by Sadler (1987). The children provided accounts of the alternation of day and night in terms of the sun going down behind the hills or being covered by clouds, or they gave explanations based on the notion that the sun revolves around the earth



or that the earth revolves around the sun or rotates around its axis. There was one explanation identified by Sadler (according to which the moon blocks the sun at night) which was not identified in the present sample. Also, in the study conducted by samarpungavan et al. (1996) the Indian children who explained the day-night cycle say that the sun and moon go down into the ocean underneath the earth. This idea was not found in the participants of this study.

#### 4. How do seasons occur on earth

It was found that students have alternative conceptions about the phenomena of day and night. Out of 56 participants, just 10% of the participants completely and accurately answered the question, 41% participants replied that the seasons were related to the tilt of the Earth, and 49% participants answered incorrectly. The correct answer to this is: seasons on the Earth are the result of the angle of the Sun's rays. The different alternate conceptions surfaced in their responses were:

*Seasons are caused by the Earth's distance from the Sun (the distance model)*

*The Earth comes closer to the Sun during summer and moves away in Winter.*

*Clouds in winter block light coming from the Sun weakening it.*

*The Sun is hot in summer and cool in winter.*

Some mentioned that the direction of the Sun's rays caused the seasons but made no specific mention of the Earth's tilt. A few commented that the Earth faces away from the Sun in winter, evidently confusing winter with night. Some students also discussed about climate which is not the effect, but the cause for seasons to occur. The dominant alternative concept for the cause of seasons was that the distance from the Sun to the Earth changed during the year; when the Earth is closer to the Sun, we experience summer and when the Earth is farther, we experience winter. This has been the dominant research findings in many studies.

#### 5. What causes the phases of the moon

The analysis of student responses for the *moon phases* showed another misconception area of astronomy for young children. In this study, only 10% of the participants gave the correct explanation and majority of the participants (90%) held common alternate conception about the cause of Moon phases which are caused by the Earth's shadow. Some of their responses which contained misconceptions are:

*Clouds cover the part of the moon that we cannot see;*

*The shadow of the earth falls on the moon, blocking our view;*

*Phases of the Moon are caused by the Sun covering Moon.*

It is very clear why students have misconception about the moon phases because the phases are explained in terms of the portion of illuminated side of the moon visible from the earth. Students' conceptions of the lunar phases are divergent from the scientific perspective, yet they also have components that are consistent with it. It appears that some students adopted some scientific information such as the moon's revolution around the earth or the observed shapes of the moon. However, they also constructed their own notions that are inconsistent with the scientific view. For example, some students asserted that cloud coverage determines the lunar phases, whereas others believed that one's location on the earth with respect to the moon's position determines the lunar phase.

The results presented in this research indicate that there are many such mixed models expressed as alternative conceptions about simple astronomical phenomena in students' responses. The majority of grade 7 students in this research held alternative conceptions or were unable to provide a scientifically correct explanation about concepts that are supposed to be covered in primary school such as, the causes of day and night, the lunar phases and the seasons.

### TEACHING FOR CONCEPTUAL CHANGE

The influence of everyday experiences, mythological beliefs, and teaching tools used in the schools was found to be a key reason for the alternative frameworks held by students. A failure to address students' alternative conceptions could lead to an inability on the part of the students to understand subsequent concepts. Assessing students' knowledge base and using appropriate teaching tools and methods would foster students' understanding and help reduce their alternative conceptions regarding astronomical concepts and events.

Traditional teaching methods (whole class instruction, failing to consider students' preliminary knowledge, too little time for discussions, too much emphasis on factual knowledge) have proven inefficient in changing children's preliminary knowledge if it is consistent and conceptual change is needed (e.g., Diakidoy & Kendeou, 2001; Vosniadou et al., 2001).

The most important single factor influencing learning is what the learner knows. Ascertain this and teach accordingly (Ausubel, 1978). Research has shown that preconceived ideas in science develop early in a student's experience and can be tenacious. Sometimes these ideas are congruent with scientific knowledge. Other times they conflict with the scientific view. This formation of students' conceptions, which may be correct, partially correct,



or incorrect, continues throughout their school years. If these ideas are ignored, they may get in the way when new ideas are introduced. They simply do not go away, even as students' progress from elementary grades to middle school and even into high school and adulthood. Thus, simply presenting a new concept or telling the learners that their views are inaccurate will not result in conceptual change.

Teaching for conceptual change primarily involves 1) uncovering students' preconceptions about a topic or phenomenon and 2) using various techniques to help students change their conceptual framework. Teaching for conceptual change requires a constructivist approach in which learners take an active role in reorganizing their knowledge. Cognitive conflict strategies, derived from a Piagetian constructivist view of learning, are effective tools in teaching for conceptual change. These strategies involve creating situations where learners' existing conceptions about phenomena or topics are made explicit and then directly challenged in order to create a state of cognitive conflict or disequilibrium. Cognitive conflict strategies are aligned with Posner's (1982) theory of conceptual change in that their common goal is to create the four conditions necessary for conceptual change. That is, learners must become dissatisfied with their current conceptions and accept an alternative notion as intelligible, plausible, and fruitful.

The goal of teaching for conceptual change is for students to adopt more fruitful conceptions while discarding the misconceptions they bring to the learning environment. Science educators should create such learning environments in which the children meet challenges that can encourage them to activate and evaluate what they already know in the light of scientific knowledge that they encounter in the school. By this way it will be possible to promote a conceptual development which is consistent with our existing scientific knowledge about the nature.

To promote conceptual change teacher should integrate educational technology, such as 2D models, 3D visualization, animations, movies, formative assessment probes, concept cartoons, interactive simulations, kinesthetics and use the planetarium as an educational resource (Türk & Kalkan, 2015) which can offer explanations from two different reference systems (from a point on the Earth's surface or from a point external to the Earth).

## CONCLUSION

The results of study showed that many seventh graders possess very limited ideas about the apparent motion of celestial bodies, day and night cycle, phases of moon and seasons. There some reasons why students encounter difficulty of understanding about the Earth-Moon-Sun concepts. Common reasons are one of reconciling out of school experiences, such as observing the rising and setting sun, seeing stars only at night, moon during the night,

school experiences, such as misleading diagrams, ambiguous terminology (rising sun, setting sun) and inappropriate teaching methodology used by teacher. The findings of this study may provide impetus to teachers and curriculum developers for designing classroom activities and teaching strategies that could address students' alternative conceptions in astronomy related topics and textbook writers to provide ample visualisations, graphs, concept cartoons, and explanations to bring more conceptual clarity to the readers. These inputs might be helpful for the science teachers to use strategies such as conceptual change model to transact the concepts and subsequently science learning of students especially astronomy related topics may be optimised.

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