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Stories as a Pedagogical Tool for Teaching-Learning of Basic Astronomy

Abstract

The study explored the influence of story-telling onprimary grade learners' intuitive conceptions about the relative movement of the Sun, Earth and Moon (SEM) and related phenomena (day and night, phases of moonMoon). It was observed that learners possessed a great deal of narratives heard or read from various sources as Sun, Moon and other planets are deemed to be of religious importance in the Indian context. These alternative conceptionsdiffered significantly from scientifically accepted conceptions. Also, learners had little to no understanding of the actual cause cause-and and-effect relationship involved in the phenomena. Designing and enactment of modules to address these preconceptions using story-telling as a pedagogical strategyenabled learners to establish scientifically accepted conceptions, which were assessed using questionnaires and rubrics.
Keywords: Astronomy, story-telling, primary grade learners, pre-conceptions

Introduction

Knowledge about learners' ideas has been recognised as an essential component of teacher knowledge (Shulman, 1986). For designing effective learning environments that contribute to conceptual understanding, teachers must be aware of the learners' preconceived notions, learning difficulties, domains of interest and alternative conceptions. According to the constructivist approach to learning, new knowledge is actively constructed by an individual by the complementary processes of assimilating the new information or accommodating schemes to adjust the incoming information. Viewing learning from this perspective requires a paradigmatic shift from the traditional pedagogical approaches where learners are perceived to be 'empty vessels' to be filled with scientific knowledge to learner-centred teaching-learning. National Curriculum Framework 2005 (NCF 2005) calls for the need to embed teaching-learning processes within the learners' experiences and context. This view recognises that children have naïve ideas about various physical phenomena. These ideas are formed due to the everyday activities that a child engages in as part of his/her sociocultural milieu, such as fictional stories given in textbooks, folklore, media exposure in the form of cartoons, movies, etc. However, these conceptions might be in contradiction with the scientifically accepted ideas and recognising these alternative conceptions is integral to bring about a conceptual change. Pointing to the tenacity of the preconceptions, Ausubel (1968) claimed that these naive ideas are resistant to change. Promoting conceptual change requires designing of effective learning environment that allows learners to become cognizant of their existing ideas and address their deeply embedded pre-suppositions through engagement with external representations and models (Vosniadou et al., 2001). This requires the teacher to provide opportunities to learners to express themselves and share their conceptions. Pintrich et al. (1993) argued that apart from the cognitive factors, the motivational beliefs of students and the classroom context plays a significant role in

inducing conceptual change. Motivational factors including learners' interests, choice of a task, persistence at a task, control beliefs and self-efficacy are important in influencing learning in the classroom (Pintrich et al., 1993). Storytelling is one such pedagogical tool that manages to engage learners with educational experiences that interact with their emotions as well as their intellect (Joubert et al., 2019). It allows learners to engage with the content through the powerful visual imagery which enables them to make personal and emotional connections (Morgan and Dennehy, 1997). Moreover, storytelling can be a powerful way to nurture engagement with science as it offers a meaningful context to conceptualize scientific ideas by encouraging emotional, imaginative and analytic responses (Banister & Ryan, 2001). Being an effective medium of communication between the teacher and the learners, stories stimulate vivid images in children's minds and help them grasp content more engagingly.

Introducing astronomy at the elementary level to young learners promotes their curiosity and nourishes their imagination around the naturally occurring phenomena such as day and night, our place in space and time, and existence of stars (Plummer, 2009). We teach calendars, time and directions starting from a young age to learners and many research studies have pointed out that the learners have various conceptions relating to basic astronomy which are acquired through personal experiences and media. Astronomical concepts and images have a universal appeal, inspiring wonder and resonating uniquely with human questions about our nature and our place in the universe. This widespread interest of children in astronomy can be tapped not only to enhance their knowledge but also to illuminate them on the nature of science.

Against this backdrop, the present study explores the possibilities of using stories for teaching concepts related to basic astronomy in the context of a primary classroom.

Research Questions

The following research questions guided the study:

1. What are the intuitive ideas of primary school learners about the concepts related to basic astronomy?
2. Can these intuitive ideas be addressed to build a scientific understanding about basic astronomy in a primary classroom?
3. How can storytelling be used as a teaching strategy to develop scientific understanding about the concepts related to basic astronomy?

Context of the Study

This research study was conducted during a 4-month long teaching internship in a government school as part of a teacher preparation programme, namely, Bachelor of Elementary Education Programme offered by the University of Delhi. This study was conducted with 26 learners of Grade 4 studying in a government school of Delhi, India. Most of the learners belonged to economically weaker sections. The learners learn about calendar, time, seasons, space travel and many more related ideas as part of the primary school curriculum. They are exposed to these ideas through children's literature as well. However, no formal, explicit attention is given to the scientific reasons and causes for such physical phenomena. The researcher, during her classroom interactions, observed that learners had various conceptions about basic astronomical concepts acquired through variety of formal and informal experiences. This study used a qualitative approach to probe children's thinking about the astronomical concepts within the context of the curriculum of Environmental Studies.

Data Collection

The complexity of classroom processes cannot be captured by a single instrument. Particularly, an assessment of the learners' understanding requires a combination of

approaches that can collect information about the learners' thinking. In this regard, data was collected from multiple sources including classroom observations, focus group discussions (FGD), learners' drawings, questionnaire and rubrics. Learners' preconceptions on the concepts related to the relative movement of the Sun, Earth and Moon and related phenomena (space and time, Cause of day and night, relative movements of Sun, Earth and Moon, and phases of Moon) were probed through focus group discussions and representational diagrams. For FGDs, groups of 6–7 learners were formed randomly. Along with verbal participation, learners were allowed to draw their interpretations of the world around them. They drew diagrams and gave verbal explanations for the same. These diagrams were assessed by the researcher/ teacher using a rubric. The responses of the learners were recorded and later transcribed verbatim. A rubric was used to assess the representational diagrams in terms of the learners' notions of proportion and positioning of the celestial bodies in relation to each other and animistic thinking. This was followed by design and enactment of an intervention planned with the learners, which included storytelling sessions followed by activities to reinforce their learning. A structured questionnaire was designed and implemented to assess the change in conceptions of the learners after the formal instruction. During the intervention, several stories including the adapted version of *The Story of Time by Nita Berry, What Makes Day and Night* by Franklyn M. Branley, the adapted version of *Time to Shine* by StoryBots, *Earth's Tilt* by NASA and a picture book titled देखो चाँद by S. Rao & Marudu were taken up with the learners and a checklist was used to keep track of learners' participation in storytelling sessions conducted throughout the learning cycle. Interaction with the learners was recorded during these sessions and transcribed later. Rubrics were used to assess learners' performance in various follow-up tasks of the storytelling sessions. The objective was to look for their concept clarity, their thought process in the selection of objects to represent celestial bodies, the accuracy of those objects and the space vocabulary they employ in order to explain the concept. In the post-instruction phase, a structured questionnaire was designed and implemented to gather information on the understanding of relative movement of Sun, Earth and Moon and related phenomena. The questions included a number of diagrams and concept cartoons as the pedagogy was centred around developing visual mental models using stories.

Data Analysis

The data collected from the responses of the participants in the pre-instruction focus group discussions and the post-instruction questionnaire was classified, tabulated and analysed qualitatively. These were correlated with the participants' pictorial representations for an in-depth understanding of their conceptions. The data collected was descriptive and captured viewpoints of the participants. The responses were organised according to themes predefined during the course of the study based on the astronomical concepts addressed. The responses of participants falling into the respective categories were recorded.

Results

The focussed group discussions revealed that the learners have preconceptions regarding all of the phenomena relating to the characteristics and the relative movement of the Sun, Earth and Moon. The preconceptions were categorised under various sub-themes such as notions about Sun and Moon, the concept of shadow, the day and night, and the phases of Moon.

Notions about Sun and Moon

The learners perceived Sun and Moon to be god-like figures created by nature. They believed that Sun, which emits heat, is a

grumpy celestial body since it is always hot, and Moon is the calm one because it always provides us a cool atmosphere at night.

Table 1: Frequency of Learners' Preconceptions about Sun and Moon

Preconception	Frequency
Moon is a star because it is made up of many small stars	04
Moon shines white and sun gives yellow light, white ones are stars	24
Sun and Moon are gods, Sun, a grumpy one and Moon, a calm one	17
Sun shines in the morning and moon shines at night	25
Moon used to shine before but then Lord Ganesha cursed him	02
We live on a planet called Earth	26
Earth only rotates; it doesn't revolve	23
Earth revolves around both Sun and Moon	03

Table 1 lists the learners' preconceptions that emerged during focussed group discussions. All learners except one said that Moon gives its white shine at night and Sun gives it yellow light in the day. On the other hand, two learners believed that Moon used to shine but after Lord Ganesha's curse, it lost its shine. Hence, there is no light it emits. When asked if Sun or Moon is a star, 24 learners responded that Moon is a star because stars are white in colour, and 4 of these learners further said that Moon is composed of numerous small stars taken together. These responses illustrated their unfamiliarity with the relative sizes of the celestial bodies. Learners' conceptions were found to be based completely on what they were able to observe with the naked eye and stories they had been told in their community.

All the learners were aware that the Earth is in some sort of motion. Most of the learners (23) believed that it only rotates and 3 learners insisted that it only revolves around Sun and Moon. All the learners ruled out the possibility that Earth could possibly be rotating as well as revolving. Diagrammatic representations showed that no learner could depict the correct relative position of the three celestial bodies in the solar system. Apparently, it was observed that 16 learners out of 26 thought that the Sun, Earth and Moon were living beings and drew features of human beings such as facial expressions, hands, etc. on these celestial bodies. Only 1 student could identify the correct proportion in size of these 3 bodies. (Figures 1 & 2)

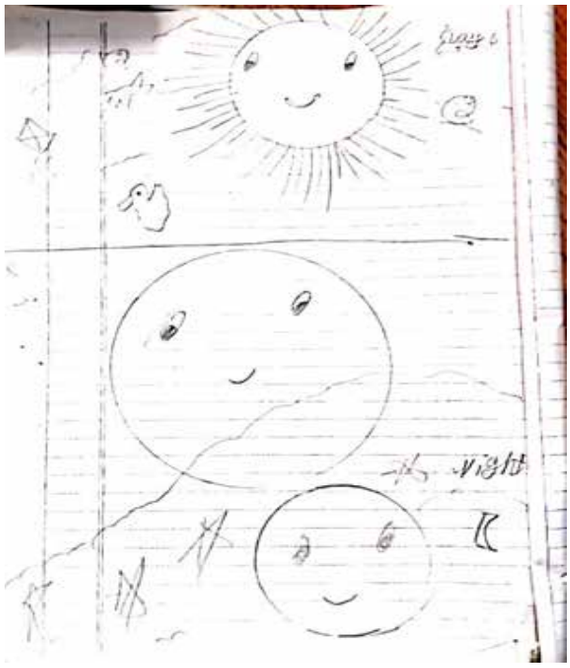
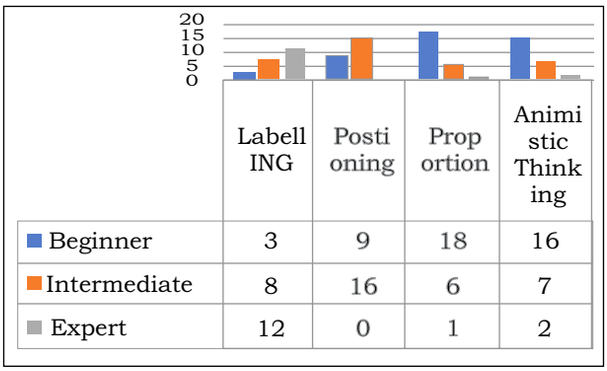


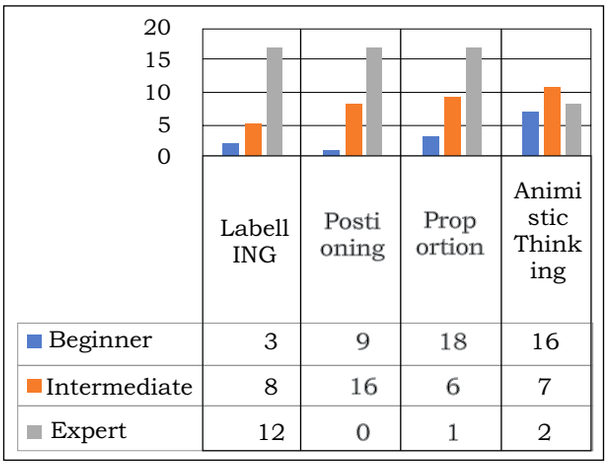
Fig. 1

Fig. 2



	Labell ING	Posti oning	Prop ortion	Animi stic Think ing
Beginner	3	9	18	16
Intermediate	8	16	6	7
Expert	12	0	1	2

Rubric 1



	Labell ING	Posti oning	Prop ortion	Animi stic Think ing
Beginner	3	9	18	16
Intermediate	8	16	6	7
Expert	12	0	1	2

Rubric 2

Students' diagrammatic representations of relative movement of Sun, Earth and Moon before (Rubric 1) and after the intervention (Rubric 2).

The assessment of the change in students' ideas following the intervention showed a shift in the learners' understanding towards scientifically accepted ideas (Rubrics 1 & 2). As illustrated above, out of 26 learners, 17 were able to label the diagrams and position all the celestial bodies correctly (Figures 3 & 4). They were able to label Sun, Earth and Moon and represent their relative position in the solar system. 30 per cent learners showed the positioning of only 2 celestial bodies correctly (Figure 5). 14 learners drew all the models proportionate to each other. There was considerable progress in terms of labelling, positioning and proportion but 69 per cent of learners still displayed their animistic thinking as they assigned human like characteristics to one or more of the celestial bodies (Figures 3, 4, 5).

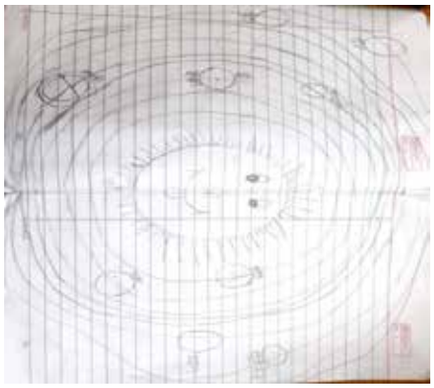


Fig. 3

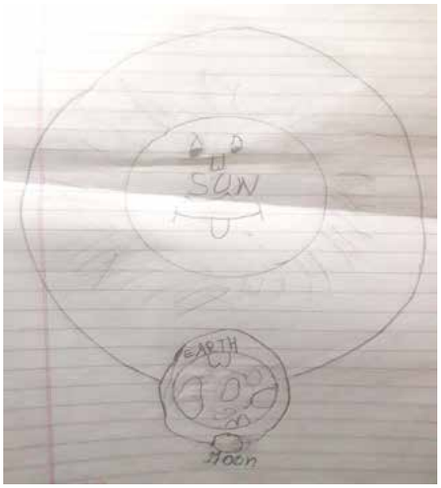


Fig. 4

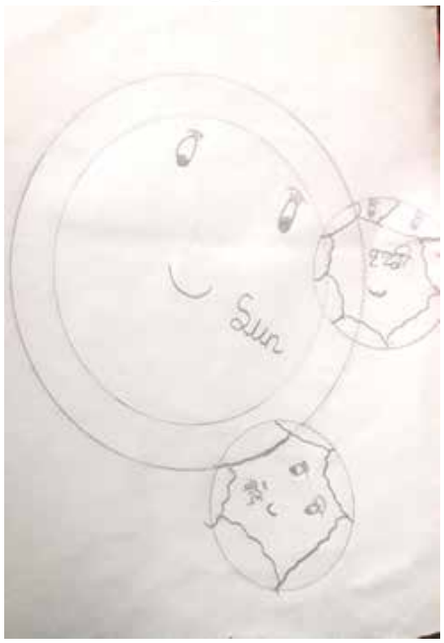


Fig. 5

Table 2: Learners' Conceptions about Sun, Earth and Moon in the Post-intervention Questionnaire

CONCEPT	CONCEPTION	FREQUENCY
Rotation and Revolution	a) Earth's spinning motion is rotation.	17
	b) Earth revolving around Sun is called rotation.	09
	c) Earth revolving around Moon is called rotation.	0
Relative motion of the Sun, Moon and Earth	a) The Moon and Sun revolve around Earth in the same orbit.	0
	b) The Sun and Moon revolve around Earth in concentric orbits.	03
	c) Sun and Moon orbit around Earth, with Sun on the left and Moon on right.	0
	d) Earth orbits around Sun and Moon orbits around Earth.	23
Characteristics of Moon	a) Moon stores light and releases it at night.	0
	b) Moon gives away light from Sun.	21
	c) Moon gives away light from Earth.	05

Table 2 depicts the change in learners' conceptions in the post-intervention questionnaire. Sixty-five per cent of the learners correctly identified Earth's rotating motion and distinguished it from Earth's revolution around Sun but 35 per cent of the learners still had confusion in distinguishing between the two types of motion (rotation and revolution) of Earth. For the relative movement and positioning of the Sun, Earth and Moon, 88 per cent of the learners selected the right model and also illustrated it diagrammatically. 12 per cent of the learners that is, 3 learners chose the model in which Sun and Moon both revolved around Earth, but they did understand that Moon is closer to Earth than the Sun. With respect to the characteristic properties of Moon that is, it shines or not, 80 per cent of the learners answered that Moon doesn't have light of its own.

Cause of Day and Night

Learners' naïve ideas revealed a geocentric model of the universe, that is, everything revolves around Earth be it Sun or Moon. While 5 learners believed that Sun goes around Earth during the day and the Moon revolves around Earth during the night, 6 of them believed that Sun and Moon come up in the sky and go down behind the mountains at their respective time, thus, indicating Earth-based observations.

Table 3: Frequency of Learners' Preconceptions with regard to the Cause of Day and Night

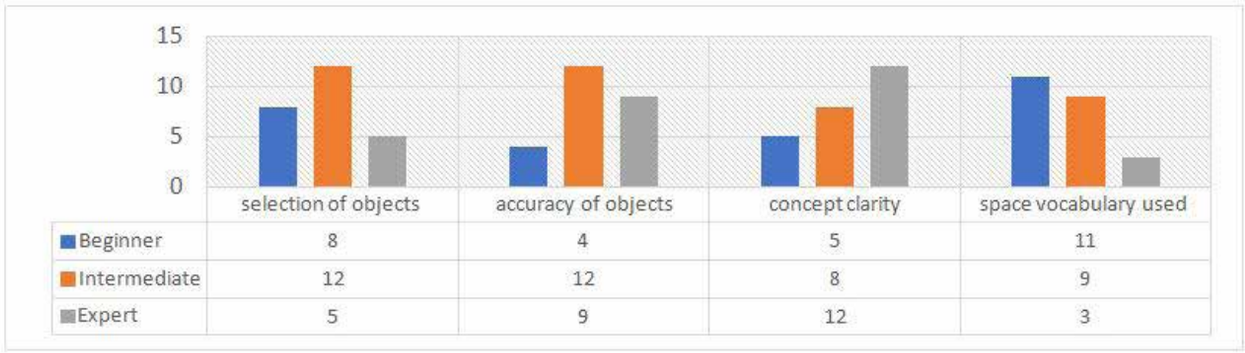
Preconception	Frequency
Sun orbits around Earth in day and moon orbits at night	5
Sun is at the right-hand side of Earth, and Moon is at the left. Earth spins in between	8
Sun comes out from hiding and sets again behind the mountains at 6 in the evening	6
Sun and moon orbits along the same path around Earth, but remain on opposite ends. When it's daytime in India, it's night in America.	4
Earth orbits around Sun in the day and around Moon at night	3

When asked about the distance of Sun and Moon from Earth, learners believed that Sun and Moon are in the sky with nearly no distance among the three celestial bodies. Eight learners were of the view that Earth spins between stationary Sun on the right-hand side and Moon on the left or vice-versa. So, when Earth faces Sun, it is day and when it faces Moon, it is night. It is interesting to note that learners associated Moon with night and nobody shared any observation of seeing Moon in the daytime

as well. Four learners believed that Sun and Moon revolve around the Earth in the same orbit causing day in the part exposed to Sun and night in the other part (where Moon is present). Moreover, 3 out of 26 learners believed they see Sun during the day and Moon at night as result of Earth's revolution around sun during the day and around the moon at night. The children were found to be using the concepts of rotation and revolution interchangeably as per their convenience without recognising the difference between the two.

The use of models and storytelling sessions conducted as part of the intervention helped the learners in predicting what part of the globe would have a day and which part would have a night. Learners were also able to understand that one complete rotation of Earth makes it one complete day for us, using the globe and torch light that is, 24 learners out of 26 were able to grasp the concept using both these stories.

The following graph compares 25 students' (one learner was on leave) representations of the cause of day and night before and after the intervention.



Rubric 3 Concept of day and night using models

Rubric 3 gives an overview of learners' progress in the understanding of the concept of day and night. It was observed that 32 per cent of the learners used random objects like eraser, scale, notebooks to represent the celestial bodies and hence, were categorised to be at the beginner stage. Forty-eight per cent were at the intermediate level as they chose the same objects as were used in the story. Twenty per cent of the learners were in the advanced stage as they chose objects, which could rightly substitute the objects used in the story (balls of different sizes, and material). Forty-eight per cent of the learners clearly explained the cause of day and night on Earth using their models. The following discussion took place during a storytelling session of *The Story of Time*:

Learner 17: पर पहले के लोगों को नहीं पता चलता होगा ना टाइम का, घड़ी तो थी नहीं उनके पास

The teacher helped them recall how people in the story used to determine what time of day it was. The learners were amazed at how shadows could be used to predict time. They further explored the idea and made the observations mentioned below.

Learner 17: तो जब सूरज बिल्कुल हमारे ऊपर होता है तो परछाई ज़मीन के नीचे बनती है?

सूरज, बिल्कुल ऊपर वाली परछाई कहां बनती?

Simultaneously, the teacher demonstrated an activity of shadow formation using a pin and torch light.

Learner14: मैंने देखा है शाम को लंबी-लंबी परछाई बनती है |

Learner14 predicted: अब आदि - मानव को पता चल गया ना कि 5:00, 6:00, 7:00 व

8:00 बजे कितनी लंबी परछाई बनती है |

As evident from the responses, the learners understood the difference in the size of shadows with respect to Sun's position observable in the sky and shared their observations. One of the learners made

an interesting remark regarding Sun being stationary.

Learner 6: पर मैम सूरज थोड़ी ना ऊपर नीचे होता है, हम होते हैं ना |

Learner 7: हम नहीं होते पृथ्वी होती है |

Learner 17: पृथ्वी भी नहीं होती, पृथ्वी घूमती है |

Learner 2: रोज़ सुबह 5 बजे सूरज निकल आता है।

Learner 17: नहीं, कभी देर से भी आता है।

Learner 2: वो सर्दी में आता है, 7 बजे तक |

Thus, the learners tried to predict the relationship between the position of Sun in the sky during various seasons and its relation to time.

The storytelling session resulted in the learners sharing their own stories and analogies.

Learner 4: पृथ्वी वैसे घूमती है ना जैसे बॉल घूमती है; बॉल तो रुक भी जाती है पृथ्वी रूकती है क्या?

Learner 16: ऐसा होगा तो हमेशा ही धूप या हमेशा ही रात रहेगी ना फिर?

Table 4. Frequency of Learners' Conceptions in the Post-intervention Questionnaire

Concept	Conception	Frequency
Cause of day and night	a) Earth's revolution around Sun.	7
	b) Sun and Moon revolve around Earth; the part exposed to Sun experiences day.	1
	c) Sun and Moon go up and down in the sky.	0
	d) Earth's rotation, the part facing Sun experiences day.	18

The above table shows the result of the post-intervention questionnaire. It was found that 69 per cent of learners selected the correct answer for the cause of day and night on the Earth, while 27 per cent of learners selected the picture of Earth's revolution as the cause for the phenomena. Also, 100 per cent learners responded that a day consists of 24 hours.

Phases of Moon

Learners' preconceptions (Table 5) showed that 11 learners out of 26 felt that Moon originally has a crescent shape whereas remaining 15 learners believed it to be a sphere. Out of those 11 learners, 3 held the perception that Moon is originally a crescent and stars join in to form a full moon gradually day by day. But sometimes Moon breaks into pieces and gets restored to its original crescent shape. Eight learners believed that just as plants grow, die and grow again, Moon grows each night, then gradually dies and then grows again the next night.

Table 5. Frequency of Learners' Preconception on the Phases of Moon

Preconception	Frequency
Clouds hide Moon.	7
Smog in winter hides Moon.	1
Stars join in a crescent Moon to form full Moon.	3
Moon grows in size as the night falls.	8
Moon comes out in full phase and reduces in size gradually, completely disappearing in the morning.	5
Earth's shadow causes different phases.	2

Out of 15 learners, one learner's views were guided by the contemporary socio-scientific issue of increasing pollution in the city. He reasoned that we are not able to see a full moon phase during winter season as smog covers Moon in winter. Five learners were of the view that Moon comes out each night in a full phase but as the night grows, it reduces in size and disappears completely in the morning when it is time for Sun to come out. Two of the learners reasoned that it is because Earth casts a shadow on Moon due to the light coming from Sun that we see

different shapes of Moon each day but the Moon is actually a sphere.

The picture book used to show the various phases of Moon helped the learners recall their own observations and cultural knowledge related to it.

Learner 17: होली अमावस वाले दिन मनाते हैं ना ?

Learner 8: और Ma'am, दिवाली वाले दिन चांद नहीं निकलता तभी हम दिए जलाते हैं |

Learner 22: करवा चौथ वाले दिन भी पूरा चांद निकलता है |

Learner 12: एक और व्रत होता है जो मम्मी हमारे लिए रखती हैं वह भी चांद को देखकर ही तोड़ते हैं |

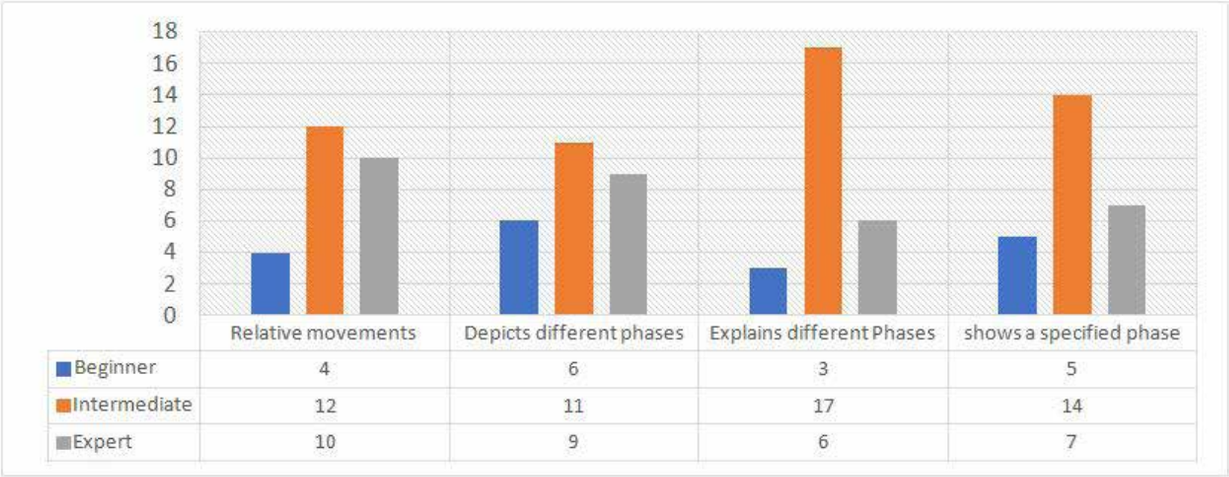
Out of 25 learners, 17 were able to make predictions about what Moon would look like next in the story. They counted the number of times it appeared to change in the book and reached to the concept of relating its phases with a month. Sixteen learners shared their experiences with different phases of Moon visible to them on various festivals.

The next storytelling session was planned to cater to these curiosities. An adapted version of the song by StoryBots' 'Time to Shine' was used to address learners' naïve conceptions. Learners' understanding was assessed using role-play activity planned for them in groups of three.

Their progress was recorded using Rubric 4 and the result of 26 learners is represented in Table 6. It is observed that 38 per cent of the learners were correctly able to depict the movement of all the three celestial bodies and 46 per cent were able to present with at least 2 objects correctly in place. 65 per cent of the learners were able to explain the cause, whereas, 76 per cent were able to depict the phases of moon with or without the help of their friends. Around 81 per cent of the learners were able to depict a specified phase of the Moon given by the teacher, with or without the help of their friends.

Table 6. Learners' Understanding of the Phases of Moon in the Post-intervention Questionnaire

Concept	Conception	Frequency
Shape of Moon	a) crescent b) spherical c) semi-sphere d) any other	4 22 0 0
Cause of the Phases of Moon	a) Clouds cover the Moon b) It dies and gets born every next day c) We only see the part on which Sun reflects light and is visible because of the relative positioning of Sun, Earth and Moon.	5 0 21



Rubric 4. Understanding of phases of moon through role-play

Specified Phase of Moon	a) Knows what the Full Moon phase looks like (and is acquainted with the space vocabulary)	26
	b) Does not know the Full Moon phase	0

The post-intervention responses revealed that 94 per cent of the learners selected the correct shape of the Moon, while 6 per cent still selected the crescent shape. Regarding the cause of different phases of Moon observable to us, 80 per cent of the learners could correctly answer the question while 20 per cent still believed that we see Moon differently each night due to the clouds hiding some or the other part of it. All the learners could predict the correct phase of Moon.

Conclusion

This study provides insights into learners' ideas regarding the relative movement of the Sun, Earth and Moon and the related phenomena. Learners' preconceptions were majorly shaped by various mythological stories and children's literature that they were exposed to. Hence, Sun, Moon and Earth majorly had a face in their diagrammatic representations as these were not celestial objects but God-like figures or objects. It was found that the learners possessed a great deal of narratives which were significantly different from the scientifically accepted conceptions. The study illustrated that selection of appropriate stories in the classroom can help the learners make a transition from their pre-causal thinking to acceptance of the scientifically correct conceptions. Storytelling, as a pedagogical strategy for the explanation of scientific concepts, was effective in nurturing learners' curiosity and provided opportunities to engage learners in making predictions, questioning and reasoning. The results of this study provide interesting insights into children's thinking and would be useful in planning a curriculum on astronomy for the primary grade learners in India. Further, it highlights the importance of storytelling as a pedagogical tool for teaching astronomy.

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