Evaluating Effectiveness of a Blended Module on Field

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Background

CLIx has designed six blended modules in the area of science pitched at the Grade 8 and/or 9 level (syllabi vary from state to state). Three of them fall under the domain of physics ('Basic Astronomy', 'Sound' and 'Understanding Motion') two under biology ('Ecosystem', 'Health and Disease') and one under Chemistry ('Atomic Structure'). These modules were implemented in the school since 2016 but there was variation in teacher preparation, infrastructure, availability of time and support teachers received from the schools and CLIx science team. Hence there was a large variance in the way they were implemented and their outcomes. Therefore, a systematic study of the process of implementation and effectiveness of CLIx modules was warranted. To reduce the failure in completing implementation of modules due to factors such as large classroom size, disfunctional of computer lab, absence or apathy of teachers etc. we decided to choose a limited number of schools (about 10) in best possible condition and study implementation and learning outcomes of one of the science modules. We chose Basic Astronomy module for this reason because it has a fair amount of digital activities (which are designed in-house), it maps well with one of the chapters and the science team (researchers) had an expertise to support this module. Details about the module are given in Subsection 'Material / instrument'.

In this report we first list the research questions specific to science study. The method section includes three sub-sections: In sub-section 'participants' we provide sample details, in sub-section 'Materials and Tools' we describe the module and other relevant material and the tools used in this study (they are provided as appendices) and in sub-section 'Procedure' we detail out the intervention. In the 'Findings' section we present the main results from the study and conclude the report by 'Discussions' which includes conclusions and limitations of the study. The ethical clearance of IRB is included in Appendix A

Research Questions

Following is the exhaustive list of research questions specific to science study.

1. Is the module helpful in changing common misconceptions and developing better understanding in the area of astronomy? (pre-post analysis)
2. Do students find the module interesting? Do they connect it with out-of-school life / their observations? Do they ask questions?
3. What kind of support do teachers need to implement the 'Basic Astronomy' module?

Methods

Although the overall process of module development and implementation followed the Design Based Research method, quasi-experimental design was adopted for this particular study. There were two groups of schools: 'intervention schools' and 'non-intervention schools'. In intervention school, students completed a pre-test before the implementation of the module in their classes. Then they went through the module. About 5 to 6 classes of intervention were observed in each school by a member of the science team. Most part of the module was taught by their regular teachers, however, the CLIx science team helped teachers in teaching some of the initial sessions. The teachers were given continual support on both content and pedagogy during the module implementation. The study was concluded with the post-test and teacher interviews.

Non-intervention schools followed the similar procedure, the only difference is, instead of teaching using modules, the teachers used their textbook chapter and taught using their regular method (without ICT). Two classes of each non-intervention school were observed by CLIx science team members.

The details of the procedure are given in subsection 'Procedure' and it is summarized in Table 1.

Participants

For this study, we chose thirteen schools in Jaipur district with the following criteria of selection:

1. Number of students in a class was less than 40.
2. Computer lab had a minimum of 9 terminals working.
3. Teachers were willing to participate: To ensure the authentic implementation of the module it was necessary that the teachers teach the module in their respective schools instead of allowing designers or experts to teach it.
4. Schools were not too far from Jaipur to allow for classroom observations

Table 1: Procedure of the study.

<table>
<tr><th colspan="2">Experimental schools</th><th>Control schools</th></tr>
<tr><th colspan="2">Period of Intervention: 20 August to 8 September 2018</th><th>Period of observations: 15 to 25 October 2018</th></tr>
<tr><td colspan="2">Teachers attended the first face to face workshop</td><td>NA</td></tr>
<tr><td colspan="2">Pre-test</td><td>Pre-test</td></tr>
<tr><td>Teachers taught half of the Basic Astronomy module (6 lessons)</td><td rowspan="3">* Total number of working days between pre and post-test (excluding the days of workshop) were 11 or 12 (typically included 12 lessons).
* 5 or 6 (average 5.5)classes were observed by science team member
* Observed classes and teacher interviews were audio recorded</td><td rowspan="3">* Teachers taught and students learned the chapter through their regular method.
* Two classes were observed by CLIx team member</td></tr>
<tr><td>Second face to face workshop for teachers was scheduled on 7th working day.</td></tr>
<tr><td>Teachers taught remaining half of the module (6 lessons)</td></tr>
<tr><td colspan="2">Post-test</td><td>Post-test</td></tr>
</table>

The teachers from the selected treatment schools were invited to a meeting to give an overview of the study. They had access to the module on their school computers, and we also provided a hard copy of the support material two weeks before the study started. However, we anticipated that teachers would not be familiar with the module by the onset of the study and would also require on-site support. Prior to the study start date, we held a one day face to face workshop in which we took the teachers through half of the module in the same way the students would experience it. Out of 13 teachers who indicated interest in the study, only nine teachers (6 females, 3 males) participated in this workshop, out of which one female teacher was to be on leave for the entire duration of implementation so we dropped her school and decided to conduct the study in eight schools. Another female teacher was also planning to go on leave for 3 days but she was willing to take extra classes and we thought we can take some of the digital activities during her absence. However, this teacher’s interest declined after she returned from the leave, she fell back and eventually could not finish even half of the module. So we dropped that school as well. Our final data comes from seven schools (See Table 2 for details).

Non-intervention schools were chosen on the basis of two factors: The number of students should be matching to one of the intervention schools and the socio-economic background of the students should be equivalent. We started with eight non-intervention schools out of which we could complete the observations in seven schools (one school had to be dropped because it declared holidays during the observation period). Details of these schools are given in Table 3.

Table 2: Participants from intervention schools

School	Students		Total Number of Students*	Teacher
School A	08 Boys	10 Girls	18	1 Female
School B	17 Boys	17 Girls	34	1 Male
School C	18 Boys	16 Girls	34	1 Male
School D	09 Boys	19 Girls	28	1 Female
School E	00 Boys	22 Girls	22	1 Female
School F	15 Boys	09 Girls	24	1 Male
School G	02 Boys	07 Girls	09	1 Female
Total	69 Boys	100 Girls	169	4 Female, 3 Male

Table 3: Participants from non-intervention schools

School	Students		Total Number of Students*	Teacher
School H	00 Boys	23 Girls	23	1 Female
School I	07 Boys	08 Girls	15	1 Female
School J	00 Boys	13 Girls	13	1 Female
School K	09 Boys	18 Girls	27	1 Male
School L	05 Boys	06 Girls	11	1 Male
School M	06 Boys	09 Girls	15	1 Male
School N	12 Boys	01 Girls	13	1 Female
Total	39 Boys	79 Girls	118	4 Female, 3 Male

*In both Table 2 and Table 3 we have given only those students who were present for both pre-test and post-test since those are the students we have used for data analysis. Actual number of students enrolled for that class are higher than that given here.

Materials and Tools

Hindi being the medium of instruction in the sample schools, Hindi version of all the material and instruments was used.

Material for students: The 'Basic Astronomy' Module

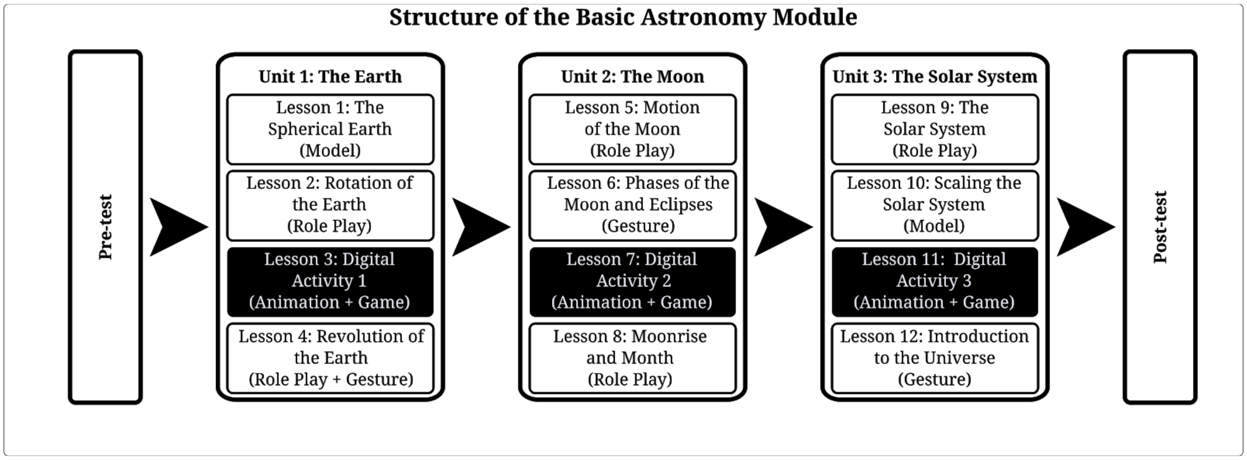
Basic astronomy is a part of most high school curricula. It includes an introduction to the solar system and explanation of easily observable astronomical phenomena such as the occurrence of phases of moon, eclipses and seasons. Research in science education shows that many students come to the classroom with alternate conceptions about the earth and astronomical phenomena (Vosniadou and Brewer, 1992, 1994; Padalkar and Ramadas, 2008).

Models in astronomy, such as that of the solar system, include spatial information such as size, shape, distances, relative positions and trajectories of celestial bodies. Understanding models and explanations of commonplace phenomena such as occurence of day-night, seasons, phases of moon and eclipses require visuospatial thinking. Our understanding of space is developed through the combination of visual, haptic, kinesthetic and vestibular perception. Hence, the corresponding external representations such as visual images (photos, diagrams and digital animations), handling of concrete models, gestures and bodily actions can play important roles in pedagogies which require spatial thinking. Padalkar and Ramadas (2008, 2011) proposed a pedagogy which used a sequence of concrete models, gestures & actions and Diagrams. We selected and appropriated some activities of the pedagogy proposed by Padalkar and Ramadas and combined digital activities in it to design a blended module to teach astronomy to high-school students.

The basic astronomy module was developed through design based research. Several pilot trials were conducted during its development, out of which some are documented in Chopde and Padalkar (2016). The first round of implementation took place in Rajasthan and the science team members were present to support it. Our experiences from the first implementation are documented in Shaikh, Chopde and Padalkar (2018). Based on the feedback from the field we revised the module and prepared the support material for teachers in form of text and videos. The module was conducted for the second time as a part of present study.

The module contains twelve lessons divided in three units (see figure 1). The third lesson of each unit is a digital lesson in which students directly interact with computers. Rest of the lessons are to be conducted in the classroom by the teacher.

Figure 1: Structure of the Basic Astronomy Module



The number of activities focused on different kinds of spatial representations in each unit are shown in Table 4.

Table 4: No. of activities focused on different kinds of spatial representations

Unit No.	Concrete Models	Gestures	Role plays	Diagrams (given + asked to draw)	Photos	Videos
1	3	2	5	17 + 7	0	0
2	1	1	5	11+6	8	0
3	1	1	1	3+1	23	2
Total	5	4	11	61+14	31	2

An example of a concrete model used in the module would be geosynchron which is a globe attached to a stand such that its axis is parallel to the actual axis of the earth (pointing towards Pole Star). The lesson in which the geosynchron is used includes putting it in direct sunlight and observing the time of day at different locations. Examples of gestures used in the module include the right-hand thumb rule to determine the direction of the rotation of the earth and to track the path of the sun in different seasons. An example of role play is mimicking the motion of the moon to understand why we see only one face of the moon (and motions of other celestial bodies to explain particular phenomena). Most of the explanations are accompanied by diagrams, or students are required to draw a diagram after they complete the role-play activity. Photos of most of the celestial bodies which are discussed in the module are provided and two short videos on stars and galaxies are also included in the end. Teachers are expected to show the photos and videos in the classroom and to initiate appropriate discussions about them.

Digital activities: We used multimedia principles of Mayer (2014) as guiding principles to design our digital content. All digital lessons are divided into two parts. In the first part, students see animations. The animations include representations from different perspectives (to convey the three dimensional nature of the systems) and are mainly emphasizing the motions of the celestial bodies. Some of the animations also morph into diagrams to help students see the correspondence between an animation and diagrams they regularly see in textbooks and classrooms. The second part of the digital lesson includes a sequence of a digital game called AstRoamer. The details of the digital activities are shown in Table 5.

Table 5: Details of the digital lessons

Unit No.	Lesson No.	Part 1: Animation	No. of Animations	Part 2: Game	Astronomy Concept	No. of demos + No. of clues
1	3	Rotation of the earth	4	AstRoamer: What's the time	Rotation of the Earth and time of the day	1 + 7
2	7	Motion of the moon	3	AstRoamer: Moon Track	Phases of the moon	1 + 7
3	11	Solar System	4	AstRoamer: Planet Trek	characteristics of planets	0 + 10

Apart from multimodality to facilitate the visuospatial thinking which is crucial in learning astronomy, three more guiding principles directed the design of the module: Collaborative Learning, Authentic learning and Learning from mistakes.

Collaborative Learning**:** Most activities in the module are to be done in pairs or groups. For example, in Roleplays students become different celestial bodies and mimic their motion. Given that the school labs have a limited number of computers (typically 10) and the number of students is at least 20, we expect that two students will use one computer when they are in the computer lab for the digital lessons. We have deliberately designed the first part of the digital game (AstRoamer: What Is the Time?) for two students to answer alternately so that students can discuss while solving the problems and hoped that it will set the trend for the rest of the activities.

Authentic Learning: India has a rich tradition of astronomy and has a variety of calendars (some are lunisolar some are lunar and some are solar). Since most of the festivals fall on a particular phase of the moon, students are well aware of the calendar used in their area. We tried to bring this aspect to the module by explaining terms used in the indigenous astronomy and designing the second part of the digital game (AstRoamer: Moon Track) around phases on different festivals. Incidentally, the terms used in indigenous astronomy and astrology are the same. We hoped that explaining them will demystify them and help students to think rationally about the astrological claims.

Learning from mistakes: In the digital game (AstRoamer), each trial has two chances. Case-specific feedback is designed which appears after the first wrong answer to help students find the correct answer. Teachers were also encouraged to ask open-ended questions to students and use their incorrect responses as a resource to engage in the discussion rather than giving immediate feedback in terms of right or wrong.

The module can be accessed at http://www.demo-clix.tiss.edu

Material for teachers

A Teacher's handbook (called 'Coursebook in context of online courses for CLIx teachers) was prepared as a support material for teachers to implement the module. It also included links of the YouTube videos of all the classroom activities which are to be conducted as a part of the module. Teachers were provided a printed copy of this handbook three weeks before the implementation. Teachers were required to go through each lesson on the module and then read the corresponding part from the Teacher's Handbook to understand how to implement it (See Appendix B).
We assumed that the teachers have access to the module on computer and hence did not give the printed copy of the module. But the teachers asked for it during the first part of the implementation, so it was provided to them during the second workshop (See Appendix B).

Tools for students

Pre-test: pre-test on platform included 20 multiple choice questions. The pre-test and the post-test were the same on the platform. However, we decided to revise these tests since we wanted to include questions of beliefs and attitudes. The revised pre-test included 20 questions based on the content covered in the earlier grades or things that students would know from simple observations or social interactions (19 were multiple choice questions and one question required students to draw a diagram), 5 questions on attitudes towards science and astronomy and two questions related to beliefs regarding astronomy (total 27 questions). Among the content related questions, roughly equal numbers of questions were based on each unit and they also tested different kinds of knowledge (observations, conceptual, cultural knowledge).

Since the revised pre-test included questions related to attitudes and beliefs which require students to respond on Likert scale and a new question to draw a diagram, we pilote tested Hindi version of this test with grade 9 students (5 girls and 6 boys) from a Hindi medium school in sub-urban area of Mumbai. Grade, medium of instruction and socio-economic background of the students was similar to the target students in Jaipur district of Rajasthan, where the test was to be used. We found that students understood how to respond on the Likert scale. We made minor changes in the formats and phrasing of the questions and finalized the pre-test (See Appendix C). Students were given 40 minutes to attempt the pre-test which was more than enough for most students. Some students had to borrow pencils and compass from their peers for whom the extra time was useful.

Post-test: The pre and post-test were not identical but were equivalent; the post test contained 5 extra questions on the content which was not taught in earlier grades but covered in the module (See Appendix D). Time allotted to students to attempt the post-test was 40 minutes.

Since we wanted quick access to the data, and conducting tests on computers at individual level would require conducting them in batches , we decided to conduct them on paper.

Students' workbooks: The module contains several questions where students are required to draw a diagram in their notebook. Since we wanted to access these diagrams to study what students understood, how they draw it and whether there was any progression in students' proficiency in drawings we compiled all these questions in 'Students' Workbook' (See Appendix E). Each student was given a copy of Students' Workbook, were asked to write their personal details on it and given time to draw in it. Teachers were told to encourage students to draw what they understood rather than copying the diagrams from the board.

Platform data: Each digital activity included one part of the 'AstRoamer'. These activities were application of the content they learned in the previous class. Each part contains 7 to 9 questions of similar kind.

a. Total scores Students responses reflect how much students have understood.
b. Incorrect answers to these questions provide data about what mistakes students made
c. Time spent on these tasks and the number of times they watched a particular video or played the game gives a sense of interest generated among students and whether they learned through successive iterations.
d. Observations during lab sessions provide data on collaboration among students, students' engagement and difficulties and teacher's role while students learn using ICT.

Tools for teachers

A survey tool was designed for teachers (Appendix F). Teachers were also given a chance to attempt the pre-test designed for students so that they are familiar with the questions and may also realize their own misconceptions during the course of learning.

Tool for classroom observations

Some of the classes in both intervention and non-intervention schools were observed by science team members. In intervention school, classes were observed to determine the fidelity of implementation and to provide on-site support. As mentioned earlier, the module was intended for 12 lessons, out of which minimum 5 and maximum 6 lessons (average 5.5 sessions) in the intervention school were observed. In non-intervention schools, classrooms were observed to see how teachers teach the chapter. From our earlier observations that in normal circumstances teachers typically spend 2 to 4 lessons to teach the same chapter. Hence 2 sessions from each non-intervention school were observed.

An audio recorder or a mobile phone was kept on a table near the teacher to audio record the sessions and important activities were video recorded (or taken snapshots of) using a mobile phone. Running notes (with time recording) were kept for entire class with the following pointers in mind:

1. Number of questions asked and their type (Rhetoric / Yes/No/ Open ended)
2. Use of diagrams
3. Use of gestures
4. Use of role play
5. Use of concrete models

6. Using analogy to explain something
7. Instances of collaboration between students
8. Instances in which teacher gave examples relevant to students' lives (authentic learning)
9. Instances in which teachers used students' mistake as an opportunity to learn from them (learning from mistakes)

Summary of the notes was entered everyday.

Science team members also had discussions with the teacher whenever they visited the school for classroom observation. The details of these discussions will be given in the sub-sub section 'Teacher Preparation'.

Procedure

The details of the procedure for intervention schools is described in this subsection.

Teacher Preparation

For teacher preparation, we took two workshops, one in the beginning of the study and second in the middle. The researchers also engaged with discussions with teachers before and after observation sessions and on phone. A brief description of each mode of teacher preparation is given below:

<u>Workshop 1</u>: Most teachers came within one hour of the given time. All but one teacher were present till the end (he left during lunch time). The teachers actively participated in all the activities and were engaged in learning the content. They expressed their doubts about spending so much time for this chapter and gave two contradictory feedback about the module: One point was that the content covered in the module is too elementary. They thought that students have learned about shape and motion of the earth and it causes seasons etc. so we do not have to repeat it. Another was that the explanations (including seasons which students already know) are too detailed and their students will not be able to understand them. They seemed to be satisfied with the crude explanations they teach and students learning them by rote. When we invited them to explain some of the simple phenomena such as seasons and phases of the moon some of them proposed faulty explanations. Then we pointed out that these were misconceptions, and tried to communicate that the purpose of learning science is not just to remember things but also to learn to reason. When they engaged in some of the activities in the module (for example, the role play to explain why we see only one face of the moon) they experienced some aha! moments and felt that these activities might be useful. By the end of the day, although teachers were not completely convinced, they were ready to give it a try and seem to be mentally preparing for the exercise.

It is interesting that, although teachers went through the same activities during the workshop, they were so engaged in learning the concepts that they did not pay attention to the pedagogy through with they were taught. So, in the evening before the class we called teachers to remind them what content is to be taught, which activities to be carried out and sent the links of the YouTube videos (which we had prepared for the teacher's handbook) of the activities which are to be carried out in the next class.

After the class researchers usually praised teachers for their achievements (For example, meaningfully engaging students in an activity or or improvising on a diagram or an activity) and encouraged them. Researchers also pointed out if a teacher made any mistake in content, if he/she skipped any activity and how the class or a particular activity could be improved.

In the next 6 working days, teachers were asked to teach the first six lessons of the module (approximately one each day). We held another workshop for teachers on the seventh working day to cover the remaining half part of the module with them.

Workshop 2: All but one teacher attended the second workshop and most of them arrived on time which shows that the teachers were more committed to the study now. We started by asking teachers to share how much part of the module they have completed and their experiences. All teachers thought that it was a fruitful learning exercise for them and the students are engaged and enjoying the module (evidence of teachers' feedback is given in sub-sub-section 'teacher feedback'. Then we shared the pre-test results with teachers. School-wise scores were deliberately not shown to refrain teachers passing any judgement about any particular school or teacher. Instead, percentages of correct response to each question and responses which were chosen by maximum students (popular misconceptions) were shown. Then we covered the rest half of the module and teachers were free to ask questions. We concluded with reading a motivational note which appears at the end of the module.

Pre and post-testing

Paper-pencil version of the pre-test was conducted on 21 August in all the schools. One CLIx team member (4 from science team and 4 from Rajasthan field team) was present in each school. Teachers were present at least for some time. Students were assured that this was not an exam, but they will be participating in a program and before we start, we just want to get a sense of what they know. Then all the question types were explained. They were told that for the diagram they can just draw a stick figure (no need to draw detailed human beings). Typically, MCQs were completed in 15 minutes, most students completed the entire paper in 30 minutes. Some students kept drawing till the end (40 min.) because they had to wait till they got pencil and compass from their peers. Some students tried to copy the answers from the peers, but the percentage seems to be low.

Post-test was conducted in the same manner.

Classroom observations - process

As mentioned earlier, science team members visited the school to observe the classes and to provide on-site support. The teachers did not start the module until the researchers visited the school for the first observation and did not teach the module unless the researcher was present initially. During the first couple of classes, teachers were very unsure about what exactly to be done in the class. Most of them seem to be unable to visualize an interactive classroom with students drawing on board or engaging in role play. Some of them explicitly mentioned that what you are asking us to do in the class is very different from what we usually do. All the teachers requested the researchers to take the class to demonstrate the classroom. The researchers directly engaged with the class in the first class. Second class was taught by researchers and teachers together (who took the lead role varied from teacher to teacher). By the third class, most of the teachers were taking the classes independently (though some of them continued to discuss with the researchers during the class as and when necessary).

The classroom observations were accompanied by discussions with the teacher either before or after or both times. Most of the discussions, particularly during the first half of the implementation circled around content. Teachers wanted to make sure that they wouldn't make any mistake before the class. Some of them searched on the Web and watched YouTube videos for extra information and asked us questions about that. At this time, researchers also reminded them which activities they were supposed to carry out with the students.

Teacher feedback

In the second workshop, all the teachers shared their experience. It was audio recorded. Transcripts show that most of the teachers were surprised with the fact that an alternate pedagogy can be executed in their classroom. Many teachers were skeptical at the beginning and they had shared their skepticism in the first workshop. In the second workshop, teachers felt that much of their skepticism was unfounded and new pedagogy can give unexpected results.
For example, a female teacher was said (emphasis added):

> *I did not expect that students will respond positively (to change in the pedagogy)... but they respond so well… they showed so much interest.. And the most interesting part is that I learnt this (that different pedagogies can be used).*

Teachers also emphasised the importance of preparations before the class. As the content and pedagogy was new to them, they had to spend extra time in preparing for the class. Teachers asked for the printed version of the students module so that they can use it for preparations. Teachers felt that digital activities were helpful, students took interest in the topic because of the digital activities. Also the digital activities gave opportunity to learn from mistakes.
Teachers saw the experience of teaching with new pedagogy as an opportunity to learn even after initial skepticism. They compared the new pedagogy with the new one and felt that new pedagogy is better and it helps students learn better.

Findings

This Section is divided into two sub-sections: 'Comparison between intervention and non-intervention schools' followed by the Qualitative analysis' of each kind of questions. As mentioned in the 'Participants' section, since we wanted to compare the pre and post tests, we included only those students who were present for both pre and post tests are included in the entire analysis.

Comparison between intervention and non-intervention schools

Since the maximum possible score for the pre and post-test were different, all the scores were converted into percentages. Also the question which elicits the diagram response is not included in this analysis.

The average percentage for each school for pre and post-tests for the intervention group is provided in Table 5 (Figure 2) and that for the non-intervention group is provided in Table 6 (Figure 3).

Table 5: Statistics for Intervention schools

Name of the school	Average % score on pre-test (S.D)	Average % score on post-test (S.D)	Effect size (* pre- to post-test difference also significant at $p<.01$)
School A	27.50 (8.45)	36.67 (12.29)	0.82*
School B	42.79 (11.36)	74.00 (6.17)	1.73*
School C	30.74 (12.01)	38.12 (11.95)	0.60*
School D	33.75 (11.11)	40.43 (10.80)	0.59
School E	32.5 (11.73)	46.91 (12.60)	1.04*
School F	27.92 (14.21)	37.17 (11.03)	0.70*
School G	33.89 (13.41)	38.22 (10.22)	0.38
All school together	33.31 (12.71)	46.58 (17.63)	0.79*

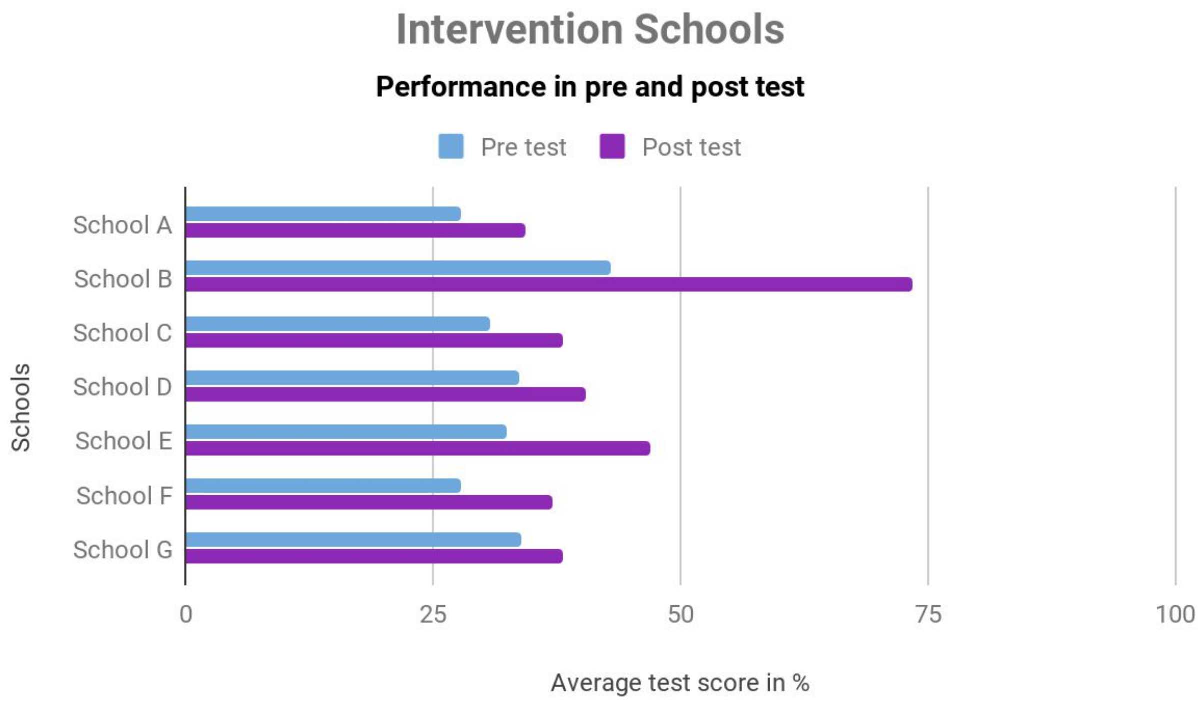


Figure 2: Performance of the intervention schools in pre and post test

Table 6: Statistics for Non-intervention schools

Name of the school	Average % score on pre-test (S.D.)	Average % score on post-test (S.D.)	Effect size (* pre- to post-test difference also significant at p<.01)
School H	30.65 (7.28)	29.91 (8.17)	-0.10
School I	32.33 (10.67)	33.33 (9.52)	0.14
School J	33.21 (9.32)	34 (7.65)	0.10
School K	32.24 (11.69)	36 (10.47)	0.34
School L	33.33 (9.85)	30.33 (7.13)	-0.36
School M	24.67 (5.50)	35.73 (9.25)	1.20*
School N	39.33 (11.00)	29.87 (11.10)	-0.81
All school together	32.07	32.98	0.09

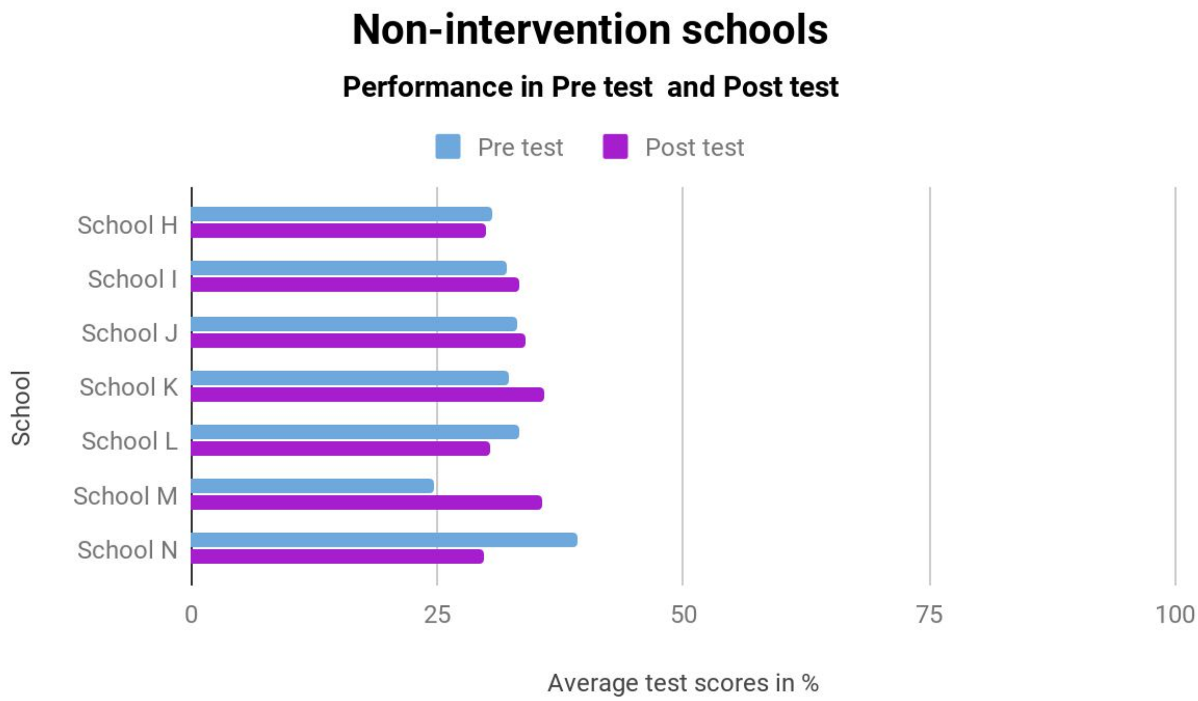


Figure 3: Performance of the non- intervention schools in the pre and post test

As seen in Tables 5 and 6, the average percentage in pre-test of both groups was about 33.31 and 32.07%, which is very low. This shows that students had very little knowledge in the domain of astronomy when they started.

The difference between pre-test scores for the intervention schools and non-intervention schools was not statistically significant ($p=0.88$) so the intervention and the non-intervention groups were equivalent.

Scores of the students from intervention school significantly improved after the intervention ($p<.001$) where those in the non-intervention group did not improve significantly ($p=0.10$).
Not only the difference between post-test scores of intervention and non-intervention groups is significant (Figure 4) but the difference in improvement between intervention and non-intervention groups is also significant ($p<.001$) (See Figure 5). Note however that, in the non-intervention group, the post-test score is close to 47% so there was scope of more improvement.

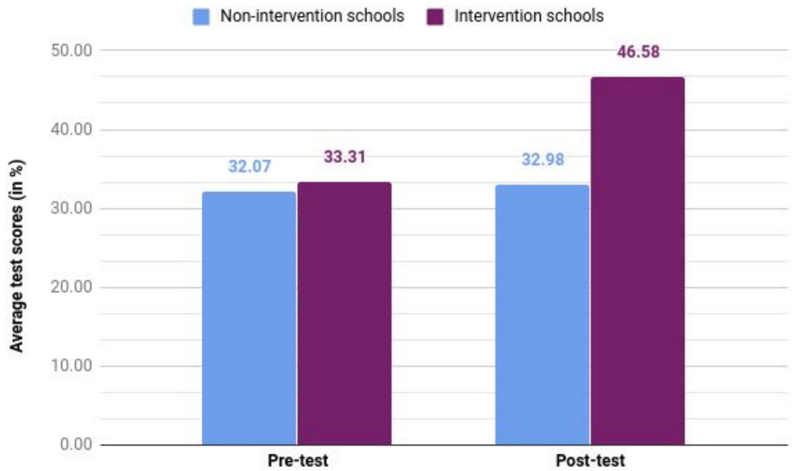


Figure 4: Comparison of test results of both intervention and non intervention schools.

Qualitative Analysis

This subsection is divided into three sub-sub-sections: Analysis of responses to content related questions, Analysis of responses to attitudinal questions (Attitudinal change) and Analysis of responses to questions related to beliefs (Belief change).

Content related questions

The pre-test included 19 questions which tested content knowledge (Que. no. ka 1, 2, 3 and 4; kha 1 to 15). First, we point out some of the most common misconceptions surfaced in the pre-test among the intervention group and how they changed after intervention (Table 7, Appendix G).

On seven questions (Question No. 1, 5, 6, 11, 15, 16 & 17) less than 20% percent students gave correct answers but improved significantly after the intervention.
Two of these questions (Questions 1 and 11) were observation based: In pre-test only 8% students knew that the sun **isn't** exactly overhead everyday at noon, but this percentage improved to 37% in the post-test. Only 2% students knew that the name of the brightest star in the night sky is Sirius (69 % thought it was a Pole star, which clearly shows that they have never seen the Pole star). Percentage of students who could name the correct start increased to 25% and the percentage of students who chose 'Pole star' as the brightest star decreased to 35% after the intervention.

Two of the questions required visuospatial reasoning (Questions 5 and 6) Only 19% knew that day and night occur because of the rotation of the earth in pre-test, but 36% students answered this question correctly in the post-test (major alternative conception being it occurs due to revolution of the earth (chose by 45% in the pre-test which decreased to 12% in the post-test). Similarly, only 17% students attributed the cause of seasons to the earth's tilted axis which increased to 33% in the post-test (on the other hand, 39% students attributed it to its elliptical orbit which decreased to 22% in the post-test).

Most students did not have a good idea about relative sizes and distances (Questions 15 and 16). For example, only 19% students could choose the correct order of celestial objects according to size and 18% students could choose that according to relative distances from the earth. These percentages improved to 35 and 34 in the post-test.

The last question in which students showed major misconception was fact-based (Question 17). Only 19% of students knew that a star is a self-luminous object (as opposed to the moon which was chosen by 56%). The percentage of students who learned this fact increased to 60% and students who believed that the moon is self-luminous decreased to 26% after the intervention.

Three other questions (Questions 4, 14 and 19) saw major improvement, although the percentage of students who gave correct answers was not too low to begin with. Two of these questions required visuospatial reasoning. In the pre-test 33% students were relative revolution periods for planets (closer planets need less time and vice versa) which increased to 64% in the post-test. Also, only 22% students could choose the correct diagram for a particular phase of the moon which increased to 47% in the post-test. One question was based on indigenous knowledge. In pre-test 25% students could identify the name of a Nakshatra which increased to 49% in the post-test (About 27% confused it with the name of a zodiac sign, 'Makara' in both pre and post-test.

Most students knew facts such that the moon rotates around its own axis (59%) and the moon moves around the earth and the earth moves around the sun because of the gravitational force. (64%) in the pre-test and these percentages did not improve much in the post-test (63% & 66% respectively).

Most students did not know that Saturn (and Mars in post-test) can be seen by naked eyes (28% gave correct answers) but there was not much improvement even in post-test (38%). Similarly, only 24% students knew that the asteroid belt is situated between mars and jupiter and this percentage also did not improve much in post-test (32%).

Finally, students regressed on 5 questions (Questions 7, 9, 10, 13 and 18), with average regression of 12% (minimum 5%, maximum 21%). More than 50% students gave correct answers to four of these questions (questions 7, 9, 10, 18) and 39% students gave correct answer for one question (# 13). Thus, a good number of students already knew the correct answer for questions on which students regressed.

Two of these questions required students to observe (Questions 7, 10 and 13). For example, 54% students knew the directions of moonrise and moonset in the pre-test which decreased to 49%. In pre-test 39% students could identify the picture of the moon which is not a phase (it was eclipse) which regressed to 18% in the post-test. The possible reason for this regression might be that the module did not include explicit instructions on the observations, which was one of the major shortcoming of the module. It must be noted that 28% of students marked a photograph of Gibbous moon as 'Not phase of the moon' which decreased to 18% in the post-test. The reason for this regression seems to be a lack of specific instructions for observations in the module. This was the conscious decision because the module was already quite long. Also, from our earlier experience we know that incorporating observations is difficult and activities based on them tend to fail in implementation. Including observations would have made the module more bulky and difficult to implement so we skipped observations (we introduced some softwares and mobile apps which aid observations to teachers). The trade-off we see is, students regress on some of the questions which can be answered through simple observations.

Two other questions (Questions 10 and 13)on which students regressed were related to indigenous knowledge. For example (in response to question 10), 63% students knew that the period from New Moon to Full Moon is called *Shukla Paksha.* But only 49% students knew that the period from Full Moon to New Moon is called *Krishna Paksha.* Most prevalent incorrect answer was *Krishna Paksha* for the first question (~18%) and *Shukla Paksha* for the second question which shows that the students were confused between the two.

Another question (#13) which tested for indigenous knowledge (and possibly observation) on which students regressed was naming the phase of the moon on particular festivals. In pre-test 50% students knew that Diwali falls on the new moon night but in the post-test only 39% students could answer that crescent is seen on Eid. Although the two festivals asked in the pre and post differ in the sense that Diwali is a Hindu festival and Eid is a Muslim festival, both the festivals are important in this region, sighting of a thin crescent moon is very important for declaration of Eid (because of which the sometimes the holiday changes) and most importantly, the digital activity on phases of moon included questions in these two festivals. Nonetheless, we see regression in the question.

The last question on which students regressed after intervention is information based (#18. Which of the objects is not part of the solar system). In post-test 63 % students correctly responded that it is a Galaxy but in post-test this percentage reduced to 54%.

It should be noted that out of 10 questions on which students improved significantly, 6 questions required visuospatial reasoning or spatial understanding (Questions 4, 5, 6, 14, 15 and 16). The concepts dealt in these questions were taught using role-play, diagrams and digital activities.

Change in the percentage of students who gave correct responses in intervention and non-intervention groups is plotted in Figures 5 (a and b). Figure 5a shows students' average scores improved on 13 questions in the intervention group and Figure 5b shows that it improved on 11 questions in the non-intervention group. The questions on which scores regressed in intervention are marked in purple, those in the non-intervention group are marked in blue and those in both the groups are marked in red.

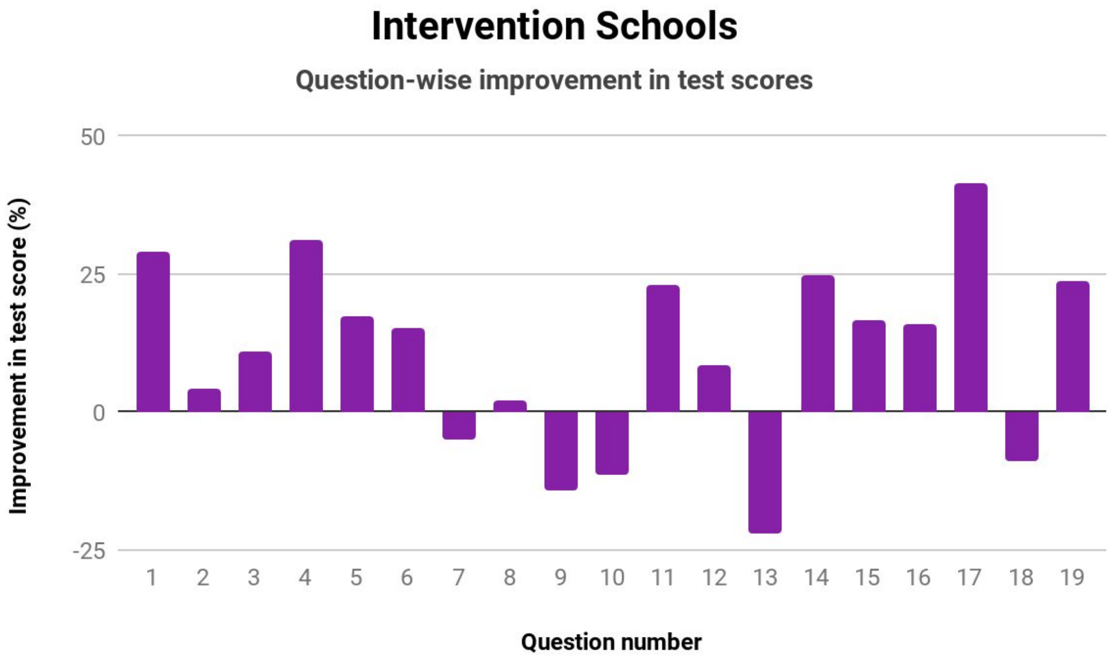


Figure 5a: Question number vs the improvement in the intervention group

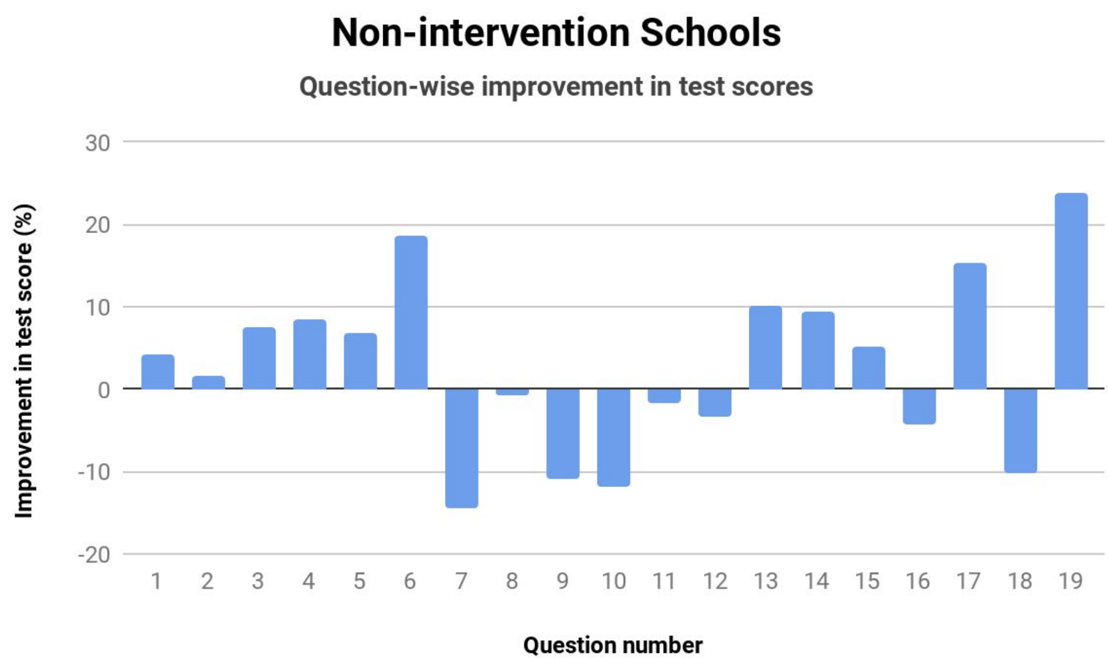


Figure 5b: Question number vs the improvement in the non-intervention group

Figure 5: Question-wise Improvement and regression in intervention and non-intervention groups [Questions ka 1-4 (True or False): Questions 1. Everyday at noon, the Sun is exactly overhead. 2. The Moon does not rotate around its own axis. 3. Saturn can be seen by the naked eye (without telescope).

4. Planets which are closer to the Sun take more time to complete one revolution than the planets which are farther away from the Sun.
kha 1-15 (MCQ): Questions 5. Day and night occur because-. 6. Seasons occur on the Earth because-. 7. The Moon rises from-. 8. Which force is responsible for the Moon to revolve around the Earth? 9. The period from New Moon to Full Moon is called-. 10. In what phase is the Moon on Diwali night? 11. Which is the brightest star in the night sky? 12. The asteroid belt is situated in between-. 13. Which of these pictures is NOT a phase of the Moon? 14. Mark the picture which shows the position of sun, earth and moon at full moon. 15. Which is the correct order from the smallest to the largest in size? 16. Which is the correct order from the nearest to the farthest from the Earth? 17. Which of the following objects produces its own light? 18. Which of the following is not part of our Solar System? 19. Which of the following is the name of a nakshatra (lunar mansion)?)]

The questions on which each of the group regressed are plotted in a Venn diagram in Figure 6).

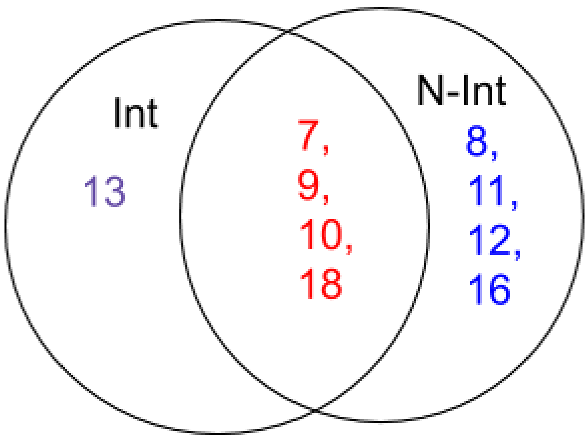


Figure 6: Questions on which students regressed in intervention group (set Int), non-intervention group (set N-Int) and in both groups (Int ∩ N-Int).

Out of 6 questions related to the moon (Que. 2, 7, 8, 9, 11 and 12), both intervention and non-intervention groups regressed on 2 questions (Que. 7 and 8, both happen to be questions related to observations), and only non-intervention group regressed on 2 questions (Que. 11 and 12). Thus overall students regressed on 4 out of 6 questions related to the moon which shows that it was one of the difficult areas and students did not get enough input even through the module.

Other difficult questions are, which force is responsible for the moon's revolution around the earth, selecting the object which is outside the solar system (correct answer being 'Galaxy') for both intervention and non-intervention group, name of the brightest star in the night sky (for intervention group) and relative distances of celestial objects (for non-intervention group).

Attitudinal questions

Out of five questions related to students' attitude towards science in general and astronomy in particular. Four questions elicited response on Likert scale (ga 1 to 4). The percentages of students who chose a particular response for each of these questions is given in Appendix G,

Table 8. One was a check-box question (gha). The percentages of students who gave particular responses is given in Appendix G, Table 9.

We calculated a single score based upon the responses to all attitudinal questions. It is an addition of the four questions on the Likert scale (ga 1 to 4) and the number of check-boxes they ticked for the things in astronomy which interests them (gha - we did not include the point for interest in astrology and if they marked for astrology does not interest them (D2 and G in the pre-test respectively)). The maximum possible score for attitudinal questions is 28.

For the intervention group, the average score for attitudinal questions in pre-test was 18.45 (S.D = 5.09). Thus, to begin with, students showed good attitudes towards science and astronomy in the pre-test, which increased to 19.47 (S.D = 4.61) in the post-test. The difference turned out to be statistically significant on the t-test (p value = 0.02) although the effect size (0.21) is low.

For the non-intervention group, the average score for attitudinal questions in pre-test was 17.79 (S.D. = 4.13) which is not statistically different from that of the intervention group in the pre-test (p = 0.23). However, the average score significantly (p=0.002) dropped to 16.63 (S.D. = 4.06) in the post-test, thus making the difference between intervention and non-intervention group significant in the post-test (p=0.00). The average scores on attitudinal questions of the intervention and the non-intervention group on pre and post-tests are plotted in Figure 7.

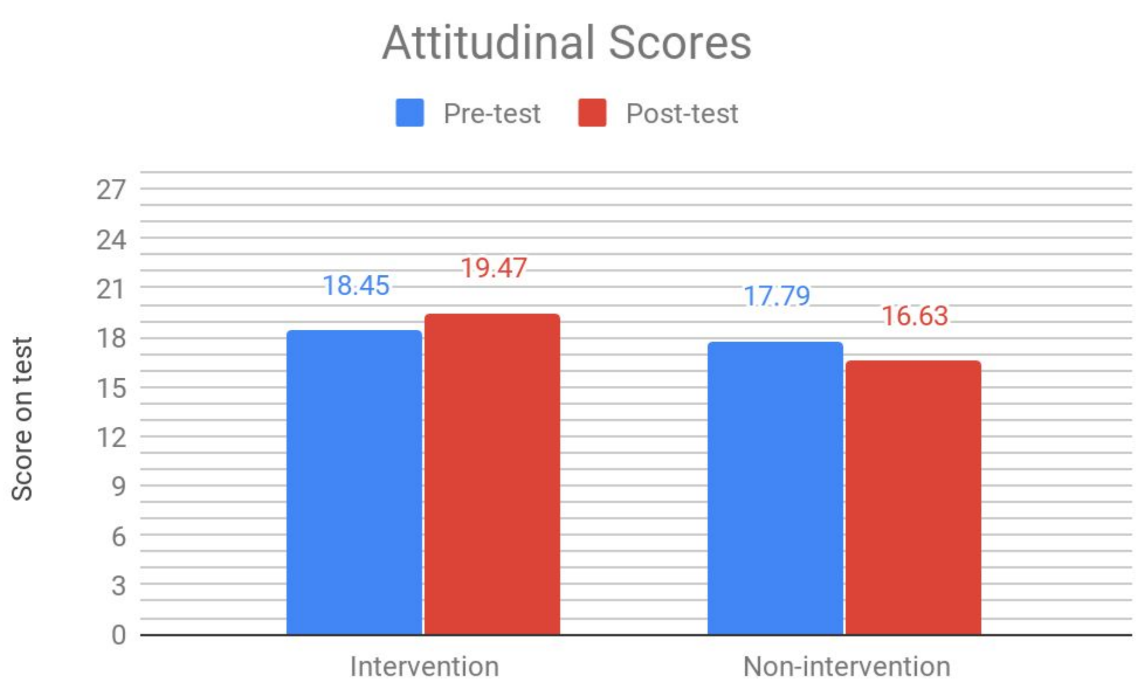


Figure 7: average scores on attitudinal questions of the intervention and the non-intervention group on pre and post-tests

Thus the module helped to improve students' interest and attitudes towards science and astronomy whereas regular teaching in the non-intervention schools decreased students' interest and attitudes towards science and astronomy.

Belief change

The module connects indigenous knowledge to observational astronomy wherever possible so that textbook knowledge does not remain disconnected to students' cultural lives. Many of the terms which are used in indigenous astronomy are common in astrology as well. By explaining these terms we hoped that the mysterious aura around them would be shredded down and the students will be able to think rationally about them. The module had a couple of explicit questions and discussions around this. However, Figure 8 shows that the change in percentage of students who believed in astronomy related superstitions and Figure 9 shows the change in percentage of students who believed in astrology.

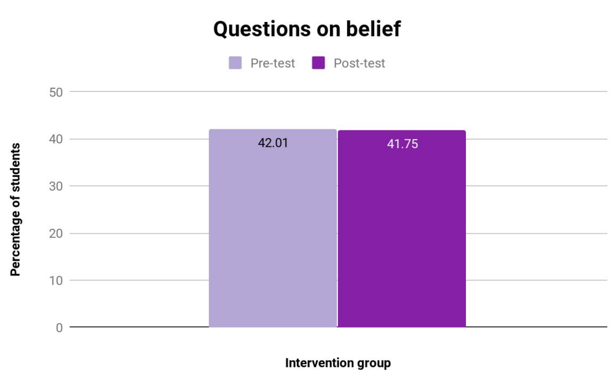
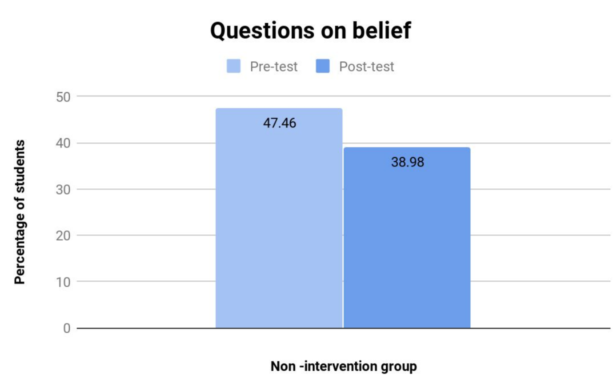
Intervention schools	Non-intervention schools
	

Figure 8: Percentage of students who believed in astronomy related belief (pre-test: Eclipses are bad omens and should not be seen; post-test: If you make a wish while watching a shooting star it comes true).

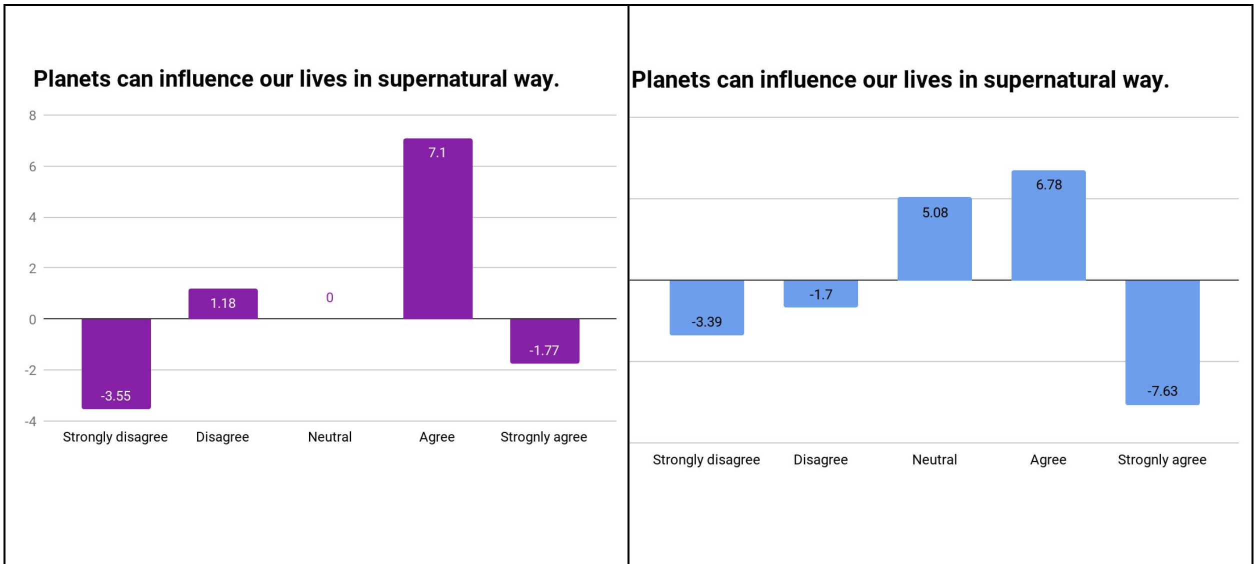


Figure 9: Change in percentage of students who believe that 'planets can influence our lives in supernatural way' from pre-test to post-test

The module was not successful in changing the students' deeply held belief that planets can influence our life in a supernatural way. Same thing can be see in another question in 'Kha' category, where we asked about eclipses and shooting stars and superstitions related to them. In that question also students' beliefs did not change.

Discussion

Conclusion

The intervention resulted in significant improvement in students' understanding of astronomy, as opposed to the regular teaching of the chapter which did not lead to significant improvement. Students from intervention schools showed remarkable improvement in questions which required visuospatial reasoning or spatial understanding particularly, those for which underlying concepts were taught using role-play, diagrams and digital activities.

However, even after the intervention, average scores remained less than 47% which shows the limited success of the module in the field. It is premature to attribute limited success ONLY to the potential of modules since there were other factors such as lack of teachers' content knowledge and unfamiliarity with the pedagogy intended in the module.

The module was seen to be successful in improving students' interests and attitudes towards science as opposed to the regular teaching in the non-intervention schools which hampered students' interest and attitudes towards science. However, the module was not successful in changing students' beliefs related to astrology and astronomy related superstitions. The reasons could be that the teachers themselves believed in astronomy and hence did not challenge them in the class. We have a couple of examples in which teachers suggested the astrological significance of astronomy. Moreover, these beliefs are part of an overarching belief system (which includes existence of supernatural entities such as god, sole, heaven, afterlife and so on). Knowledge in one domain such as astronomy is not sufficient to change this entire system. However, we still hope that many such pieces of knowledge (about evolution, diseases, conservation of matter and energy and so on) will help the learners to question the entire belief system at some point and hence necessary for this large.

It must be noted here, that the teacher preparation undergone for the module implementation was exhaustive. Two one-day workshops, about 5 to 6 school visits during the implementation and as many phone calls to encourage me to read the module, to solve the queries and to insure the implementation was necessary. Personal bonds between researchers and teachers motivated teachers and gave them confidence to try out the new pedagogy. Some other factor which affect the implementation are as following:

1. Support of school principals.
2. Smaller class size (to conduct the classroom and digital activities effectively)
3. Working computer lab with enough number of computers

Limitations of the study of future directions

Two of the main limitations of the study is teachers' insufficient content knowledge and lack of time. Teachers were not aware that they have misconceptions to begin with. They realized it just before the implementation started and hence they were under confident in the classroom. As a result their entire attention was focused on producing correct explanations. Most of them used such kind of pedagogy for the first time. They were also unable to understand the overarching principles (importance of collaboration and context in learning, how students' mistakes can be exploited to engage them in discussion and role of inquiry, visuospatial thinking and multiple external representations in learning science) behind the pedagogy. Hence most teachers had limited success in meaningfully engaging students in activities and guiding students to construct the mental models and finding their own explanations.

Also some of the teachers could not spend sufficient time in preparation and even for the implementation. Many teachers did not implement the module unless the researcher went for the observations, and then covered large portions in one session to catch up (sometimes in an extended period). Most of the digital activities were facilitated by the CLIx team, so what was taught in the class might have remained a bit disconnected with the digital activities.

One of the main limitations of the module is, it does not include any systematic observations. Earlier research has shown that although students are aware of common place phenomena such as phases of moon and seasons, their accurate and quantitative observations are lacking and contrary to common belief, it is not easy to make these observations (reference). The module should include activities which includes systematic observations of shadows, stars and the moon, but that was omitted for two reasons: first, observations are time consuming and the module was already large in terms of its duration and what it covered. Second, observations (especially that of night sky) are difficult to ensure (it is very often cloudy, certain phases of the moon are not visible until late at night). Moreover, students mostly forget to observe, and if they observe, they forget to note it or make mistakes while noting it. Therefore, if we included anything which was dependent on observations, the implementability would have gone down. We did show the 'SkyEye' app and Stellarium to teachers during the workshop but teachers did not use them during the period of implementation.

Finally, we would like to see the long-term effects of the module on both students and teachers. It would be interesting to know whether students' knowledge is retained at least till the final examination and also whether the teachers use at least some elements of the modules in the next year. It would be wonderful if some of the teachers develop interest in astronomy and some of the students pursue astronomy, or at least science in their later life.

Appendices

Appendix A: Ethical Clearance from IRB

टाटा सामाजिक विज्ञान संस्थान
Tata Institute of Social Sciences

TISS

Institutional Review Board
Ethics Clearance Report

Serial No. of IRB Meeting	2016-17	02
Project Title	Monitoring and Evaluation Study of CLIx Design and Intervention	

Name of Faculty In-charge/Project Coordinator/Principal Investigator
Prof. Padma M Sarangapani

Date of Submission to the Committee	2	6	0	8	2	0	1	6
Date of Submission to other IRB's (if applicable)								
Date of Review	1	3	0	9	2	0	1	6

IRB Members present for the meeting:

Prof. Indra Munshi (Chairperson), Prof. Surinder Jaswal (Member Secretary), Prof. Kanchan Mukherjee, Prof. Mouleshri Vyas, Prof. Shalini Bharat, Prof. Bino Paul, Prof. Satyajit Majumdar, Prof. T. V. Sekher, Dr. Kamal Hazari, Dr. Amar Jesani, Dr. Monica Saakhrani, Mr. Bhaskar Kakad, Ms. Pallavi Palav

Comments from IRB Members:

1. The ethical issues which can arise in using observation as a method for data collection need to be elaborated.
2. The risks which students may face as a result of their participation in the study need to be elaborated.
3. How will anonymization of schools be done?
4. Do the tools cover all domains of the study? Have the tools been standardized?

All suggested changes have been successfully incorporated

Signature of the Chairperson

Signature of Member Secretary

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Appendix B: Material for Teachers and Students

Teacher's Handbook: Basic-Astronomy-Teachers-Handbook
Students' handbook: Hard copy of Students module for teacher

Appendix C: Pre-test in Hindi

लर्निंग आउटकम स्टडी

मूलभूत खगोल शास्त्र

प्री टेस्ट

विद्यार्थी का नाम : लडका / लडकी

स्कूल का नाम : तारीख:

क. निम्नलिखित वाक्य सही हैं या गलत यह बताइए।

1. सूर्य हर दिन दोपहर को बिल्कुल सर के ऊपर होता है। सही या गलत?

   सही गलत

2. चंद्रमा अपने धुरी पर घूमता नहीं है। सही या गलत?

   सही गलत

3. शनि को नंगी आंखों से (दूरबीन के बिना) देखा जा सकता है। सही या गलत?

   सही गलत

4. सूर्य के करीब वाले ग्रह, सूर्य से दूर वाले ग्रहों की तुलना में, एक परिक्रमण पूरा करने में अधिक समय लेते हैं। सही या गलत?

   सही गलत

5. ग्रहण बुरे अपशगुन होते हैं और इन्हें नहीं देखना चाहिए। सही या गलत?

सही गलत

ख. सही विकल्प चुनें।

1. दिन और रात होती है क्योंकि:
    a. सूर्य पृथ्वी के चारों ओर घूमता है।
    b. पृथ्वी सूर्य के चारों ओर घूमती है।
    c. पृथ्वी अपनी धुरी के चारों ओर घूमती है।
    d. पृथ्वी की धुरी झुकी हुई है।

2. पृथ्वी पर मौसम होते हैं क्योंकि:
    a. सर्दियों की तुलना में सूर्य गर्मी में पृथ्वी के करीब होता है।
    b. पृथ्वी की कक्षा दीर्घ वृत्ताकार (अण्डाकार) है।
    c. पृथ्वी की धुरी झुकी हुई है।
    d. पृथ्वी अपने चारों ओर घूमती है।

3. चंद्रमा ……….से उगता है:

    a) पूर्व   b) पश्चिम

    c) उत्तर   d) दक्षिण

4. चंद्रमा पृथ्वी के चारों ओर घूमने के लिए कौनसा बल जिम्मेदार है?

    a) ज्वार बल   b) चुंबकीय बल

    c) गुरुत्वाकर्षण बल   d) परमाणु बल

5. अमावस्या से पूर्णिमा की अवधि को ……….कहा जाता है:

    a) शुक्लपक्ष   b) पितृ पक्ष

    c) कृष्ण पक्ष   d) उत्तरायण

6. दिवाली की रात को चंद्रमा की कौनसी कला होती है?

    a) पूर्णिमा   b) हंसिया बालचंद्र

    c) कुबड़ा/ अर्द्धाधिकचंद्र   d) अमावस्या

7. रात के आसमान में सबसे चमकीला तारा कौन सा है?

a) ध्रुव तारा　　b) शुक्र

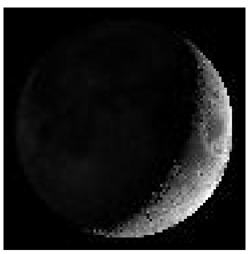
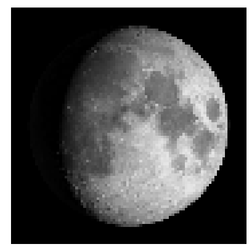
c) चंद्रमा　　d) सीरियस (व्याध)

8. क्षुद्रग्रह घेरा .... के बीच में स्थित है:

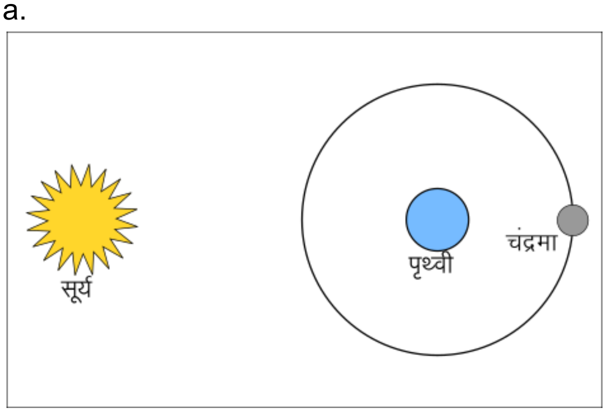
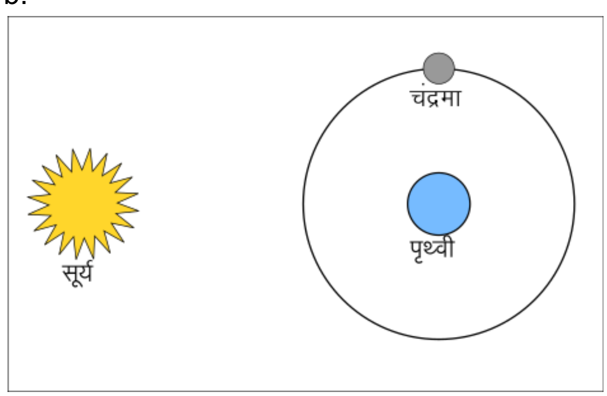
a) पृथ्वी और मंगल　　b) मंगल और बृहस्पति

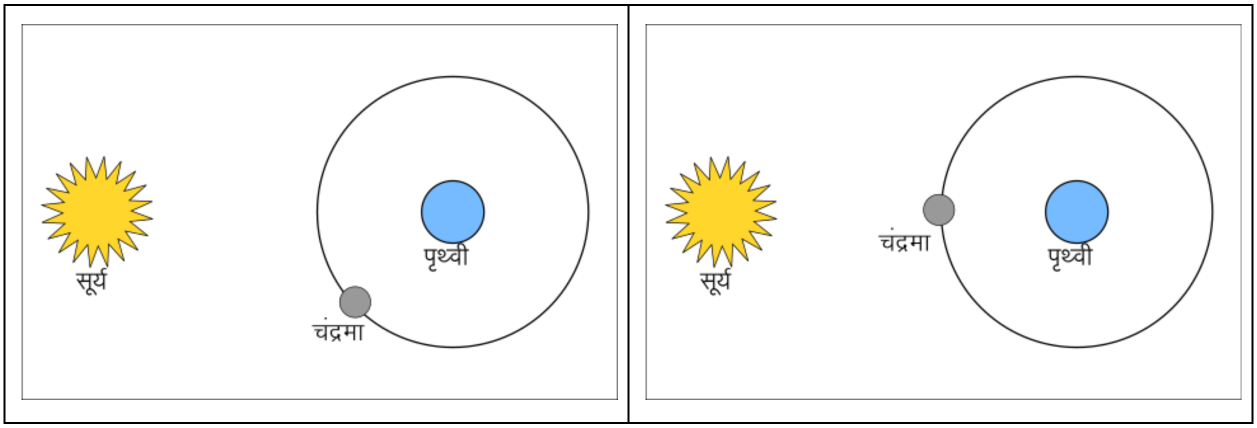
c) बृहस्पति और शनि　　d) शनि और अरूण

9. इनमें से कौन सा चित्र चंद्रमा की कला नहीं दर्शाता है?

a		b		c		d	

10. इनमें से कौनसा चित्र पुर्णिमा की स्थिति दर्शाता है?

a. 	b. 
c.	d.



11. नीचे दिए गए पिंडों में, छोटे से सबसे बड़े आकार का, सही क्रम पहचाने।

   a. चंद्रमा - शनि - पृथ्वी - सूर्य
   b. शनि - चंद्रमा - सूर्य - पृथ्वी
   c. चंद्रमा - पृथ्वी - शनि - सूर्य
   d. पृथ्वी - चंद्रमा - सूर्य - शनि

12. नीचे दिए गए पिंडों में, पृथ्वी के निकटतम से दूर तक का, सही क्रम पहचाने।

   a. चंद्रमा - अरूण - सूर्य - ध्रुव तारा
   b. सूर्य - चंद्रमा - अरूण - ध्रुव तारा
   c. ध्रुव तारा - अरूण- चंद्रमा - सूर्य
   d. चंद्रमा - सूर्य - अरूण - ध्रुव तारा

13. निम्न में से कौन अपनी रोशनी स्वयं उत्पादन करता है?

a) चंद्रमा b) मंगल

c) तारा d) क्षुद्रग्रह

14. निम्न में से कौन हमारे सौर मंडल का हिस्सा नहीं है?

a) मंदाकिनी b) धूमकेतु

c) उपग्रह d) क्षुद्रग्रह

15. निम्न में से कौनसा नक्षत्र का नाम है?

a) मकर b) रोहिणी

c) शनि d) ब्रम्हहृदय

ग. कृपया उन विकल्पों का चयन करें जिनके साथ आप सहमत हैं

1. मैं विज्ञान सीखने में आनंद लेता हूं।

बिलकुल असहमत बिलकुल सहमत

1	2	3	4	5
☐	☐	☐	☐	☐

2. दैनिक सोच में निर्णय लेने में वैज्ञानिक सोच का उपयोग किया जाना चाहिए।

बिलकुल असहमत बिलकुल सहमत

1	2	3	4	5
☐	☐	☐	☐	☐

3. मुझे खगोल विज्ञान दिलचस्प लगता है।

बिलकुल असहमत बिलकुल सहमत

1	2	3	4	5
☐	☐	☐	☐	☐

4. मैं कॉलेज में खगोल विज्ञान सीखना चाहूँगा (10 वीं कक्षा के बाद)।

बिलकुल असहमत बिलकुल सहमत

1 2 3 4 5

☐ ☐ ☐ ☐ ☐

5. गृह और तारों की स्थिति हमारा भाग्य (भविष्य) निश्चित करती है।

बिलकुल असहमत				बिलकुल सहमत
1	2	3	4	5
☐	☐	☐	☐	☐

घ. कृपया उन विकल्पों का चयन करें जिनके साथ आप सहमत हैं

भविष्य में , मैं इसमें शामिल होना चाहता हूं : (आप कई विकल्पों को चुन सकते हैं)

- ❑ A. चंद्रमा, सूर्य , सितारों और अन्य खगोलीय वस्तुओं का निरीक्षण
- ❑ B. सितारों और सौर मंडल के गठन जैसे विभिन्न सिद्धांतों के बारे में और जानना
- ❑ C. खगोल विज्ञान के बारे में चित्र और फिल्में बनाना
- ❑ D. दूरबीनों, उपग्रहों और अन्य उपकरणों की तैयारी
- ❑ D. कुंडली बनाने की विद्या और ज्योतिषी
- ❑ E. कक्षाओं, ऊर्जा इत्यादि की गणना करना
- ❑ F. अध्ययन करना कि कैसे दुनिया के विभिन्न हिस्सों में खगोल विज्ञान विकसित हुआ
- ❑ G. खगोल विज्ञान में रूचि नहीं है

च. कृपया पृथ्वी का एक चित्र बनाएं, उसमें नीचे दी गयी चीज़ें दिखाए और उन्हें नाम दें:

1. पृथ्वी के घूर्णन की धुरी,
2. उत्तरी ध्रुव,
3. दक्षिण ध्रुव,
4. भूमध्य रेखा
5. पृथ्वी पर खड़े छोटे मनुष्यों को दर्शाएं जैसे आप उन्हें एक अंतरिक्ष यान से देख रहे हों (ये दर्शाने के लिए कि वो पृथ्वी पर कहाँ रहते हैं)।

Appendix D: Post-test in Hindi

लर्निंग आउटकम स्टडी

मूलभूत खगोल शास्र

पोस्ट टेस्ट

विद्यार्थी का नाम : लडका / लडकी

स्कूल का नाम : तारीख:

क. निम्नलिखित वाक्य सही हैं या गलत यह बताइए।

1. हर दिन दोपहर को सूर्य बिल्कुल सर के ऊपर होता है |

   सही गलत

2. चंद्रमा अपने अक्ष के चारों ओर घूमता नहीं है |

   सही गलत

3. मंगल को नंगी आंखों से (दूरबीन के बिना) देखा जा सकता है |

   सही गलत

4. सूर्य से दूर वाले ग्रहों की तुलना में, सूर्य के करीब वाले ग्रह एक परिक्रमा पूरा करने में कम समय लेते हैं।

   सही गलत

5. सूर्य हमारे आकाशगंगा के केंद्र में है।

   सही गलत

6. टूटते हुए तारे को देखकर मांगी गई इच्छा पूरी हो जाती है।

   सही गलत

ख. सही विकल्प चुनें।

1.सूर्य पूर्व से पश्चिम की ओर जाते हुए दिखता है क्योंकि:

a) पृथ्वी सूर्य के चारों ओर घूमती है।

b) पृथ्वी अपनी धुरी के चारों ओर पश्चिम से पूर्व की ओर घूमती है।
c) पृथ्वी अपनी धुरी के चारों ओर पूर्व से पश्चिम की ओर घूमती है।
d) सूर्य पृथ्वी के चारों ओर घूमता है।

2. कल्पना कीजिए कि सूर्य के चारों ओर पृथ्वी की कक्षा को एक संपूर्ण वृत्त में बदल दिया गया है, जिससे सूर्य से पृथ्वी की दूरी को कभी बदला नहीं जा सकता । यह मौसम को कैसे प्रभावित करेगा?

a) अब हम मौसमों के बीच अंतर अनुभव नहीं करेंगे।
b) हम अभी भी मौसम अनुभव करेंगे, लेकिन अंतर बहुत कम ध्यान देने योग्य होगा।
c) हम उसी तरह मौसम का अनुभव करते रहेंगे, जैसा हम अभी करते हैं।
d) हम मौसमों को बीच बड़े अंतर का अनुभव करेंगे।

3. चंद्रमा ....में अस्त होता है:

a) पूर्व b) पश्चिम
c) उत्तर d) दक्षिण

4. पृथ्वी सूर्य के चारों ओर कौनसे बल के कारण घूमती है?

a) ज्वार बल b) चुंबकीय बल
c) गुरुत्वाकर्षण बल d) परमाणु बल

5. पूर्णिमा से अमावस्या की अवधि को ....कहा जाता है:

a) शुक्लपक्ष b) पितृ पक्ष
c) कृष्ण पक्ष d) उत्तरायण

6. चंद्रमा की कौनसी कला ईद का प्रतीक होती है?

a) पूर्णिमा b) हंसिया बालचंद्र
c) कुबड़ा (अर्द्धाधिकचंद्र) d) अमावस्या

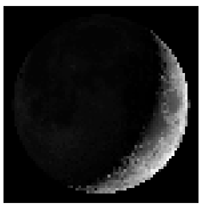
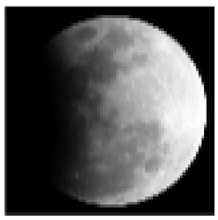
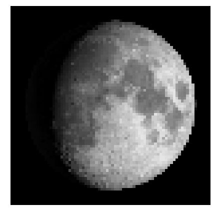
9. रात के आसमान में सबसे चमकीला तारा कौन सा है?

a) ध्रुव तारा b) शुक्र
c) चंद्रमा d) सीरियस (व्याध)

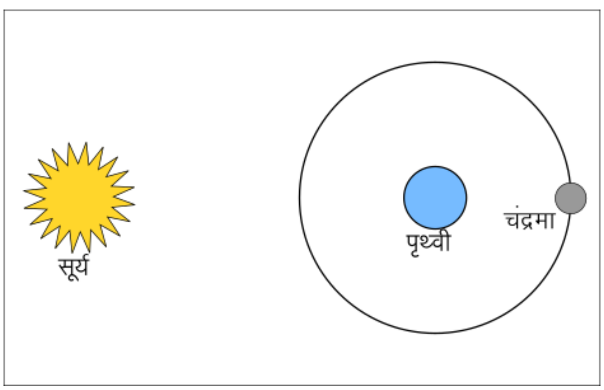
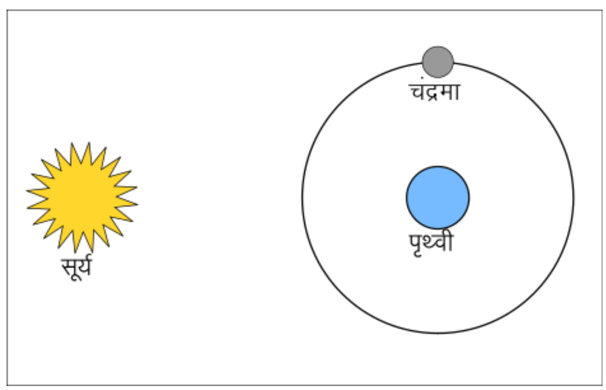
10. क्षुद्रग्रह घेरा .... के बीच में स्थित है:

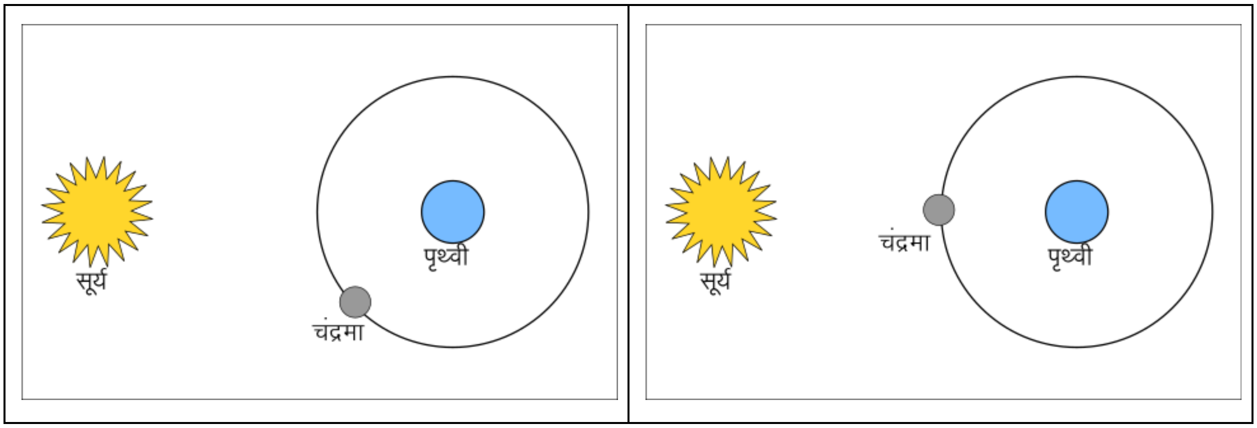
a) पृथ्वी और मंगल
b) मंगल और बृहस्पति
c) बृहस्पति और शनि
d) शनि और अरूण

7. इनमें से कौन सा चित्र चंद्र ग्रहण को दर्शाता है?

a		b		c		d	

8. इनमें से कौनसा चित्र अमावस्या की स्थिति दर्शाता है?

a. 	b. 
c.	d.



11. नीचे दिए गए पिंडों में, छोटे से सबसे बड़े आकार का, सही क्रम पहचाने।

a. चंद्रमा - शनि - पृथ्वी - सूर्य
b. शनि - चंद्रमा - सूर्य - पृथ्वी
c. चंद्रमा - पृथ्वी - शनि - सूर्य
d. पृथ्वी - चंद्रमा - सूर्य - शनि

12. नीचे दिए गए पिंडों में, पृथ्वी के निकटतम से दूर तक का, सही क्रम पहचाने।

a. चंद्रमा - अरूण - सूर्य - ध्रुव तारा
b. सूर्य - चंद्रमा - अरूण - ध्रुव तारा
c. ध्रुव तारा - अरूण- चंद्रमा - सूर्य
d. चंद्रमा - सूर्य - अरूण - ध्रुव तारा

13. निम्न में से कौन अपनी रोशनी स्वयं उत्पादन करता है?

a) चंद्रमा   b) मंगल
c) तारा   d) क्षुद्रग्रह

14. निम्न में से कौन हमारे सौर मंडल का हिस्सा नहीं है?

a) मंदाकिनी   b) धूमकेतु
c) उपग्रह   d) क्षुद्रग्रह

15. निम्न में से कौनसा नक्षत्र का नाम है?

a) कर्क   b) कृत्तिका
c) मंगल   d) अगस्त्य

16. जब पृथ्वी से चंद्र ग्रहण दिखता है, उसी समय चंद्रमा से क्या देखा जाएगा?

a. सौर ग्रहण
b. संपूर्ण प्रकाशित पृथ्वी
c. आधी प्रकाशित पृथ्वी
d. चंद्र ग्रहण

17. मंगल का पारगमन ....से दिखाई देगा ।

a) बुध b) शुक्र
c) पृथ्वी d) बृहस्पति

18. इस ग्रह की ठोस सतह है, यह सौर मंडल में सबसे गर्म है और पूर्व से पश्चिम की ओर घूमता है । यह कौन सा ग्रह है?

a) बुध b) शुक्र
c) मंगल d) सेरेस

19. सूर्य ज्यादातर .... से बना हैं ।

a) ऑक्सीजन b) सोडियम
c) हाइड्रोजन d) सोना

ग. कृपया उन विकल्पों का चयन करें जिनके साथ आप सहमत हैं

1. मैं विज्ञान सीखने में आनंद लेता हूं।

बिलकुल असहमत बिलकुल सहमत

1	2	3	4	5
☐	☐	☐	☐	☐

2. दैनिक सोच में निर्णय लेने में वैज्ञानिक सोच का उपयोग किया जाना चाहिए।

बिलकुल असहमत बिलकुल सहमत

1	2	3	4	5
☐	☐	☐	☐	☐

3. मुझे खगोल विज्ञान दिलचस्प लगता है।

बिलकुल असहमत बिलकुल सहमत

1	2	3	4	5
☐	☐	☐	☐	☐

4. मैं कॉलेज में खगोल विज्ञान सीखना चाहूँगा (10 वीं कक्षा के बाद)।

बिलकुल असहमत — बिलकुल सहमत

1	2	3	4	5
☐	☐	☐	☐	☐

5. गृह और तारों की स्थिति हमारा भाग्य (भविष्य) निश्चित करती है।

बिलकुल असहमत — बिलकुल सहमत

1	2	3	4	5
☐	☐	☐	☐	☐

घ. कृपया उन विकल्पों का चयन करें जिनके साथ आप सहमत हैं

भविष्य में , मैं इसमें शामिल होना चाहता हूं : (आप कई विकल्पों को चुन सकते हैं)

- ❑ A. चंद्रमा, सूर्य , सितारों और अन्य खगोलीय वस्तुओं का निरीक्षण
- ❑ B. सितारों और सौर मंडल के गठन जैसे विभिन्न सिद्धांतों के बारे में और जानना
- ❑ C. खगोल विज्ञान के बारे में चित्र और फिल्में बनाना
- ❑ D. दूरबीनों, उपग्रहों और अन्य उपकरणों की तैयारी
- ❑ D. कुंडली बनाने की विद्या और ज्योतिषी
- ❑ E. कक्षाओं, ऊर्जा इत्यादि की गणना करना
- ❑ F. अध्ययन करना कि कैसे दुनिया के विभिन्न हिस्सों में खगोल विज्ञान विकसित हुआ
- ❑ G. खगोल विज्ञान में रूचि नहीं है

च. कृपया पृथ्वी का एक चित्र बनाएं, उसमें नीचे दी गयी चीज़ें दिखाए और उन्हें नाम दें:

1. पृथ्वी के घूर्णन की धुरी,
2. उत्तरी ध्रुव,
3. दक्षिण ध्रुव,
4. भूमध्य रेखा
5. पृथ्वी पर खड़े छोटे मनुष्यों को दर्शाएं जैसे आप उन्हें एक अंतरिक्ष यान से देख रहे हों (ये दर्शाने के लिए कि वो पृथ्वी पर कहाँ रहते हैं)।
6. साथ ही, पृथ्वी की परिधि पर हर जगह गिरने वाली बारिश की दिशा दिखाएं।

Appendix E: Student's Workbook

Students workbook

Appendix F: Survey for Teachers (Hindi)

प्रारंभिक सर्वेक्षण (शिक्षकों के लिए)

कृपया हमें बताएं कि निम्नलिखित बयानों से आप कितना सहमत या असहमत हैं।

1. खगोलविज्ञान एक दिलचस्प विषय है।

1 बिलकुल सहमत नहीं
2 असहमत
3 निरपेक्ष
4 सहमत
5 पूर्णत: सहमत

2. खगोलविज्ञान स्कूल विज्ञान पाठ्यक्रम का एक हिस्सा होना चाहिए।

1 बिलकुल सहमत नहीं
2 असहमत
3 निरपेक्ष
4 सहमत
5 पूर्णत: सहमत

3. दिन और रात का आकाश निरीक्षण करने से खगोलविज्ञान के बारे में बहुत सी जानकारी हो सकती है।

1 बिलकुल सहमत नहीं
2 असहमत

3 निरपेक्ष
4 सहमत
5 पूर्णत: सहमत

4. खगोलविज्ञान को हमारे दैनिक अनुभव से जोड़ा जा सकता है।
1 बिलकुल सहमत नहीं
2 असहमत
3 निरपेक्ष
4 सहमत
5 पूर्णत: सहमत

5. खगोलविज्ञान के शिक्षण के दौरान समकक्षी अध्ययन (Peer learning) का इस्तेमाल किया जा सकता है।
1 बिलकुल सहमत नहीं
2 असहमत
3 निरपेक्ष
4 सहमत
5 पूर्णत: सहमत

6. कृपया हमें बताएं कि निम्नलिखित कौन सी गतिविधियों में आप शामिल हुए है। लागू होने वाले सभी विकल्प को चिह्नित करें।
- तारों का अवलोकन
- ग्रहण देखना
- धूमकेतु देखना
- उल्का बौछार देखना
- किसी ग्रह को देखना
- सौर धब्बों को देखना
- दूरबीन या द्विनेत्री (binoculars) से किसी आकाशीय पिंड को देखना
- चन्द्रमा का व्यवस्थित / नियमित अवलोकन
- पूरे वर्ष के दौरान सूर्य के पथ में होनेवाले बदलाव का अवलोकन
- खगोलीय फोटोग्राफी
- अन्य कुछ, कृपया उल्लेख करें

7. खगोलविज्ञान के क्षेत्र में आपके पढ़ने का या अन्य माध्यमों से जानकारी प्राप्त करने का क्या अनुभव है?
- मैं कभी-कभी अखबार में समाचार पढ़ता / पढ़ती हूं।

- मैं खगोलविज्ञान से जुड़ी खबरों पर ध्यान देता / देती हूं और अगर कुछ नया है तो मैं इसके बारे में अधिक जानकारी इकट्ठा करने की कोशिश करता / करती हूं।
- मैंने खगोलविज्ञान पर पुस्तक / पुस्तकों को पढ़ा है।
- मैंने इंटरनेट पर खगोलविज्ञान के बारे में पढ़ा है।
- मैंने खगोलविज्ञान पर वीडियो / सिमुलेशन देखा है।
- मैंने डिजिटल गेम खेला है या खगोलविज्ञान से संबंधित सॉफ्टवेयर या मोबाइल ऐप का इस्तेमाल किया है।
- मैंने एक वेधशाला (कार्यरत या ऐतिहासिक) का दौरा किया है।
- मैंने एक वैज्ञानिक संस्थान / विश्वविद्यालय / कॉलेज का दौरा किया है जहां खगोलविज्ञान में शोध किया गया है।
- मैंने खगोलविज्ञान पर एक सार्वजनिक व्याख्यान में भाग लिया है।
- मैंने एक खगोलविज्ञानी के साथ बातचीत की है।

8. निम्नलिखित कौनसी गतिविधियों में आपने अपने छात्रों के साथ भाग लिया है (स्वयं के द्वारा या एक कार्यक्रम का आयोजन करके)? लागू होने वाले सभी विकल्प को चिह्नित करें।

- एक विशेष खगोलीय घटना का अवलोकन
- तारों का या किसी भी अन्य खगोलीय घटना का व्यवस्थित / नियमित अवलोकन
- खगोलविज्ञान पर एक वीडियो देखना
- खगोलविज्ञान से संबंधित समाचार पर चर्चा करना
- किसी वेधशाला या खगोलीय संस्थान का दौरा
- एक खगोलविज्ञानी को आमंत्रित करना और उनका छात्रों के साथ संवाद करने का प्रबंध करना
- छात्रों को खगोलविज्ञान की पुस्तकें पढ़ने के लिए प्रोत्साहित करना
- खगोलविज्ञान के क्षेत्र में छात्रों के प्रोजैक्ट का मार्गदर्शन करना

9. खगोलविज्ञान पढ़ाने के दौरान आपने निम्न में से कौनसे शैक्षणिक उपकरण का उपयोग किया है?

- रेखाचित्र
- ठोस मॉडल
- हाथ से बनी गतिविधियां
- डिजिटल गतिविधियां / डिजिटल गेम
- सिमुलेशन / वीडियो
- हाथ के इशारे / हाथ के हावभाव
- नाटक (रोल प्ले) / शरीर के हावभाव
- अन्य कुछ, कृपया उल्लेख करें

10. निम्नलिखित वाक्य को सही या गलत चिह्नित करें।

- मैं ज्योतिष में विश्वास करता / करती हूं।

- मैंने मेरे जीवन में बड़े निर्णयों (जैसे शादी का निर्धारण, बच्चे का नामकरण) में ज्योतिषी से परामर्श किया है।
- मैंने अपनी कक्षा में ज्योतिष के बारे में चर्चा की है।

लर्निंग आउटकम स्टडी (मूलभूत खगोल शास्त्र)
अंतिम सर्वेक्षण (शिक्षकों के लिए)

स्कूल का नाम : तारीख:

कृपया हमें बताएं कि निम्नलिखित बयानों से आप कितना सहमत या असहमत हैं।

1. खगोलविज्ञान एक दिलचस्प विषय है।

1 बिलकुल सहमत नहीं
2 असहमत
3 निरपेक्ष
4 सहमत
5 पूर्णत: सहमत

2. खगोलविज्ञान स्कूल विज्ञान पाठ्यक्रम का एक हिस्सा होना चाहिए।

1 बिलकुल सहमत नहीं
2 असहमत
3 निरपेक्ष
4 सहमत
5 पूर्णत: सहमत

3. दिन और रात का आकाश निरीक्षण करने से खगोलविज्ञान के बारे में बहुत सी जानकारी हो सकती है।

1 बिलकुल सहमत नहीं
2 असहमत
3 निरपेक्ष
4 सहमत
5 पूर्णत: सहमत

4. खगोलविज्ञान को हमारे दैनिक अनुभव से जोड़ा जा सकता है।

1 बिलकुल सहमत नहीं

2 असहमत
3 निरपेक्ष
4 सहमत
5 पूर्णत: सहमत

5. खगोलविज्ञान के शिक्षण के दौरान समकक्षी अध्ययन (Peer learning) का इस्तेमाल किया जा सकता है।

1 बिलकुल सहमत नहीं
2 असहमत
3 निरपेक्ष
4 सहमत
5 पूर्णत: सहमत

6. कृपया हमें बताएं कि निम्नलिखित कौन सी गतिविधियों में आप शामिल हुए है। लागू होने वाले सभी विकल्प को चिह्नित करें।

- तारों का अवलोकन
- ग्रहण देखना
- धूमकेतु देखना
- उल्का बौछार देखना
- किसी ग्रह को देखना
- सौर धब्बों को देखना
- दूरबीन या द्विनेत्री (binoculars) से किसी आकाशीय पिंड को देखना
- चन्द्रमा का व्यवस्थित / नियमित अवलोकन
- पूरे वर्ष के दौरान सूर्य के पथ में होनेवाले बदलाव का अवलोकन
- खगोलीय फोटोग्राफी
- अन्य कुछ, कृपया उल्लेख करें

7. खगोलविज्ञान के क्षेत्र में आपके पढ़ने का या अन्य माध्यमों से जानकारी प्राप्त करने का क्या अनुभव है?

- मैं कभी-कभी अखबार में समाचार पढ़ता / पढ़ती हूं।
- मैं खगोलविज्ञान से जुड़ी खबरों पर ध्यान देता / देती हूं और अगर कुछ नया है तो मैं इसके बारे में अधिक जानकारी इकट्ठा करने की कोशिश करता / करती हूं।
- मैंने खगोलविज्ञान पर पुस्तक / पुस्तकों को पढ़ा है।
- मैंने इंटरनेट पर खगोलविज्ञान के बारे में पढ़ा है।
- मैंने खगोलविज्ञान पर वीडियो / सिमुलेशन देखा है।
- मैंने डिजिटल गेम खेला है या खगोलविज्ञान से संबंधित सॉफ्टवेयर या मोबाइल ऐप का इस्तेमाल किया है।
- मैंने एक वेधशाला (कार्यरत या ऐतिहासिक) का दौरा किया है।

- मैंने एक वैज्ञानिक संस्थान / विश्वविद्यालय / कॉलेज का दौरा किया है जहां खगोलविज्ञान में शोध किया गया है।
- मैंने खगोलविज्ञान पर एक सार्वजनिक व्याख्यान में भाग लिया है।
- मैंने एक खगोलविज्ञानी के साथ बातचीत की है।

8. निम्नलिखित कौनसी गतिविधियों में आपने अपने छात्रों के साथ भाग लिया है (स्वयं के द्वारा या एक कार्यक्रम का आयोजन करके)? लागू होने वाले सभी विकल्प को चिह्नित करें।

- एक विशेष खगोलीय घटना का अवलोकन
- तारों का या किसी भी अन्य खगोलीय घटना का व्यवस्थित / नियमित अवलोकन
- खगोलविज्ञान पर एक वीडियो देखना
- खगोलविज्ञान से संबंधित समाचार पर चर्चा करना
- किसी वेधशाला या खगोलीय संस्थान का दौरा
- एक खगोलविज्ञानी को आमंत्रित करना और उनका छात्रों के साथ संवाद करने का प्रबंध करना
- छात्रों को खगोलविज्ञान की पुस्तकें पढ़ने के लिए प्रोत्साहित करना
- खगोलविज्ञान के क्षेत्र में छात्रों के प्रोजैक्ट का मार्गदर्शन करना

9. खगोलविज्ञान पढ़ाने के दौरान आपने निम्न में से कौनसे शैक्षणिक उपकरण का उपयोग किया है?

- रेखाचित्र
- ठोस मॉडल
- हाथ से बनी गतिविधियां
- डिजिटल गतिविधियां / डिजिटल गेम
- सिमुलेशन / वीडियो
- हाथ के इशारे / हाथ के हावभाव
- नाटक (रोल प्ले) / शरीर के हावभाव
- अन्य कुछ, कृपया उल्लेख करें

10. निम्नलिखित वाक्य को सही या गलत चिह्नित करें।

- मैं ज्योतिष में विश्वास करता / करती हूं।
- मैंने मेरे जीवन में बड़े निर्णयों (जैसे शादी का निर्धारण, बच्चे का नामकरण) में ज्योतिषी से परामर्श किया है।
- मैंने अपनी कक्षा में ज्योतिष के बारे में चर्चा की है।

Appendix G: Data

Table 7: change in percentage of correct answer and most popular incorrect answer

Correct answer		Most popular incorrect answer in pre-test	
Percentage of students in pre-test	Percentage of students in post-test	Percentage of students in pre-test	Percentage of students in post-test
1. Everyday at noon, the Sun is exactly overhead.			
False		True	
8.28	37.28	91.72	62.72
2. The Moon does not rotate around its own axis.			
False		True	
58.58	62.72	40.83	29.61
3. Pre-test: **Saturn** can be seen by the naked eyes. Post-test: **Mars** can be seen by the naked eyes.			
True		False	
27.81	38.83	70.41	40.29
4. Pre-test: Planets which are closer to the Sun take **more** time to complete one revolution than the planets which are farther away from the Sun. Post-test: Planets which are closer to the Sun take **less** time to complete one revolution than the planets which are farther away from the Sun.			
False	True	True	False
32.54	63.59	65.09	17.96
5. Pre-test: Day and night occur because - Post-test The Sun appears to move from East to West because -			
The Earth rotates around its own axis.		The Earth revolves around the Sun	
18.93	36.41	47.93	12.14
6. Pre-test: Seasons occur on the Earth because - Post-test: Imagine that the Earth's orbit were changed to be a perfect circle about the Sun so that the distance to the Sun never changed. How would this affect the seasons?			

The Earth's axis is tilted.	We would continue to experience seasons in the same way we do now.	The Earth's orbit is elliptical.	We would still experience seasons, but the difference would be much less noticeable.
17.16	32.52	38.46	22.33
7. Pre-test: The Moon rises from Post-test: The moon sets in			
East	West	West	East
53.85	49.03	28.99	18.93
8. Pre-test: Which force is responsible for the Moon to revolve around the Earth? Post-test: Which force is responsible for the Earth around the sun?			
Gravitation		Tidal force	
63.91	66.02	12.43	7.77
9. Pre-test: The period from New Moon to Full Moon is called - Post-test: The period from New moon to full moon (post) is called -			
Shukla Paksha	Krishna Paksha	Krishna Paksha	Shukla Paksha
63.31	49.03	18.34	23.3
10. Pre-test: In what phase is the Moon on Diwali night? Post-test: Which phase of the moon signifies Eid?			
New moon	Crescent	Full moon	Full moon
49.7	38.35	33.14	17.48
11. Which is the brightest star in the night sky?			
Sirius		Pole Star	
2.37	25.24	68.64	35.44
12. The asteroid belt is situated in between -			
Mars and Jupiter.		Earth and Mars	
23.67	32.04	42.6	25.24
13. Which of these pictures is NOT a phase of the Moon?			

 (eclipse)		 (Gibbous)	
39.40	17.48	28.4	12.14
14. Pre-test: Mark the picture which shows the position of sun, earth and moon at full moon Post-test: Mark the picture which shows the position of sun, earth and moon at new moon (post)			
Sun-Earth-Moon	Sun-Moon-Earth	Waning half moon	Full moon
21.89	46.6	31.36	17.96
15. Which is the correct order from the smallest to the largest in size?			
Moon – Earth – Saturn – Sun		Earth - Moon - Sun - Saturn	
18.93	35.44	27.81	16.02
16. Which is the correct order from the nearest to the farthest from the Earth?			
Moon – Sun – Uranus – Polestar		Sun - Moon - Uranus - Plestar	
18.34	34.32	45.56	27.22
17. Which of the following objects produces its own light?			
Star		Moon	
18.93	60.36	55.62	26.04
18. Which of the following is not part of our Solar System?			
Galaxy		Comet	
62.72	53.85	18.34	13.61
19. Which of the following is the name of a nakshatra (lunar mansion)?			
Rohini (रोहिणी)	Kritika (कृत्तिका)	Makar (मकर)	Makar (मकर)
24.85	48.52	27.81	26.04

Table 8: Percentage of students' responses on questions related to attitudes about science and astronomy (percentages for intervention group are in purple and those for non-intervention group in blue)

Question	Strongly disagree		Disagree		Neutral		Agree		Strongly agree	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
I enjoy learning science (int)	3.55	1.78	2.96	5.33	12.43	10.06	19.53	22.49	58.58	60.36
I enjoy learning science (non-int)	2.54	2	4.24	11	15.25	14	16.95	25	61.02	47
Scientific thinking should be used in taking decisions in everyday life (int)	10.06	3.55	4.73	5.92	14.79	21.3	20.12	27.22	46.75	40.83
Scientific thinking should be used in taking decisions in everyday life (non-int)	7.63	5.93	5.08	13.56	20.34	32.2	16.95	19.49	49.15	27.97
I find astronomy interesting (int)	11.24	3.55	6.51	4.73	17.75	15.38	22.49	33.73	40.24	42.01
I find astronomy interesting (non-int)	11.86	10.17	8.47	16.1	18.64	24.58	17.8	22.88	43.22	25.42
I would like to continue to learn astronomy in college (int)	5.33	5.92	8.88	5.33	10.06	17.16	16.57	25.44	56.8	44.38
I would like to continue to learn astronomy in college (non-int)	15.25	14.41	11.02	21.19	19.49	22.03	9.32	15.25	44.07	26.27

Table 9: Percentage of students who find particular activity of astronomy interesting (percentages for intervention group are in purple and those for non-intervention group in blue)

In future I would like to engage in	Intervention schools		Non-intervention schools	
	Pre-test	Post-test	Pre-test	Post-test
A. Observations of moon, sun, stars and other	55.03	59.76	26.27	44.07

astronomical objects				
B Learn more about different theories such as formation of stars and solar system	50.3	51.48	34.75	37.29
C. Drawing pictures and making films about astronomy	53.25	56.8	46.61	41.53
D. Preparing telescopes, satellites and other instruments	54.44	59.17	34.75	43.22
E. Horoscope and astrology	29.59	26.04	13.56	16.95
F. Doing calculations of orbits, energy etc.	43.2	49.7	41.53	44.92
G. Studying how astronomy was developed in different parts of the world	44.97	57.99	47.46	51.69
H. Not interested in astronomy	24.85	21.89	19.49	21.19