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Teaching and learning basic astronomy through a blended module

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***Abstract*— A module on basic astronomy has been prepared for Grade 8 or Grade 9 students as a part of a large-scale field action project called 'Connected Learning Initiative' (CLIx). It is a sequence of 12 classroom lessons in blended mode. The module was rolled out in nine schools in Jaipur district of Rajasthan, India. For this study, we observed one school where the module was being rolled out. The study was done to understand how the teacher adopted the module for her classroom and how the students interacted with it. Our main observations are: the teacher and the students felt that role play activities and digital activities are complementary to each other. Role play, gesture and model activities helped students visualize whereas digital activities gave immediate feedback to students. The teacher used the feedback from digital activities to modify her teaching plan and asked her students to help each other.**

Keywords—role play, gesture, blended learning, e-learning

I. Introduction

It is well documented that both students and adults carry many alternative conceptions about astronomical phenomena (Lelliott & Rollnick, 2009). Researchers have deliberated upon possible causes of it. Subramaniam and Padalkar (2009) and Padalkar and Ramadas (2011) have argued that root of many alternate conceptions can be traced back to the students inability to use visuospatial thinking. Science teachers use diagrams in the textbooks and explain astronomical phenomena on the blackboard. But diagrams and written descriptions in the textbooks have limitations, diagrams represent 3D space in 2D which makes it harder to interpret (Parker and Heywood, 1998) and fall short in helping students in visualizing astronomical phenomena. This has lead many researchers to explore other pedagogic strategies which might help in enabling visuospatial thinking such as concrete models or computer simulations.

Moreover, diagram, computer simulations or concrete models which are intended to explain astronomical phenomena represent the system from outside (extrinsic frame of reference) whereas we observe the phenomena from within the system (intrinsic frame of reference). Coordinating between these two frames of reference is difficult. For these reasons, Padalkar and Ramadas (2011) have found that gestures and role plays are useful tools in enabling visuospatial thinking in astronomy.

Latest development in new media provide an opportunity where many complex actions which require mental visualization and mental rotation, can be performed by moving few actions outside the head into the world. Understanding astronomical phenomenon requires students to visualize complex phenomena, and it has been argued that computers can be used to help students visualize astronomical phenomena better. Chen (2007) found that virtual reality environments can used to introduce solar system. Koun-Tem Sun, Ching-Ling Lin, and Sheng-Min Wang (2010) used 3D VR model to teach sun-earth-moon system and found that it helped in clearing alternate conceptions.

Advent of networked computers made computer supported collaborative learning possible. Computer environment is used to provide pedagogical support and scaffolding to collaborative learning, computer is not seen as something that will replace human or peer group but something that will support it (Stahl, 2013).

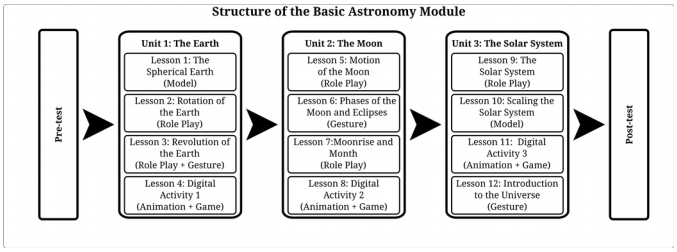
On this basis we prepared a module on 'Basic Astronomy' which is dealt in Grade 8 or 9 in different states of India. Details of the modules are given in the next section. CLIx modules are prepared as an exemplar material with the expectation that it will help teachers to bring 'active learning' into practice. The main aim of this study is to see whether and how teachers' knowledge, beliefs and practices changed over the course of implementation of the module and how students responded to it. In this paper we present our observations and findings from implementation of the basic astronomy module in one of the Grade 9 classroom in government school in Jaipur district in Rajasthan, India.

II. Materials and Methods

A. Basic Astronomy Module

Connected Learning Initiative aims to provide quality education to young students from disadvantaged communities through leveraging technology. Three guiding principles (referred as 'pedagogic pillars') directed the design of all the CLIx modules: Peer learning, Authentic learning and Learning from mistakes. The 'Basic Astronomy' module is a blended module based on these pedagogic pillars. It also followed another pedagogic principle of 'multimodality' to facilitate the visuospatial thinking which is crucial in learning astronomy. The module was developed through design-based research. The details of the first trial are documented in Chopde and Padalkar (2018) and the details of another revision are being documented elsewhere (authors, in preparation).

Figure 1 shows the structure of the module. The module has multiple choice pre test and post test which probed the students understanding of the basic astronomical phenomena. Sandwiched between pre test and post test was the intervention which was divided into three units: 'The Earth', 'The Moon' and 'The solar system and beyond'. Each unit had one digital lesson and three classroom lessons resulting to total 12 lessons of 40 minutes each (a total of 8 hours). Classroom lessons mainly included activities such as role plays, gestures and handling concrete models to explain astronomical phenomena as proposed by Padalkar and Ramadas (2011). Each digital lesson includes short digital animations (with minimal interactivity) in the beginning. Main strength of these animations are, they are dynamic and expose students to the representations from realistic to abstract manner. The second part of each digital lesson is an interactive activity. The interactive activities of the three digital lessons make a game called 'AstRoamer'. The module has features which supported collaborative learning. At the end of each activity students are asked open questions, they are suppose to write about those questions in 'Notebook' and discuss with other students using 'Discuss' feature. Students can see each others notebook posts and can comment on those posts. These features were added so that students can share their views and discuss conflicting ideas. Students are expected to work on the digital activities in pairs to promote peer learning and also for practical reasons of not have enough number of computers for individual students.



Drawing 1: Structure of the Basic Astronomy Module

B. Sample

In the present study we are reporting observations from a school from Rajasthan a state in India where Basic Astronomy Module was being implemented. The reason behind choosing this school was that the teacher implemented the module in fair length and allowed us to observe her classes. The school is in a village which is 33 km from Jaipur (capital city of Rajasthan). It is a government school, like most government schools in the state, medium of instruction is Hindi. The school has a computer lab which has ten desktops and a school server which hosts the CLIx-platform. At a given time, 20 students can sit in the computer lab and access digital activities given in the Basic Astronomy Module. Twenty students of grade 9 participated in the study. They were all girls as it was a girls' school. All the students were from nearby villages and their average age was 15 years. The teacher who implemented the module was a female with more than 10 years of teaching experience. She has a bachelor degree in biology and education.

C. Research Design

We follow the case study approach to study the implementation of the module. The rollout of the module started with a one day face to face workshop with nine high school government teachers from various schools in Jaipur district. During this workshop teachers were exposed to some of the classroom activities and all the digital activities. We choose six classroom activities out of 17 activities in the module and invited the teachers to participate as if they were students. The videos of all the classroom activities were accessible to teachers if they wanted to refer to it before carrying out in their classroom. Based on the interactions with the teachers during the workshop we chose some of the schools to visit and observe the rollout. The rollout in the school chosen for the study started on Monday, exactly one week after the face to face workshop.

We observed a total of 4 sessions ranging from 35 minutes to 135 minutes (2 hours 15 minutes). The total interval of observations was 365 minutes (approximately 6 hours). During the intervention, data was collected in the form of classroom observations, audio and video recordings of the classroom transactions and interviews of the students and the teacher. The module had two major components: classroom activities (which involved role play, gestures and models) and digital activities (which needed computers). Activities involving role play were done on the terrace of the school as the activities needed much larger space than the classroom whereas activities which involved models and gestures were done in classroom. Digital activities were done in computer lab where two students shared one desktop computer. Each student was given a unique login id which they used to log in to the CLIx-platform. Same id was used to track each students' work on the CLIx-platform. As two students were sharing one computer, one student was asked to login as a user and then she added the second student as her 'Buddy'. This was done to record the pair of students who used one desktop computer and track their work.

1) Pre-intervention test results

Before starting the Basic Astronomy Module all the students from different schools took the pre-test on computer. It gave us an idea about students conceptual understanding. Majority of students had misconceptions about the simple astronomical phenomenons. Here is the list of questions organized based on how they were answered (Detailed questionnaire is in appendix):

Questions which majority of the students answered correctly:

1. The Moon does not rotate around its own axis. True or False?

2. Which force is responsible for the Moon to revolve around the Earth?

3. In what phase is the Moon on Diwali night?

4. Which of the following is not part of our Solar System?

Questions which showed mixed response (approximately half of the students could answer it correctly):

1. Eclipses are bad omens and should not be seen. True or False?

2. The Moon rises from the:

3. Which of the following is the name of a 'nakshatra' (lunar mansion)?

Questions which majority of students could not answer correctly:

1. Everyday at noon, the Sun is exactly overhead. True or False?

2. Saturn can be seen with the naked eye. True or False?

3. Planets which are closer to the Sun take more time to complete one revolution than the planets which are farther away from the Sun. True or False?

4. Day and night occur because:

5. Seasons occur on the Earth because

6. Which of these pictures is NOT a phase of the Moon?

7. The New Moon occurs when:

8. The period from New Moon to Full Moon is called:

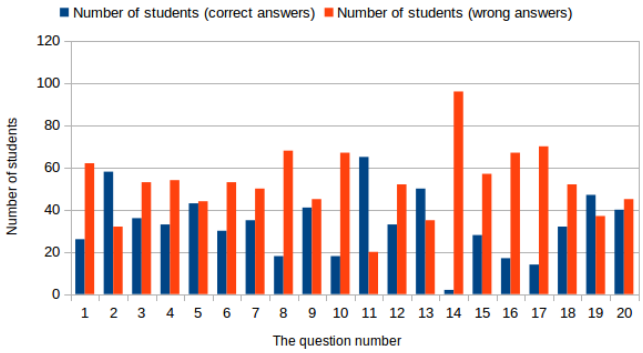
9. Which is the brightest star in the night sky?

10. The asteroid belt is situated in between:

11. Which is the correct order from the smallest to the largest in size?

12. Which is the correct order from the nearest to the farthest from the Earth?

13. Which of the following objects produces its own light?



Drawing 2: Pre-intervention test results

Pre-intervention test results were used in planning the intervention. In next session we describe how the Basic Astronomy Module was implemented in one of the school. The description is based largely on the field notes taken by the observers and video recorded interviews of the the students and teachers.

III. Observations and Data Analysis

First we note some of the observations during the face to face workshop. After introducing the module, we invited the teachers on the terrace to participate in the role play activities. Teachers were reluctant to participate. Most of them expressed that "Why do we need to put so much of effort for simple things such as motion of the earth and the moon.?" But for the first activity on the rotation of the earth, some rotated from the left and others from the right. After pointing out this discrepancy, there was a slight shift in their attitude towards the role play. The crucial activity which changed teachers' attitude towards role play was the motion of the moon around the earth. Most teachers either knew that period of rotation is same as the period of revolution of the moon or knew that only one face of the moon can be seen from the earth, or both. However, when teachers were asked to mimic this motion in pairs, they were completely confused. Some teachers rotated multiple times, sometimes in a non uniform manner, some actually mimicked the motion correctly, always facing the earth. But they thought that it was incorrect because they thought they were not rotating. Then when we systematically asked them to do only rotation, only revolution and then rotation+revolution broken into four quadrants they understood the motion. This activity convinced most of the teachers that role play can be useful in learning astronomy. However many of them still thought that demonstrating a role play in the classroom should be good enough.

Now we record and analyze our observations from our session logs. Following are the highlights of the sessions:

Day 1: Session 1 (Computer lab)

1 11:15 am - The teacher asked the students to read Lesson 1 of Unit 1 of the Basic Astronomy Module.

2 11:17 am – Two students were sharing one computer and reading text on the screen.

3 11:21 am – The teacher used a small model (about 12 cms in diameter?) of globe which was present in the room to talk about directions but student did not pay attention to as they were busy reading from the screen.

4 11:30 am – The teacher asked students to continue reading from the screen.

5 11:35 am – The teacher used a small model of globe to explain how day and night happens.

6 11:40 am - The students started reading Lesson 3: Revolution of the Earth from the screen

7 11:50 am - The teacher ended the session

Day 2: Session 2 (Computer lab)

8 11:00 am - The teacher started the session by asking students to start computers and open the Basic Astronomy Module on CLIx-platform. Two students shared one computer.

9 11:05 am - The teacher asked the students to start Lesson 4: Digital Activity 1.

10 11:10 am - The students started playing the first level of the game 'AstRoamer: What is the time?' (Lesson 4).

11 11:15 am - Many students struggled with the AstRoamer game. They were unable to give correct answers even in two attempts.

12 11:20 am - The teacher noticed that the students are struggling. She explained how the earth rotates using role play.

13 11:25 am - All the students participated in a role play activity to understand how the earth rotates.

14 11:45 am - The Students went back to the computers and started playing AstRoamer game again.

15 11:55 am - Few students gave correct answers whereas others still struggled.

16 12:00 pm - The teacher declared that session has ended.

17 12:10 pm - The teacher started talking with the researchers who were observing the class. The students continued playing AstRoamer game. The teacher allowed to continue playing.

18 12 :35 pm- The students continued playing the AstRoamer game. Now most of them gave correct answers.

19 13:00 pm - The Teacher asked the students to leave the computer lab. The session finally ended.

Day 3: Session 3 (Classroom + Computer lab)

20 11:15 am - The Teacher started the session with a role play activity to mimic the motion of the moon (Lesson 5, Unit 2).

21 11:18 am - The teacher called two students explained the role (one student was the earth and one was the moon) what they are suppose to do. Other students observed.

22 11:22 am- The teacher asked the students to choose a partner and do role play activity. The students started the role play activity.

23 11:26 am - The teacher watched while the students were doing the role play activity.
24 11:29 am - The teacher explained phases of the moon through a role play activity (from Unit 2).
25 11:41 am - The students started the role play activity designed to understand phases of the Moon.
26 11:55 am - All the students were busy in doing role play activity.
27 11:58 am - The teacher asked the students to go to the computer and start the Basic Astronomy Module on CLIx-platform.
28 12:02 pm - The Students started CLIx-platform. Few students are already at Lesson 8 of Unit 2.
29 12 :03 pm - The teacher sat with one student and explained her the 'AstRoamer: Moon Track' while other students explored the module on their own.
30 12:04 pm - Another student asked the teacher to help. The teacher went to help that student.
31 12:06 pm - The students watched the animations given in the Digital Activity 2.
32 12:09 pm - The students started playing level 2 of the game 'AstRoamer: Moon Track' (Lesson 8)
33 12:10 pm - The students helped each other (within the group and across the group)
34 12:13 pm - The students proudly showed the medals to the teacher (virtual medals are given after successfully completing the game)
35 12:14 pm - The students shouted to get the teacher's attention to show the medals they had won.
36 12:15 pm - The teacher looked happy perhaps because her students enjoyed the game. Also maybe because many of the students had won gold medals which could be won only after giving correct answers. (The gold medal is received if the answers are correct)
37 12:16 pm - While students were busy playing game on CLIx-platform, the teacher did not sit at one place. She moved around the class and watched what her students were doing. She also asked the students to help others.
38 12:20 pm - The students were leaving their place to help other students.
39 12:25 pm - The teacher asked the students to close the CLIx-platform and sit in a circle.
40 12:27 pm - The teacher asked the students what they learnt. Few students said they learnt about the moon and about the phases of the moon.
41 12:30 pm - Session ended.

Day 4: Session 4 (School ground + Computer lab)

The teacher was on leave on day 4 so one of the authors of this paper conducted the class.

42 11:15 am - Session started. The teacher revised what was done in the earlier classes.
43 11:22 am - The teacher talked about the Sun and the solar system from Lesson 9 of Unit 3.
44 11.25 am - The teacher asked a few students to name of few planets. Some of the students knew the names but were confused with the sequence.
45 11.27 am - The teacher discussed the trick to remember all planets in sequence in local language.
46 11.45 am - The teacher explained the details of all planets and few characteristics specifically which will help students to play the third digital game of the module.
47 11:48 am - The teacher took the students to the ground for role play activity.
48 11:50 am - The teacher explained role play activity (mimicking the solar system) to the students.
49 11:54 am - The students performed the role play activity on the playground of the school. Few girls felt shy as the other students watched from their classrooms.
50 11:55 am - The teacher observed while students performed the role play.
51 12:03 pm - The teacher explained the second activity -- Scaling the solar system- from the Unit 3 to the students.
52 12:12 pm - The teacher asked the students to do the activity. The students started the activity.
53 12:25 pm - The students performed the role play to mimic the solar system (planets move in an orbit around the sun). The teacher moved around to observe.
54 12:30 pm - The role play session ended. The teacher asked students to go to the computer lab.
55 12:35 pm - Two students shared one desktop computer. The digital activity started.
56 12:39 pm - The students helped each other to login to the CLIx-platform and in the digital activity.
57 12:44 pm - The students explored the interactive animations about the solar system.
58 12:50 pm - While the students explored the digital activity teacher moved around and observed.
59 12:59 pm - While few students are still at animation part some students started playing the game.
60 01:04 pm - The students helped each other in the digital game.

The teacher did not follow everything given in the module, given her constraints she adopted the module to her need. For example, one session in her school is of 45 minutes (commonly referred as 'period'). The module was designed to be completed in 12 sessions (each session of 35 minutes) but teacher finished the module in around 6 sessions. She also clubbed two sessions together by altering the timetable of the school so that she can take both role play activities and digital activities one after other (as done on day 3).

Both the students and the teacher did not pay attention to features like 'Notebook' and 'Discuss' because of which across group computer, mediated interactions did not happen. As two students shared one computer, intra-group learning was seen but inter-group collaboration was limited. It only happened when either students asked for help or when they offered to help or when the teacher asked one group to help another group.

It appears that along with the students, the teacher also learnt while implementing the Basic Astronomy Module. For Unit 1, teacher asked students to open the module on CLIx-platform and read each lesson. In between, she did use small globe model of earth to explain few things but she did not conduct any role play activities. But when she saw that students struggled in answering questions while playing the game in the Digital Activity 1 she changed her strategy in the next session. On day 3, teacher started with role play activities and then came to digital activities. When the teacher was asked about it she said:

Teacher: We began with the class activities first (referring to role play activities), it was helpful. We should first conduct the class activities followed by digital games. This enables children to understand the game. Today (referring to day 3) all students were able to perform activities very easily. Yesterday (referring to digital activity session on day 2) they found these activities little difficult. Today, since they did the class activities first, they understood it clearly and then they were able to play games by themselves.

Teacher also felt that teaching astronomy using role play, gesture and digital activities is better than the traditional way of teaching astronomy using diagrams and text.

T: Teaching using the module is much better. Textbook diagrams & text was not clear to understand. Some things like rotation-revolution cannot be seen and hence we can't explain it very well. I am telling you that we ourself were not able to learn these things on blackboard so clearly; then how can we teach it to our students. We learnt it for the first time. Now we understood that we can teach this things so easily to children . We have now learnt everything properly. The day we had training (referring to TPD workshop which happened one week before) I learnt those things properly.. and was surprised to know about these things. Usually we hear that the rotation happens in some specific brief.. but never understood that what will be the exact positions of these objects in the space.

Interviewer: Specifically of Moon…
Teacher: Of Moon.. The children and myself understood how all three (the Sun, the Moon and the Earth) of them revolve around each other. We have read about lunar and solar eclipses, also read that one object covers another etc., but today we got better clarity about it. Digital activities were helpful for better understanding. It's nice, very nice.

The teacher has a background in biology and not in physics. It appears that she herself never understood many astronomical phenomena but she did never realized it. While implementing the Basic Astronomy Module she got an opportunity to correct them. She correctly pointed out that text and diagrams (in textbooks and on blackboard) can not help students visualize abstract astronomical phenomena such as rotation and revolution of earth-moon-sun system (Parker and Heywood, 1998). She also valued the new pedagogical strategies of using role play, gesture, model and digital tools. According to her, not just students but even the teachers also will benefit from it.

Along with classroom activities (role plays, gestures and models), the digital activities played an important role in students' learning process. While doing role plays and gestures, students got very little feedback about their performance as teacher could not attend every student to give feedback on their understanding. But through digital activities students got immediate feedback on what they learned through role and gesture activities. Perhaps, that is why on day 2 after playing digital game for almost one hour students were able to answer questions correctly. Digital activities also gave some free time to the teacher which she spent with the students who were having problems. At this time, the teacher could gauge whether the students have understood the concepts or not. For example, on day 2 teacher realized that by simply reading text about activities on the computer screen, the students did not understood the concepts and hence they are facing problems in answering the questions in the digital games. Whereas on day 3, when the digital activities were done after the role play, the teacher realized through digital activities that students understood the concepts. The teacher also identified the students who understood the content and she used this information by asking those students to help others.
Teacher: Teachers have to look/observe students performing activities.. need to check if the students are able to do it or not, are they able to move from one lesson to another. If they need help, I guide them, this helps children to get clarity. They will enjoy when they will win.. and they win only when they understand it correctly.(referring to winning medal in dig activity).
Teacher: When a student understands the activity clearly, we ask them to help other children.

The element of games in the digital activity made it interesting for the students. That is the reason on day 2 even after teacher declared that session ended the students continued to play the games. Incentives in the form of medals motivated students to keep trying till they get the correct answers.

The students also felt that if they do role play activities first and then go to digital activities they have more fun and better understanding.

Interviewer 1: was there any connection between that game (referring to role play activities) this game (referring to digital activities)?
Students: Yesss… yes sir.. yes..
Interviewer 2: What if we had not played that game (referring to role play activities) would you have understood this game (referring to digital activities).. played this game?
Students: No ma'am
Interviewer 2: Would you like to play more of these kinds of games?
Students: Yes ma'am.. we like it

From the students reaction it appears that not only they enjoyed playing digital games but also saw value in the Basic Astronomy Module. Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections A-D below for more information on proofreading, spelling and grammar.

IV. Conclusion and Discussion

We observed one school from the state of Rajasthan where the Basic Astronomy Module roll out was going on. We found that teacher and student did not use features which enabled collaborative learning. Collaboration happened but it was not mediated by computers. It appears that maybe due to limited time the teacher did not conduct the activities like writing in notebook and discussing it with peers. But it is also possible that the instructions given in the module were not clear enough. The Basic Astronomy Module needs explicit instruction on how and where to use features like 'Notebook' and 'Discuss' so that collaborative learning can happen.

The teacher felt that the Basic Astronomy Module was well designed and combination of classroom activities (role play, gesture and model) and digital activities (animations and digital games) is helpful in teaching-learning abstract concepts in astronomy. Teacher also realized that sequence of activities also matters. Classroom activities followed by digital activities leads to better understanding.

The teacher used digital activities as a tool to understand what students learnt in classroom activities. She used feedback from digital activities to change her pedagogic strategy and also to decide which student needs her help and which students can be asked to help others.

We observed change in teachers practice during the module implementation. She moved from more traditional approach to traditional-cum-blended learning approach. We also saw change in the teachers' belief about teaching, at the end of the module she understood that same topic can be taught in multiple ways. Lecture mode is not the only way to teach.

The students enjoyed the digital activities. They also used feedback from digital activities to judge what they understood through classroom activities is correct or not. The students also saw the connection between the classroom activities and the digital activities and they felt that for better understanding both activities are necessary.

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