Designing for Children 2019

Play and Learn

Designing play-based learning material under constraints

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Abstract

As a part of the connected learning initiative a blended module called ‘Basic Astronomy’ is designed for Grade 8 and 9 students. This paper focuses on the play material included in this module namely a digital game and role-plays. Since scalability was one of the main objectives of the project and consequently, the module was meant to be implemented in government schools, there were several constraints in terms of hardware available in schools, time, space and students’ familiarity with computer and content. All these factors influenced our design. In this paper we will describe some of the conscious decisions we made to overcome these constraints. Through our field observations and digital data collected through CLIx platform as well as tests conducted on the field at different points of time, we found out that some of these decisions made the implementation module smooth, while some of the constraints could not be addressed fully.

Keywords: Blended module, roleplay, digital games

Introduction

Connected Learning Initiative (CLIx) is a technology-led innovation to improve the quality of learning of high school students, under which six science modules, three mathematics modules and two English modules have been developed for Grade 8 and 9 students. In this paper, we will describe the play-based material in one of the modules titled ‘Basic Astronomy’. This blended module is divided into three units: The Earth, The Moon and the Solar System. Each unit consists of three classroom lessons and one digital lesson. The digital lesson includes a digital game and some interactive material such as animations, videos and photos so that students can recall what they learn in the classroom and fill-in some details about what they learned. We describe the digital game in detail in the following paragraph. The classroom lessons included activities such as role-plays, gestures, discussions around those activities and instructions to draw diagrams and solve some problems.

In the remaining part of this section, we present a brief literature review on the two types of play material used in the module, namely a digital game and role-plays, and describe the activities used in the module. In the following section, we briefly describe the process of data collection, followed by the factors which influenced our design decisions. In the last section we present outcomes of each of these decisions.

Digital Game

Currently a plethora of digital educational games are available and digital games are widely used in various educational settings. Multiple studies have shown that games have a motivating effect on students (Kirriemuir & McFarlane, 2004; Shaikh, et al., 2017). Specifically games affect attention, relevance, confidence and satisfaction along with motivation (Klein & Freitag, 1991). Games provide context for learning, and make them interesting (Kirriemuir & McFarlane, 2004). Studies on games (like *Environmental Detectives* or *Revolution*) specifically designed to teach science have found that students better engage in subject-related practices such as planning a scientific investigation (Bransford, et al., 1990). Moreover, the positive effects of games on the motivation of the students are gender-neutral(Klein & Freitag, 1991; Papastergiou, 2009) unlike students' attitude towards ICT, where female students are seen to have a negative bias (Broos, 2005).

This is why the digital material in Basic Astronomy is game-based. The name of the game 'AstRoamer' is a combination of two terms: Astronomer and Roamer. As the name suggests, the players take up the role of an astronomer who is on a journey. The description of the three parts as follows:

1. AstRoamer I: What is the time? (belongs to Unit 1): In Unit 1 students learn about the rotation of the earth and as a consequence different time zones on the earth. In the first part of the game, players have to collect eight elements from different locations on the earth using corresponding clues. Clue, diagram (picture of the earth, along with the sun-rays) and slots to put the elements appear on the screen (See figure 1A and B). Clue includes the time of the day and the name of the country. On the interface when a player brings the cursor on the arrow of direction of rotation of the earth, it starts rotating. The player has to stop rotation when the country and the time of the day mentioned in the clue matches by removing the cursor away from the earth and submit. If the answer is correct they get the element, if it is incorrect, they get feedback and another chance to play. If the answer is correct in the second chance they can move to the next trial. If the answer is incorrect, they are given the correct answer and then they move to the next trial (without having the element in its designated slot).

Figure 1a: Display for Prayer 1 (from above the North pole)

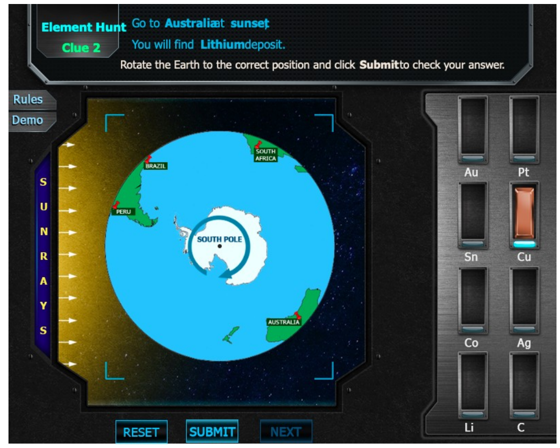

Figure 1b: Display for Prayer 2 (from above the South pole)

2. AstRoamer II: Moon Track (belongs to Unit 2): In Unit 2 students learn about the motion of the moon and its consequences. One of the consequences, the phases of the moon, is a phenomenon which students can't escape to observe, but often develop alternative explanations for it (Lelliott and Rollnick, 2009). In this part, players have to place the moon in its orbit on a certain phase of the moon. Clue, the diagram (the Earth, the moon's orbit, picture of the moon in a corner), a window for feedback and score appears on the screen (Figure 2). The clue includes the name of the festival on which the moon is in that particular phase. Players have to drag the moon from the corner and put it in its orbit so that the person from the earth will see the phase indicated in the clue. If the answer is correct (±22 degrees of error) they get 2 points, if it is incorrect the feedback window shows how the moon would look from the earth if the moon was at the position where Players kept it. If they put the moon in the correct position in the second attempt, they get one point. If the position is incorrect in the second attempt, they are shown the answer on the screen after which they have to go to the next clue without getting any points.

3. AstRoamer III: Planet trek (belongs to Unit 3): In Unit 3, students learn about the planets in the solar system. In this part of the game, they have to collect different elements and chemical compounds which are abandoned on certain planets. A clue, all the planets (correct relative sizes) in the solar system in a line and ten test-tubes to keep the collected elements or chemical counts appear on the screen (Figure 3). The clue includes a description of the features of the planet and abundance of the element which is to be collected also provides a hint. If the player clicks on the correct planet they get the element or chemical compound, if not, they get a hint and another chance to play. If they get the element/chemical compound in the second chance they can move to the next clue, if they give an incorrect answer in second response, they are shown the correct response after which they can go to the next clue, without getting element / chemical compound in its designated test-tube.

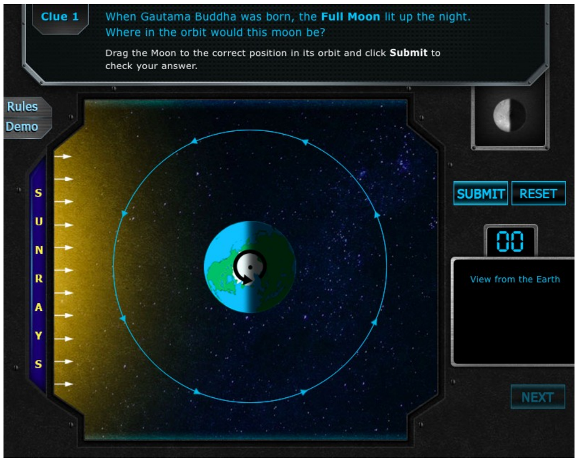

Figure 2: Display of AstRoamer: Moon track

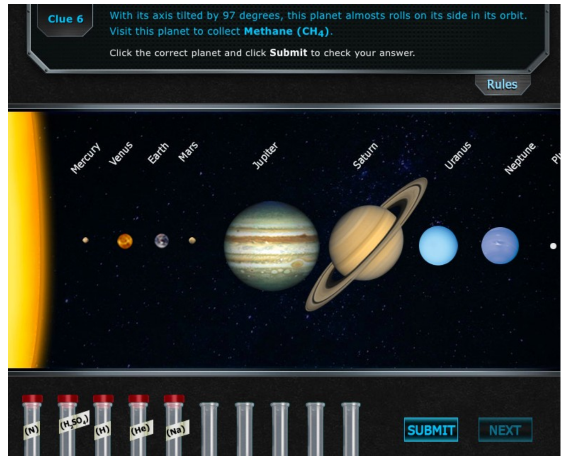

Figure 3: Display of AstRoamer: Planet trek

In all three parts if a player solves all the riddles correctly, s/he gets a gold medal.

Role Plays

Game-based learning was also carried into the design of hands-on activities. Kinesthetic, vestibular, haptic and visual perception together are responsible for spatial cognition. Padalkar and Ramadas (2008) argue that understanding models and explanations in astronomy rely on spatial cognition, hence using spatial representations such as concrete models, gestures, role-plays and diagrams is seen to be beneficial. In particular, models in astronomy are often drawn as if we are outside the model (from an extrinsic frame of reference) but most of us, is bound to the earth, have access to phenomena only from within the model (from the intrinsic frame of reference). When students engage in role-plays they enact the model but they witness the phenomenon. The role-plays in the modules were adopted from those documented by Padalkar and Ramadas (2010).

Research Design

The process of development of digital and hands-on activities followed by design-based research. Both digital and classroom activities were tried out in classrooms as well as with students, lay-adults and experts. Details of the development of Unit 1 are documented by Chopde and Padalkar, 2017. Post development, the module was implemented in nine Rajasthan government schools. Our observation note then led to module revisions and a wrap-around for teachers that includes the rationale and videos of classroom activities. We then conducted a controlled experiment study in eight other schools in Rajasthan to test the module's effectiveness. The preliminary findings of the pre-post analysis are documented by Shaikh et al. (in press). This paper discusses the qualitative analysis of field observations and interactions with teachers, students and the field team.

Decisions made during designing

The design of CLIx modules was focused on delivering quality at scale despite constraints found in government and low paying schools. This section presents the challenges in the field as found in the trials conducted in varied settings and the resultant, iterative design changes.

Computer Hardware

One of the main constraints on the field was poor internet connectivity. For this reason, all the schools which participated in CLIx are given the CLIx modules on a server which is connected to all the computers in the lab. The server also collects data of students' responses to interactives and it is collected by the field teams from time to time.

Teaching Basic Astronomy digitally requires graphics and animations since visualisations and spatial representations need to be materialised for the learner (Padalkar and Ramdas, 2010). However, schools did not have the requisite hardware. School labs used N-computing (multiple client desktops connected to a parent machine) and the CLIx modules had to work on systems with even just 2GB RAM and Pentium or above processors. We further designed to not use sound since learners would traverse the games at a varying pace and school systems did not have headphones.

High students to computer ratio

An additional constraint was the student to computer ratio that stood at 7:1 with the average class size being 68 with 10 computers in the lab. While batching students is a common strategy to combat this, it is too time consuming and management intensive to be sustainable in schools. We, therefore took the following two decisions:

1. Pedagogically, we saw merit in designing a blended module. Science relies on sensory experiences, be it in the form of observations, hands-on activities, demonstrations or experiments. It is important for students to smell the chemicals, see the stars, feel the electric shocks and hear the sounds of different frequencies. Moreover, spatial cognition, which is pivotal to learning astronomy, primarily develops through haptic, kinesthetic and vestibular senses. Therefore we included many gestures and role-plays which involve whole-body movements. These role-plays and discussions around them constituted the classroom lessons. However, the school constraints also enabled us to decide that the digital component leading to batches would not be more than one-fourth of the module such that the classroom and digital activities complement each other.
2. Another design feature of CLIx Modules is collaborative learning and is seen in the buddy system that allows multiple logins (ideally two or three). Not only does it allow more students to learn simultaneously with just 10 computers, it also enables them to learn from each other in authentic ways. To ensure this, we designed the game to enable players to assume roles. For example, in the very first unit, one student has to play in the Northern hemisphere and his buddy in the southern hemisphere.

Students’ abilities

The government school students hailed from low socio-economic backgrounds with access to computers only in schools. Oir baseline surveys showed just 33.55% having a computer at home. They, therefore, had low digital literacy skills. Our game design, therefore, is not only simple, but also includes a demo trial in the first two parts of the game to familiarise the students with the tools and techniques of the game.

Students’ proficiency in content

Astronomy is a misconception prone area and know to pose difficulties to students and teachers (Lelliott and Rollnick, 2009). Indian students from low socioeconomic backgrounds are not an exception to this (Padalkar & Ramadas, 2008; 2011). Our baseline data showed that 37.45 % of students correctly attempted the science-related questions on the test designed to check students' basic knowledge of science. Results showed that students had not learned the basic content taught in earlier grades. For this reason, we decided to cover the important concepts from earlier grades such as shape, rotate and revolution of the earth and their consequences in terms of astronomical observations required in 8th and 9th grade syllabus.

Alignment with textbook

Astronomy is a vast subject. However, our review of textbooks from all four states and NCERT textbooks showed that they typically stick to introduction to the solar system and its components, explanation of commonplace phenomena and very briefly mention stars, galaxies, etc. During our interaction with teachers during the ideation phase, teachers clearly indicated that the material will be useful only if it matches their textbooks, so we decided to cover the common content from the textbook. We did add interesting information here and there and reorganized the content. Since different state textbooks had their own organisation of content, we designed the game to follow a logical sequence based on conceptual mapping.

Time constraint

The official time allotted to astronomy was 14 to 16 lesson periods. However, teacher interviews made it evident that typically they allotted fewer periods to this concept. For this reason, our Basic Astronomy module requires just 12 periods despite covering essential concepts already presented in earlier grade textbooks.
Furthermore, we clubbed all information based digital material in a single 'Digital Lesson' that could be shown to the whole class to reduce time lost in moving to the lab for the interactives.

Observations and Findings

Findings from observations made by researchers/field team members, computer logs collected and chat logs on our Telegram groups for this community of Science practitioners inform this section.

Computer Hardware

The Basic Astronomy modules showcase good design model despite hardware limitations of N-computing and outdated machines. The module was successfully implemented in 70 schools across three states of Rajasthan, Telangana and Chhattisgarh. While other CLIx modules faced incompatibility issues, no such issues were reported for Basic Astronomy, thus validating our design principles.

The problems faced were due to peripheral, albeit important, issues such as teachers' inability to handle even basic N-computing issues, the resultant reliance on field team members to conduct the lab sessions and recurrent power cuts coupled with a lack of UPS in schools.

High Student to computer ratio

Focusing on student collaboration in the design was appreciated by teachers in reducing batching demands. Furthermore, field reports corroborate intra-group discussions and even inter-group collaboration aiding learning.

Students' Abilities

Unfamiliarity with computer and gaming

Our field observations showed that students struggled during the first digital lesson, mainly because they intended to skip the demo and the rules, but figured out a way to by combining discussions with peers, some readings, falling back on demo whenever necessary and mainly by playing it again and again.

Students' proficiency in content

The average score on the pre-test conducted in seven government schools was 33.31%. Less than 20% of students could answers based on content taught in earlier grades such as choosing the correct explanation of occurence of day-night and seasons (Shaikh et al, in press). Moreover, our field observations showed that students who did not go through the classroom activities (typically because of teachers' haste) and jumped to the digital game found the game, even the first part of it which is based on the concepts learned in earlier grades, very difficult (Shaikh, et al., 2018). However, once they picked up the basic concepts and ability to use them to solve problems, they could cover the later part of the module much faster.

Alignment with textbook

The teachers were used to a summary account of astronomy as presented in the textbooks. They initially resisted the module despite its alignment to the state curricula because of its

'rigour'. Gradually, during trainings they appreciated the need for deep learning of the concept.
While we have prepared a coursebook that includes visual and 15 demonstration videos of role-play to support remote implementation and communicate the rationale of the activities, we realise that the process will have glitches since teachers rely on personal hand-holding as evident in teacher interviews and our observations.

Time constraint

The ground reality is that astronomy lessons are completed in a mere two or four lesson periods. The reasons vary from lack of time and this lesson being placed at the end of the textbook to perceived importance of the concept. While the trainings and mentoring on Telegram did convince them of the value of deep diving rather than giving superficial explanations of concepts, astronomy continues to be taught in fewer lessons than allotted.

Conclusion

Designing innovative, play based material under field constraints was like a tightrope walking. On the one hand we were presented with challenges such as the limited capacity of computer lab is limited in terms of hardware and the number of computers. Class sizes are large and students do not have mastery on what they learned in earlier grades or on handling computer. Teachers are reluctant to give time, they want the module to exactly match to their chapter and are not enthusiastic about its implementation because of their lack of mastery over content and mistrust on new pedagogic technique. On the other hand, the digital medium and new pedagogic technique offers great potential. There is a dearth of novel well designed educational material, especially in Indian languages and suitable for indian context and the students are hungry for it. Many a times, field constraints will make us choose more mundane options rather than noverl, creative possibilities, and these were the testing times as a researcher and designer. However, when we witness the implementation on the field, with slight shifts towards more interactive, constructivists teaching-learning practices rather than authoritative transmission of content we felt that all the struggle was worth it (Figure 4). Seeing students take charge of their learning during digital lessons, or when two girls tell you that they received a gold medal, or when a boy shows his teacher the inclined orbit of the moon using a gesture which she did not use, and the teacher reports it back to us as her success have been the most satisfying moments!

Figure 4: Students engaged in digital activity (left) and in a role-play (right)

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