Play to Learn!

Engaging school students to learn geoscience with fun

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Abstract— Learning with fun is the pedagogic cornerstone of effective teaching to the millennial students - both at the secondary school and the undergraduate levels. The element of fun in teaching promotes amusement, astonishment, and accomplishment amongst students that spurs them to learn with purpose and responsibility through collaborative team-efforts. Research shows, “when we enjoy learning, we learn better” (Rose and Nicholl, 1999). In effect, fun motivates the learners to repeat their learning experience until a level of expertise is achieved; fun also engages the learners in activities where they have no previous experience.

Geoscience education, being exploratory in nature, is well suited to embed the elements of play and fun into learning. The pedagogical underpinning are towards community-based inquiry, driven through formal and informal ways of data collection, analysis and generation of suitable alternatives, and recommending solutions backed by well-researched rationale to the multitude of problems faced by this wonderful planet – The Earth!

The authors opine that the structural elements of games that encompass its rules, goals and objectives, outcomes and feedback, conflict, competition, challenge, and opposition, interaction, and representation or story (Marc Prensky, 2001) can be adapted to build suitable game-based learning content and exercises to teach the subjects related to Geoscience.

The authors have created two representative learning contents, one with a knowledge-element, and the second with practice-element that employs game-based pedagogy and invite educators and academicians to provide feedback on its suitability and efficacy, which can lead to further refinement and adaptation to include other topics of Geoscience in secondary school curricula.

Index Terms— Play, learn, games, geoscience education, pedagogy

I. INTRODUCTION

India is expected to become the most populous country with a head count of 1.4 billion by the year 2028 (UN Report, 2013). This will entail demographic changes, where 64% of India’s population is expected to be between 15 and 59 years of age (Ernst & Young, 2013). Often referred to as the demographic dividend, India is poised to become the youngest country having the largest working population in the world by 2020.

The demographic dividend provides India a window of opportunity to catapult to become an economic super power. This however, depends on how the Country builds capacity and nurtures talent that can meet the workforce demands of the world. Education truly is the edifice upon which the demographic dividend can be leveraged for the Country’s growth and prosperity.

The main challenge in leveraging the demographic dividend is to improve the quality of education and vocational training. Reportedly, less than 20% engineering graduates in India are employable for software oriented jobs, and just a dismal 7.49% are employable in the core engineering jobs (Aspiring Minds, 2014). Almost 47% of graduates in the Country are not employable in any sector of the knowledge economy (Aspiring Minds, 2013).

The quality of education is also reflected in the fact that not one university from the South Asian countries are ranked amongst the top 100 universities in the world (Times Higher Education Ranking, 2012-13). Equally, a matter of serious concern is that 40% of university lecturers in India are contract staff and earn less than US$325 per month (Times of India, 2013).

The number of students enrolled in science streams at the university level is showing a declining trend. A report by the National Council of Applied Economic Research (NCAER) indicates that less than three percent of school children want to pursue a career in science (Rajesh S., 2005). Even those students who complete degrees in science prefer to pursue job-oriented courses. A career in basic science is often perceived as not lucrative when compared to jobs accruing through professional degree courses.

The decade since post-liberalization in 1991 saw a ten-fold increase in the intake of students for engineering degree courses (Chopra and Sharma, 2009). On the other hand Varghese (2006) reports that enrolment into basic science degree courses has remained stagnant, and in fact shows a declining trend. The preference for pursuing studies in Earth and Geospatial Sciences by inference and anecdotal discussions may be assumed to be showing a declining trend as well.

This paper suggests one change in approach, viz. play to learn, for teaching Earth and Geospatial Sciences to school students so as to attract their interest and motivate them to pursue a career in Geospatial Sciences, not as much for the monetary rewards it may bring to them, but for the very sustenance of
planet earth, upon which our future survival and growth largely depends.

II. GEOSCIENCE EDUCATION - SURVEY

The authors conducted a brief online survey between July and August 2014 at www.survs.com, which was targeted at Geoscience professionals and academicians in India.

The survey received ninety responses comprising 90% male and 10% female. 80% of the respondents held educational degrees that were at either at graduate level or above. Almost 8% of the respondents were doctorates. 60% of the respondents were industry professionals, 20% students and 10% each from academia and government.

The survey comprised ten questions that dealt with the importance given to geoscience education in the schools; the pedagogic orientation and learning methodologies primarily adopted by school-teachers; and the perception of school-students towards a geoscience based career. The salient findings of the survey are depicted in Fig. 1.

Almost 10% of school-students stated that Geoscience related subjects did not interest them; and another 70% felt that they studied Geoscience subjects as part of curriculum than to pursue a serious career using them.

Less than 20% of school-students preferred a career in Geoscience based work.

The respondents were also requested to make one key suggestion that can make geoscience learning interesting and meaningful for school-students. Table-1 summarizes the suggestions offered by the respondents in this regard.

Table 1. Possible interventions to make geoscience education interesting and meaningful

<table>
<thead>
<tr>
<th>#</th>
<th>Recommended learning interventions</th>
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<tbody>
<tr>
<td>1</td>
<td>Provide more emphasis on practice-driven learning</td>
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<tr>
<td>2</td>
<td>Introduce community-based project work that relates to real-life issues and develops inter-personal skills</td>
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<tr>
<td>3</td>
<td>Add video-based content to demonstrate natural hazards</td>
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<tr>
<td>4</td>
<td>Add fun-games, outdoor excursions and group-based project work</td>
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<tr>
<td>5</td>
<td>Regular field-visits to capture relevance of geoscience to human lives</td>
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<tr>
<td>6</td>
<td>Make geoscience related subjects compulsory part in school’s curriculum</td>
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<td>7</td>
<td>Educate the educators. Periodic awareness programs for students and teachers will help</td>
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<td>8</td>
<td>Make students and teachers environment-conscious thorough structured road-shows, exhibitions, seminars and workshops</td>
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<td>9</td>
<td>Encourage students to create practical models of earth-science related topics of significant interest</td>
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<tr>
<td>10</td>
<td>Undertake focused drives to reduce environmental hazards</td>
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<tr>
<td>11</td>
<td>Learn from nature.</td>
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<tr>
<td>12</td>
<td>Make geoscience based careers more rewarding and attractive</td>
</tr>
</tbody>
</table>
III. PLAY TO LEARN – AN APPROACH TO MAKE GEOSCIENCE LEARNING INTERESTING AND MEANINGFUL

The Structural Elements of Games’ (Avedon and Sutton-Smith, 1981) elucidated the following elements in a game:

- purpose of the game;
- procedure for action;
- rules governing action;
- number of required participants;
- roles of participants;
- results or pay-off;
- abilities and skills required for action;
- interaction patterns;
- physical setting and environmental requirements;
- required equipment.

Although the aforesaid elements are comprehensive enough, they were cast more in the mold of conventional games than modern online or mobile games that are spread across geographies and can be played anywhere, anytime, and anyplace.

In the present context, the following defining attributes of play (Prensky, 2001) form compelling reasons as to why geoscience must be learnt in schools through play and fun:

- play is something one chooses to do;
- play is intensely and utterly absorbing;
- play promotes the formation of social groupings.

For the purposes of this paper, the structural elements of play enumerated by Prensky (2001) that are enumerated below has been adapted to design two sample cases which have been elaborated in the succeeding paragraphs.

- rules;
- goals and objectives;
- outcomes and feedback;
- conflict/competition/challenge/opposition;
- interaction; and
- representation or story.

The two case studies selected for this paper represent the teaching of cognitive (knowledge) and skill (practice) aspects of learning, which are merely representative to bring home the point of importance of play in teaching geoscience.

IV. CASE STUDY 1: PROBLEM-SOLVING THROUGH ESTIMATION

This case study is intended to teach the students to estimate heights and distances of objects in their vicinity. The elements of this case study cast as a play is enumerated in table 2.

Table 2. Elements of play for case study on problem solving

<table>
<thead>
<tr>
<th>Element</th>
<th>Design attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rules</td>
<td>Participants play in groups;</td>
</tr>
<tr>
<td></td>
<td>Standard landscape used for all groups;</td>
</tr>
</tbody>
</table>

No gadgets nor measuring instruments are permitted in the game. Plain paper and pencil may be used;
- Consultation within the groups permitted;
- Time limit prescribed applies to all groups.

Game outline

The groups are required to undertake a treasure hunt which comprises ten entities within the landscape area.

A clue sheet is given to all groups which can guide them in identifying the entities during the treasure hunt.

Instructions:
1. The group will receive the clue sheet at a pre-designated spot.
2. The clue sheet is a list of locations. To get to these locations, the group needs to decipher the clues.
3. Once the group deciphers them, they will be pointed to a location.
4. In the blank following each clue, the group will have to fill in some unique detail about that location, as asked in the sheet.
5. Whilst filling in the details, some of the letters will fall within circled blank spaces.
6. Once the group fills in the correct details of all locations, they will use these circled letters to identify the finishing sentence.
7. After you identify the finishing sentence, and you get to call yourself the NUMBER ONE number cruncher.

Rules:
1. The team has to stay together while going to each checkpoint.
2. The team cannot leave anybody behind; it will be disqualified.
3. The team has to close in together at the destination. The timing will be taken after the complete team reports at the Finish Point. The start timing will be taken at the Start Point.
4. Scoring: Total time to finish the route.

Examples of clues:
Location: Obsession of more than a billion though twenty-two is all I need
Clue: A bowler’s reward  _ _ _ _ _ _ _ _ _

Location: Whisk up, whisk down
Clue: Defining a series of parallel lines _ _ _ _ _ _ _ _ _
Objectives

1. Identify the entities in the landscape;
2. Estimate distances between the entities in serial order of entities listed in the treasure hunt clue sheet;
3. Groups are encouraged to use different methods for estimating distances. These may include estimating by pacing steps from one entity to another after estimating the distance of a single pace. Alternately trigonometric formulae could be used. The method of choice is left to the imagination of the groups.
4. Estimate the heights of the entities identified in the treasure hunt.
5. After heights and distances have been estimated, the groups will draw a map of the landscape using the start point as the origin – North South East West
6. With the experience gained from the game, the groups will find methods to estimate distances of far off objects at the landscape area – e.g. cliff, tree, building, clock tower etc.

Outcomes and feedback

Upon completion of the game, each group member will be able to:
1. Estimate heights and distances;
2. Compute averages from a series of data sets;
3. Compute errors;
4. Analyze errors;
5. Devise methods to estimate heights and distances of far-off objects of known heights and distances;
6. Validate estimation methods;
7. Draw maps indicating approximate directions;
8. Peer review maps of other groups;
9. Reflect upon the outcomes from the game and write a self-assessment sheet indicating lessons learnt and applications of the methods to other areas of study.

Conflict, challenge, competition

1. The game will throw up considerable conflicts amongst the team members who may not agree with the proposed methods or estimated data. The observer must note and possibly video-record how these conflicts are resolved by the groups.
2. Challenges will be encountered whilst deciphering the clues within the prescribed time limits.
3. Competition between groups will encourage stronger collaboration within the groups.

Story

Self-assessment with reflection on the outcomes from the game provides an opportunity for the participants to narrate their own story highlighting lessons learnt. As feedback, the participants may also indicate how the game can be further enriched for future.

V. CASE STUDY 2: MAP READING SKILLS

Maps are amazing teaching tools. The ability to read, interpret and comprehend maps form important components of visual literacy. Grasping the intended meaning in maps, evaluating them, and incorporating them into other knowledge applications is a crucial skill.

This case study is intended to develop map reading and interpretation skills amongst students. A topographic survey map showing features of the land, like lakes, ponds, rivers, and streams, and man-made landmarks like permanent buildings, roads, religious monument, heritage sites will be needed to undertake this exercise. It will be preferable to obtain an authorized map from the Survey of India of an area that the class intends to visit as part of an excursion tour.

The elements of play for this case study is enumerated in table 3.

<table>
<thead>
<tr>
<th>Element</th>
<th>Design attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rules</td>
<td>• Participants play in groups; • Standard map provided for all groups; • Plain paper, pencil and other geometric instruments may be used; • Consultation within the groups permitted; • Time limit prescribed applies to all groups.</td>
</tr>
<tr>
<td>Activity outline and objectives</td>
<td>Each group is given the same topo map that captures surface features of the land and contours to show altitude variation. A map of a hilly terrain will be ideal for this exercise since it adds adventure and excursion value to the activity. Prior to the activity the facilitator must discuss the various symbols and the contours that are to be found on the map.</td>
</tr>
</tbody>
</table>
Each group studies the map and makes a list of obvious geographic features found therein.

Visit the site with the class. Each group must identify as many features on the map that are apparent at the site.

The groups must reflect, did the map help them to visualize the site before the visit? They must also try to find a feature at the site which does not match the map and ask, why might this be?

As part of reflection on the activity, the groups must probe and seek answers to questions like:
- Who might use a map like this?
- Is it a road map?
- Should political boundaries like states and districts?
- What sorts of uses would this map have that, say, a sightseeing map wouldn't?
- Why should altitude be recorded? Can groups think of way other than contours to record it?
- If the contours on a hill are closer together, does that mean the hill is more or less steep than one whose contours are farther apart?

<table>
<thead>
<tr>
<th>Outcomes and feedback</th>
<th>1. Explain the symbols and concepts of scale in a map; 2. Identify features contained in a topographic map; 3. Differentiate a topo map with other kinds of maps and their specific uses; 4. Appreciate why periodic survey updates must be undertaken and incorporated in a map; 5. Compare the map studied in the activity with other similar maps available from public domain; 6. Probe how the quality of maps may further be improved using the best practices and contemporary and futuristic technologies. 7. Plan and manage an excursion with available resources.</th>
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</thead>
</table>

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<thead>
<tr>
<th>Conflict, challenge, competition</th>
<th>1. Being an adventure-driven excursion the activity provides numerous challenges and generates curiosity to explore nature. 2. Conflicts within the group will need to be resolved as and when they arise.</th>
</tr>
</thead>
</table>

VI. GEOFUN – EXPERIENCE OF IIC ACADEMY

IIC Academy, the learning arm of IIC Technologies, is a world leader in geospatial products and services. The range of company’s expertise spans terrestrial, marine and aerial geospatial applications that include GIS, LiDAR and photogrammetric mapping solutions.

The Academy seeks to be an international center of excellence offering customized programs on nautical cartography, terrestrial and marine surveys, GIS, photogrammetry and LiDAR. The Marine Geospatial Information and Hydrographic Survey courses of the Academy are recognized by international professional bodies.

The Academy evinces keen interest in nurturing ‘leaders of tomorrow’ and offers customized courses addressing the needs of middle and secondary school students.

One such program called GeoFun was conducted by the Academy for an International School in the Country using an approach similar to that expounded in this paper.

The objective of GeoFun was to introduce the students to the exciting world of map-making and 3D modeling using Google SketchUp 8.0. Students were introduced to the basic concepts of Geography in a fun-way which was followed by practical exercises on estimation, both small and large distances, and heights. Students also used simple pocket magnetic compass. Students used Google SketchUp for 2D and 3D models, and modeled their school which was geo-referenced and published on the Google Earth. Students also used their creativity to model a futuristic class room.

The program was well received and feedback obtained from the participants was as follows:
- Quality of Content: 4.41 out of 5 (where 5 is excellent);  
  Program Design: 4.28 out of 5;  
  Quality of Instructions: 4.54 out of 5;  
  Achievement of Learning Outcomes: 4.32 out of 5;  
  Overall program rating: 4.48 out of 5.

The testimonial received from the school with regard to GeoFun read as follows:

“Grade 8 and 9 had their first taste of GIS in a two days introductory workshop held in campus on 17th and 18th February, 2012. Mr. Kasi and Mr. Shekhar Murthy were our
trainers from IIC Academy of Hyderabad. After establishing the basics of mapping techniques, estimation etc. we launched ourselves in understanding free tools of the net like Google Earth and Google Sketch Up. We were fairly surprised that though we were aware of Google Earth we had never explored it beyond a simple use like locating our own homes. Our understanding of this tool took a considerable jump.

Google Sketch Up proved to be another interesting tool which can be used for 3D modelling of buildings and structures. We learnt to import pictures in Google Sketch up and clad them on these 3D models to give them realistic look. At times students found it challenging and it was a bit taxing to be focused. We have peeped in the world of GIS and felt the pulse of it. Our next step would be train ourselves to create events which are pitched according to the curriculum needs. Also we would be starting such things with grade 6 onwards to have the proper base by the time our students reach grade 8.”

VII. CONCLUSION

John Dewey said, “if we teach today’s students as we taught yesterday’s, we rob them of tomorrow.” Play based learning is an effective pedagogic paradigm that can address the learning needs of the millenial.

Play based learning in teaching geoscience at school may rejuvenate interest of students in the field of environmental and earth science studies. The students may begin to explore options beyond the customary technical and basic science degrees, keeping in view that the very sustenance of planet earth is at stake. In the future, learning and working in areas related to earth science and environment may no longer be an option but a hardcore necessity.

“What's the use of a fine house if you haven't got a tolerable planet to put it on?”
— Henry David Thoreau

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