A Design and Development Model for Creating an Immersive 3D Problem-Based Learning Environment for Middle School Science

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on behalf of the Alien Rescue team

Learning Technologies Program
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Alien Rescue

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Goal of Alien Rescue

The goal of Alien Rescue (AR) is to engage sixth-grade students in solving a complex problem that requires them to use the tools, procedures and knowledge of space science and apply processes of scientific inquiry while learning about our solar system. Students, acting as scientists, are asked to participate in a rescue operation to find suitable relocation sites within our solar system for six different species of aliens who have been displaced from their home planets. Through inquiry-based activities, students practice a variety of problem-solving, self-directed, and collaboration skills using multimedia enriched cognitive tools.

Target Audience

Alien Rescue is designed for sixth-grade space science as a curriculum unit for about fifteen 50-minute class sessions. It is aligned with National Science Standards and the Texas Essential Knowledge and Skills (TEKS). Although the primary intended population is sixth graders, the use of this program, with proper instructional modification, has expanded to include 5th through 9th grade populations. Teachers have used it with students of various ability levels with success. From 2012 to present, the program is being used as part of the science curriculum by 16 middle schools in Central Texas with a diverse ethnic base. In addition, schools in at least twenty states (AZ, CA, CO, CT, FL, HI, IL, IA, KS, MD, MI, MO, MS, NM, NJ, OH, PA, SC, TN, WA) and three countries (Australia, Canada, China) have used and are using Alien Rescue.

To assist teachers’ implementation in the classroom, a comprehensive teacher’s manual (over 160 pages delivered via a wiki-format) is provided to assist teachers in their implementation. The manual details PBL pedagogy, lesson plans for each of the 15 days, additional science content materials, and assessment tools.

Key Design Features

Alien Rescue delivers a playful experience in an intentional problem-based narrative. It combines game elements, play, and authenticity for the purpose of engaging students’ learning of science and enhancing student motivation. Authenticity is achieved by placing students in the role of young scientists and charging them with the task of saving distressed aliens. This central problem is presented through a compelling introductory video to create a sense of urgency. As scientists, the students are challenged to find new homes for the aliens by engaging in the process of scientific inquiry: identifying the problem, researching, forming hypotheses, testing and validating their hypotheses, and justifying their rationales. Thus, the problem-solving process requires students to think and act like scientists and communicate with each other, thereby demonstrating scientific literacy. In addition, students use a set
of 14 media-rich tools designed to assist learning. Learning therefore occurs as a result of solving a complex problem. There are six different types of alien species and each species has its own unique characteristics. There is not one single correct answer to the central problem. Some answers are more optimal than others. It is therefore up to the students to present evidence and justify their problem solution with a rationale. These complications present a challenge to sixth graders that encourages them to control their own learning path.

This real-world scientific inquiry is coupled with a more playful experience and delivered through a 3D immersive, discovery, and sensory-stimuli-rich approach. When students enter the program, they are not given explicit instructions on how to begin problem solving. They must explore and discover the available tools, understand their functions and determine when to use which tool at the time. This design evokes uncertainty, mystery, and curiosity. The Research Lab (that houses Alien Database) presents information about each of the six alien species, including details about their physique, nutritional needs, and habitats. This detail is packaged into an interactive 3D tool that is designed to help establish a sense of fantasy. That is, the environment situates the learning experience through scientific inquiry in ways that help students learn the language of science through role-play in a science fiction fantasy setting.

Performance Data

All sixth grades from two public middle schools (n=430) in a mid-sized southwestern city in the U.S. participated in a recent study (Liu, Rosenblum, Horton, & Kang, accepted). These sixth graders used AR in their daily 50-minute science classes as their curriculum for space science for three weeks. The findings using ANOVA with repeated measures showed sixth graders significantly increased their science knowledge scores after using the program. The average gain score from pretest to posttest for School 1 was 24.29 with $M_{\text{male}} = 23.34$ and $M_{\text{female}} = 25.78$; and 13.31 with $M_{\text{male}} = 12.28$ and $M_{\text{female}} = 14.46$ for School 2. It is worth noting that for both schools female students had higher gain in points than their male counterparts.

<table>
<thead>
<tr>
<th>Science Knowledge Score (% on 0-100 scale)</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>School 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>69</td>
<td>45</td>
<td>114</td>
</tr>
<tr>
<td>Posttest</td>
<td>80.51%* (18.55)</td>
<td>77.89%* (22.55)</td>
<td>79.47%* (20.17)</td>
</tr>
<tr>
<td>School 2</td>
<td>134</td>
<td>123</td>
<td>257</td>
</tr>
<tr>
<td>Pretest</td>
<td>49.54% (21.81)</td>
<td>41.82% (19.7)</td>
<td>45.85% (21.15)</td>
</tr>
<tr>
<td>Posttest</td>
<td>61.82%* (19.18)</td>
<td>56.28%* (16.28)</td>
<td>59.17%* (18.03)</td>
</tr>
</tbody>
</table>

*Significantly different from the pretest, $p < .01$. Only those who completed both pre- and posttests were reported.

In their open-ended responses, sixth graders stated what they had learned: about our solar system (the planets, moons, and their characteristics) (51% out of 515 units of responses); the scientific instruments (creating and launching probes and various instruments needed for each type of probe) (16%); alien species (8%); scientific concepts such as magnetic fields, gravity, and temperature scales (7%); problem solving (4%); conducting research (4%); managing a budget (2%); and working with others (2%).

To compare students who used AR with those who did not, a study was recently conducted in a school district with two middle schools of comparable demographics. *Alien Rescue* was used with all sixth-graders in one school while sixth graders in the other school were taught the space unit in the usual way. Both schools have access to computers and the Internet. At the end of the unit, all students took a school district-created 15-item test on space science. The results showed a significant difference in the test scores between the two groups: $F(1,766), p < .01$, indicating the school used AR scored significantly higher. (This study is currently being written up.)
Mean % Score (out of 100) | Scored 66% or better | Scored 90% or better
--- | --- | ---
School did not use AR: \(n=384\) (female=174, male=210) | 80.11% | 89.58% | 26.82%
School used AR: \(n=384\) (female=195, male=189) | 87.56% | 94.79% | 54.17%

**Attitude Data**

In another recent study (Liu, Horton, Kang, Kimmons, & Lee, in press), sixth graders were asked the question: “How would you describe *Alien Rescue* to a friend?,” a total of 1,072 words were extracted out of the 358 statements. The word “fun” has the highest frequency:

<table>
<thead>
<tr>
<th>Word Cloud</th>
<th>Word</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>fun</td>
<td>183 (17%)</td>
<td></td>
</tr>
<tr>
<td>learn</td>
<td>108 (10%)</td>
<td></td>
</tr>
<tr>
<td>solar-system</td>
<td>93 (8.7%)</td>
<td></td>
</tr>
<tr>
<td>aliens</td>
<td>74 (6.9%)</td>
<td></td>
</tr>
<tr>
<td>find</td>
<td>46 (4.3%)</td>
<td></td>
</tr>
<tr>
<td>helpful</td>
<td>41 (3.8%)</td>
<td></td>
</tr>
<tr>
<td>home</td>
<td>38 (2.7%)</td>
<td></td>
</tr>
<tr>
<td>information</td>
<td>30 (2.5%)</td>
<td></td>
</tr>
<tr>
<td>interesting</td>
<td>29 (2.7%)</td>
<td></td>
</tr>
<tr>
<td>probe</td>
<td>27 (2.5%)</td>
<td></td>
</tr>
<tr>
<td>game</td>
<td>24 (2.2%)</td>
<td></td>
</tr>
<tr>
<td>computer</td>
<td>20 (1.9%)</td>
<td></td>
</tr>
</tbody>
</table>

The following comments, unedited, from teachers and students further showed positive attitude:

**Sample Comments from Teachers (2012 - present)**

- *Alien Rescue* (AR) was a fantastic activity. I've been involved with problem based learning since '95 and this is terrific way to include/integrate 21st century technology and skills. AR takes a problem, allows the students to ask questions and research and then propose possible solutions. The interaction and communication amongst the team members was terrific. It was great listening to them discuss/argue as they researched and collected info from their probes. It allowed them to learn about so many topics as they tried to find new homes for the aliens. Thanks so much for allowing me to use this in my class. I look forward to using this again next year!  
  --Mr. P, Chartiers-Houston Jr./SR. High School, PA

- I was amazed at how, after two weeks, all 125 of my students were still so drawn to *Alien Rescue*. They were having conversations about magnetic fields and elements on the periodic table in my classroom during lunch, and kids were going to the Library on their off-time to send probes and take notes in *Alien Rescue!* The lesson plans provided by *Alien Rescue* were rigorous, and all the background information I needed was available on the website. We will definitely use *Alien Rescue* in our Space Unit next year!  
  --Ms. V, Four Points Middle School, Leader, TX

- *Alien Rescue* is engaging for the students. It is a great example of problem based learning. The students must work as a team to solve a problem so it also encourage[s] collaboration. Our test and quiz grades are higher than the years before when we did not use *Alien Rescue*. I can tell they are learning the material because of the conversations we have when we debrief at the end of class.  
  --Ms. C, Running Brushy Middle School, Leader, TX

- I have never seen middle school students so engaged in reading and using data as when they were ‘playing’ *Alien Rescue*. When we were finished they asked if they could do it again because it was so much fun!  
  --Ms. C, Loftis Middle School, TN
• My students have really enjoyed using Alien Rescue. Alien Rescue was a wonderful tool to integrate science in a fun, challenging, and innovative way. Alien Rescue embraces the idea of teacher acting as facilitator as opposed to teaching. Alien Rescue provides the circumstance that definitely keeps the students engaged while the teacher facilitates the learning environment.

--Ms. A, Columbia Local Schools, OH

Sample Comments From the Sixth Graders (2012 - present)

• I like Alien Rescue much more than other science activities because we’re not just sitting at our desk doing work that must be done on our own, it’s a fun activity that ties in with what we’re learning.
• Alien Rescue was better than other activities because I liked learning about the different things. Alien Rescue gave us a chance to work independently on a project by ourselves. I also liked that we could work with different people. Collaboration caused us to debate and come up with more correct answers than if we were working by ourselves.
• Because Alien Rescue you can learn what scientist really do and how they learn about all the planets.
• I liked Alien Rescue more than other science activities because it was a group project, we got to do it on the computer, and it was like a video game.
• I liked doing Alien Rescue more than other activities because you get to do hands on activities. I find it more interesting than reading out of the book. It would prepare me to be an astronaut!
• Alien Rescue is educational, but at the same time interactive and fun, like a video game. You are also much more independent in Alien Rescue.

Videos of what teachers and students say are available at: http://alienrescue.edb.utexas.edu/feature_videos.php

Our Development Model

Alien Rescue team consists of a group of graduate students working collaboratively under the supervision and guidance of faculty. Harnessing students’ diverse talents and ideas is a major characteristic of our development model. Students’ engagement in the project is largely driven by their interest in creating a quality technology program to enhance learning while developing multimedia production and research competencies. Through this process, students have gained valuable software design and technical development skills. This has been a training platform for future designers and developers, instructional technologists, and educational researchers.

Access to Alien Rescue

To access Alien Rescue:
1. Install the Unity Web plugin (free): http://unity3d.com/webplayer/
2. Log in to: https://alienrescue.net
3. Use the Registration Code:

(When you use Alien Rescue for the first time, click the "Click here to register" link. On the registration page, you can create your own username and password with the unique code we provide you for the Class Code. Once your account has been created, you will be able to login to use it.)

References

Liu, M., Rosenblum, J., Horton, L., & Kang, J. (Accepted). Designing Science Learning with Game-Based Approaches. Computers in the School.