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Space Race: A Voyage to the Moon Board Game for K5-K8 Students

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Abstract

There is a growing need to increase diverse students within STEM fields, especially in aerospace due to the opportunities and careers in the near future. The goal of this senior capstone design project is to design and develop a space themed board game to attract young minds and provide them with an early exposure to design and engineering related fields. The objective of the board game design concept is to create a fun and informative learning product that inspires students (grades 5-8) to develop an interest in STEM careers by emphasizing the theme of "voyage to the moon." Three interrelated design? principles are also integrated into the design of this game. Though the final board game, cards, and character pieces were all completed, the game could not be tested with our target audience due to health and safety concerns arising from the global pandemic. Based on our design and development, we believe that our game will have a significant learning impact on students and teachers provide them with a fun and educational medium to reinforce STEM concepts.

Keywords

Board Games, STEM, Design Thinking, Middle Scholars

Introduction

Most elementary and middle schools lack the engineering (design innovation) component in the STEM curriculum as identified by the National Academy of Engineering (NAE) and the National Research Council (NRC). These reports also emphasize that "engineering design" should be taught in schools to promote engineering education and the engineering habits of mind. In addition, there is a need to provide early exposure to STEM fields and use innovative methods to engage future generations, particularly students from underrepresented groups.

In light of the 50th anniversary celebration of the first moon landing, we are excited and proud to note that we used nontraditional learning tools and created a design strategy game based on a voyage to the moon to boost STEM learning and skills of elementary and middle school students and attract the next generation of students to engage in space exploration and education. Motivating middle school students to learn STEM concepts will help them to ultimately pursue STEM degrees later in their schooling, as noted in a recent report by the President's Council of Advisors on Science and Technology. [1] Game-based Learning (GBL) offers a unique and innovative approach for students to learn and appreciate the STEM topics learned in the class-room as well as increase their academic engagement. Recently, there have been many studies related to introducing aerospace to K-12 students using non-traditional ways including board games and video games. [2-3] These GBL studies have shown that they contribute to enhancing student experiential learning in a variety of ways in engineering in particular, including problem solving, design learning

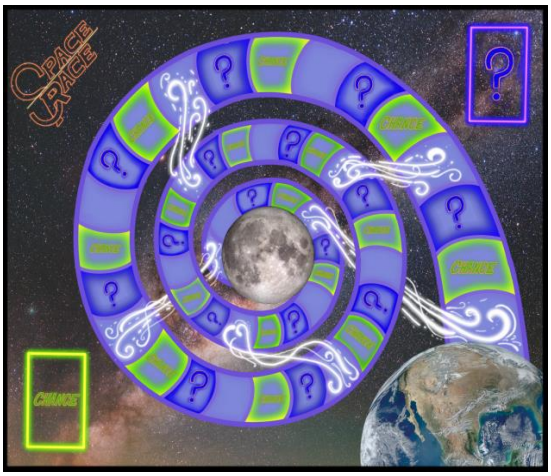
concepts and skills. This paper presents an aerospace themed board game developed for students in grades 5-8 students as part of a capstone design project conducted by senior mechanical engineering students at UGA. The project design objective and the game design and testing are briefly described below.

Design Objective

The goal of the design game concept is to create a fun and informative learning product that inspires students (grades 5-8) to develop an interest in STEM careers by emphasizing the theme of "voyage to the moon". Three interrelated principles are also integrated into the design of this game. The first is the game primarily emphasizes engineering design. Second, it integrates students learning and draws upon their knowledge of math, science and technology. Third, it fosters creativity, teamwork, and application of engineering theory to real life. The design game concept is easily implemented in classroom or as a stand-alone activity that students can have fun completing at home.

Approach

This project was carried out as a capstone design project for senior students within the College of Engineering at UGA. After reviewing the existing board games, and also surveying schoolteachers, it became clear that there was a need to design a board game that is inspiring, educational and entertaining for the students. Through surveys from teachers (stakeholders) and reviewing the educational standards, the team focused on Georgia science standards for grades 4-6 (specifically 4th grade curriculum involve physical attributes of stars and planets) as well as duration of game to be 50 minutes, similar to the one class period. Also, to inspire students for STEM careers, the game theme is based on journey to the moon with space exploration. The team followed a concurrent design process, and evaluated multiple concepts using a design matrix to determine the final design concept. The developed concepts include the existing games (Life, Sorry and Monopoly) and the Zones (original). The final concept using the criteria – entertainment; ease of use; functionality; board design; and incorporation of standards) was evaluated for all the 4 concepts using a decision matrix. Additionally, using Zones concept, three different concepts (Super Zones, Swirls, and Zig Zag) were developed. The final concept (Swirls) with highest score was selected that involves a competitive, traditional style board game in which players roll a die to chart progress from the earth to the moon, while implementing Chance and Question cards to provide historical context and assist the students in understanding STEM concepts. This design underwent several revisions after testing the game amongst our group and with college aged peers. The resulting board game incorporated missions to complete before reaching the moon in addition to original game elements. Figure (on the right) shows the final game design concept.



Typical Mission and Cards/Questions

The cards/questions are related to the mission that relates to science and mathematical concepts. They are color coded to easily identify them.

For example, here is a description of a typical mission relate to *meteorology and geology*: A meteorologist wants to study the atmosphere of the moon and how the moon impacts the Earth's weather. He wants you to study the moon's atmosphere. As you continue your journey to the moon, you have to answer specific questions. The correct answers are in "red"

Example of Question Cards:

- The International Space Station orbits around the Earth about every 90 minutes. Approximately how many times will The International Space Station orbit the Earth in one 24 hour day?

- *A. about 12 times* *B. About 16 times* *C. about 20 times* *D. about 24 times*

- On a clear night, groups (or clusters) of stars forming recognizable patterns can be observed. These are traditionally named after their apparent form or identified with a mythological figure. What are these called?
- *A. calcination* *B. concentration* *C. constellations*

Example of a "Chance" Scenario:

- After risking their lives for the advancement of humanity, Neil Armstrong and Buzz Aldrin had the pleasure of being stuck in planetary protection quarantine on their return. Since humans had never been to the moon before, NASA scientists couldn't be sure that some deadly space-borne plague was not inside the astronauts. As soon as their re-entry capsule splashed down in the Pacific Ocean on July 24, the trio was transferred to a mobile quarantine facility inside which they were transported to the Johnson Space Center where they had access to a larger quarantine facility until their release on August 10, 1969. - History.com
  Lose a Turn

Testing the Game

Students in the team tested the game themselves to determine the optimal length of the game, the impact of spacing questions, and the chance scenarios. After the initial testing it was decided to reduce the amount of Chance tiles by half and increase the Questions tiles. This is due reasons that each player landed on spots that didn't reward; difficult to get the required amount of "mission-specific" cards; chance tiles had too big of an impact on gameplay. This feedback was used in creating the second version of the game. Using this version, peer testing was conducted with college students from various academic backgrounds including pharmacy, psychology, engineering and biology. The game was completed 10 times over a period of 2 days with the same 4 players, and none of them are a part of the project. During the course of testing, it was found that the average game length was between 15 and 25 minutes, 10 minutes shorter than the testing we performed on our initial board game design. However, almost every Question card was answered correctly, so we expect our target audience to take longer to finish the game. The Chance cards still added an interesting dynamic to the game but did not determine the outcome as it did during our first revision. We anticipate that once 4th to 6th grade students are able to test the game, we will be able to gauge as to whether the questions are appropriately difficult and add an element of strategy to the game. Unfortunately, due to the global pandemic, we were unable to test our product as thoroughly as we had initially hoped. A big portion of our design modifications and considerations were going to be derived from student and teacher feedback.

Concluding Remarks

A design game concept emphasizing the theme of "voyage to the moon" was developed to create a fun and informative learning product that inspires students (grades 5-8) to develop an interest in STEM careers. This paper presented an approach to engaging and motivating K5-K8 students through the space race board game to get excited and inspired to pursue STEM topics and careers in future. Through the development of the board game, undergraduate students were exposed to design, development and prototyping that encourages them to work on community related projects. Further testing was not carried out due to COVID-19 pandemic and also students graduated. Once the game is tested and receiving the feedback from both students and teachers will further improve the board game and can be implemented into the classroom. Finally, our product could be used as an educational tool at home, which could reinforce these concepts the children are learning in class and keep them thinking about them outside of the classroom in a fun and engaging manner.

References

1 President's Council of Advisors on Science and Technology (PCAST). (2010). Prepare and inspire: K-12 education in Science, Technology, Engineering, and Math (STEM) for America's future. White House Office of Science and Technology Policy (OSTP), Washington, DC.

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3. Rawat, K. S., E.E. Lawrence., R. R. Mangham., O.D. Gooden (2018) K-12 Aerospace Academy: An Out-of-School Authentic and Experiential STEM Learning Experience for College and Career Pathways to Aerospace/Aviation. Paper ID #22847. Paper presented at the 2018ASEE Annual Conference & Exposition, June 24-27, 2018, Salt Lake City, UT.

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