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Bringing Aerospace to K-12 Students Using Nontraditional Applications

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Bringing Aerospace to K-12 Students Using Non-Traditional Applications

Abstract

There is a growing need to increase gender and ethnic diversity within science, technology, engineering and mathematics (STEM) related fields, and aerospace in particular. The intent of this project is to show that early STEM exposure, along with the implementation of unconventional aerospace concepts, might naturally increase diversity in the field. Furthermore, there are many factors contributing to whether or not a student may choose to pursue a STEM-related career. Research suggests that early math achievement, math self-efficacy beliefs, and early exposure to STEM-related subjects are all indicative of whether students enroll in STEM majors. While math achievement is a significant indicator of a student's interest in engineering related fields, early exposure to STEM is one of the most influential factors in whether students continue to seriously pursue related fields in their later academic career.

The intent of this paper is to show that early STEM exposure, along with the implementation of unconventional aerospace concepts, might naturally increase diversity in the field. The developed game, *Space (Traffic) Jam!*, teaches K-12 (specifically aimed towards K-6) students about aerospace engineering through a basic analog by relating the familiar subject of road traffic management to the likely unfamiliar subject of space traffic management. By playing the game, students are able to absorb concepts in a virtual format, one that is more easily digestible than being given the information plainly.

Introduction

Nationwide data shows that approximately 85% of aerospace engineers are male. Additionally, approximately 15% of all aerospace engineers (regardless of gender identity) comprise underrepresented ethnic groups [1]. Thus, the industry, and specifically STEM, stands to benefit from boosting diversity, as this provides new perspectives, leading to an increase in innovation and productivity [2][3]. The authors believe that early exposure to science, technology, engineering, and mathematics (STEM) fields spurs new interest in young students and is highly effective in the decisions they make regarding their careers later in life [4]. It is also unfortunate that many students are not exposed to STEM at young ages. Thus, the facilitation of educational outreach programs give the opportunity for teachers to share more about STEM-related fields to younger students, so that new interest and stronger diversity may be created.

Research has shown the importance of motivating students earlier in middle grades to learn STEM content. The President's Council of Advisors on Science and Technology in 2010 stated, "Students who express interest in STEM in eighth grade are up to three times more likely to ultimately pursue STEM degrees later in life than students who do not express such an interest" [5]. In a recent study, high-school students often cited their teachers as key influences in their choice of major in college [6]. Many high school students, however, lack key math and science skills. In a recent study by the Programme for International Student Assessment that evaluated scholastic performance of 15-year-old students, the United States ranked 38th out of 71 in math and 24th in science [7]. This demonstrates a lack of knowledge and interest in STEM for students that will continue to affect the future of engineering.

The authors' hypothesis is that a limited perception of aerospace negatively impacts interest in the industry. Prospective students often attribute their disinterest in aerospace engineering to the narrow focus of the field or limited job opportunities. STEM fields in general traditionally lack diversity [8], and fields perceived to be specialized within STEM, such as aerospace engineering suffer even more from the lack of diversity and inclusion.

Thus, one of the main goals of *Space (Traffic) Jam!* is for students to draw correlations to fields they previously viewed as unrelated to aerospace. By relating space and car traffic, the student can more easily perceive the unconventional topic of Space Traffic Management through the lens of a familiar application, regardless of the player's age, gender, ethnicity, or prior experience. The game's need for critical thinking coupled with a simple presentation make for a fun and engaging experience for children. The game thus expands the perception of aerospace engineering to more applications than just planes, rockets, and helicopters, and introduces them to the novel issue of space traffic management. This newfound knowledge will thereby increase students' interest in aerospace engineering. Furthermore, these methods of hands-on learning and the incorporation of real-world issues are the two most effective ways of teaching STEM concepts [7].

Background on *Space (Traffic) Jam!*

Space (Traffic) Jam! was developed by the authors over the course of a year. Key concepts for the game include a simple voxel art style, descriptive controls, and direct analogs between managing a map of space traffic and the concepts of dynamics and controls in aerospace engineering. The game started as a collaborative board game but evolved into a one-person strategy video game.

While collaboration is a mainstay of the engineering process, the authors found that team management of a map of space traffic took far too long. The feeling was that younger audiences would begin to lose interest, counter to the purpose of spurring interest in aerospace engineering. For most young people, board games have become an outdated medium—but video games are more relevant now than ever. Video games provide unique opportunities to hold the attention of the young audiences, such as the addition of music and a colorful art style to keep players engaged.

Development of the video game was done through Godot, a free and open source engine with a versatile and simple integrated development environment [9]. Assets for the game were all made in MagicaVoxel, another free and open source program that makes 3D models and assets for video games [10]. These assets were transformed into an isometric view and ported into the game as sprites. Godot and MagicaVoxel gave the authors' the ability to create a complex game with a very simple feel. Using low-resolution textures makes objects on the screen more distinguishable to young audiences, and the player is only required to make one input at a time to progress in the game. Figure 1 depicts elements of the *Space (Traffic) Jam!* game.

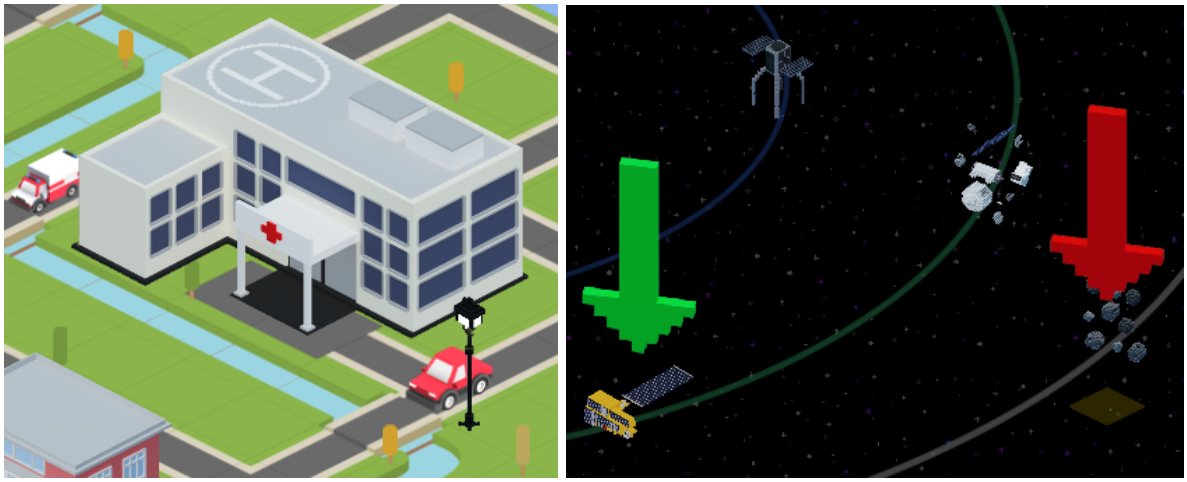

Figure 1. (Left) Earth level with two cars and a hospital. (Right) Space level with Terra satellite and its target.

The game provides a structured experience to young students interested in STEM in a variety of ways. Players play two levels in the game, each with different methods of play to achieve victory. Similar to a board game, cars move as "pawns" in a turn-based order, one car after another. All cars must reach their predetermined destinations safely to win in level one, as must all spacecraft in level two. Within both levels, analogs exist to make the direct connections to aerospace engineering easy for the player. The overarching analog is the idea that managing a map of space traffic is similar to managing a map of car traffic on earth. Each car and spacecraft has the probability for a random event to occur, meant to simulate the spontaneity of road and space travel. Moreover, players must plan the timing of each movement they make with careful precision. The movements of each car and spacecraft are closely coupled with each other. All of the aforementioned serve as an introduction to dynamics and controls, an important element of aerospace engineering, which addresses problems relating to modeling, simulation, and control of aerospace systems. Analogs are made even more apparent by the use of pop-ups, most of which serve as direct comparisons while others are fun facts meant to entertain further. The pop-ups serve to explicitly make connections for the player between the actions in the first level and its aerospace equivalent in the second. The combination of all of these elements come together to teach basic engineering fundamentals: the importance of critical thinking, planning for variables, and the necessity for creative solutions to solve complex problems.

The project's video game form makes the activity easy to access. Players are able to play the game in-browser directly through a website [11]. No download is required; load times are minimal; and the game's two-dimensional isometric quality makes the game able to run properly on any computer. From the start screen, players have the opportunity to access both of the game's levels. However, the game's experience is tailored to have the player play the second level after the first. The game is not a live service, but it receives regular updates for bug fixes and quality-of-life changes. Entirely new features continue to be added to the game, as a direct result of data collected through playtesting.

Playtesting

As with any video game, improvements come from vigorous playtesting. Given the ongoing COVID-19 pandemic, the options for in-person outreach have been limited. However, many virtual forms of STEM events are still happening. The first target for outreach is the Bryan/College Station area of schools to promote the game to students interested in STEM. Opportunities may be provided by teachers within the classroom or virtually in the case of some STEM events.

After promoting the game through outreach events, the authors will survey students across multiple metrics. Given that the proper clearance is granted by parents of those under the age of 18, the authors are able to use this valuable data to understand the impact of the project and improve the game in a variety of ways. The surveys begin with simple questions on demographics, the demand for STEM activities, timing for the introduction of STEM concepts, and the perception of aerospace applications in different fields. Thus far, teachers have provided feedback on what they liked and disliked about the activity after playing the game.

Results

The authors premiered *Space (Traffic) Jam!* to teachers at the AIAA ASCEND 2020 conference, and the educators provided valuable feedback via the post-game survey [8]. It is important to note that the results may be biased because the teachers most likely already had some familiarity with aerospace engineering as attendees of the ASCEND conference. Most educators agreed that there is a need for more STEM-related activities within K-12 education (Fig 2), and they suggested that most children should be introduced to STEM concepts from kindergarten to second grade (Fig 3). As for the aerospace applications, most teachers connected aerospace engineering to exploring space and providing energy for the future. Some connected aerospace engineering to improving urban infrastructure and improving the environment, and few connected aerospace engineering to improving healthcare technology and improving education through personalized learning (Fig 4). This data supports the authors' hypothesis of a limited perception of aerospace many times. By expanding the projects but yet still tying them into aerospace engineering fundamentals, the reach and interest in aerospace will greatly exceed the traditional topics typically associated with it.

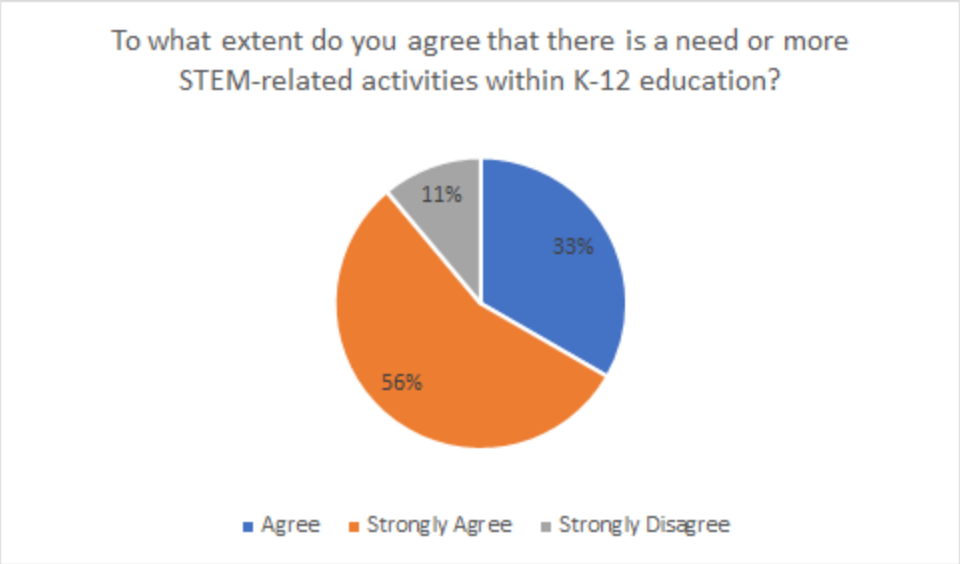

Figure 2. Educator feedback on the need for more STEM-related activities.

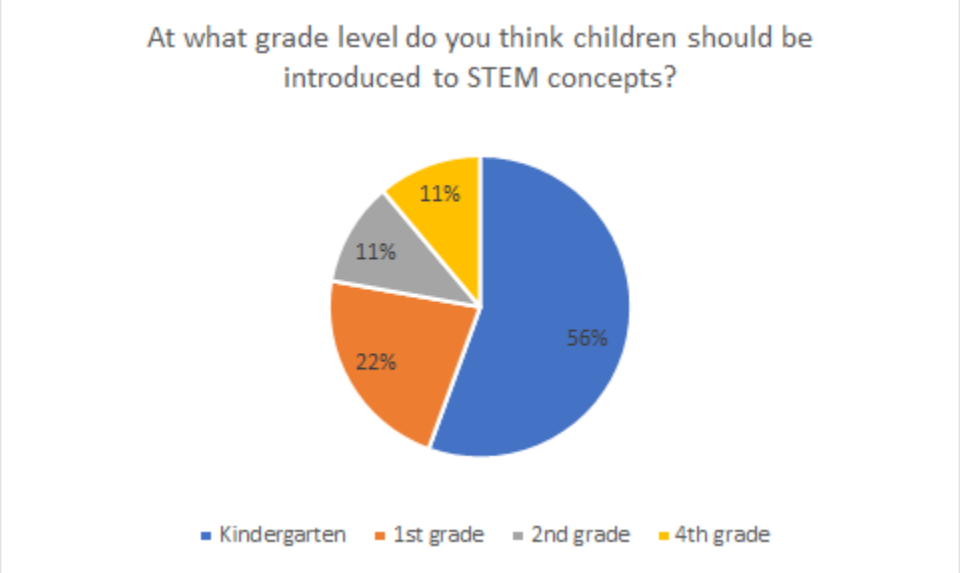

Figure 3. Educator feedback on timing of STEM concept introduction.

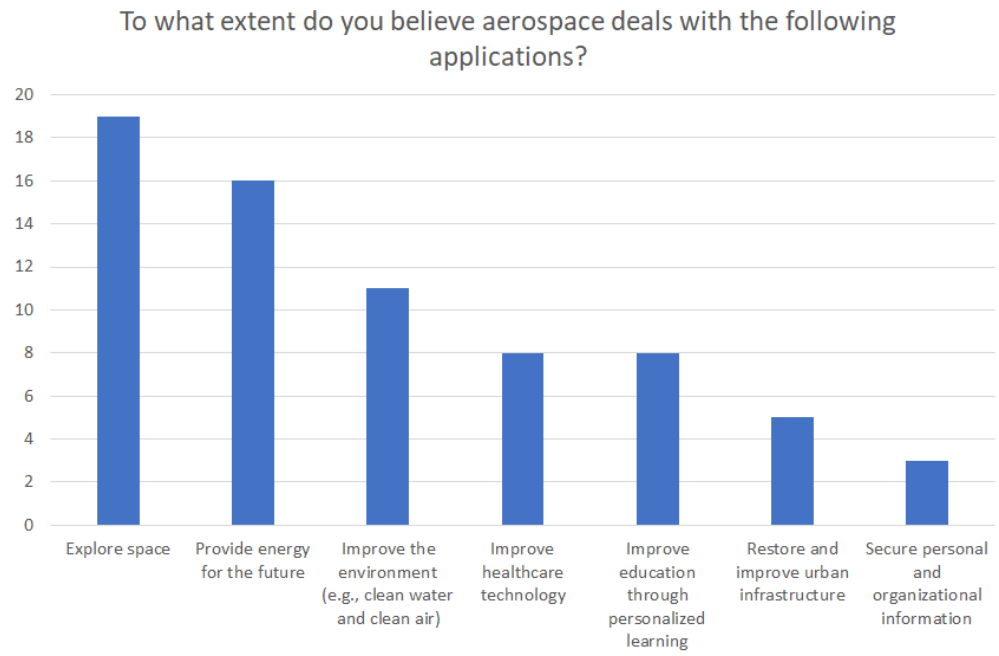

Figure 4. Educator feedback on aerospace applications in different fields. (Not at all = 1, extremely = 5)

Furthermore, the authors inquired about the teachers' experience playing the game and what could have been improved. Educators replied that they liked the overall idea, the music and visuals for the game, and the concept of providing a fun way to learn about the risks and dangers of space traffic. One teacher commented that *Space (Traffic) Jam!* seems like it would be very helpful to educators in keeping young minds engaged in the learning material. For improvements, teachers mentioned that the game was confusing due to not understanding the random occurrences, unclear vehicle movement mechanics, not being able to use the mouse, and unclear indication of the vehicle locations. Additionally, the 2nd level was exceptionally difficult due to the likelihood of crashing the satellite. This feedback was very helpful in making adjustments to the game. Furthermore, although educators first suggested students should be introduced to STEM at earlier grade levels, they recommended introducing *Space (Traffic) Jam!* to students in 4th grade or middle school.

Lessons Learned and Path Forward

After gathering the educators' feedback, the authors learned what the educators' liked and disliked about the game and were able to come to some conclusions for improvement. The main consensus was that the game needs to be more intuitive and players need more guidance. The random occurrences were confusing, making it hard to get a feel for how the game works without repeated failures that are not the player's fault. This challenge can be alleviated by including a starter/tutorial level without any random occurrences before getting to the actual game or by providing a better indicator/explanation of the random occurrences. For the unclear vehicle movement mechanics, the game could mention that there is one turn per move, and it could be made clearer that the dice roll corresponds to an event happening, not the number of moves. Additionally, the game could make it clearer that the vehicle changes each time you hit an arrow. Furthermore, clearer visuals are necessary because it is difficult to tell which tile an object is on.

One way to solve this problem would be adding a grid of tiles as an overlay to show how many turns players are from collision. Finally, further development of the game would benefit from collaboration with educators who can provide insights to a young student's mind. Moving forward, the authors are working with more teachers, especially those who do not have a background in aerospace, to obtain feedback. Hopefully, approvals will be granted soon to allow students playing the game to be surveyed to obtain a richer set of feedback.

Acknowledgements

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