**Coordinate: MARS**

*Game Rules*

1) Players advance through the levels of this single-player game by solving the puzzle missions. This is done by inputting the correct numerical data into the question spaces, via keyboard and mouse.

2) The game is won when all the levels have been successfully completed.

**1.** **Introduction**

*Coordinate: MARS* is a single-player computer game designed to teach younger middle-school-aged children fundamental concepts relating to the Cartesian coordinate system and 3D mapping, via a series of humorous puzzle-like challenges. The game offers players a hands-on introduction to concepts such as the XYZ axes, fixed origin coordinates, relational coordinates, and basic spatial algebra.

The game is built as a series of levels, in which players are thrust into the shoes of various professionals working on a space colony mission (spaceship dispatcher, urban planner, etc.), and confronted with spatial mapping challenges. Players advance through the levels via inputting coordinate data. The game is won by successfully establishing a sustainable colony on the planet Mars.

The importance of this subject matter to young students can hardly be overestimated: The Cartesian coordinate system forms the basis of modern geometry and serves as the foundation for physics, engineering, astronomy, and so forth. While of cardinal importance to STEM education in general, the ability to understand and articulate space via maps is deeply tied to countless other walks of life, from spelunking to computer-aided design, from navigating museums to navigating seas.

Thus, we consider it a useful approach to introduce this educational material via such real-life examples - presented in an interactive game interface - rather than following the traditional method of solving abstract problems from a book.

**2. Background**

***Target Audience***

*Coordinate: MARS* has been designed primarily for middle school students.

The game situates the content learning within challenges derived from ‘real-world’ problems derived from professions that typically evoke interest among children of this age, and thus demonstrates the relevance and application of the subject matter at hand in a targeted way.

The game’s sci-fi narrative reflects themes common in popular culture. It will include the option to play in different languages, and thus cater to international audiences or to language minority students.

For a learner, the game will take about 30 - 45 minutes to complete, thus lending itself to curricular integration as a special homework session. The learners needn’t have any prior knowledge of 3D axes system, but a basic exposure to the 2D graph system will be helpful as it will increase the speed of players.

***Educational/Learning Objectives***

Upon completion of this game, students will be able to (a) better understand concepts relating to 3D space, as well as engage in analytic thinking that applies to the application of this knowledge, and (b) relate the learned concepts to real-world scenarios where this knowledge can be applied.

According to the Bloom’s Taxonomy (Bloom et al., 1965), the following dimensions will be implemented in design of the game: *Knowledge, comprehension, application, and analysis*. By the end of the game, students will have a strong conceptual understanding of 3D axes and coordinate mapping which can be used as building blocks for further complex concepts such as equation of line, slope of line, etc.

***Description of Content***

It is assumed that learners will have some prior knowledge of working with two axes, hence the game’s initial levels contain 2D axes challenges before progressing to all three. The game is designed as an introductory tool for formal classrooms to familiarize students with the content in an engaging, interactive way and also help them transfer this knowledge to real life by exposing them to application-based situations. Hence, it does not introduce formulas or complex equations, in order to avoid a steep cognitive load for learners taking their first steps.

***Market Analysis***

As per our research, several apps and games (digital and board) are available to teach 2D coordinate geometry. Games such as [Study ladder](https://www.studyladder.com/games/activity/cartesian-coordinate-system-activity-2-22915) and [Cartesian Alien](http://www.flashymaths.co.uk/game.asp?n=Cartesian%20Alien&l=alien), may provide some value for students, yet are very limited in their scope and engagement. This limited narrative and surface-level connection of the learning mechanic to the game mechanic is typical of our findings.

**3. Design**

***General Design***

*Coordinate: MARS* is a single-player game played online via a browser, on any type of personal computer. It requires the player to be familiar with a keyboard and mouse/trackpad. There aren’t any explicit rules of play. The narrative itself will unfold the directions of play for the players.

The game is designed as a series of increasingly complex levels through which the player advances. In each level, the player is placed in the role of a different character on a mission-to-Mars team. The first levels take place on Earth in preparation of the launch, and later ones happen on Mars. In order to beat the levels, the player must calculate and input correct data, according to the challenges presented by the characters.

The game contains two types of levels: Regular missions and ‘clock missions.’ The regular missions form the backbone of the game: It is through these that the general game mechanic is understood, the mathematical concepts are introduced, and the narrative is advanced. The game is won when all the regular missions have been completed. Clock missions, which play a more specific role, occur intermittently, and will be explained separately.

***Level progression***

\*2-5\*

Success may prove elusive or difficult, but there is no lose state in *Coordinate: MARS*. The intrinsic incentive system is based on building an interest in the narrative, rather than on fear of failure or on a sense of competition. That said, in order to add a measure of excitement to the gameplay, occasionally players will encounter a clock mission. These missions must be completed within a given amount of time, and thus present players with a short-term goal which has a lose state. Failure to beat these missions will *not* lead to a setback in the gameplay - rather, only to a momentary, contained defeat, framed in a humorous way.

***Theory of Change (Logic Model)***

Table

***Cognitive Design***

As such, *Coordinate: MARS* incorporates in an interactive, dynamic way educational objectives and content, learner characteristics, and prior knowledge that may help in the integration of this game into a formal education curriculum.

***Affective Design***

*Coordinate: MARS* is heavily based on evoking a high level of intrinsic interest, and general affective considerations have been taken into account in order to allow for its players to engage in meaningful learning (Isbister, Flanagan, Hash, 2010) facilitated by enjoyment.

***Social Design***

While a multiplayer competitive/collaborative mode might help further involve some students, at this point we are satisfied with the single-player design, which more closely mirrors the evaluation systems typically found in schools.