



# Utilizing Specific Game Elements to Investigate Student Engagement in Educational Programming Games



## The Problem

**Introductory programming** is a common **point of attrition** for students looking to study Computer Science. Part of this problem is because **students** struggle to **maintain engagement** with introductory programming.

**Game-based learning systems** have been introduced, in recent years, as a means of maintaining student engagement while learning introductory programming..

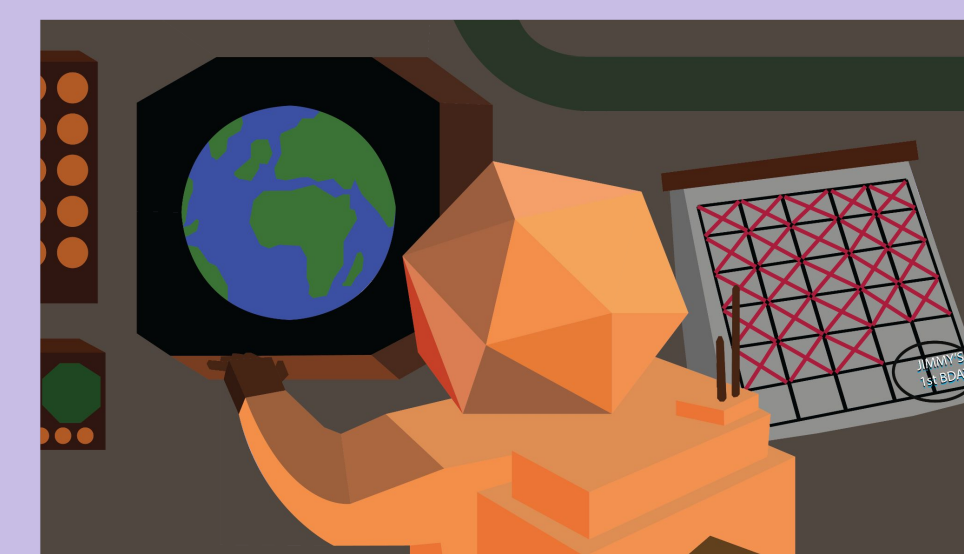
However, game-based learning systems as tools to motivate student engagement in introductory programming have seen **positive**, yet **mixed** results. This high degree of variation has been partially ascribed to the fact that games are **complicated** and **varied** systems that make use of many different game design principles.

## Our Solution

A proposed solution to the problem is to identify **specific elements** of games and to test their effects on **student engagement in isolation**.

We have identified **Narrative**, **Point-of-View** and **Puzzle** elements as underutilized and potentially effective elements of games to maintain student engagement.

We've designed and developed **two game-based learning systems**. One focuses on narrative elements and the other focuses on puzzle and point-of-view elements in tandem to explore their effects on student engagement.



## PyStory

**PyStory** is an **educational game** in which students play as an astronaut who has crash landed on a distant planet. Throughout the game, students are required to write **Python code snippets** in order to 'reset' their crashed rocket ship's computer. Solving these code snippets relies on an understanding of first-year Computer Science concepts such as if-statements, variable types and for-loops.



PyStory consists of **four scenes**:

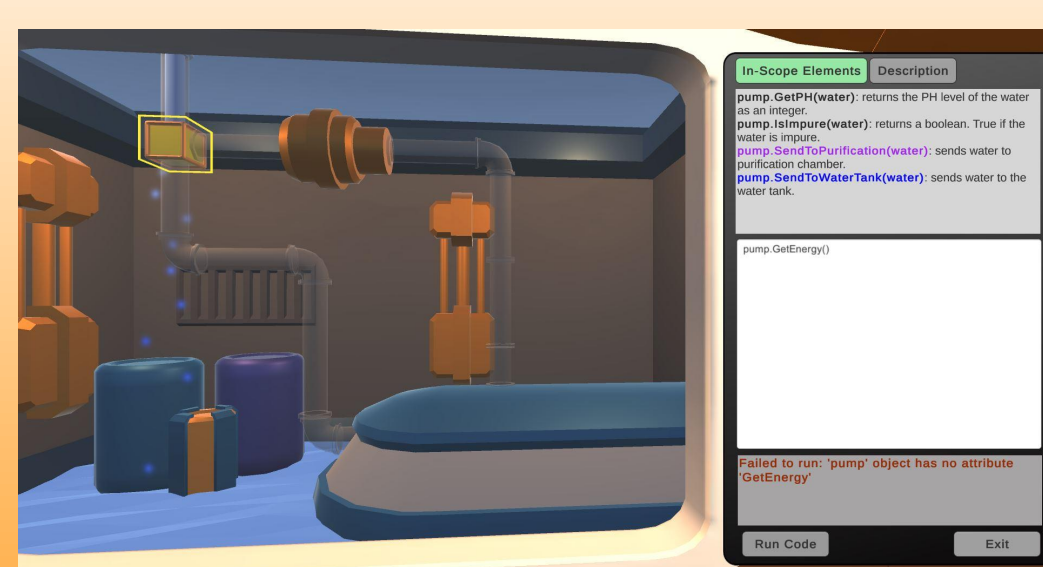
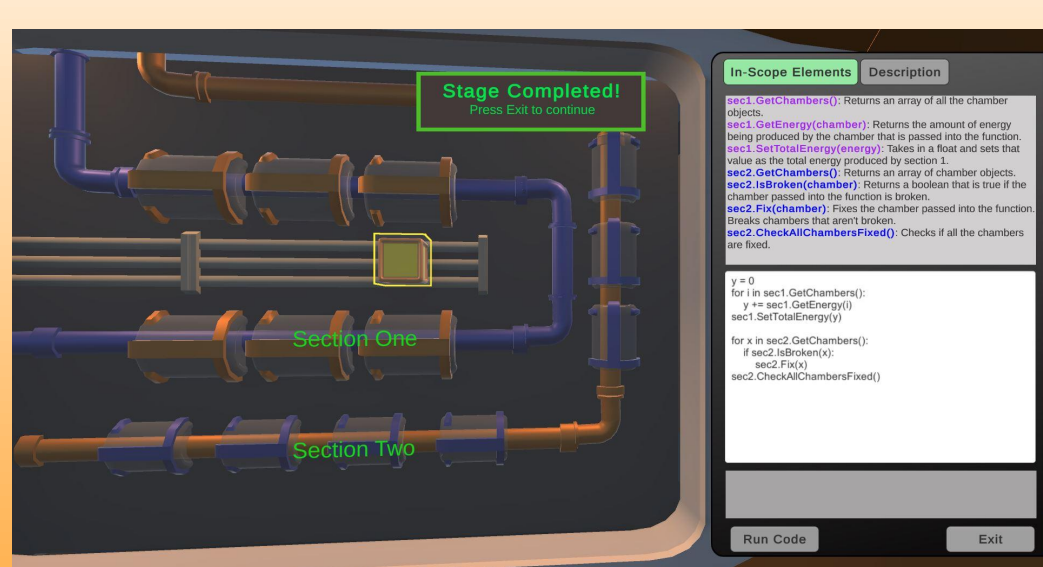
- A main scene, where a user navigates about the ship
- Three coding scenes, the generator room, water station and engine room.

It can be played in two modes:

- **Narrative mode:** gets the player to engage with the coding challenges within the game by introducing a storyline that attempts to increase a player's sense of immersion, emotional investment and transportation.
- **Non-narrative mode** provides the player with a visually appealing game-world where coding challenges are needed to be solved in order to complete the game.



PyStory provides a game-based learning system to aid learning introductory programming concepts and provides a means of testing the effectiveness of narrative elements on student engagement in isolation.



## Code Rover



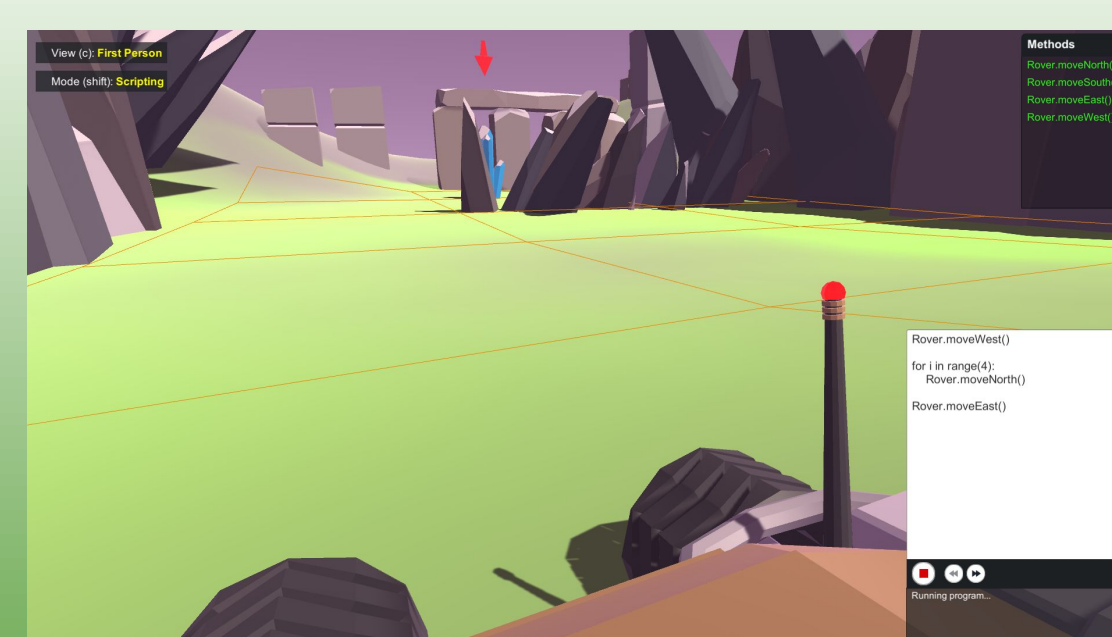
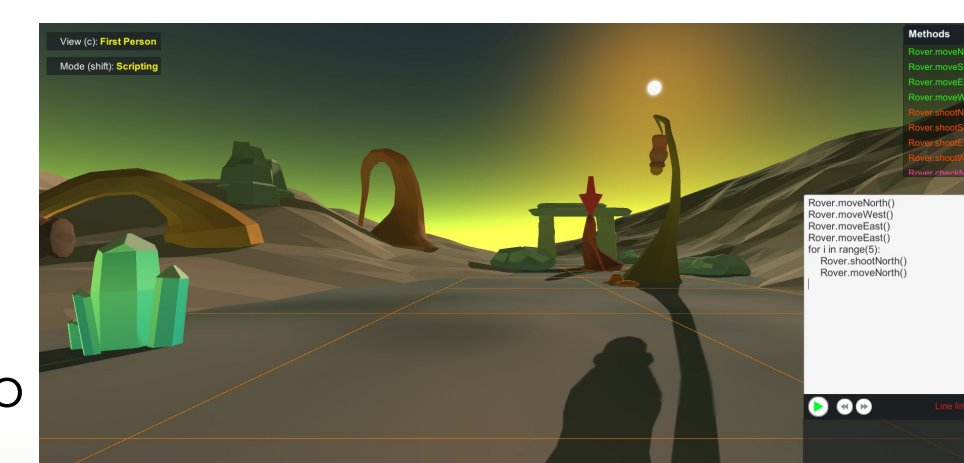
**Code Rover** is an **educational first-person puzzle game** in which students write **Python code** to control a space rover and navigate an alien planet. In the game, students program the movements and actions of their rover, avoiding obstacles and collecting valuable crystals. The aim is to introduce the fundamental coding concepts of if-statements and for-loops in a visual, engaging way.

The game is made up of **multiple levels**, consisting of seven 3D environments. The levels are scattered with various obstacles that need to be avoided, such as rocks and poisonous plants. To complete a level, students have to **program the rover** to get past all the obstacles. The rover can be programmed to:

- move in a particular direction.
- shoot in a particular direction.
- detect what objects are around it.

As students play, they are faced with more challenging coding levels to test their problem solving abilities.

The game utilises **point-of-view** elements to draw students into the game world and engender feelings of engagement. It also utilises **puzzle elements** to expose students to the problem solving required to be an effective programmer and create a sense of challenge.



## Results

To test the **effectiveness** of these specific elements on student engagement, research was conducted on students at the University of Cape Town. This involved a half-hour playthrough of one of the games, followed by a short survey and qualitative discussion. Due to the COVID-19 pandemic, all research was conducted remotely.

### PyStory

- + Narrative elements showed increased perceived user engagement
- + Narrative elements helped to link introductory programming concepts to real world scenarios
- + Students felt the game helped them practice basic coding concepts and that it would be a valuable tool for first year students.

### Code Rover

- + User testing showed positive results, suggesting that Code Rover is effective in eliciting feelings of engagement in students.
- + Students responded positively to the first-person and puzzle elements, and linked them to their feelings of engagement.
- + Students felt the game helped them practice basic coding concepts, and would be valuable to first year students

The experimental research indicates that narrative, point-of-view and puzzle elements may be effective tools for enhancing student engagement when learning introductory programming concepts. This indicates that a larger scale study of these elements would be a useful line of research.



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