**Overall Approach**

We began implementing the game by creating a *JPanel* class and a *JFrame* class to ensure that we have a board to draw our game with the PaintComponent() method and a window to display it. Then, we set up different states of the game and added functional buttons so that by pressing a button, it would lead the user to another state, such as instruction screen, starting a game, and exiting a game. Next, we added a *Player* class and made sure *Player’s* movement is controlled by the arrow keys. Once *Player* was functioning properly on the game board, we coded a 2D array that stores the values of the maze map in the *Cell* class, where 0 indicates a wall and 1 indicates a valid cell. After the map was set up, we added wall detection methods so that the Player cannot move into a wall cell.

With a functional map, we were able to start implementing the rewards and punishments. We created an abstract *Item* class that has multiple abstract methods to be shared by *Reward*, *Punishment*, and *Bonus* classes and it is also a superclass of these three. Inside the Cell class, we created an ArrayList for each of these three classes and used the ArrayList methods to either add them to the game board or remove them from the game board. Once the rewards the punishments were working, we added score, a winning condition, and a losing condition and if either one was triggered, it would lead the user to its respective state. Lastly, we implemented the *Moving Enemy* class and added its tracking method that calculates the shortest path to catch up to *Player*. Overall, we successfully executed all the required functions for the game.

**UML Modifications**

1. Initially in phase 1, we had a Character superclass, extended by both Player and Enemy classes (Figure 1). However, in phase 2, we removed the Character superclass and created independent Player and Enemy classes that have their own fields and methods instead of inheriting from a superclass (Figure 2). This change was made because we thought that Player and Enemy behave differently from each other.
2. Another change we made is that initially we wanted to implement all the rewards and punishments inside the Board class (Figure 1). Yet, in phase 2, we created separate classes for regular reward, punishment, and bonus reward because according to separation of concerns, we should divide our software into addressable modules. Therefore, instead of having everything inside one class, we took out those three components and divided into three parts, or in this case, three classes (figure 2).

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Figure 1. Phase 1 UML

Figure 2. Phase 2 UML

**Use Case Modifications**

**Roles and Responsibilities**

We had meetings twice a week during phase 2 to ensure everyone was on the right track and work was produced according to our plan.

Brian – Completed the full implementation for the Enemy’s movement method and helped devise strategy for implementation.

Jasim – Coded the game timer, scheduled group meetings, and assisted in game design logic.

Kevin – Assisted in coding the enemy and player classes. Assisted in writing the report.

Vera – Was the brains of the project and helped significantly with all of the code. Spearheaded the report and code production, giving a good backbone for the others to assist.

**External Libraries**

We did not use any external libraries in our code. However, we used a number of Java core libraries to complete the project. Java core libraries that we used are:

1. **java.awt.event**; the ActionListener methods this library provides allow the user to interact with our system by clicking different buttons, such as Play, Instruction, and Exit with a mouse. The KeyListener methods allow the user to control the player with arrow keys.
2. **java.awt.Graphics2D**; this library allows us to display images and draw shapes.
3. **java.awt.image**; this library allows us to load images into the game so that we can display the characters, rewards, and game backgrounds with different images.
4. **java.util.ArrayList**; this library allows us to create different ArrayLists for storing regular rewards, bonus rewards, and punishments and to control their behaviour with ArrayList methods such as add() and remove().
5. **java.io/java.imageio**; this library allows us to catch any input or output exception.
6. **javax.swing**; this library allows us to add JButtons to our game, draw graphics on JPanel, and display everything in a JFrame window.

**Improvement**

1. Multiple constants were created to indicate different states of the game, including START\_SCREEN, INSTRUCTION, GAME, WIN, and LOSE (Figure 3). This is repetitive, not as maintainable, and can often get lost in a pile of code. Therefore, to improve the quality of our code, we created a new enumeration class (Figure 4) to hold these constants. By singling out these constant variables, we emphasized the importance these variables have in our game since it is essential to have different states in a game. Along with this change, we also modified the if-else statements (Figure 5) that would switch the state of the game into switch cases (Figure 6) that use the State enumeration class to do the job.

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Figure 3. Multiple constant variables

Figure 4. State enumeration class

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Figure 5. if-else statements

Figure 6. switch cases

Challenges

A large challenge was getting used to and using the core libraries since for half the group this is the first time they have coded with java. Developing the movement method for the enemy took a bit of time to draft out and implement due to the logic. Another large challenge was sticking to the original UML. This was likely because we had naively drafted things, for example just because the enemy and the player are characters does not mean they should have their own superclass. I believe all these issues boil down to a lack of experience in developing a program of this size.