# Reflective Report

## Creating the Model

Creating the model was a challenging aspect of this project. While the game itself was very simple in its design and rules translating those rules and constraints into a VDM model provided to be quite the challenge. For quite a while, I struggled with trying to create a mental model of the game and how various feature could be mathematically and abstractly determined. For example, the simple concept of how the grid itself was simulated offered a range of possible implementations. Initially, I decided to portray the grid as a set of points. The user would then make moves and which would transfer the points from one set to another. However when it came to modelling a valid move this implementation added additional complexities as I now had to worry about moves wrapping around the grid. In the end, I decided to go with another implementation style (storing the grid as an x and y-axis). This was done in an effort to make the proofing process easier by removing any unnecessary complexities.

## Translating the Model

Once again, I had some troubles translating the model from the previous task. Thanks to the simplifications made during the model development process most of my model was easy to translate as most functions just consisted of basic Boolean operators. Things changed though when it came to my primary operation (makeAMove). Due to the complexity of the operation and how it called on multiple functions in different ways, it proved to be extremely difficult to translate that into Isabelle. In the end, I had to go back to the operation and see how functions could be grouped together or broken down. I managed to remove a large amount of complexity by creating separate swap turn functions and grouping the captureAnchor function and add move to play set function together. These simplifications then helped me to translate the operation.

## Issues Found During Translation

Due to the nature of translation, I was often combing through my model paying attention to every detail. This directly led to the discovery of several bugs or unintended side effects of my system. For example, while translating the invariant for the move type I discovered that its invariant could be broken if the user created a move on the minus x and y-axis. Therefore, I went back to the model and updated the invariant to counter-act this issue. Similarly, I found several other small bugs and issues while translating and I fixed those as I went along. Such as players being gaining double bonus turns, by simplifying and grouping functions together I managed to avoid this issued and removed the double bonus turns.

## Proof Finding

This was by far the most difficult aspect of the entire coursework. For most of the time working on the project, I had been entirely focused on creating the model of the game as well as learning Isabelle so that I could translate the model over. This meant that by the time I had finished with the translation I had very little time to learn how to complete the proofing process. Proofing itself is a difficult process that takes a long time to get a handle on so leaving myself so little time to learn it was significant downside of the project. I should have focused on learning all aspects of Isabelle at the start so when it came to proofing I at least had some ground to work on.

## Conclusion

Overall, CSC3323 was one of the most challenging modules of the semester. It required a great deal of thought and creative problem solving to not only come up with solutions to nuance problems but to evaluate them against future requirements. I found it rather difficult to model the system at the same time as trying to figure out what would be easy to translate and prove. This led to some parts of the system being simplified and easy to prove while other parts being very complex and difficult to prove. If I were to do things differently I would have focused on proof far earlier as I found it to be the most complex and difficult topic in the module.