

Lab 1- PolyMorpher Description

Peter I. Riley

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Professor Thomas J. Kennedy

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1 Introduction

Object oriented programming is an important concept for computer science students. It is a key concept for major programming languages such as C++ and Java. However, learning object oriented programming is a hurdle that faces many Computer Science students.

Programming, especially object oriented programming, can be difficult and intimidating for the uninitiated. Based on the enrollment data received from Professor Kennedy, this project's mentor, there is a notable drop off from CS 150 and 250 to 300 level courses like CS 330, 350, and 361, which is shown in Figure 1. As noted in figure 1, the data is subject to a margin of error because the cited enrollment data does not contain the declared major of each student, and CS 150 and 250 serve as prerequisite courses for other majors, including Engineering, Cyber Security, and Modelling and Simulation. However, even given the expectation that a number of students who take 100 and 200 level Computer Science courses are not required to take further courses for their major, there still remains a decrease in the number of students enrolled in 300 level Computer Science courses.

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| | CS 150 | CS 250 | CS 361 | CS 330 | CS 350 |
|-----------|--------|--------|--------|--------|--------|
| 2013-2014 | 804 | 327 | 161 | 111 | 93 |
| 2014-2015 | 672 | 367 | 208 | 203 | 148 |
| 2015-2016 | 937 | 327 | 217 | 195 | 183 |
| 2016-2017 | 920 | 337 | 199 | 180 | 182 |

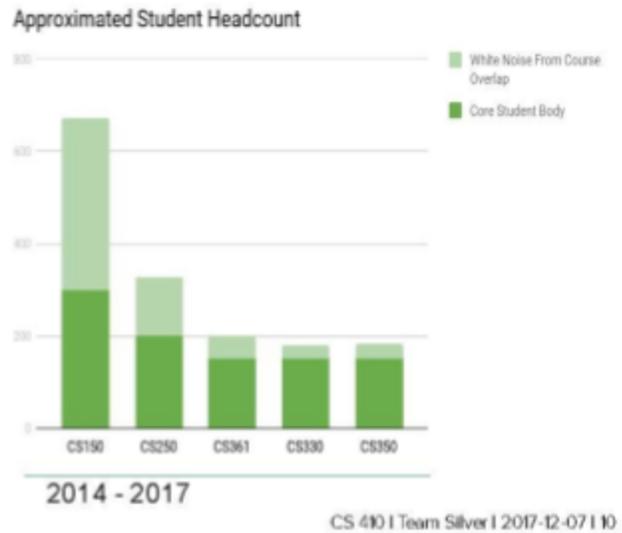


Figure 1 - Old Dominion University Approximate Student Headcount

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1.1 Problem Characteristics

With the current situation, as outlined in Figure 2, new Computer Science students can end up on a path to either pass or fail their introductory courses. If a student enters an introductory course and learns fundamental programming concepts over the course of that class, then that student is on course to pass their introductory class and progress in their Computer Science major. However, if a student struggles to understand programming fundamentals, that student could end up failing their introductory class and even dropping out or changing their major. Additionally, a student may end up having to retake an introductory class multiple times if they are still unable to learn the content being taught.

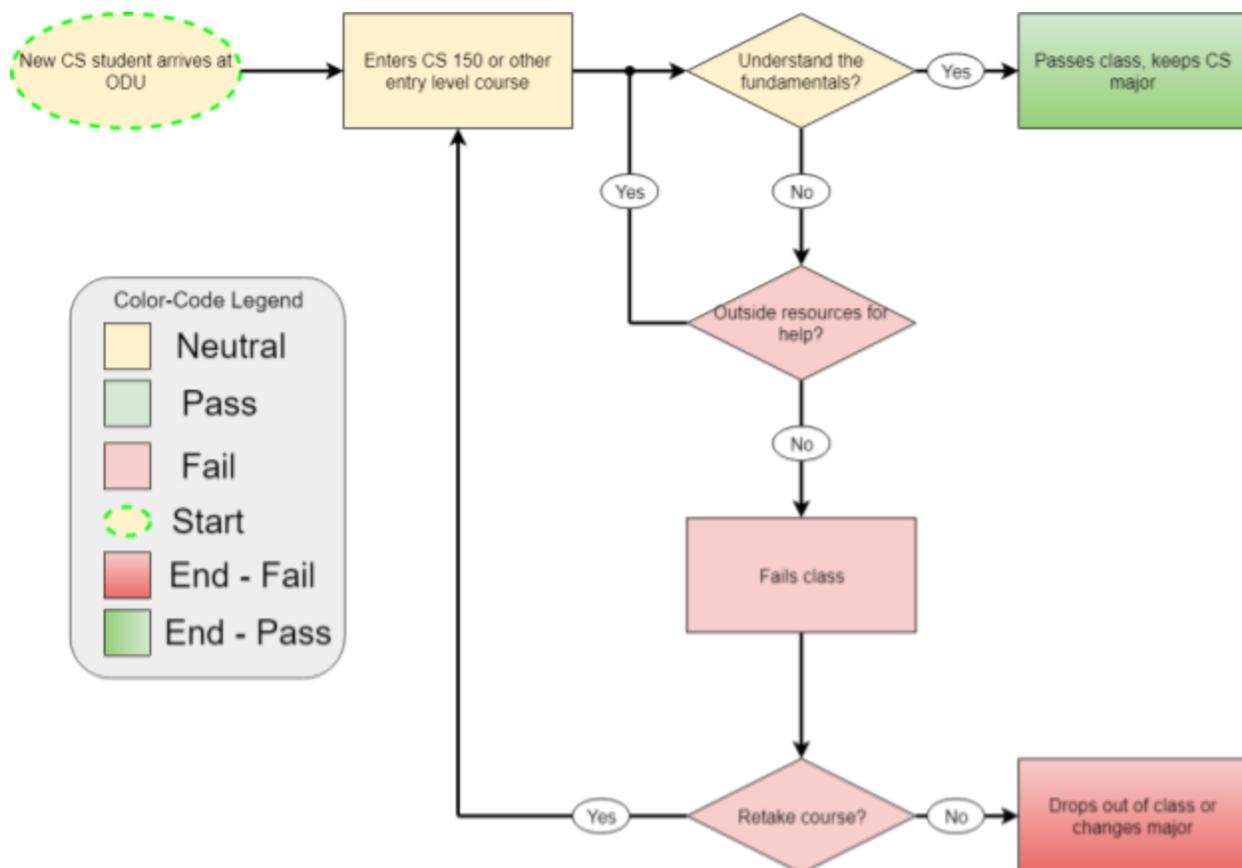


Figure 2 - Current Process Flow

1.2 Solution Characteristics

If the PolyMorpher programming game is used as a supplement to class instruction, a student who struggles to understand programming concepts from the lecture will be able to use the game to get a better understanding of those concepts. Use of PolyMorpher can help fill in gaps in knowledge and prevent a student from having to repeat a class, as shown in Figure 3.

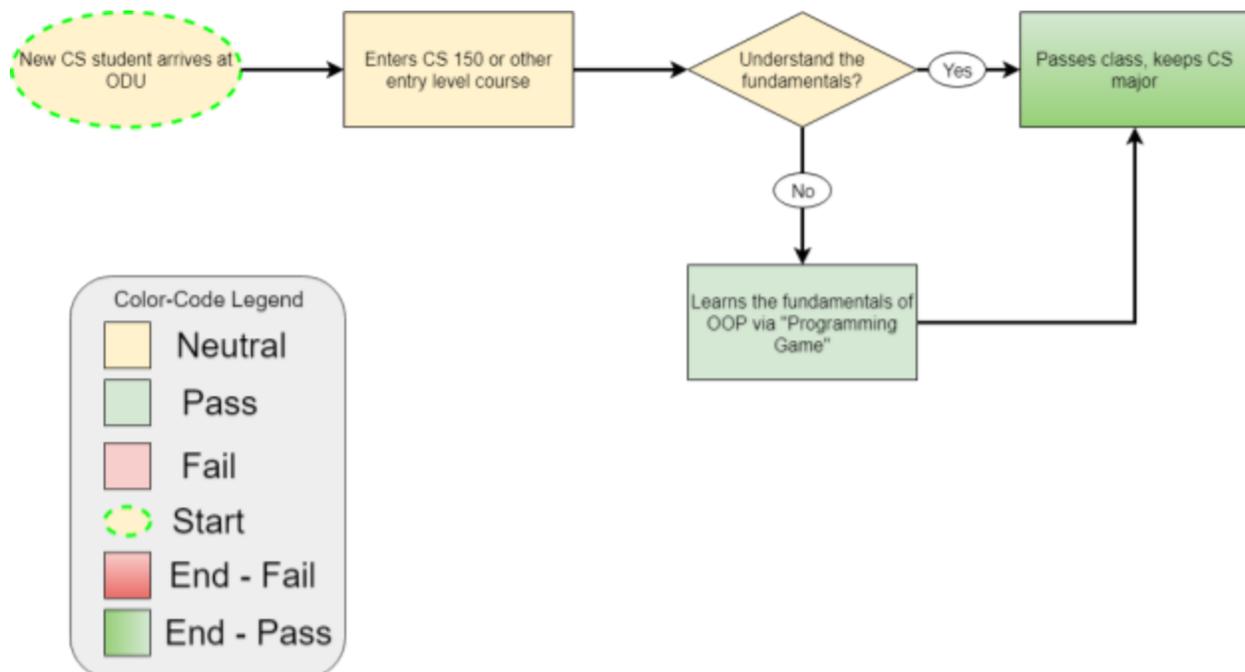


Figure 3 - Revised Process Flow

The idea to use a game as a medium for learning is not a new one, and there have been many games already made to teach programming. The data compiled in Figure 4 shows the characteristics of each noteworthy competing game. The majority of games surveyed were aimed at users with low to mid-range programming experience, which is defined as no knowledge of programming and beginner's knowledge of programming respectively. Most existing games also aim for this demographic. Object oriented concepts were separated into two

categories, using and teaching, because many games included object oriented concepts but did not include any tutorials or instruction on those concepts. PolyMorpher will fill in this gap by focusing heavily on the object oriented concepts that are ignored in other games. Most games focused on one programming language. PolyMorpher will use one language initially, C#, with the possibility of adding one or more other languages in the future. The inclusion of multiplayer varied based on how each game implemented programming in its gameplay, and PolyMorpher will not have multiplayer because it would clash with the chosen method of gameplay.

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| Game | Experience | Uses OOP | Teaches OOP | # of Lang. | Multiplayer |
|-----------------|------------|----------|-------------|------------|-------------|
| PolyMorpher | Low-Mid | Yes | Yes | 1 | No |
| Code Combat | Low | Yes | No | 5 | No |
| Screeps | Mid-High | Yes | No | 1 | Yes |
| CheckIO | Low-High | Yes | No | 1 | Yes |
| Code Monkey | Low | No | No | 1 | No |
| Elevator Saga | Mid-High | Yes | No | 1 | No |
| Codewars | Mid-High | Yes | Yes | 6 | Yes |
| Codingame | Low-High | Yes | No | 25+ | Yes |
| Git Games | Low | No | No | 1 | No |
| CSS Diner | Low | No | No | 1 | No |
| Flexbox Defense | Low-Mid | No | No | 1 | No |
| Ruby Warrior | Low | No | No | 1 | No |
| Untrusted | Mid-High | No | No | 1 | No |
| Empire of Code | Low-Mid | Yes | No | 2 | Yes |
| Ruby Quiz | Mid-High | Yes | No | 1 | No |

Figure 4 - Competition Matrix

2 PolyMorpher Product Description

PolyMorpher is a computer game made to teach object oriented programming to beginning Computer Science students.

While PolyMorpher will teach general programming concepts, its focus will be on object oriented programming. Users will learn these concepts naturally by progressing through the game's levels.

The gameplay in PolyMorpher will revolve around selecting objects and obstacles in the game environment and changing their code to progress through puzzles. The object code will be compiled during runtime to change the level while it is being played.

The levels in PolyMorpher will be designed to teach the object oriented concepts of encapsulation, inheritance, abstraction, and polymorphism. Each concept will have one level dedicated to it, along with a tutorial level to teach the gameplay mechanics.

PolyMorpher will be a 2D game and will be optimized to avoid requiring a powerful graphics processor. A fourth generation Intel i3 processor will be used as a benchmark for minimum hardware requirements. PolyMorpher will be distributed for Windows, MacOS, and Linux to be as accessible as possible.

3 Identification of Case Study

PolyMorpher will primarily be used in an education environment. PolyMorpher is being developed to help alleviate the enrollment drop from introductory to 300 level classes. So, students will be the primary end users; although, it will be available for anyone who wants to expand their programming knowledge. Universities will be the customers for PolyMorpher, with

Old Dominion University being the primary customer. There are no plans for a price at this time.

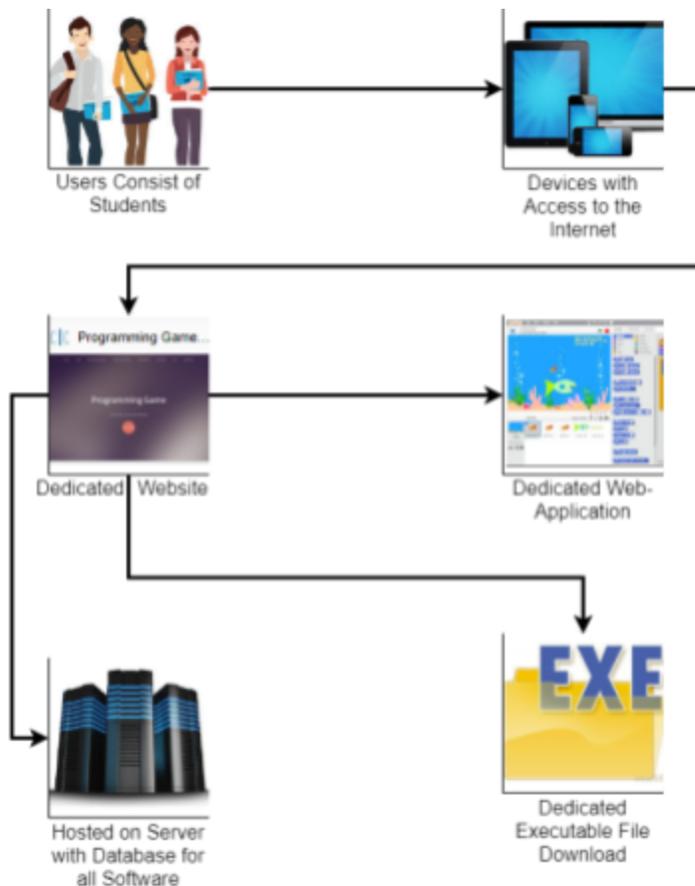
4 Product Prototype Design

The PolyMorpher prototype will consist of an executable program that the user will download. The prototype will contain almost all the functioning components that the real world final product would and is built around three major algorithms.

4.1 Prototype Hardware and Software

The prototype will consist of an executable that users will access by downloading it from a dedicated website onto their computer. The download website will be hosted on the Computer Science department servers.

4.2 Prototype Features and Capabilities



The PolyMorpher prototype will contain most of the elements in the real world product, as shown in Figure 6. The sandbox level and player-made content are not vital to the prototype. So, these elements will be included if sufficient time remains after the rest of the prototype has been completed. Multiplayer features and a web-based implementation of the game will not

Figure 5 - Prototype Architecture

be included in the prototype because of the difficulty in implementation as well as the additional security features needed to prevent players from affect other players' computers.

| Elements | Description | Real World Product | Prototype |
|------------------------|--|---------------------------|------------------|
| Teaches Polymorphism | Provision of a single interface to entities of different types | | |
| Teaches Abstraction | Technique for arranging complexity of systems | | |
| Teaches Encapsulation | Building of data with the methods that operate on that data | | |
| Teaches Inheritance | When an object or class is based on another object or class, using the same implementation | | |
| Single Language Taught | A single programming language will be focused on C#. | | |
| Single Player | Focused on an experience targeted to interact with only one player | | |
| Downloadable .EXE File | Desktop application version of the game | | |
| Game Assets | Primary components that are used as building block to construct the more complex features and levels of the game | | |
| Developed Story | Narrative used to drive progression or direct player throughout a more guided/linear experience | | |
| Portable Compiler | Code compiler used to run player-made code on the fly in game | | |
| Tutorial Section | Precursor series of levels meant to help the player adjust to the in-game toolset given to them and also prep them with knowledge of the | | |

| | | | |
|---------------------------|---|--|--|
| | language(s) they will be working with | | |
| Multiple Platforms | Version support for multiple operating systems (Windows, Mac OS, Linux) | | |
| Sandbox Level | Open level where the player has access to all tools at once and can build their own level sequences and puzzles | | |
| Player-Made Content | Variant of Sandbox Level, potentially allows the player to share custom levels with one another | | |
| Multiple Player | An experience geared toward multiple players interacting with a game environment together | | |
| Web Application | Web based version of the game running in-browser | | |
| Multiple Languages Taught | Alternative programming languages for the player to use and learn in-game | | |

| |
|----------------------|
| KEY |
| Fully Functional |
| Partially Functional |
| Eliminated |

Figure 6 - Real World Product vs. Prototype

4.3 Algorithms

PolyMorpher is based around three major algorithms that allow the player to change the code of selected objects and recompile the game during runtime.

4.3.1 Core Algorithm

The core algorithm, shown in Figure 7, manages the other two based on the actions of the player. It launches when the player selects an object to change its code. The algorithm loads the source code for the selected object in a text editor. From there, the player can write their own edits of the code in the text editor, enter the API book algorithm to insert sample code, or click a reset button to reset the code in the editor to its original contents. When the player chooses to compile, the compiler algorithm is run. If the compiler algorithm passes, the code editor is closed and the player returns to the standard gameplay mode.

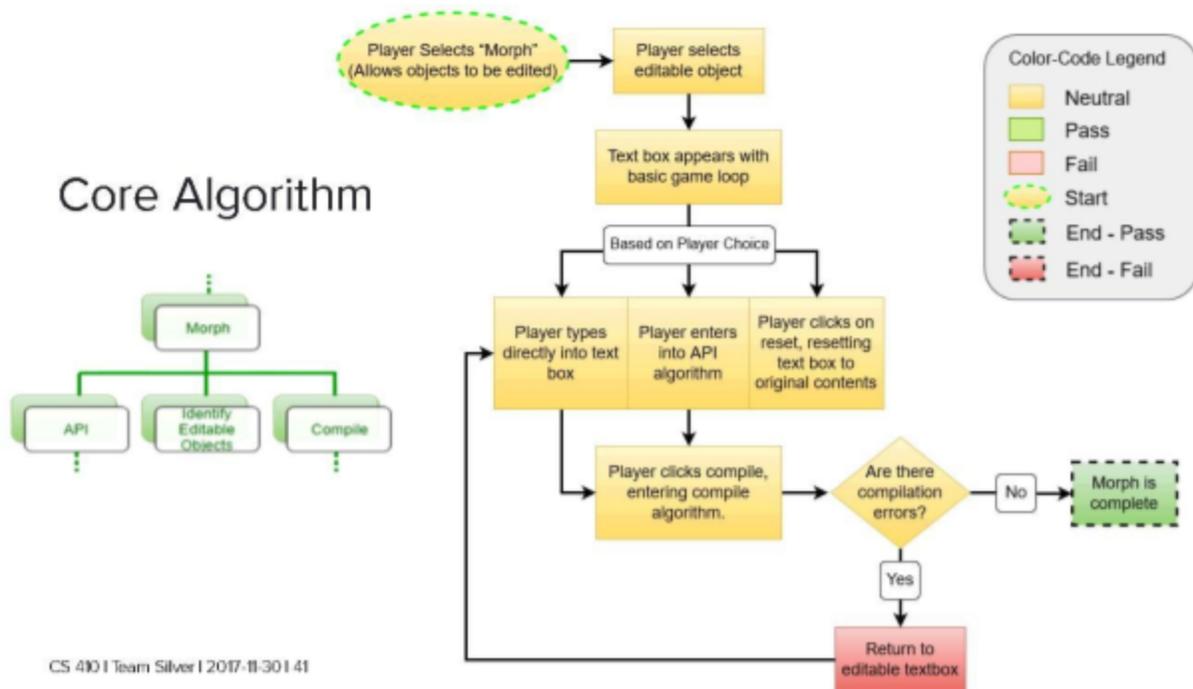


Figure 7 - Core Algorithm

4.3.2 API Book Algorithm

The API book algorithm, shown in Figure 8, is a linear algorithm. If the player selects the API book, a menu opens that contains example code and player-created solutions. The player may choose one of these and the chosen code is inserted into the code editor for the player to use or change.

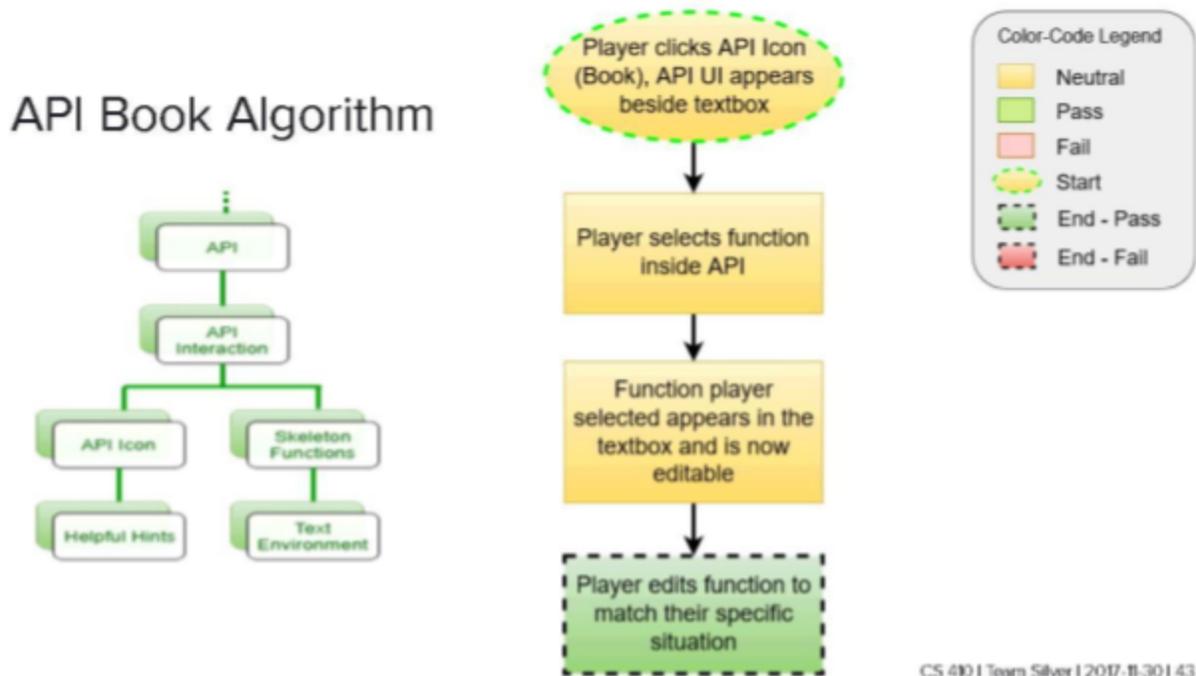


Figure 8 - API Book Algorithm

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4.3.3 Compiler Algorithm

The compiler algorithm, shown in Figure 9, enables the game to change the source code of an object and recompile it during runtime. When the player selects the compile button, the compiler algorithm creates a runtime object with LoadScripts.cs attached to it. LoadScripts.cs puts the player's code into the source code for the object and calls the compiler. The compiler checks for any errors. If there are errors, the player is returned to the code editor with an error message. If there are no errors, the selected object is recompiled with the new source code and the player is returned to standard gameplay.

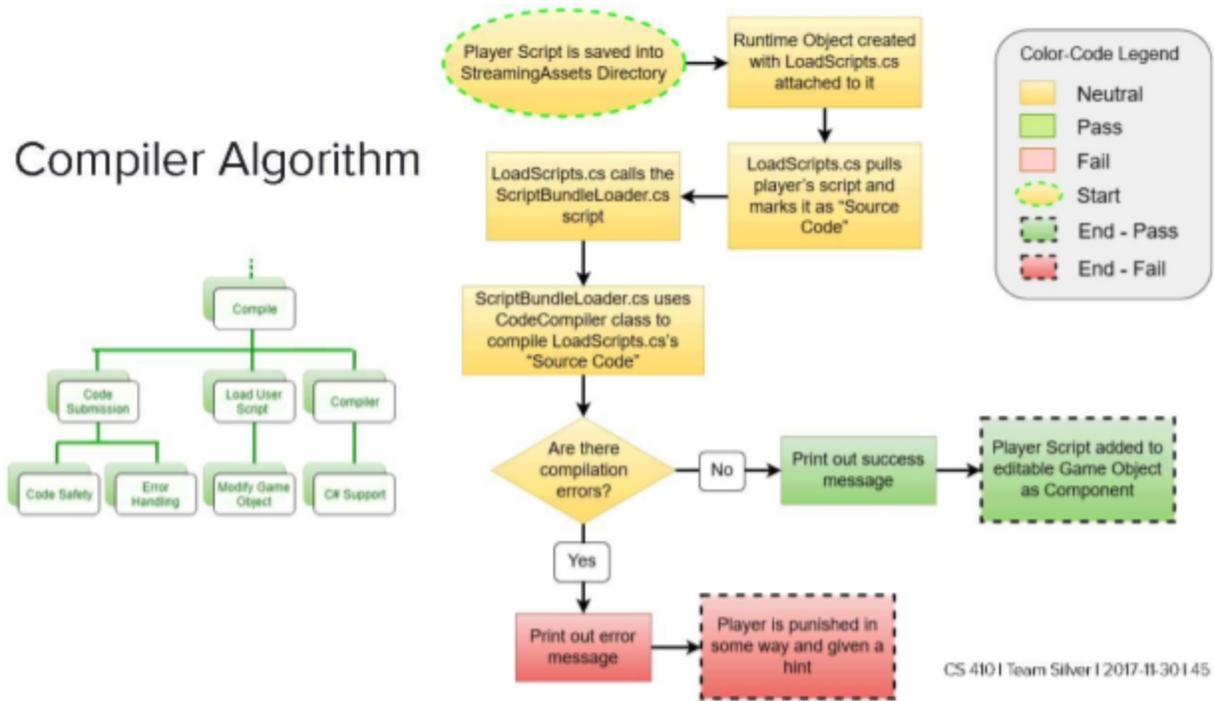


Figure 9 - Compiler Algorithm

4.4 Prototype Development Risks and Mitigation

Development of PolyMorpher has some risks, both with the customers and technical aspects, that will be addressed. These are shown in Figure 10. If the user gets lost in the game and cannot figure out the proper solution, that would defeat the purpose of the game. To mitigate this, the PolyMorpher game will go through thorough playtesting to fine tune the rigor of gameplay and helpfulness of the tutorials.

A user might be dissatisfied with PolyMorpher because of its gameplay or the player's inability to learn object oriented concepts. Mitigation for this will again be handled through playtesting.

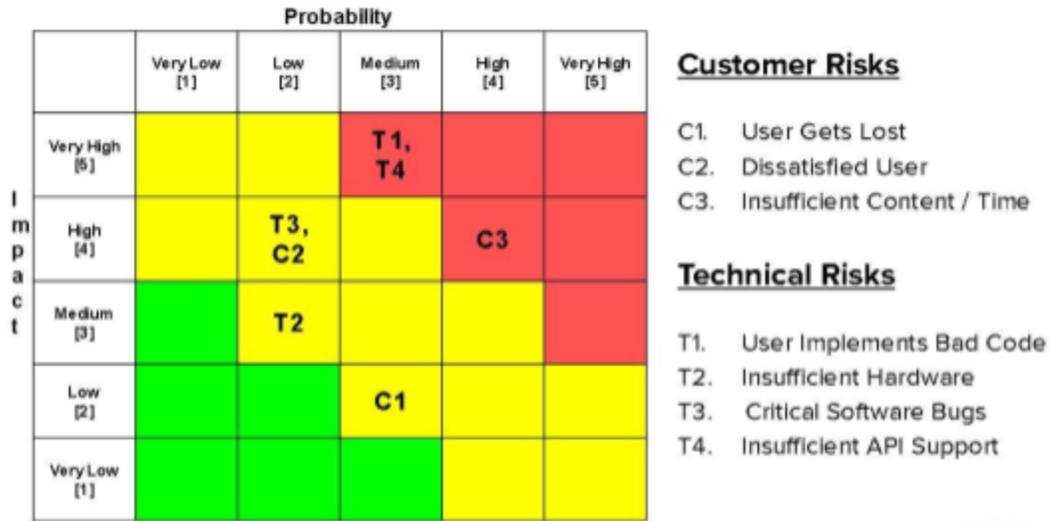
A user may feel that the game is lacking in content or does not have proper pacing. Once again, this will be mitigated through playtesting. Playtesting is an important step in game design and helps to mitigate most customer related risks.

If the user implements unintentionally bad or intentionally malicious code, this could negatively impact the user's computer and possibly other computers. In order to mitigate this, the entire PolyMorpher game will be sandboxed. The game will have no access to other files on the user's computer. Also, the compiler will scan the player's code for potentially malicious or destructive scripts. There will also be a page on the development website dedicated to informing the player on possible threats and providing the player with a guide to safe solutions.

A user without sufficient hardware to run the game will prevent the game from helping the user at all. To prevent this, PolyMorpher will be designed to minimize graphics processing.

The target minimum requirements are a fourth generation Intel i3 processor and 2 Gigabytes of RAM.

To prevent critical software bugs and insufficient API support, PolyMorpher will be playtested specifically to test functionality.



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Figure 10 - Risk Matrix

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5 Development Pipeline

PolyMorpher will be developed using the Unity game engine. Source Tree will be used to integrate git version control since Unity does not support it natively. Work will be separated into groups by level using an agile development model.

5.1 Unity Game Engine

PolyMorpher will be developed on the Unity game engine. Unity is a free game creation program commonly used in the video game industry. PolyMorpher will be coded with and teach C# because it is a powerful, widely-used language that Unity supports out of the box. Monodevelop will also be used in conjunction with Unity for C# development.

5.2 Source Tree Software

Source Tree will be used to connect Unity game files to the group's git repository because Unity does not have any built-in version control. Source Tree uses PuTTY to interface with the repository via SSH.

5.3 Version Control

The organization of version control for PolyMorpher is shown in Figure 11. All editing of the game code will be done through Unity. Source Tree will use PuTTY to interface with the git repository in order to push and pull changes. Each development team will have its own branch for the level they are working on. These will be merged with the main branch near the end of development to export the full game.

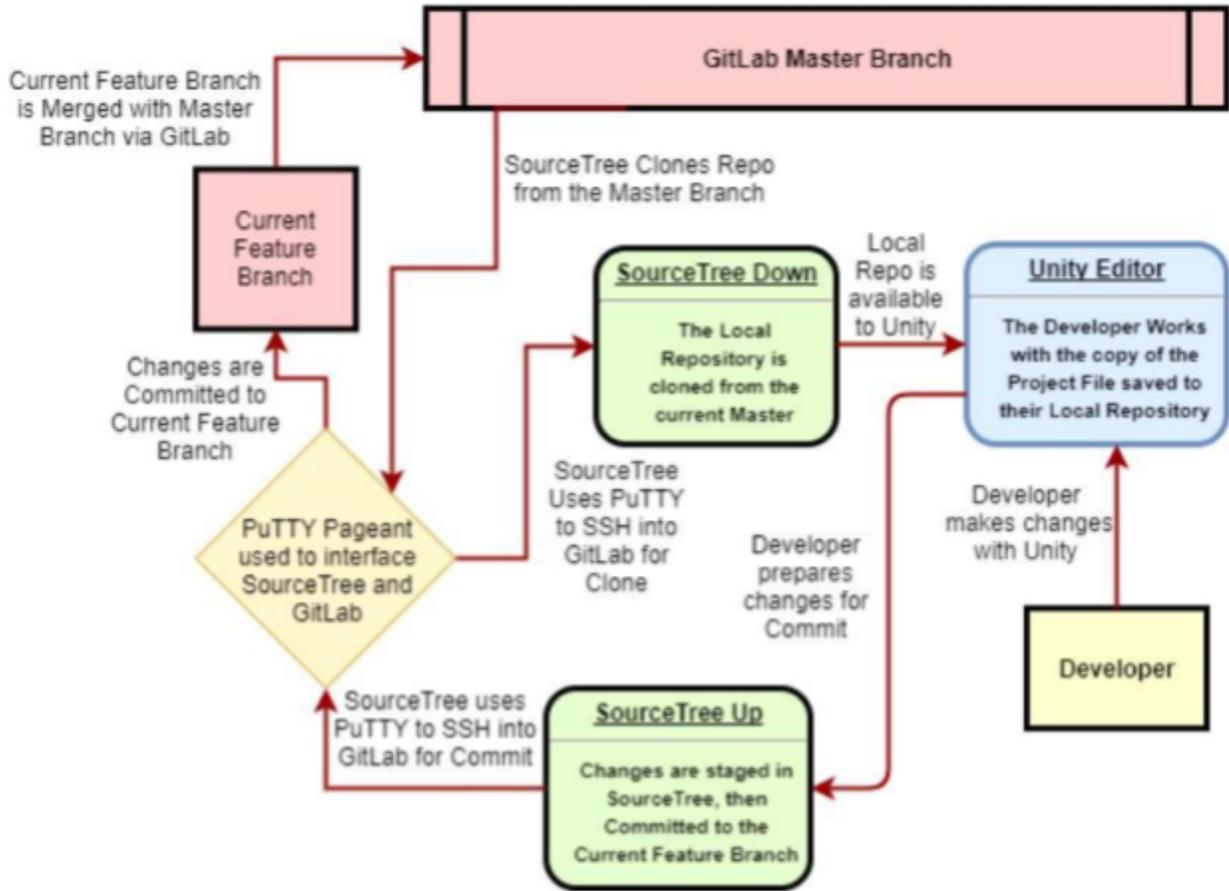


Figure 11 - Version Control Diagram

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5.4 Agile Development

PolyMorpher will be developed using an agile development approach, which is diagrammed in Figure 12. Each group will work in short development cycles to create workable demos, from which elements of the game will be worked on, tested, and implemented.

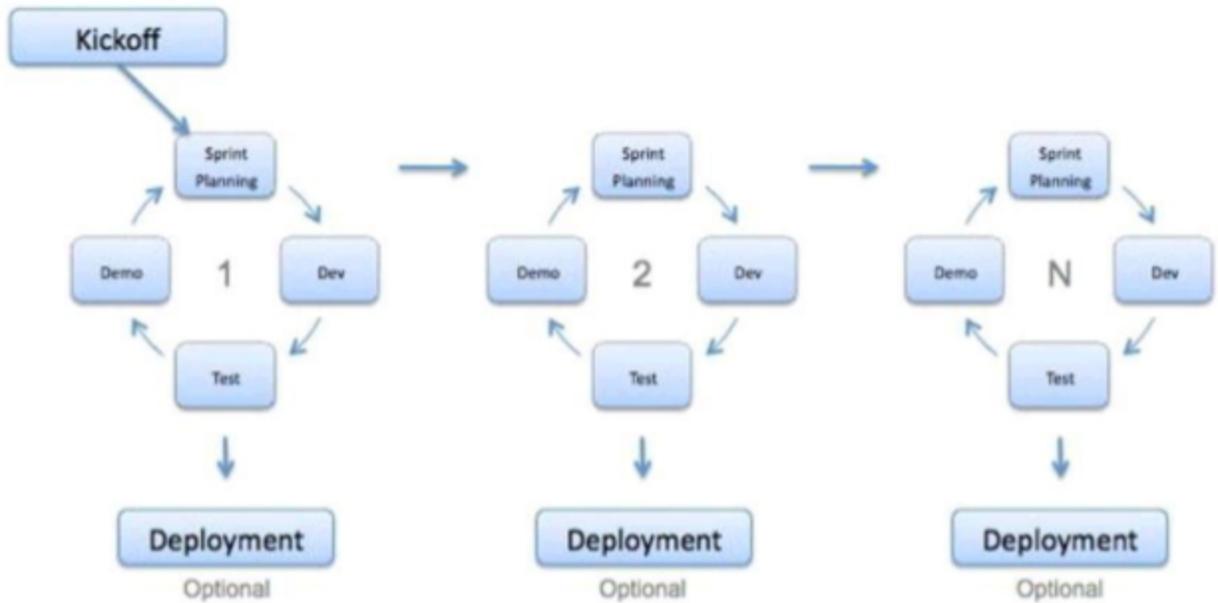


Figure 12 - Agile Development Model

5.5 Work Management

Development for PolyMorpher has been split into four groups. Each group will take one of the elements of object oriented programming (Encapsulation, Inheritance, Abstraction and Polymorphism), with the group working on inheritance also working on a tutorial level. Each group will create a level based on the element assigned, and the levels will be tweaked later in development so they form one cohesive game.

6 Glossary

Code Compiler Directory: File directory holding the portable compiler, and the associated companion files, which are used to manipulate the scripts in the Streaming Assets Directory.

Coding Interface: An in-game GUI accessible to the player that pulls specified scripts from the Streaming Assets Directory for them to edit and compile using the portable compiler from the Code Compiler Directory.

LoadScripts.cs: Manages files accessed by the entire portable compilation system by identifying which script is currently in focus as the “source” script for any selected object in game, pulling this file from the Streaming Assets Directory and passing it off to the Script Bundle Loader for compilation.

ScriptBundleLoader.cs: Takes scripts passed off from the Load Script file and marks them for compilation, setting up the Assembler and Compiler and running the selected script through them. In the event of any compilation errors it will send out an error report through the Unity Error and Log files, otherwise it will attach the script to whichever game object was selected.

Streaming Assets Directory: File directory where all scripts accessible to the player via the in-game Coding Interface are stored and organized according to level and programming concept relevance. It is unique in that it is one of the few source file directories that are accessible to the player in the Unity Engine under any condition.

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