Lab 1 – PolyMorpher Product Description

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1 Introduction

1.1 Problem Statement

Programming is intimidating for the uninitiated. As a result, first time Old Dominion University (ODU) programming students drop out or switch majors. Existing tools fail to teach Object-Oriented Programming (OOP) concepts and problem-solving skills.

1.2 Problem Characteristics

There exists a student progression dilemma for Computer Science (CS) students at ODU. Numbers obtained from the Student Factbook indicate significant drops in student enrollments during natural course progression. Introductory CS courses can require students to think differently than what they are used to which can make it difficult for newer students to pass introductory courses.

1.3 Solution Characteristics

Multiple educational games have been created in the past to teach programming in general, but few of those games attempt to teach OOP to its players. The few that do require the player to have more than a beginner's experience to play. A solution that minimizes the required experience while also teaching a high level of OOP is needed. PolyMorpher is an educational video game designed to teach OOP concepts to novice programmers. The game does this by allowing players to type and compile relevant code while playing the game. This game utilizes puzzles of increasing difficulty to develop the player's problem-solving skills.

1.4 Team Members

The team that is undertaking the development of PolyMorpher is Team Silver of the

Professional Workforce Development course at ODU taught by Professor Thomas Kennedy.

Team Silver consists of Colten Everitt, Casey Batten, Peter Riley, Kevin Santos, Joel Stokes,

Matthew Tuckson, Nathaniel DeArce, Daniel Dang, and Tyler Johnson.

2 PolyMorpher Product Description

PolyMorpher is an educational game that will provide players the opportunity to learn

OOP concepts with minimal experience in programming. OOP will be used to help players

understand how to connect their code to the real world.

2.1 Goals and Objectives

In order to make PolyMorpher as accessible as possible, PolyMorpher will strive to

minimize the programming experience required to effectively play the game. Previous

programming experience will not be assumed. Introduction of OOP concepts will be done in a

way that does not overwhelm the player.

2.2 Key Product Features and Capabilities

In PolyMorpher, the player will be able to interact and modify the code of objects within

the game. For example, if the player needs to move a box that will not budge, the player will be

able to modify its code to make it respond to the player's actions. The player will need to use this

mechanic to solve puzzles throughout the game. PolyMorpher will support multiple object-

oriented languages like C++, C#, and Java. Code written by the player will be compiled in a

sandboxed environment and the game will update according to the changes.

2.2.1 Game Concept

2.3 Major Components

PolyMorpher will be developed for PC, Mac, and Linux. To make PolyMorpher more accessible, the game will be a 2D game so that most computers can run the game without a problem. The game will be available through the CS 411 Team Silver website as a downloadable executable file and through other game distribution services such as Steam.

3 Identification of Case Study

This solution was born to remedy the student progression dilemma for ODU Computer Science students. This section will go into more detail regarding this dilemma and identify the potential customers and target end-users.

3.1 End User

The end users of PolyMorpher will be students, teachers, and anyone that wants to have a resource with which to learn object-oriented programming.

3.1.1 University Students

PolyMorpher is being developed with the goal of providing students an extra resource through CS 150 at ODU. This solution is not inherently exclusive though. PolyMorpher could just as easily benefit programming students from other universities.

3.1.2 Instructors

PolyMorpher can be used by instructors as a resource for their students. PolyMorpher can be provided by instructors who wish to provide their students with another way to learn concepts they are teaching.

3.1.3 Interested Non-Traditional Learners

Although PolyMorpher is being developed as a game targeted toward traditional learners (e.g. students), non-traditional learners can benefit just as much from playing PolyMorpher. The nature of games as educational tools makes PolyMorpher an effective tool for non-traditional learners.

3.2 Customers

The intended customers of PolyMorpher are educational institutions. Team Silver has chosen to target ODU in particular as that is where its members have identified the problem PolyMorpher aims to solve.

3.3 Influences on Product Development

Team Silver has identified a student progression dilemma for CS students at ODU. New CS students tend to drop out or change majors while in introductory courses of the CS program. Team Silver believes that this is because of the way programming is taught at the introductory levels. Object-Oriented Programming concepts are not introduced in the ODU CS curriculum until 200-level courses, and OOP concepts can help newer programmers understand programming better.

Figure 1 shows data that has been collected regarding student enrollment in ODU CS courses. One will notice the drastic drop in student enrollment between CS 150 and CS 250. A majority of that difference is due to the fact that most Engineering, Math, and Physics students are required to take CS 150. There is some of this white noise in the headcounts for other CS courses, but they are smaller than the white noise in CS 150. Accounting for this, one will notice that there is still a drop-off worthy of attention. One may also notice a significant drop between CS 250 and CS 361 and CS 330. This drop is because the ODU CS curriculum branches off at this point. Students have the option of either CS 361 or CS 330 after CS 250.

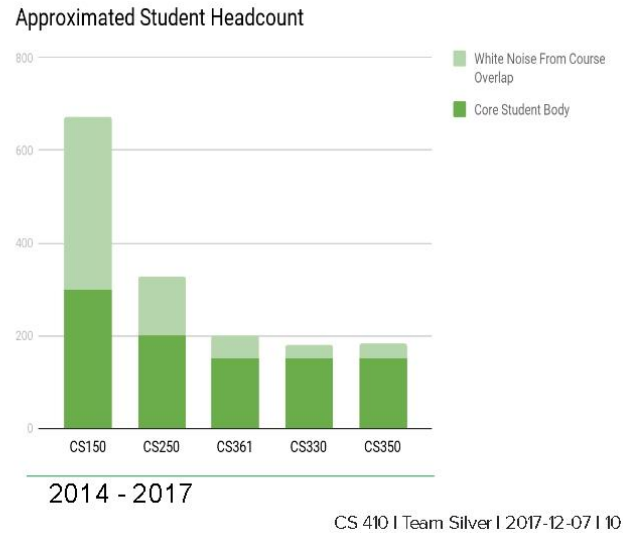|	CS 150	CS 250	CS 361	CS 330	CS 350
2013-2014	804	327	161	111	93
2014-2015	672	367	208	203	148
2015-2016	937	327	217	195	183
2016-2017	920	337	199	180	182

Figure 1 Statistics from the ODU Student Factbook

4 Product Prototype Description

To demonstrate the functionality and effectiveness of PolyMorpher as a teaching tool a prototype will be developed to showcase primary functions.

4.1 Prototype Architecture

This prototype will be offered as an executable file on PC, Mac, and Linux machines. The prototype will require that the player has a minimum 4th Gen Intel i3 Processor.

4.2 Prototype Features and Capabilities

The prototype of PolyMorpher will not have the full capabilities of the real-world product. Table 1 below highlights the differences between the prototype and real-world product.

Table 1 Real-World Product vs Prototype Features

Element	Description	Real-World Product	Prototype
Abstraction	The game will provide a section that covers Abstraction	🟩	🟩
Developed Story	The game will feature a narrative to drive progression	🟩	🟩
Encapsulation	The game will provide a section that covers Encapsulation	🟩	🟩
Inheritance	The game will provide a section that covers Inheritance	🟩	🟩
Polymorphism	The game will provide a section that covers Polymorphism	🟩	🟩
Portable Compiler	A compiler will be provided that can compile player-edited code	🟩	🟩
Single Player	The game will feature gameplay for only a single player	🟩	🟩
Tutorial Level	Provides players a way to familiarize themselves with game controls and mechanics	🟩	🟩
Multiple Languages	The game will support multiple object-oriented programming languages	🟩	🟨
Player-Made Content	Players will be able to create their own puzzles or content	🟩	🟨
Sandbox Level	Players will have access to all tools they would receive through normal progression	🟩	🟨
Multiplayer	Gameplay features aspects that require the cooperation of multiple players	🟩	🟥
Web Application	Web-based version of the game running in browser	🟩	🟥

Table 2 Key to Table 1

Fully Functional
Partially Functional
Eliminated

4.2.1 Fully Functional Components

The goal of PolyMorpher is to teach OOP concepts. This prototype will showcase how PolyMorpher will teach the OOP concepts to its players. To do this, the prototype will have a fully functional C# portable compiler that can compile code written by the player during gameplay. The language of focus for this prototype will be C# because Unity scripts are written in C#, so this simplifies development of the prototype to focus on the teaching aspects of PolyMorpher. This prototype will only be provided with a single-player component. The reasons for this will be discussed later. A tutorial section will be provided in the prototype that will teach game mechanics, like controls and how to modify game objects, and teach players preliminary knowledge of C#, like control structures and data types. This prototype will also feature a story to drive progression through the game.

4.2.2 Partially Functional Components

These components are not necessary to be implemented within the prototype to demonstrate its effectiveness as an OOP teaching tool. The inclusion of these components will be dependent on time. The final real-world product of PolyMorpher will provide the player with a choice of object-oriented programming languages to play the game with. The prototype may not have all possible languages implemented and development will be focused on the use of C# as the primary language. PolyMorpher will include extra modes that give the player the ability to create their own puzzles and share them online with others. The ability for players to create their own content may not be developed in the prototype. PolyMorpher will also include a sandbox mode which allows the player to use any tools they receive through normal game progression in an endless level. The previous two components are not necessary to teach OOP concepts, so their development is subject to time.

4.2.3 Eliminated Components

The prototype of PolyMorpher will not be capable of multiplayer. The ability of the

portable compiler to compile any player written code in real-time can be very dangerous.

Malicious code could damage a player's installation of the game, or their system itself. Steps that

can be taken to mitigate this will be discussed later, but one mitigation is to not include

multiplayer at all until a suitable solution can be developed. This prototype will also not be

available as a web application. This is simply due to the nature of the portable compiler. Its

implementation does not allow for it to be included in a web application.

4.2.4 Algorithms

This section will discuss the three major algorithms that make up gameplay in

PolyMorpher. The three algorithms are the Core algorithm, API algorithm, and Compiler

algorithm.

The first algorithm to be described will be the Compiler algorithm. Figure 2 shows the

flowchart of the Compiler Algorithm. Whenever the player requests for their code to be

compiled the script they modified is first saved to the StreamingAssets directory. This directory

holds files that are changed while the game is running. A runtime object is created with

LoadScripts.cs which pulls the player-edited script and marks it as "source code."

ScriptBundLoader.cs then compiles the code LoadScripts had marked as its "source code." The

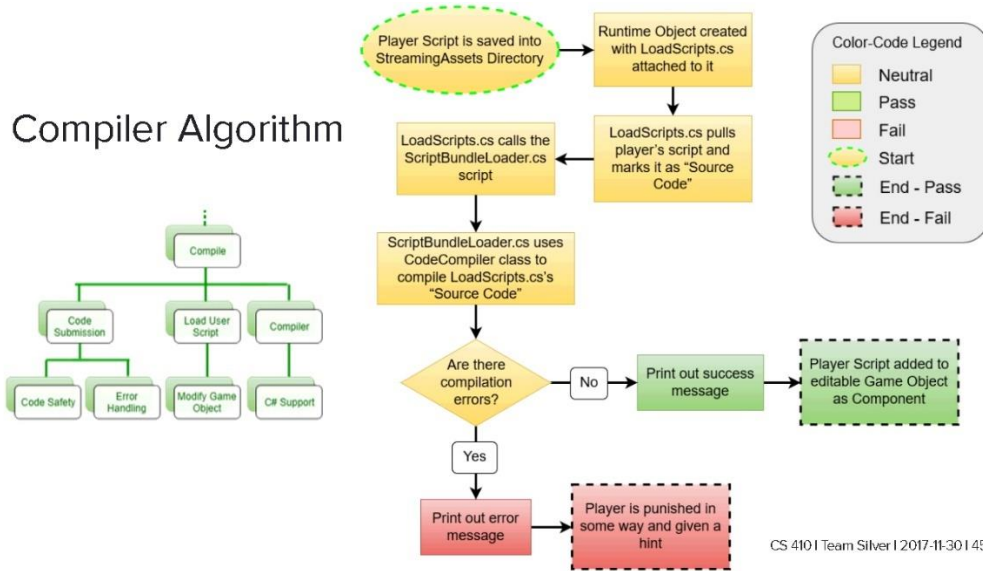compiler checks for any errors and takes the appropriate actions.

Figure 2 Compiler Algorithm

The next algorithm for discussion is the API Book algorithm. This algorithm refers to the ability for the player to select function templates to edit from a list. Figure 3 shows the flowchart for the API Book algorithm. When the player clicks on the API icon (in PolyMorpher it will take the form of a book) the API UI will appear. The player will select a function inside the API and it will appear inside the editable text window. The player may then edit it to their needs.
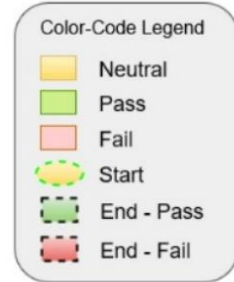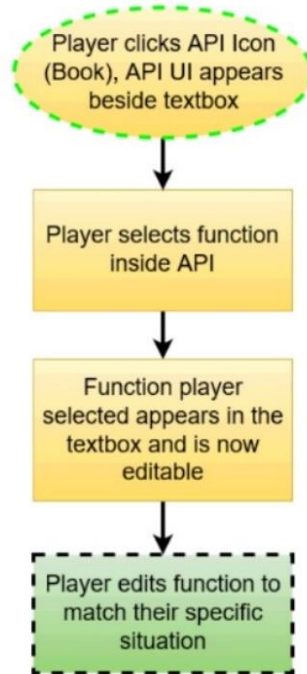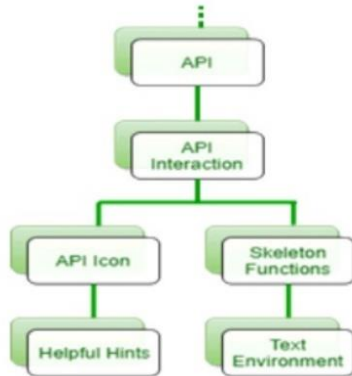
Figure 3 API Book Algorithm

The final algorithm to be discussed is the Core algorithm. This algorithm dictates most of the gameplay involving the modification of code in-game. Figure 4 shows the flowchart for the Core algorithm. The player will select the "Morph" button on the UI. This will highlight any object that can be edited by the player. A text box will appear with options to modify the object. The player may type their own code directly into the text box to modify the script, choose a function from the API Book, or reset the script to its original, stable contents. The player will then compile their code, and the game takes the appropriate actions according to the presence of compiler errors.
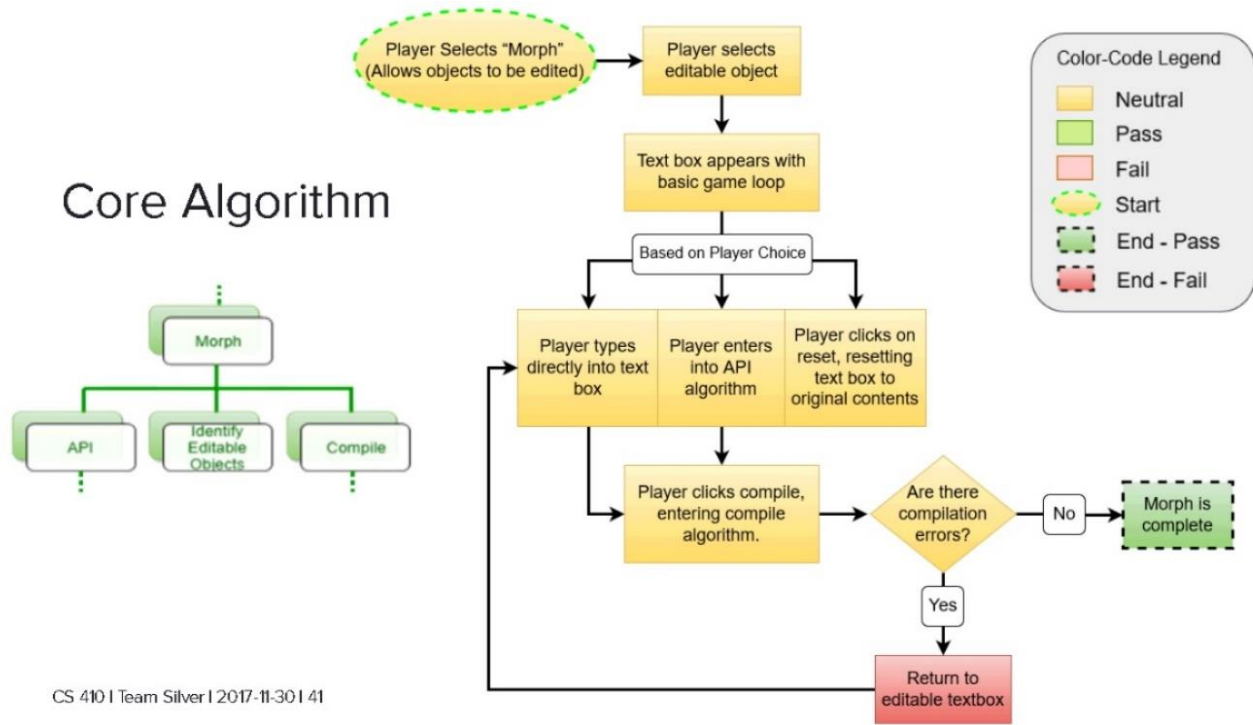
Figure 4 Core Algorithm

4.3 Prototype Development Challenges

Development of this prototype will come with many challenges. It is important for the

game to remain cohesive as it is being developed. It is also important for PolyMorpher to teach

its lessons effectively without losing the interest of its players.

4.3.2 Play Testing

Games should be difficult, but not too difficult so as not to isolate an audience. Puzzles

within PolyMorpher should be difficult and rewarding. If they fail to be either of those the player

may not learn anything from the experience.

4.3.3 Effective content

PolyMorpher aims to teach OOP concepts. One of the main development challenges will

be to decide if PolyMorpher is teaching enough to its audience, or even if its audience is invested

enough in the game to learn those concepts. Steps to mitigate this risk will be discussed later.

4.4 Identification of Risks

This section will discuss the risks that have been identified regarding the development of PolyMorpher. Potential risk mitigations will be presented as well. Figure 5 shows the Risk Matrix for PolyMorpher.
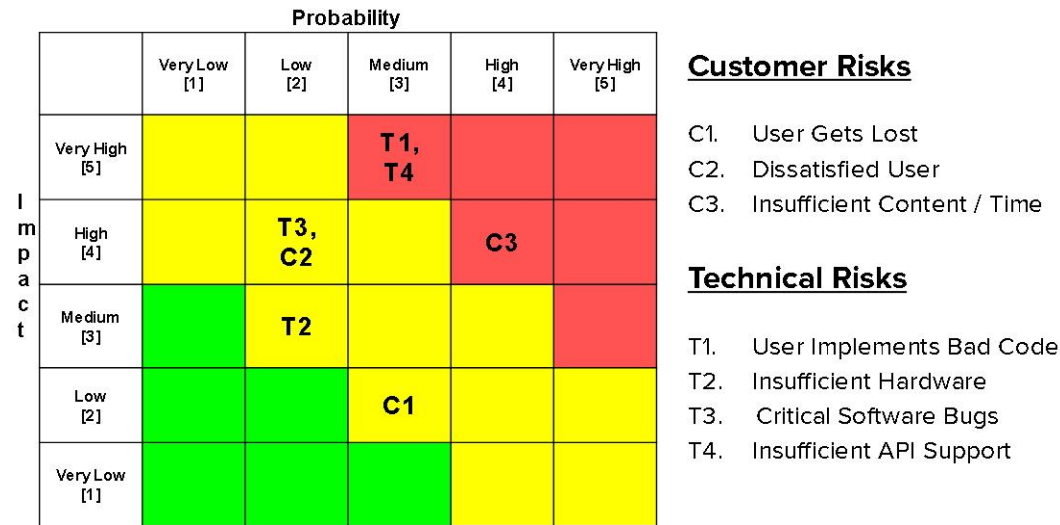
Figure 5 Risk Matrix

4.4.1 Technical Risks and Mitigations

The first technical risk is the user's ability to implement bad code. This code could be their own error or a malicious third party. Bad code has the capabilities of crashing a player's game or damaging their system. A mitigation has not been decided on, but potential mitigations include sandboxing the game, scanning player code for known malicious code, and offering official solutions to code puzzles. Another technical risk is that players may have insufficient hardware to play the game. To mitigate this, PolyMorpher will be a 2D game to minimize the draw on computer resources, and the game will be optimized for Intel i3 4th Gen Processors. As with any software, there are bound to be bugs in the implementation of the game. This will be mitigated by continuously testing the game throughout development. The final technical risk is one that affects the ability of the game to teach. If the API does not have sufficient support for

the player to reference they may not be able to progress in the game or learn any OOP concepts. The API will have all the necessary tools to help the user understand code syntax and OOP concepts to mitigate this risk.

4.4.2 Consumer Risks and Mitigations

There are three consumer risks that have been identified. The first is that the user gets stuck in gameplay and cannot progress due to the lack of helpful resources. The mitigation for this is to supply the player with enough resources to get them through the game's puzzles while also challenging them. The second consumer risk is that the user dislikes the UI. This seems small, but can be game breaking. If the UI is not helpful to the player it is only a distraction. To mitigate this the UI will serve to enhance an approachable interface. Menu options will be clear and concise. The last consumer risk is a failure of PolyMorpher. If PolyMorpher is not effective, its players will not be able to use it as a resource to pass introductory courses in CS. To mitigate this the game will be continually playtested to optimize the pace and content of the game.

5 Development Pipeline

This section highlights key aspects of the development process Team Silver will be using during the development. This will include tools used by Team Silver to aid in development, software used to develop PolyMorpher, and the software development methodology that will be used by Team Silver.

5.1 Unity

Team Silver will be using the Unity SDK for the development of PolyMorpher. Unity is a cross-platform game engine developed by Unity Technologies. Unity supports 2D and 3D game development. It is powerful enough that it has gained popularity in uses outside of game development like simulations.

5.1.1 C#

C# is the default scripting language supported by Unity. It is an object-oriented language

and is the most flexible and powerful language that Unity supports. It has a large suite of built-in

functions and methods. The large community that surrounds Unity development ensures that

support is always available.

5.1.2 MonoDevelop

MonoDevelop is the default IDE built into any installation of Unity. Use of this IDE is

usually personal preference, however, the portable compiler that will be used by the game is built

from the Mono C# compiler. Attempting to use the portable compiler with Microsoft's Visual

Studio will actually prevent the game from building properly.

5.2 Sourcetree

Sourcetree is a free Git client created by Atlassian. Sourcetree will be used to interface

with Git without the command line. Sourcetree supports Git LFS (Large File Storage) out-of-the-

box. Git LFS will be used to manage the tracking of large files often included in a video game

including sound files and image files.

5.3 Version Control

Git will be the version control system used in development. It is a familiar, simple, and

powerful software to Team Silver. The ODU CS Department's Community GitLab will host

Team Silver's development repositories.

5.4 Agile Development

Development will follow the Agile development methodology. Agile development can be

described in Figure 6. Small teams work together to develop assigned features and will demo

their feature to the team. Feedback from the team will be given and any necessary changes will
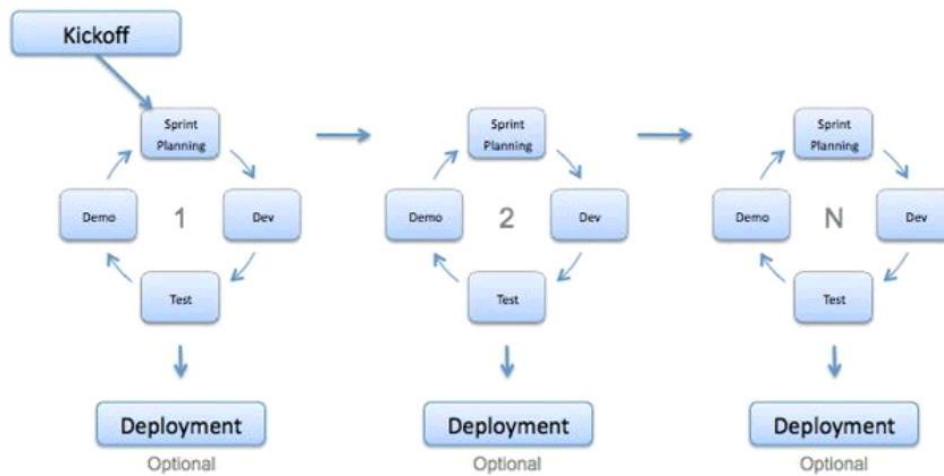
be made to the feature.

Figure 6 Agile Development Model

5.5 Work Management

Teams will be assigned to develop certain features of the prototype. A team consisting of

Matthew Tuckson, Colten Everitt, and Tyler Johnson will focus on the topic Abstraction and a

tutorial of game mechanics. The team of Joel Stokes, Nathaniel DeArce, and Kevin Santos will

focus on the topics of Encapsulation and Polymorphism. The team of Casey Batten, Peter Riley,

and Daniel Dang will focus on the topics of Inheritance and a tutorial of the C# programming

language.

6 Glossary

API: Application Program Interface

C#: Object-Oriented Programming language developed by Microsoft. Primary scripting language for

Unity.

Git: version control system for tracking changes in computer files and coordinating work on those files

among multiple people.

GitLab: web-based git repository manager the includes wiki and issue tracking.

GUI: Graphical User Interface

Non-Technical Game: user-friendly gameplay able to be utilized by non-technical users.

Non-Technical User: a user who lacks formal education or knowledge in computer science, computer

programming, object-oriented programming, or problem-solving skills.

ODU: Abbreviation for Old Dominion University.

Platform: an integrated set of packaged and custom applications tied together with middleware.

Regression Testing: a type of application testing that determines if modifications to the application

have altered the application negatively.

Student Involvement: the amount of physical energy students exert and the amount of psychological

energy they put into their college experience.

TUI: Tangible User Interface

Unity: Game engine developed by Unity Technologies

User-Friendly: easy to comprehend by non-technical users.

Virtual Machine: an emulation of a computer system that provides functionality of a physical

computer.

Web Application: a client-server computer program in which the client (including the user interface

and client-side logic) runs in a web browser.

Wiki: a website on which users collaboratively modify content and structure directly from the web

browser.

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