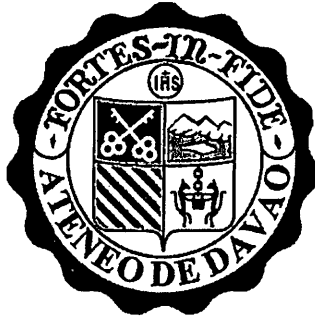


**CRYSTAL DEFENDERS: DEVELOPING A TOWER DEFENSE GAME
USING A PHASED DEVELOPMENT FRAMEWORK**



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USING A PHASED DEVELOPMENT FRAMEWORK**

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JOSEPH A. REAS AND KARL JOHN D. VENUS

ABSTRACT

Multi-touch screen devices have given a new impetus to the strategy games genre. Tower Defense Game (TD Games) are one of its most popular variants. The success of a Tower Defense Game relies mostly on its gameplay. Like other application development process, there is a proper way of developing this kind of game. For this research, A Tower Defense Game entitled, "Crystal Defenders" was developed using a game development framework which is divided into three phases: Conceptualization, Implementation and Testing.

Keywords:

General Terms: Tower Defense Game

Additional Key Words and Phrases: Game Framework, Game Design Process, Phased Development Framework

1. BACKGROUND OF THE STUDY

Strategy games were already popular and recognized even before multi-touch screen devices such as iPad existed. But as the demand of mobile games rose, many strategy games have been developed thus becoming even more popular. One of its successful variants is Tower Defense game. It attracted a lot of users because of its gameplay. The gameplay allows its players to develop a creative strategy. Another element that makes a tower defense games even more engaging is the game content. The story, graphic designs, sound effects and mechanics must be able to draw attention to the user.

2. TECHNOLOGY APPLICATION CONTEXT

The study seeks to address the problems on game development process. A Development Framework is divided into three phases: Conceptualization, Implementation and Testing. The study discusses the importance of these different phases, their roles in the development process and the use of appropriate game development tools.

The proponents have decided to develop the game in Construct2 which is a HTML5 based game engine that uses CocoonJS wrapper to be able to export the game in iOS.

3. OBJECTIVES OF THE STUDY

The general objective of this study is to develop a Tower Defense Game using a phased development framework.

The specific objectives:

- To be able to demonstrate the game development process.
- To be able to develop an engaging Tower Defense game phased-development framework.
- To be able to create an improved Tower Defense game based on the original Tower Defense game the proponents developed.
- To be able to evaluate the game by conducting an Alpha Test and Usability Test.

5 elements of Tower Defense Games which are the terrain or the map, the towers, creeps, the reward systems and lastly the type of players.

6.3 Construct 2 vs Game Maker vs Game Salad vs Stencyl

[3] Lastly, an Article by John Bura wherein he made a list of pros and cons between these 2d game engines:

Stencyl	An easy to use non-programming game engine where in it allows user to create flash games quickly. The only problem is that users will be having hard time using stencyl as a commercial platform because only few supports Flash nowadays.
Game Salad	A streamlined game engine which makes game development easy. It has a ton of features that can be useful for game development. The only problem is that its biggest issue is the lack of updates.
Game Maker	It allows creating really good game without coding. It also has an interface to do programming. It's beneficial especially to professional game developers. The only problem is that some features might not work exactly as expected.
Construct2	It allows user to create the games that they want. It also develops HTML5 games and recently upgraded to WebGL. Once the developed project is done, users can get 100% of export control. Its updates are on regular basis. The only problems are sometimes there are bugs and some features are not working as expected to any softwares.

7. PROJECT METHODOLOGY

Research Design

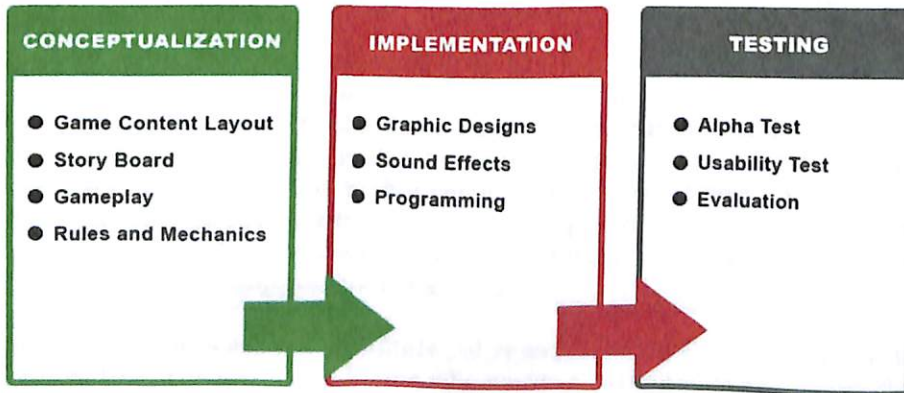


Fig. 1. Phased Development Framework

Like any Application Development there are certain processes to consider. In this study the proponents used a Framework that is divided into three phases: Conceptualization, Implementation, and Testing.

7.1 Conceptualization Phase

The proponents first considered the formulation of Game Content and Layout as this would serve as the background of the game that will be developed. Deciding on what type of Tower Defense game layout to implement: Isometric, Top-Down or Side-Scrolling. The Isometric Layout is a type of game layout wherein the viewpoint is slightly rotated to reveal other environment of the game. It displays three-dimensional scene by combing two-dimensional graphics that displays the environment with a fixed camera orientation. The Top-Down Layout also known as Bird's Eye-view layout and Overhead layout. It is a type of game layout wherein it refers to a camera angle that shows the environment from above. The Side-Scrolling Layout is a type of game layout that refers to a camera angle is viewed from side-view. It allows you to scroll anywhere in the environment. The proponents picked the Top Layout because it is easier to create the map and the sprites. Next is pitching different ideas for the story like the game environment, game world, possible scenarios for the storyboard and storyline, characters along with its role, personality and function that a player can relate to.

After all necessary elements of the game were identified, storyboarding immediately followed. The storyboarding process starts with creating a model sketch for the characters, objects and game world. Then sketching the storyboard to produce a story line.



Fig. 2. Model sketch (left) and Storyboarding process (right) of the game Mage Defenders.

The Gameplay must be able to attract the user, at the same time it must be connected and related with the theme of the game. It must have certain uniqueness to make the game stand out from other tower defense game. In the game crystal defenders its gameplay is that it allows players to build any type of towers around the map but with a certain twist. Each tower only has certain amount of energy points and once this energy points turns into 0 the player must reload it using a pots that was provided to them by the game. Also as the game goes on, the number of generated alien's increases per waves to make it even more challenging and engaging.

The rules and mechanics must be simple yet reasonable. In the game is that the players must defend their territory from the swarm of Aliens who wants to take over the protected territory. Player are allowed to build any tower around the map but this tower has only limited energy points and must reload the tower once the energy points turns into zero.

7.2 Conceptualization Phase

Once the model sketch and the storyboard sketch is finalized, then using Adobe Photoshop and Adobe Illustrator to convert those sketches into graphic design. Applying appropriate color variations to stand out each of the objects and characters role and personality.

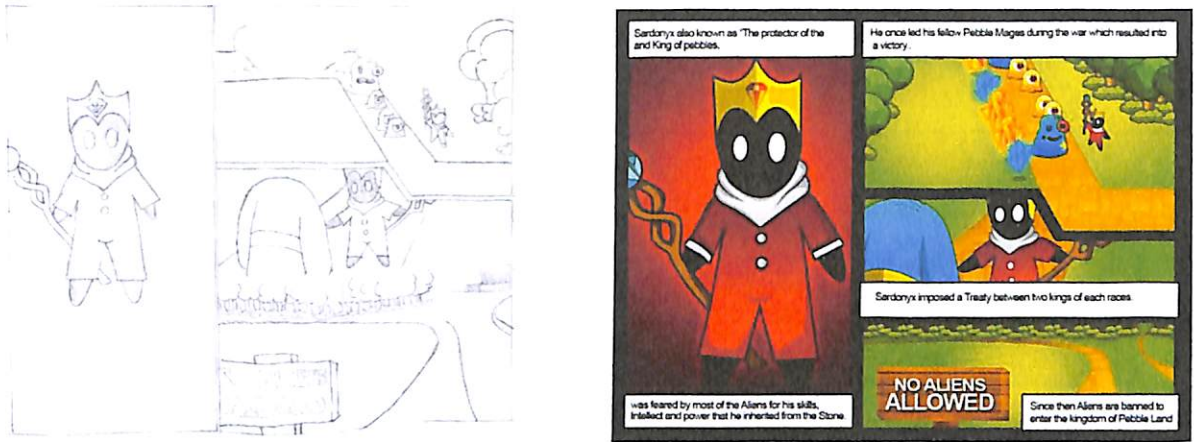


Fig. 3. Converting sketch into graphic image. A snippet from the game Mage Defenders.

The Sound effects used are royalty-free and part of the package whenever Construct2 is legally bought. The Sound effects are in wav formats and the only file format for music that Construct2 accepts.

Finally, using Construct2 to integrate the first phase, the graphic Designs and Sound effects. This where development process begin. The development of the game starts on creating a new event. Events are created in by selecting necessary conditions from the list provided by Construct2. Then it allows user to import the images and sound effects. Each sprite can be assigned as a variable or with a behavior. Construct2 helps user learn how to think in a logical way using basic understanding of programming concepts. By creating an event it allows you to choose the right object, select a condition and add it to the event.



Fig. 4. Snippet of the towers from Mage Defenders (left) and Crystal Defenders (right) and function from the event list.

From the figure shown above it shows the process on how to assign behavior on the towers and assigning variables in order to function as intended. The turret is the behavior of the tower and whenever an alien is at the range of the turret it will initiate a target.



Fig. 5. A snippet game layout of Crystal defenders showing the path finding.

One unique element of Tower defense game that other game genres does not have is the Path finding. It is an algorithm that certain Aliens (creeps) follows so that they may only travel to specific path as intended. Construct2 has already a built in function for that. Which would lessen usual development time of just developing a hardcoded Path finding Algorithm.

7.3 Testing Phase

After the Development of the game, series of tests will be conducted. It is necessary in order measure and evaluate on whether or not that created game is engaging and more enhanced than the previous game developed. Usability test will be conducted to check if the user interface is easy to use and understand. Alpha test will also be conducted for an actual operational testing for potential users. Along with the series of tests are survey forms. This will check on feedbacks from the users during their experience in the game.

Once all tests are done conducted, the data that has been gathered from the surveys will serve as a basis for the evaluation of the game.

8. TECHNOLOGY BACKGROUND

Game Development Framework is a tool for a game development process. It would include artistic development and technical development.

HTML5 is the markup language used by web developers to build web contents. It allows web browsers to become a development platform. The primary goal of HTML5 is to ensure its abilities among web browsers so that web contents behave the same way no matter what web browser is used to access them.

Construct2 is a powerful and innovative HTML5 game creator designed specifically for 2D games. It allows developers to export their projects to a variety of platforms with the use of cross-platform a feature of HTML5. Almost everyone can use Construct2 due to its unique and simple approach on developing a game that a user can easily understand. It allows developing a game without having to learn difficult languages. A faster alternative to coding. Construct2 has a powerful event system, Flexible behaviors, Stunning Visual Effects, Multiplatform export and easy extensibility.

In Pascal Rettig’s book entitled “Professional HTML5 mobile game development”. He shows how to package the HTML5 game in different ways to get it deployed the various app store. CocoonJS is a native wrapper created using Ludei. Ludei is a mobile game development platform that enables user to create, deploy, accelerate and monetize their iOS and android apps from HTML5 Games.

Adobe Photoshop and Adobe Illustrator are perhaps the most recognized and famous graphic creator and editor software. Adobe Illustrator allows creation of vector file and is a famous to for creation of Illustrations. Adobe Photoshop allows user to manipulate image and vector file. With a complete tools and settings that is necessary for graphic editing.

9. RESULTS AND DISCUSSION

During the course of the game development project the proponents had develop two Tower Defense Games. Both games developed have features that are distinct and unique with each other. The first game developed was entitled Mage Defenders.

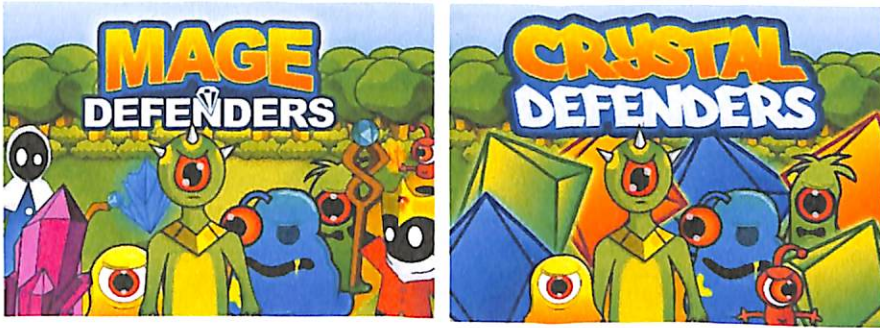


Fig. 6. Title screen of Mage Defenders (Left) and Crystal Defenders (Right).

Mage Defenders:

As stated the proponents have developed two Tower Defense Games. The game was entitled Mage Defenders. The story of Mage Defenders was about a mage named *Onyx* whose fate is to defend its kingdom *Pebble Land* from Alien Invaders. These Aliens are on a quest to find the eternal birthstone so that they may become the strongest species. The objective of the game is to help *Onyx* prevent the alien invasion. This is where user engagement and interaction comes in.



Fig. 7. Snippet of the game and its tutorial stage.

Originally the proposed gameplay of Mage Defenders was that towers can only be built in a specific area. This should function as the unique feature of the game since most towers of other Tower Defense games can be built almost anywhere in the map. There are 5 waves per map and the starting wave is composed of 5 aliens. You can build two types of tower: Fire for damage and Ice for slow.

It also has a skill bar where in skills will be unlocked at a selected levels. The map is composed 186 x 186 tiles.

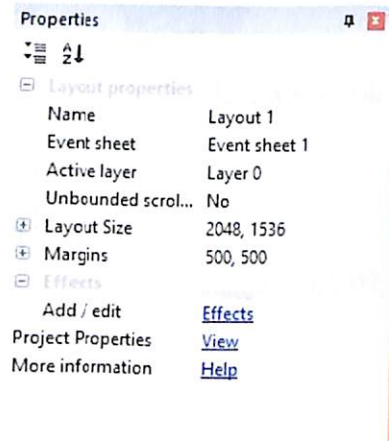


Fig. 8. Snippet of the Layout Size and other specific properties.

After the development of the game, series tests was immediately conducted along with survey forms.

Story

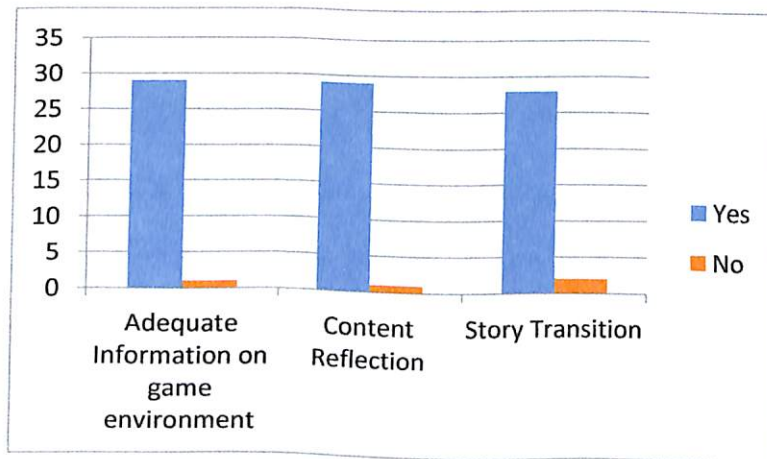


Fig. 9. Survey results - Story.

Based from the survey results gathered using a Bernoulli Probability Distribution the average test respondents that agreed about adequate information of on game environment was properly introduced were 96%. 96% of them also agreed that necessary content such as the title reflects the game and 93% of them agreed that they like the story transition.

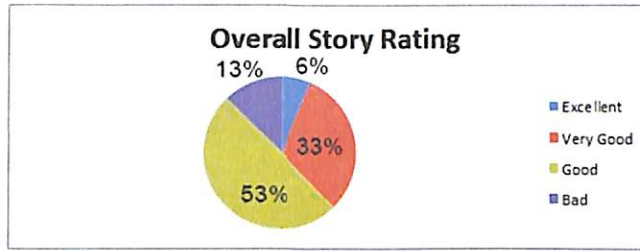


Fig. 10. Survey results – Overall Rating of the Story

The chart shows the results of the overall rating the story. 53% (16) of them rated the story as good. They said the story was fine but needs improvement.

Accuracy

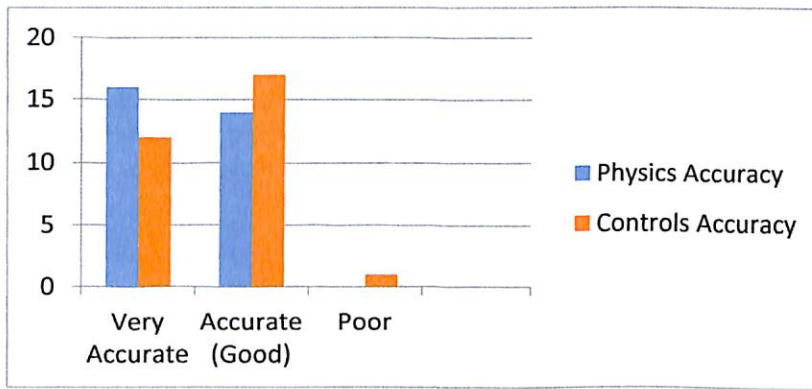


Fig. 11. Survey results – Accuracy of physics and Controls

Graphics

rate_graphics	
Mean	8.366667
Standard Error	0.227345
Median	8
Mode	8
Standard Deviation	1.245221

Fig. 12. Survey results – Accuracy of physics and Controls

For the overall graphics of the game, the game is measured on a scale of 1 to 10 where 10 being the highest. Using Descriptive Statistics the average rating of the graphics is 83% based on the survey results gathered.

Sound Effects

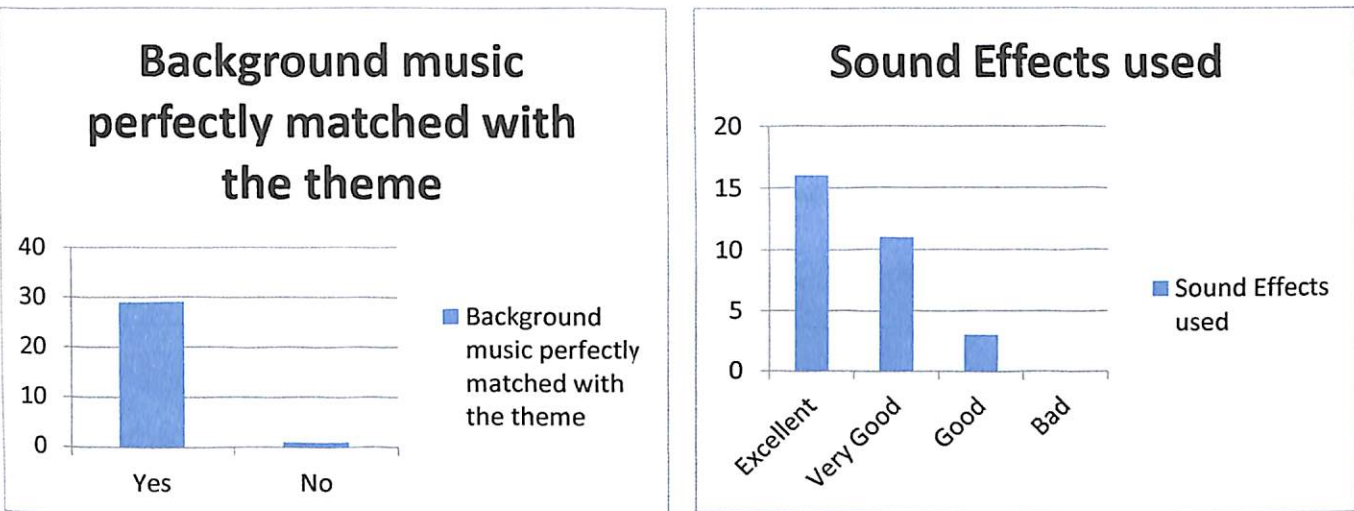


Fig. 13. Survey results – Background music and Sound Effects used

Based from the survey results gathered using a Bernoulli Probability Distribution the average test respondents agreed that the background music perfectly matched the theme is 96%. For the sound effects 53% (16) of them were impressed with the sound effects used.

game_rate		v
1 Mean	8.333333	N
0 Standard Error	0.226586	S
1 Median	8.5	N
1 Mode	9	N
0 Standard Deviation	1.24106	S

Fig. 14. Survey results – game rating

For the overall rating of the game, it is measured on a scale of 1 to 10 where 10 being the highest. Using Descriptive Statistics the average rating of the game Mage Defenders is 83% based on the survey results gathered.

Though the survey result was good there was still some weakness in the game that led us into decision of developing another tower defense game. First, the total memory of the final output exceeds the limit required by Apple Store when uploading an Application. The limit is about 30mb but the final output of Mage Defenders is around 40mb. This is due to the resolution used and the file size in each graphic design is at least 2mb. Second, because the memory of the final out is extensively large there are some tendencies in the game that the FPS (Frames per Seconds) count lowers thus making the game slower. Third, there are some bugs that are still yet to be identified. Fourth is that The Mage was not given emphasis in the game. Lastly, based on the Adviser’s point of view the gameplay does not promote any creative strategy due to the fact that only in a specific area can the users build a tower.

Crystal Defenders:

The proponents decided to create an improved Tower Defense Game based on the feedbacks gathered. The proponents started from scratch up until the final output. The story of Crystal Defenders was about a species of living crystals that needs to defend their planet from Alien Invasion. These aliens are seeking for an energy source from planet to planet and found out that these crystals possess an energy source.



Fig. 15. Snippet of the game and its tutorial stage.

The game contains a lot of improvement based on the feedbacks that the previous game received. First is the gameplay. It now allows player to build a tower anywhere in the map. There are now three types of towers available: Fire for damage, Ice for slow and Poison for a special type of tower. All these towers are upgradable and once upgraded the range of the tower increases. Also, these towers has a corresponding energy points and when this energy points turns 0 the player are required to either sell it, or regenerate it using the pots that is provided by the game. This time it does not only allow player to develop creative strategy but also allows players to observe resource management. As the wave increases the number of Aliens that be generated also increases.

Layout properties	
Name	Level1
Event sheet	Level1
Active layer	BG
Unbounded scrol..	No
Layout Size	1024, 768
Margins	500, 500
Effects	
Add / edit	Effects
Project Properties	View
More information	Help

Fig.16. Snippet of the Layout Size and other specific properties.

The proponents also have been able to solve the slowing of performance of the game every time the FPS count decreases by changing the map layout into 1024x768. Changing the dimension of each tile into 68x68. The proponents also decreased the file size of each graphic design so that the total memory of the final output won't exceed the required limit. Currently the final output of Crystal Defenders is just about 8mb.

10. CONCLUSION

The Phased Development Framework can be a perfect tool for a game development courses as the proponents have been able to successfully develop a game based from this framework. Each phases of the framework were discussed accordingly. Each of the game components that are required in the game development process were identified.

Though the survey result of Mage Defenders was good, there is still a lot of weakness in the game that made the proponents decide to create a new Tower Defense Game. First, is the game exceeds the 30mb limit required by Apple and also due to this there are some tendencies in the game that the FPS lowers thus affects the performance of the game. Second, there are still bugs that are yet to be identified. Third, based on the adviser's opinion the game itself does not promote any creative strategy which is very crucial especially in developing a strategy game.

The game Crystal Defenders is more improved and engaging compared to the previous game developed Mage Defenders. The gameplay allows users to develop a creative strategy and resource management.

Lastly, based on the survey results gathered the respondents were engaged on playing the original game Mage Defenders and the new game developed Crystal Defenders.

11. RECOMMENDATION AND FUTURE WORK

1. Future work on this research project is improvement by adding more twist to its gameplay in order to make the game more engaging.
2. Add more characters, towers and story line to make the game environment realistic and fun.
3. The Phased development framework could be a tool for aspiring game developers and for a game development course as the demand of game development is increasing.
4. Uploading the game to the online stores to let other players experience the game and in order to create a community that will help for the game's future works.

12. DEFINITION OF TERMS

1. Game Development Framework - a set of libraries that is use as the foundation in any simple 2D tile-based game.
2. Tower Defense Game - is a subgenre of real-time strategy video games. The goal of tower defense games is to try to stop enemies from crossing a map by building traps to slow them down and towers which shoot at them as they pass.
3. Construct 2 - is an HTML5 game engine that allows developers to make games with no programming.
4. HTML5 - is a markup language used for structuring and presenting content for the World Wide Web.
5. Game Layouts - a variety of computer graphic techniques that is used to display the game content.
6. Sprites - is a two-dimensional image or animation that is integrated into the game.