IBM Case Study

Proposed Software Solution Report

Software Design – CMP5354

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Introduction

The project proposed by IBM is one to "create a web game to teach children the basics of maths" **[1]** with the game functioning as a card game at the base level. I have conducted research into popular card games that have been out for a long period of time (but also new video games of the same kind) and mainly focused on those that have a large positive feedback from their communities to grab attributes and features that could be implemented into this solution. Some of these games are Hearthstone (a digital card battling game), Balatro (poker themed deck building game) or Slay the Spire (a rogue-like deck builder) which all share some common features building up a deck with different upgrades / new cards or defeating waves of enemies to get stronger.

Additionally, below are the technologies that will be required to be used in the development of this solution:

- Google Chrome
    - A widely used, free and accessible browser will be utilised as a gateway to play the game on the internet where the game will be embedded into a webpage for the user to play on, rather than creating a download for the user, this way will provide a much better experience to the user and make it easier to access the game as the user only has to load the page and press play rather than having to download the whole project to be able to play it on their device (which may not necessarily be able to run it
- XAMPP
    - XAMPP is a "popular cross-platform web server" **[2]** tool used for web development which allows a developer to host their web projects on a local server on their device and network to test any features / functionality that would require a server – in this case this tool will be crucial as the webpage will act as the client where the user can interact and play with the game, and XAMPP will help simulate the server that will be hosting the game and website
- VSCode
    - VSCode is a widely used code editor used by developers as it has a plethora of useful features like built in debuggers for different languages, useful code editing tools like syntax highlighting, customisable visuals and constantly updated extension to help with development of different projects.
- IBM Watson Text to Speech
    - IBM Watson text to speech is a tool used to convert text into audio while also being able to convert the speech into a different language, allowing for a much broader audience to be accounted for

Functional Requirements

Functional Requirements are the necessary features outlined in the project, in this case, it is the requirements that IBM has presented in creating a video game that teaches maths to school children. In the table below (*Figure 1*) are some of the functional requirements that I have identified for this project that will account for all of the details provided in the project aim (provided by IBM) and tackle the target problem appropriately.

Functional Requirement ID	Functional Requirement Description
FR1	As identified in the project aim, "the player must battle through hostile NPC alien ship and challenges" **[1]** indicating that there must be a progression system implemented into the game, more specifically a stage / level progression, where the player will face off against enemies (potentially waves of enemies) in a single stage, and then proceed onto the next stage if they have successfully defeated all enemies – creating a game in the genre of a "dungeon crawler". The player will keep battling until they are defeated or until they defeat the final boss enemy. Additionally, the player will have a running health amount throughout the duration of the game, this way the user can take damage from the enemies, just like the enemies will also have a health bar that way the player can also deal damage to them
FR2	As identified in the project aim, "the game will be at its core a card game" **[1]** meaning that for every encounter that the player has with an enemy, the main way the user will be able to complete these mathematical calculations to battle the enemy would be done via cards. An example of how this could work is by generating mathematical calculations that contain at least 2 numbers and a singular operation and then removing either a numbers or the operator from the calculation and allowing the user to place a card from their deck into that calculation to either deal damage to the enemy, or block incoming damage from the enemy, depending on the card played. Additionally, because this game will work on an encounter basis, there will need to be a "board" displayed in every encounter to simulate the effect of playing a card game (a good example of how this could look is by looking at the board used in the game Hearthstone, where the board is split into the player's half, and the enemy half).
FR3	As identified in the project aim, "use text to speech to interact with the player" **[1]** this feature will be utilised in every enemy encounter where the enemy will be introduced to the player (in a similar way enemies are introduced in every encounter in the game "Middle-Earth: Shadow of

	War"), and every turn, the calculation will be read out to the player and the current cards in their hand. Another utilisation of this feature could potentially be when a player hovers over a card, the operation on that card is then read out to the user.
FR4	As identified in the project aim, "discover new technologies and powerups for their ship" **[1]** this feature will be implemented at the end of every stage / wave of enemies that the player defeats, this way the player can receive an upgrade to their ship to make it stronger or pick new cards to add to their deck. These upgrades could also be implemented in a way to make a modular ship with upgrades that can be "drag and dropped" that can also be received after major or more difficult enemy encounters, these upgrades can give permanent upgrades to the players ship throughout the game.
FR5	As identified in the project aim, "battle through hostile NPC alien ship" **[1]** the game must provide the user an enemy NPC (non-playable character) that can interact the same way that the player can – complete mathematical calculations to attack the player / defend attacks from the player, contain varying upgrades depending on the stage of the game

Figure 1: Table displaying Functional Requirements of the proposed solution

Non-Functional Requirements

Non-Functional Requirements are the features that aren't specifically outlined in the project details, but much rather are features that can be implemented into the project to help aid the experience but also guide the design and feel of the project. In the table below (*Figure 2*) are some of the measurable requirements that should be met during this project.

Non-Functional Requirement ID	Non-Functional Requirement Description
NFR1	To increase replay-ability and increase player retention, the game will have varying enemy styles of ships and NPC's to keep each play of the game feeling "fresh" and "new" by seeing a different style of enemy from a select few styles
NFR2	To engage the users in a competitive way, a global leaderboard can be added to the game, where users can compete for the fastest completion time, most stages cleared, etc. This way users are more enticed to do better to compete against their friends and try to reach the 1st position on the leaderboard
NFR3	As this game will be playable through a webpage, a fast load time and good performance is crucial to how the game will be played (although its not a functional requirement, it is immensely important) as good optimisation can provide a better and smoother performance to the gameplay and won't frustrate the user with sudden crashes or framerate drops An example of how load time can be minimised is by minimising asset load time as large assets can slow down how fast a game can start up [3]

Figure 2: Table displaying Non-Functional Requirements of the proposed solution

Ethical and Legal Issues

Ethical issues are potential problems that affect the conduct towards humans, life and culture from a moral point of view, whereas legal issues are more directed towards legislations or laws that have been put into place to protect people. In the table below (*Figure 3*) are some of the ethical and legal issues outlined that could potentially be faced during the development of this project.

Ethical / Legal Issue ID	Ethical / Legal Issue Description
E1	Seen as the IBM text to speech tool is an AI tool, there is a potential for the data that was used for training the tool was bias or there were some anomalies present in the training stages of the AI, which could provide an unfair experience to the users Another issue with an AI text to speech tool is it could potentially fall under cultural appropriation with its usage of different languages / accents as the mimicking of these accents or dialects which can affect certain communities This ethical issue links to the Functional Requirement of ID **FR3**
E2	Seen as the intended audience for the game is primarily going to be school children, the game will need to be made accessible for those students, as some may have certain disabilities like epilepsy which in some cases can potentially endanger a student's life – as the game theme is sci-fi it is possible to have flashing / bright lights that could potentially trigger this Another accessibility issue that could be present is choosing the correct font type / font size and colours to allow for all text to be clearly readable to the user, as some users may need larger text to comprehend what is happening on screen and if this isn't satisfied then the user won't be able to use the product This ethical issue links to the Functional Requirement of ID **FR2**
E3	As mentioned before, the theme for this game is a "sci-fi spaceship" game with "hostile NPC aliens" where the goal of the game is to destroy the enemy ships – which can be filled with gore / sights that young students shouldn't be exposed to as it can potentially ruin how a student thinks and potentially turn them aggressive. This ethical issue links to the Non-Functional Requirement of **NFR1**
L1	One way that the game will potentially store data is by creating login credentials for the user, that way they can retrieve their progress for the

	game, however, this data will need to be stored in a secure way as this data is unique per user and a student shouldn't be able to gain access to another one's account

Another way the game will store data is by the leaderboard function that can be implemented, as such data from that user will be stored inside of the database, as some sort of alias / username will be needed from the user before they can be posted onto the leaderboard, as such the data that will be made public will need to be non-confidential data and data that will not harm the user in any way

This legal issue links to the Non-Functional Requirement of ID **NFR2** |
| **E4** | Another ethical issue that could be present is not creating clear guidelines on how this game works, the content inside of it and any potential warnings that the user will need to be aware – this also takes into account the secondary target users that are outlined (the educators at schools and the parents of the students) because if the students are exposed to something potentially dangerous or unsettling then the parents or tutors will turn away from using this product for further education, which can result in a fluctuation in reputation and trust for IBM |

Figure 3: Table displaying ethical and legal issues of the proposed solution

Risk Assessment

A risk assessment is a crucial step in the design stage of the project as it outlines the potential problems that can come up during the development stages. Defining these problems early allows for a plan to be made to mitigate these issues and provide a much smoother transition from design, into development, into deployment. In the table below (*Figure 4*) are some of the major risks that could affect the development of this project.

Risk ID	Severity	Risk Description
RA1	Medium	Compatibility Issues One of the major risks that all games face are compatibility issues, where a game can't be played on a specific device (this could be due to the specifications of that device, or just a lack of support for certain devices), this will limit the amount of users that can play the game and actually learn from it. Not all students can have access to a desktop computer, some could potentially have access to laptops (although it is a device similar to a desktop computer it is still less powerful) or potentially neither of those and only a mobile phone. Another compatibility issue that is present could be the usage of different browsers, as in the technology specified by IBM only Google Chrome is mentioned, although Chrome is one of the major browsers, there are still different browsers used by users like Safari (iPhone browser), Microsoft Edge or Brave, which all work in a different way and support different web features that will need to be taken into account during development, as some browsers may lack the features of Chrome and potentially be unable to display the same content. One of the ways to mitigate this issue would be by developing the website in such a way that it can be accessed and functioning as intended on all major devices (Desktop, Laptop, Tablet, Phone) that way students can navigate around the page no matter what device they are on Another way to mitigate this issue would be to optimise the game for different sort of inputs, if the user would access this game on a phone or tablet then the game would require touch reactivity to function (this would also allow for touch screen devices like laptops to be utilised), or potentially use a controller input if a student is unable to utilise a keyboard and mouse (which links to the Ethical Issue ID of **E2**)

RA2	Medium	Performance Issues
		Performance is a crucial challenge that all games face, as how a game performs can be the "make or break" for the user experience – as a game that runs poorly will not be fun no matter how entertaining the actual content in game is.
		One possible way of improving the performance of the game would be using optimisation tools on the assets used in the game (like the images, videos or audio) to get the same effect as you would get without the optimisation but taking up less storage – resulting in faster load times (although it may be minimal)
		Another possible way of minimising the performance issues is developing optimised algorithms (minimising algorithm complexity where possible) as an algorithm with the complexity of $O(n)$ is more preferable than an algorithm with the complexity $O(n^2)$ as the less complexity it has, the less processing power it will utilise
RA3	Low	Player Retention
		One of the main challenges that video games face is ensuring the retention of players to keep playing the same game. Usually, users tend to turn away from games that don't receive frequent updates with new content, don't look visually pleasing or just aren't fun or educative.
		As such, the developers will need to be aware of the trend changes in the genre of sci-fi and how the younger audience react to these changes. As such, new content will need to be regularly implemented to the game – both visually and mechanically – to keep the game feeling fresh and engaging to the user as it would show that the developers care for their game and genuinely want the users to learn from playing this game.
		This risk links to the Non-Functional Requirement of ID **NFR1**
RA4	High	Data Security
		Theres countless amounts of data that is being collected by game developers from players, and this data usually falls under these 3 major categories - "behavioural data, social data and biometric data" **[4]**. Because data is being collected from users and is being stored, this has to be done in a secure and legal manor and has to be done in a way that doesn't breach any data collection laws (such as GDPR).

		One possible way of minimising this risk is by being open with the users as to what data is being collected by the developers and how it is used and for what purpose the specified data is collected. This is usually done with a Terms & Services clause which is either accepted or declined by the user before starting the game, and in said clause it would state how the data collected is used, why it is used and how it is stored. This way clarity is shown to all the users (both the students and their tutors and parents)
		Another way to protect data in the event of data breaches (as this is a client server game) would be encrypting or hashing data that way in the event of being hacked, the data that the hacker takes is unreadable without being decrypted.
		This risk links to the Legal Issue of ID **L1**
RA5	High	Usage of AI tools
		AI and AI tools are still upcoming technology and are very new to the business market, and more so into the games and education industry. Seen as it is a new technology there is constant change in it and more possible vulnerabilities are being discovered daily. However, one of the major ways an AI model can be damaged is through the data it is trained on, and with non-factual (or at least not supervised data) will cause a model to be trained incorrectly and resulting in an unwanted output and functionality.
		One way to mitigate this risk would be to constantly train the AI tool with new and factual data (or use assistance from real humans that consent to being used as training data) to help develop a more human-like experience rather than making a robotic narrator. Additionally focusing on security and checking the validity of the training data for the AI model as biased data could be given as training, misinformation could be fed to the model or just false data (like impersonating a language) to throw off the model to make it less accurate, which could potentially damage the learning journey of the students.
		This risk links to the Ethical Issue of ID **E1**

Figure 4: Table displaying potential risks of the proposed solution

Use Case Diagram

Below (in *Figure* 5) is the use case diagram for this proposed solution, where the **Actor** (represented by the stick figure) is the student that will be playing the game. In the diagram, the actor only has 4 actions which are used to interact with the system: Encountering an enemy, playing a turn, selecting an upgrade and viewing current statistics and upgrades. Each **Use Case** is represented by a differently colour coded circle:

- Purple circles reference the Functional Requirement ID **FR5**
- Green circles reference the Functional Requirement ID **FR2**
- Blue circles reference the Functional Requirement ID **FR3**
- Red circles reference the Functional Requirement ID **FR1**
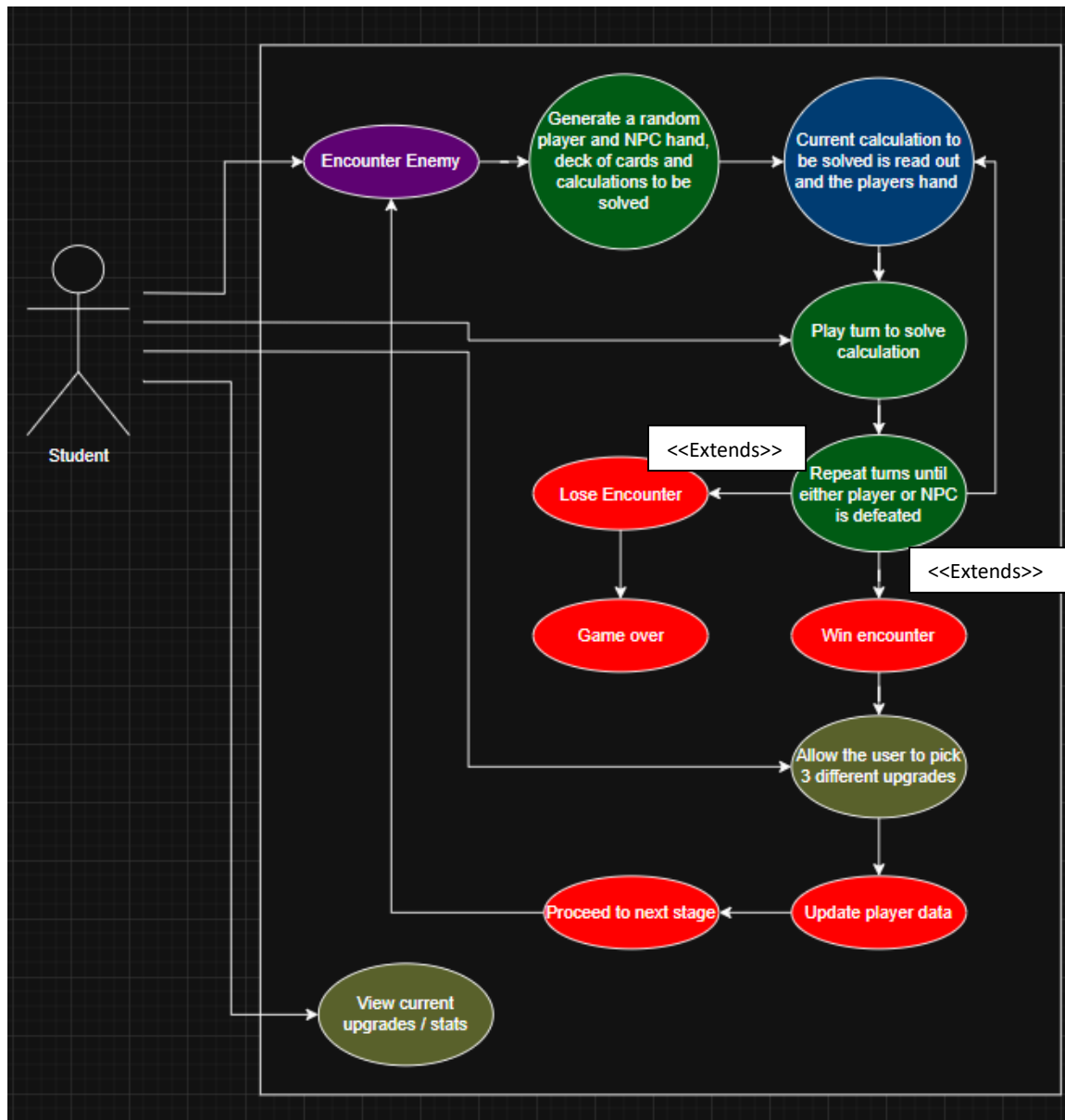- Yellow circles reference the Functional Requirement ID **FR4**

Each use case circle has a small description of the function that it will be completing inside of the system, for example "proceed to next stage" would allow the user to move onto the next stage in the game to battle more enemies, or "view current upgrades / stats" would allow for the user to be able to get a rundown of all their player information such as health, current deck, any currencies they hold or any upgrades that they have.

The actual **Uses** are displayed via the arrows connecting each of the use cases together to show how each of the different functional requirements interact with each other and how the basics of the game will work. Additionally, there are 2 lines that **"extend"** a use case, which root from "Repeat turns until either player or NPC is defeated", this is because this case can have 2 different outcomes (outcome A – the player is defeated, or outcome B – the NPC is defeated) if the outcome is outcome A, then the system will choose the path that leads to the "lose encounter" case, but if it is outcome B, then the system will choose the path that leads to the "win encounter" case.

The **System Boundary** is displayed as a box surrounding all of the use cases, but excluding the actor (the player) from the system.

Use Case Specification

A use case specification allows to go into depth as to how a user will interact with the proposed system. It also allows for the steps to be explained in much greater detail (compared to the cases in *Figure 5*) and focus in on a specific step of the system and how the user can interact with the system at that given moment. In the table below (*Figure 6*) is one of the use cases looked at in more detail, with more user considerations in mind.

Use Case	Current user hand and calculation to be solved is read out to the player
Purpose	The player is able to get an understanding of what the required task is t defeat the enemy (by having the calculation that is to be solved) read out to them, and then the cards that they have in their hand to be read out to them for the player to solve the calculation and strategize the most optimal choice for that turn
Prerequisites	The use case "generates a random player and NPC hand, deck of cards and calculations to be solved" must be completed otherwise the text to speech tool will not have anything to read from
Narrative	1. The calculation is generated 2. The calculation is read out to the player (with the respective blanks) 3. The hand of cards is generated 4. The hand of cards is read out to the player – one card at a time 5. If the user hovers over the calculation, it is read out again 6. If the user hovers over a card, the card value is read out again
Outcome	The AI tool reads out to the player the calculation and the values of each card in their hand in a clear and understandable voice
Alternative Narrative	The player pauses the game
Alternative Outcome	The AI tool stops reading text and pauses alongside the game

Figure 6: Table displaying a use case example

References

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