

Optimizing Theme Pack and Node Selection in Limbus Company's Mirror Dungeon Using Binary Tree and Weighted Graph

Ferdinand Valentino Darmawan - 13525149

Program Studi Teknik Informatika

Sekolah Teknik Elektro dan Informatika

Institut Teknologi Bandung, Jalan Ganesha 10 Bandung

E-mail: ferdinandvalentino1@gmail.com , 13525149@std.stei.itb.ac.id

Abstract— Limbus Company's Mirror Dungeon, a roguelite mode that exists within the game where players need to repeatedly choose between theme packs and navigate through a non-backtrack able node maps across each run, decisions that are made through intuition and experience gained from playing the game without a systematic analysis. This paper proposes a system of choosing theme pack and node traversal within a floor's map using discrete mathematics concepts. The theme pack selection is modeled as a binary decision tree, with branch conditions based on pack difficulty. A theme pack difficulty is determined by the possibility of it being completed by a team using the base Identities and E.G.O at Uptie III. The node traversal within a floor's map is modeled as a weighted directed acyclic graph (DAG), with node types being assigned a value depending on the completion goal, either a general approach, a resource-focused approach prioritizing obtaining Cost and E.G.O Gifts, and a strategic approach prioritizing the option to manually target each skills. Together, these models form a reusable general framework for evaluating which theme pack and node within a floor map optimization, intended as the base for a keyword-specific team builds.

Keywords—Decision tree, Weighted-directed acyclic graph, Mirror Dungeon, Limbus Company

I. INTRODUCTION

With the improvement of technology, people have searched for more ways to have fun. One of them is video games, with various genres that have increased over the years, whether on mobile, PC, or various other consoles, one of the genres is the gacha genre. Usually in a free-to-play game, this type of game utilizes in-game currencies that can be bought with real life money to obtain various in-game items. Despite these types of games can have predatory behavior with how low the chances are to obtain certain items; there are some games of this genre that are more forgiving with easier ways to obtain in-game currencies outside of spending real life money.



Fig 1.1 Mirror Dungeon Season 7 Title Screen [4]

One of them is Limbus Company, a story driven, turn-based RPG, gacha game based on various literary works from history. While Limbus Company has in-game currency called Lunacy, there are other ways of obtaining it without using real-life money. The most repeatable and accessible way is through the Mirror Dungeon, a roguelite mode of the game that can provide up to 750 Lunacy per week.

This is why completing Mirror Dungeon as fast as possible is a goal that most players want to achieve. But as the game updates, older units or known as Identities become outdated with newer and stronger Identities from the newer updates. And to quickly complete Mirror Dungeon, a specific list of Identities is needed, whether it be they synergize well with each other or just because they are strong and easy to use Identities that can easily complete Mirror Dungeon. And it's a luxury that not all people have, especially for newer players or players that aren't too active playing the game.

So, the next better way would be carefully picking enemies that are easy to defeat with even the most outdated Identities. This paper aims to use binary trees and weighted graphs to provide the easiest Mirror Dungeon experience to help players with their limited available Identities. By doing so, players can build their understanding of which enemies to choose in a Mirror Dungeon and can complete Mirror Dungeons with their preferred Identities without worrying too much whether they'll be able to complete it or not.

II. THEORETICAL BASES

A. Graph

Graph is usually used to represent discrete objects and their relations between them. A graph consists of a non-empty set of vertices where vertices represent the objects and a set of edges where edges represent the relations between vertices. It is usually represented in mathematics as $G = (V, E)$ where G is the graph, V is the non-empty set of vertices, and E is the set of edges. One of a few ways to classify graphs is through direction orientation, which are separated into undirected and directed graphs. Undirected graph is a graph where the edges don't have a direction orientation. Examples of this type of graph:

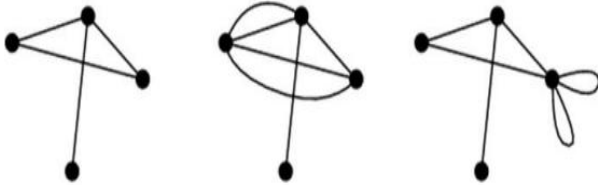


Fig 2.1 Undirected graphs [1]

The other one is a directed graph or also known as digraph, which is a graph where each of the edges have a direction orientation. Examples of this type of graph:

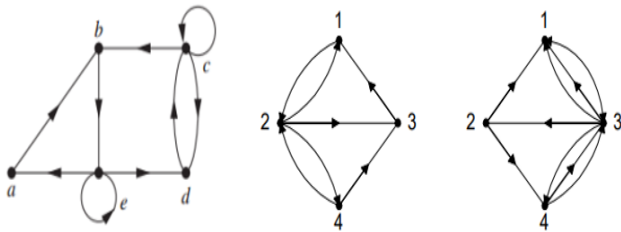


Fig 2.2 Directed graphs [1]

There are several terminologies for graphs, one of them is path. A path is a route that connects two vertices, e.g. V_x to V_y in a graph. Another terminology is a cycle, which is a special type of path where it starts and ends at the same vertex. The reverse of it is acyclic, which is when a graph doesn't have a cycle in it.

There is also a terminology called connected graph. Which is when for each pair of V_x and V_y within the V set, there exists a path from V_x to V_y . And another one is weighted graph, which is a type of graph where each edge is given its own value. Example of this type of graph:

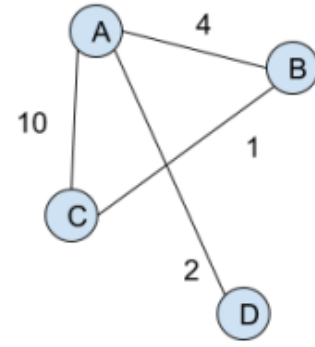


Fig 2.3 Weighted graph [1]

From these terminologies, there exists a specific graph called weighted DAG which stands for a weighted directed acyclic graph.

B. Tree

Tree is a special type of acyclic graph with the constraint that it is a connected undirected graph. Examples of trees:

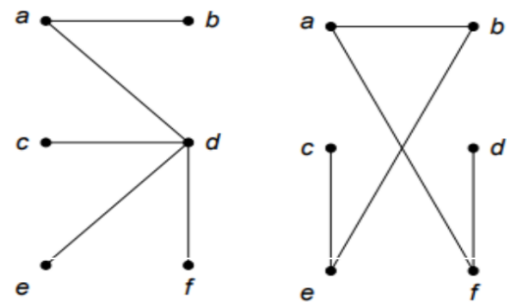


Fig 2.4 Tree [2]

There are several types of trees, one of them is a rooted tree. A rooted tree is a type of tree where a node is picked as the "root" of the tree and the edges are given direction pointing away from the "root", so it becomes a directed graph. Examples of rooted tree:

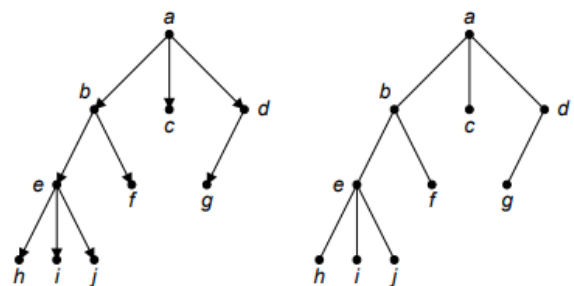


Fig 2.5 Left: Rooted tree. Right: As a convention, the arrow signs on edges can be removed [3]

There are several terminologies for rooted trees, one of them is parent and child nodes. A node is a parent if they precede another node, while a node is a child if they succeed another node. Another is internal nodes, which are nodes that have children and leaves, which are nodes that don't have any

children. There is also a terminology called level which is the total number of nodes needed to reach a certain node from the root node, with the root node being at level 0. And the maximum number of levels is called a depth.

A type of rooted node is a m-ary tree. This is a type of tree where each node can only have a maximum of m-m-number of children. Another type is an ordered tree where the orders of the children are important. A combination of these trees is a binary tree, which is a m-ary tree where m is 2, an ordered tree, and separated between left child and right child. In a binary tree, each internal node acts as the condition while the leaves act as the final decision. The edges after an internal node act as an evaluation of the condition with eventually an edge leading to a leaf. An example of binary tree:

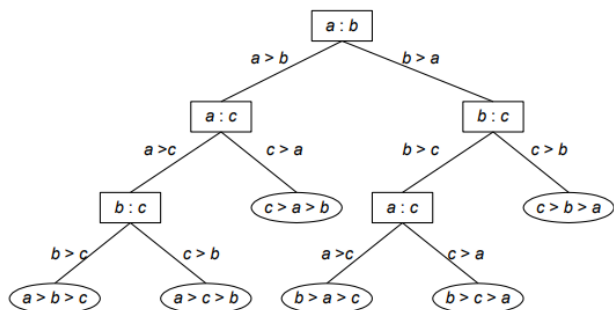


Fig 2.6 Decision tree, an example of a binary tree [3]

C. Mirror Dungeon

In this paper, it uses the Normal mode of season 7 of Mirror Dungeon as the example. A season is only a periodic content update cycle, so as of writing, season 7 is the most recent content update of the game. There are two modes for Mirror Dungeon, Normal and Hard mode. Normal mode is accessible upon completion of chapter or known as Canto II of the game while Hard mode is accessible upon completion of the Canto to the season's number + II. This paper uses Normal mode to simulate a newer player that has just gotten access to Mirror Dungeon with their limited owned Identities.

As shown in Fig 1.1, Mirror Dungeon is a roguelite mode consisting of multiple floors, each floor with its own branching node map. Before entering a floor, the player is presented with a choice of a theme pack between multiple packs. Theme pack is a set of enemies with a final boss that needs to be defeated before being able to advance to the next floor. This is an example of choosing a theme pack for a floor:

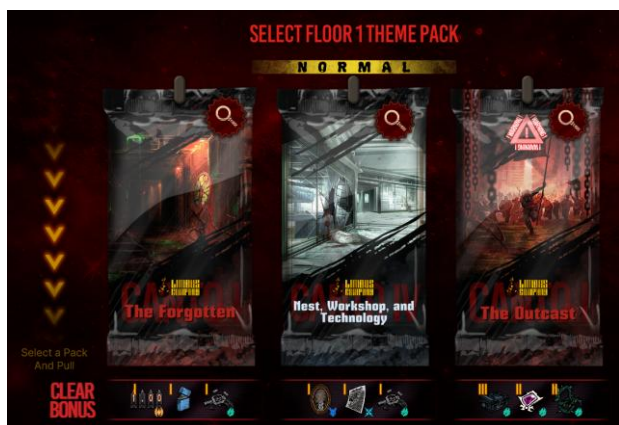


Fig 2.7 Choosing a Theme Pack [4]

When choosing a theme pack, a list of boss(es) and E.G.O Gifts that may appear in the floor are shown, if the player has encountered it beforehand. E.G.O Gifts are a mechanic to strengthen the units or also known as Sinners through various effects that are given from it. Additionally, the affinity or also known as Sin weakness of a boss may be shown for specific theme packs. An example of a theme pack with the Boss' Sin weakness:



Fig 2.8 Details of a Theme Pack [4]

It should be noted that not all theme packs are available for newer players to pick since certain theme packs are gated behind the completion of the respective Canto, Intervallo, or Walpurgisnacht event. Intervallo and Walpurgisnacht are stages that appear after certain Cantos, so it's also gated behind certain Canto's completion. But this paper assumes full availability of all theme packs regardless of whether the player has unlocked it, to generalize the model throughout all possible theme pack choices.

When a theme pack is chosen, the player will enter that floor's map. The map is a branching graph consisting of various non-backtrack able nodes starting at a start node and ending with the boss node. An example of a floor's map:



Fig 2.9 A floor's map [4]

There are various node types that can make up a map, with the icons and names of these types shown below:

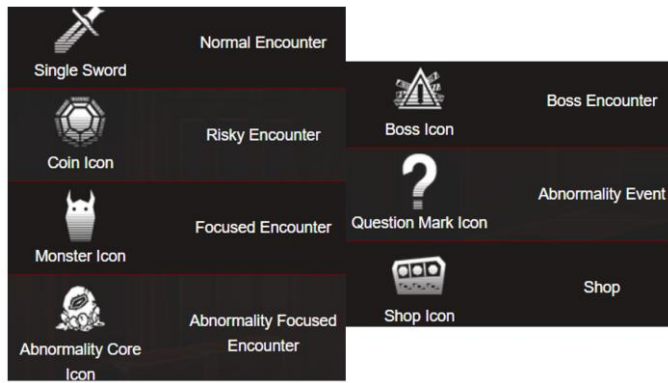


Fig 2.10 Icons and types of existing nodes within a map [5]

These types can be grouped into battle type nodes, which consists of Normal, Risky, Focused, Abnormality Focused, and Boss encounter nodes, and into non-battle type nodes, which consists of Abnormality Event and Shop nodes.

Battle type nodes can be separated into two types, chain and focused encounters. Normal and Risky encounters are considered chain encounters. In this type of encounter, the player can only choose which skill to use without the ability to direct the skill to a specific enemy. This results in a simpler but less controllable battle since the player can't target specific enemies. Focused and Abnormality Core encounters are considered focused encounters. In this type of encounter, the player can manually target a skill to go against a specific enemy. This results in a more complex but more controllable battle since the player can target specific enemies. The Boss encounter can be either a chain or focused encounter, depending on the boss itself, with usually a chain encounter if the boss is accompanied by 4 to 5 other enemies and a focused encounter if a boss is on its own.

A risky encounter is just a more difficult normal encounter with more and stronger enemies. While an Abnormality Core encounter is a mini-boss consisting of a strong single enemy compared to the Focused encounter that consists of multiple enemies. Each enemy type of node rewards the player with a Mirror Dungeon currency or known as Cost, with harder enemies resulting in more Cost and a chance to obtain an E.G.O Gift as well. The Abnormality Event node is an event node where the player can pick specific choices which may lead to a battle or an E.G.O Gift. And the Shop node is a place where the player can spend Cost to strengthen themselves, either by healing or reviving Sinners, replacing certain skills for a Sinner, buying E.G.O Gifts, enhancing E.G.O Gifts, or fusing new E.G.O Gifts. An example of a Shop node:



Fig 2.11 Features within a shop node

As written before, this paper will only use Identities that are given at the start of the game with base E.G.O, which is a special skill consuming certain Sin resources, all of them at advancement or known as Uptie III to simulate a newer player experience. And since mechanics of a Mirror Dungeon changes as seasonally, this paper will avoid using any starting buffs that can be obtained using special resources as well. It should be noted that in season 7, the player can use up to 7 Sinners in a battle in the Mirror Dungeon, which will be used in this paper.

III. METHODOLOGY

As written before, this paper will use a full team of starting Sinners at Uptie III. Because of that, this paper will only consider theme packs that are possible to be completed by a full team of starting Sinners at Uptie III. The possible theme packs based on events completion can be separated into Canto, Intervallo, and Walpurgisnacht theme packs.

While the difficulties between all of them vary, it can be ranked from easiest to hardest from Canto, Intervallo, and lastly Walpurgisnacht. This is because in Normal mode, Canto theme packs are limited to only Canto V while Intervallo and Walpurgisnacht theme packs don't have a limit. While Intervallo theme packs have varying difficulty, it is ranked easier since the earliest theme pack can be accessed upon the completion of Canto III while the earliest Walpurgisnacht theme pack can only be accessed upon the completion of Canto VI. The other theme pack types are Sin affinities for bosses that have a similar Sin affinity for their attacks and Attack type for bosses that have a similar attack type for their attacks.

For a Canto theme pack, it can be separated by the boss enemy, either it's a mini boss within the Canto itself or the final boss of the Canto itself. With the varying amounts of theme packs, deciding the optimal theme pack can take some time to ensure that it is still possible to complete using the player's current team.

There are several points to consider when choosing a theme pack. Those points are:

1. Type of theme pack (stage completion or not)

Stage completion theme packs have a farther range of difficulties compared to Sin affinity and attack type theme packs.

2. Type of stage completion theme pack

As written before, this type of theme pack can be ranked easiest to hardest from Canto, Intervallo, and lastly Walpurgisnacht theme packs.

3. Origin of Canto theme pack

By identifying the possible maximum rolls of the skills used by the mini boss and boss enemy from a Canto, Canto IV is a realistic cutoff that is possible to be beaten by a team consisting of base Sinners at Uptie III. On average, the maximum rolls of the skills are 11, outside of special skills based on certain conditions.

4. Origin of Intervallo theme pack

By identifying the possible maximum rolls of the skills used by the boss enemy from an Intervallo, any Intervallo before Canto VI is a realistic cutoff that is possible to be beaten by a team consisting of base Sinners at Uptie III. On average, the maximum rolls of the skills are 11, outside of special skills based on certain conditions.

5. Type of Sin affinity and attack type theme pack

Picking certain Sin affinity and attack type theme pack based on the weaknesses of Sinners that are used can reduce the difficulty when fighting the boss.

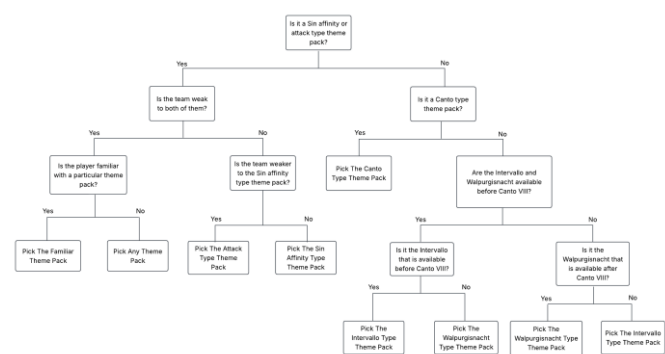


Fig 3.2 “Bad” theme pack decision tree

Since a floor map is considered a DAG, each room is considered as a node while each path between one node to the next node is considered as an edge. Each type of node will have a weight. This weight is based on the goal of the map’s completion, general for a broader approach, resource-focused approach for a more focus on gathering Cost and E.G.O Gifts to empower the team, and strategic approach for more options to manually target the skills used to minimize casualties from fighting enemies. This weight is based on a 1-10 scale, with a weight of 10 having the highest priority.

For the general approach, the node types are ordered from the highest to the lowest by Event, Normal, Risky, Focused, and Abnormality Core nodes. The Event node has a weight of 10 since it is quickly completable by just making a decision with the possibility of obtaining rewards or downsides based on the decisions. The Normal node has a weight of 7 since the player usually will be able to complete the battle quickly and without much strategizing. The Risky node has a weight of 4 since it is a harder version of Normal node that the player doesn’t have much strategizing and should be picked if the player feels their team is strong enough. The Focused node has a weight of 3 since it can be considered as an easy battle to complete that needs some strategizing of targeting the skills used. And lastly, the Abnormality Core node has a weight of 2 since it is a much harder battle that needs quite a bit of strategizing for each specific Abnormality enemy.

For the resource-focused approach, the node types are ordered from the highest to lowest by Event, Abnormality Core, Risky, Focused, and Normal nodes. The Event node has a weight of 10 since the player can easily obtain Cost or E.G.O Gifts based on the chosen decisions without necessarily needing to fight any enemy, with the option of fighting enemies to obtain more E.G.O Gifts. The Abnormality Core node has a weight of 8 since it will reward the player with two E.G.O Gifts based on that enemy with the largest amount of Cost from a battle. The Risky node has a weight of 6 since it rewards the player with the second highest amount of Cost from a battle with the possibility of obtaining an E.G.O Gift. The Focused node has a weight of 4 since it rewards the player with the third highest amount of Cost from a battle with the possibility of obtaining an E.G.O Gift. And lastly, the Normal node has a weight of 3 since it only rewards the player with the lowest amount of Cost from a battle with no possibility of obtaining any E.G.O Gift.

From these points and through testing, it can be determined that the decision tree for choosing a theme pack on each floor will look like something like this:

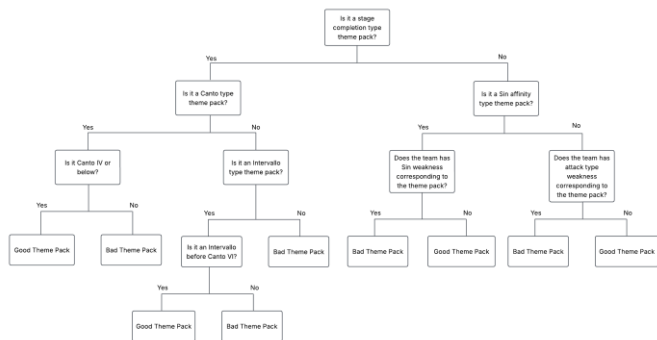


Fig 3.1 Theme pack decision tree

If the list of available theme packs is considered a bad theme pack, an additional decision can be made. By comparing whether the list of available theme packs are stage completion packs, Sin affinity, or attack type theme packs. In this condition, a Sin affinity or attack type theme packs are preferred, with the decision being based on which weakness the team has more. If the team is weak to either the Sin affinity or attack type theme packs, then the player can choose the theme pack that the player has more familiarity with.

If the list of available theme packs is stage completion theme pack, then the Canto type theme packs are preferred since there aren’t any bosses from the final boss of the respective Canto. Between Intervallo and Walpurgisnacht type theme packs, Intervallo packs are preferred if it is an Intervallo before Canto VIII, followed by Walpurgisnacht packs before Canto VIII. If both are only available after Canto VIII, then Walpurgisnacht packs are preferred, ascending from when they are available after a specific Canto. And lastly, Intervallo theme packs are picked, ascending from when they are available after a specific Canto.

From these additional points and through testing, a decision tree for a considered “bad” theme pack will be look something like this:

For the strategic approach, the node types are ordered from the highest to lowest by Event, Focused, Abnormality, Normal and Risky nodes. The Event node has a weight of 10 since the player can avoid a battle entirely by picking the correct choice. The Focused node has a weight of 8 since it is an easier battle that the player can manually target their skills against enemies. The Abnormality Core node has a weight of 7 since the player still can manually target their skills despite it being a harder battle. The Normal node has a weight of 6 since it is the easiest battle to complete where the player doesn't have the option to manually target their skills. And lastly, the Risky node has a weight of 3 since it is a more difficult version of the Normal node and the player can't manually target their skills as well.

As seen from all approaches, the Event node is always prioritized since the player can choose to either just skip battles, gain E.G.O Gifts, or intentionally fight a difficult enemy to obtain additional E.G.O Gifts. The node traversal for this DAG is by picking the nodes that have the highest weight possible, where if all nodes have the same weight, the node that leads to a higher next weight node is picked.

IV. CONCLUSION

The decision trees and weighted DAGs proposed on this paper have been tested through several Normal mode Mirror Dungeon runs. These mathematical models have provided an easier option of choosing which theme packs and nodes to choose from without needing to check the details of each theme pack and nodes thoroughly using the community's resources.

Although the decision trees and weighted DAGs provided here still can be improved on, since it only has discussed the Normal mode of Mirror Dungeon, I believe this model can be improved on with including the Hard mode of Mirror Dungeon and including the keyword-specific team used by a player to be a more inclusive experience of Mirror Dungeon that most later player will have.

V. ACKNOWLEDGMENT

The author would like to express gratitude first of all, to God for the guidance throughout learning the materials and applying it to finish this paper. The author would also like to express gratitude to Mr. Rinaldi Munir as the author's Discrete Mathematics lecturer. It is thanks to his guidance and teaching that this paper can be finished and the author's ability to

understand the concept and use of graphs, trees, and other mathematical models taught in Discrete Mathematics. And finally, the author would also like to express gratitude to friends and family that have supported the author throughout the entire semester. The author hopes that this paper can help and inspire other people to learn and apply mathematical models in games, and specifically in a game I have adored and liked so much.

REFERENCES

- [1] R. Munir, "Graf (Bagian 1)" lecture notes, Institut Teknologi Bandung, 2026. [Online]. Available: <https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2025-2026/20-Graf-Bagian1-2026.pdf>. [Accessed: Jun. 18, 2026]
- [2] R. Munir, "Pohon (Bagian 1)" lecture notes, Institut Teknologi Bandung, 2026. [Online]. Available: <https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2025-2026/23-Pohon-Bag1-2026.pdf>. [Accessed: Jun. 18, 2026]
- [3] R. Munir, "Pohon (Bagian 2)" lecture notes, Institut Teknologi Bandung, 2026. [Online]. Available: <https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2025-2026/24-Pohon-Bag2-2026.pdf>. [Accessed: Jun. 18, 2026]
- [4] Project Moon, *Limbus Company* (Season 7) [Video Game]. 2026. [Accessed: Jun. 19, 2026]
- [5] "Mirror Dungeon," Limbus Company Wiki. [Online]. Available: https://limbuscompany.wiki.gg/wiki/Mirror_Dungeon. [Accessed: Jun. 19, 2026]

PERNYATAAN

Dengan ini saya menyatakan bahwa makalah yang saya tulis ini adalah tulisan saya sendiri, bukan saduran, atau terjemahan dari makalah orang lain, dan bukan plagiasi.

Bandung, 19 Juni 2025



Ferdinand Valentino Darmawan - 13525149