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A Study on Mixed-Initiative for Fostering Creativity in Game Design

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Abstract

Mixed-initiative systems highlights the collaboration between humans and computers in fostering the generation of more interesting content in game design. In light of the ever-increasing cost of game development, providing mixed-initiative tools can not only significantly reduce the cost but also encourage more creativity amongst designers. This study focused on the improvement of mixed-initiative aspects for a previously developed tool called Evolutionary Dungeon Designer or Eddy for short. Eddy placed a focus on using its genetic algorithms to produce content that adhere to game design patterns.

Using the feedback from Eddy 2.0's user study and studying other related works, new features have been planned and implemented to improve the elements of mixed-initiative in Eddy for version 3.0. The results primarily feature a new and improved workflow as well as enhancing a room's context with the addition of a logical world grid. This in turn improves the program's intuitiveness and makes it possible for the designer to create more complex designs of their preference while maintaining the general functionalities of the original Eddy.

The study was evaluated with a small scale user study of five users at a game development company with most of the feedback being positive in nature. From the feedback more features have been planned for a future version of Eddy being version 4.0.

Keywords: Mixed-initiative, Evolutionary Dungeon Designer, User Interface (UI), Human-Computer Interaction (HCI),

Popular science summary

The idea of having machines and humans working together to create things have been a concept since the introduction of the computer. From simple things like text editors to complex concepts where the computer is doing the main computation, the concept of mixed-initiative is very broad. The idea with mixed-initiative and human-computer interaction is to reduce cost and time when producing any content while also increasing the complexity of the designs that can be created.

With the ever-increasing cost of developing games, introducing mixed-initiative to game design happens naturally. A mixed-initiative tool can reduce the time to create game designs thus reducing cost, but the tools can also help the game designers to create more complex designs and ideas that otherwise would not have been thought of. With tools like the Evolutionary Dungeon Designer (Eddy), with version 2.0 developed by Alexander Baldwin and Johan Holmberg, the game designers can quickly create rooms for dungeons to be used in various game genres.

The user study that was previously conducted for Eddy 2.0 brought up a few concerns regarding the mixed-initiative aspects as well as the user interface. This thesis has worked to answer this feedback by implementing new features to Eddy 2.0 as well as improving the user interface and the workflow of the tool.

A big contribution that was made is the ability to create a larger dungeon comprising of multiple rooms. This was one of the biggest concerns with Eddy 2.0 as the context of a room was unclear when designing it. With this implementation the user can design an entire dungeon with richer context and can always see how each room relates to one another.

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List of acronyms

PCG	Procedural Content Generation
Eddy	Evolutionary Dungeon Designer
CAD	Computer Aided Design
HCI	Human-Computer Interaction
AI	Artificial Intelligence
RPG	Role-Playing Games
NPC	Non Playable Character
UI	User Interface
FPS	First-person Shooter

1 Introduction

Mixed-initiative systems in game content creation [5] refer to the combination of functions produced by procedural content generation (PCG) algorithms and human designer intentions. This study focuses on developing a solution that will improve the mixed-initiative elements in game design by using the existing work of mixed-initiative procedural generation of dungeons using game design patterns as a foundation. The particular software to be used in this study will be Baldwin and Holmberg's Evolutionary Dungeon Designer 2.0 (Eddy 2.0) [1]. The software and algorithms developed in this thesis have been published in two articles, each respectively focusing on Eddy 2.0's mixed initiative aspect and pattern-based design [9] [10].

1.1 Purpose

Creativity produced collaboratively by both humans and machines is not uncommon in today's design paradigm; computers have become one of the main tools for a designer to create artifacts within the areas of architecture, product and interior design. As a result, computer-aided design (CAD) has been an important facet for design practices [8]. It could be argued that one of the areas where this practice is extensively used the most is game development.

Games are an evolving medium of creative expression, but limitations still exist in regards to its design tools' accessibility due to the risky and expensive nature of game development. In Yannakakis et al.'s book on Artificial Intelligence and Games, as well as in other related works, the rise of cost in game development due to games' technological evolution has resulted in the invention and push towards automatically generated content [6] [11] [12]. Cost may refer to multiple factors, and in this context human designers and artists are mostly considered as they are expensive. Games' complexity in design requires

the involvement of tens to hundreds of staff across a development period that can span years. This can negatively affect a company's profitability and the development team's innovative and creative vision.

Introducing PCG to game development was not meant to mitigate this problem by acting as a replacement for designers. Instead, its functions are used to promote cooperation between humans and machines in providing more diverse game content that would increase quality and replayability [3] [6] [8]. Various development tools and level editors can be used by human designers at their disposal, making them the sole driver of the creative process. PCG, however, may limit the human designer's intentions by strictly following its own algorithms, without regarding the designer's desired parameters before generation [5]. Rather than simply being limited tools of support for the other, mixed-initiative systems can foster co-creativity in game design by combining the best of these two perspectives. Not only would it improve a development team's overall productivity, it can also guide and improve the creativity of smaller indie teams and individuals in developing more interesting and content-rich games with lesser worries on development costs [3] [4] [6].

This study will use the previously conducted Master thesis [1] by Baldwin and Holmberg as a foundation, in which they explore the potential of using game design patterns with PCG of levels in games. With the help of their mixed-initiative tool Eddy 2.0, human designers can intuitively save an automatically generated dungeon room, which they can also manually edit. Eddy 2.0 further generates rooms based on the map the designer is currently editing with the help of the genetic PCG algorithms.

At the center of the existing work is the human designer driving the evolutionary process of iteratively generating levels. This study will further develop it from the perspective of its mixed-initiative and human-computer interaction (HCI) elements. The previous

research addressed room for future work stemming from the feedback they received from their user study conducted with a game developer studio. This presents multiple areas of further development.

1.2 Goal

A new iteration of Eddy, version 3.0, shall be developed, consisting of the various solutions that would enhance the software's usability in providing a more flexible and expanded mixed-initiative experience.

1.2.1 Research Questions

The following research questions are to be considered in this thesis work:

RQ1: How can the mixed-initiative aspects be improved further in the Evolutionary Dungeon Designer?

RQ2: How can the user interface be improved to give more relevant feedback to the user in the Evolutionary Dungeon Designer?

RQ3: Do the newly implemented features foster more creative content that adheres to the game designer's choices?

In the previous iteration of Eddy, the study did not have a primary focus on evaluating the software as a mixed-initiative tool. This brings up RQ1, which places this current work into the focus of mixed-initiative and how this aspect of Eddy can be improved. RQ2 serves as a support for RQ1, as it refers to Eddy's mixed-initiative interface and experience. Finally, RQ3 refers to the evaluation of the new version of Eddy and its usability.

2 Related Work

A literature review has been conducted which provides an overview of mixed-initiative principles, their usage in existing game design tools, Eddy 2.0, and how dungeon levels are defined in video games. The goal of this chapter is to provide an insight on these different areas which are relevant to Eddy 3.0's development and evaluation.

2.1 The Main Principles of Mixed-Initiative

Mixed-initiative systems in game design promote the co-creativity between human designers and machines, providing more interesting and exciting creations [8]. With developing games it has become more common to use some form of artificial intelligence (AI) to aid the developer in their work [2]. When anything is generated with PCG the program takes a few parameters that are specific to the task and through mutations generates seemingly random content [6]. This ensures that the generated content would guarantee more variety in the game's narrative options and exploration, as well as replayability. However, what is made by the computer is not always perfect, thus the reason for still having game developers doing manual designs from scratch. Some drawbacks of completely relying on PCG is the low reliability, believability, and high predictability of the game - all which guarantees difficulties in evaluating a dungeon level's quality [17]. By following the principles of mixed-initiative through combining the content generation with the guidance and input from a human designer, you get the experience of co-creativity.

According to Liapis et al. [5] there are two different types of mixed-initiative. The first type is when the human comes up with the idea and the computer aids in the task e.g. a text editor. The other type is described as the computer generating the idea or the content, where the human can then change and edit the content to their liking. This sort of divide

in mixed-initiative is also described by Yannakakis and Togelius [6] where they present a scale with the two extremes on opposite ends: purely human design on one and purely computational design on the other. In between these extremes are varying forms applied to mixed-initiative content generation tools used for game design, which this thesis will contribute in.

2.2 Evolutionary Dungeon Designer

In their Master thesis, Baldwin and Holmberg have iterated on an existing program called Evolutionary Dungeon Designer (Eddy) and produced Eddy 2.0 [1]. This program uses different algorithms in order to generate maps for dungeons that could be used for game design. Although these algorithms are very integral to Eddy 2.0 they are of less interest for this work. What is of interest, however, is the human computer interaction (HCI) or the mixed-initiative that Eddy 2.0 provides when developing dungeons.

For Eddy 2.0 the type of mixed-initiative that is used the most is the one where the computer does a lot of the idea generation. However, aspects of human input are also used. Not only can a user edit the content that the program generates, the program can also take the edited content and generate new content with the human edited one as a "seed" for future versions.

The content that Eddy 2.0 generates consist of layouts for dungeon rooms that can be used for many different genres of games. The genres of games that Baldwin and Holmberg suggest are suitable for Eddy 2.0 are RPGs with dungeon aspects such as Legend of Zelda or dungeon crawlers such as Diablo. It is also mentioned in the performed user study that one could use Eddy 2.0 for other genres such as first-person shooter (FPS) games [1].

Eddy 2.0 allows the user to select one of its generated maps, which they can then edit to their liking. These maps are generated using different parameters as a seed, which gives the user distinctly different dungeons. In order to ensure that the dungeon is feasible Eddy 2.0 highlights the map if the user edits the map in such a way that it would not be playable. This feature is described by Liapis et al. to exist in other mixed-initiative game generation tools such as Tanagra and Ropossum albeit for other genres than RPGs [5]. In the new version this thesis will work on, multiple new mixed-initiative features will be implemented.

The main view of Eddy can be seen in Figure 2.1. This view depicts the room view where the user can edit the dungeon as well as get suggestions from the program of how to change the dungeon.

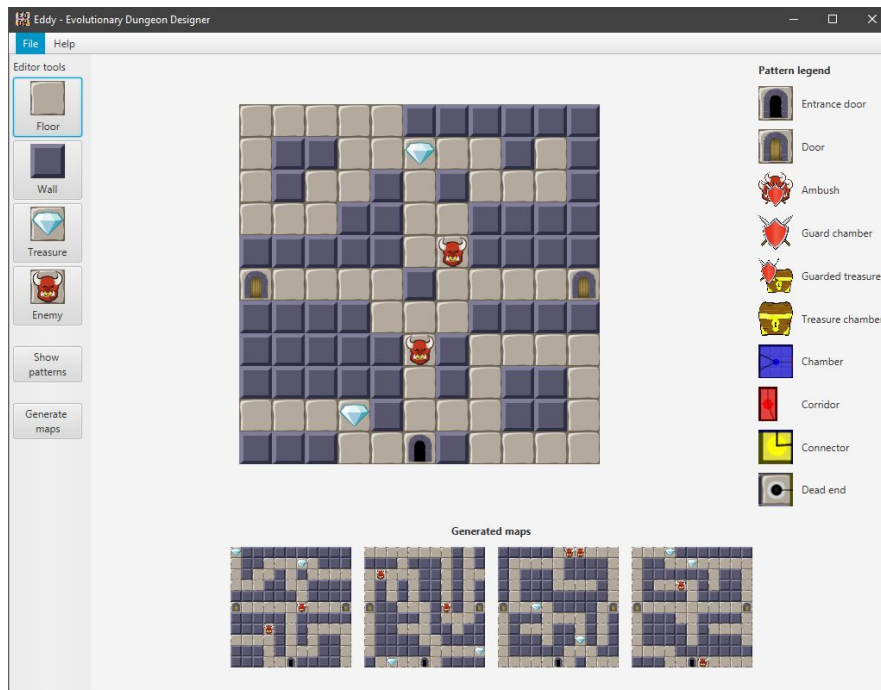


Figure 2.1. The main view of Eddy called the “Room View”.

2.3 Other Mixed-Initiative Tools in Game Design

Other programs similar to Eddy have been developed for use in game design such as Tanagra, CICERO and Sentient Sketchbook, all focusing on providing mixed-initiative functions to the designer. An issue with these tools is that they are limited to the types of games that they can generate content for [4].

Sentient Sketchbook is probably one of the more well known mixed-initiative game design tools. This tool is aimed at strategy games such as Starcraft where terminologies such as bases and resources are used [3]. Sentient Sketchbook works by giving the user a low-resolution sketch of the generated game where the user can edit it to their liking. The reason for only giving the user a low-resolution sketch of the generated map instead of the entire high-resolution map is not only to reduce the creative strain on the user but also to make it easier for the program to detect patterns in the map [3]. Once the user deems the generated and edited low-resolution map good enough, the program can then generate the higher resolution map while still maintaining the patterns that were detected in the low-resolution map.

As mentioned, Tanagra is another tool used for game generation that shares a similarity to Eddy 2.0 in that it can detect whether the generated content is playable or not. Tanagra is, however, used to develop 2D platformers [7]. A big difference between Tanagra and other mentioned PCG-systems is that the user is not presented with any generated content upon starting the program. Instead the user is presented with an empty grid where they can place different tiles in the game such as enemies, coins, and more [6]. The way mixed-initiative plays a part in Tanagra is that the user can select tiles or objects that they want to maintain and Tanagra can then generate new content around those static objects and tiles.

Tanagra is, in a sense, similar to the way Eddy 2.0 tries to maintain patterns upon generating new content. However, it is not possible with Eddy to select specific tiles or pseudo patterns that the user wants to maintain. This is an issue brought up by Baldwin and Holmberg. Users felt like they were implementing a certain pattern but due to Eddy 2.0's definition of said pattern it would ignore the user-edited content for future generations of the map [1].

CICERO is perhaps the program that is most similar to Eddy 2.0 in that they are both designed for RPG-style dungeons. Machado claims, however, that CICERO is designed to be more general than previous tools [4]. With CICERO the user can define the behavior of the games content such as power-ups, win and lose conditions and what happens when two elements collide. CICERO can then from the user-specified behaviors recommend different game mechanics that would suit the game. An example of these mechanics could be some form of weapons such as swords or shooters [4].

Machado brings up an example of where a Zelda-style map was implemented in CICERO. While CICERO ran the dungeon and tested it there were two rules that were never triggered. One rule was to be triggered if the player was killed by an enemy and the other rule was to reach the end of the dungeon without the dungeon key. In order to test how different layouts and scenarios work, the user can add enemies to trigger the death by enemy rule or to move the key in such a way that when CICERO runs the game it reaches the end without the key [4]. By shifting around content in the dungeon and having CICERO run the game and test different triggers a game developer can see how different layouts can affect the playthrough and thus design maps with different goals in mind.

In order to improve Eddy 2.0 elements from the presented programs could be considered. Despite being intended for different genres of games the general ideas behind the

programs can be used for generation of content for most games. For example, the way Tanagra allows the user to specify which parts are to remain after the program runs its generative code could be used for Eddy 2.0. By doing this, Eddy 2.0 could maintain user added elements that does not coincide with Eddy 2.0's definitions of patterns. This specifically was one of the complaints that the users expressed in the user study conducted by Baldwin and Holmberg [1].

With all possible features found within the different game generation tools in combination with the previous user feedback on Eddy 2.0 it can be challenging to select what features to implement for version 3.0. With time being limited it is important to focus on relevant features that will not be too complex to implement. For example, the way Sentient Sketchbook abstracts the entire game generation will perhaps be too big of a feature to implement for Eddy 3.0.

2.4 Designing Dungeons in Video Games

Dungeons, which can also be referred to as a type of level in games, primarily have the purpose of completing objectives or missions in order to advance to the next section. When a designer considers how they should construct a dungeon, they often keep in mind how their creations would properly coordinate with a specific mission that has been decided for the game to have. In Karavolos et. al's work they explore how they can procedurally generate dungeon levels depending on the mission slated for the specific game's section. They have emphasized in their paper the importance of considering the aspects of goals, missions, the narrative or themes, visual style, and gameplay rules when designing levels. With this in mind, they can be considered when developing a mixed-initiative tool for content generation [17]. These factors are mostly decided by the human designer, which have to be integrated into the generated dungeon designs. With Eddy 2.0's structure only focusing on creating a single room one at a time, it is difficult

to integrate these aspects into the creations as its features are too limited to fully realize a dungeon with rich context.

Other than objectives and missions, the last important aspect integral to dungeons is the player's progression through them [21]. Designers ensure that the player's experience throughout a level will be coherent and effective, which will be affected by the content they create. This includes the consideration of challenge and difficulty balance within dungeons.

The level of complexity dungeon creation requires can prove to be a difficult work for designers, especially less experienced ones who have less resources and access to design tools that can help them. It is also important for the designer to maintain the content's quality and coherence through different periods of development. Eddy 3.0's goal in enhancing the mixed-initiative aspects of Eddy 2.0 include the improvement of the designers' capabilities to address these concerns with more ease, as they receive better assistance from an overall improved mixed-initiative user interface.

3 Methodology

In order to carry out the tasks and achieve the goals for this thesis the Design Science methodology was chosen.

3.1 Design Science

This thesis will utilize the three main cycles of design science. In Peffers et al's paper on design science research methodology for information systems research [14], the principles of design science have been described to be the creation and evaluation of design artifacts to provide solutions for identified problems. By involving a rigorous process in the design approach and an evaluation of results which give insight to further work and innovations, the validity to contribute for the research is confirmed.

In a similar way to how Baldwin and Holmberg have followed its principles, this study will perform the processes of constructing the system and evaluating it [1]. In Alan Hevner's commentary on the key properties of design science [13], he has identified three research cycles that make up the core of the process. This study on improving Eddy 2.0's mixed-initiative aspects cover each of the cycles in different aspects, which can also be seen in figure 3.1:

1. **The Relevance Cycle.** According to Hevner's analysis, the principles of design science pertain to the desire of improving an environment with the introduction of innovative solutions. This cycle accentuates the opportunity of the application context, which in this case is the improvement of Eddy 2.0's mixed-initiative elements to further strengthen the co-creativity between humans and computers for game design. Furthermore, the opportunity's conception is developed by acknowledging the evaluations that must be done on the research results, providing more insight into different conclusions and possible future design

iterations. This role will be fulfilled by the research's user study, which will evaluate Eddy 3.0's usability.

2. **The Rigor Cycle.** The foundations for a rigorous design is said to be supported by the amount of existing past work and knowledge used in the research. The literature review details four main sections: the concepts of mixed-initiative argues its importance in a design process; the different existing mixed-initiative tools for game design provide perspective of what has been done and their different results and conclusions; an insight of the most important factors in designing dungeons in video games is provided. Lastly, this research is built upon two existing works: Baldwin and Holmberg's previous iteration [1] was an evolution from Font et al's work on constrained level generation through grammar-based evolutionary algorithms [12], which focused on generating the layouts of dungeons only. As such, it strengthens this study's validity in contributing to the research area.
3. **The Design Cycle.** The core of design science, it ensures that there is a balance between the construction and evaluation of the system. The first part of this study details the implementation of the new Eddy 3.0, while the second half encompasses the user study, which will provide qualitative data that will answer this thesis' research questions. The rigor and relevance cycles shall act as this cycle's two main pillars of support.

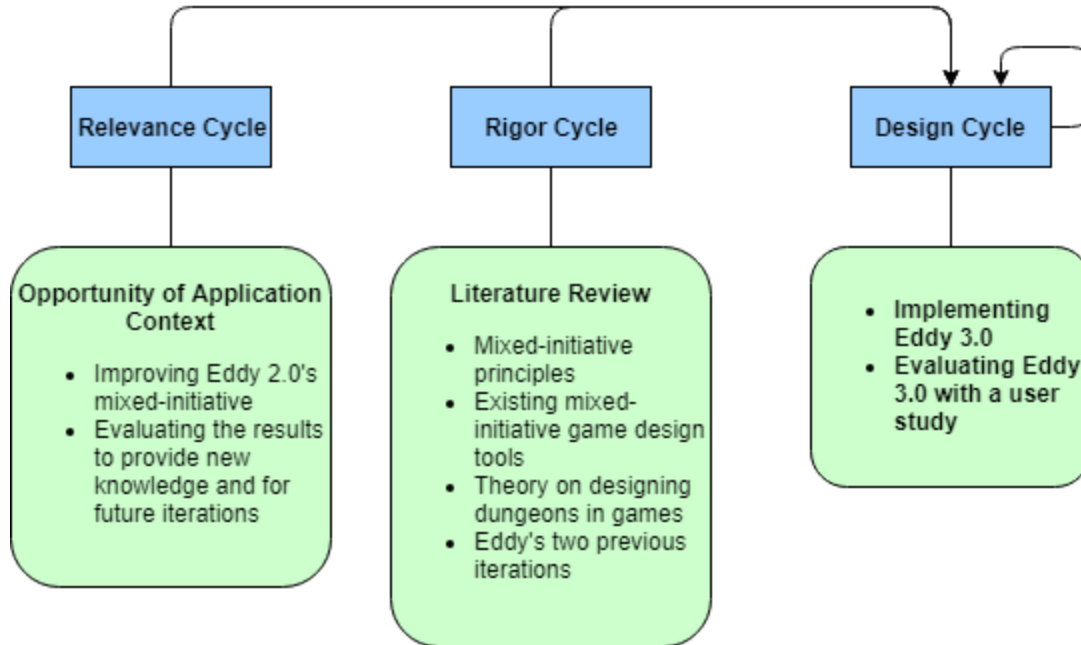


Figure 3.1. Design Science process used for Eddy 3.0.

3.2 Limitations and Threats to Validity

Some methodologies that could have been considered for this thesis besides Design Science are Iterative Design, Prototyping, and Comparative Study. While all of these methodologies could have worked there are different reasons as to why they were not picked over Design Science with the main concern being time limitations.

With Iterative Design the intent is that whatever you are developing is to be properly tested after each phase or implemented part. While this sounds good on paper and would work well with the goal of this project, implementing various additions to a previous program would take too much time, especially when every new functionality needs to be properly evaluated [23]. It was then seen as a better option to go for Design Science as you could then evaluate all the implementations at the same time within the Design Cycle.

The Prototyping methodology is very similar to the Iterative Design methodology and was discarded for the same reason: time constraints. With this method the idea is that you create prototypes with ever increasing complexity until you reach a final implementation. Similarly to Iterative Design, each of these prototypes should be evaluated properly in order to continue to the next prototype or iteration [23]. However, creating these prototypes can take a lot of time. Instead, the various functionalities implemented were reviewed during bi-weekly meetings with the supervisors in order to ensure that the project was going in the right direction. These meetings were also used to decide what features should be implemented next. In this way, a combination of Iterative Design and Prototyping were somewhat done for the Design Cycle of the Design Science methodology.

The main reason as to why a Comparative Study was not chosen was not only that the user study would have taken too long to conduct, but it was also due to the nature of the implemented changes. With all the new additions in Eddy 3.0 the program has a completely different approach with a lot of new functionalities. Comparing Eddy 2.0 with Eddy 3.0 does not make sense since all the features of the former are present within the latter but with extra functionalities. Therefore using a Comparative Study as the methodology for this thesis was discarded.

Finally the biggest reason that Design Science was chosen was due to the timing of the different phases of the thesis. The foundation and the literature review section was created in the Research Methodologies course during late autumn with no implementations made at all. The initial bulk of features was then implemented during the Advanced Study Project course where the only evaluation that was made was self-evaluation by the authors. This left the actual thesis course with a month of further implementations as well as a proper evaluation in form of a user study. With all the

different parts of the thesis being split up, they naturally adhered to the different cycles of Design Science.

4 Evolutionary Dungeon Designer 3.0

The implemented changes done on top of Eddy 2.0 will be brought up in this chapter. Alongside the results, a discussion is presented to give insight in the results' relevance and importance.

4.1 Results

A new workflow has been implemented for this study which can be seen in Figure 4.1. The workflow is depicted as such: the blue rectangles are the different views for Eddy 3.0; the red ones represent actions; the yellow diamond is a condition; the green ellipsis represents the start of the workflow. While the old version of Eddy called the rooms that were being edited a “dungeon”, it is now more commonly referred to as a “room” with the new workflow. The term “dungeon” is now used to describe the connection of several rooms within the same context. Such dungeons are also sometimes called a “world” in this thesis work. For the workflow this means that the “World View” is the view where all the connected rooms can be seen whereas the “Room View” is the view where a single room can be seen and edited.

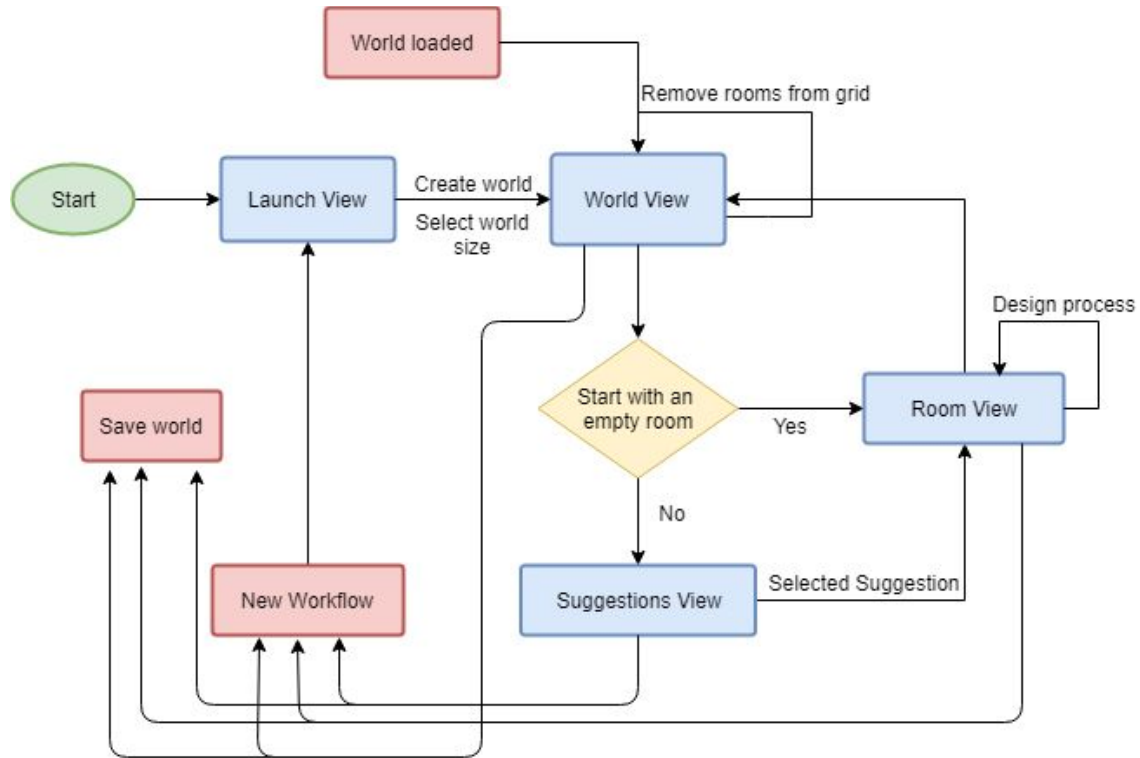


Figure 4.1. A flowchart that depicts an overview of the general workflow with the new additions.

With the new additions to Eddy 3.0 the user is first greeted with a “Launch View”. Here the user can select the size of the dungeon that they want to develop. The sizes can go from 2x2 rooms up to 7x7 rooms in a world grid. The Launch View can be seen in Figure 4.2.

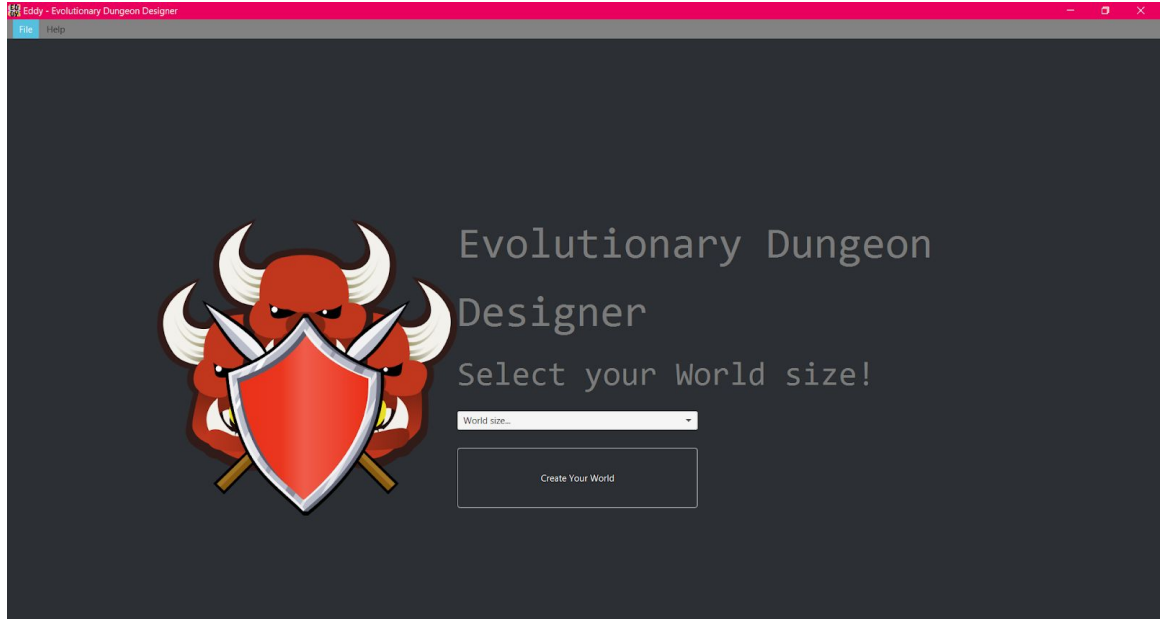


Figure 4.2. The initial Launch View for The Evolutionary Dungeon Designer 3.0.

Once the user has selected a size for their dungeon they will be sent to the “World View”. Here the user will see the entire map and how the rooms are connected. When the program is initially launched the world grid is filled with empty rooms that are connected with each other. However, if the user already has a partially designed map (whether it is from a save file or a dungeon being currently worked on) and decides to open it, then this view would be showing the world grid of the loaded map with all the tiles present in the different rooms. The World View can be seen in Figure 4.3 where a 3x3 and a 7x7 grid can be seen. Figure 4.4 shows an example of how the world grid can look if there is any content within the maps besides the doors.

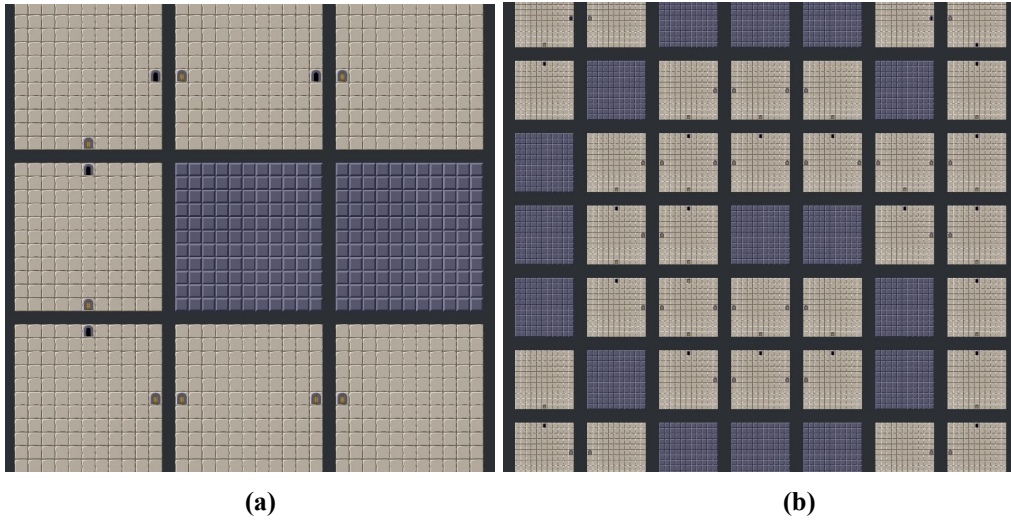


Figure 4.3. The World View with a (a) 3x3 grid and (b) 7x7 grid for the world.

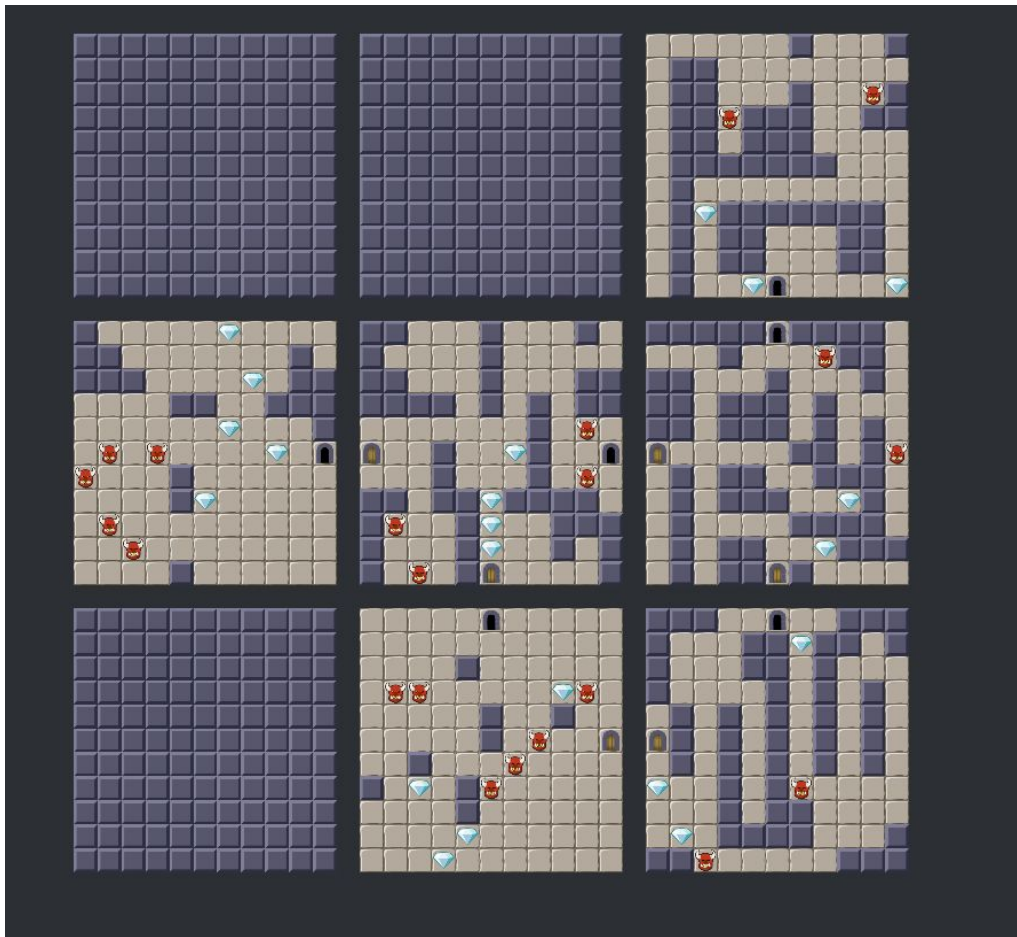


Figure 4.4. The world grid with content for an entire dungeon.

Once the program is launched and the world grid is displayed the user can then click on the different rooms displayed in the grid. When this is done the selected cell in the grid is highlighted. Once a room in the world grid has been selected the user can choose between three different actions regarding the room. The user can choose to edit the room that is selected. Since the rooms are initially completely empty, besides the doors, the user will have a lot of freedom in designing their rooms this way. However, if the user desires, Eddy 3.0 can provide some generated maps to start the design process. By selecting the button "Start with our suggestions" six uniquely generated rooms are presented to the user. These rooms will have the same door layout as the selected room and will be placed at the same location in the grid as the selected room. This functionality is the same as the Start View of the previous version, Eddy 2.0. In that version, when the program was launched, the user was also presented with the six generated rooms. By making this a separate functionality the intent is that the user can choose whether to start with a clean slate or to get inspiration from the generated rooms. A slight difference between the two versions of starting with a suggested room is that with the old version the positioning of the doors were randomized, although they would always be placed in the middle of the sides of the room. In order to maintain the functionality of the expanded dungeon the generated rooms will now have to keep the original door position as to fit in with the dungeon. The Suggestions View can be seen in Figure 4.5 where the room in cell [0, 0] has been selected. The doors for the generated room are placed according to this position within the grid.

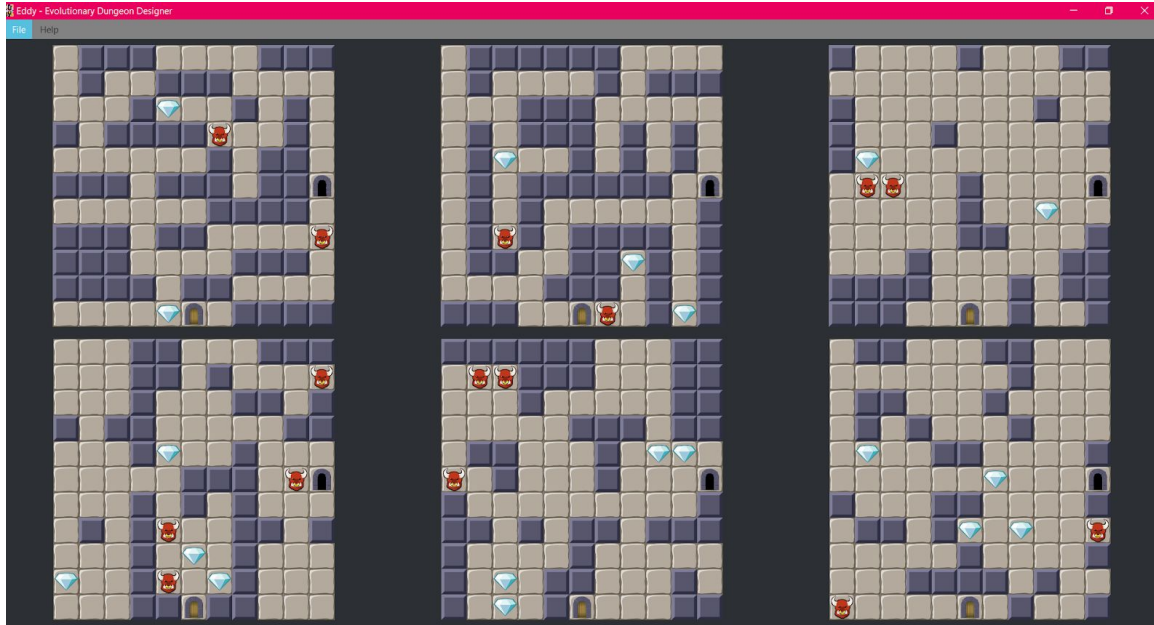


Figure 4.5. Suggestions View with the 6 generated maps for cell [0, 0] in the world grid.

The final action that the user can take in the World View is to “disable” a room in the dungeon. By doing this the selected room gets filled with walls making it inaccessible. This will also cause adjacent rooms to remove the doors that would connect to the now disabled room. If a disabled room is selected this functionality is then changed to enable the room. This is essentially the reverse of disabling a room, the room gets turned into an empty room with doors placed at the correct locations and the adjacent rooms gets their doors back so that the newly enabled room can be accessed. In addition to disabling the rooms, if a room were to be completely cut off from other rooms (all of its adjacent rooms disabled) the isolated room would then be automatically disabled. The World View is seen in Figure 4.6 with some of the rooms being set as disabled. This figure also depicts how the selection of rooms work in the form of highlighting.

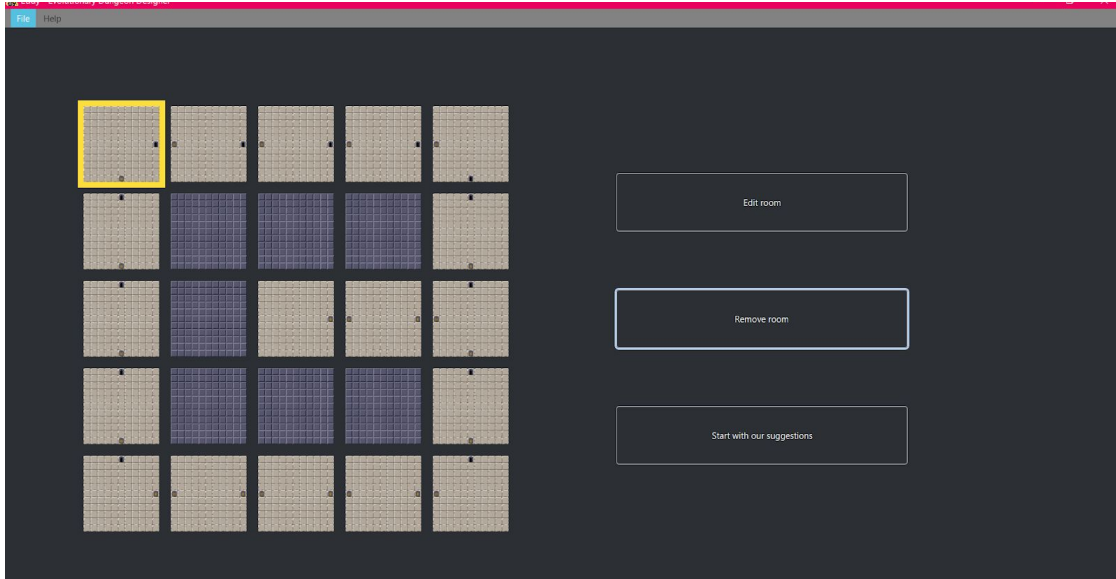


Figure 4.6. Highlighting of a cell in the world grid. In this case cell [0, 0] has been selected as can be seen with the yellow highlight.

Once the user selects a generated room to start with or to just start with an empty room, they are presented with the “Room View” which can be seen in Figure 4.7. This Room View contains elements from the Edit View of Eddy 2.0 while also bringing some new features into it. Since the dungeon that the user is designing with Eddy 3.0 is not limited to a single room, navigation had to be implemented between the rooms. The navigation is done by having buttons on the sides where doors are present. These buttons have the adjacent room overlaid so that the user can see the room that would appear if the button were to be pressed.

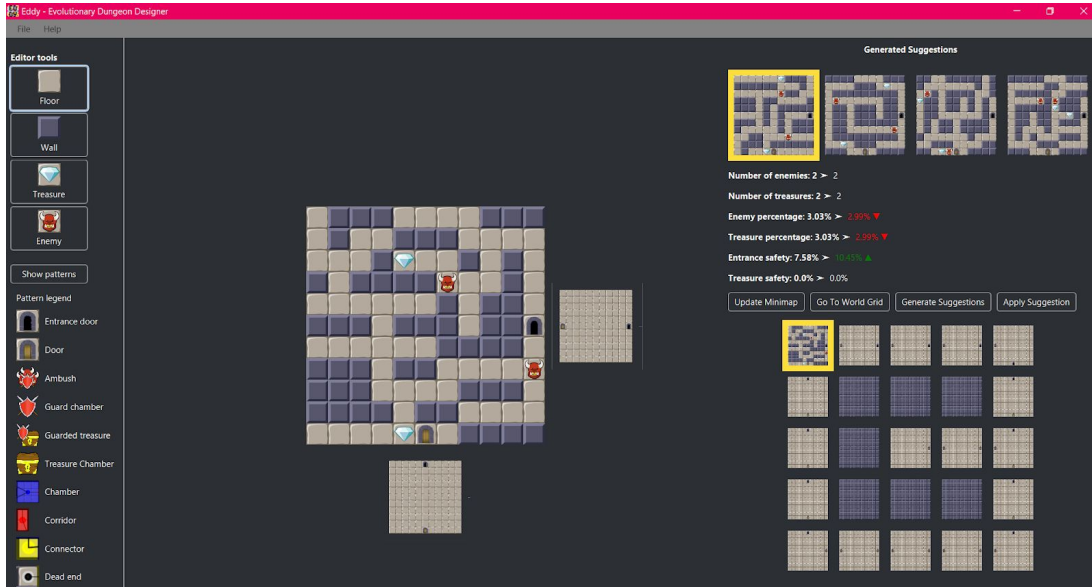


Figure 4.7. The Room View after selecting a suggested room from the Suggestions View.

Another new addition to the Room View that relates to the larger dungeons is the added minimap. Since the dungeons can now be as large as 7x7 in size, it is not feasible for the user to have to go back to the World View in order to see the whole dungeon. The minimap is a smaller scale of the world grid that shows the content of the entire dungeon. The currently selected room, similarly to how selected rooms work in the World View, is highlighted in yellow so that the user knows the context of the room that is currently being edited. Since navigation can be rather tedious with larger dungeons, navigation is also present through the minimap. By selecting a room on the minimap the user is taken to that room and can edit it. For both styles of navigation, navigating to a disabled room is not permitted. The directional buttons are also removed for the traditional way of navigation. If an adjacent room were to be disabled and if the user were to click a disabled room within the minimap, nothing happens as navigation to disabled rooms is not permitted.

Above the minimap are a few buttons with various functionalities. The “Back To World Grid” button takes to user back to the World View incase they want to enable or disable

any rooms but also if the user would like to start an empty room from a generated suggestion. The “Update Minimap” button is there to manually update the current room in the minimap. This is done to reduce the load times for the minimap. The whole minimap is updated whenever the user navigates to a different room, but if the user would like to see the currently edited room on the minimap a manual refresh has to be done. The remaining two buttons are related to the generated suggestions.

The generated suggestions work the same way as they did for Eddy 2.0. Four unique maps are presented that take into account different statistics from the room that is currently being displayed. The two buttons that are related to this are “Generate Suggestions” and “Apply Suggestion”. The “Generate Suggestions” generates four new maps from the currently displayed room. This is necessary if for example the user has made drastic changes to the room. The generated suggestions are only derived from what is on the map when they are created. If the user has made a lot of changes the generated maps may be outdated. The “Apply Suggestion” overwrites the current room with the selected generated map. This is different to Eddy 2.0 where the maps were applied the moment they were clicked. In this version, however, the maps get highlighted yellow when selected.

The reason for not applying map changes immediately when they get clicked is due to the final new feature of the Room View. When a generated map is highlighted relevant statistics are displayed for the currently displayed room as well as the generated room. These statistics are shown as a comparison and indicates whether applying the generated room would increase or decrease certain statistics or whether they would remain the same. The aforementioned buttons, generated rooms, as well as an example of the statistics view can be seen in Figure 4.8. As seen in Figure 4.8, two checkboxes are present with a short description regarding symmetry and similarity. These are fitness functions that were developed by a parallel thesis by another student and will thus not be

explained further within this report. However, these fitness functions has been added to Eddy 3.0 and using the checkboxes the user can decide whether they want the old “randomly” generated styles of suggestions or if they want similarity and/or symmetry for the generated suggestions.



Figure 4.8. Some of the major changes to the Room View in Eddy 3.0. Shown are the generated rooms (present in the previous version) as well as the statistics comparison of the current room and the selected generated room. Shown are also the buttons related to the generated maps as well as the Update Minimap and Go To World Grid buttons.

As a final touch to Eddy 3.0, the theme of the entire program was changed to a darker version. The idea is that by having a dark background the program would feel more modern but also reduce eye fatigue when it is being used for an extended period of time.

With Eddy 2.0 the user could only work with one single room, while the concept of connecting rooms through the world grid did not exist. Instead when the program launched the user was immediately greeted with the six suggested rooms. These rooms

would have randomly generated door positions which worked fine since the rooms were never intended to be connected. For reference on how the flow of Eddy 2.0 was before these new additions see Figure 4.9 and Figure 4.10.

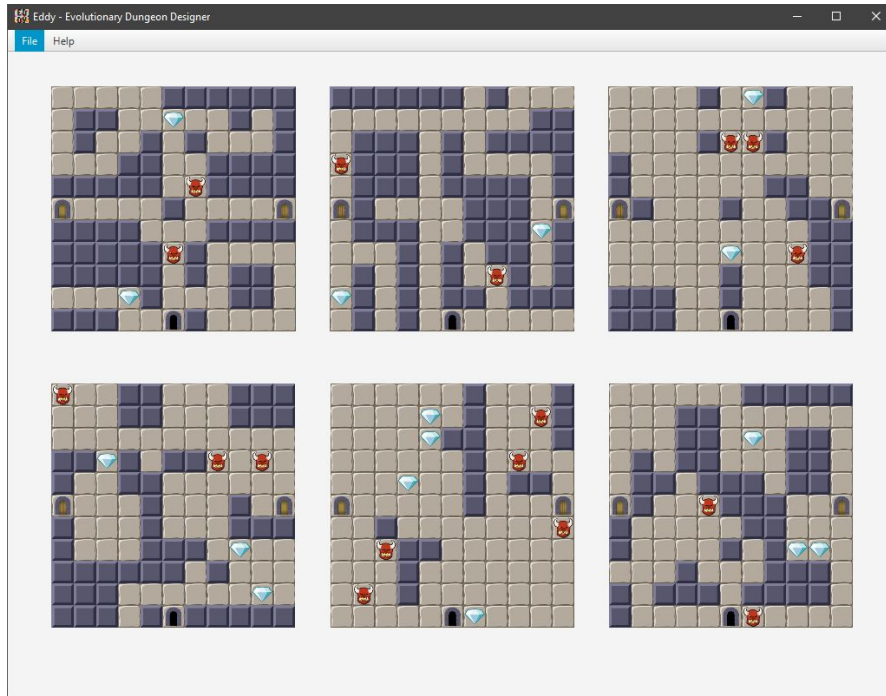


Figure 4.9. Start View for the original Eddy 2.0.

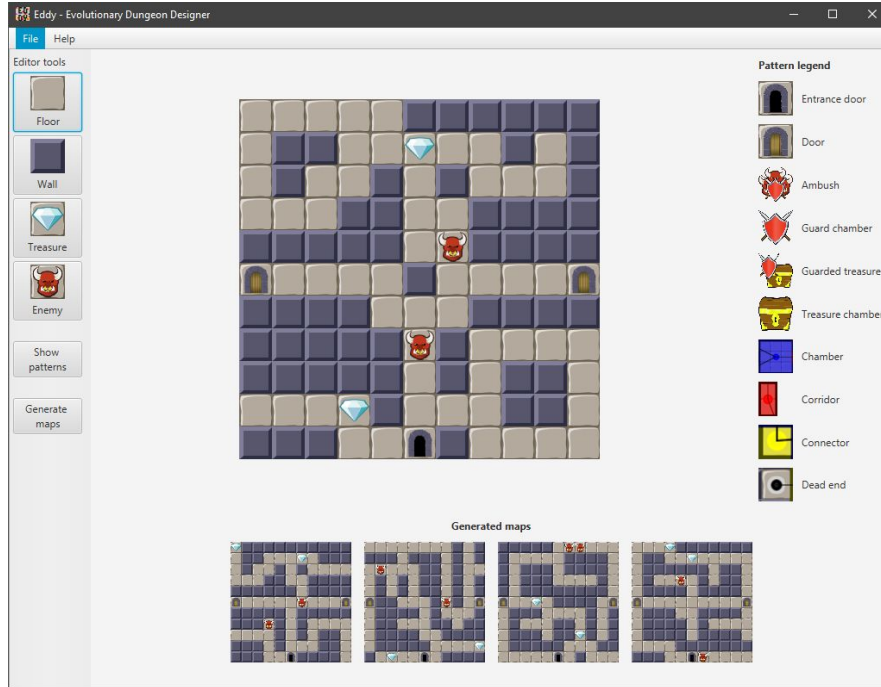


Figure 4.10. Eddy 2.0 after selecting a generated map.

4.2 Discussion

In Eddy 3.0 the mixed-initiative aspects have been improved to bolster the creativity and the complexity of the dungeons that the user can design.

4.2.1 Implementing a Fully Realized Dungeon

Providing the ability to create a fully realized dungeon was derived from identifying the most important factors in designing dungeons (section 2.4) and the feedback obtained from Eddy 2.0's user study. One of the major issues in Eddy 2.0 was the lack of information about a room's context. This context refers to the room's placement within a level, which would help the designer understand information about the level's progression and room's relevance. There was also criticism in regards to designing multiple rooms at once as expected from a dungeon designer, which Eddy 2.0 completely lacked. As there was a strong emphasis on the lack of providing a bigger picture of a

dungeon level, an instance of World View was introduced in the program's workflow, which directly addresses the problem. With the World View Eddy 3.0 connects multiple rooms into a grid; by doing this the user can see how the different rooms are connected which can make room for more advanced designs compared to when only a single room was present [1].

In order to preserve the mixed-initiative aspect of the program with the new additions, it was made sure that the suggested room generations would be maintained and adapted with the world grid in mind. In Eddy 2.0, the number of doors were hardcoded with their positions randomized. In this new version, the number of doors and their positions were updated to fit the world grid and its dynamically changeable size. A shortcoming of this is that the rooms will have doors generated for every side where adjacent rooms are present.

With the ability to create larger dungeons, having them be restricted to a grid can feel somewhat limited, especially when all the rooms within the grid are accessible. In order to reduce limitations of a grid the functionality to remove rooms from the grid was added. When a room gets removed it does not get completely removed from the grid, instead the room gets turned into a room filled with impassable terrain as well as removing adjacent doors leading to the now removed room. This serves two purposes, it makes it easier for the underlying logic that is creating the map, but more importantly, it makes it easy for the designer to enable the room again incase they change their mind. By disabling rooms a designer can create dead-ends and overall much more complex dungeon designs compared to if all rooms were enabled and accessible.

Mixed-initiative is dedicated to producing more interesting and exciting content that adheres to the designer's decisions. The world grid helps improve the human's judgement of their own creations by providing an overview of what they have done so far and a

better picture of the world's context. In this context we also assume that dungeons primarily are mazes [15] [16]. Expanding the world grid in size and complexity with the removal and enabling of rooms has significantly increased the structural possibilities and variety of narrative options for the designer when considering the player's exploration. As seen in section 2.4, the development of a dungeon's context is complex as it requires narrative variation and dynamic challenges that do not feel generic for the player [17]. Not only does Eddy 3.0's dungeons finally provide an even wider range of possibilities but it also enhances the input of the designer into its content which makes it a dynamic and more interesting subjective experience for the player.

4.2.2 Granting the Designer More Choice Through Mixed-Initiative

By providing the user a choice between starting with an empty room or a generated room, Eddy 3.0 maintains all of the mixed-initiative aspects while giving more control to the designer. With the previous implementation of Eddy 2.0 the user was always greeted with the Suggested Room View, meaning that starting with a completely empty room was never a possibility. The human designer will not feel imposed by the computer generated content if there is a choice to start with a clean slate. This is an issue that was brought up by one user in the user study conducted for Eddy 2.0 [1]. Some users purposefully selected rooms that were as close to empty as possible when selecting a suggested room. With these changes the user can make a conscious decision whether to start with a clean slate or from a suggested room without trying to find a somewhat clean but still generated room. Additionally, the human designer having the ability to easily enable or disable specific rooms to develop more intricate maze designs empower their role in the design process. By preserving human decisions in the design process, the collaboration between the human and computer generated content is improved.

As part of valuing the significance of a player's interaction with the game, game designers strive to inject interpersonal and dynamic challenges in their content. Even

without NPCs dungeons can still possess illusory personalities, which help add value to the game's replayability [15]. Aside from mitigating the issues of generic and random PCG designs, this is the main reason as to why the designer's manual designs should be enhanced and supported by the software's features rather than be disrupted.

4.2.3 Mixed-Initiative User Interface

While the new workflow for Eddy 3.0 is a large part of this work, another big part of it is the updates to the user interface, mainly for the Room View. In the previous version the elements present in this view was the room being edited, pattern legend, editing tools as well as four generated suggestions for new maps. All these elements were kept for the new version although moved around to better fit the new UI.

Due to the implementation of a larger world connecting multiple rooms, navigation had to be added so that the user can go between the different room in a natural way. In order to do this directional buttons were added around the map for every edge where a door was present. The reason for this was to clearly show the user where and in which directions navigation could be done. It would not make much sense showing a button to go to the north when there is not any room present at the north of the room currently being edited. In order to further emphasize where navigation is possible and not, preview images of the adjacent rooms were applied on the navigation button. This not only shows more clearly where navigation is possible but also shows the user what room to expect when navigating in either direction.

Another feature that was added to the UI that correlated to the larger dungeon was the addition of a minimap. The initial purpose of the minimap was to show the user all rooms for the dungeon so that the user can see how everything is connected. While this functionality was technically already present in form of the world grid, going back and forth between the two views would feel unnatural and add extra time and strain on the

user's work process. A later functionality that was added to the minimap was the ability to navigate using the minimap. While it works to only use the navigation buttons for a smaller world, like 3x3 for example, navigating from one side to the other in a 7x7 dungeons takes way too many clicks. By using the minimap to navigate the user can go from any room in the dungeon to any other room. This does not mean that the navigational buttons had to be removed nor that they were useless as both the minimap and the buttons serve extra purposes beyond navigation.

The final big UI change to Eddy 3.0 was the ability to compare certain stats between the currently edited map and the four suggestions that Eddy 3.0 provides. The stats that are displayed are limited to the underlying information regarding the maps, thus the stats that were shown were amount of enemies and treasures, percentage of enemies and treasures, as well as entrance and treasure safety. Eddy 3.0 displays these stats when a suggested map has been highlighted and colors the different texts red, green or white depending on whether the stat in question will decrease, increase or remain the same after applying the suggestion. Small up and down arrows were also added to emphasize increase and decrease.

4.3 Limitations and Threats to Validity

One of the major limitations to the features that have been developed is that they mostly relate to the feedback received for Eddy 2.0. This means that the features developed and implemented are quite limited and may have been affected by researcher bias. However, since these features were implemented within the timeframe of the thesis with not much time left over for other features, this limitation can be disregarded as there would not be any time left over to develop any original ideas.

Although the features implemented for this thesis are all based on the user study for Eddy 2.0 not all feedback is addressed with this thesis. However, this is not a big concern since

the missing features or changes can always be addressed in a Eddy 4.0. Some of the feedback that is not addressed within the thesis are also outside of the scope of mixed-initiative and user interface.

It is also possible that the features that have been implemented do not completely answer the feedback Eddy 2.0 received. Since there may be multiple approaches to implement any given feature, the way the features are implemented for this particular thesis may vary compared to if someone else would have implemented them. This is also true for the new workflow. There are no real guidelines as to how an optimal workflow should be constructed for a program like Eddy. The workflow that has been introduced, is however, rather standard with it following a top-down approach. These are concerns that would be present in any work that focuses on implementing any new feature to a program and should therefore not be of big concern for the validity of this work.

Despite these limitations, the validity of this work's contribution to the research area is still strongly supported by the conducted literature review. This is especially in the case of existing mixed-initiative game design tools, where the generation of dungeon levels consider different types of parameters both within and outside the genres of RPGs and dungeon crawlers. Eddy 3.0 provides a new perspective on how a dungeon with rich context can be created, while supported by mixed-initiative concepts and theory on dungeon creation within video games.

5 User Study

The goal of the user study is to answer this thesis' research questions. By observing and evaluating the usability of Eddy 3.0 and its newly implemented features, a conclusion can be derived as to whether this new iteration of the software does foster more creative content that adheres to the designer's intentions. In turn, the user study should also garner relevant feedback as to how Eddy's mixed-initiative and user interface can be improved further to provide a more intuitive and richer user experience, with a considerate value of usability as a game design tool.

5.1 Procedure

In order to obtain a large amount of qualitative data sufficient enough to evaluate Eddy 3.0 and help answer the research questions, a survey was conducted in a major game development studio with five professional employees who are within the development field. The participants were recruited by this thesis' supervisors and were all unknown to the researchers.

5.1.1 Process

The user study followed a similar structure to the user study of Eddy 2.0 and was as follows:

Introduction to the study: One of the authors gave a brief explanation to the study, which functionalities were present in the study and why it was being conducted. The user was also asked whether they had been part of the user study for Eddy 2.0.

Demonstration of Eddy 3.0: One of the authors gave a demonstration of Eddy showcasing the different features it possesses as well as what actions the user can take. The demonstration were as follows:

- Selecting a 3x3 grid as the dungeon
- Describing and showing the actions present in the World View, these actions being edit room, enable/disable room as well as starting with a suggested room.
- A suggested room was selected to start with.
- While at the Room View the different parts of the view were demonstrated and explained:
 - Editing the map.
 - Enabling/disabling the pattern view.
 - Navigation using the navigation buttons.
 - Navigation using the minimap.
 - How the suggestions work depending on the different checkboxes.
 - What the shown stats mean.
 - How to apply a suggested room
- Going back to the world grid and showing enabling/disable of rooms again
- Saving the map

Designing a dungeon: After the demonstration the users were tasked to design a 3x3 dungeon within approximately 10 minutes. When the period of 10 minutes has passed the users were then asked to save the dungeon so that it could be referred to in the result section of the user study. While the user designed their dungeon two observers took notes regarding how often certain tools and functions were used. The template for the observers can be seen in Appendix B.

Questionnaire: The users were asked a few preliminary questions regarding their background in game design as well as dungeon based games. They were also asked whether they had heard of or used any mixed-initiative tools before.

Interview: An interview was conducted as a semi-structured interview using the questions in Appendix A as a guide. Notes were taken by three people and audio recordings were taken from the interview as a transcript for later analysis.

5.1.2 Participants

User 1 has been working for more than ten years within the game industry as a data scientist and user experience researcher. They have prior experience with RPGs and dungeon crawlers. This user is familiar with the terms of mixed-initiative tools and has used The Sentient Sketchbook in the past. This user is also the only one that was present in the previous user study and thus the only one who had experience with Eddy 2.0.

User 2 has been working for six months as a project coordinator for eSports events and has a lot of experience playing dungeon crawlers and RPGs. This user has no familiarity with mixed-initiative concepts and has never used a mixed-initiative authoring tool before. They were not involved in the last iteration of Eddy 2.0's user study.

User 3 has been working for six years in the game industry as a user experience researcher and a biometrics expert. The user has prior experience with dungeon style games. They have very little knowledge about mixed-initiative tools and have no prior experience with any such tool nor Eddy 2.0.

User 4 has been working for nine years as a senior user experience researcher and has a lot of experience playing dungeon crawlers and RPGs. They are not familiar with mixed-initiative concepts and has never used a mixed-initiative authoring tool before. They were not involved in the last iteration of Eddy 2.0's user study.

User 5 has worked for three weeks as a game user researcher. This user has no experience with dungeon crawlers or dungeon based RPGs. They have also no knowledge regarding mixed-initiative tools and was not part of the testing of Eddy 2.0.

5.2 Results

The qualitative data taken from the user study consist of synthesizing together the end-result of the participants' respective dungeon designs, their answers to the survey questionnaire, their first impressions and feedback for Eddy 3.0, and the direct observations done during the designing process by one of the authors and three other colleagues who are involved within Eddy's research area.

5.2.1 User 1

User 1's main intention with their design had a high consideration on the rooms' contexts and connections with each other within the dungeon, following a main theme. Their design decisions were mainly driven by the desire to have chambers in a room only accessible from a specific adjacent room. This proved the usefulness of the minimap in the Room View which the user highly appreciated. However, this also resulted to very little interest in switching to the World View and the function for enabling and disabling rooms. The user thinks that the World View's functions should already be available within the Room View's minimap. The minimap was primarily used and highly studied for making design decisions, as well as for navigating around the dungeon. The directional buttons were only used once for navigation.

The feasibility warning of a room being currently edited was not clear to the designer in terms of what defines it. This in turn restricted the designer's intention of having the rooms contextually related with each other. Eddy 3.0's current definition of what is feasible specifies the inability to have closed off chambers within a room, which did not

adhere to the user's desire to access these chambers from specific adjacent rooms. As the user has tested Eddy 2.0, they have described that the illusion of a fully realized dungeon with rooms has been somewhat achieved, but due to this limitation the designer feels that their intent has been disrupted.

User 1 started with an empty room during the beginning of the design process, and never switched to Suggestions View throughout its entirety. They preferred designing a room always from scratch.

The stats for suggested maps were highly studied when inspecting the suggested maps in the Room View, especially the entrance and treasure safeties. However, the user still shows some doubt that they are representative of the specific map as they are described to be not informative enough. The checkboxes for symmetry and similarity for suggested maps were not easily understandable at first. The user also wants the ability to select a suggested map and preview it on the current room and in the minimap. This is for helping their decision-making, to be able to quickly judge by comparing it to the currently implemented room. They suggested either a functionality that allows you to flip back and forth or a slider. They also desired a small form of version control where their previous room would be saved in case they have second thoughts on the applied suggestion.

There is uncertainty in regards to the design patterns' definitions as they are not self-explanatory. They were also deemed as not good visual presentations of the map's distinct parts. The user also suggested that patterns should not only be just a visual guide for the designer, but that they should also serve as tools that can be used when trying to generate a map, for example as a brush type.

The user inquired a lot about the starting room and the difference between the entrance and normal doors as they are considered to be important in making decisions. This was an

issue because Eddy 3.0 does not regard a starting point and does not have a fully implemented calculation on how entrances should be positioned. The dungeon developed by user 1 can be seen in Figure 5.1.

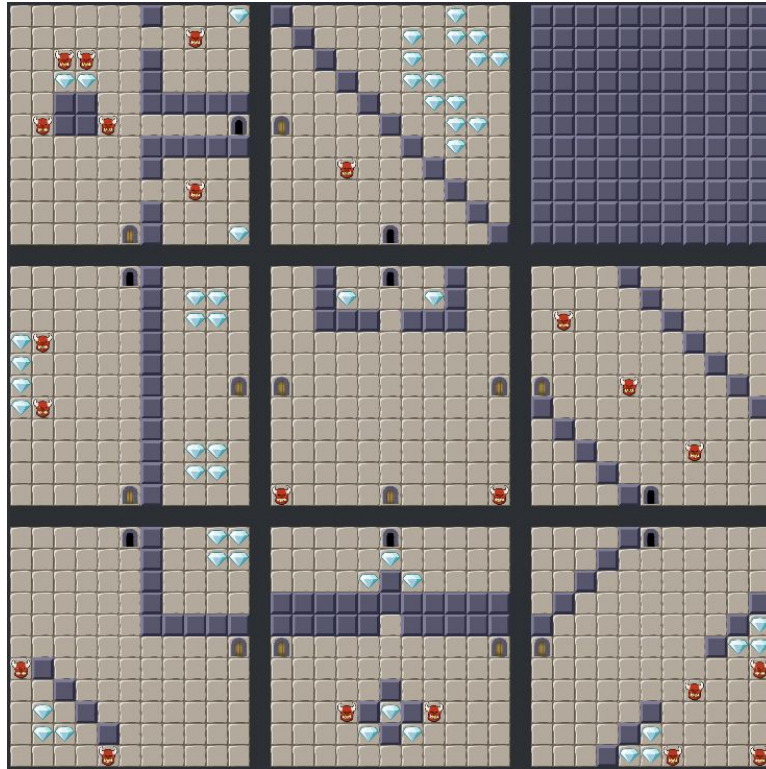


Figure 5.1 User 1's dungeon design.

5.2.2 User 2

User 2 generally thinks that Eddy 3.0's top-down workflow is logical but points out that the World View seems pointless as it was only ever used to access the Suggestions View for starting a room. The user felt that the suggestions within the Room View were too barren if they started with an empty room and would rather have a complete room to iterate on. The function to enable and disable rooms on the World View was completely ignored as it was easily unnoticeable. They also wanted the minimap to be bigger in size.

An interesting comment they made is that they rarely studied the stats of the room suggestions to make decisions. They would quickly decide based on their visual judgements of the maps' appearances and content. The user also expected the suggested maps in the Room View to be vastly different just like the maps generated in Suggestions View. This is a preference they think is important to the designer, who wants to see other possibilities that they cannot conjure with their own design ideas. They therefore think that there should be more control on the similarity and difference of suggestions between each other and the designer's current edits, as it would increase the number of more interesting variations. Suggested maps in Room View and Suggestions View served as really good inspirations if anything.

The user switched almost equally between starting an empty room from scratch and choosing from a suggested view. They were initially confused by the options' availability so they chose starting from scratch but later on started using Suggestions View for a fair amount of times. They also wanted the ability to create templates or copies of other rooms so they can continue developing on top of them. Additionally, similarly to user 1, user 2 found the patterns' meanings to be unclear because the lines go through walls.

The functions of the checkboxes were rarely used and there was confusion on their purpose initially, as to whether they inherited from the current room or not. The user also suggested the options to have checkboxes that control the number of a specific tile type in a map. The dungeon developed by user 2 can be seen in Figure 5.2.

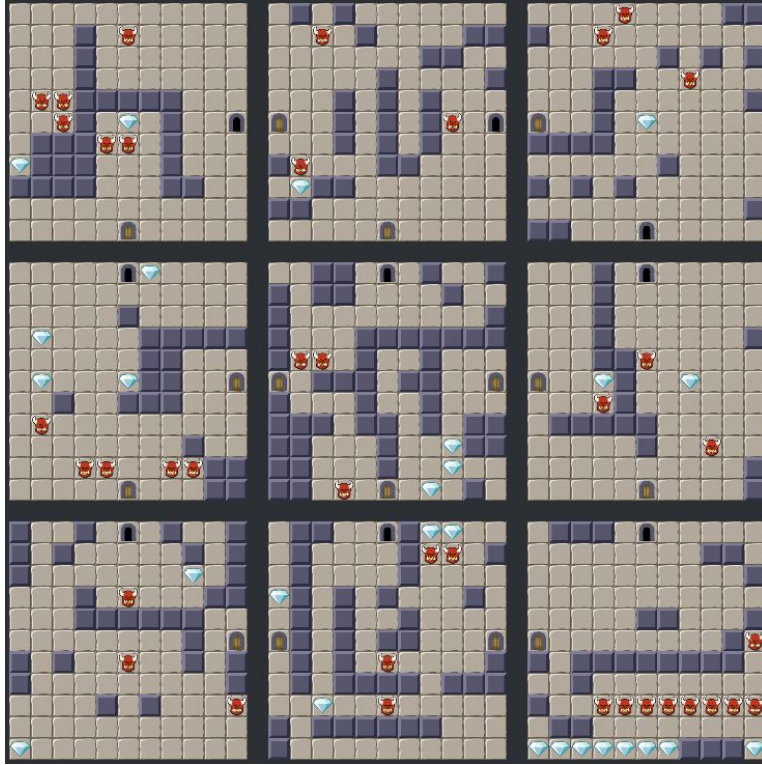


Figure 5.2 User 2's dungeon design.

5.2.3 User 3

User 3 was mainly driven by Eddy 3.0's suggestions in designing their entire dungeon while making small manual alterations. Due to this reliance, they expressed preference on showing more suggested maps in the Room View and having more control over their generation; for example, a slider that manipulates fitness functions. The World View was used a number of times solely for the intent of starting a room with Suggestions View.

The user in general is not very interested in repetitive and similar designs and often switches back to Suggestions View in order to contemplate about the next room design. Patterns would also be preferred on the World View but not necessarily on the minimap. They also are preferred to provide clearer paths in the map.

Stats are seen to be helpful for evaluating difficulty and for balancing it across the dungeon. Suggestions that are vastly different from the current room are preferred, as well as suggestions that depend on desired stats, in which they can control the generating algorithms. They would also like the program to do more analysis regarding information about map routes both on a room level and a dungeon level.

In regards to the experience itself, the user complained that there is too much clicking around. More automated assistance while doing manual input would be welcome. Similarly to user 1, user 3 was highly curious about the dungeon's starting point and was confused about doors and entrances. In general they wanted more information about the dungeon. Another issue they pointed out was that feasibility was not clear as it does not take into consideration the full scale of the dungeon. The dungeon developed by user 3 can be seen in Figure 5.3.

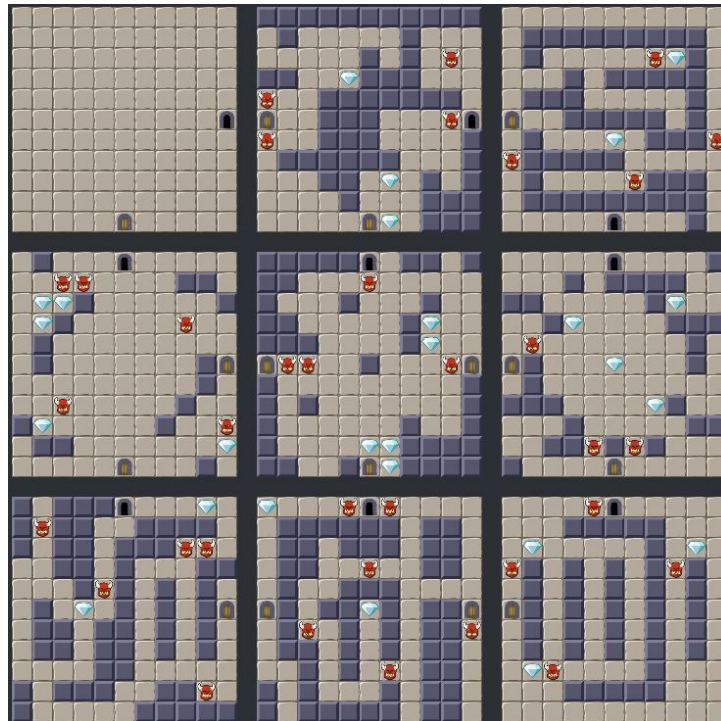


Figure 5.3 User 3's dungeon design.

5.2.4 User 4

User 4 found Eddy 3.0 in general to be intuitive and not restrictive, with its top-down approach making sense. They built new rooms from scratch and sometimes considers adjacent rooms when making design decisions. They never used the Suggestions View at all. They highly prefer the minimap and never used the World View throughout the design process. The room previews of the navigation buttons were also helpful for understanding the current room's connection to its adjacent rooms, aside from using the minimap. They mainly used the navigation buttons to move through the dungeon consecutively. Disabling and enabling rooms were certainly found to be interesting but only for bigger world sizes.

They placed a strong emphasis on desiring the ability to have a closer examination in the suggested maps of Room View by having them bigger in size while having more control of their values. Stats were suggested to be improved to help evaluate challenge and balance across the dungeon. Checkbox options were used but only to check the possibilities. They also wanted the ability to inherit a grid's content to another, similarly as user 2. The ability to save suggestions for later use was also suggested.

Similarly to some previous users, the dungeon's starting point and clarification of doors were inquired. The stats for suggested maps in the Room View were quite lacking, as user 4 wanted more information about the wall occupation and free space of the rooms, as well as the amount of routes. Patterns were also unclear and not self-explanatory. Suggested maps were primarily used as inspirations which user 4 found to be very useful, which is interesting as they would only manually design a room from scratch. They also wanted the ability to tinker with patterns and use them to generate rooms based on them.

Less clicking throughout the program was desired, such as suggesting features like dragging brushes. The dungeon developed by user 4 can be seen in Figure 5.4.

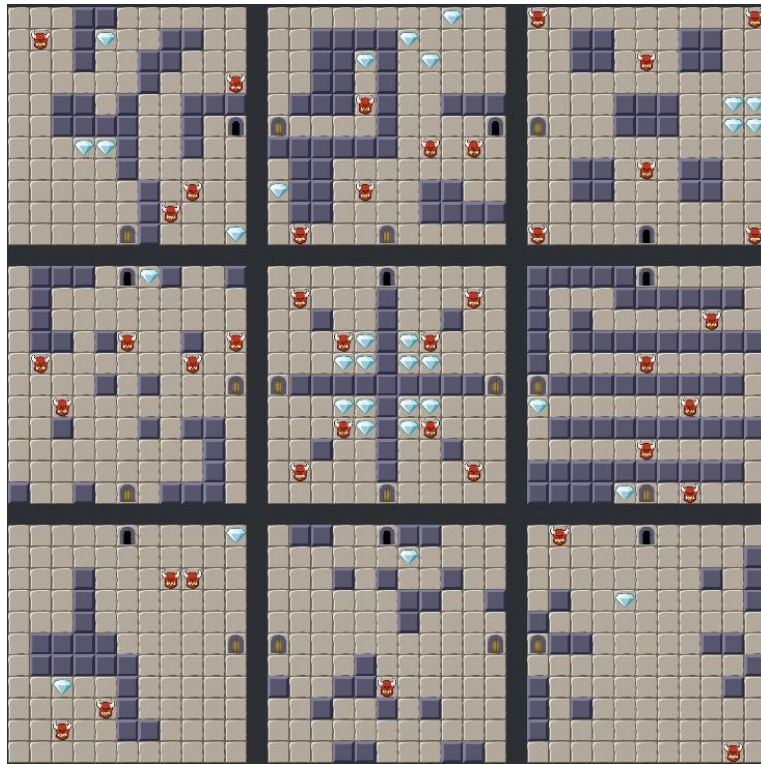


Figure 5.4 User 4's dungeon design.

5.2.5 User 5

User 5 positively commented on Eddy 3.0's top-down approach. They highly prefer the minimap when making design decisions but deems the World View to still be helpful because it provides a more focused view. The enabling and disabling of rooms feature was also appreciated and was described to be useful for bigger world grids. They almost always used suggestions for creating rooms, and frequently checked the patterns while sometimes keeping them on as they design. However, the patterns' implications sometimes confused them.

They highly preferred using the minimap for navigation and would have preferred world view's functionalities to be present on the minimap as well.

User 5 did not really pay much attention to study the stats of suggested maps in the room view similarly as user 2. However, they claim this was due to the testing's time constraints. They were also confused on the checkboxes' functions as they did not know they would manipulate the suggestions depending on the current room. They claim that the suggestions would definitely be more helpful when designing bigger dungeons. However, when asked about whether they would like more automated assistance while doing manual design decisions, they answered that this would be invasive for the designer, possibly making them falsely doubt their own decisions. The dungeon developed by user 5 can be seen in Figure 5.5.



Figure 5.5 User 5's dungeon design.

5.3 Discussion

This section will comprise of a condensed summary of results from the user study and further discuss them within the context of mixed-initiative principles.

5.3.1 Condensed Data Summary

As with any raw qualitative data, the data collected from the user study has to go through a condensation process in order to isolate the most relevant information that will answer the research questions. In a blueprint provided by Srnka and Koezegi [24], the qualitative data obtained has underwent four out of five stages:

1. Material sourcing - An audio recording the user study, interview materials, and the authors' own observations.
2. Transcription - Combining and writing down the observations and questionnaire answers for each participant in the user study.
3. Unitization - Dividing the data according to the mixed-initiative features of Eddy 3.0
4. Categorization - Dividing the data according to categories relevant to the research questions while taking into consideration the principles of mixed-initiative.

All participants in the user study perceived Eddy 3.0 as overall good and intuitive. In this section their general consensus of Eddy 3.0's usability has been extracted and condensed in Table 5.1 as well as Table 5.2.

Table 5.1: General Consensus on Eddy 3.0's Features

Description	Participants' Consensus
World Grid of the dungeon	Its purpose of establishing an illusion of a fully realized dungeon is somewhat achieved. However, limitations exist with how it defines feasibility, a dungeon's starting point, and the entrances, which disrupts the designers' decisions.

World View	The World View's usefulness for the most part could not be established, other than for the purpose of going to the Suggestions View (which was already seldom during the user study) and having a closer look at the entire dungeon without any distractions. Some participants preferred features to be already in the Room View's minimap, and some wanted to see more specific functionalities within the World View itself.
Enabling and disabling rooms	As the user study restricted participants to create 3x3 dungeons, this feature for the most part has been neglected. This is also in part because of its accessibility only being in the World View, which proved to be an inefficient view in general. However, its use for bigger dungeon sizes later on was appreciated, especially for more intricate design purposes.
Suggestions View	Similarly to enabling and disabling rooms, it was quite difficult to encourage the use of this functionality due to the World View's inefficient usability. However, this could also be due to the dungeon's small size, as some participants expressed high interest in using more suggestions with larger dungeon sizes.
Minimap and navigation	The minimap proved to be a strong tool not only for navigation purposes, but also for supporting design decisions and choices. The directional buttons were rarely used, but their room previews were helpful in emphasizing the current room's connection to adjacent rooms without looking at the minimap. On the other hand, this lowered the usability of the World View.
Stats	The stats were, in general, lacking. They served to be important in decision-making when choosing a suggested map in Room View, but there were still doubts on their accuracy and sufficiency when providing information about the generated suggestions.
Generated maps for suggestions in Room View	Suggestions in the Room View proved to be very helpful in supporting the whole design process as they primarily acted as inspirations for the users. The most prominent comment among the users is the preference of having more control on how suggestions should be generated depending on different types of parameters.
Design patterns	The patterns' visualization was, in general, lacking and not self-explanatory. Some participants have expressed interest in using patterns as a parameter in the generation of suggestions.
Dark theme	Eddy 3.0's dark theme received a positive response as it makes working with the program easier.

Table 5.2: Participants' Most Demanded Features

Feature	Description
Design patterns	Their visualization and accuracy should be improved. Other than acting as visual guide for map information, they should be used to help generate rooms as well. They should also be available for the entire dungeon.
Stats	They need to have more information about the specific room, and have better visualization that will make the designer trust their accuracy more. They should also consider the entire dungeon as a whole in different terms such as difficulty and balance.
Generated suggestions	In general, the participants want more variety and control in the generation of suggestions using different types of parameters e.g. their degree of similarity and fitness functions.
Redefined feasibility	Eddy 3.0's definition of feasibility should be revised which considers the whole dungeon and its connected rooms.
World View	The World View should be revised and enhanced with more special features which would encourage users to visit it more.
World grid	The computation of the whole dungeon should be improved. It should have an option to define a starting point. Its definition of entrance doors should be improved, as well as the calculation of distances of tiletypes.
Version control and previews	Some participants want to preview suggestions within the Room View to help their judgment and the ability to save suggestions for later use. They also want to revert to old designs in case they have second thoughts.
Templates	Some participants want the ability to save their own manual designs to be carried over in other grids.
Automated assistance	The participants in general welcome a bit more automated assistance when doing manual designs, which can reduce clicking around the program. It should also not be too invasive for the designer.

5.3.2 Eddy 3.0 as a Mixed-Initiative Tool

The main goal of mixed-initiative interaction pertains to the flexibility of roles between the human and computer as a team and simplifying the experience [19], and this was

somewhat achieved by Eddy 3.0. This could be proven by how features such as suggestions and the implementation of a whole dungeon with navigation have definitely supported the users when making decisions throughout the design process. As a result the experience was overall simple and intuitive. It could not be said, however, that this has been fully achieved; a fully successful mixed-initiative system emphasizes interchangeable roles of the human and computer while maintaining the balance between them. The participants in the user study did not feel restriction, but they still desired more control in Eddy 3.0's assistance in the design process, as well as different suggestions that the designer cannot come up with themselves.

In Horvitz's work for Microsoft Research, he provided a list of principles for mixed-initiative UI which would enhance HCI. [18] This has been used as a model for isolating the most relevant factors within the context of what Eddy 3.0 has achieved and they are shown in Table 5.3. Eddy 3.0 has achieved four out of twelve in Horvitz's list of critical factors that would make up a fully successful mixed-initiative system.

Table 5.3: Mixed-Initiative Principles Within Eddy 3.0

Principles	Definition	Eddy 3.0
Developing significant value-added automation	Providing an automated solution that cannot be achieved with direct manipulation	The generation of complex dungeon with different sizes, and the improved suggestions within the dungeon while providing information about them in the room view.
Considering uncertainty about a user's goals	Taking advantage of a user's uncertainty in their intentions	Providing the choice to start rooms in a dungeon with either an empty slate or from Eddy 3.0's generated suggestions.
Inferring ideal action in light of costs, benefits, and uncertainties	Considering the value of an automated service in regards to the usually expected value of taking actions	Eddy 3.0's main motivation is to significantly reduce the cost of game design while maintaining and improving creativity.
Employing dialog to resolve key uncertainties	Establishing an efficient dialog between the human and computer when uncertainty arises while considering the costs of potentially disrupting the user	Providing stats of a suggested map for the user to guide their decisions. The minimap also plays this role.

There are other principles which are relevant to Eddy 3.0 which fall in line with the participants' feedback. For example, some principles such as the ability to continuously learn from the user's input and to preserve memory of their decisions and actions may pertain to the desired features of having more control in the generation maps and receiving more assistance in preserving their own manual designs for different purposes.

5.4 Limitations and Threats to Validity

Evaluating mixed-initiative systems can be difficult to extract data from. To this date, in regards to evaluation tools, there is currently little work done for establishing a standard which can be used when conducting important user studies and experiments when it regards to the system's mixed-initiative performance [20].

With a user study of a survey type conducted on such a small scale with only five users in a short amount of time, gaining any form of quantitative data is almost impossible. As the evaluation of Eddy 3.0 directly pertains to its usability, there are main aspects in which quantitative data would have been significantly more helpful for measurement: effectiveness, efficiency, satisfaction, and their correlations with each other [22]. If the user study was conducted on a much bigger scale, quantitative data would have been obtained and plotted using this model garnering higher quality results. This is the main reason why the qualitative analysis skips the fifth stage of coding the data to numerical values in the guideline aforementioned in section 5.3.1.

This, however, does not mean that the qualitative data gained from the user study is useless. With all users having some form of background in game design, their input and feedback is highly valued as qualitative data. Furthermore, due to the nature of the work done for this thesis, getting any form quantitative data is tough. Since the changes made to Eddy are mostly related to user interface changes, most data that can be gathered would be subjective. There is no real measurement in whether a feature or a UI change is good or bad or how good or bad. With this in mind it can then be seen as sufficient to only have conducted a smaller scale user study in order to gather data.

Another issue regarding the user study is the time each user had in order to design their dungeon. For this user study each user had approximately 10 minutes to design an entire 3x3 size dungeon. With the user study for Eddy 2.0 each user had 15 minutes to design three separate single rooms and even that was argued to be too little time to properly evaluate Eddy. With the additional features Eddy had for the 3.0 user study, 10 minutes to design effectively nine rooms could definitely be argued as to being too little time. However, the intent was that the users would utilize the disabling of rooms more than what ultimately happened. On the other hand, when user 5 were running out of time they

chose to disable the last few unedited rooms making use of the feature in an interesting manner.

Lastly, the qualitative data was obtained from three researchers (including the author) from different backgrounds within Eddy, decreasing the chances of high researcher bias.

6 Conclusion

The goal of this thesis was to explore how the user interface and the mixed-initiative aspects could be improved for the Evolutionary Dungeon Designer in order to increase creativity in dungeon designs. The following three research questions were asked at the start of the research in order to guide the process of evolving Eddy:

RQ1: How can the mixed-initiative aspects be improved further in the Evolutionary Dungeon Designer?

RQ2: How can the user interface be improved to give more relevant feedback to the user in the Evolutionary Dungeon Designer?

RQ3: Do the newly implemented features foster more creative content that adheres to the game designer's choices?

Since Eddy has been subject to a user study in the past, answering RQ1 results in simply answering the feedback that is related to mixed-initiative. For this research this meant mainly the implementation of a world grid connecting multiple rooms to a more complete dungeon. With the addition of the world grid a new workflow was also adopted. This new workflow enhances the choices a user can make when creating a dungeon as both empty rooms as well as complete suggested rooms are present to start with. Although the user study provides very broad feedback for the entire program, the feedback received regarding these new additions were overall positive. The positive feedback regarding the world grid and the like would indicate that RQ1 is fully answered.

With the addition of the world grid, various user interface changes had to be made to accommodate the increased dungeon size. With a larger dungeon, navigation had to be

added in form of buttons. Furthermore, by overlaying the adjacent rooms as a preview on the button the user can get a better understanding of the context of the room currently being edited. In line with the navigation and larger dungeons, a minimap was also added to further enhance the experience when designing a larger dungeon. Alongside these changes, visual cues for stats regarding rooms were added so that the user can make a more conscious decision when selecting suggested maps. These UI changes all serve to answer RQ2 by improving the user interface and provide a greater feedback to the user. While these changes are not the only changes that were made to the user interface they are the most vital ones that serve to increase the feedback the user receives from Eddy 3.0.

RQ3 is, by nature, difficult to answer since it asks whether the implemented changes will foster *more* creative designs which makes it a very subjective question to answer. Since the user study conducted for Eddy 3.0 only had one user that was present for the user study of Eddy 2.0, comparing the results between the two user studies to see if any of them are more creative than the other is pointless. Furthermore, evaluating whether a design is creative or not or how creative it is can be subjective in itself. However, since the implementation of the world grid allows the user to design multiple rooms that connect to one another, one could argue that by nature more complex and creative designs will always be made compared to the single room designs. It is worth noting that some of the designs that were made during the 3.0 test would never have been possible with Eddy 2.0. Lastly, creativity can directly adhere to the amount of interesting possibilities a designer can exploit, which is relevant to providing rich contexts to dungeon designs. Eddy 3.0 has provided a mixed-initiative experience that provides adequate flexibility for the designer's intentions as the user study's results have shown. With all this in mind one could argue that RQ3 is answered with the evaluation of this research.

6.1 Future Work

Since this thesis has primarily focused on the mixed-initiative aspects of Eddy as well as the user interface, some feedback from the user study of Eddy 2.0 has not yet been addressed. These missing features should still be taken into consideration for future versions of Eddy. However, amongst these changes are requests for fitness functions dealing with similarity and symmetry. Since these fitness functions have been implemented by another student in a parallel thesis, depending on the outcome these features may not be needed for future version of Eddy.

Alongside the unanswered feedback, future versions of Eddy should attempt to answer the feedback received during the user study for Eddy 3.0. A list of these features and functionalities are brought up in Table 5.2 in the Discussion section of chapter 5 User Study.

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Appendix A

Pre-Questionnaire

1. How long have you been working in game development?
2. What is your current role and position in it?
3. Have you played or do you play games with dungeon-style levels?
4. Are you familiar with the concept of mixed-initiative? If so, briefly explain it in your own words.
5. Have you used mixed-initiative tools before? If so, what are they and what did you think of them?

Main Questionnaire

1. First impressions about the application?
2. World grid view
 - a. Do you like the strictly top-down approach of going from the world view to the other views?
 - b. Did you find the ability to remove rooms useful in creating complex designs?
 - c. Do you prefer starting with an empty room or a suggested generated room?
 - d. Are there any features missing you'd like to see in the world grid view?
 - e. Does the removal of rooms make sense in the design context to you?
3. Room View
 - a. Do you find the minimap useful in designing your world?
 - b. Do you prefer navigating in the world using the directional buttons or the minimap?
 - c. Do you prefer checking the adjacent rooms in the world using the directional buttons or the minimap?
 - d. Were the stats helpful on deciding whether you want to use a generated room or not?
 - e. Do you find the patterns helpful in designing your room?

- f. Do you find it useful to be able to go back to the world grid or is the minimap sufficient? Or would you prefer to have the World View's functionalities present in the room view with the minimap?
4. Suggestions and PCG
- a. Did you find the provided suggestions interesting? Why or why not?
 - b. How interesting did you find similarity and symmetry?
 - i. How important these features are while designing a room?
 - ii. Would you like to have the capability of tuning the level of similarity/symmetry in the generated suggestions?
 - c. Do you prefer to build from scratch or on top of a suggested room?
 - d. Are there any features missing you'd like to see in the Suggestions View?
5. General questions
- a. Do you feel that the design process is restricted in any way when thinking about the world's complexity?
 - b. Do you want the program to assist you more while manually editing a room?
 - c. Are the generated suggestions enough recommendations in the design process or do you want the program to suggest more recommendations in other areas?
 - d. How often do you wanna see the design patterns on the map?
 - e. How much do you care about the dark theme?
6. FINAL COMMENTS?

Appendix B

Notes From the Observer

Considerations: Frequency of usage

Description	Frequency of usage?	Other
Uses the world view		
Uses the minimap to navigate		
Uses the buttons to navigate		
Uses the disable/enable room on the world		
Observes the dungeon through minimap		
Save / loading dungeons		
Study stats of room suggestions to make decisions		
Choose between empty and suggested rooms		
Checkboxes		