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Full Paper

Development and Validation of a 2D Educational Adventure Game on Dental Health Using the GDLC Method

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ABSTRACT

Currently, dental and oral health problems in Indonesia are still quite high, because according to the 2018 Basic Health Research Results, the largest proportion of dental problems in Indonesia are damaged/cavities/painful teeth. Oral diseases can cause pain, suffering, psychological obstacles, and social deprivation, which are very detrimental to both individuals and citizens, including children. Poor oral conditions, such as many cavities, can disrupt daily activities. The purpose of this research is that games created using the Game Development Lifecycle (GDLC) method can convey information to users, and when played by players, the gameplay stage will be examined using the Blackbox Testing method. The creation of an educational adventure game project plays an important role in increasing insight by utilizing technology to understand the science of dental and oral diseases. The party involved in this research is a dental expert to validate this game according to valid material. With this research, results can be obtained with a validity value on the educational game material and a feasibility value. Later, the percentage value will determine whether this game is good or bad, using the Game Development Lifecycle (GDLC) methodology. Of the two dentists who have validated the material in the Denterra educational game, the average result of expert validation reached 91% valid, meaning the material in this educational game is Very Feasible according to the Achievement Level Conversion Table. The results of Blackbox Testing reached a value of 94% or 237/252, with features that are less agree that the feature is functional for players are the "Level" button (Before completing the game), "Dental Plaque beats PD", and "Dental Crust beats PD". From the Blackbox Testing Analysis, it can be concluded that the functionality of the Denterra educational game is Very Feasible for use by the public. Then, the difficulty level at each level is appropriate for those with 3 players. The sample data that has been produced is not comparable to the student population in Banyumas Regency, due to time constraints and the environmental conditions of the subjects.

KEYWORDS

Dental and Oral Diseases; Games; GDLC; Health; Technology

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1. INTRODUCTION

Director of Primary Health Services drg. Saraswati, MPH, said the prevalence of dental and oral health problems in Indonesia is still very high. The results of the 2018 Basic Health Research (Riskesdas) stated that the largest proportion of dental problems in Indonesia are damaged/cavities/painful teeth (45.3%). Meanwhile, the oral health problems experienced by the majority of the Indonesian population are swollen gums and/or abscesses at 14% [1]. This quite worrying because if the presentation of damaged teeth, cavities, swollen gums, and abscesses added up, the result are 59.3%.

Dental and oral health plays a useful role in a person's life to obtain good universal health. Oral diseases can cause pain, suffering, psychological obstacles, and social deprivation, which are very detrimental to both people and citizens, including children. Poor oral conditions, such as many cavities, can interfere with the function and activity of the stomatognathic system [2]. This dental disease can also be implemented using technology that has entered all areas of life. In addition, technology can also help improve efficiency in learning. An example of technology that can be implemented in learning is by using 2D games [3]. This game can be designed using the Game Development Lifecycle (GDLC) method with application design and The Game Design Document (GDD) as output and benchmark. Game Development Lifecycle (GDLC) has a method that makes it easier for researchers to design and improve this educational game and can help game makers follow structured steps, avoid chaos, and minimize the risk of errors [4]. Meanwhile, the Game Design Document (GDD) is used as a guide to create the game that will be made [5]. So, this study aims to design and build a 2D educational game with an adventure genre to eradicate tooth germs that is implemented with the CONSTRUCT 3 website, which is the best and most mature game development tool targeted for HTML5 [6].

In the research results later, the game will be released publicly on the internet via HyperText Markup Language. The results of the game's value will be presented in 2 ways, namely validating the content that will be displayed in the game and the functional value of the game, ensuring that the game played by the player can function properly. Based on the background that has been described above, it can be seen that the problem in this study is how to implement game design for dental and oral disease education as a learning medium about knowledge of the disease. This game needs to be made so that players do not only consult a dental clinic, but by trying this game, players can gain insight into the causes of dental disease. The goal of this health research is to ensure that games created using the Game Development Lifecycle (GDLC) method can deliver information to users. When played, the gameplay will be examined using the Black Box Testing method. Based on the identified research objectives, the benefits of this study are practical, namely that the information generated by this game can provide new experiences. Theoretical benefits include its use as reference material and inspiration, benefiting researchers, providing new knowledge and information, as well as experience and skills problem-solving. Games are a form of entertainment that people choose to a relieve boredom fill their free time. Beyond entertainment, games can also be an educational tool [3]. Games defined as arenas for player decisions and actions, with targets to achieved and intellectual agility to a certain degree, a dimension of how engaging the game is to play optimally [7]. A game defined as an environmental activity embedded with rules, gameplay, and culture. A game is a system in which players engage in artificial conflicts. Here, players interact with the system, and the conflicts within the game are either engineered or artificial [8].

The game genre chosen for this game is adventure because the genre presents long-term challenges that must overcome using equipment or items to overcome obstacles, as well as smaller obstacles that are almost constantly present. Furthermore, as stated in the background, the game category used for this game is 2D. A 2D game is a two-dimensional object represented in a plane consisting of x and y axes, often also the Cartesian plane [8]. Construct was one of the first examples of creative development-level software running in the browser and now has one of the best and most mature game development tools targeted at HTML5 with the JavaScript programming language [6]. Construct 2 was developed by Scirra and founded by Ashley and Thoma Gullen in 2011. Since then, the application has been updated regularly with new features. Construct 2 tends to be user-friendly. The software has been around for more than 5 years, has an active user community, and has a responsive development team [9].

Educational games are games that combine games with scientific material [10]. Players not only find pleasure in the games they play, but also gain knowledge that absorbed from the game. Educational games can used in non-formal educational contexts by encouraging a learning environment that does not necessarily follow certain norms [9].

2D games are two-dimensional objects represented in a plane consisting of x and y axes, often called the Cartesian plane [8]. 2D images can created using Vectors or Bitmaps. In 2D games, all objects and character

movements are limited to a single flat plane called StaticView, the movement will only vertical and horizontal, referring to objects and background images that can move left or right based on the speed of character played [7].

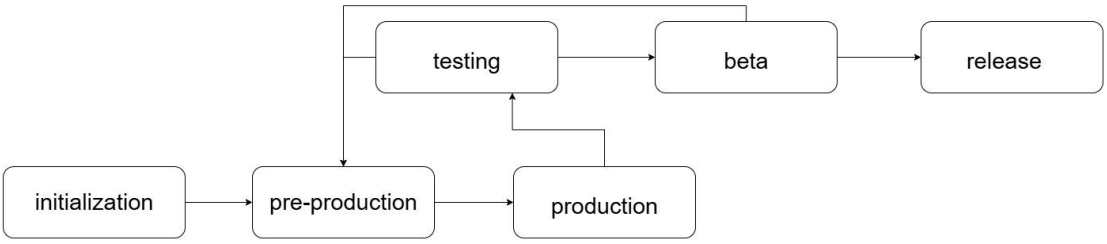


Figure 1 GDLC

Game Development Life Cycle (GDLC) see Figure 1 is a game development process that uses an iterative approach consisting of 6 development phases, starting from the initialization phase, or concept creation, pre-production, production, testing, beta, and release. The reason this study uses the GDLC method is because it contains a special cycle in game development and aims to respond to 3 issues that arise when improving games, namely what criteria must be considered when developing games, how to produce games with good quality, and what steps must be tried when improving games [9].

Human teeth act as a tool for tearing and chewing food. In the human oral cavity there is a hard structure called teeth. The shape and structure of human teeth are diverse, and each tooth can perform various functions [11]. Cavities are a condition of damaged teeth due to erosion of the outermost layer of teeth (enamel). This condition is caused by the accumulation of bacteria in the mouth due to frequent consumption of sweet foods and poor oral hygiene [12]. Dental plaque is a sticky and clear layer on the surface of the teeth that is created from food residue. The danger of dental plaque is that if not cleaned, it will become tartar, which can affect dental and oral health and can even disrupt overall body health [13]. Tartar is a layer of hardened dirt on the teeth. Tartar is difficult to remove even after repeated cleaning or brushing. Therefore, it can only be treated by a dentist. Tartar is caused by plaque on teeth that are not brushed regularly. Untreated plaque can harden and form tartar, or crust, that is difficult to remove just by brushing your teeth [14]. A Game Design Document (GDD) is a very descriptive document for video game design. The GDD is created and edited by the development team and is used in the video game industry to organize the various teams that exist [5].

2. METHODS

The research subjects were designated for students, so there were two places that became the research subjects, namely the head of the foundation and the children of the Dharmo Yuwono Purwokerto Orphanage on 06/15/2025. Then the students at SMK Negeri 2 Purwokerto on 06/19/2025.

For the research object in the form of educational game software, Denterra, a 2-dimensional game that has an educational theme of the world of teeth (Dental), this game can be played publicly. Interview results and questions are given to resource persons/experts/dental and oral medicine to obtain material for this final assignment. The following are questions that are the subject of research and will be answered by experts:

1. What is a cavity?
2. Where does dental plaque come from, and what happens if dental plaque is left untreated?
3. What is dental plaque?
4. What is Streptococcus mutans bacteria in teeth?
5. What is Mineral Fluoride?
6. Is the source willing to be an external examiner?

Because material from books and other media is used only as a reference, interviews with experts are necessary to validate the material. To compile the Expert Validation Form, Table 1 is used as follows:

Table 1 Validation Form

No.	Question Indicator	Answer Indicator	Clue Indicator	Valid Rating (1-5)
1	If dental plaque is left, it will turn into...	Dental Plaque/Iron	Dental plaque comes from food substances. If the pile becomes thicker, then dental plaque will turn into tartar.	
2	The outermost surface of the tooth is called....	Enamel/Chlorophyll	The outermost surface of the tooth is called Enamel	
3	Dental plaque comes from residue food and drink that contain...	Vitamins/Sugar	Dental plaque comes from leftover food and drinks that contain sugar.	
4	Dental plaque will disappear if...	Eat 3 More Meals/Brush Teeth	Dental plaque will not disappear if we don't brush our teeth.	
5	If dental plaque is left, then it becomes more and more thick and hardened.	True/False	If dental plaque is left, it will get thicker and harden over time.	
6	Tooth crusting can cause teeth to become...	Shaky/Hollow	Tartar sticks to the neck of the tooth; if left on the neck of the tooth, the tooth will become loose.	
7	STREptococcus mutans bacteria can cause teeth to become....	Shaky/Hollow	If Streptococcus mutans bacteria come into contact with food remains, they will produce acid, which causes cavities.	
8	Tartar is a buildup of....	Water/Dental Plaque	Tartar is a buildup of dental plaque.	
9	Tartar is very attached to....	Neck of Teeth/Tongue	Tartar is yellow in color and sticks tightly to the neck of the tooth.	
10	Tartar can also be removed by simply brushing your teeth.	True/False	Tartar cannot be removed by just brushing your teeth.	
11	How to prevent cavities is by brushing your teeth with....	Mineral Fluoride/Charcoal	It is mineral fluoride that can protect and prevent tooth decay.	
12	If the tartar has thickened, you should seek treatment at	Bakery/Dental Clinic	If the tartar has thickened, go to a dental clinic immediately.	
13	Tartar can cause gums to....	Protected/Easily bleeding	Tartar causes the gums to become inflamed so that they enlarge and bleed easily	
14	STREptococcus MUtans bacteria are ..... bacteria found in the mouth.	Natural/Mutation	Streptococcus mutans bacteria are natural bacteria found in the mouth.	

No.	Question Indicator	Answer Indicator	Clue Indicator	Valid Rating (1-5)
15	The mineral Fluoride can be found in toothpaste in addition to food and drinks.	Wrong/Right	Mineral Fluoride can be found in toothpaste as well as in food and drinks.	

Initiation is the initial stage where the initial concept of the game is developed. This includes gameplay controls, main character images, enemy characters, challenge ideas, and how to incorporate content into the game. The obstacle ideas include elements to be prepared, such as the map layout, setting the game's setting, and the characters or objects that will play a role in the game.

Pre-production is an analysis activity so that the game can be in accordance with the initiation stage by forming a game flow like a diagram. Production is the stage after pre-production, which starts from implementing the game design that was created previously and compiling the assets that support the game. During the testing phase, the game's content will be validated, and errors in the educational content will be identified. This validation will be conducted by a group of experts from the dental field.

The beta stage is almost the same as Testing, the difference is that it is carried out by an external party. With Blackbox Testing carried out so that the game function can run according to its function. In the beta stage, the game that has been made will be tested for the game's mechanism, and we will try to find the shortcomings of the game. The beta stage uses the black box testing method. This method can test errors in the game thoroughly.

In the final stage of the GDLC methodology, namely the release, the game will be released publicly and openly. This game will be released with the HTML 5 system through the itch.io open sales site. For the analysis of the percentage results in Expert Validation and Blackbox Testing, it can be generated with the Achievement Level Conversion. Here is the Achievement Level Conversion table that will be used to analyze the percentage results:

Table 2 Conversion Achievement Rate

Percentage Results	**Conversion**
90%-100%	Very Worthy
75%-89%	Worthy
65%-74%	Quite Decent
55%-64%	Less than worthy
0%-54%	Not feasible

3. RESULT

The game is named DenTerra, with the concept of an educational game about teeth. The user's goal is the public; the player will play as a character named PD (Poem Dental). PD lives in the molars, and his hometown has been attacked by bacteria and dirt from outside the mouth. PD must eliminate all the dirt before his house has a hole.

PD is a small tooth-shaped character who adventures in the human mouth to clean all germs and bacteria and collect points. At the first level PD must finish off all dental plaque that spreads on a tooth. If dental plaque is not cleaned from the teeth, then this dental plaque will develop into dental crust which is more difficult to finish off because the nature of this dental crust is very hard and sticky. The image below is a Gameplay Flowchart. Gameplay refers to the gameplay path during the game.

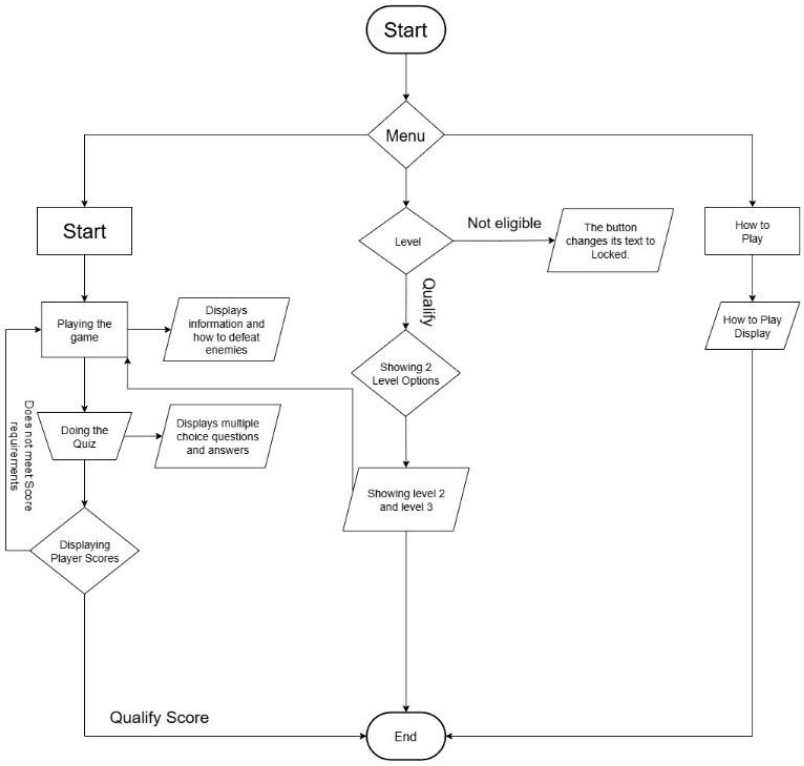
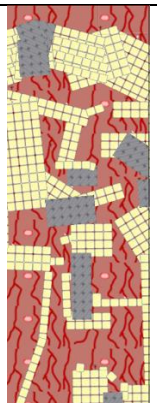
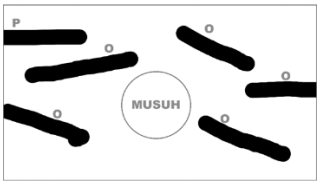


Figure 2 Flowcart Gameplay.

Table 3 is a storyboard, which is a plan to visualize each view in the game.

Table 3 Storyboard

Appearance	Information	Design
Menu	The menu display in Denterra shows the game title, a start button, and a how-to button.	JUDUL Mulai Cara Bermain Level
How to Play	Denterra Gameplay Screen. Shows how to move the main character in the game. After pressing the back button, you will be taken to the menu screen.	Kembali Isi Cara Bermain

Appearance	Information	Design
Level 1	A preview of Level 1 in Denterra. The map is shaped like a molar tooth, and the player's task is to defeat all the Dental Plaques present and advance to Level 2.	
Level 2	A look at Level 2 in Denterra. The map is shaped like a tooth that's starting to develop cavities and decay. Players are tasked with defeating all the tartar and collecting Orids to advance to Level 3.	
Level 3	A look at Level 3 in Denterra. The map in this game is shaped like an inner gear, and the player's task is to collect all the Orids while avoiding the pursuit of bacteria called Stremu.	
Quiz	After completing a level, players take a quiz. The quiz consists of questions and two multiple-choice questions.	
Score	After completing the Quiz, the results in the form of a Score will be shown to the player.	

In testing, it begins to validate the quiz material in the game. The quiz in this game was validated by two dentists on May 28, 2025. The validation results are shown in Table 4.

Table 4 Validation Results by Dental Experts

No.	Question Indicator	Answer Indicator	Clue Indicator	Expert 1	Expert 2
1	If dental plaque is left, it will turn into...	Dental Plaque/Iron	Dental plaque comes from food substances. If the pile becomes thicker, then dental plaque will turn into tartar.	4	4
2	The outermost surface of the tooth is called....	Enamel/Chlorophyll	The outermost surface of the tooth is called Enamel	5	5
3	Dental plaque comes from residue food and drink that contain...	Vitamins/Sugar	Dental plaque comes from leftover food and drinks that contain sugar.	4	4
4	Dental plaque will disappear if...	Eat 3 More Meals/Brush Teeth	Dental plaque will not disappear if we don't brush our teeth.	5	5
5	If dental plaque is left, then it becomes more and more thick and hardened.	True/False	If dental plaque is left, it will get thicker and harden over time.	5	5
6	Tooth crusting can cause teeth to become...	Shaky/Hollow	Tartar sticks to the neck of the tooth; if left on the neck of the tooth, the tooth will become loose.	4	4
7	STREptococcus mutans bacteria can cause teeth to become....	Shaky/Hollow	If Streptococcus mutans bacteria come into contact with food remains, they will produce acid, which causes cavities.	5	5
8	Tartar is a buildup of....	Water/Dental Plaque	Tartar is a buildup of dental plaque.	4	5
9	Tartar is very attached to....	Neck of Teeth/Tongue	Tartar is yellow in color and sticks tightly to the neck of the tooth.	4	4
10	Tartar can also be removed by simply brushing your teeth.	True/False	Tartar cannot be removed by just brushing your teeth.	5	5

No.	Question Indicator	Answer Indicator	Clue Indicator	Expert 1	Expert 2
11	How to prevent cavities is by brushing your teeth with....	Mineral Fluoride/Charcoal	It is mineral fluoride that can protect and prevent tooth decay.	4	4
12	If the tartar has thickened, you should seek treatment at	Bakery/Dental Clinic	If the tartar has thickened, go to a dental clinic immediately.	4	4
13	Tartar can cause gums to....	Protected/Easily bleeding	Tartar causes the gums to become inflamed so that they enlarge and bleed easily	5	5
14	STREptococcus MUtans bacteria are ..... bacteria found in the mouth.	Natural/Mutation	Streptococcus mutans bacteria are natural bacteria found in the mouth.	5	5
15	The mineral Fluoride can be found in toothpaste in addition to food and drinks.	Wrong/Right	Mineral Fluoride can be found in toothpaste as well as in food and drinks.	5	5
			Total	68	69
			Percentage	91%	92%
			Average percentage	91%	

The method that will be used for the beta stage is black box testing. What will be tested and evaluated with the black box testing method are all game features, starting from buttons, character controls, and character rewards/debuffs. Blackbox testing on this game was done in two environments on June 15, 2025, and June 19, 2025. Here are the results on Table 5.

Table 5 Blackbox Testing Results

Testing	Input	Output	Wish Result	Result
"How to Play" button	Press the button	Users immediately enter the guide page for playing this game.	Players can learn how to play this game.	14
"Level" button (before finishing the game)	Press the button	The user can't enter the level page, and the text changes to locked.	Players cannot choose level	11
"Start" button	Press the button	The user directly enters the game page.	Players can immediately move the character, start the game, and start the music.	14

Testing	Input	Output	Wish Result	Result
PD moves to the right.	Press the right button on the keyboard.	PD moves to the right	Players can move to the right when the button is pressed.	14
PD moves to the left	Menekan tombol kiri pada keyboard	PD moves to the left	Players can move to the left when the button is pressed.	14
PD moves to jump	Menekan tombol atas pada keyboard	PD moves up	Players can jump when the button is pressed.	14
PD takes Orid	PD menyentuh Orid	Orid's score increases	The Orik Score amount increases as long as Orid is taken.	14
PD beats Dental Plaque	PD steps on Dental Plaque	Dental Plaque disappears and Dental Plaque Score increases	PD successfully defeated dental plaque, and the dental plaque score increased.	13
Dental Plaque beats PD	Dental plaque touches PD	Orid score decreased	Dental plaque will defeat PD and the Orid score will decrease.	11
PD touches the Flag at Level 1	PD touches the Flag at Level 1	The user will be moved to the stage 1 quiz page.	The player successfully entered the quiz page.	14
PD defeats Tooth Decay	PD steps on tartar	Tooth Crust disappears and the Tooth Crust Score increases	PD managed to defeat Tooth Crust, and Tooth Crust's score increased.	12
Tooth Decay Defeats PD	Tooth Decay Touches PD	Orid score decreased	Tartar will beat PD and Orid score will decrease	11
PD touches the Flag at Level 2	PD touches the Flag at Level 2	The user will move to the stage 2 quiz page.	The player successfully entered the quiz page.	13
PD beats Stremu	PD collects all Orid	Stremu stops moving and crumbles	PD successfully defeated Stremu and went to Quiz stage 3	13
“Repeat” button on the Score page	Press the button	User enters previous level	Player repeats previous level	14
“Next” button	Press the button	If it does not meet the requirements, then the text button changes. If it meets the requirements, the user goes to the next level.	Players can continue the game or not.	14
“Skip” button	Press the button	If it does not meet the requirements, then the button does not work. If it meets the requirements, the user goes to the next level.	Players can continue the game or not.	13

Testing	Input	Output	Wish Result	Result
"Level" button (After completing the game)	Press the button	Users can enter the level page	Players can choose the level	14
			Total	237
			Percentage	94%

Blackbox Testing percentage results for the Denterra game reached 94%. At the Release stage, after the Beta stage, which produces the game test, the next-to-last stage is the Release stage. The average result of Expert Validation reached 91% valid, meaning that it can be concluded that the material in this educational game is Very Eligible, according to the Achievement Level Conversion Table. For the average result of Blackbox Testing, it reached 94%, meaning that it can be concluded that the functionality of the Denterra educational game is Very Eligible for use by the public.

4. DISCUSSION

Of the two dentists who have validated the material in the Denterra educational game, the average result of expert validation reached 91% valid, consisting of the first expert reaching 68/75 and the second expert giving a score of 69/75, meaning that the material in this educational game is very eligible according to the Achievement Level Conversion Table.

For the results of Blackbox Testing, it reached a value of 94%, or 237/252, with features that were less agreeable that the feature was functional for players, namely the "Level" button (before finishing the game), "Dental plaque beats PD", and "Dental crust beats PD". From the blackbox testing analysis, it can be concluded that the functionality of the Denterra educational game is Very Suitable for use by the public. The sample data that has been produced is not comparable to the student population in Banyumas Regency due to time constraints and the subject's environmental conditions.

5. CONCLUSION

An educational game called "DenTerra" was developed using the Game Development Life Cycle (SDLC) method applied to a personal computer platform. The process of making educational games with the GDLC method consists of 6 stages of creation, namely initialization, pre-production, production, testing, beta, and release. Initialization contains the initial concept of the game; pre-production with the formation of the game flow; production, which contains the formation of the game; testing validation tests on the content; beta to ensure that the game functions properly; and release by making the game playable to the public. The results of this game have two values, namely the validation value on the educational game material and the feasibility value. The material in this game has been tested by experts and received an average value of 91%. On the feasibility value with the blackbox testing method, it received a value of 94%. The percentage value shows that this game is very feasible to be played by the public.

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7. AUTHORS

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