

# Halogen: A 2D Simulation Game on Dental Health Challenges in the Philippines

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## ABSTRACT

The thesis is about a 2D top-down educational medical simulation game from the perspective of a dentist participating in a dental mission. The main goal of the thesis is to educate players on the general practice of dentistry while raising awareness on the relevant issues related to Philippine dental health care such as inaccessible and scarce dental care, especially in far-flung areas, lack of dental health awareness, and poverty that exacerbates said inaccessibility. The researchers utilized a custom-made game to immerse the player within the medical simulation, with the intent of increasing their interest in the subject. Game testing was conducted to gather data regarding player experience and the effectiveness of the interactive and simulation game in teaching and raising awareness about dental health challenges. The results show that the game was effective in teaching dental health hygiene, operations, and concepts, but lacked a number of features that would make the game more fun for players, including minigames and indicators. This suggests that games are an effective way to teach dental health, but would need a lot more elements, features, and mechanics to make them enjoyable as well as educational for players in some areas.

## CCS CONCEPTS

• Interaction Design • Life and Medical Sciences • Learning Education • Game Design

## KEYWORDS

Medical simulation game, Dental hygiene, Philippines, Dental Health

## 1 INTRODUCTION

Dental health care in the Philippines is often overlooked but crucial for overall health and quality of life. Statistics show high rates of dental issues like caries, gum disease, and tooth decay among Filipinos [1, 2]. Accessibility to

healthcare providers and facilities is limited, especially in rural areas [3]. The presence of "faith healers" adds complexity to the healthcare landscape [4]. There have been multiple government initiatives and advocacies to bring dental health services to strengthen awareness and provide support but said efforts are unfortunately still lacking [5,6].

There is a lack of existing literature and knowledge in the capabilities of games in educating regarding dental health and hygiene, especially in the Philippine context. The study aims to determine the effectiveness of using serious games for dental health education in the Philippines. The game developed, Halogen, simulates dental procedures from a dentist's perspective during a medical mission. Key questions and objectives of the study include the effectiveness of game elements, teaching basic dentistry, highlighting industry challenges, and assessing player enjoyment.

The game was developed using Unity Game Engine 2021, targeting Windows 10 and 11 Personal Computers (PCs). The target demographic of the study are young adults aged 18-25, primarily university students, with no prior knowledge requirement. Limitations include focus on core dental procedures like check-ups and cleanings, prioritizing foundational knowledge and player engagement. Being targeted towards young adults, the effectiveness for other age groups may need further exploration.

## 2 REVIEW OF RELATED LITERATURE

### 2.1 A Video-Game-Based Oral Health Intervention in Primary Schools—A Randomised Controlled Trial

A Video-Game-Based Oral Health Intervention in Primary Schools—A Randomised Controlled Trial is a study by

Aljafari, A., Elkarmi, R., Nasser, O., Atef, A., Hosey, M. T. [8]. This study made use of two groups, one of which played a standalone dental health game while the other received no intervention. Afterward, their dietary knowledge, plaque levels, and toothbrushing habits were compared.

The results showed that there was a significant improvement in the intervention group's knowledge of dental hygiene and dietary choices, but it did not translate to improved dental practices. The authors conclude that though the game educated the students, other school interventions are necessary to cement the proper behaviors in children. They also highlighted the need to include parents in educating and building proper dental hygiene habits for children, and the need for digital, child-friendly oral health education games that could be used for online education

## 2.2 Current State of Serious Games in Dentistry: A Scoping Review

Current State of Serious Games in Dentistry: A Scoping Review is an article by Zaror, Mariño, and Atala-Acevedo in 2021 [7]. This article reviews research on serious games in dentistry (video games used for education or training). Researchers found two main uses: training dental professionals and teaching kids about oral health. Dental training games focused on skills and patient management, while children's games aimed to raise awareness and build healthy habits.

The studies mentioned in the review used different devices (computers, phones) and game elements (quizzes, rewards). There was no strong evidence to prove how well the games worked, but some studies showed promise. For example, children's games helped them identify unhealthy foods and improve brushing. Dental professional games may improve skills, but there is not enough evidence yet to say for sure if they are effective. The researchers concluded that more studies are needed to see if these games can truly improve oral health education.

## 2.3 Previous Games

The researchers also reviewed previous games that were relevant to the subject matter and/or game design. These games range from free simulation games to role-playing games. Among these games, there were medical simulation games such as Surgeon Simulator, Dentist for Children, and Toothsavers. These games were reviewed to examine the educational aspect and appeal of medical and dental simulation games. The researchers borrowed elements like level design and dental procedures from said games. Furthermore, there were also nonmedical simulation games that influenced the game such as 1.) Super Mario Bros. 3, for the game's overworld map, 2.) Pokemon Red and White, for its non-player character (NPC) interaction mechanics,

and 3.) Cooking Dash for its level design and interaction with tools.

## 3 METHODOLOGY

### 3.1 Game Design Principles

In developing the game in line with the goals of the study, multiple principles have been considered. These served as a guide not only for the development of the game, but also for emphasizing the topic in the game and assessing the effectiveness of the game in doing its intended purpose after doing participant testing.

#### Game Elements and Mechanics for Meaningful and Engaging Representation of Dental Operations

The main gameplay loop will have the player treating multiple patients with varying dental-related ailments with increasing complexity throughout each stage. These operations will be represented in the game through an interface that allows the player to interact with the patient's teeth using the various tools at their disposal to fully accomplish each operation. This interface will show both rows of upper and lower teeth in a neatly arranged 2D sub-screen. The player will be interacting with the patient's teeth by first selecting the applicable tool and using the said tool by selecting the specific tooth that the player will be interacting with. For example, the player can select the sickle probe and interact with the teeth to remove any initial plaque from the teeth before proceeding with a thorough cleaning.



Figure 1: Dental View and main gameplay. Here, the player is cleaning the patient's mouth, separated into sections, with a dental tool.

#### Effectiveness of the Game in Educating the Young Adult Audience about Dentistry and Oral Health

To measure effectiveness for the study, a pre-test and post-test was utilized. The test used is a Knowledge Assessment Questionnaire which contains seventeen (17) objective questions, aimed at assessing the knowledge of the participants before and after the testing of the game. The content of this questionnaire is also discussed in the

game, through dialogue and mechanics, and was validated by the study's Subject Matter Expert (SME). This helped determine if the game is effective in teaching dentistry and oral health. The pre-testing and post-testing scores were analyzed using descriptive statistics (mean) to measure the difference in scores before and after the game testing with the given sample size, and thus the effectiveness of the game in teaching dental health concepts.



Figure 2: Part of the intro cutscene of the game, where the player character arrives at a town where the dental mission is.

### Utilizing the Game to Shed Light on Issues in the Philippine Dental Industry

The primary premise of the game focuses on the player taking on the role of a dentist undergoing a dental mission. This dental mission will take place in a remote poverty-stricken rural town where the populace does not have easy access to dental care. Throughout the game, dialogue via NPC interaction and cutscenes show the problems plaguing the town, which in turn have caused them to have difficulties in accessing basic dental care. This is how the player would experience and learn about the issues that unfold as the game progresses, more levels are completed, and more of the populace is interacted with.



Figure 3: A portion of the overworld map of the game with an NPC dialogue on-screen. The player can explore the

area and converse with its residents, learning more about them and the town

### Assessing the Enjoyability Factor of the Game

To assess if measures and features added to the game were fun and interesting for the player, the researchers made use of a Game Experience Questionnaire (GEQ). This questionnaire has three variations, but for the study the core module is sufficient[9]. The GEQ does not draw on a specific psychological theory and is based on conceptual accounts of player experience. The questionnaire makes use of Likert scales (1-5) intended to measure positive affect, negative affect, frustration, flow, challenge, immersion, and competence. In particular, components such as positive affect, flow, and immersion are indicators of enjoyment. Challenge, tension, and competence can also be included in assessing enjoyment. Negative affect can be used to denote dissatisfaction or negative experiences with the game, the opposite of "fun". Descriptive statistics (mean) was implemented in the mentioned components to get their component scores. This was followed by a qualitative response into what makes the game enjoyable or otherwise for feedback and future improvements.



Figure 4: Scoring system in the game.

## 3.2 Game Design

The game has two main game modes. The first is the core gameplay loop involving the simulation of various dental operations which will be the primary means with which players interact with their patients during each stage. The second is the overworld traversal that is present in between stages.

### 3.2.1 In-stage Gameplay Mechanics and Core Gameplay Loop

During each stage, the player is tasked with giving treatment to various patients who enter the 'clinics' for free treatment. The dental operations that have been included in the game are the following: Cleaning and Tooth Extraction.



The player earns a corresponding number of points based on their performance during treatments. During stages, a line system is implemented to automatically seat each NPC in a queue-type fashion, one after the other. Additionally, each level has a short time limit to give the player a sense of urgency when completing the game.

For the player to perform operations, the player will have to obtain the required items before interacting with the patient. These items are placed on a table for players to use as they please. Items are divided into two categories, reusable and non-reusable. The two categories have separate inventories. Reusable items include the following items: Sickle Probe (also known as the Scaler), Mirror Probe, and Dental Pliers. While non-reusable items include the following items: Toothbrush, Mouthwash, and Anesthesia. Reusable items can be reused, while Non-reusable items will have to be disposed of via the trash can. Each item also has unique features which allow them to interact with the patient.

When the player has obtained the necessary items, the player can then move on to the diagnosis and treatment. To begin, the player must interact with the seated patient in order to open what the developers call the 'Dental View'. This interface is the primary medium that allows the players to directly access the patient's teeth and interact with the teeth using whatever tools are necessary. When viewing the teeth from the dental view, the player will first have to choose which section to view, the left, right, and middle sections of the patient's teeth.



Figure 5: The main gameplay, with the complete UI

The separation of the teeth into sections allows the players to view the teeth neatly and accurately. It also emphasizes the various ailments that each patient may be suffering from. In the Dental View, the player is able to perform a number of operations provided they have the necessary tools in their inventory. This includes, cleaning or tooth extraction.

Cleaning is accomplished with the toothbrush and sickle probe. It involves using the toothbrush on the patient's yellowed teeth and using the sickle probe to fully clean it afterward.

Tooth Extraction is done with the dental pliers, anesthesia, and mouthwash. The player must identify the tooth or teeth to be extracted (these are teeth that are blackened), use

mouthwash before extraction, apply anesthesia in the gums near said tooth, and finally, extract the tooth with the dental pliers. As a final step, the player must use mouthwash again after extraction.

When all required operations are done (full cleaning and all decayed teeth extracted), the player must select the finish patient button, after which the player will gain a large number of points and the next patient will be automatically seated.

### 3.2.2 Overworld Traversal and Stage Select

After clicking "Play" from the main menu, the players will be greeted with a short introduction cutscene and will be transitioned into the overworld stage. The overworld acts as a hub and stage select area. Here, the player can walk around, interact with NPCs, and explore the small town where the dental mission is being conducted. Movement is limited to a small invisible border around the town. Interaction is limited to accessing a stage and initiating dialogue with the NPCs.



Figure 6: Complete overworld play area

The gold tooth icons will be where the player accesses the levels. The player will be restricted to accessing the tutorial level at the start and will unlock another stage after completing the tutorial. The current game has a total of 2 levels, the tutorial and the first stage.

### 3.2.3 Aesthetics and Visual Design

The game takes place in a rural setting, immersing players in a remote town far from urban areas. The visuals depict a lack of access to many conveniences, implying the potential consequences of neglecting dental health in such an environment. This design choice aims to engage players with the realities of limited resources.



Figure 7: Game Concept art and Title Screen background

The assets in particular were made with an animated sprite and pixel art tool, Aseprite. These assets include sprites, backgrounds, cutscenes, etc. The researchers envisioned the game's aesthetic to be reminiscent of a rural scene in the Philippines. As such the assets chosen were made to further the immersive experience of the player.

### 3.3 Game Development

The game is being developed in Unity Game Engine. The initial experience of the researchers with Unity prior to this thesis project was rather limited. The primary programming language of choice for this project is C# as that is what Unity uses for its scripts.

Large portions of the programming were done with modularity in mind. A lot of the code has been rebuilt and remade to be more dynamic in that its reusability across differing scenes in the game is much more friendly.

## 4 RESULTS

The game underwent two types of testing: alpha-testing and beta-testing. Alpha-testing made use of an earlier version of the game, which did not have NPC dialogue except for a short tutorial for the controls, three patients to clean, and a lack of a timer feature. Feedbacks from alpha-testing would be implemented and improved in a later version, which was then used for beta-testing.

### 4.1 Alpha-Testing

Alpha testing was done supervised and with the participants consisting of two (2) interns from the University of the Philippines Integrated School (UPIS) who were undertaking their internship in Ateneo de Manila University, and the Subject Matter Expert (SME) of the researchers. The former group were not specifically chosen by the researchers, nor were their identities disclosed before testing, and were simply chosen for their availability for testing as part of their internship. Participants were tasked to fill out a form asking

for their comments regarding aspects of the game such as concept and game premise, interface design and story, gameplay, bugs encountered, and other additional comments they had.

#### 4.1.1 Key Takeaways from Alpha-testing

User	UPIS Interns	SME
<b>Strengths</b>	<ul style="list-style-type: none"> <li>- Interesting concept and premise</li> <li>- Easy to understand gameplay, suitable for all ages</li> <li>- Original mix of mechanics (Cooking Mama &amp; Surgeon Simulator)</li> <li>- Aesthetically pleasing 2D pixel style</li> <li>- Entertaining, enlightening, and good cutscenes</li> <li>- Simple and easy-to-understand controls</li> <li>- Enjoyable exploration and character interaction</li> </ul>	<ul style="list-style-type: none"> <li>- Good representation of dental operations</li> <li>- Aesthetics well-represent the context</li> <li>- Educational merit in teaching dental concepts</li> </ul>
<b>Weakness</b>	<ul style="list-style-type: none"> <li>- Average user interface</li> <li>- Lack of pointers/markers for completing goals</li> <li>- Missing in-game instructions and tutorials</li> <li>- No competitive elements or minigames</li> </ul>	<ul style="list-style-type: none"> <li>- Inaccurate order of operations (procedures)</li> <li>- Gameplay doesn't reflect real-world practices (toothbrush usage)</li> <li>- Skepticism about effectiveness for teaching (limited experience with simulation learning)</li> </ul>

User	UPIS Interns	SME
Areas for Improvement	- Enhance user interface with pointers/markers	- Correct order of dental operations
	- Include in-game instructions and tutorials	- Refine gameplay practices to reflect real-world dentistry
	- Add competitive elements and minigames	- Variety and replay value

Table 4.1 Summary of Feedback from Alpha-Testing

Overall, participants found that the game successfully raised awareness about dental hygiene and taught basic dental concepts, such as procedures and tools. However, opinions were mixed on whether the game effectively conveyed the dental health situation and context in the Philippines. While the SME believed the game could effectively teach this narrative, UPIS interns felt the storytelling aspect needed improvement. These insights were taken into account for the development of a later version of the game for Beta-testing.

### 4.2 Beta-Testing

Beta-testing was conducted with five (5) participants, young adults between the ages of 18 to 25 years old. Participants were recruited through face-to-face communication, and were chosen randomly. Testing was conducted with the participants one-by-one and with the presence of the researchers. The average duration of testing was 30 minutes. Unlike in alpha-testing, beta-testing made use of the pre-test and post-test Knowledge Assessment Questionnaire, as well as the Game Experience Questionnaire for feedback on the game to consider specific aspects of the game that were effective.

#### 4.2.1 Key Takeaways from Beta-Testing

Results from the Knowledge Assessment Questionnaire in both pre-test and post-test show that the game had mixed results in terms of teaching dental health concepts, effects, and issues. 60% (3) of the participants had better scores after playing the game, but 20% (1) of the participants had a worse score after playing the game, and another 20% (1) of the participants had the same score. The summary of the results can be seen below:

Knowledge Assessment Questionnaire Results

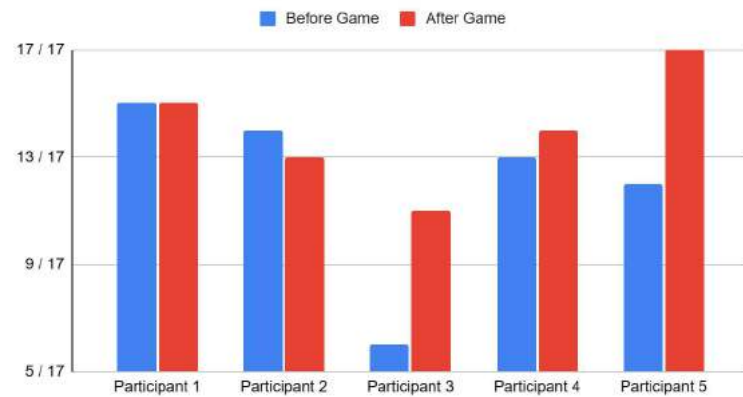


Figure 8: Knowledge Assessment Questionnaire Results Before and After Game Testing

### 4.3 Game Experience Questionnaire Results

Results from the Game Experience Questionnaire (GEQ) indicate high consistently high scores in components such as Competence, Immersion, Flow, and Positive Affect. The scale used for the GEQ is as follows: Not at all (1). Slightly (2), Moderately (3), Fairly (4), Extremely (5):

The average Competence component score stands at 4.2, suggesting that participants felt reasonably proficient in the game and subject matter both during and after gameplay. As for immersion, the average component score is 3.9, indicating a moderate level of engagement with the game's art and world, though not reaching a high level of immersion. Regarding Flow, the component score of 3.5 suggests that participants were moderately engaged and focused on the gameplay experience.

User	Competence	Immersion	Flow	Positive Affect
Participant 1	4.4	3.5	2.4	4.0
Participant 2	4.0	3.5	5.0	4.6
Participant 3	3.2	4.0	2.8	3.8
Participant 4	4.4	3.5	3.8	4.2
Participant 5	5.0	4.8	3.4	4.8
<b>Average</b>	<b>4.2</b>	<b>3.9</b>	<b>3.5</b>	<b>4.3</b>

Table 4.2 GEQ Results for Competence, Immersion, Flow, and Positive Affect

And finally, for Positive Affect, the overall component score was 4.3, indicating that the participants felt fairly content and happy with the game, and had enjoyed it.

<i>User</i>	<i>Annoyance</i>	<i>Challenge</i>	<i>Negative Affect</i>
Participant 1	2.0	3.6	1.0
Participant 2	1.0	3.2	1.0
Participant 3	2.3	2.4	2.0
Participant 4	2.0	2.2	1.8
Participant 5	1.3	1.4	1.5
<b>Average</b>	<b>1.7</b>	<b>2.6</b>	<b>1.5</b>

Table 4.3 GEQ Results for Annoyance, Challenge, and Negative Affect

The Tension or Annoyance component yielded an overall score of 1.7, suggesting that participants experienced minimal irritation or frustration during gameplay. Regarding the Challenge component, it received an overall score of 2.6, signifying that participants found the game slightly challenging above the average level, yet not to the extent of being considered moderately challenging. Lastly, the Negative Affect component garnered an overall score of 1.5, indicating that participants did not report feelings of boredom, fatigue, or other negative emotions while engaging with the game.

This is supported by the participants' qualitative feedback on the game. Many noted that the game mechanics allowed them to understand dental operations, knowledge about infections, promotion of better hygiene, along with the engaging gameplay loop, art utilized, NPCs and dialogue, as well as the implementation of the scoring system for competitiveness and measurement of learning and thus creating an enjoyable experience.

Overall, the component scores and qualitative feedback indicate that the participants thoroughly enjoyed the game, its world, and its content, and that the game made them feel that they were fairly competent, and only encountered minimal annoyance, challenges, and negative emotions. These results suggest a positive reception and engagement with the game.

## 5 CONCLUSION

After conducting alpha-testing and beta-testing, considerable conclusions, suggestions, and recommendations can be derived at this point in time to

improve future works and research pertaining to the use of games in teaching dental health and hygiene. The results of the Knowledge Assessment Questionnaire is able to show that Halogen is able to teach, however there needs to be further studies and improvements in order to conclude this as fact, as the study had only made use of 5 participants, and only 3 of them displayed learning. The results of the GEQ, however, has proven that the use of serious games to teach dental health concepts and issues was fun and enjoyable for the participants, and thus they were able to engage with the material. These findings underscore the potential of serious games in effectively engaging learners in dental health education, while also highlighting the need for further research and development to ensure broader efficacy and impact.

### 5.1 Future Work, Suggestions, and Areas of Improvement

After the testing phases,, the researchers have determined that while the thesis project has a lot of merit already in its potential as a learning tool, there is still a lot of future work that can be done to further improve it.

One of the research goals of the study was to determine, identify, and implement elements and mechanics that would make the game engaging and enjoyable. While to an extent this has been fulfilled, it should be noted that this term is highly subjective, and the researchers believe that there is a lot to be desired in this aspect of the simulation game. New challenges and new obstacles for the player to overcome would help keep the player's attention and help add replay value to the game. The current problem that the researchers believe needs to be addressed is the lack of challenge. As suggested by the SME of the study, adding a third operation will help add replay value to make the game more interesting. A suggestion by the participants on the other hand was to add a guessing game of sorts before the operation proper where the player must inspect the teeth of the patient and determine the correct choice among a set of options as to what the correct operation needs to be.

Another suggestion was to incorporate a more interactive tutorial. In this way the player is more engaged as they learn the game's mechanics by using a more visual and interactive tutorial with minimal dialogue. Adding more operations, different gameplay styles, and enhancing the tutorial stage would improve the variety of activities in the game, thus improving player retention and enjoyment. Along with that, another suggestion was to make elements clear and visible to the users, adding more visual response to actions to determine that they register or that they happened, like when anesthesia has been applied, or if certain items are unavailable and are already used, like the

disposable items anesthesia, mouthwash, and toothbrush. Halogen also had indicators for when a tooth was clean, however players suggested to make it more distinct, as there were instances where the participants were left thinking they had correctly finished cleaning, but were unable to use the explorer to clean the teeth fully. A suggestion was to implement particle effects to make the game be closer to actual brushing and to have visual indicators.

Another element that needs future work is the accuracy of dental operations. The researchers believe that there is room for improvement in this regard. Some reworking of the internal systems may be required to help make the game more accurate to real-life standards. However, it should be noted that since the game was not developed to aid the education of medical practitioners, it does not have to be accurate to the finest detail, as long as it represents the proper flow of the dentistry operations alongside teaching oral hygiene.

As this study only had 5 participants, another area of improvement would be to increase the demographics in this field of study. Considering that this study brought mixed conclusions to the effectiveness of serious games in teaching dental health, future studies should include a greater number of participants to further shed light into this body of knowledge.

Other areas of improvement include exploring the capabilities of other game development platforms for developing games primarily for teaching. Unreal engine is a powerful game engine known for stunning visuals and advanced features such as real-time ray tracing and physically based rendering. Godot is also another free and open-source game engine that is becoming increasingly popular for its ease of learning and use. As such, it is a great choice as it is a powerful and flexible engine. GameMaker Studio 2 is another popular game engine designed specifically for 2D Game Development, that makes use of a scripting language instead of coding. This study made use of the Unity game engine primarily out of familiarity, but exploring other game engines specializing on desired results could optimize performance, as well as streamline projects leading to a more polished gameplay experience.

Minor improvements could include the addition of language options to the game. The dialogue of the game is primarily in English. English is considered a secondary language in the Philippines. However, if the goal of the study is to teach and bring awareness to dental health and issues in the Philippines, then it would be beneficial to also include the primary and native language, Filipino, as the primary

language option for the dialogue in the game. This could help emphasize the teachings and points made regarding dental health to the demographics that it matters to the most: those who live in far-flung areas.

## 5.2 Concluding Remarks/Final Points

In conclusion, the results suggest that the use of serious games in the education of medical concepts may prove to be effective. To be more specific, the results have shown that participants, after playing the game, learned information regarding dental health, processes, operations, and tools. While it is lacking in areas related to dental hygiene in the Philippine context and visual cues in mechanics, the game was successful in being fun, thus fulfilling an objective of this study, yet only partially successful in teaching as shown by the mixed results in the knowledge assessment indicating that further studies need to be conducted in methods that will be better at these areas. Future development should address these areas to enhance engagement and ensure the game effectively tackles dental hygiene in the Philippine context, and could involve incorporating Philippine-specific information and enhancing the visual clarity of the game mechanics as well as investigate the long-term knowledge retention and behavioral changes for effectiveness.

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