



Development of Three Dimensional Simulation on Colon Cancer

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ABSTRACT

Colon, or colorectal cancer is a cancer that starts in the large intestine, also called colon, or happens in the rectum, which is the end of the colon. This simulation on colon cancer will show the user in 3D animation all about colon cancer. In addition, this simulation will explain about colon cancer and how cancer cell developed in the colon. Nowadays, the style of channeling the information makes it boring to public. Moreover, the 2D simulation gives less impact to the audience. An effective delivery of knowledge of colon cancer is important as colon cancer is the third commonest cancer worldwide. The main objective of this project is to develop a simulation that explains about colon cancer. The project also aims to implement 3D simulation in explaining in more detail about the colon cancer. Besides, this project aims to evaluate the effectiveness of 3D simulation of the colon cancer. There are three modules presented in this simulation, which are Introduction to Colon Cancer, Simulation on How the Colon Cancer Happens and Effects if Colon Fails to Function Properly. It is envisaged that this project will contribute in delivering a more effective understanding about colon cancer by using 3D animation. It is also hoped that this 3D simulation is useful for public by providing the information on colon cancer.

Key words : Animation, Colon Cancer, Simulation, Three Dimensional.

1. INTRODUCTION

The 3D Simulation on Colon Cancer shows the user in 3D animation all about colon cancer. The project explains about colon cancer and how cancer cell developed in the colon. Apart from that, this simulation also includes the effects if colon failed to function. World Health Organization (WHO) reported in [1] that cancer is the second leading cause of death worldwide, contributes for almost 9.6 million deaths in the year of 2018.

It is also revealed that colorectal cancer is the third most common cancers with 1.80 million cases, after lung and

breast cancer, both with 2.09 million cases. In addition, World Cancer Research Fund, agreed that colorectal cancer is a common cancer globally [2]. Meanwhile, it is reported in [1] that the most common causes of cancer death are lung cancer with 1.76 million cases, followed by colorectal cancer with 862,000 deaths. According to the American Cancer Society, in United States, colorectal cancer is the third commonest cancer for both men and women [3]. It is estimated in the United States that the number of colon cancer cases will be 104, 610 cases and 53, 200 deaths for the year of 2020. The ratio of lifetime risk of developing colon cancer claimed for men is 1 in 23 (4.4 percent) while for women, a bit lower, which is 1 in 25 (4.1 percent).

These prevalence of colon cancer shows that colon cancer is a leading cancer type and cause of death. Thus, an exposure and knowledge about colon cancer should be given to the public. This simulation which presented in 3D animation could contribute as a way to raise an awareness of colon cancer, as early diagnosis often leads to a complete cure.

Therefore, this simulation which explains about colon cancer can help user especially those from non-medical background to get a clear idea about colon cancer. The user or patient may find it difficult to understand the explanation given by the doctor and medical staff. Hence, this 3D simulation can be used in order to make the user more understand about the colon cancer in a more interesting way of presentation. Normally, the conventional style in giving information to the public, such as by using flyers and pamphlet provided in the hospital, produces a boring and ineffective style of channeling and delivering the important information. In addition, the presentation in 2D simulation becoming less interesting and gives less impact to the audience, since the 3D era begins. Meanwhile, colon cancer is among the commonest cause of deaths worldwide and also in Malaysia, therefore giving a complete and effective information regarding colon cancer is a way to help public in understanding how dangerous it is to them.

The objective of this project is to develop a simulation that explains about colon cancer. Secondly, the project aims to implement a 3D simulation in explaining in more detail about the colon cancer occurrence and finally, to evaluate the effectiveness of 3D colon cancer simulation. This simulation is suitable to be viewed by user aged 12 and above. The simulation presents three main modules, which are, Introduction to Colon Cancer, Simulation on How Colon Cancer Happens and finally, Effects if Colon Fails to Function Properly.

2. EXISTING SYSTEM

Existing system is a system that is related or has similarities with the project. Based on research done, there are some systems in medical cases, such as colon cancer and other diseases, for example medical simulation in [4]-[6], and other medical application in [7]-[13].

Laparoscopic Colon Surgery [14] is an application that allows better patient awareness for a more effective and efficient procedure depicting Open Surgery versus Laparoscopic Surgery. This application developed due to the demand for an effective method to show a need for an advanced surgical technique could meet the second leading cause of cancer death in the United States. This simulation is good because it explains in a good way that can make the audience understand quickly on laparoscopic surgery. All the steps involved in the surgery are explained according to the valid flow of the surgery. However, since this simulation only focusing on the surgery, it would be better if more modules are included in one simulation. Besides that, audience can save time by watching one simulation instead of searching for other related modules.

The second related system is 3D Surgery Medical Animation [15], developed by MOA Education. This simulation focuses only on the tracheostomy, which is an operative procedure that creates a surgical airway in the cervical trachea. This simulation provides all the steps involved in tracheostomy, but this only involve one module of the simulation. The limited module will be resulting insufficient information to the audience.

The other related project is 3D Simulation of Blood Flow in Arterial Stenosis [16]. The study was performed at the National Center for Engineering with Complex Fluids, from the Polytechnical University, Timisoara, by a multidisciplinary research team of fluid mechanics, engineer and cardiology researchers. The project simulated the problem of the blood flow in the vessels.

Table 1 shows a comparison between these existing systems. Therefore, the proposed project will be focusing on important features of colon cancer in more details. All multimedia

elements will be included in order to enhance the understanding and attraction of the target users.

Table 1: Comparison of Existing System

Features	Laparoscopic Colon Surgery	3D Surgery Medical Animation	3D Blood Flow Arterial Stenosis
Attraction	Attractive	Attractive	Less Attractive
Format	AVI	FLV	PDF
Type	3D animation	3D animation	Document
Type of Effect	Text, animation, colour, audio	Animation	Text
Software	Autodesk 3D Max Studio	Autodesk Maya	FLUENT 6.0
Duration	1:45 min	0:55 min	-
Content	Laparoscopic Colon Surgery	Steps in tracheostomy	Blood flow in arterial stenosis

3. METHODOLOGY

Project methodology for this 3D Simulation on Colon Cancer project is Multimedia Production Process. It has three processes namely; pre-production, production and post-production. Pre-production is the first part in developing any multimedia projects. It includes a proposal, storyboard, research and schedules. Storyboard is important to be completed before proceeding to other steps of development because storyboard gives a clear view for the whole project and provide the complete flow of the project. After finishing the storyboard of the project, then will start the production process. This phase includes the modelling part for the objects in the project. This phase will take a lot of time to produce a quality product because of much constraint, such as limitation of hardware and skills. Therefore, in this production phase, modelling the object is the most important things to be completed. After that, all the object will be animated in the Autodesk Maya itself according to the storyboard. Post-production is the last part of Multimedia Production Process. After the product has finished rendered, the scenes will be compiled together to produce a complete simulation on color cancer.

3.1 Analysis

This simulation is mainly to explain in detail about colon cancer. In this simulation, there are three modules included which are:

- i. Module 1: Introduction to Colon Cancer
The first content for this module is the introduction of parts in the colon. There are five main parts in normal

human colon, which are, ascending colon, transverse colon, descending colon, sigmoid colon and rectum.

The second part in the first module is the polyp condition in the colon. Colon polyps are fleshy growths that occur on the inside of the large intestine, also known as the colon. Polyps in the colon are extremely common, and their incidence increases as individuals get older. It is estimated that 50% of the people over the age of 60 will harbor at least one polyp. The significance of polyps is that we know that when certain types of polyps grow large enough, they can become cancerous.

The third part is the symptom and signs of colorectal cancer. The contents include; change in bowel habit, persistent in diarrhea or constipation, change in the frequency of stools, passing blood mixed with stools, and finally, persistent ill-defined abdominal discomfort of pain.

ii. Module 2: Simulation on How Colon Cancer Happens

There are altogether five stages presented:

Stage 0 : Cancer is confined to inner lining of the colon wall (the mucosa).

Stage 1 : Cancer has spread beyond the mucosa to the middle layers of the colon wall.

Stage 2 : Cancer has spread beyond the colon's middle layers and possibly into nearby organs, but still do not spread to lymph nodes.

Stage 3: Cancer has spread to lymph nodes, but not to other parts of the body.

Stage 4 : Cancer has spread to distant areas, like the liver or lungs.

iii. Module 3: Effects if Colon Fails to Function Properly

Liver helps to break down all the waste product that is left in the blood stream and digestive tract. Excessive toxic and waste product are released to the blood stream because of the colon malfunction. Liver will need to work harder to neutralize the toxic. Then, the liver gets exhausted and the toxin will start to accumulate and destroy the liver.

3.2 Design

Figure 1 shows the scene sequence diagram. The primary purpose of a sequence diagram is to show event sequences that lead to a desired outcome, besides provide an understanding of the interaction logic between objects to the user.

In addition, a storyboard is drawn to organize the flow of the animation before it is being developed. A storyboard consists of panels or series of rough sketches outlining the scene sequence and major changes of action or plot in a production of 3D animation. Some of the storyboard designed for this simulation is illustrated in Figure 2. Meanwhile, Figure 3 presents the character profile, which is a description of the 3D object that was designed in the Autodesk Maya.

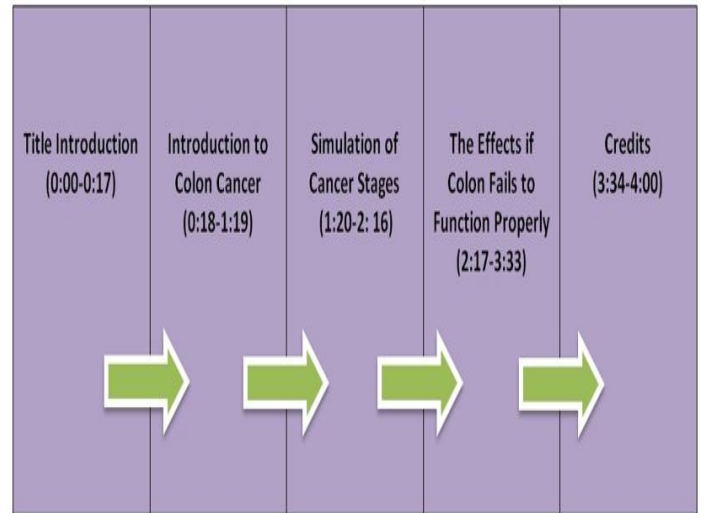


Figure 1: Scene Sequence Diagram

3.3 Implementation

Text is a medium to deliver information and message. Adobe After Effects is used to create text in the animation. The text in this project are applied in the title, introduction to colon cancer part, title of each module, descriptions in the animation and the credit part. Generally, this simulation about colon cancer will give knowledge about colon cancer to viewers and the animation must be understandable. Besides audio and animation, text will enhance the level of understanding among viewers. The amount of text in one scene must not be too many to avoid disturbance to the animation. Adobe After Effects is used because it is easier to insert text according to suitable scene.

In this project, graphics is used in order to design or create a 3D model and character. Autodesk Maya software is used to insert the character's modelling surface. This software is also used to create the 3D animation. The 2D surfaces are inserted to the 3D character to give it a more realistic look. An audio is a sound element that is used to give the viewers a more alive and understandable contents in this project. The audio is embedded after the animation has been rendered. The audio will then be combined with other multimedia elements such as graphics, animations and text in order to synchronize them together. There are two audio types in this project, which are, background music and voice over. The sound will be edited in Adobe SoundBooth software and will be converted into WAV file format. Then, it will be imported to Adobe After Effects software to be arranged in the suitable scene.

A series of editing and combining the video has been done in Adobe After Effects software and Adobe Media Encoder software. Adobe After Effects software is used to create video of introduction for title and credits for this project. Then the video that have been created will be imported into another main file in After Effects to be combined with the other elements such as, animation and text. After finish all the editing, the video will be rendered in .avi file format. After the video is successfully rendered, it needs to be converted into .f4v file format. This action need to be taken because the previous rendered video is too large in size. In order to convert the video from .avi file format into .f4v file format, another software that used is Adobe Media Encoder.

Basically there are two phases that need to be done before an animation can be rendered. One of them is modelling the characters. In modelling phase, all the character needs to be created in Autodesk Maya software. Next is the animating phase, where all the completed character is being animated. Animating steps are done by referring to the storyboard designed in the pre-production phase. In addition, lighting is added to the animation in Autodesk Maya software to make it more interesting and alive. In this project, there are two types of lighting used, which are spot light and ambient light. The camera also added other different kind of perspective for each shot. After all the steps have been completed, the animation will then be rendered in the form of sequence of images. Frame by frame is being rendered in targa file format.

All the completed and rendered media files which are text, graphics, animations, and audio will be gathered. Then, all the media elements involved will be imported into Adobe After Effects CS5 workspace to be combined. In order to produce a full video, all of the elements will be edited in Adobe After Effects software. After all the editing is done completely, the video will be rendered in Adobe After Effects. Later the rendered video will once again undergo rendering process in Adobe Media Encoder CS5 software to obtain .f4v file format video. Figure 4 to Figure 8 show some of the interfaces of 3D Colon Cancer Simulation.

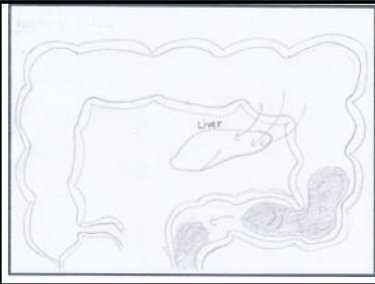
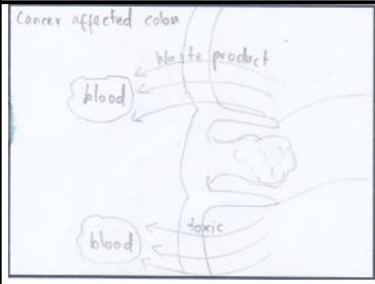
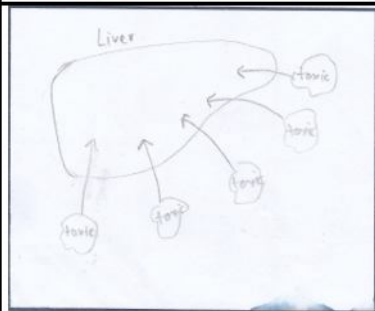
	<p>Scene #12</p> <p>Description: Liver helps to breakdown all the waste product that is left in the blood stream and digestive tract.</p> <p>Duration: 42 seconds</p> <p>Type of shot: Wide shot</p>
	<p>Scene #13</p> <p>Description: Excessive toxic and waste product are released to the bloodstream because of the colon malfunction.</p> <p>Duration: 15 seconds</p> <p>Type of shot: Close-up</p>
	<p>Scene #14</p> <p>Description: Liver need to work harder than usual to fight the toxic. Then, the toxic will start to accumulate and damage the liver.</p> <p>Duration: 30 seconds</p> <p>Type of shot: Medium shot</p>

Figure 2: Storyboard



Figure 4: Main Interface



Figure 5: Symptoms and Signs Interface

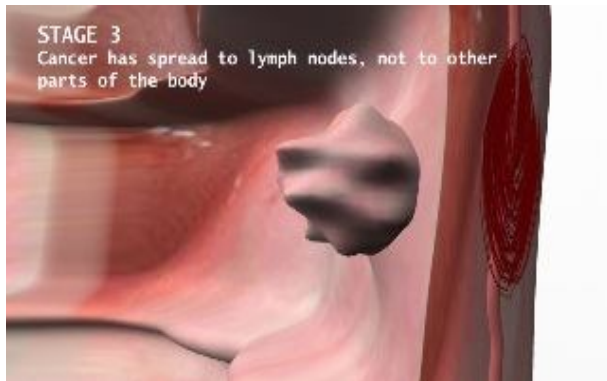


Figure 6: Stage 3 Interface



Figure 7: Stage 4 Interface

Object	Character
Human colon	
Human Torso	
Inner wall of colon	
Cancerous colon	
Human liver	
Faeces	
Red blood cell	

Figure 3: Character Profile

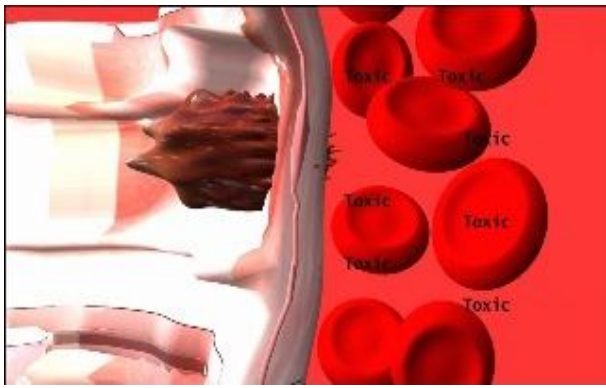


Figure 8: Colon Malfunction Interface

4. TEST RESULT AND ANALYSIS

This phase is the final phase, where various kind of test will be conducted to get the feedback from the user before this product can be released. The testing strategy is to conduct user test on 3D techniques, user test on level of understanding and test user on the content. During the test implementation, all the test description is documented. After the testing process is done, the data will be analyzed in order to show the outcome from the testing that have been conducted to the target user.

Table 2: Testing Schedule

	Cycle 1	Cycle 2
Type of Testing	Understanding, content	Functionality, usability, user interface
Venue of Testing	Klinik Kesihatan Hutan Percha Melaka	Programming Lab 4 (MP4), Faculty of Information and Communication, UTeM
Respondent	Medical staff and waiting patients	Interactive Media lecturer and 3 DIT students
Number of Respondent	10 medical staff, 20 waiting patients	1 lecturer, 19 multimedia students
Duration	60 minutes	30 minutes

The testing process is divided into two groups, which are:

- i. Group 1 : Doctor, nurses, support staff and also waiting patients at Klinik Kesihatan Hutan Percha Melaka.
- ii. Group 2 : Media Interactive lecturer and Diploma in ICT students from Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka (UTeM).

For Group 1, the user understanding testing is conducted to the waiting patients at Klinik Kesihatan Hutan Percha Melaka. Public viewers will test the product and evaluate on their level of understanding about colon cancer simulation presented. Content testing is the testing that is conducted to the medical staff, including doctor, medical assistants and nurses. These medical staff will test the product and evaluate the validity of the information provided by the product. There are three aspects that user from Group 2 will evaluate on, which are functionality, usability and also user interface. In the functionality testing, the respondent will test the functionality and the smoothness of the animation. The evaluation aspects include animation, content, design, sound, video effects and other multimedia aspects. Meanwhile, in the usability testing, the respondent will evaluate the product after the demonstration process has been carried out. The user will check the contents, whether it is suitable to be used in the hospital and clinic or not. User interface is the process of testing the product’s user interface to ensure it fulfills its specification. The respondents will evaluate whether the interfaces are suitable for this project. Table 2 below shows the details of the testing schedule.

Table 3 shows the questions for the understanding testing, comprises of ten questions. The other ten questions of the product content are shown in Table 4. The results of the understanding and content testing are visualized in Figure 9 and Figure 10, respectively. Meanwhile, Table 5 shows the questions for functionality, usability and user interface testing, each five questions. The result of functionality testing is shown in Figure 11, the usability testing result is presented in Figure 12, while Figure 13 shows the outcome of the user interface testing.

Table 3: Question for Understanding Testing

Question 1: Based on the 3D Simulation on Colon Cancer video, did you understand the parts in the human colon?
Question 2: In your opinion, can this video provide the viewers with the information about colon cancer?
Question 3: After watching this video, can you identify the differences between each stage that occurs in colon cancer?
Question 4: Are the explanations in this video are clear and complete?
Question 5: Based on the video, can you understand the effects if the colon fails to function properly?
Question 6: Does the audio explanations can be understood?
Question 7: In your opinion, does the explanation using a video is easier to be understood compared to the explanation on the pamphlets?
Question 8: Does a video like this attracts you to learn more about colon cancer?
Question 9: In your opinion, does a video like this is suitable to be view in public?
Question 10: Do you feel that the information in this video helps you to understand in more detail about colon cancer?

Table 4: Question for Content Testing

Question 1: The contents of this simulation are true.
Question 2: The explanation about colon cancer is understandable.
Question 3: The animation is suitable to be viewed for the public viewers.
Question 4: This project content is suitable to be used in the clinics and hospitals.
Question 5: The content for Module 1: Introduction to Colon Cancer is complete and simple to understand.
Question 6: The content for Module 2: Simulation on how the colon cancer happens is complete and easy to understand.
Question 7: The content for Module 3: Effects if colon fails to function properly is complete and easy to understand.
Question 8: The process in this simulation is animated in a correct way.
Question 9: The flow of the modules is suitable that makes it easier to understand.
Question 10: This simulation is useful for educational purpose.

Table 5: Question for Functionality, Usability and User Interface Testing

Question for Functionality
Question 1: This animation has fulfilled the objectives.
Question 2: The explanation about colon cancer is understandable.
Question 3: I can recall all the information provided in this animation.
Question 4: This project content is suitable to be used in the clinics and hospitals.
Question 5: The process occurs is animated smoothly.
Question for Usability
Question 1: Explanations about the stages of colon cancer are detail.
Question 2: The content of this animation is simple to understand.
Question 3: This project is suitable to be used for educational purpose.
Question 4: I am able to understand well the topic and answer the related question after viewing the animation.
Question 5: I am satisfied with the content of this project.
Question for User Interface
Question 1: The color of the background is suitable for this animation.
Question 2: The background music is suitable and clear for this animation.
Question 3: The text in this animation is readable and understandable.
Question 4: The narrator explanation is clear and understandable.
Question 5: The audio helps to attract user attention.

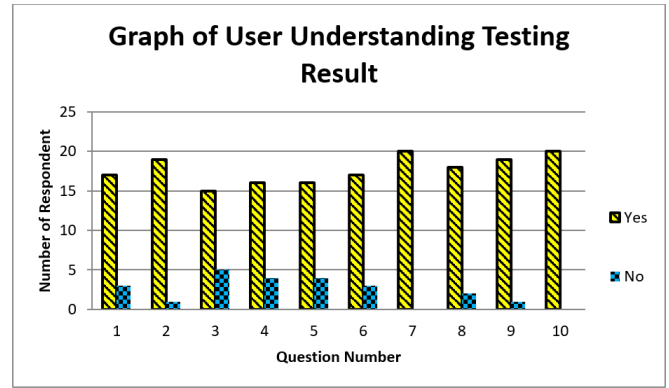


Figure 9: Result of Understanding Testing

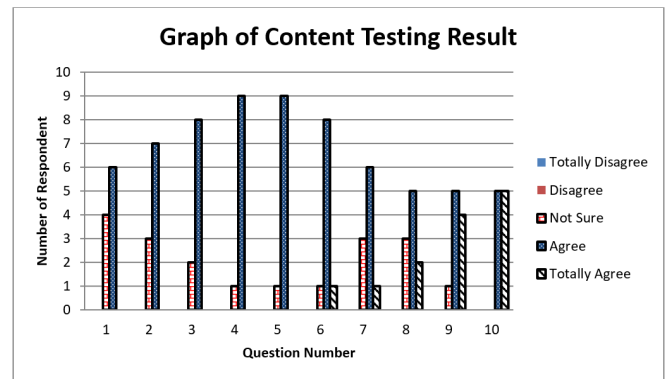


Figure 10: Result of Content Testing

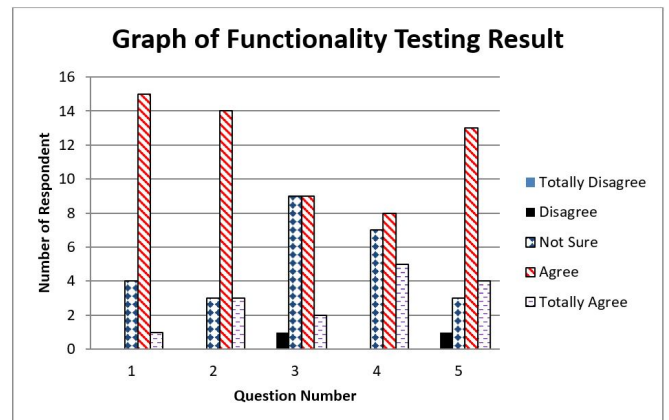


Figure 11: Result for Functionality Testing

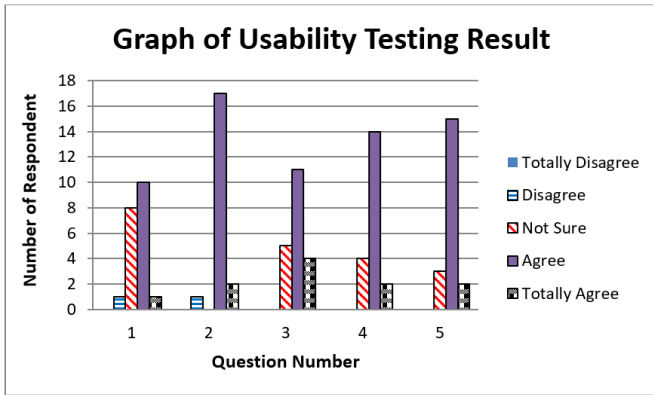


Figure 12: Result of Usability Testing

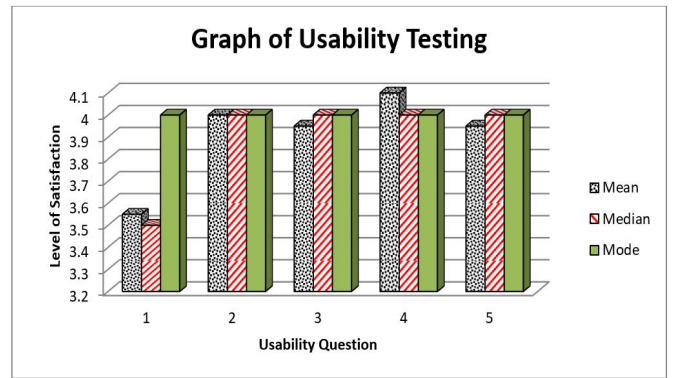


Figure 15: Result of User Interface Testing

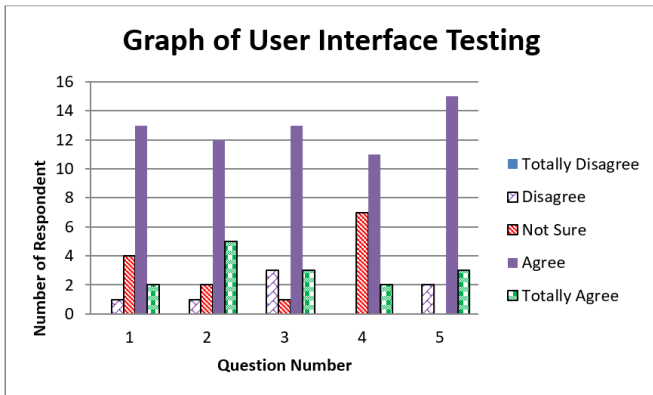


Figure 13: Result of User Interface Testing

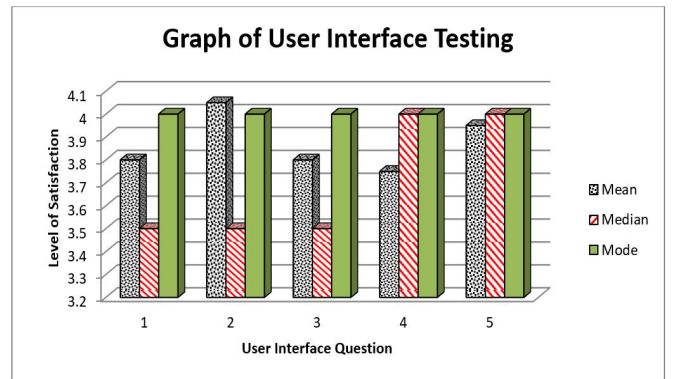


Figure 16: Result of User Interface Testing

Figure 14 to Figure 16 represent the results of functionality, usability and user interface testing, respectively, in mean, median and mode based. The purpose of calculating the mean is to indicate the average level of satisfaction from the users after the demonstration of this product. Meanwhile, the median representation indicates the middle entry level of satisfaction from the test users of each question. Finally, mode is calculated to identify the highest level of satisfaction for each question through all the testing, which are the user understanding, content, functionality, usability and user interface testing.

Meanwhile, Figure 17 shows the pie chart to indicate the preferred category between functionality, usability and user interface criteria. There are 34% of respondents who relate the product with the usability aspect, 33% of respondents vote more for functionality and the remaining 33% of the respondents select user interface. This result shows that most of the respondents like the usability aspect of 3D Simulation on Colon Cancer. For the usability aspect, the user found that this product is easy to use. The respondents also found that this product is easy to understand. Meanwhile, for the user interface, some of the respondents satisfied on the elements of text, audio and color used in this product. It is similar to the functionality aspect, where the respondents like the animation and the way of delivering the product information.

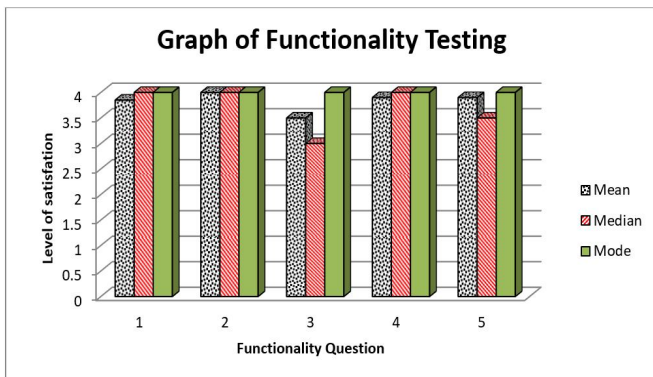


Figure 14: Result of User Interface Testing

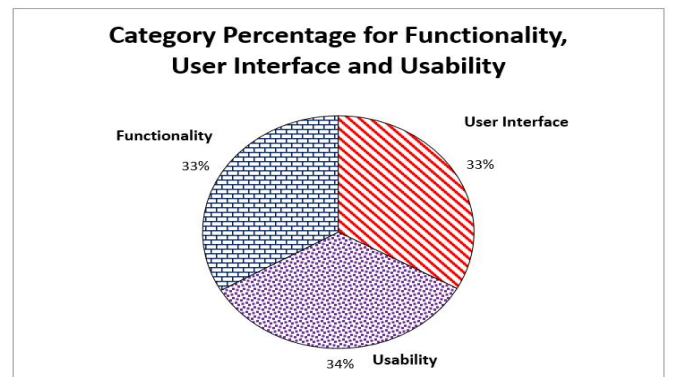


Figure 17: Pie Chart of Category Percentage

It can be summarized that this product provides the target user with 3D animation which gives a more realistic view about colon cancer. This will make the target user easy to understand and imagine what actually happens in the colon, if someone is having a colon cancer. Moreover, using 3D animation as learning content provides a better way to illustrate the processes that happens in the colon. This product provides the user with three modules, which shows about the introduction to colon cancer, how colon cancer happens and the effects if the colon fails to function properly.

5. DISCUSSION

From all the test result analysis gathered, it can be concluded that visualization on specific colon cancer can be improved to increase the viewer's understanding. The information for each stage of colon cancer can be added to assist viewer on understanding more about colon cancer. In addition, it is discovered that the animations in this product are not enough. There should be more animation because the product is a 3D based content. The impact of having not enough animation may cause the information delivery is not successful to the target user. Texts are important to be readable by the target user. The color of texts must be contra from the background color to make it easier to be read by the target user. However, some color of the text in this product is not suitable because it is similar to the background color. It is also commented that the type of font used in the product is also important to make the information readable by the target user. The consistency of the font used in this project is also important to make it easy to be read by the target user. Moreover, the language used in this product is only English language. The user that is not familiar with English will face some difficulties in understanding this simulation. Therefore, for target users that are not familiar with English, a Malay version may help to improve their understanding on this product.

As a future improvement to this product, it is suggested to include more animation, so that this product can be more attractive and will be able to deliver better information to the target users. In addition, the elaborations of the content should be added to improve the target user understanding on colon cancer.

6. CONCLUSION

As a conclusion, this proposed product will contribute in medical field for public viewers to learn more about colon cancer. Colon cancer is among the commonest cause of cancer deaths not only in Malaysia, but worldwide. Therefore, it is important for the public to learn more about colon cancer. This product also provides a better and faster way to learn about colon cancer, compared to the conventional styles, like, brochures and pamphlets. All multimedia elements, such as graphics, text, audio and animation that have been included in this product can help the public viewers to expose themselves about colon cancer. The usage of multimedia elements can provide a better learning process. Although this

product has some weaknesses, but it still can be improved to become a better product in the future.

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