

Eye Simulation Using 3D Animation

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Abstract-The project “Eye Simulation using 3D Animation” is an application developed under Aakash Lab at IIT-B which aims to maximize usage and reach of open source educational content using Aakash. This paper discusses the practical realization of basic difficulties faced by students to access and use multiple learning materials for complex human body structures like the eye and the approach to solve the same.

Index Terms- 3D Model, Aakash, Android Application, Blender, Blender Game engine, E-learning, Human Eye Simulation, Open Source 3D Animation.

1. INTRODUCTION

3D Netra is an E-learning application that provides a platform to students and teachers of Indian Certificate of Secondary Education (ICSE), Central Board for Secondary Education (CBSE) and Secondary School Certificate (SSC) boards, to learn about the concepts of the human eye, as outlined in their syllabus.

It overcomes the drawbacks of traditional classroom methods where the 2D perspective of eye is given in textbooks and it is insufficient. Also, students do not receive equal opportunity to query or participate and they have no easy means to evaluate their knowledge.

“3D Netra” will offer students an alternative to purchasing reference material, getting online help, or enrolling in extra tuitions. Teachers will use it to teach theory and practical simultaneously.

The application has inbuilt features like 3D, animation and interaction, coupled with user-friendly navigability and reusability.

Blender 3D which is a free and open source animation software [2], is used for making the model of the human eye and applying material, texture and lighting to it in a realistic way.

Interesting score-based activities and games included in the application will allow for repetitive practice and self-evaluation for the students.

Due to widespread use of desktops, HTML, CSS and JavaScript has been used to develop the application on desktop.

Also, because of the fast growing use of Low Cost Access

Devices (LCAD) in android [3], the application has been developed for Android device users as well.

The rest of the paper is organized as - Section 2, covers the literature survey which gives the overview of the existing systems used for teaching concepts of eye. Section 3 talks about the Proposed Approach which covers the idea and objectives of choosing the proposed method. Section 4 is about the Design and Implementation, explaining the design and building method of the application. Section 5 describes the teaching model that has been adopted for teaching concept of the eye. Section 6 discusses Results obtained along with sample outputs. The paper ends with conclusion and the future scope.

1.1 Traditional Methods of Classroom Teaching

Currently, most teachers adopt the simplest methods of teaching about the human eye, which are textbooks and blackboards. Textbooks are the one which are prescribed by the current syllabi of various boards and contain theoretical knowledge. Blackboards are the methods used in classrooms to emphasize and teach certain important fundamentals of the subject. However, neither the textbooks nor the blackboards contain any 3D visuals to grab student’s attention.

Sometimes, teachers make use of physically created 3D models of the eye which can be brought to the classroom. Students can view the detailed internal structure of the eye. However, they are not usually well defined, and are bulky to handle by students.

Furthermore, teachers need to manually point out the individual parts of the eye. They usually cannot be dismantled and offer no interactivity or simulation options.

1.2 2D Videos

There are numerous 2D videos available on the internet which shows the working of the human eye. Some examples of available videos are “The Human Eye”, “Sense of Sight-How Human Eyes Work”, etc. Students can refer to them to get some reprieve from the everyday textual matter of textbooks. However, as the name suggests, they offer only a two dimensional view, whereas the eye is actually a three dimensional organ. Thus it is necessary to provide a three dimensional perspective to explain the concept of the eye.

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1.3 3D Videos without Interactivity

Research suggests that the 3D animated models represent information in the most economical manner to facilitate learning and comprehension, thus simplifying complex, abstract and impossibly large amounts of information into a coherent form [4]. Some examples of 3D animations are "Amazing 3D Eye Animation", "Anatomy and Function of the Eye", etc.

However, just simple 3D videos do not provide any form of interactivity to the students. Interactivity allows the students to control various parameters and scenarios to see how the eye adapts to them.

Interactive computer simulations with complex representations and sophisticated graphics are a relatively new addition to the classroom [5]. Our research work also focuses on this aspect.

1.4 Current Mobile Applications

In the market, a mobile application called "Eye Anatomy and Physiology" is available [6]. It is an elegant and immensely satisfying App. It clarifies all concepts related to the mechanism of converting light energy into electrochemical impulses by the human eye. However, it provides no means for assessing or evaluating what the user has learnt whereas assessment is an important aspect in teaching-learning process.

2. LITERATURE SURVEY

Currently, there are a number of traditional approaches being used to teach school students about the human eye. This section covers the existing methods including classroom teaching, 2D online videos and real physical models.

2.1 General Observations on Existing System

As seen in Section 2, the various teaching tools which are currently in use by the teachers in schools to teach about the concepts of the human eye. After the in-depth study of these methods, following are the observations about the existing system and its shortcomings.

- Students mainly have to rely on their prescribed textbooks filled with only theory and 2D images. Due to the 3D nature of the eye, students need a better tool to learn about its movements and defects.
- Videos available online are mainly 2D based. They are of poor quality and authenticity and offer no simulation.
- There are mobile applications which only provide 3D animated videos, and some theoretical content without any interactivity. Students need some interactivity and a more accurate detailed view of eye in the E-learning scenario. Interactive environment allows students to experiment with different scenarios and inputs and watch their effects. This helps them to visualize and learn better.
- Other simulators are not easily or freely available to students/teachers in India or are too high scale projects to be used by them. What they need is an open source, free

and easily portable application available across a wide range of basic platforms, i.e., Windows and Android.

- None of these teaching techniques include any method of quiz or game to test the knowledge of the students after they have learnt about the eye. Students as well as teachers need assurance that their current method of learning is actually effective. Quizzing via games makes the teaching-learning process more interesting.

Keeping in mind these shortcomings of the existing system to teach about the eye, it has been decided to develop an application "3D Netra".

3. PROPOSED APPROACH

Before looking at the approach to designing and building an application-3D Netra, let us see the content covered by the syllabi at school level about the eye.

3.1 About Eye

Eyes are considered to be our windows to the outside world. They are small compared to most organs of the human body, but their structure is incredibly complex. Discovering the marvels of the eye and how it exactly looks at things is not a simple process.

Almost every education system at school level includes a chapter having a detailed study of the human eye. In general, each of the syllabi has explained the following concepts regarding the human eye.

1. Structure of the Eye: Functions of the eye along with structure of its various layers and parts, as seen in Fig. 1.

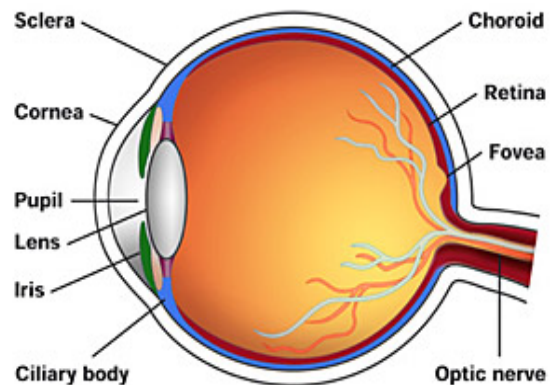


Figure 1: Structure of the eye [7]

2. Viewing of images: How images are formed in the eye and how it "sees".
3. Accommodation: How the eye brings objects at different distances into focus.
4. Light and Dark Adaptation: How the pupil constricts and dilates when exposed to various intensities of light, as shown in Fig. 2.

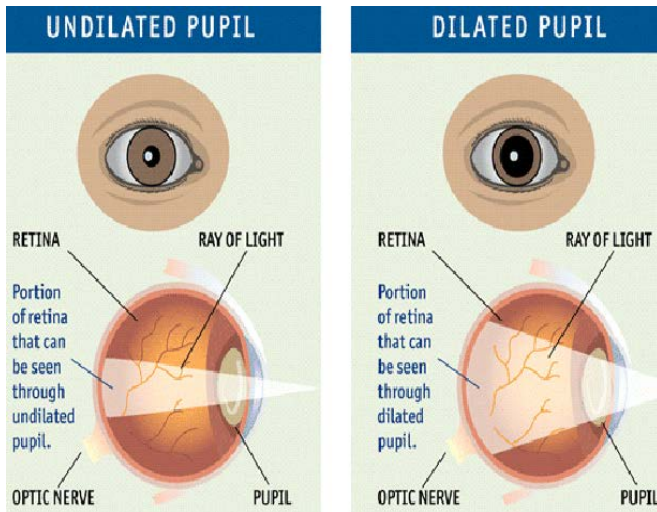


Figure 2: Light Adaptation of the Eye [8]

5. Eye Defects: Lastly, it lists out some common defects of the eye such as Myopia, Hypermetropia, Astigmatism, Presbyopia, Cataract, their causes and their cures, as well as methods to take care of the eyes.

In the proposed solution, it has been decided to cover the detailed structure of the eye, the formation of images in the eye, and how the eye adapts to different intensities of light.

3.2 The Approach to Teach about Eye

The prime objective in the proposed work is to minimize the dependency of students on their imagination and the existing sources for learning the complex processes of image formation and working of the eye.

3D Netra is an E-learning application as it provides flexibility that can expand access to rural areas and to educators or students that have difficulty with traditional educational settings because of their schedules or their accessibility. This has been made possible by 3D Netra using Desktop and Android device porting. Three dimensional view of the human eye will help students better visualize its parts and functions.

As a part of the teaching strategy, the teaching model includes a graphical representation of the working of the eye and image formation as an animation, to enhance the understanding of the students. Another teaching strategy allows the students to interact with various parameters of the eye functions and viewing its outputs will give them a practical approach to learning. The teaching model also provides students with a means to assess the knowledge they have gained by taking tests and activities corresponding to each stage. In this way, the interactivity and self assessment activities help the students to understand the concept of eye in a better way. The design and implementation of these

elements will be discussed in the next section.

4. DESIGN AND IMPLEMENTATION

This section covers in detail the design and implementation of the system as a realization of the approach outlined in the previous section.

4.1 System Architecture

The basic architecture of the system is represented in Fig. 3. Layered Architecture has been used as the framework for the application, because it is a stand-alone application and it is best suited for the system. The system architecture is divided into two main layers, Presentation and Business Logic Layers.

The Presentation Layer includes the User Interface which has been developed for Desktop and for Android OS devices. This layer gives the input to the business logic layer and takes the output to it.

The Business Logic layer incorporates the Domain Model, where Blender tool is used to make the 3D models of the eye. The textures for the models have been created in Adobe Photoshop and these have been applied to the models in Blender. Furthermore we have added appropriate lighting, to give a more realistic view to the human eye. The Teaching Model contains the Blender Game Engine which is used to create the animations and logic bricks to lend interactivity and motion to the dynamic model of the eye. The output of the Game Engine is then ported to the various 3 stages, i.e., Structure, Working and Adaptation along with the corresponding activities.

Business Logic Layer receives the user input from the Presentation Layer, processes it, produces the output and transfers it back to UI for graphical display. Presentation

Layer receives the output from the Teaching Model of the Business Logic Layer and makes use of BlenderPlayer and Burster Plug-in to run the .blend files on Android devices and Desktop respectively.

The roles of the models in the architecture of the system are as follows:

- Domain Model contains the human eye model in three dimensional view along with realistic materials and textures, which has been created using Blender. This model is then imported into the Teaching Model.
- Teaching Model uses Blender Game Engine to add interactivity during the teaching-learning process to the imported model. It also includes the three stages to teach about the eye processes and the two activities to assess what was learnt by student which will be covered in detail in the proceeding section.

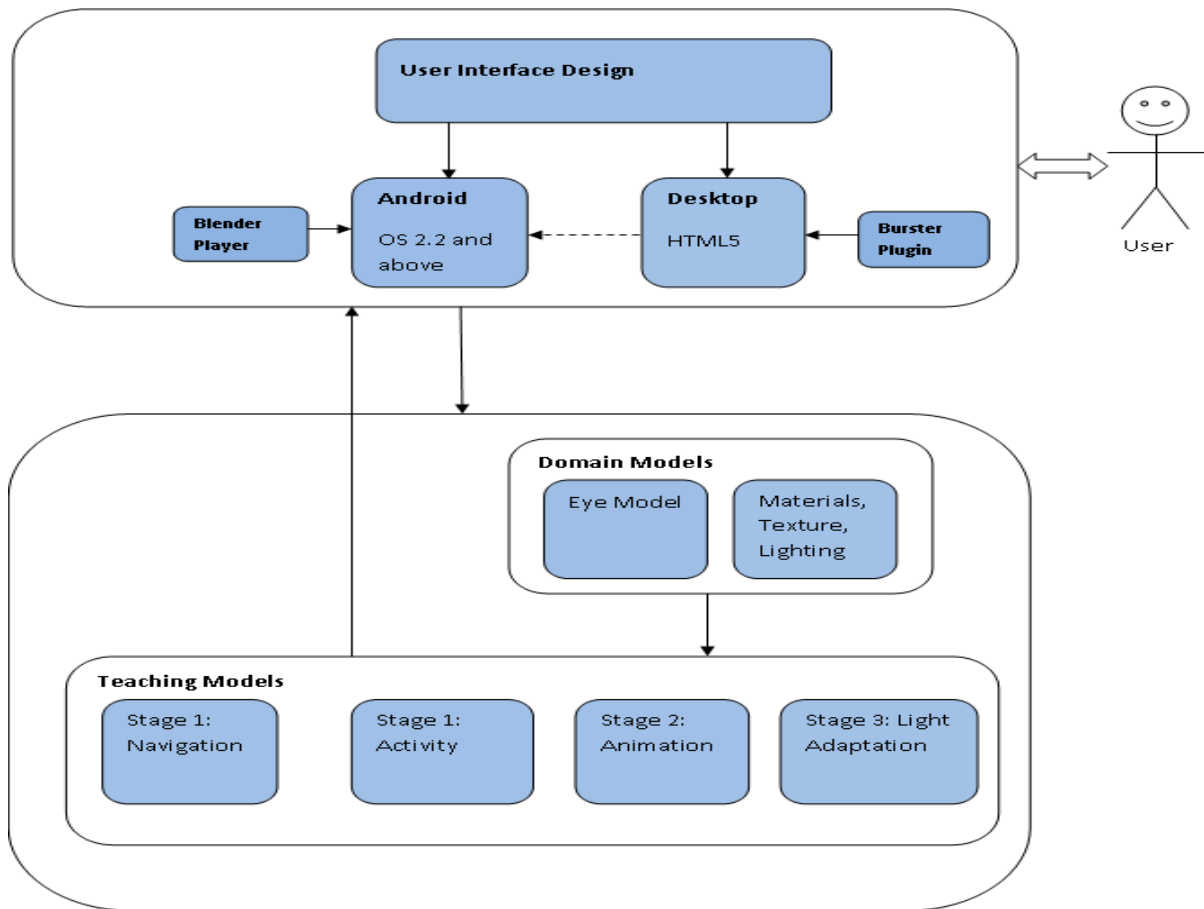


Figure 3: System Architecture

- User Interface for desktop has been designed using HTML and CSS to provide easy interaction and navigation to the student. With the help of Burster plugin, the blender and video files can be executed on web pages.
- User Interface for Android and extending the use of most html pages into the Android application using java android programming and running blender files on BlenderPlayer for Android.

Looking at the role of various models of the system architecture, now the teaching-learning process.

5. TEACHING MODEL

E-learning and collaborative/co-constructive pedagogies go together. It changes the dynamics of the entire classroom. Using collaborative, interactive pedagogies that also foster co-operation appear to lead to effective learning and better teacher-student relationships over time [9].

In the teaching-learning that is chosen for this application, students will first view the three main stages and grasp the concept using basic navigation, click events and animation. The corresponding two activities will then ask them to solve certain problems to test their understanding and common mistakes. The teaching-learning processes that are used have been discussed below.

5.1 Stage 1: Structure of the Eye

The students are given a three dimensional-cross sectional view of the human eye, with each part clearly labeled as seen in Fig. 4. The left and right buttons allow for rotation of the model in two directions and the labels appear as the parts come into view. Clicking on a label will display some information about it. The zoom in and out icons allow for zooming into smaller parts. Thus they will get a clear understanding of the detailed structure of the eye in every angle along with information about each individual part.

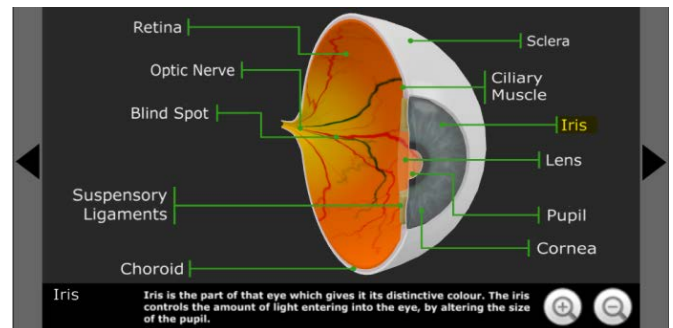


Figure 4: Stage 1 Structure of the Eye

5.2 Stage 1 Activity

To test whether the student has learned the basic structure of the eye, an activity is designed where the student will be given a choice of three labels for any one part, as shown in Fig. 5. If he selects the correct label, it turns green, else it will turn red. Three levels have been included to cover all the parts, which would be difficult using a single angle. They depict the side view, the angular view and a front view respectively. Finally, after he has clicked all the correct labels over the three levels, he is given a total score at the end. This will tell the student about the degree of his understanding.

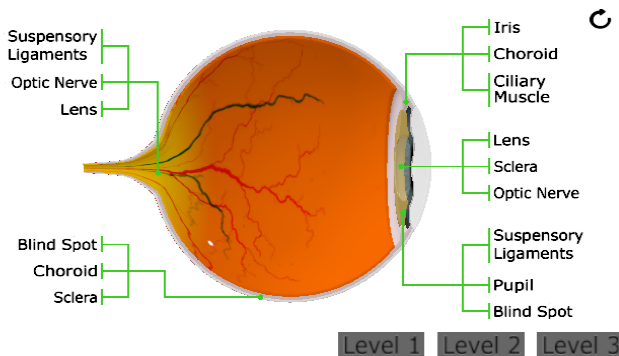


Figure 5: Stage 1 Activity

5.3 Stage 2-Working of the Eye

The second stage shows an animated video about the formation of image in the brain, as seen in Fig. 6. It starts with the object emitting four rays which enter the pupil, travel through the lens and finally hit the retina forming an inverted image. The image pulses are then sent through the optic nerve to the brain, where we finally “see”. Since this concept of image formation is actually a sequential process, a 3D animation would be the best way to represent it. A student will better understand the entire process using a video rather than through text or images.

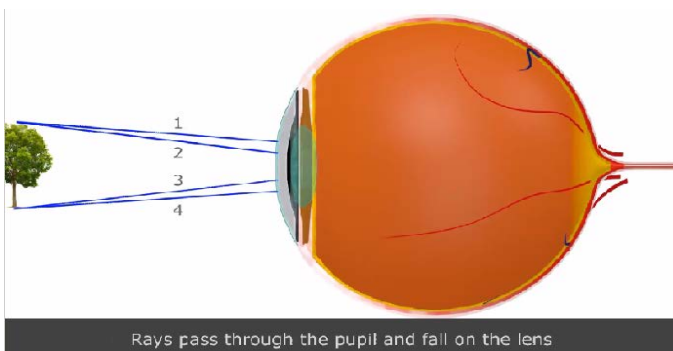


Figure 6: Stage 2 Working of the Eye

5.4 Stage 3-Adaption of the Eye

The third stage lets the user see how the eye reacts to different intensities of light by controlling the light intensity

using up and down arrows, as seen in Fig. 7. On clicking the down arrow, the brightness decreases while the pupil dilates. On clicking the up arrow, the brightness increases while the pupil constricts. These interactive buttons will give the student more freedom and control to experiment with different degrees of light and view its effects.

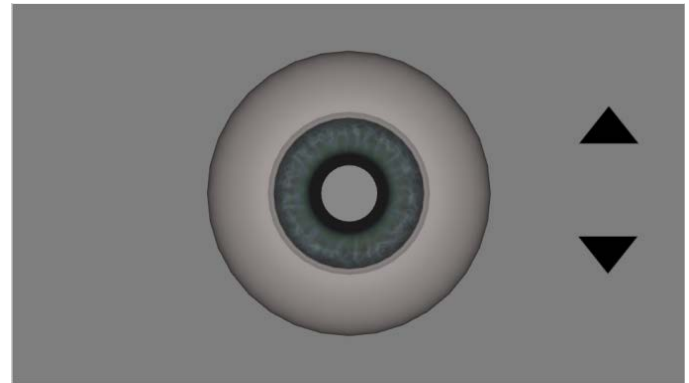


Figure 7: Stage 3

5.5 Stage 3 Activity

The activity corresponding to stage 3 includes a game where the student navigates between 4 scenes depicting 4 different stressful light conditions. Each scene has an accompanying pupil size of the eye. The student is asked to choose the correct object that will reduce the stress on the eye, for that particular condition. By looking at the realistic graphics of the scenes, he will relate to them by his own daily activities. It is shown in Fig. 8. Accordingly, he will be better informed to understand the stress and take appropriate measures to reduce it.

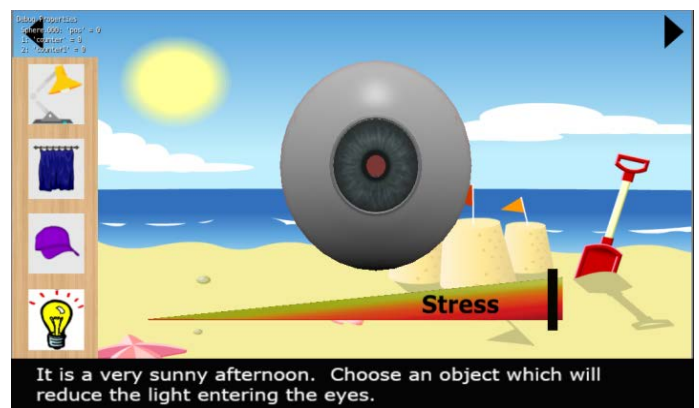


Figure 8: Stage 3 Activity

Thus from the above outlined teaching models, the student will be able to get a good grasp over the basic structure and functions of the eye.

5.6 Implementation Challenges

The following are the challenges that have been addressed in this project.

1. Authenticity of the 3D eye model, its parts and its

functions was a challenge so that students learn the concept correctly.

2. Controlling the visibility of labels in Stage 1 of the application was challenging because the labels have to appear and disappear with the correct rotation angle of the eye model.
3. Converting the high poly model of the eye to low poly model to avoid heavy file size was difficult as each individual vertex, face and edge of the model had to be scaled down and reduced.
4. Keeping the user interface consistent while porting the application on android devices with different screen resolutions was a major challenge. This was solved by excessive testing on various screen sizes of desktops and tablets.

5.7 Benefits of the System

Some of the benefits of the system are:

- The animations make it more interesting to understand the working of the eye.
- Allows the students to learn at their convenience and individual pace.
- It is ported to desktop as well as Android for high availability.

6. EVALUATION AND RESULTS

Following is the evaluation plan that has been used to carry out the experimental evaluation of the system.

- Evaluating Usability: Students of ICSE board have tried out the application and given their feedback about the user friendliness and ease of navigation.
- Evaluating Accuracy: Consultation with an eye surgeon to test the accuracy of the eye model, its structure, its working and its adaptation functionalities.

The evaluation test cases, parameters used, method applied and the results obtained after testing are given in Table 1.

TABLE 1: EVALUATION CASES AND RESULTS

Sr. No.	Evaluation Parameter	Method Used	Test Results
1.	Application Design	Usability expert was consulted. Students and teachers tried out the app.	Attractive layout and design scheme.
2.	Usability	Usability expert was consulted. Students and teachers tried out the app.	Easy use and navigation.
3.	Accuracy	Eye surgeon was consulted about the content and models.	Complete model and its working are accurate.

4.	Adherence to Syllabus	Extensive research on the syllabi of ICSE, CBSE, SSC science for classes 9 and 10.	Strictly maintained textual concepts and activities as given in the textbooks.
5.	Functioning of quiz	Students took up the quiz before and after studying the concept.	They displayed a sharp increase in their overall score.
6.	Response time & Speed on various platforms	Tested on Desktop/ laptops and Android devices (Aakash tablet, Nexus, S4)	Smooth functioning and consistency in all devices.

To test the claim that 3D Netra is a better approach to learn the concepts about the eye, a sample test is designed. The test consists of 10 questions on various topics, namely, structure of the eye, parts of the eye, image formation and light adaptation. Using this test we compared the traditional classroom learning model with our system 3D Netra. Actually we evaluated these models to prove which model is better for student in learning process and who gets better understanding of the concept of eye. So we devised a strategy of conducting a pre and post test and then compared the scores obtained by the learner in both tests. To carry out this test 50 students were identified. First of all the students were asked to give the pre test and their scores were recorded. Then all students had undergone a two hour session to learn the concept of eye using 3D Netra. After taking the session all students attended a post test which consist of questions similar to that of pre test. The post test score was recorded for each student and compared with the pre test score. The improvement in the score of the student is shown in the form of bar graph in Fig. 9.

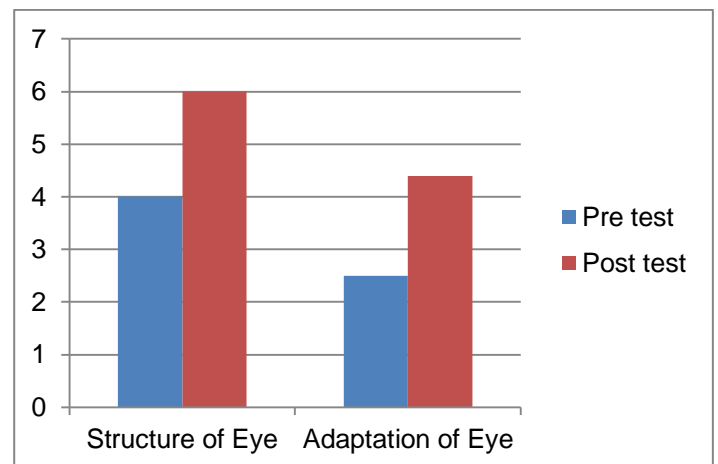


Figure 9: Test Evaluation

From these test results, it can be concluded that 3D Netra is a better teaching model as compared to the various existing models to learn the concept of eye.

7. CONCLUSION AND FUTURE SCOPE

This project allows students to study the human eye in detail by giving them a 3D perspective of the eye. By including the interactivity feature, students understand the working of the eye and how the eye reacts to different light intensities under different conditions in a better way. The assessment model also allows the students to test their knowledge about what they have learnt. In this way 3D Netra helps students in developing a thorough understanding of the eye.

The future scope for this project is to extend it for users to act as surgeons and perform real-time operations such as cataract. The students will be able to see the way the eye reacts to the light intensity in the room by processing the captured image. It can also give the users an option of lens correction on the defective eye model.

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