DIGITALIZED HUMAN BODY

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Contents

Abstract

In this report we will focus on the use of two technologies to provide a unique low-cost teaching and learning experience to those who are interested in learning more about the human body in an effective way. The project aims to increase people's knowledge of human organs, their functions and how to maintain a healthy body. The main objective of implementing this application is to enhance the learner experience through interaction.

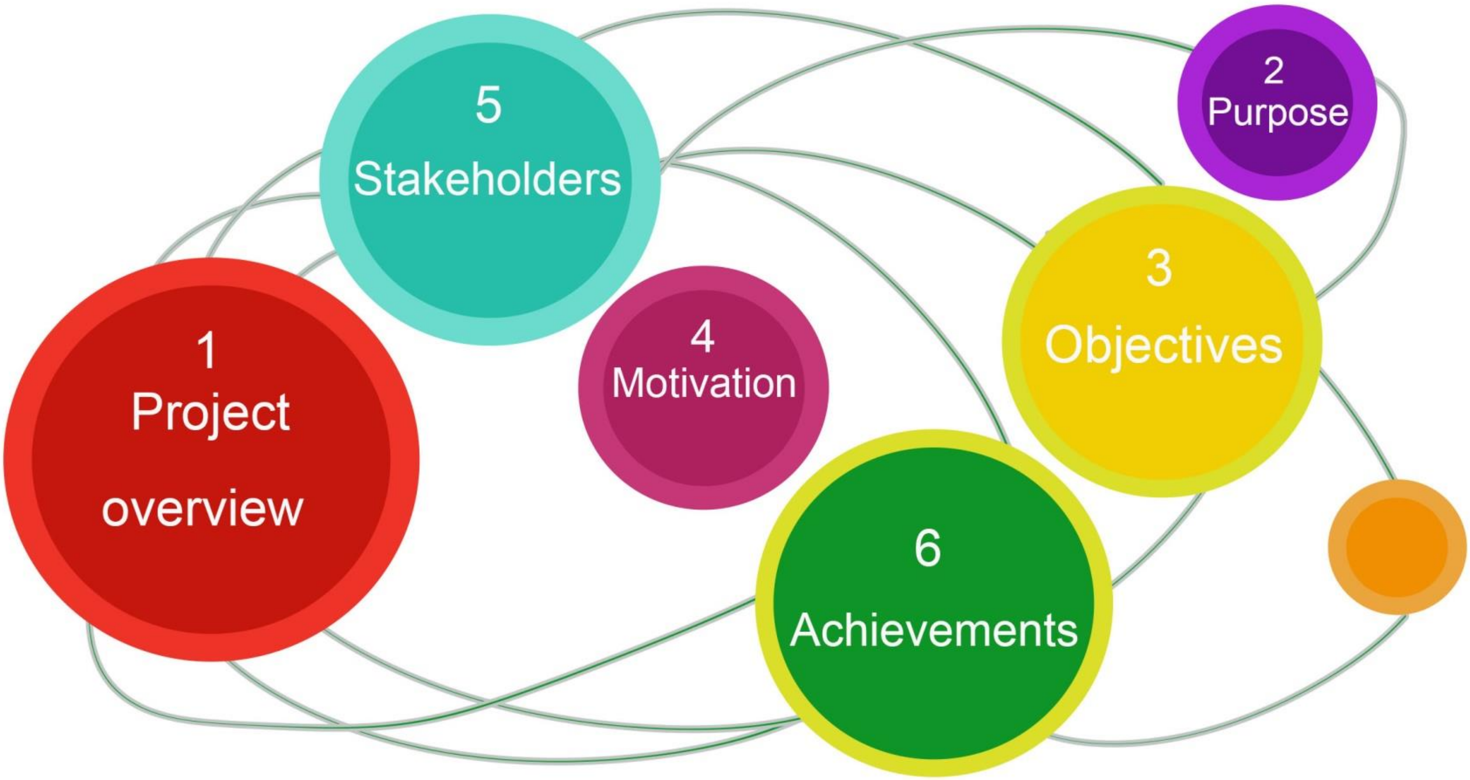
The project will be developed using Parallax design to add the interactivity to the system whilst a gesture detection sensor will be used to interact with system using hand gestures. Parallax design is a special scrolling technique in computer graphics that is becoming popular in web design. It uses Multiplane camera technique wherein the foreground layers move by the camera in different directions faster than the background layers. The Microsoft Kinect and the Leap motion are sensors that enable users to interact with computers through gestures and voice commands.

The project will enable users to drag and drop body organs to the correct place in the human body using hand gestures. Furthermore, users will be able to view the human body and its organs at different levels of detail. This low-cost system can be placed in schools, universities and health clinics and be used by people of different ages and knowledge. The main reason of choosing these locations is that they are responsible for providing society with health information. Therefore the system will be a helpful tool in promoting science and healthy living.

List of Figures

List of Tables

Chapter 1: Introduction



1.1. Project Overview

Many years ago the study of human anatomy in the medical schools was done either through physical experiments or theoretical reading. The physical experiments were done through providing a physical skeleton with its parts, and the students experience them or through autopsy. This made the learning process very slow as it is difficult to provide the study materials at any time. However, people did not have other options to use. Several years later, technology has arrived and revolutionized almost everything in the world and day by day a new way is developed to facilitate the study of human anatomy. According to the Medical Schools Council today there are more than 40 medical schools in the UK that offer different degrees in both undergraduate and postgraduate levels and 33 of them are undergraduate medical schools which are all members of the Medical Schools Council (UK, 2001-2016). There are plenty of study aspects and ways available in these schools to facilitate the study of medical education, especially in human anatomy.

Many types of research have been conducted to develop the learning methodology, and clearly we can see that they succeeded in simplifying some aspects of learning. Although, many ways were applied to simplify the learning process of human body students are still facing difficulties in understanding the anatomy. Therefore, the idea of building a fully functioned system to enhance health learning came up. The system called Digitalized Human Body is an interactive digital tool that enables collaborative learning of the human anatomy. It allows users to explore the human body and its organs using gesture-based interactions. The system provides two main interactive sections to the user which are, explore your body and challenge yourself sections.

1.2. Purpose

The DIGITALIZED HUMAN BODY system attempts to simplify the learning methodology of human anatomy by providing a fully interactive environment. So, the user has the chance to examine different body organs and their functionalities. Furthermore, this system aims to revolutionize the learning process through exploiting the existence of developed technologies. Moreover, the project aims to give benefits to as much number of people in the society as possible from different levels of study and ages whether they have studied medical courses or not.

1.3. Objectives

Figure 1 below shows the project objectives.

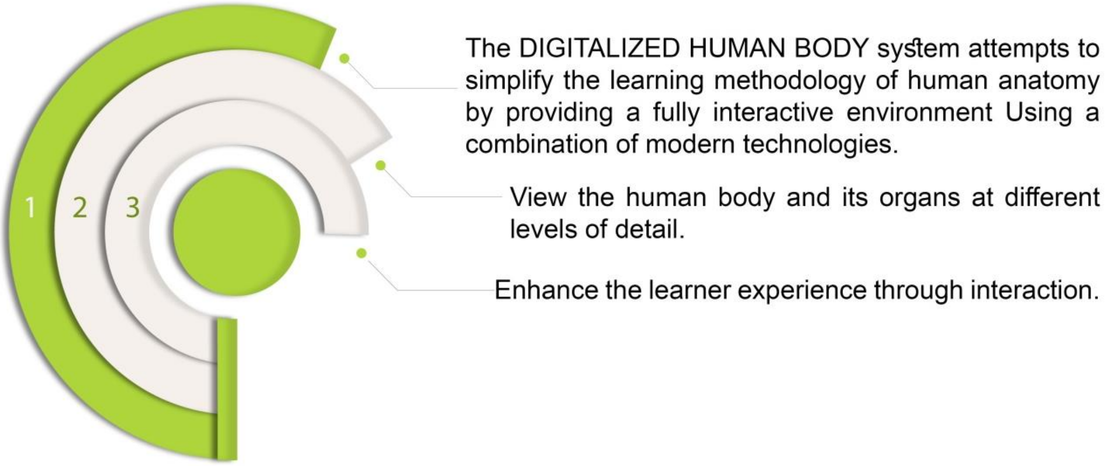


Figure 1. The project Objectives

1.4. Motivation

Having the knowledge about doing something enforces us to take the responsibility to build up the community. The most crucial angle in the society is the education in general especially health education. Therefore, developing this system will improve the health education development chain. Moreover, knowing about our body in such an easy and interactive way will reduce the percentage of nescience and increase the awareness about body organs Besides, the development of this project will give me the chance to learn new technologies especially the gesture based ones.

1.5. Stakeholders

The system can be placed in schools, universities and health clinics and can be used by people of different ages and knowledge. The main reason for choosing these locations is that they are responsible for providing society with health information. Therefore, the system will be a helpful tool in promoting science and healthy living. The stakeholders are listed below in figure 2 with the type of application:

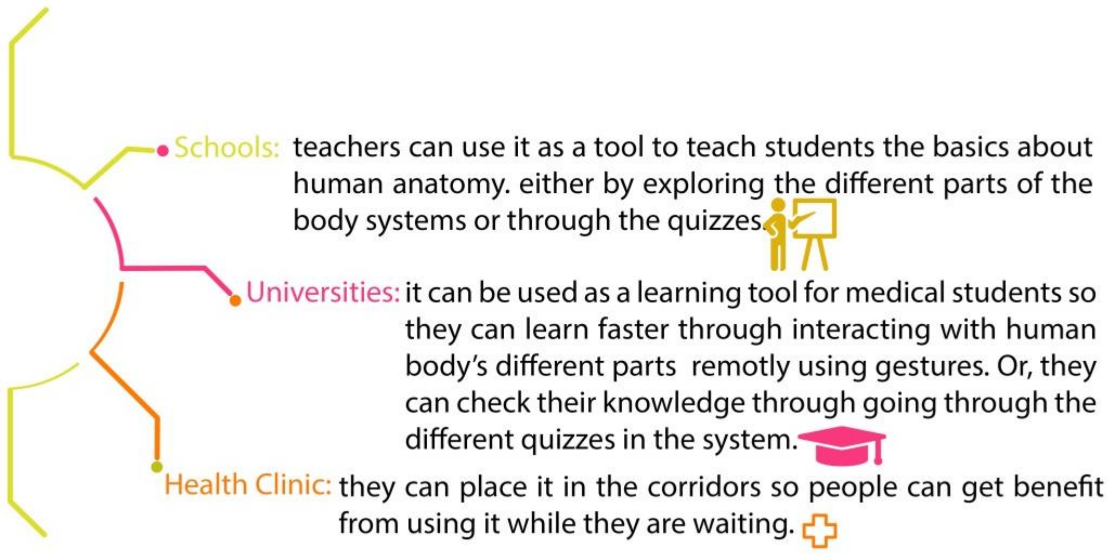


Figure 2. The project stakeholders

1.6. Achievements

The project participated and won competitions during the development process:

1. First position in master's poster among different UK universities in the 8th Women Lovelace Colloquium in Edinburgh sponsored by Google, BCS, and other famous IT companies, 9th, April 2015.
2. Third position in Oman Ambassadors Award organized by the Student Advisory Council of Oman, Oman Embassy and the Omani Cultural Attaché in the UK, Swansea, November 2015.
3. Participation Certificate in The Omani Open day at Brunel University, sponsored by Oman Embassy, London, UK, February 2016.

1.7. Report organization

The rest of the report is organized as follows:

Chapter 2: the literature review. Discusses the related work in human body study starting with learning styles and how normally people learn about something ending with how technology has enhanced the health education. It covers some related projects to this subject.

Chapter 3: the Background, speaks about all the technologies which have been examined to build the system and the best ones such as; HTML5, leap motion, Kinect and AngularJs.

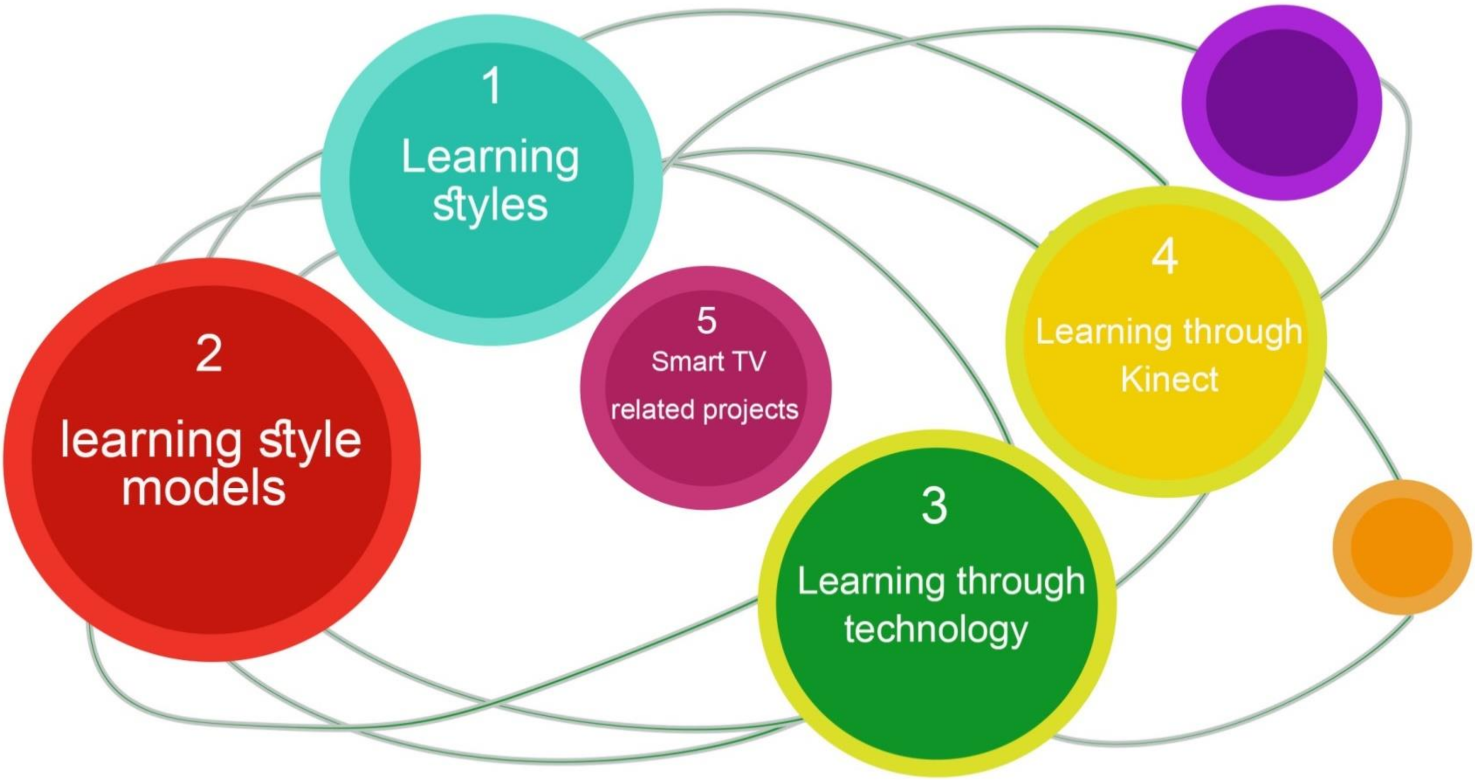
Chapter 4: Project Management, highlights the activities that need to be done to meet the project objectives as well as the methods that have been followed.

Chapter 5: Software Development, it has four subsections such as Analysis, Design, Implementation, and Testing. The analysis section covers the project functional and non-functional requirements and constraints to the project. While the design section includes the designing phase of the system such as; system architecture, system components, UML diagram, class diagram and storyboard. The Implementation section highlights the development stage of the project including the programming part. The testing section describes the testing methods of the project which are; white box and black box testing.

Chapter 6: Evaluation, discusses the results with their evaluation and whether they have met the objectives or not. What went well and what went wrong and what would happen if a certain way has followed.

Chapter 7: Conclusion and future work, summarizes the whole work along with future recommendations.

Chapter 2: Literature Review



2.1. Learning styles

The process of learning depends on different factors, and the main ones are directly related to individuals and how they prefer to learn. Learning styles represent the individual's way of dealing with any information and processing it. There was a big debate in finding a suitable definition for learning styles. However, (Keefe & J, 1979) define it pretty well when they said that it is "the composite of characteristic cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment."

Day by day with the development of technology the importance of learning styles increases. Although new technologies have revolutionized the education field, it is difficult to know the way of how people learn because it differs from one person to another even if there are some similarities in these ways. Therefore, many learning styles models have been developed to discover people's learning ways to prepare suitable material for each learning style. Dual coding is one of these models where the learner prefers to have the information presented either verbally or visually. Felder- Silverman is another models as well where information presented in a global perspective or more sequential details. Grasha-Riechmann Model classifies learners into a Collaborative and Competitive learners and the four-dimensional learning styles models which are, the Keirsey Temperament Sorter II, The Kolb model, Hermann Brain Dominance, the Honey-Mumford, the 4MAT Model and the Gregorc Model. Each model has its way to discover people's styles of learning. (Gordon & Bull, 2004) Have compared the four-dimensional learning styles models in a clear way and we can observe the diversity of learning style characteristics that have been focussed on each model and how clearly they were discussed as shown in table1 below:

The 4MAT Model	Hermann Brain Dominance	The Gregorc Model
• Type 3 (Common Sense Learners) interested in how things work prefer concrete experiential learning activities • Type 1 (Innovative Learners) interested in personal meaning, prefers cooperative learning, likes brainstorming • Type 4 (Dynamic Learners) interested in self-directed discovery, they rely heavily on their intuition, like role-playing and games • Type 2 (Analytic Learners) interested in acquiring facts to deepen their understanding of concepts and processes, likes lectures and analysis of data	• Quadrant B likes to learn in a sequential and organized way, and when instructional exercises are structured and detailed • Quadrant C has an interpersonal preference, is emotional and kinaesthetic. • Quadrant D prefers to take a holistic approach, is a very innovative learner and is strongly visual • Quadrant A is a factually-oriented learner, takes a logical, analytical, quantitative approach to learning tasks	• Concrete Sequential are hardworking, conventional learners, who are always dependable and organized • Abstract Random are sensitive, and compassionate learners, who are spontaneous and flexible • Concrete Random are quick, curious and intuitive learners, who combine a creative streak with a realistic outlook • Abstract Sequential are analytical, objective learners, who are thorough, structured and logical
Keirsey Temperament Sorter II	**The Kolb Model**	**The Honey-Mumford Model**
• Guardians are conformity oriented, and prefer systematic, structured learning • Idealists are interpersonal oriented and prefer to learn through discussion • Artisans are play-oriented and are free-wheeling and creative • Rationals are learning-oriented and prefer to learn by theorizing, to analyze and creating models	• Converging learners like to learn by solving problems and doing technical tasks, good at finding practical uses for ideas • Accomodating learners are people oriented, hands on learners, who rely on feelings more than logical analysis • Diverging learners prefer to learn by observation, brainstorming and gathering information, are imaginative and sensitive • Assimilating learners prefer to learn by putting information in concise, logical order, and using reflective observation	• Pragmatists prefer when the topic under study has an obvious link to the real world and like to give immediate opportunities to implement what they have learned • Activists enjoy new experiences and challenges, like teamwork and problem solving, and enjoy leading discussions • Reflectors prefer to watch, think and ponder on activities, can carry out carefully detailed research, and don't like pressure or tight deadlines • Theorists like to learn from models, concepts, and theories like to analyze and evaluate, and use logic

Table 1. Description and comparison of six four quadrant learning styles models. (Gordon & Bull, 2004)

Based on learning style models many learning management systems (LMSs) have been developed to facilitate the way of learning and teaching methodologies such as Moodle and Blackboard systems where a fully equipped area is provided. These systems give students the ability to discuss, share and preview course materials using different ways. From this point plenty of researches have been developed to check how electronic media is effective in enhancing student's learning by checking the student's behavior depending on Felder –Silverman learning style model.

2.2. Felder-Silverman learning style model

The felder-Silverman model was developed in 1988 to capture the differences in learning styles among engineering students. It is a preferable learning style model as it gives detailed information about the learning styles by categorizing learners into four dimensions such as Active/Reflective, Sensing/intuitive, visual/verbal and sequential/global.

1. Active/Reflective: active learners like to deal with the material actively so they learn through discussions, testing and explaining. Whereas reflective learners like to think about the material and learn alone.
2. Sensing/Intuitive: sensing learners prefer to deal with facts and data and follow the standards for problem-solving depending on examples. While intuitive learners like to deal with theories and they tend to be creative. Therefore, they are capable of answering the questions about developing new solutions which require a deep understanding of theories.
3. Visual/verbal: Visual learners prefer to learn from graphics, charts and images. Whereas, verbal students prefer to study from written documents. They understand the material by discussing it with others.
4. Sequential/Global: sequential learners like to learn by a specific and detailed step by step sequence. They stick to the course material. While global learners like to see the material in general which called "big picture." (Sabine Graf, 2008)

   Classifying students in these dimensions will short cut a lot of effort from the teacher, and it will help him/her to prepare the learning material that suits each learning depending on his/her learning pattern.

2.3. Learning through technology

Figure 3. Kinect Xbox360

"With the rapid progress of computer technology during recent years, researchers have attempted to develop more effective programs for testing and improving student learning performance." (Hui-Chun, et al., 2006) However, these systems were not enough for students as they do not give any feedback or suggestions to improve the student's way of learning. Therefore, rapid technologies came up to cover this issue such as the Kinect device shown in figure 3, Smart TVs and other E-Learning environments which provide interactive learning environments for learners. These technologies enhance the learner's process of learning in an innovative way by getting the learner involved in the system to explore a piece of information through interactions. Developers are working hard to provide more of helping tools, and clearly we can see that almost in every single day we are provided with some new specialized tools that make our life easier especially in the education field. Different learning applications have been developed using Kinect in different fields such as math, science and presentations. Many types of research were done to check the effectiveness of Kinect in education area and how student performance changes before and after using the Kinect device. The Kinect device has revolutionized the learning area by providing some valuable properties such as hands-free controls, advanced motion sensing, voice recognition and facial recognition. Researchers had the chance to exploit each of these properties for learning methodology enhancement as this device gives users the chance to capture 3D visualization of the human body which is a helpful thing, especially in health education.

2.4. Kinect Sensor and its different usages

The 4th of November 2010 was a start of technological revolution when Microsoft has launched the first Kinect Sensor. The main purpose of developing this sensor was to revolutionize the way people play games, however because of its low cost the use of it has increased to cover different usable areas such as education, healthcare, industries retail and transportation. Therefore, researchers from different fields like computer science, electronic engineering, and robotics have experienced the usage of Kinect in these areas by developing effective projects for a variety of purposes. By the start of February, the Kinect Software Development Kit (SDK) was released to enhance the developers and experts working process.

(Zeng, 2012) .Drawing with Kinect is a good example of virtual reality projects. With this project user can draw on air using his/her hands as shown below in Figures 4, 5 and 6:

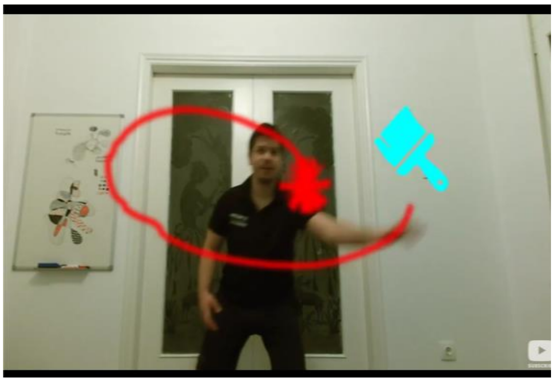


Figure 4. Drawing with Kinect project experience

Figure 5. Drawing with Kinect project icon

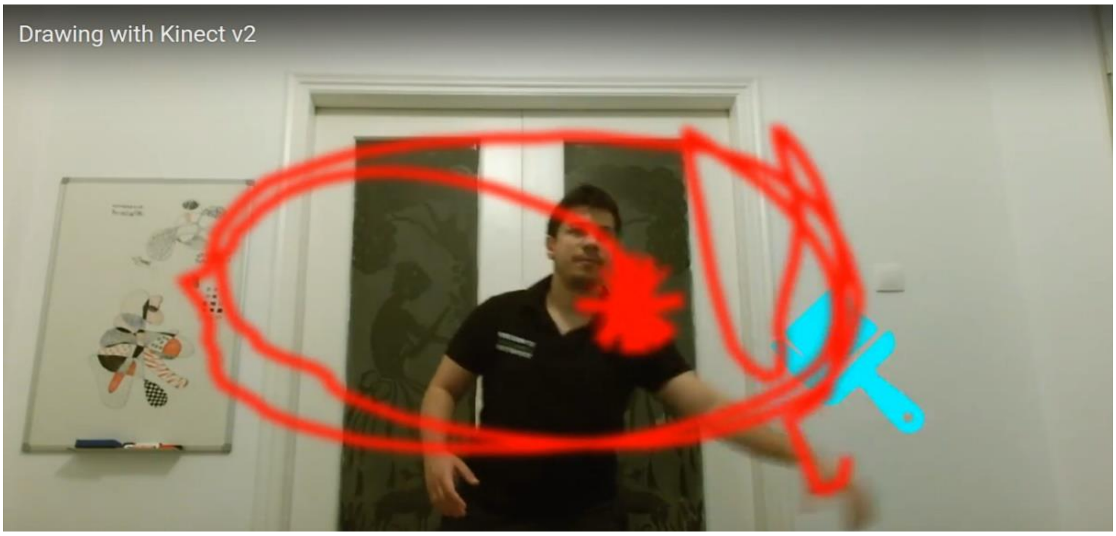


Figure 6. Drawing with Kinect project

The project was developed last March by Vangos Pterneas to enable users to draw whatever they want in the air using a combination of programming languages like C# and XAML along with the RBG color stream and hand gestures commands of the Kinect sensor.

Kinect to VR is another good example of Virtual Reality related projects using Kinect. It is mainly a combination of HTC Vive system and the Kinect sensor to track multiple people in a three-dimensional space. It gives users the chance to see other players in the VR space as well as themselves. The Kinect to VR was developed by Jasper Brekelmans(a Microsoft most valued professional) and Jeroen de Mooij. "The experimental process uses the Kinect sensor to track the bodies of two users in 3D space. By taking the Kinect data and aligning it with the Vive's positional tracking, the developers have created a unique experience that lets users see a video representation of themselves and other players in a VR environment." (Brekelmans & Mooij, 2016).The below pictures in Figures 7 and 8 show how the project works.

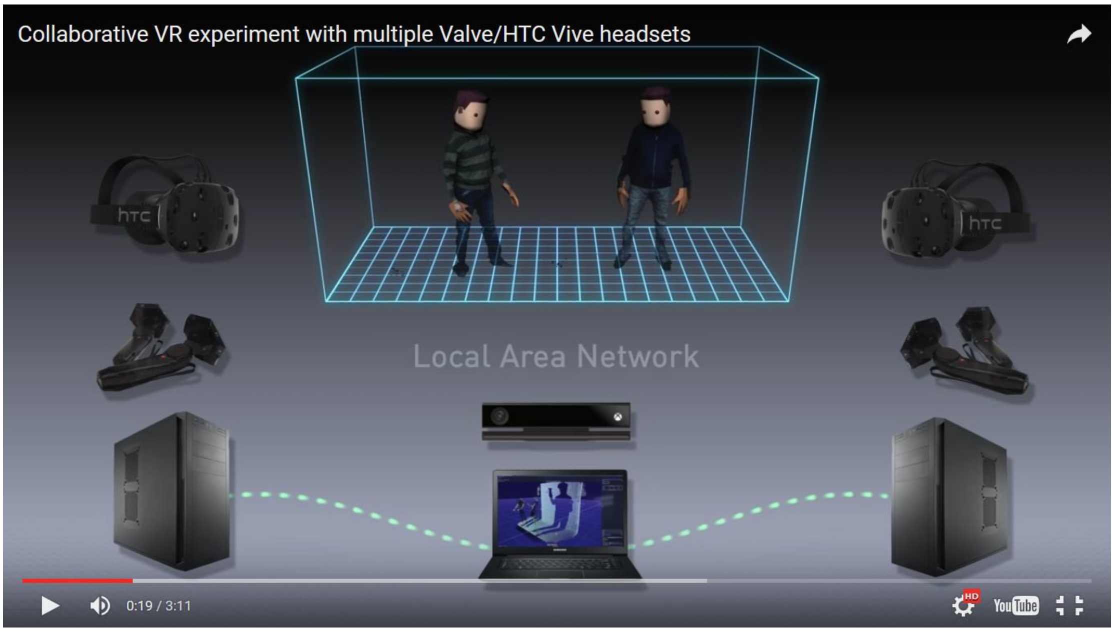


Figure 7. Kinect to VR system components

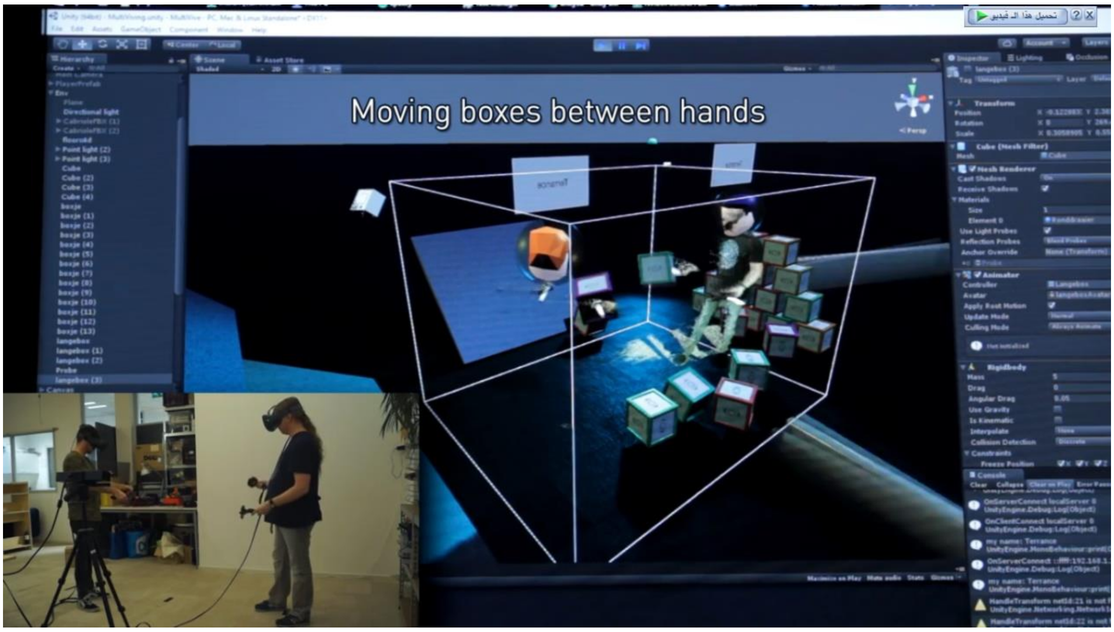


Figure 8. Kinect to VR

2.5. Using Kinect in health education

Teaching something related to health could be difficult to understand especially for children as it contains complicated terminologies and information. Therefore, researches were conducted to highlight the usage of Kinect device and how is it helpful in simplifying learning material in health education. Kinect device illustrates an effective 3D human body which makes it easy to deal with the system. Researchers have developed many related projects in this field such as (AR) Magic mirror project (miracle) figure 9 which was developed by (Meng, et al.). According to Meng, Fallavollita, Blum, Eck, Sandor, Weidert, Waschke and Navab, "Magic mirror allows intuitive visualization of realistic anatomical information on the user". It was mainly developed to enhance the medical school students' learning. It has full-color photographic slice images of the body organs in 3D visualization so; it provides virtual anatomy information of the user's image, and it gives the user the chance to examine his/her body through hand gesture and voice commands. Furthermore, the magic mirror paradigm has been used in different projects, and one of these projects is using the magic mirror for neurorehabilitation of people which has been developed by (Erazo, et al., 2014). This project aimed to help people who have some problems such as loss of motivation, routine difficulty and lack of a guide to execute a task (Erazo, et al., 2014). It provides a user interface and the Kinect sensor that enables users to do a routine training in a different manner to do a rehabilitation at home without any help. Another effective project in this area is Tactile coloring book which was developed by Kinect Team at the University of Michigan in the United States, 2015 (MconneX, 2015). The big project aim was to help certain children who have autism and do not understand how to control the pressure of doing tasks. Those children use either too high pressure or too low pressure by providing a large piece of fabric for displaying a variety of objects such as shapes, animals, people, and so on. To make the project work a Kinect device located behind the large fabric and the shape displayed. In front of the fabric, when the child does the right amount of pressure neither too much nor too little the fabric changes the color and displays visual reward to the child because he/she used the right amount of pressure as shown below:

Figure 9. Magic mirror project demonstration

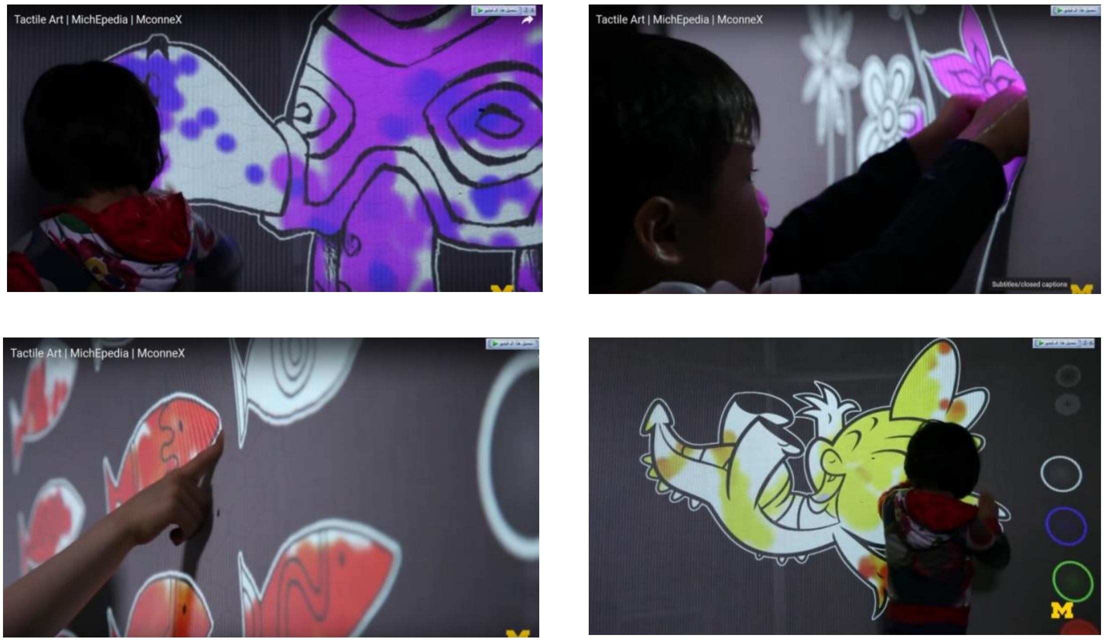


Figure 10. Tactile coloring book project

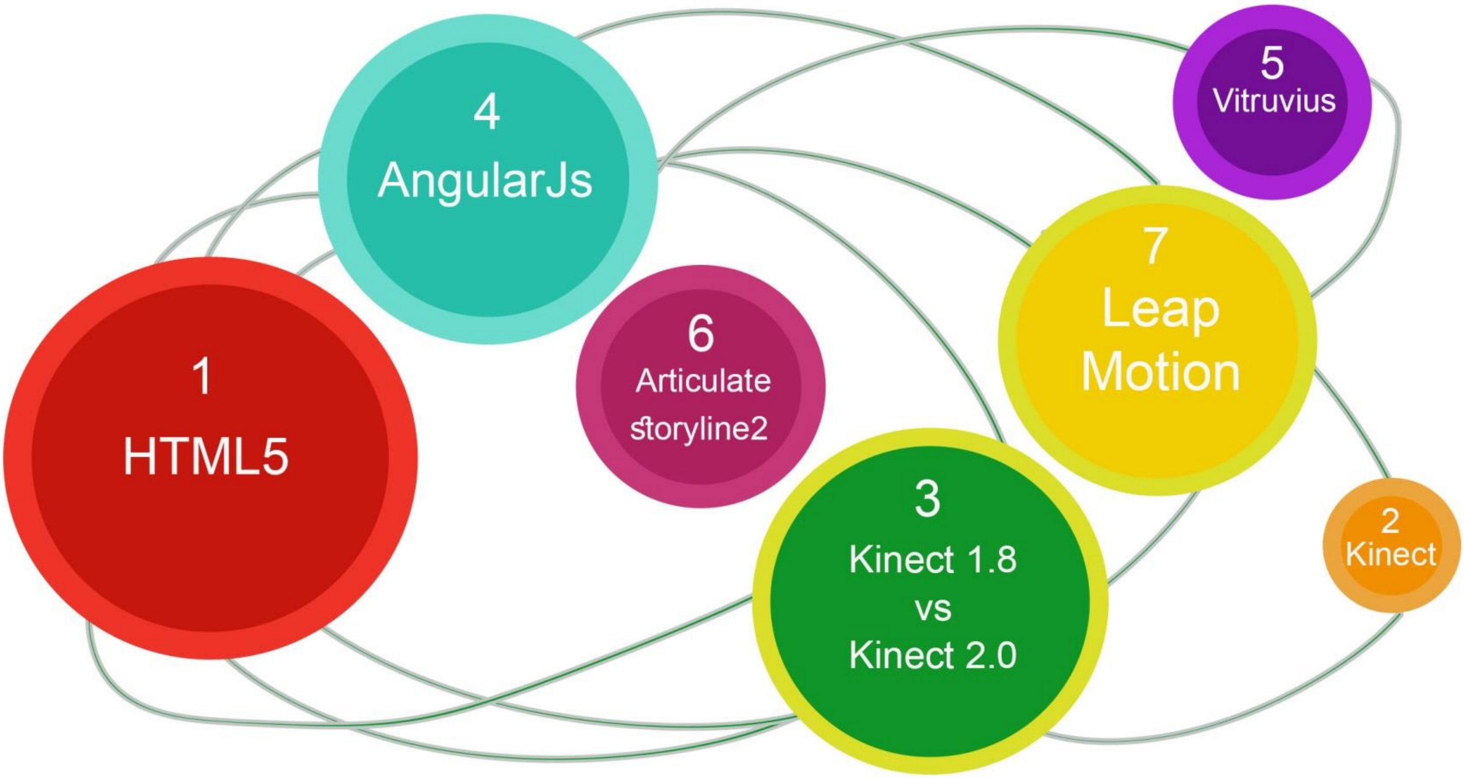
2.6. Smart TV usage and related projects

Nowadays the smart TV became a first place tool in most of the houses as it revolutionized the digital TVs world by having the Internet connection capability using apps. By this capability, users can stream their TV shows, browse the Internet or communicate with others. Beside that smart TV has two vital features such as gestures interactions and voice commands. Many apps were developed based on these two features and a system for gesture-based interaction with a smart environment which is developed by (Nebelrath, Lu, H.Schulz, Frey, & Alexandersson, 2011) is a good example of these features usage. The system connects the resulted gestures to the control commands of the smart TV and checks how efficiently people get engaged with it especially old people.

In the conclusion, according to Felder-Silverman learning style model, people are categorized into four dimensions in the way of learning such as virtual/verbal, sensing/intuitive, active/reflective and global/sequential. Therefore, knowing the learning style is crucial to develop a suitable learning environment. Moreover, the revolution of technology gave the developers the chance to produce new techniques in problems solving especially in the education field. One of these technologies is the Kinect sensor which has revolutionized the learning and teaching, especially in health education.

The digitalized Human Body project is meant to enhance the learning methodology of human organs. It will give students from different educational levels the chance to know about their body in an interactive way by using a combination of effective technologies such as, Parallax design which came with Html5 and a gesture detector like the Kinect Sensor which has developed by Microsoft company and smart TV. The reason behind choosing this project was to accomplish more in what have been done in this area and having a combination of such technologies in a system will revolutionize the study of the human body system. It will be a major source for as many numbers of people as possible from different backgrounds and ages. Furthermore, the system will follow Felder-Silverman learning style model to cover all the learning styles by displaying the information in different formats to suit the four different styles of learning.

Chapter 3: Background



Various techniques, tools and programming languages have been developed to deliver easy and interactive systems to enhance learning methodology. In this project, different technologies have been explored to come up with a perfect work such as; Html5, Kinect sensor, angular js, Adobe Captivate, WebSocket API, Jkinect browser, kinesis.io-js-sdk-master Articulate Storyline 2, Leap motion controller and Vitruvius.

3.1. Html5

Many years ago web design was a combination of pure text and static pictures. There was no interaction between the user and the web page. A hypertext markup language (HTML) developed by W3C was used to do that. A few years later the concept of the video, audio, and some interaction tools have occurred and year by year web design became more interactive where the new version of HTML (Html5) was introduced. Html5 came up with a new concept of responsive web design where the websites which use html5 are fully interactive. They are built from a combination of CSS and javascript. Moreover, the concept of parallax design has come from Html5, and it means in digital technology in the dictionary "a 3-D effect observed when images and other elements in the foreground of a screen move at a different rate than those in the background." The idea behind parallax design was 2D video games where background images used with different speeds to show that there is a noticeable distance between images. This technique is mainly used for scrolling along with a variety of html5 functions and in this project we are going to use drag and drop function to enable users to drag and drop body organs into the right place as well as the page scrolling function. (Wang & Shyu, 2014)

3.2. Kinect Sensor

Figure 11. Kinect 2.0 sensor

It has been developed by Microsoft mainly for video games. "It was built to revolutionize the way people play games and how they experience entertainment." (Zeng, 2012) On February 2012, the Kinect software development kit (SDK) was released for Windows (www.microsoft.com/en-us/kinectforwindows), which enables users to use all of Kinect properties along with a full working environment. The Kinect sensor contains a depth sensor, a color camera and a four-microphone array to capture a full 3D body, facial recognition, and voice recognition capabilities. It has an infrared sensor, infrared camera, and RGB camera which help to detect the human body among different objects in different views such as, RGB and infrared. Different fields can take advantage of using this sensor such as; healthcare, education, and beyond. There are two versions of Kinect sensor. Kinect 2.0 figure 10 and Kinect 1.8(Xbox 360) figure 3 and the differences between them are not huge.

3.3. Kinect 1.8 vs. Kinect 2.0

Kinect v2 has developed to improve the work and features of Kinect v1. The major difference between them is that Kinect v2 came with a higher resolution of the camera. Where v1 has low-resolution output and the below picture in figure 12 shows how big the difference is:

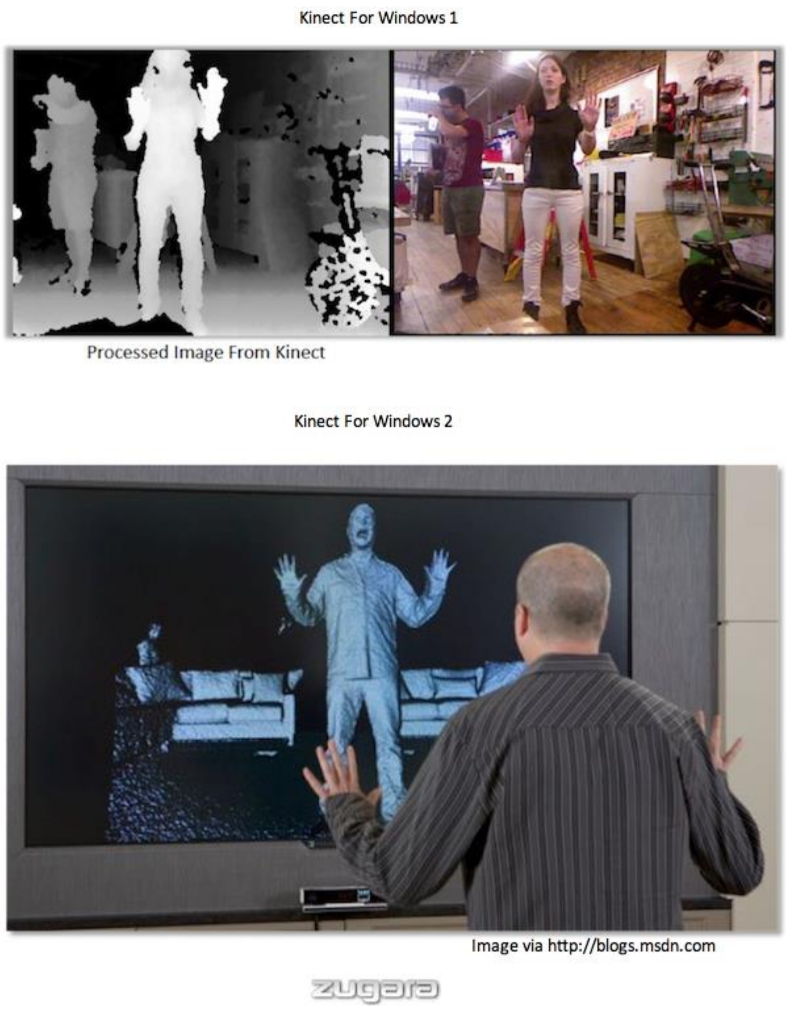


Figure 12. Comparision between Kinect v1 and v2

From figure 12 above, we clearly can notice the resolution difference between the two versions. In Compare to v1, v2 has 1080 HD camera resolution, and the face recognition along with motion detection are much better in v2 than v1. Table 2 below compares the two versions in term of features provided by both of them:

Feature	Kinect for Windows 1	Kinect for Windows 2
Color Camera	640 x 480 @30 fps	X 1080 @30 fps
Depth Camera	320 x 240	512 x 424
Max Depth Distance	~4.5 M	~4.5 M
Min Depth Distance	40 cm in near mode	Cm
Horizontal field of view	57 degrees	70 degrees
Vertical field of view	43 degrees	60 degrees
Tilt Motor	yes	no
Skeleton Joint defined	20 joints	26 joints
Full Skeleton Tracked	2	6
USB standard	2.0	3.0
Supported OS	Win 7, Win 8	Win 8
Price	$299	Around £299

Table 2. Kinect v1 And v2 comparison (Duncan, 2014)

After observing the above table, we can notice that the big differences are in cameras and the USB ports standard. The cameras difference tells us how big the resolution in Kinect v2 in contrast to Kinect v1 which means that v2 displays picture much better as we mentioned previously. The other difference shows that the data transformation in Kinect v2 is much faster than in Kinect v1 as it uses port 3.0 which is much better than port 2.0 in the time needed to read data (Duncan, 2014).

3.4. Angularjs

It is an open source, client-side JavaScript framework created by Misko Hevery and Adam Abrons in 2009 with the name GetAngular and after that, it has been developed by Google (Google, 2010-2016). It follows the MVC (model, view, and controller) pattern as well as providing a clear separation of the application layers.

Angularjs consists of different components such as; the view, model, controller, services directives, and filters. The view or template is completely written with HTML along with directives which are a type of extensions to the HTML vocabulary that adds the possibility of using the programming languages tasks like using an array of data. The controller comes behind the view where the logic implementation used by the view is located in the controller. A shared object called scope used to connect the view with the controller. It is used to exchange information related to the model. The Angularjs is a unique way of converting web pages to applications and in Digitalized Human Body System it will be used to make the quizzes part. The model according to (Branas, 2014) is a simple Plain-Old-JavaScript-Object (POJO). The diagram below in figure 13 describes the Angularjs architecture:

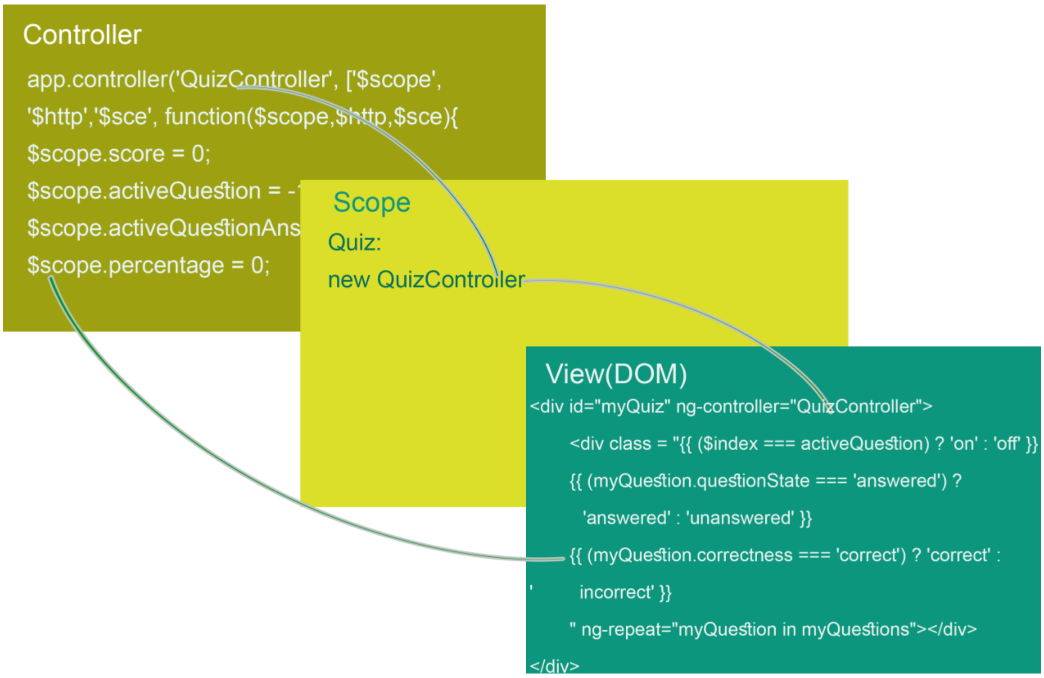


Figure 13. AngularJs Architecture

3.5. Adobe Captivate

It is an e-learning projects maker that enables users to do rapid things such as, building a fully interactive e-learning environment including Software demonstration, software simulation, branched scenarios and randomized quizzes in small Web Format (.swf) and HTML5 formats. It supports both elements dragging and dropping and basic hand gestures. It is designed to empower the everyday user to create engaging learning content. (Huettner, 2008). There are different versions of Captivate starting with RoboDemo 2 which has been released in 2002 byeHelp Corporation. Then RoboDemo 3 came in Fall 2002 followed by RoboDemo 4 and eLearning Edition in 2003.After that, Macromedia Captivate was released in 2004 followed by Adobe Captivate 2 in 2006. The new edition is Adobe Captivate 9 which has been released in August 2015. Captivate 9 includes more interactive features including improved effects and motion paths as well as supporting IOS devices. (Huettner, 2008). Figure 14 shows the Captivate Icon and working environment window of the software.

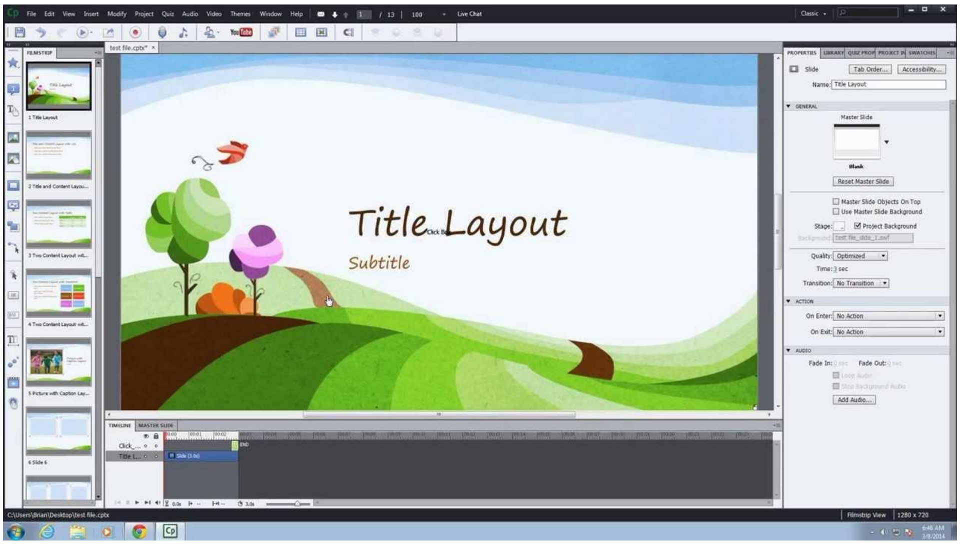


Figure 14. Captivate working window

3.6. Websocket API

It is an interface that enables applications to use WebSocket Protocol. The use of the API in an application gives the developer the chance to control a full-duplex communication channel where sending and receiving messages is possible. (Wang, Salim, & Moskovits , 2013). The WebSocket protocol enables two- way communication between two channels normally one of them is running untrusted code.

3.7. Jkinect browser

It is a tool that supports the use of Kinect in a website http://jkinect.com/#. It gives users the chance to browse the website interactively using hand gestures. It supports apps and systems developed with Kinect version 1. Figure 15 shows the home page of the browser.

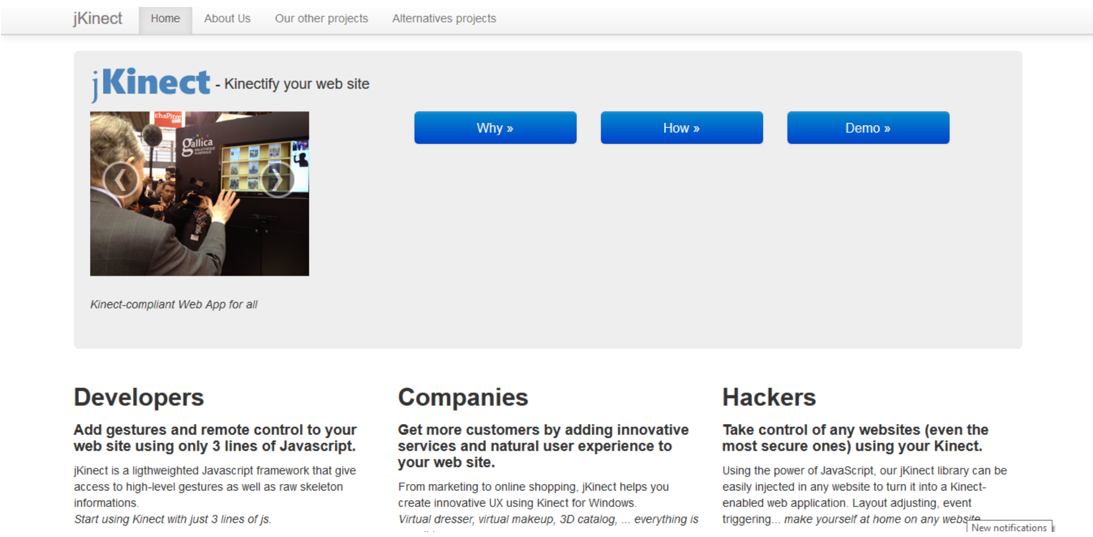


Figure 15. Jkinect website

3.8. kinesis.io-js-sdk-master

It is a javascript library that enables using the hand gestures of the Kinect by capturing them from a webcam. Simply, this file can be embedded in the website code, and it works perfectly. It has a simulator to detect and capture the wanted gestures directly from the Kinect and SDK to run the system.

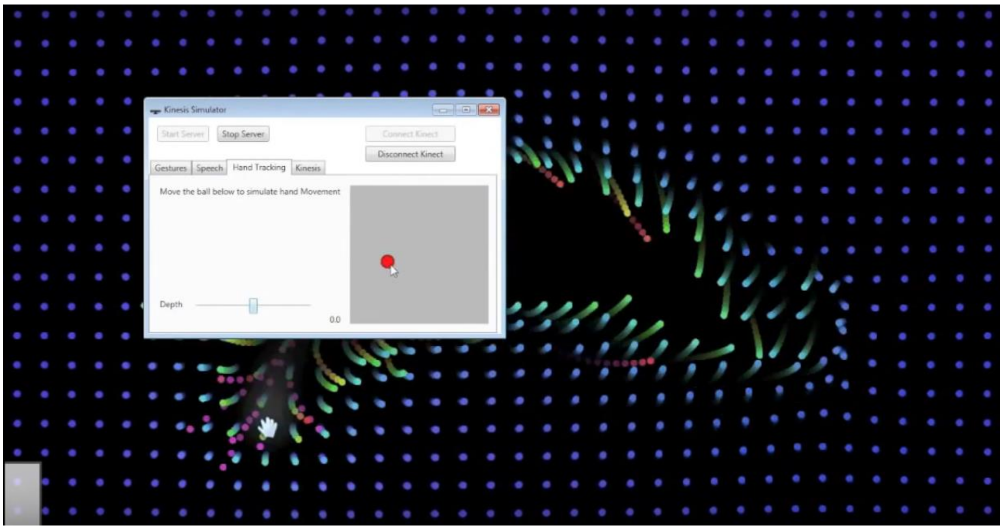


Figure 16. Kinesis.io simulator

3.9. Vitruvius

It is an advanced Kinect framework that offers solutions in different areas related to Kinect such as, advanced Kinect avateering, mathematics, Bitmap manipulation, coordinate mapping, HD face and gestures as shown in figure 17 below. In each area, Vitruvius does a valuable work. It is maintained by the LightBuzz Software Company owned by Vangos Ptereans Microsoft most valuable professional to help developers build Kinect apps quickly and easily.

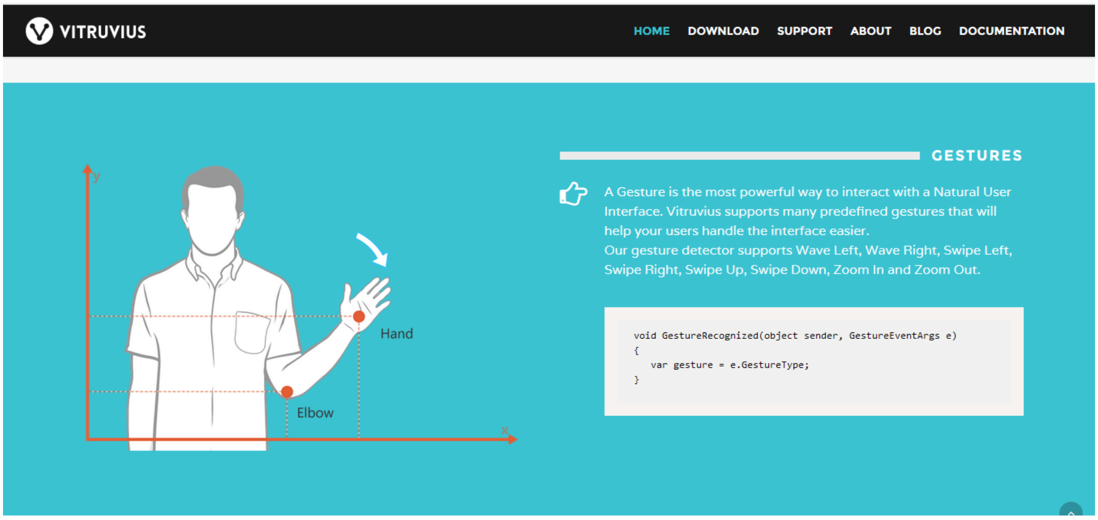


Figure 17. Vitruvius framework website

3.10. Articulate storyline2

It is software that provides the user with the basic equipment to build an interactive e-learning environment with the wanted complexity and flexibility. With Articulate users are fully engaged and by this they are likely to put their new skills and knowledge to work, and this would improve the productivity. With Articulate users have a variety of options such as developing interactive slideshows, video quizzes, and games. Figure 18 shows the working environment window of the software.

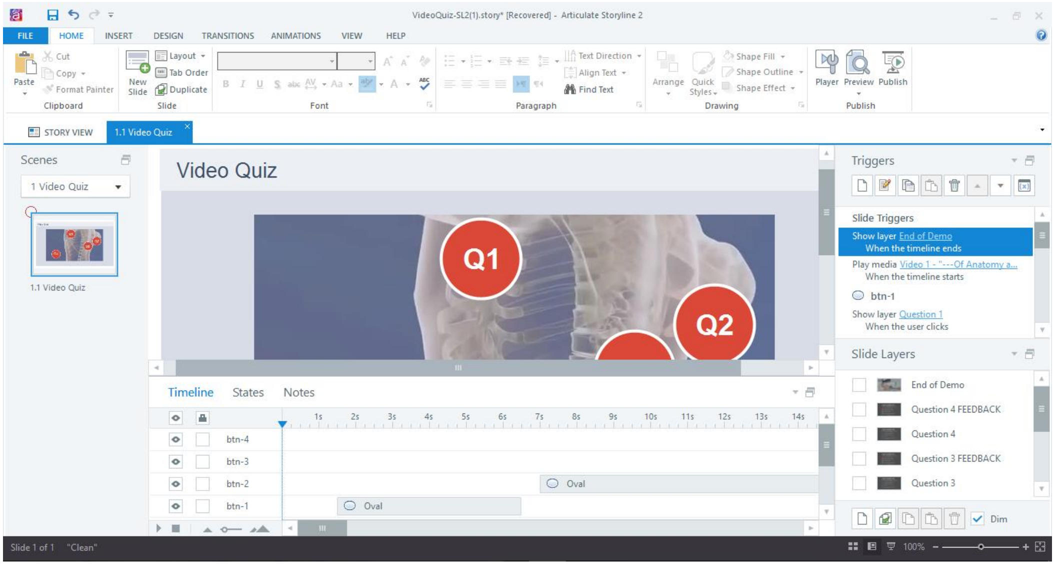


Figure 18. Articulate working environment

3.11. Leap Motion controller

The leap motion controller is a sleek, light and tiny device that tracks both hands and all ten fingers with pinpoint precision at up to 200 fps using infrared cameras. It gives the user a wide 150° field view with eight cubic feet of interactive 3d space with low latency. It was found by the Leap Motion Company 2010. The latest version of the controller was released 2013, and it works in both Windows and IOS environments. (Leap motion controller, 2016).

Figure 19. Leap motion controller

3.12. Leap Motion Vs Kinect Sensor

Leap Motion and Kinect have different capabilities, and they could be used in different scenarios. Kinect is more powerful, more popular, has more games and it is better for console games and fitness rather than applications. Comparing to leap motion it is big hence, it is less portable. It is mainly used for gaming and allows interaction in a range of 0.4 to 4 meters. While the leap motion controller is more accurate and very small which is an advantage, where users can take it wherever they go. Also, the leap motion tracks up to 200 fps, and this makes it faster with a low latency while Kinect tracks up to 30 fps. The table 3 below shows a comparison between them both:

<table>
<tr><th>Sensor</th><th>Usage</th><th>work</th><th>System requirements</th><th>Range</th><th>camera</th></tr>
<tr><td>Kinect</td><td>Gaming console and fitness</td><td>Tracks the skeleton depth sensing and audio tracking</td><td>Windows 8 (x64)
Windows 8.1 (x64)
Windows 8 Embedded Standard (x64)
Windows 8.1 Embedded Standard (x64)
64 bit (x64) processor
4 GB Memory (or more)
I7 3.1 GHz (or higher)
Built-in USB 3.0 host controller (Intel or Renesas chipset).
DX11 capable graphics adapter
A Kinect v2 sensor, which includes a power hub and USB cabling.</td><td>0.4 – 4 meters</td><td>30 fps</td></tr>
<tr><td>Leap Motion</td><td>Gaming and apps</td><td>Tracks both hands and all ten fingers</td><td>Windows® 7+ or Mac® OS X 10.7+
AMD Phenom™ II or Intel® Core™ i3/i5/i7 processor
2 GB RAM
USB 2.0 port
Internet connection</td><td>150° field view with eight cubic feet</td><td>200 fps</td></tr>
</table>

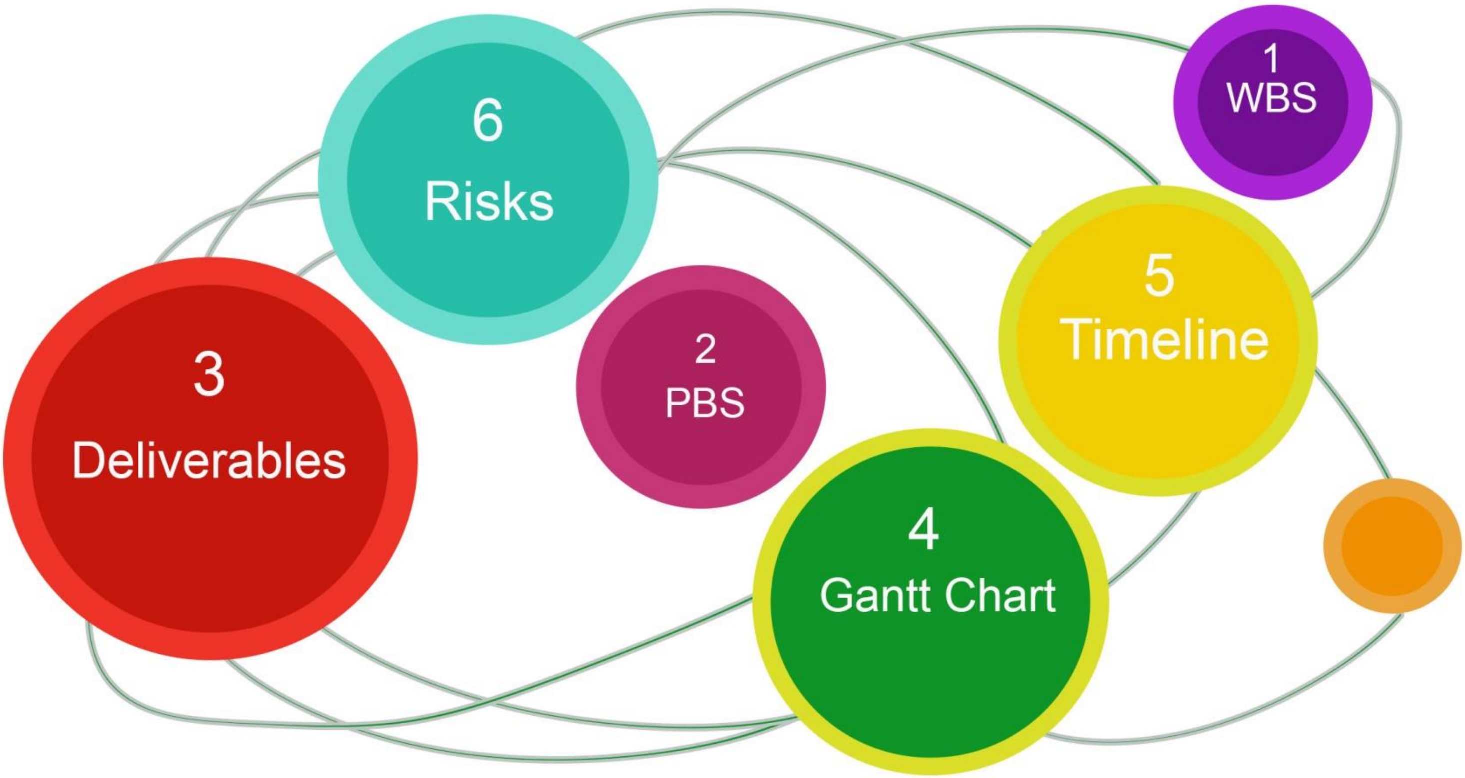
Table 3. Kinect and Leap Motion comparison

By the end of this chapter here is a comparison between the previous technologies and whether they added to the project or not and where. Table 4 below highlights this comparison:

Technology	Main job	Did I use it?	Where?
HTML5, Parallax Design	Developing the web based systems	Yes	Building the system
Kinect Sensor	Capturing human gestures	No,/ it does not support websites	
AngularJs	Transforming web pages to web applications	Yes	Developing the quizzes
Adobe Captivate	Developing E-learning environments	No,/ it is replaced by Articulate storyline2	
WebSocket API	Working as a bridge between two different servers from different environments	No,/ it just displays the human skeleton in the canvas	
JKinect Browser	Controlling the website using Kinect v1	No,/ it works with Kinect v1 for Windows	
kinesis.io-js-sdk-master	Controlling the website using Kinect v1	No,/ it works with Kinect v1 for Windows	
Vitrivius	Providing Solutions in different areas of Kinect v2	No,/ it just supports applications	
Articulate storyline2	Developing e-learning environments	Yes	Developing the quizzes
Leap Motion	Controlling apps and websites using gestures	Yes	Developing the gesture part of the system

Table 4. Comparison between technologies

Chapter 4: Project Management



Every project has to be managed either by identifying the needed activities and work through them or by drawing a clear plan to accomplish the wanted objectives. This chapter highlights the activities and tasks that need to be done to meet the project objectives as well as the followed methods.

4.1. Work Breakdown Structure

Figure 20 below describes how the Digitalized Human Body will be developed by breaking down the main activities into smaller activities. This diagram follows the bottom- up approach which means that we have started from the bottom going up to make the whole system. For example, the Analyzing activity has broken down into three smaller activities such as Review Background, Specify Requirements and Understand the Technology. Again these activities were broken down into tiny activities such as understand learning styles, examine Kinect device and explore parallax design. While the Design activity has four sub-activities such as design system architecture, draw system components, draw UML diagram and draw the storyboard. The implementing activity is divided into three stages and in each stage a part of the system is developed.

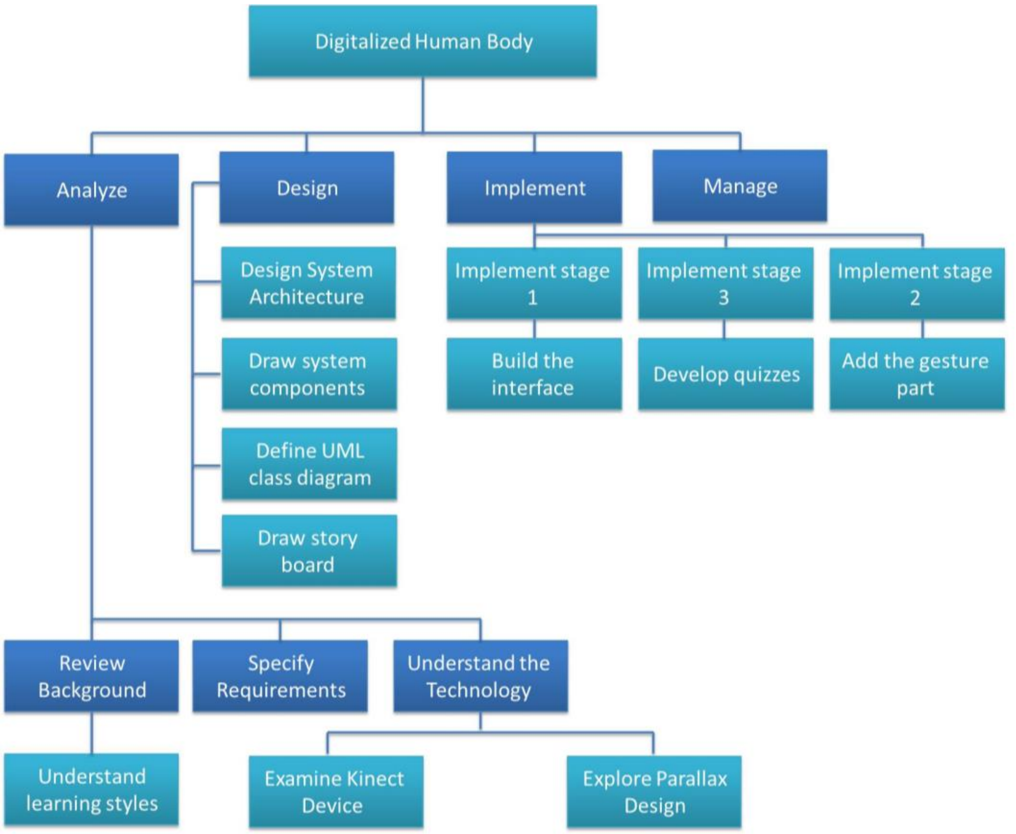


Figure 20. Work Breakdown Structure

4.2. Product Breakdown Structure

Figure 21 below shows the delivered products from each stage of project development process. For example, the analysis stage products are the Literature review and Overall Specification while the designing stage delivers the UML diagram, storyboard, system components and System Architecture. A completed website and its codes are the implementation stage products and the poster, presentation and the progress report are the project management products.

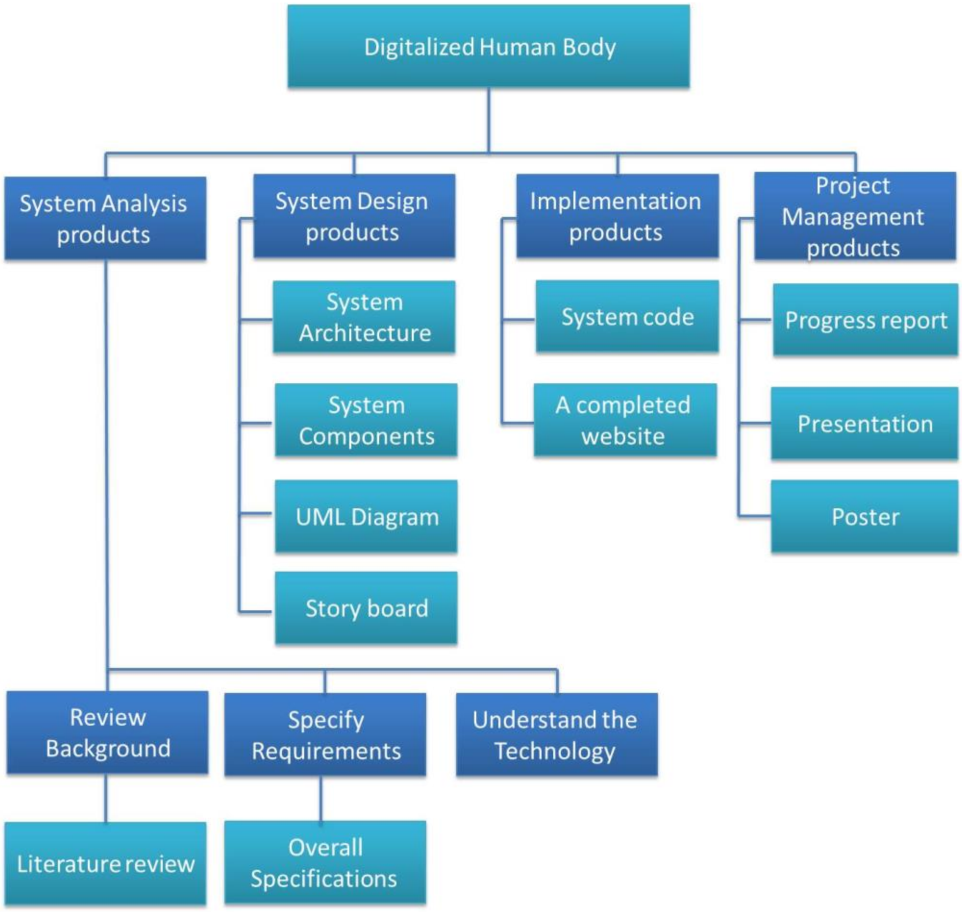


Figure 21. Product Breakdown Structure

4.3. Deliverables

By the end of this project, some deliverables will be completed. They are shown below in Table 5:

Deliverable	Due to
Proposal	16th, July 2015
Ethical form	17th, July 2015
Progress report one	28th, September 2015
Presentation	4th, November 2015
Progress report two	18th, February 2016
Poster	15th, February 2016
Final report first draft	16th, May 2016
Final report	3rd, June 2016
Project software	Week 10,11 Spring 2016

Table 5. Project Deliverables

4.4. Gantt chart and timeline

The Gantt chart summarizes the project plan and the activities that need to be done to achieve the wanted goals and objectives. Moreover, it shows the activities and sub-tasks to finish a certain activity along with dependency between the activities as well as the duration needed to finish each task. In Digitalized Human body system we have divided the plan into five main activities such as First Term, Second term, Third term, Fourth term and Project Management. Each one of these activities has some sub-activities for example; SELECT PROJECT, FEASIBILITY, WRITE PROJECT PROPOSAL, SUBMIT ETHICAL FORM, REVIEW BACKGROUND and UNDERSTAND THE TECHNOLOGY come under the main activity First term. These sub-activities have tasks under them to be done. For example, REVIEW BACKGROUND activity has three tasks under it such as REVIEW BACKGROUND IN LEARNING STYLES, REVIEW BACKGROUND IN LEARNING ENHANCEMENT and WRITE A LITERATURE SURVEY. Whereas the Timeline shows in which stage the project supposed to be at a certain time and whether tasks have been accomplished on time or not. Figure 22 below shows the timeline of the current project.

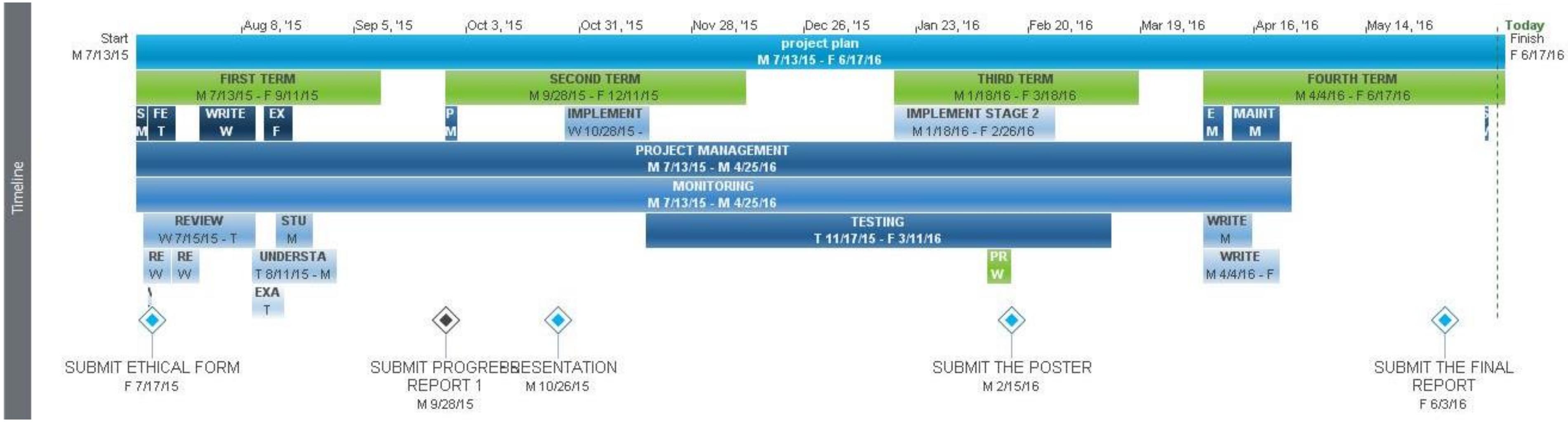


Figure 22 Project timeline

4.5. Project Risks

Table 6 below highlights the main risks to the project and the overcome.

Risk	Likelihood	Impact	Overcome
Kinect environment is new	Amber	Spend time to learn it	Went through tutorials in Github.com and msdn.microsoft.com as well as Youtube.com
Kinect does not support websites	Red	The gesture part will not work	Find another gesture based environments such as leap motion controller
Hard disk breaks	Amber	losing the work	Make different copies of work
Accuracy of human body data	Amber	Affects the whole work	Collect data from trusted authorities
Time breakdown	Green	Delay in delivering some tasks	Put time for urgent situations in the plan.
Ethics and legality of data	Amber	Leads to legal accountabilities	Ask testers to fill the consent form before testing

Table 6. Risks to the project

4.5.1. Kinect environment is new

Working with a new environment considered one of the main risks to the project as the developer will need some time to learn the main aspects of it. The learning process might last for a long time, and a course might be needed. As the Kinect is a new environment for me, it took me some time to learn about it through online tutorials and personal experiments.

4.5.2. Kinect does not support websites

The idea of the Digitalized Human Body is exploring the human body using hand gestures on a website. The gesture part should be done with Kinect. However, Kinect version 2 does not support websites, and this was a huge problem that the project stopped in. Many ways were followed, but none of them worked. Therefore, to overcome this problem another gesture based system was used which is leap motion controller.

4.5.3. Hard disk breaks

Having the hard disk broken is a common risk in the development process of a system, and if it happened, it leads to work lost. Therefore, the suitable solution to avoid it is to have multiple copies of the work.

4.5.4. Accuracy of data

Having a poor quality of data considered a big problem and the system responsible for every piece of information provided to the user. Therefore, the information will be gathered from trusted resources such as the Medical School of the University of Buckingham and health institutes in the UK.

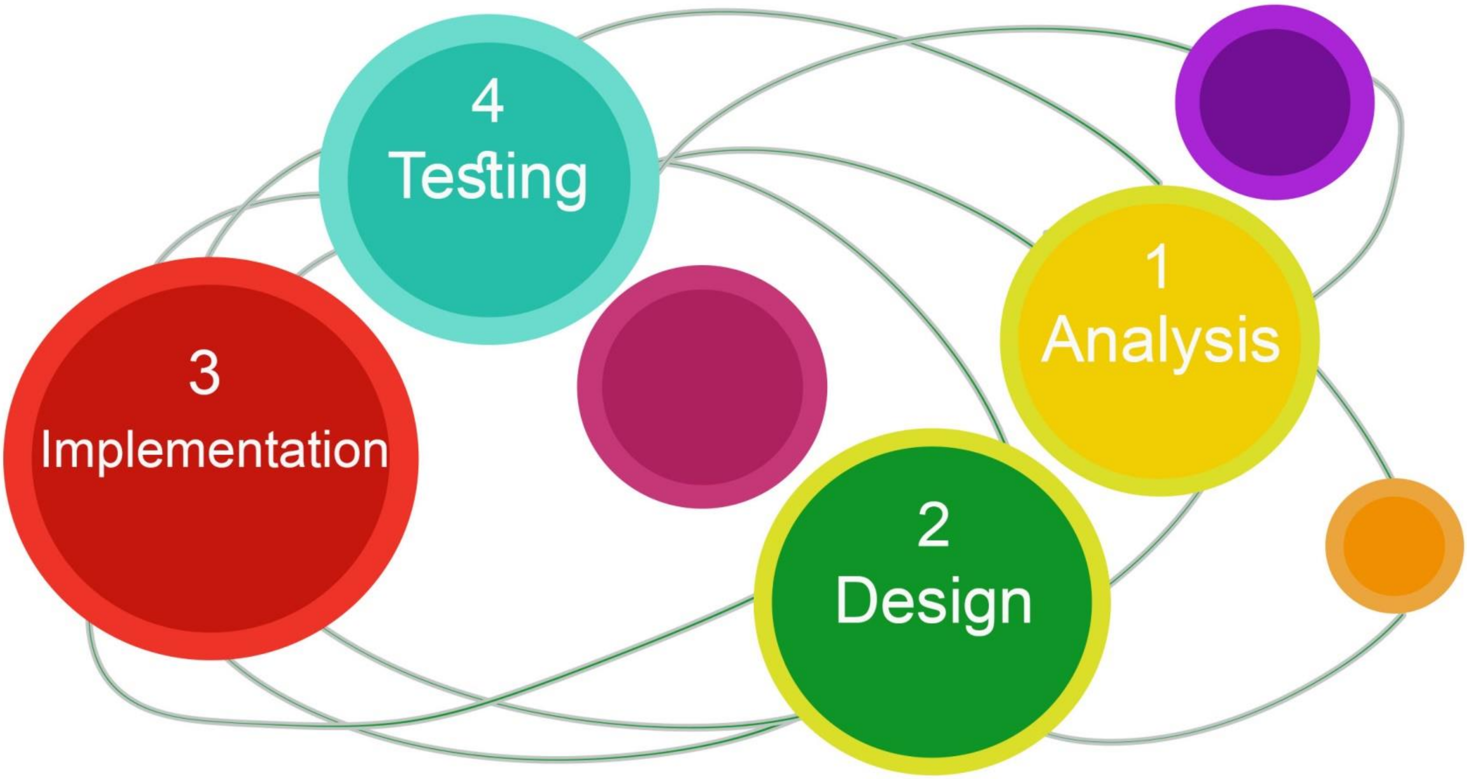
4.5.5. Time breakdown

When the project was planned we put some issues that might affect the deployment process in our consideration such as, availability of the resources, urgent circumstances like sickness and technical problems to manage the development time effectively.

4.5.6. Ethics and legality of data

This is a very common risk in project development cycle, and it is important to put it in our considerations because having this risk could lead to legal accountabilities. Moreover, using peoples' data without asking is a major ethics breach therefore to overcome this risk we have asked testers to fill the consent form to agree upon using their data like their pictures while they test the system.

Chapter 5: Software Development



1 Analysis

In this section the requirements and specifications along with different analysis tools will be highlighted.

This section describes the analysis part of the project where the requirements are specified after analyzing previous studies in the field.

5.1.1. Literature analysis

Many learning styles models were discussed in the literature review chapter along with related studies and according to the discussion some learning systems were developed to facilitate the way of learning and teaching. These systems aim to cover different learning styles.

As a result, we found that different people use different styles to learn especially when they learn about the human body. For example, some of them prefer to read a plain text where others like to see live explanation like videos or pictures. Therefore, the Digitalized human body system aims to combine the various learning methods to have as many beneficial users as possible.

5.1.2. Functional requirements

Functional requirements describe how the system work and the things needed to browse the system correctly.

1. The user must have a Kinect sensor to get the gesture part works with its SDK installed on the platform.
2. Username and password are not required to browse the system.
3. A browser that supports HTML5 is required.
4. No experience needed to use the Kinect sensor. However, the user must know which gestures to use when scrolling the pages and clicking on a button.

5.1.3. Non-functional Requirements

The non-functional requirements highlight the constraints of the functions provided by the system

5.1.3.1. System Specifications

Below are the Digitalized Human Body system specifications:

1. Html5 supported by Firefox, Google Chrome, Opera browsers and the latest version of Internet Explorer.
2. Kinect V2 and Windows 8 and 10 to get gesture part to work.

3. It can be browsed on smart TVs, big Screens, Desktop computers, Personal computers and smartphones as well.
4. The user has the freedom to start from any point in the system.

5.1.3.2. Performance

The system needs good internet signals to perform well because it deals with various data types that need some time to load such as; images, videos, and audios. Therefore, a poor network signal will affect the system's performance and the speed of response. Moreover, to make the gesture part of the system work well, the Kinect sensor must not be more than 4 meters far from the user.

5.1.3.3. Reliability

Security: Users' personal details are not required to use the system. Therefore, there is no such important information to breach.

Dependability: users can depend on the system because it is going to enhance their knowledge about the human body by providing all the information about it in an interactive way.

Compatibility: For now the system will need either a smart TV or any screen or laptops along with a Kinect device to run perfectly.

5.1.3.4. Efficiency

Response Time: The system should provide the user with any information that he/she wants as fast as possible. However, this depends on two main things such as the network signal and the storage.

5.1.3.5. Accessibility

The system will be accessible for people who have either smart TVs or Kinect device. However, it can be accessed without the gesture part.

5.1.4. Use Case Diagram

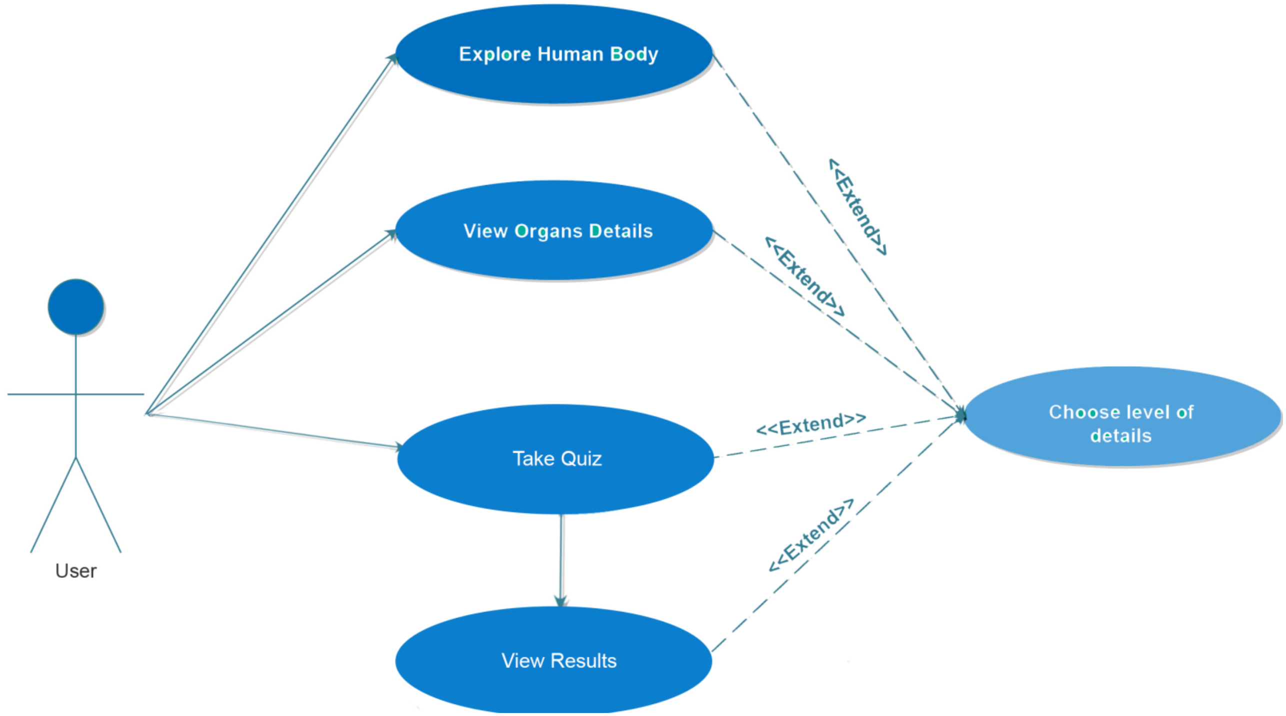


Figure 23. Use Case diagram

In Figure 23 above the user has different options to browse the system such as Explore human body, view organs details, take quiz and view results. The user actor in the diagram refers to different users such as; student, teacher and general learners. Where a student can have it as a learning tool and the teacher can have it as a teaching tool. The user has the option of choosing different levels of details in each generic option.

5.1.5. Constraints

There are many constraints that the project might face, and we must overcome them to reach the final goal.

Technical constraints: The developer needs knowledge in dealing with the Kinect device as well as the programming languages such as Jason, Html5, and JavaScript. Therefore, as a developer, I have to learn them well.

Budget constraints: The development of the project needs an enough budget and to complete the system funding is needed to provide all resources.

Time constraints: Although the system is very huge it must be finished in 6 months which is quite a short period. Therefore, time management plan is needed.

5.1.6. Resources to be used

- The Kinect device.
- Leap Motion controller.
- Laptop with more than 4 GB storage.
- Visual Studio 2013.
- DreamSpark.com.
- Windows 10 or 8.
- Papers and printers.
- Cameras to take pictures of the human organs from the medical school.

5.1.7. Challenges

There were two challenges we faced in the analysis stage. The first one was specifying the requirements as there are different learning styles users are using, and we were not sure which style will be preferred. Therefore, combining a variety of styles was the solution. The second challenge was requirements changing during the project development. The requirements defined at the beginning of the project are changing as the project progresses due to some constraints. To overcome that we had to stick to the plan.

2 Design

This section includes system architecture, the story board and different diagrams such as; use case diagram, UML class diagram and system components.

5.2.1. System Architecture

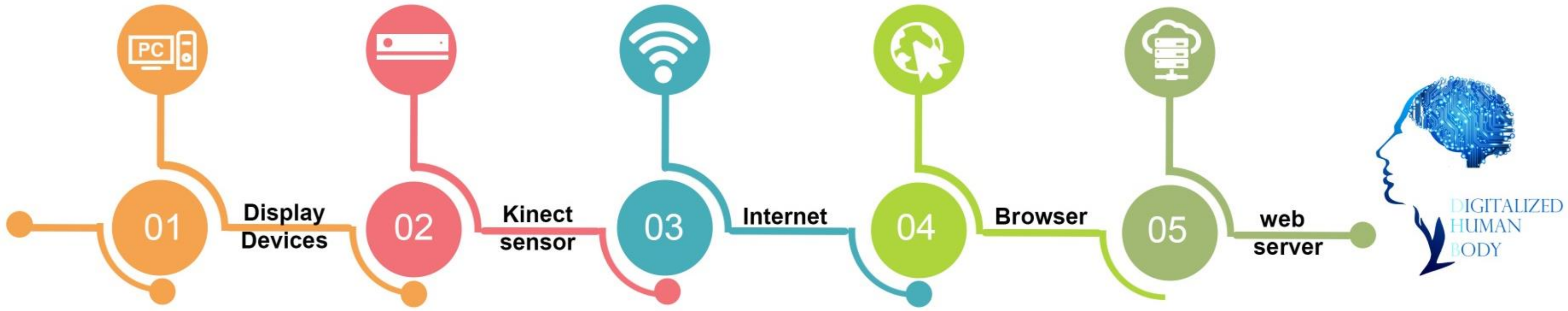


Figure 24. System Architecture

Figure 24 shows the system Architecture and how a user can reach the Digitalized Human Body system. There are four utilities user needs to have before reaching the system such as; display devices, Kinect sensor, the internet, browser and a web server. The display devices could be a desktop computer, personal laptop, smart TV, big screens or even smartphones where the system will be displayed. For the gesture based part, a Kinect sensor will be needed. Otherwise, this part will be disabled. As the system will be hosted online, an Internet access will be needed as well as a browser and web server to open the system.

5.2.2. System Components

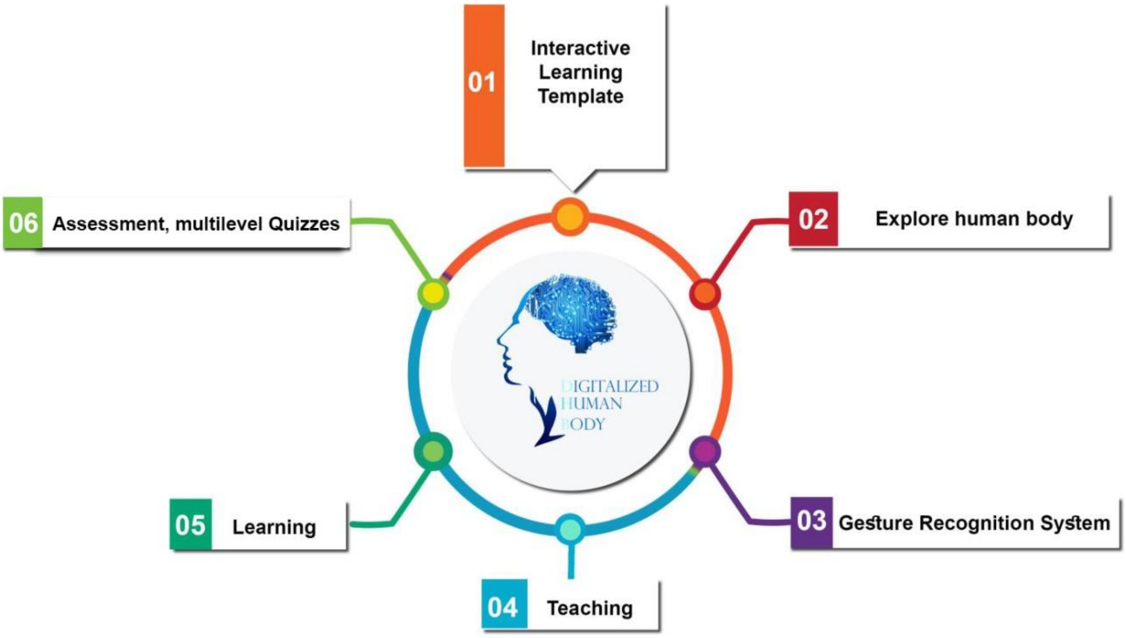


Figure 25. System Components

Digitalized Human Body is made of six components as shown in figure 25 above. They are discussed in details below:

- **Interactive learning template:** It is an interactive learning template where a user can interactively explore the human body at different levels of detail.
- **Explore human body:** Five systems of the human body are provided with their organs which are Digestive, Nervous, Skeletal, Respiratory and Circulatory Systems. They are provided in different data types such as; written text, video, picture, and audio.
- **Gesture Recognition system:** the Digitalized Human Body system has a gesture recognition system that tracks users' hand gestures and gives them the option of controlling the system remotely. It gives them the option to do several actions like scrolling, pointing, zoom in and zoom out.
- **Teaching, learning and assessment:** The system can be a teaching tool as well as a learning environment where school teachers can teach students the human body system in an interactive way, and learners can explore it in their free time. Also, it can be used as an assessment tool by providing multilevel quizzes where a user can view the result and share it with others.

5.2.3. UML Class Diagram

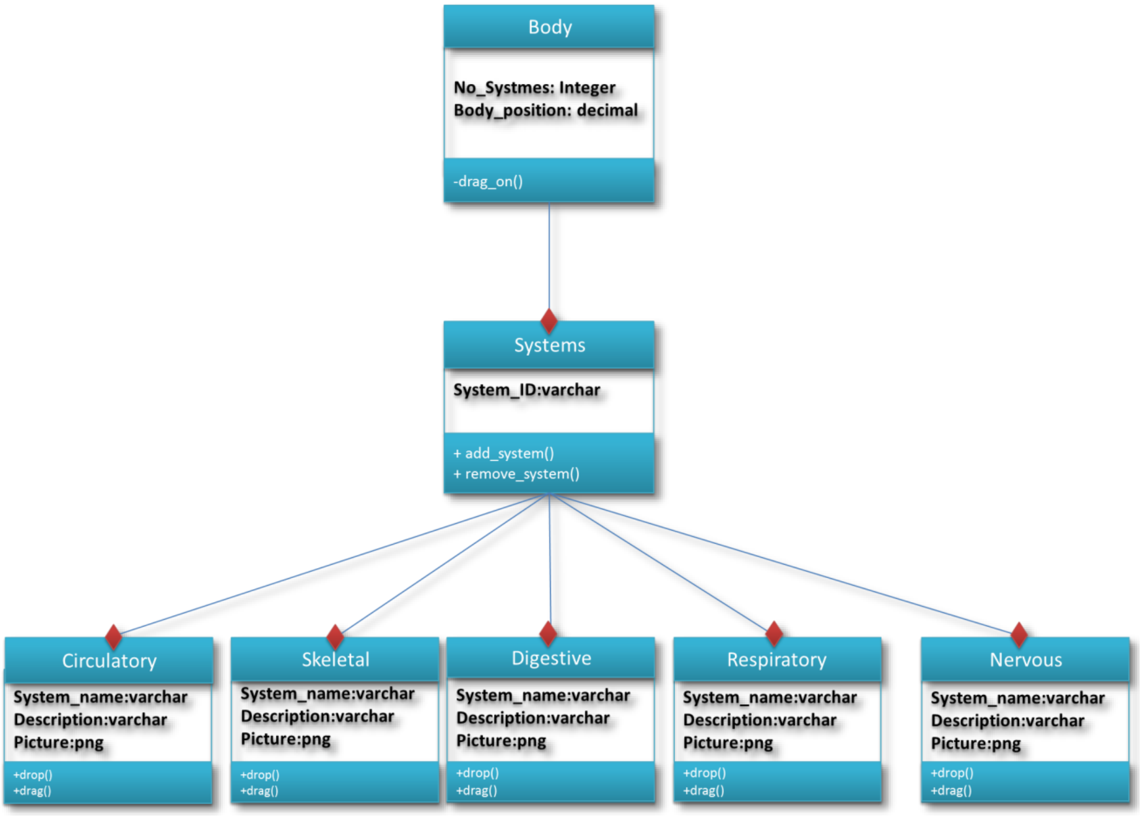


Figure 26. UML Class diagram module1

Figure 26 shows module one of UML class diagram where we have the body class as the parent class that has a child class which is System. System class has five sub-classes under it which describe five human body systems. Each system has detailed information on the organs displayed in different formats. The UML class diagram is flexible which means that more classes can be added like adding more body systems easily or even deleting any class.

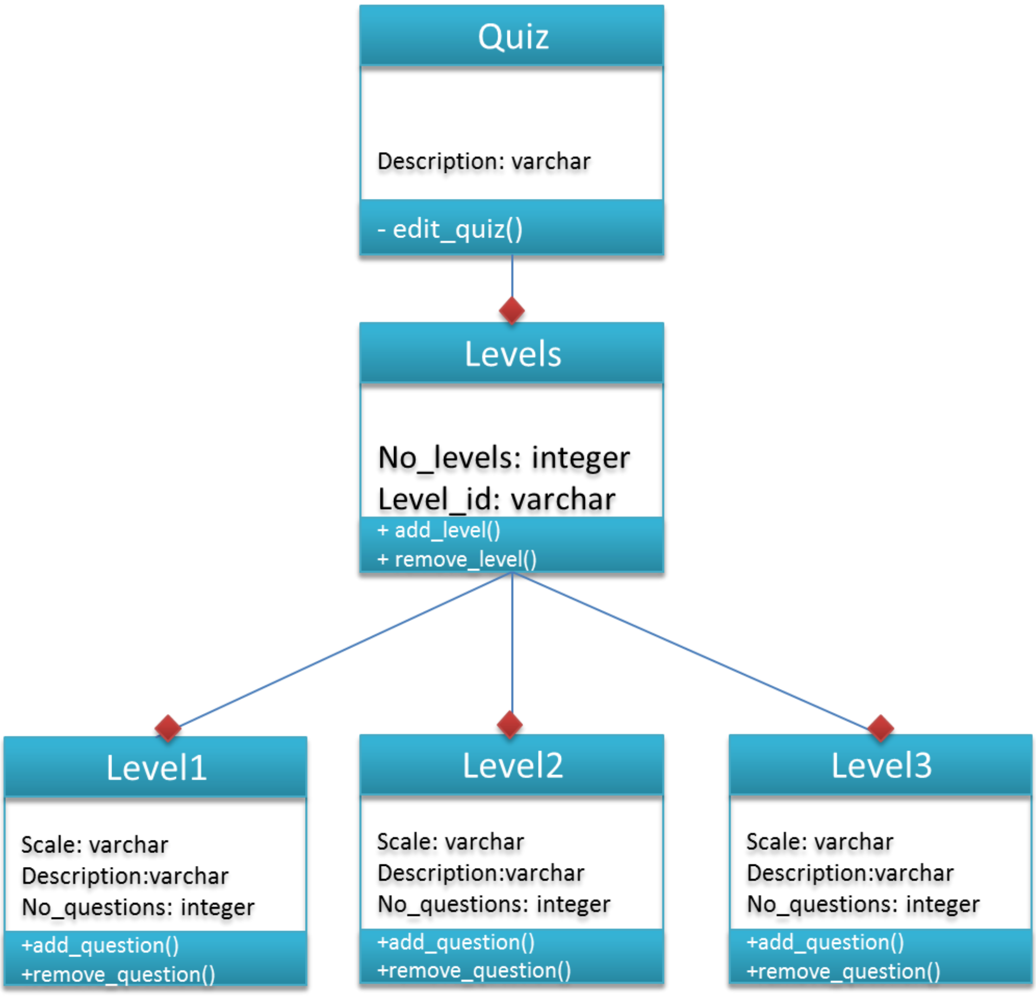
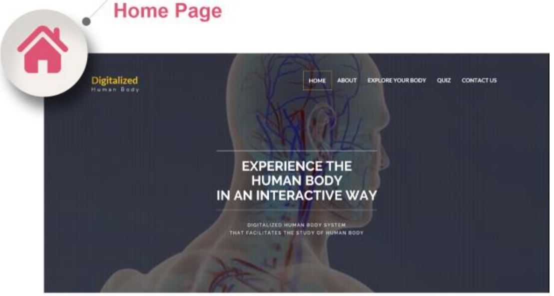


Figure 27. UML Class diagram module2

Figure 27 above shows the quiz part in module two of the UML class diagram where the quiz is the main class. The level class under the quiz class has some levels which are level one, two and three. It includes two main functions which are add_level () and remove_level (), and they control the number of levels in the system. Each level class has some details like scale, description and number of questions along with two functions which are add_question () and remove_question ().

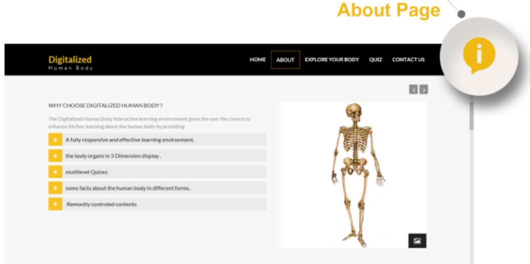
5.2.4. Storyboard

Home Page



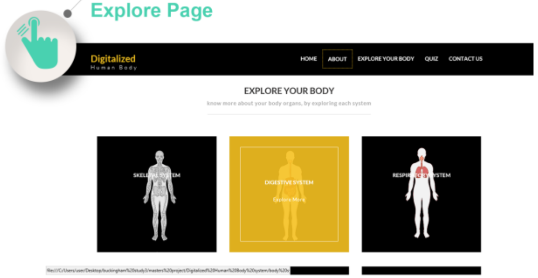
The home page or the navigation page. It is mainly the parent page that navigate to other sub-pages.

About Page



In the about page a brieve information of the system are added. It explains why users should choose to browse digitalized human body system.

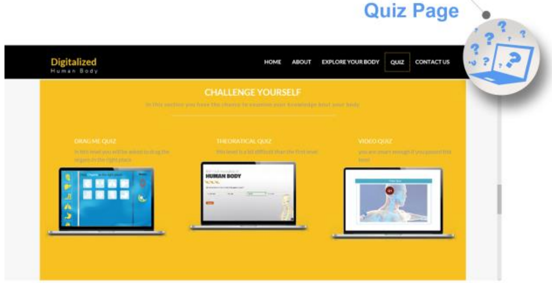
Explore Page



In this page user can explore five different systems of human body. Watch and read about each organ in these systems as well as an audio speaks about specific organ.

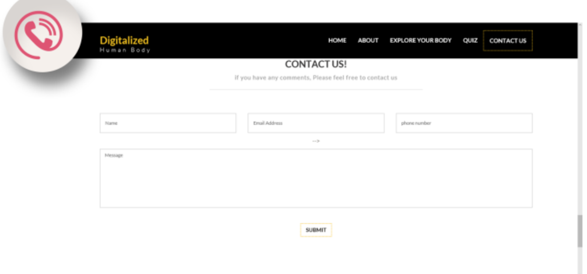
Figure 28. The website storyboard

Quiz Page



It has three modules of quizzes with different formats ans levels. The first quiz asks users to drop and drag body organs in the right place. While the second one is a theory quiz with different levels of questions and the last one is a video based quiz where the questions appear depending on a given video.

Contact us Page



The contact us page gives users the chance to communicate with the developers whether to add a comment, feedback or a query.

Figure 28 shows the different stories of the website where the user has the option to know how to navigate the website. One option is to start from the home page to contact us page in a sequence. Another option is to start directly from any page either Explore page or Quiz page depending on what the user prefers. As the system is a group of small systems that can be examined separately.

3 Implementation

This section highlights how the designed system was implemented along with some coding examples.

This section highlights the implementation part of the system, and it was done through three stages. In each stage, a part of the system was developed.

5.3.1. Implementation stage 1

In stage one the Interface of the system was developed along with explore your body page and during the project progress, the interface has changed several times. The last interface consists of five pages such as home page, about, explore your body, challenge yourself and contact us. Each part of the interface is made up from a combination of some technologies. For example, the slider in the home page is developed using a bootstrap framework which is a combination of Javascript and CSS while the body systems in explore your body page are developed using CSS, Javascript, and iframes. Figure 29 below shows the different versions of the interface:

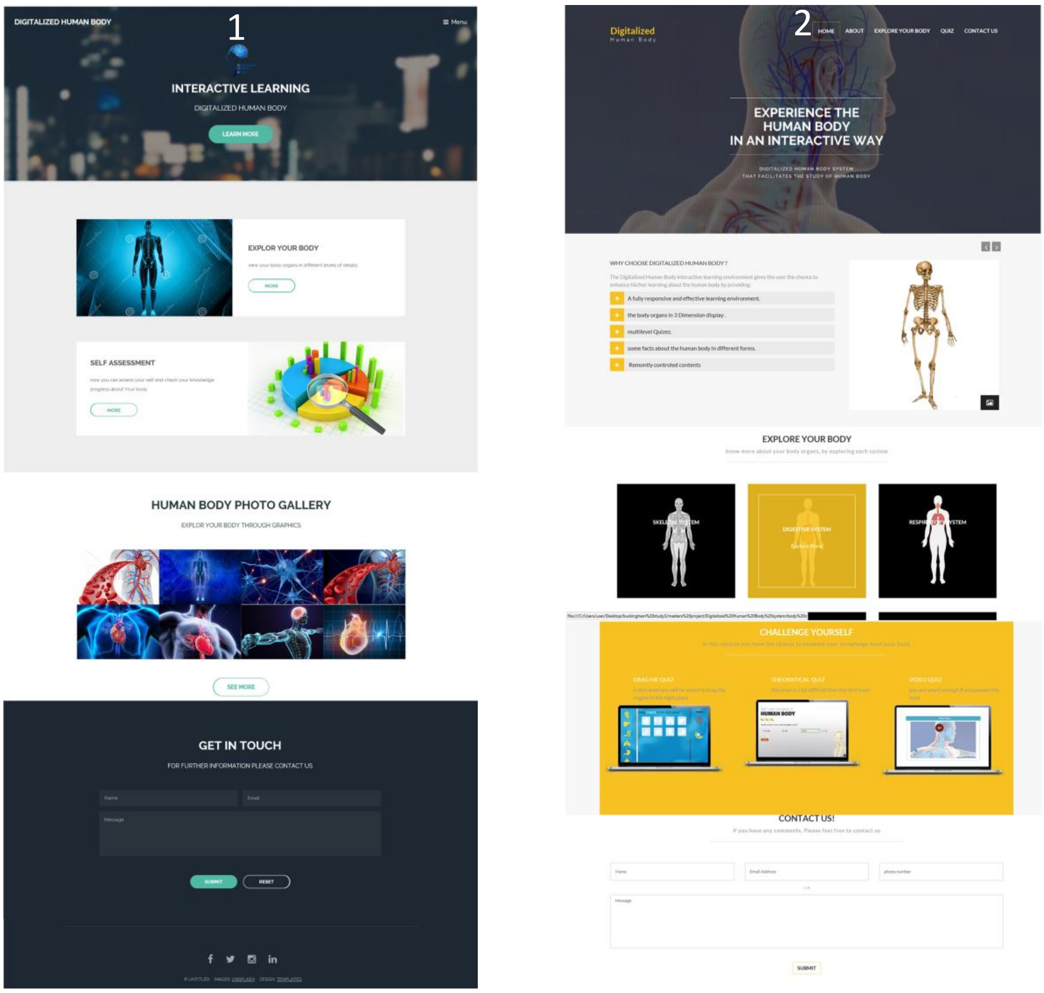
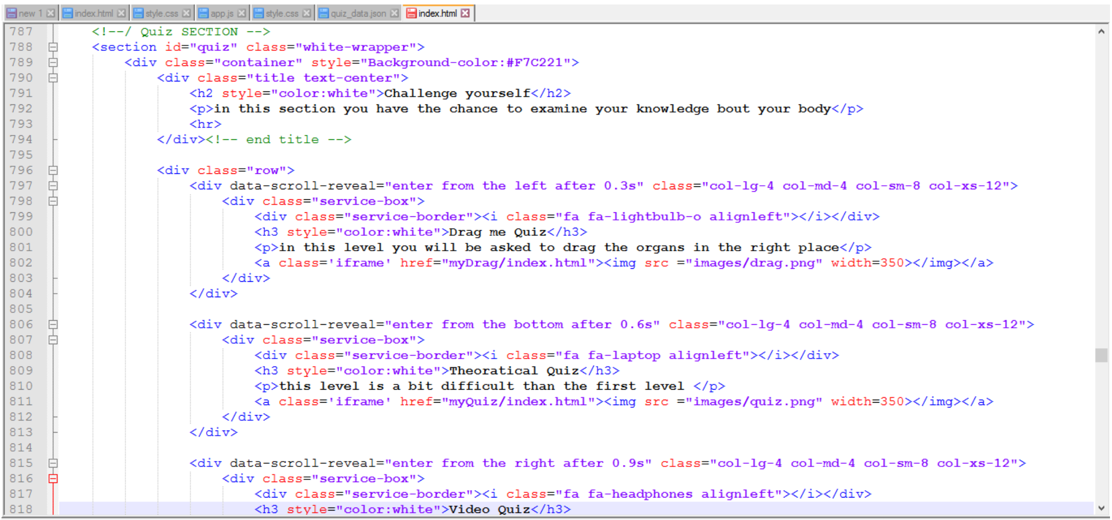


Figure 29. Interface version 1 and 2

The changes on the interface were made for some reasons such as design enhancement, accuracy, and easiness of browsing. The first version had some browsing difficulties. Therefore, the changes were applied to make it easier to browse. The new version is more accurate regarding displayed images and pages sequence than the previous one. Code below in figure 30 contains a Quiz part of the Challenge yourself section:



```
<!--/ Quiz SECTION -->
<section id="quiz" class="white-wrapper">
    <div class="container" style="Background-color:#F7C221">
        <div class="title text-center">
            <h2 style="color:white">Challenge yourself</h2>
            <p>in this section you have the chance to examine your knowledge bout your body</p>
            <hr>
        </div><!-- end title -->

        <div class="row">
            <div data-scroll-reveal="enter from the left after 0.3s" class="col-lg-4 col-md-4 col-sm-8 col-xs-12">
                <div class="service-box">
                    <div class="service-border"><i class="fa fa-lightbulb-o alignleft"></i></div>
                    <h3 style="color:white">Drag me Quiz</h3>
                    <p>in this level you will be asked to drag the organs in the right place</p>
                    <a class='iframe' href="myDrag/index.html"><img src ="images/drag.png" width=350></img></a>
                </div>
            </div>

            <div data-scroll-reveal="enter from the bottom after 0.6s" class="col-lg-4 col-md-4 col-sm-8 col-xs-12">
                <div class="service-box">
                    <div class="service-border"><i class="fa fa-laptop alignleft"></i></div>
                    <h3 style="color:white">Theoratical Quiz</h3>
                    <p>this level is a bit difficult than the first level </p>
                    <a class='iframe' href="myQuiz/index.html"><img src ="images/quiz.png" width=350></img></a>
                </div>
            </div>

            <div data-scroll-reveal="enter from the right after 0.9s" class="col-lg-4 col-md-4 col-sm-8 col-xs-12">
                <div class="service-box">
                    <div class="service-border"><i class="fa fa-headphones alignleft"></i></div>
                    <h3 style="color:white">Video Quiz</h3>
```

Figure 30. Quiz section in the system

Explore your body page consists of five body systems such as Digestive, Circulatory, Skeletal, Nervous and Respiratory Systems. Once the user clicks on a system, a window appears in front of the system that contains the system's organs with information about each organ in different formats such as, written text, audio, video, and picture. Figures 31 and 32 below show explore your body page and detailed information about Digestive System:

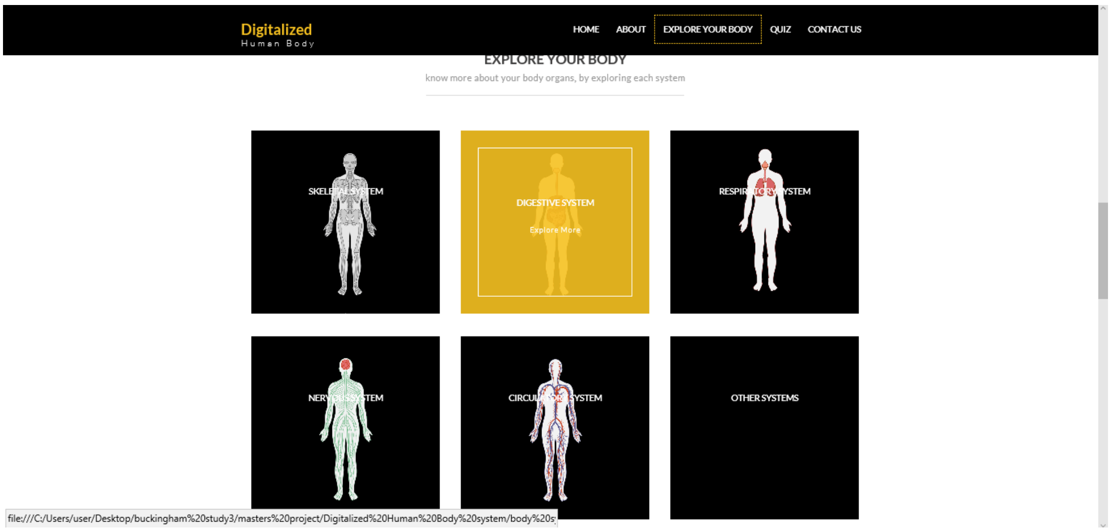


Figure 31. Explore your body page

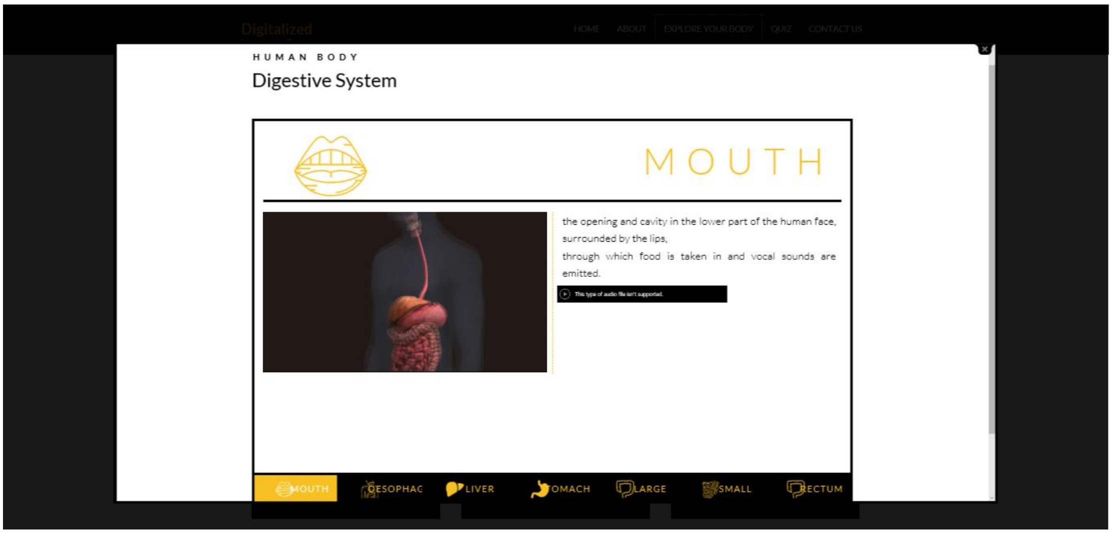


Figure 32. Digestive System detailed information

The system's popup iframe was made using Colorbox Jquery plugin developed by (jackmoore, 2015). The iframe describes a specific body system and its organs in different formats. For the storage matters and resolution and to make the system quite liter as well as displaying high quality and resolution images the used pictures were added as icon fonts using https://icomoon.io/ website to convert them into icon fonts. After the conversion, each image had a unique code to be used in the system. Figure 33 below shows some of these codes:

```
.icon-nervous, .icon-respiratory, .icon-circulatory, .icon-Skeletal, .icon-Digestive, .icon-contact, .icon-menu {
    font-family: 'icomoon';
    speak: none;
    font-style: normal;
    font-weight: normal;
    font-variant: normal;
    text-transform: none;
    line-height: 1;
    -webkit-font-smoothing: antialiased;
}

.icon-nervous:before {
    content: "\e900";
}
.icon-respiratory:before {
    content: "\e901";
}
.icon-circulatory:before {
    content: "\e902";
}
.icon-Skeletal:before {
    content: "\e903";
}
.icon-Digestive:before {
    content: "\e904";
```

Figure 33. Icon fonts display of the images

5.3.2. Implementation stage 2

By the end of stage two, the quiz part was done, and it consists of three quizzes which are Drag me a quiz, Theoretical Quiz, and Video quiz.

For the Drag, me and Theoretical quizzes a combination of AngularJs and Jason was used where the functions were built in Angularjs and Html5, and the questions are stored in a Jason file.

Quiz one is about dragging and dropping body organs into the right place. It consists of three areas, the draggable, droppable and score areas. The draggable area contains the organs to be drag in the droppable area while the score area calculates the score and has doraemon that checks the answers. Figure 34 below shows quiz one:

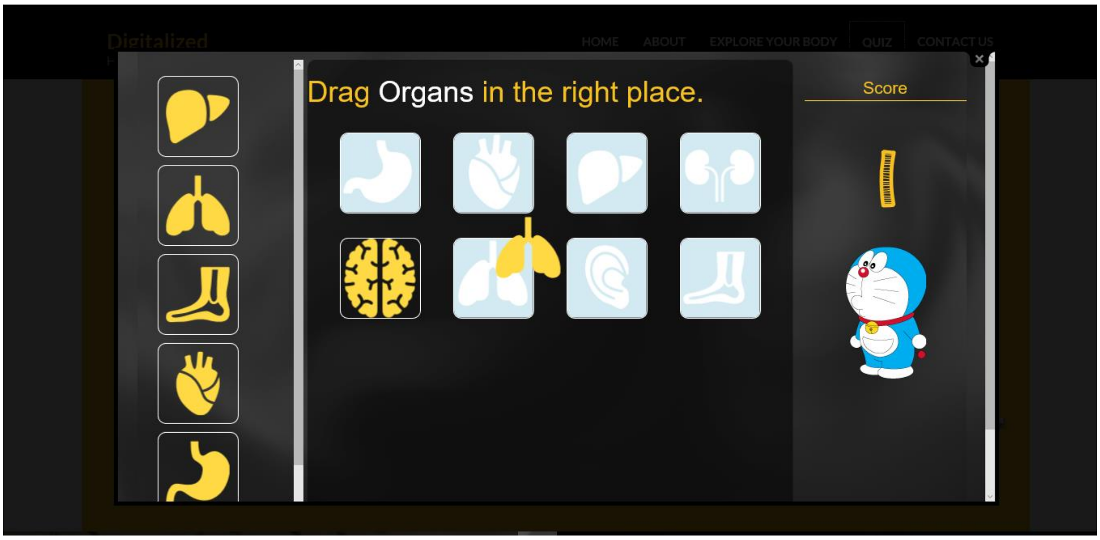


Figure 34. Quiz one screenshot

Organs are bound from the javascript file to the Html file using the data-ng attribute in AngularJs. Once the user grabs the organ from the draggable area and tries to drop it in the droppable area, doraemon status changes as shown in figure 34 above and if it went to the right place the score increases and Doraemon status changes to happy.

Quiz two contains theoretical questions with multiple choices. The structure is developed using AngularJs and Html5 while the questions and their answers are stored as arrays in a Jason file and they are bound to the HTML file. There are five questions to be answered and in by the end of the quiz, the user gets the feedback along with the result. The result can be shared through email or twitter. Figures 35 and 36 below show the starting window and Jason file.

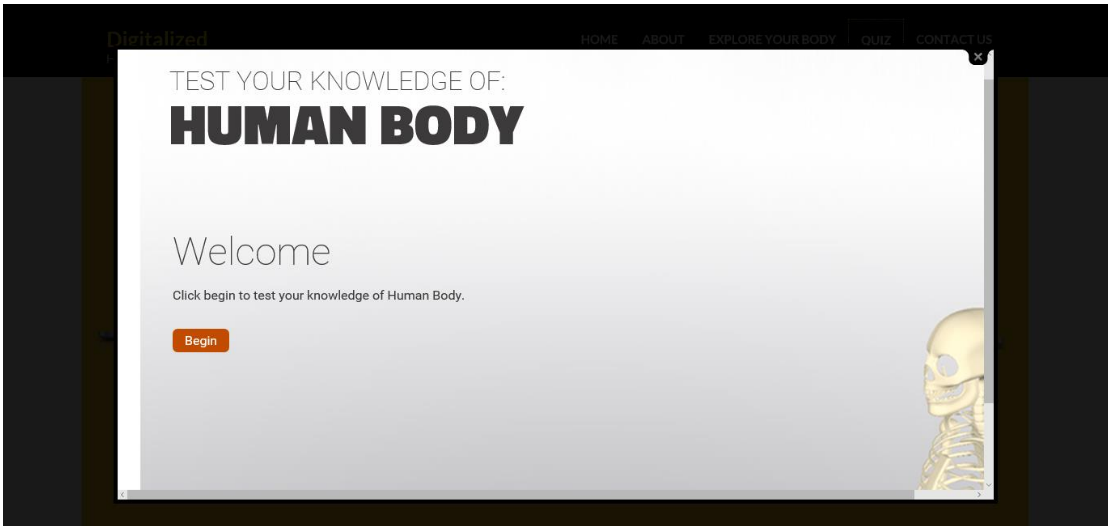
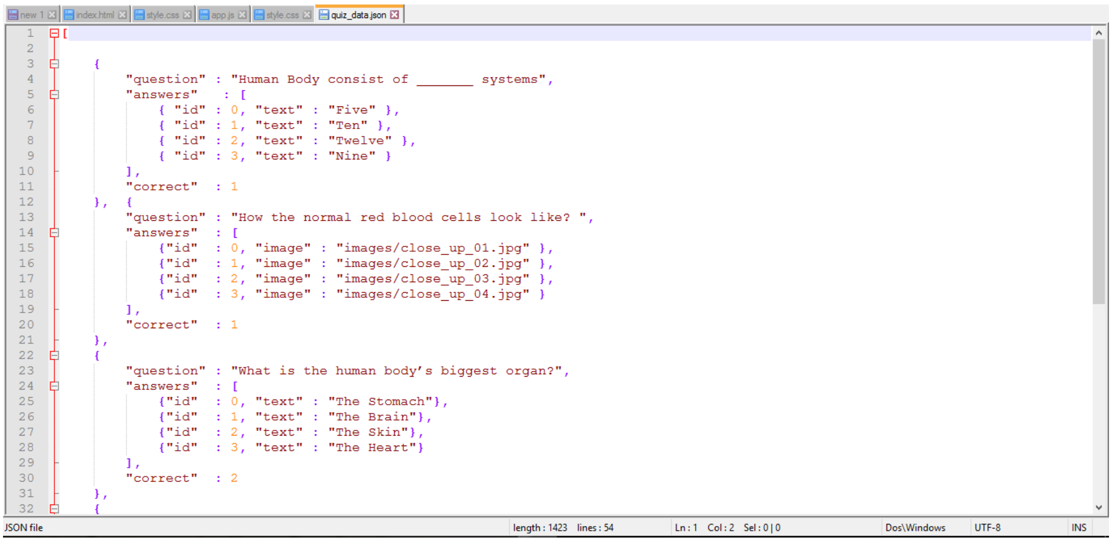


Figure 35.The starting window of quiz 2




```
[

    {
        "question" : "Human Body consist of ______ systems",
        "answers"  : [
            { "id" : 0, "text" : "Five" },
            { "id" : 1, "text" : "Ten" },
            { "id" : 2, "text" : "Twelve" },
            { "id" : 3, "text" : "Nine" }
        ],
        "correct" : 1
    },  {
        "question" : "How the normal red blood cells look like? ",
        "answers" : [
            {"id" : 0, "image" : "images/close_up_01.jpg" },
            {"id" : 1, "image" : "images/close_up_02.jpg" },
            {"id" : 2, "image" : "images/close_up_03.jpg" },
            {"id" : 3, "image" : "images/close_up_04.jpg" }
        ],
        "correct" : 1
    },
    {
        "question" : "What is the human body's biggest organ?",
        "answers" : [
            {"id" : 0, "text" : "The Stomach"},
            {"id" : 1, "text" : "The Brain"},
            {"id" : 2, "text" : "The Skin"},
            {"id" : 3, "text" : "The Heart"}
        ],
        "correct" : 2
    },
    {
```


Figure 36. Jason file of the quiz

Quiz three is a video based quiz that consists of ten body-related questions. This quiz is developed using Articulate Storyline 2 software. The user is provided with choices in each question and once he/she clicks the submit button the system checks whether the correct answer was selected or not and the correct answer will be highlighted in green. Figure 37 below shows some screenshots of the quiz. The quiz questions were in layers each layer has a question along with the events and feedback while the video was in the pace layer as a background.

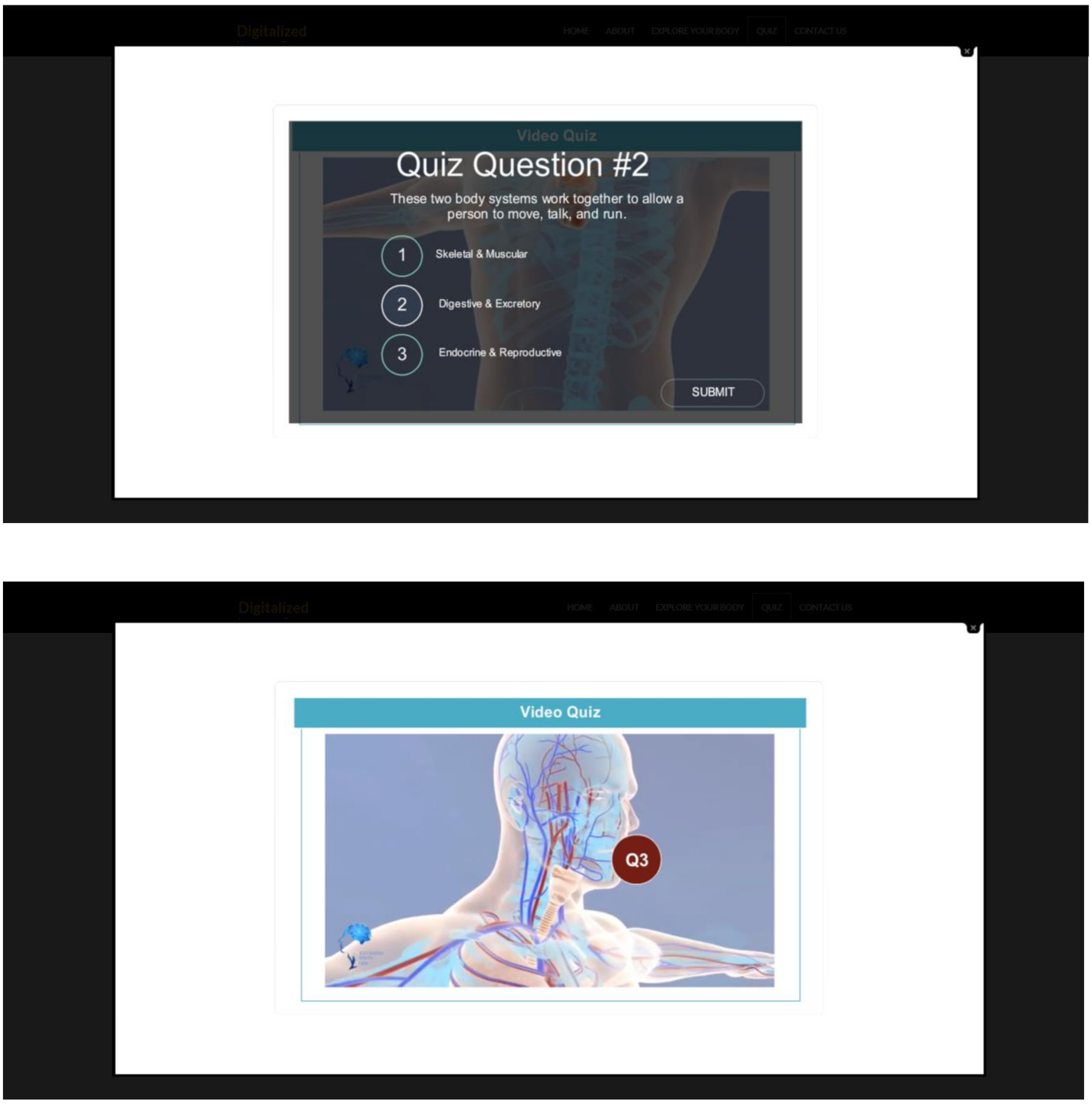


Figure 37. A screenshot of the video quiz

5.3.3. Implementation stage 3

In this stage the Digitalized Human Body system is ready and the gesture based part to be added for interactivity enhancement matter. With gestures users can remotely control the system like scrolling, clicking buttons and rotating objects. In order to apply this, gesture based system was needed which is the Kinect device. Although Kinect V2 supports human gestures in plenty of applications and supporting websites, no one tries to use it on a website because the website and Kinect are working in totally different environments. Therefore, there was no such way to follow to use Kinect in websites. However, Kinect V1 does support websites by using JKinect and Kinesis.Io SDKs. We gave it a try in Digitalized Human Body system, and it worked, but it was very difficult to control the system for the reason of high latency. Both Kinect and the system were reading from and writing to the same file which makes it very slow, and this leads to unreliability. Figure 38 below shows how the system worked with Kinect V1:

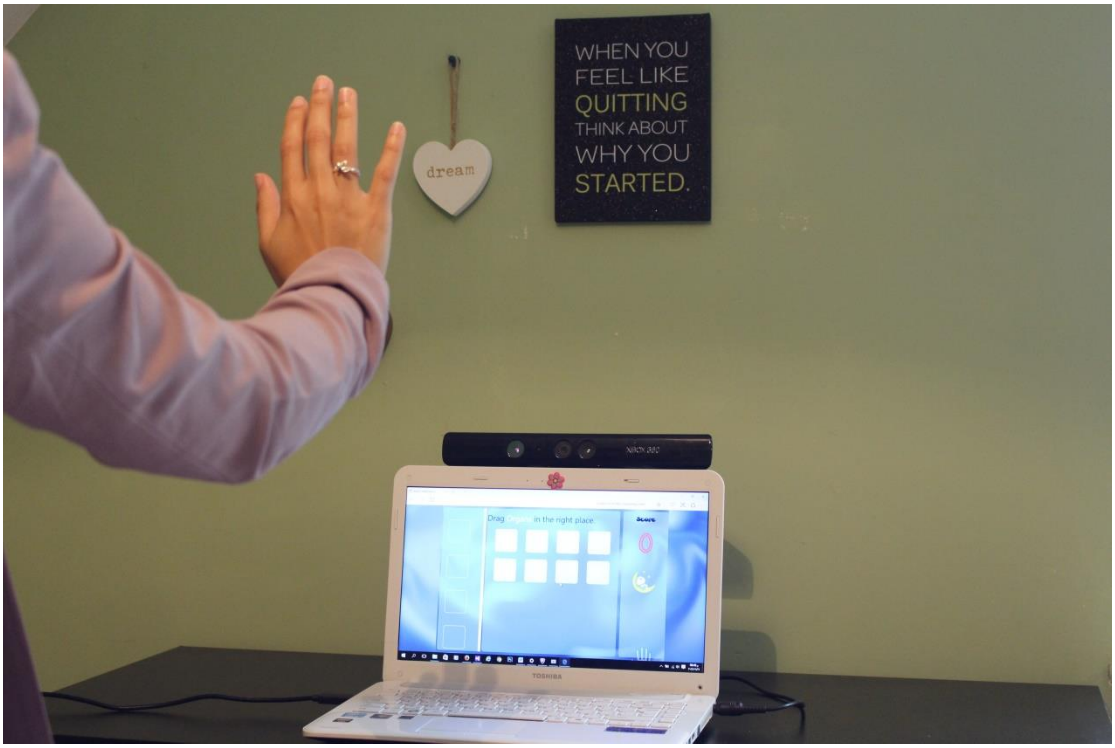


Figure 38. The system working in Kinect V1

As a solution for the problem an alternative gesture based device was used to get the same result which is the Leap motion controller. It supports websites through Javascript where the resulted gestures are added to the website as a Javascript code. To activate the gestures the leapcursor-with-dependencies.min.js file has to be added to the system. From the huge number of leap motion libraries jazz_hands.js and jazz_events.js have been used in Digitalized Human body system. These libraries support the basic hand gestures like moving up, moving down, zooming in and out, pointing, grabbing and dropping. Other gestures were built using Leap trainer UI, and they are saved as a Javascript code as shown in Figures 39 and 40 below:

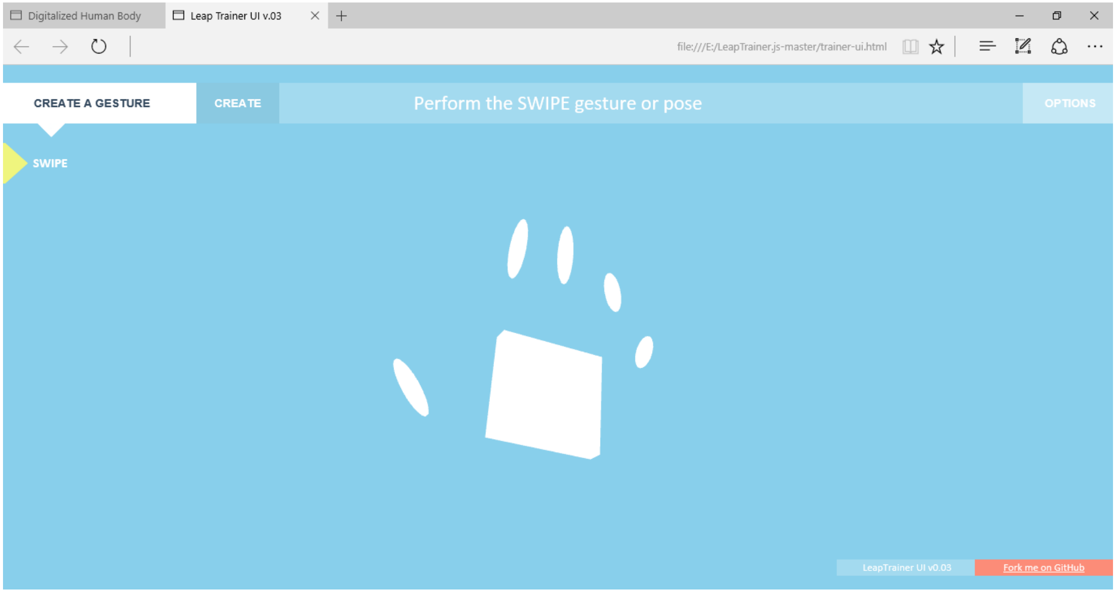


Figure 39. Recording gestures screen

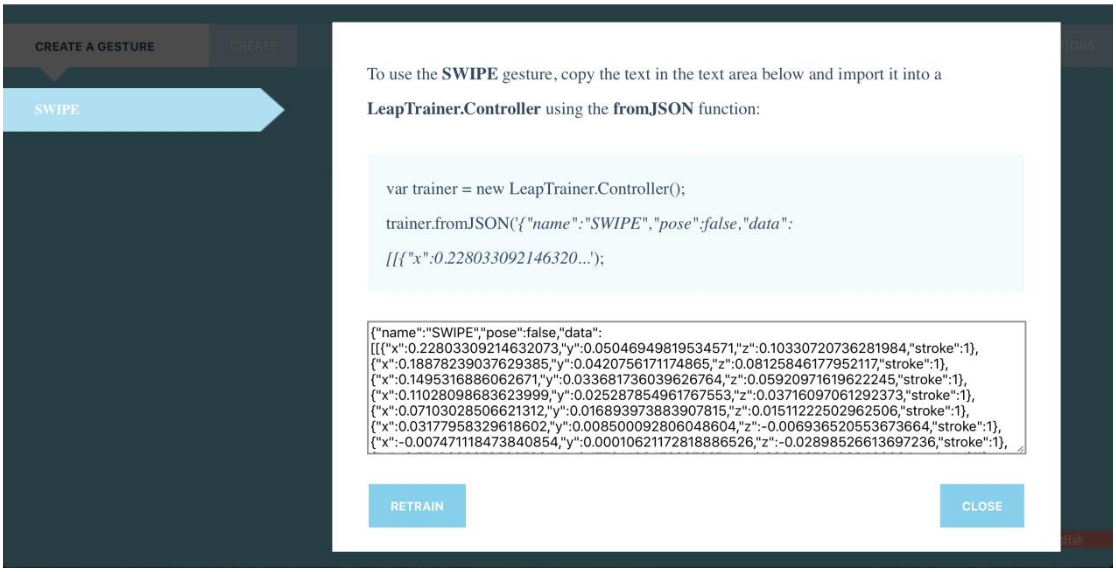


Figure 40. The Recorded Gesture

Figure 41 below illustrates how the whole system looks like after completion and how it is controlled by the leap motion:

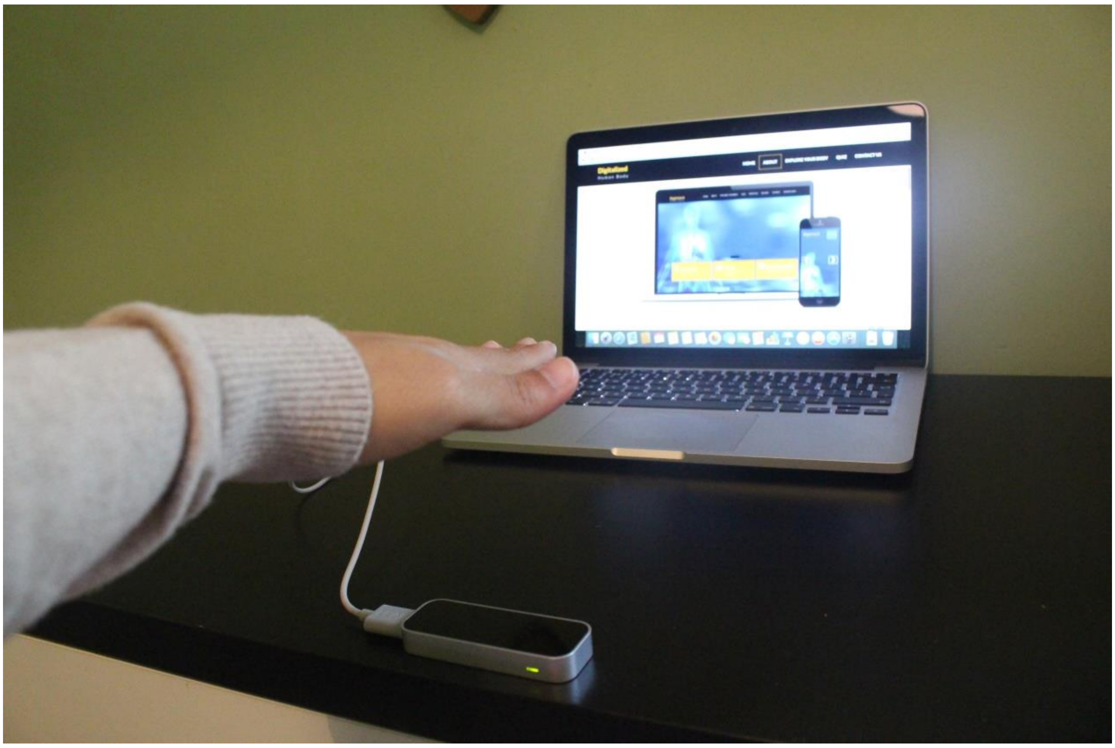


Figure 41. The system controlled by the Leap motion controller

5.3.4. Barriers to the project completion

During the implementation stage, some problems have occurred, and one of these problems was although the Kinect supports HTML body basics no one tried it on a website because both of them are working on different servers and environments. Therefore, to make them work together, we need to link their servers to work on one server. This was the most challenging part for me, and it affected the completion of the system. Many ways were tried, and they were inconvenient. Three months were spent to solve the problem, and the solution was to search for another gesture system, and Leap Motion controller was found as we mentioned earlier.

4 Testing

This section the testing methods of the system were highlighted.

Testing is the process of evaluating a software item to detect differences between given input and expected output as well as assessing the features of this item. Testing assesses the quality of the system, and it should be done during the development process. In other words, testing is mainly a Validation and Verification processes of a system.

5.3.5. Validation and Verification

To check the validity of the system we tried to make sure that the software has met the specified requirements at the end of the development phase as well as making sure that nothing went wrong during the development process and to deliver the specified product to the stakeholders. Whereas to verify the system we were trying to make sure that the system on track and everything is going as we planned at the start of the development phase.

5.3.6. The basics of software testing

There are two basic classes of software testing which are Black box testing and white box testing. The main difference between the two classes is that the black box testing focusses on the output of a selected input while the white box test tests the internal mechanism of the system.

5.3.6.1. Black box testing

According to (Williams, 2006) the black box testing or the functional testing is the testing that focusses on the output of a certain input process without considering the internal mechanism of the project. It ignores everything related to the code or programming part of the system where this part considered a black box and nothing can be seen inside. It is often used for validation. The figure below shows how this testing work:

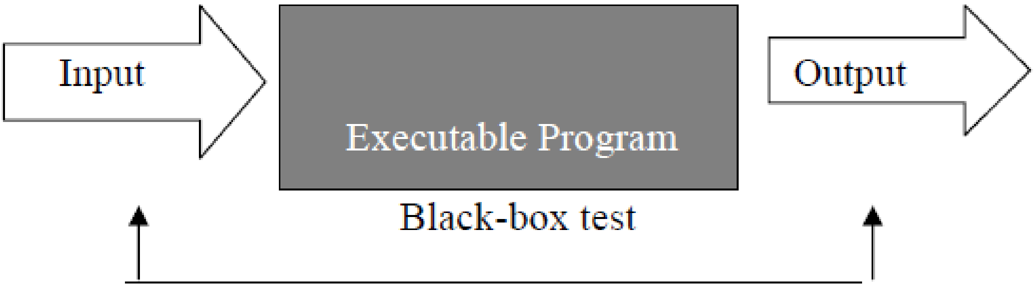


Figure 42.Black box testing

In figure 43 above we can clearly notice that the black box test focusses on the input and output of the project and ignoring the code part. (Williams, 2006)

In the Digitalized Human Body system, we have applied the black box test, and Table 7 below shows the parts of the system that have been tested:

Test ID	Description	Expected Results	Actual results
1	Click on any body system	A fully detailed sub-page of the specified system opens	A fully functioned page was opened
2	Taking a quiz	switching between questions	This option is just available in quiz two and three, and it works well in both of them
3	Viewing results	A list of the results appears with sharing option	This option is just available in quiz two for now
4	Moving hand remotely to scroll the system	System scrolls up and down	System scrolls perfectly

Table 7. A specification of the testing case

5.3.6.2. White box testing

In contrast to the black box testing, the white box testing or structural testing focusses on the internal mechanism of the software. It is a verification technique to check whether the code works as expected or not. Mainly the tester of white box testing is the developer who knows what the code looks like and tests a part of the code with certain parameters (Williams, White-Box Testing, 2006).

5.3.7. The Six types of testing

There are six main testing types that can be used to test a software such as; Unit, integration, function/system, acceptance, regression, and beta. Each type has two parameters which are the opacity (is it white or black box test) and the scale (whether a piece of code is examined or the whole code) (Williams, 2006). Table 8 below summarizes these tests:

Testing Type	Specification	General Scope	Opacity	Who generally does it?
Unit	Low-Level Design Actual Code Structure	Small unit of code no larger than a class	White Box	Programmer who wrote code
Integration	Low-Level Design High-Level Design	Multiple classes	White Box Black Box	Programmers who wrote code
Functional	High Level Design	Whole product	Black Box	Independent tester
System	Requirements Analysis	Whole product in representative environments	Black Box	Independent tester
Acceptance	Requirements Analysis	Whole product in customer's environment	Black Box	Customer
Beta	Ad hoc	Whole product in customer's environment	Black box	Customer
Regression	Changed Documentation High-Level Design	Any of the above	Black Box White Box	Programmer(s) or independent testers

Table 8. Levels of Software Testing (Williams, 2006)

In the Digitalized Human Body system, five of these testing types were used such as Unit testing, Integration, Functional/system and Acceptance. People from different places were involved in testing the system. Moreover, the testing process was applied in different environments such as PCs, Desktop computers, and big screens. Table 9 below discusses the testing process:

Testing type	Tested part	tester	Date
Unit	Gesture based functions	Me	15th, May 2016
Integration	Quizzes and explore your body parts	Me	10th, May 2016
Functional	Whole system	My sister Sara Al-Saqri	5th, June 2016
System	Whole system in different display environments	User	30th, May 2016
Acceptance	Whole system	User	23rd May 2016

Table 9. Levels of Digitalized Human Body testing

According to Table 9 above, there were five testing types the Digitalized Human Body system went through. For the Unit testing the gesture based functions were tested by me and from the testing process, I found that there were some difficulties in controlling the hand movements as it moves fast. Therefore, I decreased the movement speed by quarter. Whereas in the integration testing the Quizzes and explore your body parts were examined specifically in adding or removing questions and body systems. This part was working well, and there were no more improvements. In the functional testing the whole system was tested to check the system functionality and whether the functions work well or not and some enhancements were recommended. For the system testing the system was tested in different environments such as PCs, smart TV, and big screens as well as different platforms like Windows and IOS. The system worked well in these different environments as it is compatible with environments. Moreover, some users from the stakeholders have examined the system under the acceptance testing, and they faced a small problem in dealing with the leap motion controller as it is the first time for them to deal with it. Figures 44 and 45 below show some examples of system testing process by a school student:

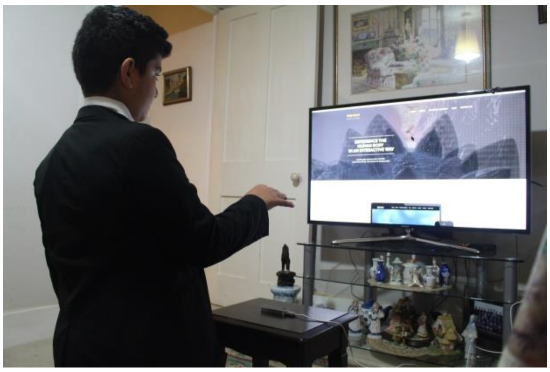


Figure 43. System testing by a school student

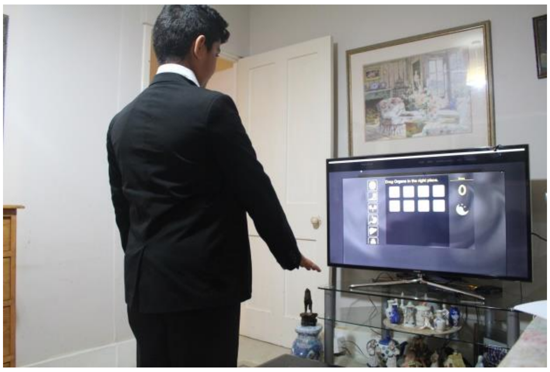


Figure 44. System testing by a school student

Figures 46 and 47 below show the system in different environments:

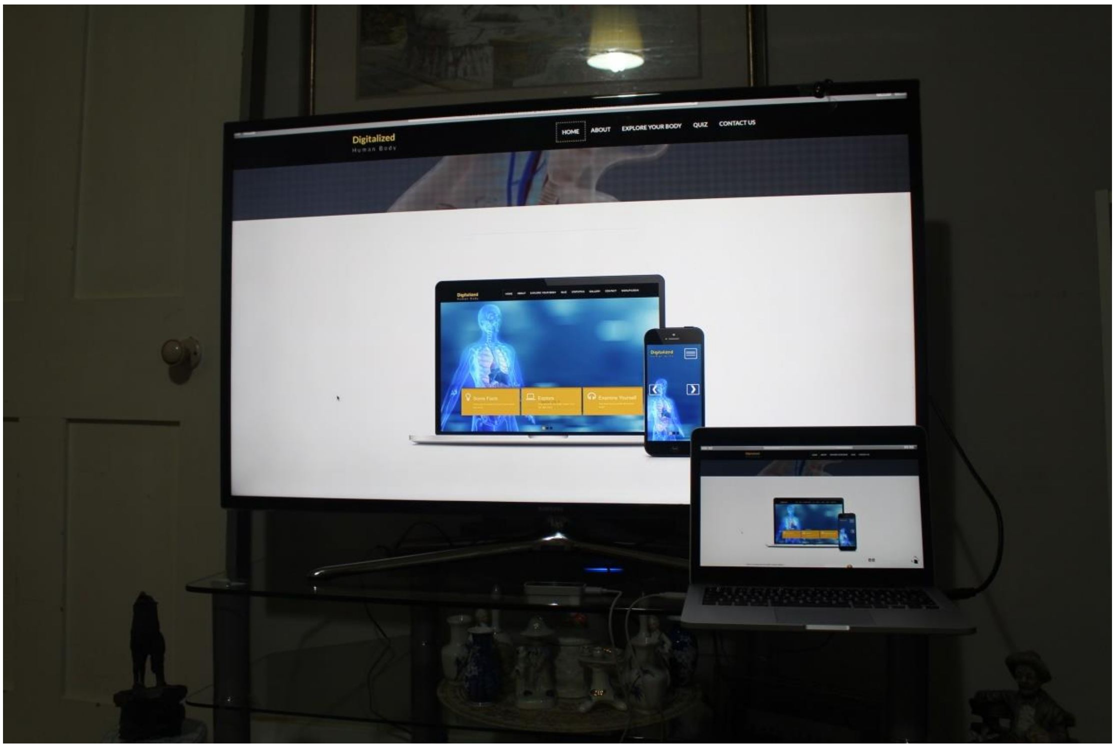


Figure 45. System displayed in different environments

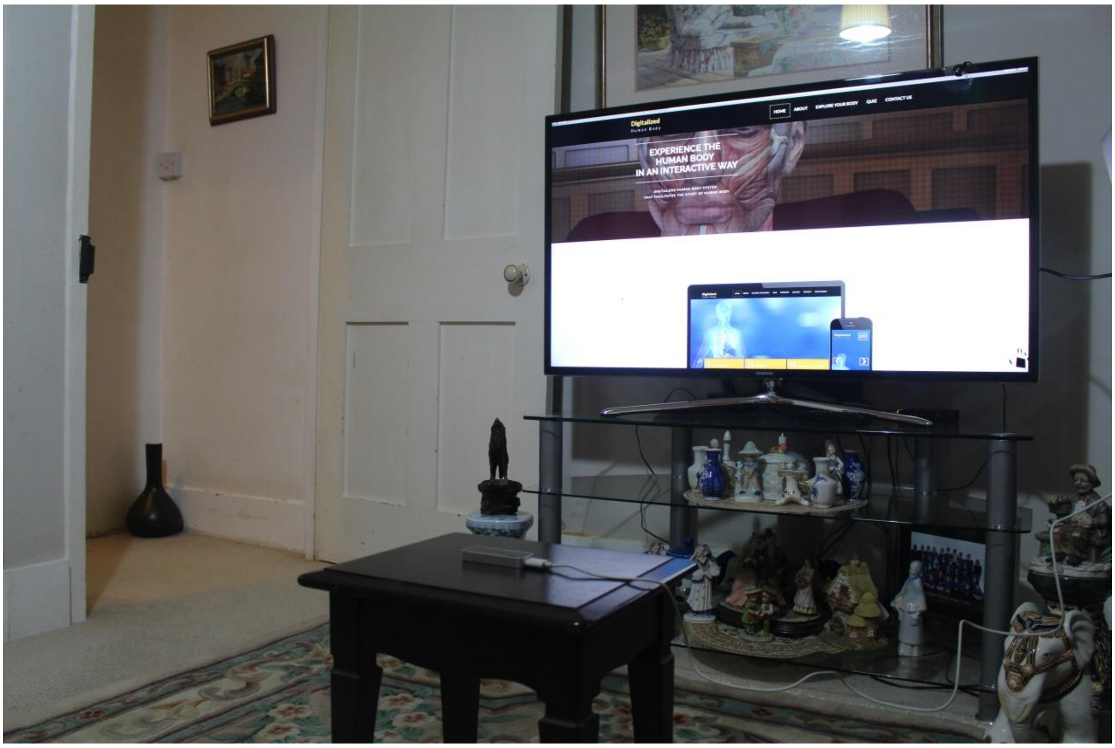
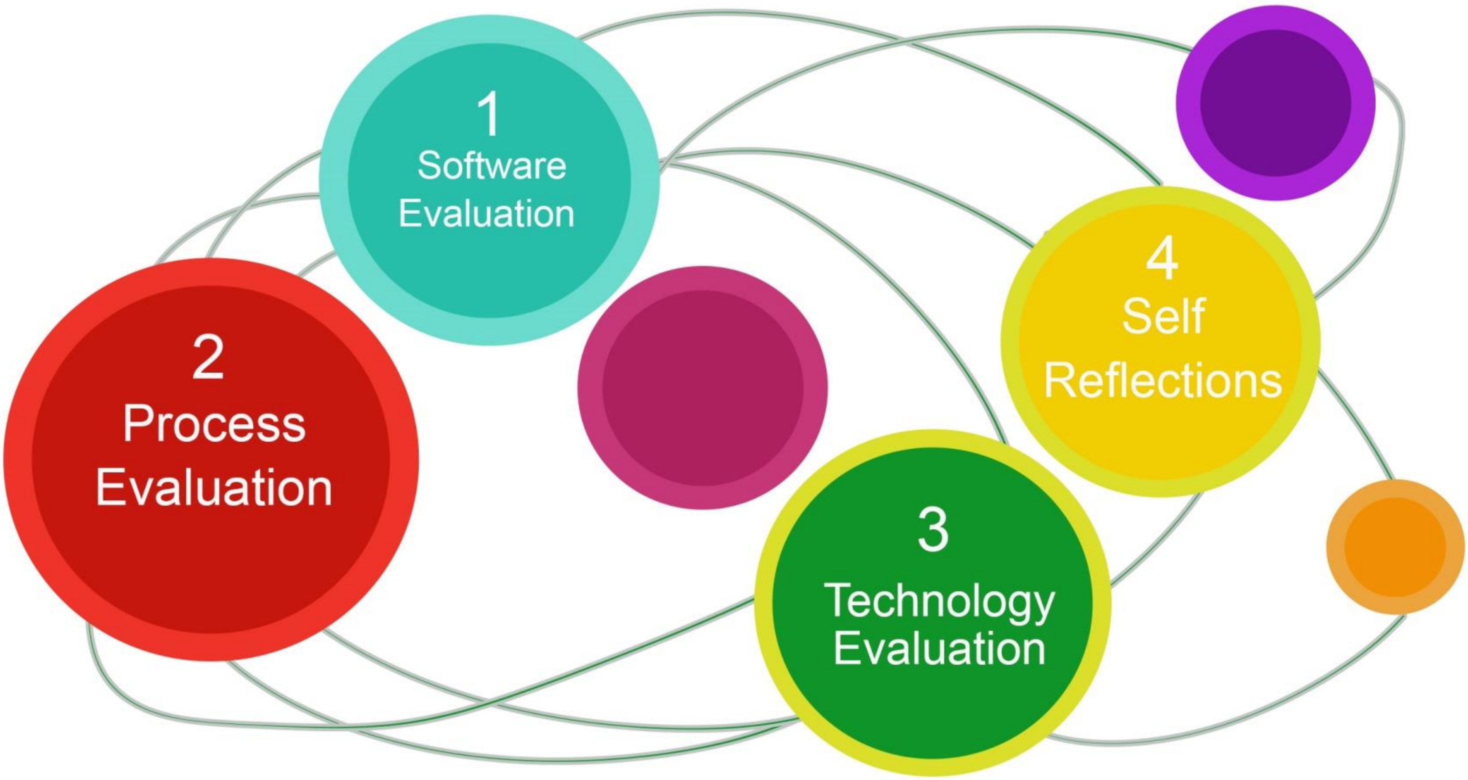


Figure 46. System displayed in different environments 2

Chapter 6: Evaluation



6.1. Software evaluation

The Digitalized human body system has succeeded in simplifying the users learning process by providing them with information of human body effectively in different formats such as written text, audio, and video. This success was observed in the testing part of the system when users examine an organ, different users with different learning styles simply can use the preferred format of information. Although the system displays human body systems and their organs quite well this was not exactly what was aimed in the beginning. It was aimed to provide users with more interactions like exploring the body organ by going in deep inside it. This needed lots of time and for that, it has been added in the recommendations section. Moreover, the system was aiming to enhance user experience through interaction and from the testing part we found that the user has enjoyed exploring the Digitalized human body system interactively using hand gestures. From a user experience, we observed that the system needed more enhancement and improvement, and this has to be done shortly.

6.2. Process evaluation

In order to deliver the system to the final stage, I have split the work into three different levels of complexity and easiness which are low, medium and high and at a time I had a combination of complex and easy tasks to do. This way worked quite well as having the easy task first done was encouraging me to do the complex one. Before doing that, I consumed more than three months trying to complete the Kinect part and nearly I stopped the work when I could not find the correct way to make it. This was a disappointing situation, and therefore, the new way has occurred to solve the time problem as three months were not a short period, and things have to be on track again. The new way worked well with the different system development stages such as analysis, design, and implementation. As there were different stages, the system has to go through to be completed each stage had things that went right and other that went wrong. Table 9 below highlights some of the tasks from different development stages with the evaluation:

Task	stage	Complexity	easiness	evaluation
Requirement specification	analysis	Medium	Medium	Quite well
diagrams	Design	High	Medium	Very good
Implementation stage 1	Implementation	Medium	Low	Very good
Implementation stage 2	Implementation	Medium	Medium	good
Implementation stage 3	Implementation	High	High	Quite well

Table 10. Tasks evaluation

From Table 10 above we clearly can see that the requirement specification did not go very well as they were needed to be changed when the Kinect device was replaced by the Leap, motion controller. Moreover, the same reason has affected Stage 3 of the implementation part of the system. Besides this, the risks to the system were evaluated too, and we found that the solutions to overcome them were suitable, and they work well.

6.3. Technology evaluation

It was difficult to evaluate the used technologies as there were more than three technologies which needed to be evaluated separately such as; Parallax design in Html5, AngularJs, Articulate storyline2, Microsoft Kinect sensor and Leap motion controller. Parallax design was a very good addition to the system as it added a unique interactivity to the system which could grab many users attention. While AngularJs did a great job in using limited lines of code through binding technique. Moreover, the video quiz developed by Articulate storyline2 software is a new way of presenting a quiz that can easily grab the user's attention and increase the interactivity level of the system. Although using the Kinect sensor was the main point of the system we did not put in our considerations that it might not work in the system. We could not find any website that is controlled by the Kinect and for that, a substitution plan had to be made. This issue had to be fixed during the research stage to save time. However, in the end, a very good alternative device was used which is the Leap motion controller to do what was needed from the Kinect sensor. The leap motion has simplified the complicated work and the three months of waiting. Although the Leap Motion has some limitations compared to Kinect sensor like gesture detection range, it has other good specifications like multi-platform compatibility which as an advantage to the system. Users from Windows, IOS or Linux platforms can browse it.

6.4. Self-reflection

At the end of the system development process, some of my personal objectives were achieved such as improving programming skills, designing skills and dealing with hardware. This project has nurtured and enhanced my theoretical knowledge about human anatomy and practical side. Also, it has helped me to strengthen my personality and eliminate my weaknesses. In the practical side, I have discovered new technologies that I never heard about or try before especially the Kinect and Leap Motion controller. I did not put in my considerations that one day I will deal with gesture-based systems, and now I have a good background about them. If I had more time, I would have better results as my experience would have increased. Moreover, I have learned how to write an effective and well-organized dissertation and the mistakes I made during the writing have taught me how to avoid them in the future. There is an important thing that I have learned which is how to be clever enough to complete as much number of tasks as possible within the timeframe and how to complete a certain task with a zero or fewer mistakes as possible. I have learned that losing the control is not wrong, and it happens as long we can get it back again. This work has added a lot to my personality, and I am thankful for that. It taught me how to be patient when I face difficult situations with the system and how to be optimistic when things don't go well. Furthermore, I have learned that there is always more than one solution to a given problem, but what matters the most is choosing the most effective one and believing in my abilities.

The Digitalized Human Body system will not stop at this stage as there are lots of development ideas that would make it professional including three-dimensional moving graphics. Along with that, the system would be a very good business idea as it gathers more than four formats for a piece of information in one place and will help people with different learning styles in enhancing their knowledge of the human anatomy.

Chapter 7: Conclusion and future work

The Digitalized Human Body is an interactive digital tool that was developed to enhance the user learning method of human anatomy. It gives users the chance to explore the human body systems and their organs interactively based on hand gestures such as; zoom in, zoom out, scrolling and pointing. The reason behind choosing this subject was because of the importance of health education and as we all know how important it is to learn about human anatomy. Another reason was improving the health education development chain in the society and to get rid of the ignorance or at least decrease its percentage.

The system is made of five main components that work independently, but systematically which are an interactive learning environment, explore your body, gesture based system, teaching tool, learning tool and assessment tool and therefore its purposes could differ from one user to another. Many types of research were conducted to discover related work in health education, as well as learning styles and plenty of projects, were found therefore the Digitalized Human Body system was trying to cover things that were not covered by the previous systems like developing a fully interactive website that covers as much learning styles as possible.

The system went through different stages as mentioned earlier starting with the used technologies followed by the management strategy, the development part which included the analysis, design, implementation and testing sections and ending with the system evaluation and the conclusion. After each stage, a part of the system was developed up to the end where the whole Digitalized Human Body system was developed. During the development process, some things went right, and some went wrong, but this did not stop the work because solutions were brought out. Each stage had its outcomes, and they are discussed below:

7.1. Outcomes and results

At the end the Digitalized Human Body system has achieved what was expected at the beginning of the development stage which is building a fully interactive website and this part was achieved very well. The collaborative learning part was aimed to be done using Microsoft Kinect sensor where up to six users can use the system together and when the use of Kinect was avoided this part was affected. However, the Leap Motion has solved the problem with less number of users. The good result was with exploring the human body and its organs part where the chosen body systems worked very well in all formats either in a written text or graphics based view. Moreover, although there were some changes in the gesture based systems from Kinect to Leap Motion regarding limitations, latency capabilities, and compatibility the gesture-based interactions using the leap motion worked well as well. Although the assessment part of the system did not go as what was planned it worked quite well and the variety of the quizzes pattern has added value and uniqueness to the system. The most important thing is that the system components listed below are working very well.

1. Assessment tool
2. Learning tool
3. Teaching tool
4. Gesture based system
5. Interactive learning template
6. Explore the human body

The good thing about is that although they are independent of each other, they are working systematically together.

7.2. Recommendations and Future work

Human anatomy is a wide subject to do an experiment on and to speak about. However, because of the time constraints we were not able to do everything or to add new things. Therefore, some points related to the learning, assessment, and teaching parts have been added as recommendations for future work. In the learning part, the recommended points are having the body organs in 3-dimensional visions and giving users the chance to go inside each organ using specialized technologies like WebGl and Blender. While changing the complexity level is recommended for the assessment part. Furthermore, adding students' progress page for the teachers to observe their learning progress. Last but not the least, one of the most important recommendations is to change the failure to use the Kinect device with success in the near future.

To end it up, by this we have reached the final stage of the Digitalized Human body system within the main timeframe, but of course, this is the first step to success which will take the system to the next stage of creativity and innovation. We have to believe that nothing is impossible in software development process unless we do not let our minds think out of the box. We have to be good time managers and to put the saying *" hard working and certainty are capable of shortcutting the time"* in our consideration before starting a new project.

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