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Serious Games

THE SKELETON – A GAME THAT TEACHES ABOUT THE MAJOR BONES IN THE HUMAN SKELTON

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1.0 INTRODUCTION

Our ability to walk, lift, run and manipulate daily objects depends on the strength and resilience of the human skeletal system. There are hundreds of games available online that can teach you about human anatomy, body parts, and their functions but without the skeleton system, it's all irrelevant. It is because the skeleton system is the foundation of human anatomy and without it, the movement would not be possible at all. Because of the extremely important role played by the human skeleton in our body knowing what it entails and learning the functions of the major bones becomes something of a necessity. Simply put, without the skeletal system, our bodies will look like a paper kite without its frame or a blob of jelly.

The human skeleton is simply a collection of nearly 206 different bones of different shapes and sizes. These bones align and articulate with each other to create a protective framework for the body that muscles wire to, to provide movement and form. Human skeleton performs six major functions in our body; support, movement, protection, production of blood cells, mineral storage and endocrine regulation. Furthermore, our bones cooperate with muscular system to provide movement and protection to the most important parts of our bodies like the heart and the brain from damage.

1.1 Why learning the skeleton is important?

When you look at the six major functions of the human skeleton there's a very little ambiguity about why learning it and knowing major bones in the body is not only important but necessary for our ability to carry out the even most basic tasks like moving our fingers. Hence, the knowledge and understanding of our skeleton can help and maintain healthy bones and enables us to carry out daily activities and perform physical tasks (Why Is The Skeletal System So Important?, 2018).

The simple understanding of human skeleton is mandatory for medical professionals and is also very beneficial in emergency first aid scenarios where a person has broken bones because of an accident, to correctly assess the situation and provide them with the right kind of help and support. Another profession that relies heavily on understanding the skeletal system are personal trainers, having knowledge and understanding of the skeletal system helps them to identify dangerous or harmful movements and helps them to correct their client's exercise techniques and prevent injuries (The Skeletal System, 2018).

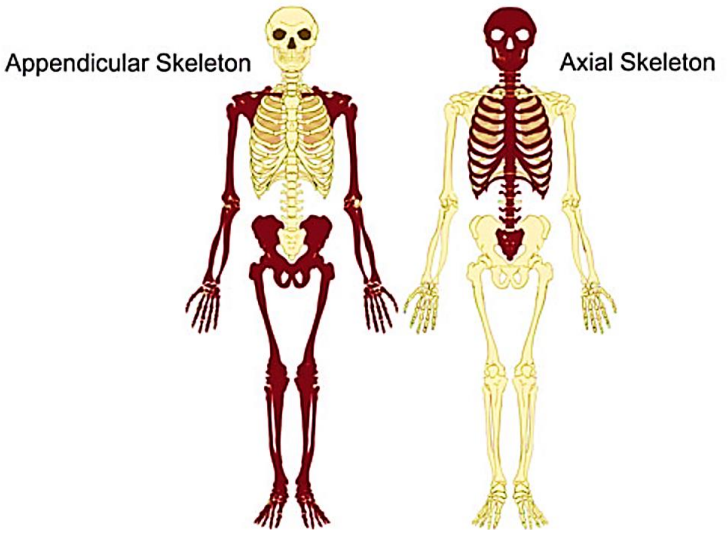
Other than emergency and safety reason knowing anatomical names do help a bit when it comes to working with other health professionals like doctors and physiotherapists. It helps them to quickly and clearly understand the area that they need to work on (Wright, 2018).

1.2 Serious Game: The Human Skeleton

This serious game will act as a platform that will provide the player the facility to learn about the major bones that make the human skeleton, to make the learning process fun an interactive 3D model of the skeleton has been created. The player can view the skeleton in 3D and click on different bones to learn their names and understand their functionality. To introduce an element of challenge there is a quiz that player can take to test its knowledge and understanding acquired after studying the 3D skeletal model.

2.0 Overview of the Human Skeleton

Although, we are used to looking at the skeleton as one composite unit, the model has been divided into two major groups, the **axial** and **appendicular**.



In Figure 1, the shaded region is part of the Axial skeleton and non-shaded region displays the parts of the Appendicular skeleton.

Figure 1

2.1 Axial skeleton

The axial skeleton is called the core of the human boy as its houses and protects the most vital organs in the human body. Its other function is to create and provide surface for the attachment of muscles. All together the axial skeleton contains 80 bones out of available 206. The axial skeleton entails the following three parts, they are:

1. Skull or the cranium
2. Vertebral Column or the Spine
3. Bony thorax or Ribcage

2.2 Appendicular Skeleton

The appendicular skeleton can be sub-divided into two parts, the first part is comprised of the bones of the upper limbs, whose function is to grasp and manipulate objects. The second part of the appendicular skeleton consists of the lower limbs that permit movement and locomotion, it also entails the shoulder girdle, that serves as a point of attachment for between the upper limbs and the body. Furthermore, it also includes the pelvic girdle that serves as a point of attachment between the lower limbs and the boy. Out of all the 206 bones in the body, the appendicular skeleton contains 126 of those. In general, the appendicular skeleton can be categorized into the following group of bones (The Skeletal System, 2018):

1. Bones of the shoulder
2. Bones of the arm and forearm
3. Bones in the hands
4. Pelvis bones
5. Bones in the legs
6. Bones in the feet

2.3 Learning Outcomes

As the primary purpose behind the development of this serious game is to increase the player's understanding of the major bones in the skeletal system. After completing all parts of the game, the player should be:

- Able to name the major bones that make up the skeleton
- Demonstrate the knowledge of their function
- Recognize their position in the Skeletal system
- Understand how different bones co-operate to provide structural support and movement

The player can test their level of knowledge and understanding anytime in the game by taking by taking the quiz.

2.4 Use of 3D models in games to teach human anatomy in the past

Use of 3d interactive models to deliver educational content I not a new concept and has been utilized by many researchers in the last decade. In this section I will outline the work of few researches from the past where such game model was used to deliver serious content within a game.

In a paper titled, "Constructionist Learning in Anatomy Education, Mihua, Ma, Kim Bale and Paul Rea (Ma, Bale and Rea, 2018) describe the use of 3D game technology in human anatomy education that were based on medical visualization and human anatomy teaching practices.

In another research titled, "A Web3D Serious Game for Human Anatomy Education", researchers leveraged the Web3d technologies. Web3d technology was used to develop a 3D web-based model to study the anatomy of lower limb of the human skeleton (Batista et al., 2018).

In both the studies the use of 3D models to teach different sections of human anatomy was largely successful, in this serious game we will use a 3D human skeleton to teach bone Anatomy of the 16 major bones in our body.

3.0 Game Design

3.1 Design Environment

After jotting down the game premise and its technical aspects, Unity was picked as the choice of game engine to be used for development purpose. As this was going to be the second time I picked for the development, I've had to start from the very basics of using unity but the amount of material online for learning unity is quite sufficient. Initially, the idea was to take the development to the unreal engine but finding material didn't come that easy. The unity website itself was very useful when it comes to learning and experimenting with unity features. The scripting and drag and drop features in Unity make it very flexible and saved a lot of time. I was initially a bit tentative about picking unity because all the scripting in Unity happens in C#, but I am glad to report that the level of similarity between C++ and C# made the transition feel easy and effortless.

3.2 The Game scene

The game has two main parts:

1. Classroom for learning
2. Quiz to test your knowledge

The classroom is exactly what is sounds like, a full 3D classroom has been put together complete with all the elements of a traditional classroom. The 3D Skeleton has been placed on the right hand-side of the class room with camera pointed at it. The player can examine the skeleton in full 3D and It also has a swivel function that enables the player to spin the skeleton along its axis, enabling him to view the skeleton from all sides. The skeleton model focuses of **16 major bones** that player can learn about, 3D model of the skeleton and spin function enables the player to get a better look at the location of each bones and their corresponding joints.

Game's Main menu

In the classroom, the player can also click on different bones that form a joint, when the player clicks on a bone, that bones are taken into focused view and it gets displayed on the board. In

the focus view, the selected bone will rotate along its center and information about that bone is displayed as text.

Figure 3

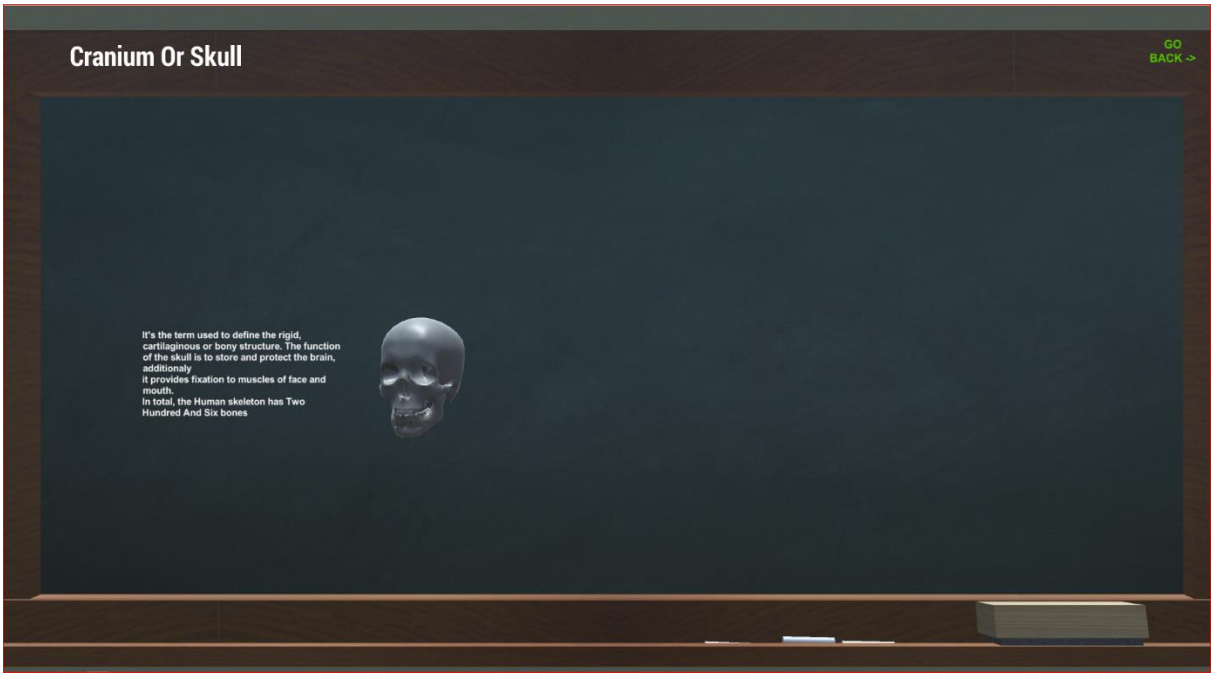


Figure 4

For Example, the scene n Figure 3 above is the general overview of the skeleton. If the user clicks on the skull of the skeleton the scene changes and the skull is transferred over to the focus view, where the player can learn and understand the skull and its functions.

To add the game element to this project and add a challenge, a 16-question quiz was developed that tests the players on their knowledge about the major bones. The quiz serves as a tool that challenges the player but also motivates them to better understand and test his/her knowledge about the bone. The player can take the quiz as many times they wish to and at the end of the quiz, the program will summarize the player's answers into correct and incorrect and will also display the number of questions that were answered correctly along with the number of incorrect answers.

3.3 Structure of the Game

When the player fires the game up, player is greeted with four different options that are as follows:

1. Instructions
2. Quiz Time
3. Classroom
4. Quit

When the player picks the instruction options, the player leaves the main menu and the instruction text appears. The text welcomes the player to the game and tells the player a little about the scope of the game and what he/she might learn.

If the player selects quiz time, the player will be taken to quiz screen where he/she will be presented with multiple choices questions about the bones in the body, their names, functions, number, and locations. The order in which the questions appear in the quiz is randomized to prevent users from cheating and learning the order of the correct answers.

The classroom option will take the player to the learning zone of the game, where players can interact with the 3D skeleton Model and learn interesting facts about the bone.

The Quit button is self-explanatory and pressing quit will exit the game world.

4.0 Assessment in the game

4.1 Assessment

The assessment in the game is through a quiz and is of formative nature. Once the player goes through all the question, the game will comment on the player's proficiency by displaying the number of questions answered correctly and will also display on the screen the number of answers that were answered incorrectly. The game, however, will not tell the player about what questions he/she got wrong, the player will just have to go back to the classroom and study the bones in the skeleton improve their understanding and try the quiz again.

The classroom is meant to teach the player but it's not going to spoon feed all the answers to the player. To be able to answer all the questions correctly will require the player to connect different parts of the skeleton together through astute observation and really form an understanding; some questions even encourage the player to consult external resources. For example, in the screenshot below in Figure 2, where one of the quiz questions asks the player that how many major joints are present in the skeleton. This information is not directly provided to the player in the classroom, but the player can extract this information by studying the model and counting the number of major joints, which is 13. In this manner getting all the answers right requires a deeper understanding and observation on the player's behalf.

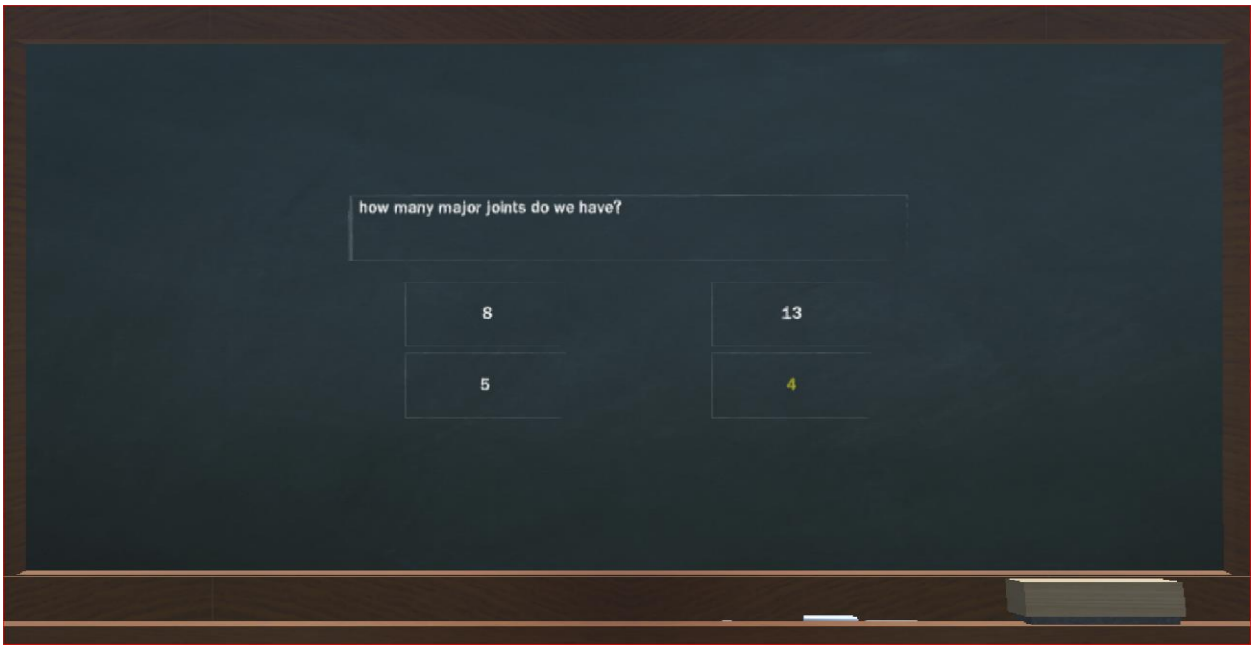


Figure 2

4.2 What is the goal of the player?

Just like every amazing game the player's ultimate goal is to complete the quiz and achieve a perfect score in the quiz because that is the only challenging aspect of this game. But, as mentioned in the earlier section the quiz itself is not very straightforward and the player is not going to get answers spoon-fed. The player may need to dig deeper and correctly understand the working of the bones in this skeletal model.

The quiz questions have been formed in a way that they require the player to do more just read through the description of different bones on the blackboard in focused view. Questions require the player to understand what bones work in different joints and player might need to visit the classroom multiple times to gain a thorough understanding. The player doesn’t have to go to the classroom to take the quiz, he/she can take the quiz whenever they want and as many times they wish to. After every run the order of the quiz questions is randomized.

5.0 Content Integration

Figuring out how a serious game will deliver learning to the player is one of the most important components of developing and designing a serious game. If implemented incorrectly the player may miss the whole point of the game and might not get the expected benefits of playing a serious game. If done a little too much the player can quickly feel overwhelmed by the amount of content and might get bored of the game very quickly. Therefore, it's important to balance and fine tune the game to deliver maximum learning and achieve expected results.

5.1 Bringing learning and gaming together

When planning to integrate serious content into a game, developers need to decide if the content needs to be integrated intrinsically or extrinsically. (Gobel and Weimeyer, 2018) define an intrinsic game as a game with very tight content integration in such a way that the gameplay is the characterizing goal itself. On the other hand, an extrinsic game is a game where learning is only loosely integrated and, in some games, it's not there at all.

In this serious game, content has been integrated statically and serious content is delivered in an intrinsic fashion. Every part of this serious game delivers learning, when the player goes to the classroom he/she learns about the human skeleton and the associated bones. When the player is taking the quiz he/she is being challenged to learn more about the content of the game to get all the answers correct. This serious game encourages the player to keep learning and keep testing his/her knowledge about the game content.

5.2 Balancing Engagement and Learning Objectives

In their research titled, "Integrating Serious Content into Serious Games", Ryan and Dennis (Ryan and Charky, 2018) found out that out of 12 participants who participated in their research, nearly every participant mentioned that they would love a balance between the educational part and the fun part of the game.

This serious game addresses the need for balance between the fun and learning content of the game by separating the learning part of the game from the challenging part of the game. The fun part of the game is in the classroom, the classroom is the spot in the game world where the player can freely explore and interact with the skeleton, learn about the bones in focused view. Being in the classroom makes the player feel at ease and it is the place where the visually appealing part of the game is located. It's fun, it's playful and delivers learning at the same time. But in a different part of the game, there's the quiz, quiz that challenges the player to test his/her knowledge about the game content. The quiz is available anytime, and it puts the player in control by allowing the player to take the quiz as many times the player wishes to, whenever the player wishes to.

5.3 Player first – The player is in control

Unlike some other games where the player is controlled by the game, meaning the player needs to be at a certain level or needs to be at a certain score threshold to unlock more content, adding to the player's frustration. This serious game does not do that! This serious game has been developed with the player first approach in mind, meaning the player chooses what to do and when to do. When the player fires the game up, it is up to the player to go to the classroom or take the quiz. There are no rules or conditions that the player needs to meet to unlock any hidden content in the game, everything is made available to the player right away. Although the

player needs to master the content to be able to ace the quiz, he/she doesn't need to qualify to be able to take the quiz.

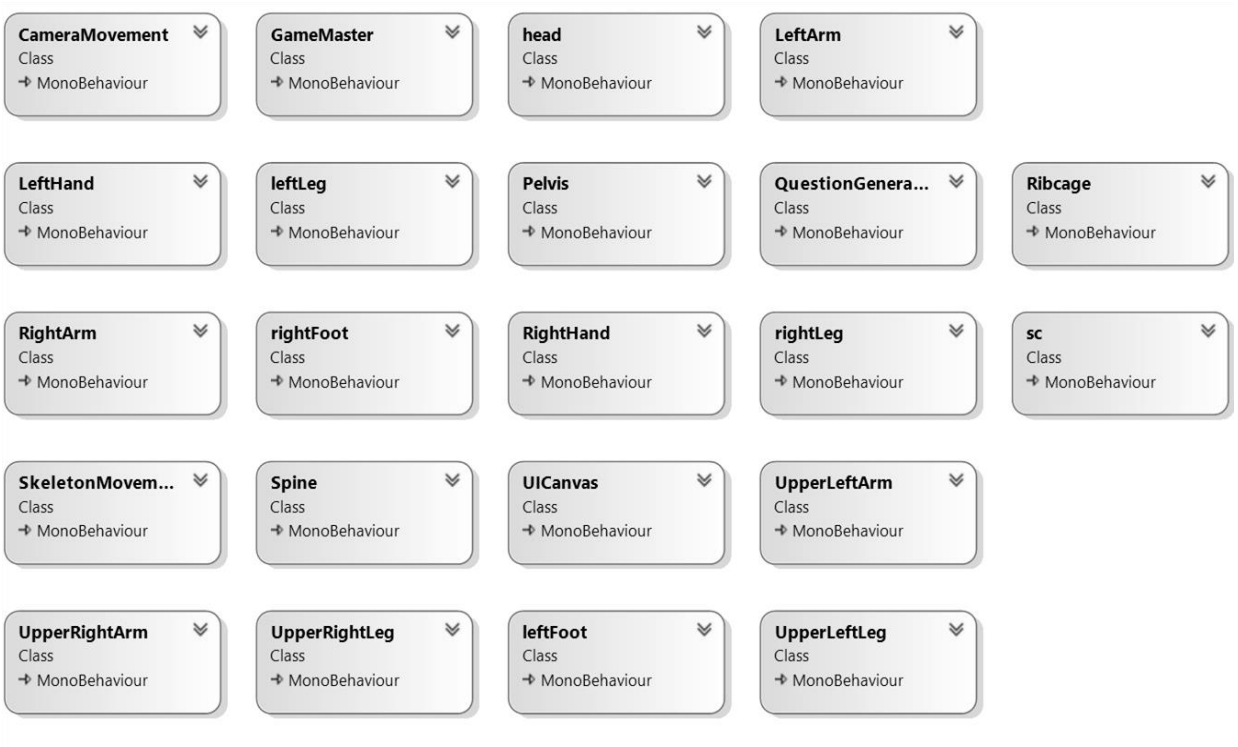
5.3 Repetition promotes learning

According to a theoretical biologist Robert F. Bruner (Bruner, 2018), almost every living organism learn by repetition. By repeating a certain action or going over the information, again and again, humans reactivate the neurons in the brain, which reinforces the connections that reduce over time when not used.

This serious game delivers learning through repetition. The game first expects the player to learn about the skeleton in the classroom by allowing the player to interact with the skeleton and go through all the embedded information provided in the focused view. If the player feels that he/she already has enough knowledge about the game content, he/she can take the quiz to test their learning level. If they did not score a perfect score in the quiz, the player realizes his/her level of understanding, the player can then head back to the classroom and go through the sections of the skeleton that demands a higher level of understanding.

6.0 Classes and Code design

Thanks to the Unity engine, the amount of coding and class management required for this project was minimal and manageable. The scripting feature of the unity was leveraged to enable class modifications in the game and the unity interface managed it all for me and allowed me to work on the game mechanics and the visual aspects of the game



Class diagram view generated using Visual Studio

The entire project has 22 classes in total that deal with different components of the game and correspond to different parts of the skeleton. I will briefly outline the important parent classes in the project.

The **GameMaster** class entails the different states in the game like the MainMenu, InstructionOptions, Update, ExitDefinitions etc. The **Cameramovement** class is responsible for perspective and transformation. The update function in this class updates the position of individual bones when they are viewed in the focus view in the game. The **QuestionGenerator** class is responsible for reading, re-ordering and randomizing questions that are loaded from questions.txt and checks for the correctness of the answers stored in correct_respose.txt file. The QuestionGenerator class also makes sure that the questions are in random order, every time the game is started. The other 16 classes contain the definitions for different bone types.

6.0 Evaluation

Evaluation is an important design aspect of any educational because the idea of using games for learning is not a brand new one and has now developed into an extensive field of research. Especially in the last decade, more and more serious games were developed and efforts to prove their effectiveness in the context of learning were high. When looking at the available literature review about the effectiveness of serious games, there is a lot of evidence where serious games have succeeded as a tool for learning but there are even more studies that question game-based learning. This reason alone makes the evaluation of serious games an important process because the overall goal of game evaluation is to prove its effectiveness to its intended purpose and application.

6.1 Proposed Evaluation Methodology

To assess the quality of this serious game and to determine if the game fulfills its intended purpose, a through randomized controlled trial(RCT) should be utilized to study the cause and effects relationship between the player and the game. Here is how the experiment will be set up. The experiment will be performed with two small groups of children above the age of 13, one group will be allowed to play the game to develop an understanding of the human Skelton. The other group will be provided learning material that embodies the learning content from the game, to learn through the traditional learning methods. Both groups will not be allowed to access the quiz section of the game and Both groups will be given a set amount of time to go through and understand the subject of the game. After the set amount of time, both groups will take the built-in multiple-choice quiz in the game. After result collection, If the group that studied through the serious game gets more correct answers than the group that learned through traditional methods; the game can be deemed successful. However, RCT is an ideal and preferred evaluation methodology for this serious game, it is quite complex to run as it requires human participants and constant supervision that is only possible if it is conducted by a team of researchers. Secondly, getting the ethics approval for such an experiment will require a lot of time, permission, and paperwork. Therefore, conducting the RCT was not feasible under the available time frame.

In absence of any kind of testing, I approached a friend who has worked as an English Language teacher for Chinese students, 24-year-old and is an avid XBOX gamer. I asked him if he knows all the names of the major bones in the body and his response was that he didn't know the names of most of them. I requested him to have a go at the game, tell me what he thinks and asked him to comment on the use of this game for educational purposes. According to him, he thinks that the classroom is visually very appealing, and the interactive nature of the skeleton makes it quite easy to use and manipulate. According to him, an application like that can be helpful in online teaching environments to foreign students, where they don't have a skeleton model to use as a reference. He commented that the quiz is a bit hard and it may take him a bit of time to get all the answers correct as he'll have to go through the entire skeleton to get all the answers right. He also suggested that use of sound would've made the game even better.

Putting it all together, the following conclusions can be drawn:

- The game UI is easy to navigate
- The quiz questions serve their purpose as intended as the classroom is not supposed to feed the information to the player and requires a deeper understanding on the player's behalf
- 3D implementation of the Skelton is appealing
- People of all ages can learn a thing or two from this serious game

7.0 Critical Self-Appraisal

Overall at the end of the project, I am satisfied with the way the game looks and the functionality that has been implemented in the game. I did not expect the project to get this big as I underestimated the amount of effort I had to put into this project.

The first issue that I encountered when I started planning the project was the lack of detail in planning on my side. My initial pitch was very different than the game I ended up creating, my lack of detailed planning led me to pitch an idea that I was not able to put together when I sat down to develop a plan for it. This led me to change my initial idea a few times, wasting a lot of precious time. When I was finally settled down on an idea and had finished gathering the resources, I was 4.5 weeks away from the submission date, but I'm satisfied with I've managed to accomplish in the amount of time I've had.

The second problem that ate a chunk of my time was re-learning Unity engine from scratch. The last time I used a game engine was in year 2, which was nearly two years ago. This was quite a bit of gap and whatever I knew about the engine was lost and I needed to learn it from scratch. I am thankful for the learning material that is available on Unity website, it made learning the basic concepts quick and after spending a couple of days on the fundamentals, I was on my way to work on my game within a few days period.

The third issue that comes to my mind is the size of this project, I did not expect the project to get this big and It was quite a lot for me to work within the given amount of time. Again, I'll blame that on my lack of clear planning.

If given a chance to work again on this project, the first thing that I would change would be the planning approach that I took in the initial planning part of the project. I would take my time to write down, clear and precise plan to break down all the technical aspects of the game before the commencement of the development phase, instead of laying them out at the same time as the time of development. I believe that all the issues I've had stemmed from my lack of having a clear technical plan for the game from the very start.

7.1 Future Work

For further work in the future, I would like to integrate and add vital organs into the skeleton to make the game more complex. I would also like to implement sound in the game, I feel that adding sound effects to the game will make it more engaging.

Another feature that might take a lot of time to implement but will be worth doing is adding narration in the game. For example, when the player clicks on a bone in the skeleton its goes into focus view and then the player can read the description of the bone. Now, If I can add a voice over feature in the game that will read the description out for the player, it'll be amazing.

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