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Three-Dimensional E-Learning Application for Anatomy and Physiology of Brain

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Abstract: Neurology is one of the most challenging areas to master among the medical students owing to the complexity of the structures and their spatial arrangement. Teaching dissection and prosecutions during the anatomy lab sessions are not necessarily effective due to large class strength. To complement teaching and learning on this subject matter, a web-based, 3D interactive e-learning application called the Brainy is proposed to help medical students and lecturers to learn and teach neurology in an efficient way. Brainy merges virtual technology with learning by breaking down the brain information into three different parts, namely the lobes of brain, parts of brain, and structures of brain. Every time a student chooses to study a part of brain, the 3D model of selected part will be complemented with brief description of anatomy, physiology and applied aspects. Thus, the student will no longer need to switch different books while studying. Brainy is thus a versatile application for students to study brain in a fun and engaging way.

Keywords: 3D, Interactive, E-Learning.

1. Introduction

Each and every one of us have a tiny three-pound organ placed protected inside the skull working non-stop to process all the information from the outside world while controlling all bodily functions. Human brain governs the intelligence, creativity, emotion, and memory. Being a vital and most complex organ in human body, it becomes the most challenging topic to study among all the medical students. The medical study of brain requires coverage from various aspects; both anatomy and physiology based on the lobes of the brain, the parts of the brain, sides of the brain, areas of the brain and the structures of the brain. Nonetheless, it is an intimidating task to master the anatomy and the physiology of brain structures. Theory can only help the students to estimate the placement and functions of different parts of a brain [1].

For medical students, the lab anatomy and physiology sessions form an important part of the curriculum, as well as their future clinical practices. These sessions use cadavers, models and plastic specimens to provide resourceful learning base for the students to learn anatomy for the first time. Practical sessions also encourage rich learning by allowing the students to observe, and interact with the specimen, provide haptic feedback to understand the texture and correlation between various structures in three dimensions [2].

However, in reality, each batch has more than hundred students per session, which makes it possible only for a few students to experience hands-on session and utilize the available resources owing to the time limitations. There are instructional videos available online but they are one-sided conversations, which makes it less effective methods of learning. The anatomy lecturers are also facing problems in terms of availability of resources like cadavers or organs. Over time, it becomes more difficult for the lecturers to ensure students of varied cognitive abilities to pick up the knowledge they aim to impart.

While the lecturers teach the students at the colleges/universities, learning the subject is entirely in the hands of the students. Often, the time allotted for practical sessions is not enough for students or they find it challenging to refer several different books and gain conceptual knowledge which forces them into rote learning. Therefore, it is the need of an hour to use the technology and help the students to learn and reinforce the knowledge they have gained at their universities in a better way.

The University of British Colombia has come up with 3D brain structures to help their students study the brain, but with a minimal level of interactivity for the users. The website consists of 3D videos of only some of the structures, thus the students may have to look for another reference to study the other structures [3]. While the structures are labeled according to their names, there

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is hardly any other information being presented, visually or complementing the video. Thus, it is insufficient to provide the students with an immersive environment, and is unable to cover all the aspects of the brain. Fig. 1 shows the interface of the website. This website consists of 3D videos of the Central Nervous System (CNS), Visual system, Subcortical fibres, Spinal tracts, Basal Ganglia and the Limbic system. The 3D demonstrations of the systems are divided based on the system in a menu.

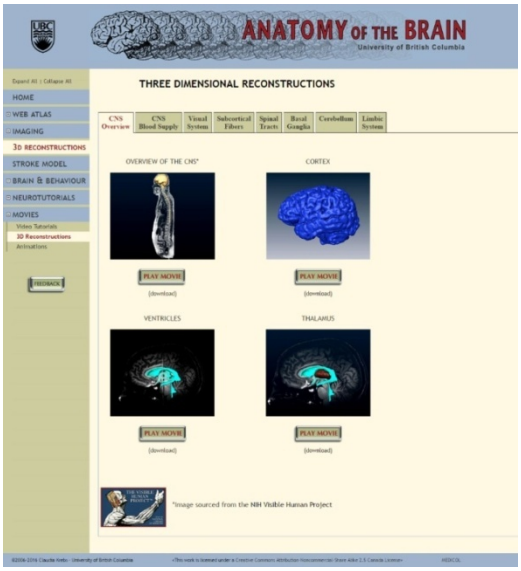

Fig. 1 Central Nervous System by the University of British Columbia.

Few students intellectually fail to master the curriculum as the amount of information to be mastered is massive, while the difficulty material is fairly average [4]. Thus, the only key to be academically sound is to have disciplined and smart study habits which will help the students to digest this large body of information in the limited period of time. In 2011, it was reported that there was a steady rise in the first-year students failing in the anatomy exams at Madras Medical College (MMC), a leading medical college in Chennai (India). The main reason for students failing in exams is probably the inability of the students to adapt themselves to shift from rote-based learning to concept-based learning [5].

Therefore, there is a pressing need to integrate the technology with the learning methods to help the medical students learn their subject conceptually and excel both in theoretical as well as the practical in anatomy and physiology courses. As these subjects form the base of the students' medical career, it is extremely important that these subjects are understood well enough, and not just for the sake of writing exams. In addressing these issues, this research proposes for a new e-learning application called the Brainy that blends the medical science education with technology to offer a three-dimensional interactive web-based application featuring the human brain. The user can rotate the entire brain in any direction they wish to, zoom into the different parts of brain, and have different views of the interior structures through dissecting them.

In addition, Brainy is more than just a 3D model of the brain. Brainy covers all these aspects of the neurology by allowing the users to precisely focus on each attribute. Brainy is designed to help the students in learning anatomy and physiology of the brain side by side, as opposed to studying both the subjects separately. Thus, studying the location of a structure along with its function in parallel will help the students to relate much better, and save their time spent in looking through different books[2].

Brainy is developed to make learning a fun process, and boost the morale of the students who struggle to learn through just books or are slow learners who find it difficult to pick all the things taught in the classes or in practical sessions. The students can use Brainy to quickly go through the structures of the brain before a neuro-anatomy class, after the lecture to revise what was taught in the class or before the exam to just have a comprehensive brush up right before the exam [3].

It is also designed to allow medical students to virtually perform the practical sessions as many times as they wish to, wherever they are by using their computers. The 3D structure will help to reinforce the knowledge[1] they gained through books, practical and theoretical sessions at their universities in a realistic and precise way. This application will therefore help the medical students to note the important parts of the brain, their structure through their dissected views and provide apt anatomical and physiological importance of an organ all in one space.

The remainder of this paper proceeds as follows. Section 2 presents the proposed Brainy e-learning application, Section 3 presents the evaluation results of the proposed application, and finally Section 4 concludes with some indication for future work.

2. Proposed Brainy Application

Neurology is a hand down, the most difficult area to master for medical students. This paper proposes for a web-based, three-dimensional interactive e-learning application designed for medical students in effort to conceptualize and gain a better understanding of spatial arrangement of structures in the brain. Brainy is designed to merge the virtual technology with learning, to help students as well as lecturers to study and teach neurology in a better, efficient way. Brainy is developed based on the ASSURE methodology: Analyze learners characteristics (A); State objectives (S); Select, modify and design materials (S); Utilize materials (U); Requirelearner response (R) and Evaluation (E). Fig. 2 shows the user interface.

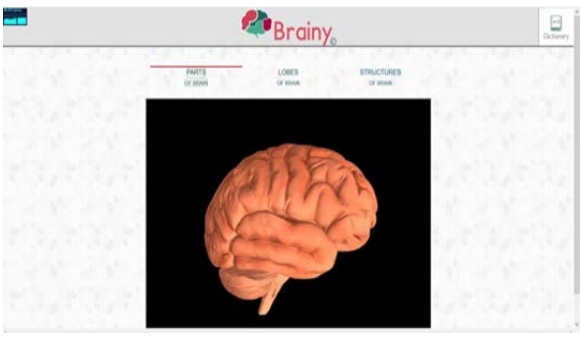

Fig. 2 User interface for Brainy.

The uniqueness of this Brainy system is that it helps revolutionizing e-learning with 3D interactive application built for medical students. This is the first application to provide 3D learning for higher education. The next Fig. 3 shows more user interface of the limbic system of the brain.

Fig. 3 User interface for limbic system of the brain.

Based on Fig. 3, it is shown that there are simplified learning which has three modes of classification, with anatomy, physiology and applied aspects all side by side. This interface includes information both from the anatomy and physiology. Each part of the brains can be broken down to smaller components which helps better understanding about the spatial arrangement of the structures within the brain.

Brainy is among the very few online platforms which provides 3D learning for medical students. This application provides an excellent alternative to traditional teaching techniques such as prossection, where only approximately 20 students get to see the anatomist doing the dissection. Their main difficulty is to get hands-on experience, or even see it in some cases. Comparing to books or theory classes only provide 2D diagrams if structures, making it difficult for the students to understand the arrangement of structures in the third dimension.

Brainy aims to give students a hands-on, interactive learning experience as compared to other monotonous study routines. It is an enhancement of available technologies providing 3D interactive experiences. Many available technologies like virtual dissection table require the students or universities to have specialized hardware equipment. Brainy, on the other hand, only requires the user to just have a laptop and access to the Internet.

The core component of Brainy is an interactive 3D model of brain, which can be rotated in 360 degrees. This is made possible by individually modeling every single structure in the brain, and each structure is rendered with JavaScript API, WebGL known as web graphic library. The 3D space allows the user to interact with the model by providing unrestricted rotational capability. The user is supported with colored feedback on the selected region of the brain model along with the labeling. The interface of the system is designed to be clean, and minimalistic, with a 3-options based menu, which allows the user to choose which classification of brain they want to focus on.

Brainy targets three major groups of users, which are medical universities/colleges, medical learning centers and medical students in Malaysia. Making it accessible for students and teachers can enhance learning at multiple levels and promote higher practical knowledge of the subject. The system includes an interactive, 3D brain which can be rotated in any direction, various realistic dissected views of selected parts of the brain. The ability to selectively view individual systems within the brain and a brief information about the anatomy and physiology of parts of the brain in form of text.

This application also covers the applied aspect of the selected structure along with the anatomical information of the brain. A navigational menu, featuring brain based on different categories of division and with a built-in medical dictionary. Brainy is developed using Maya for 3D Modeling and texturing, and it utilizes three.js javascripts for adding interactivity to the 3D model. Thus, the major production costs will include licensing the 3D software, development and application deployment only.

3. Evaluation

Brainy was evaluated using questionnaire methodology with a motive to understand the psychology and the needs of the medical students versus the resources available to them. The questionnaire helped the developer to justify that brain is indeed one of the toughest body parts to study. It can be argued that the teaching pedagogy that were effective many years before are no longer the same, and a changing trend from books to technologically forward applications or techniques is rising. Most of the students have accessibility to the Internet, as well as smartphones or applications which can make it easy for Brainy to reach the target audience.

The evaluation with user interface was carried out with a number of students on the difficult parts of learning anatomy of human body. The first question that was asked was which body structure is most difficult to study. They were given three options, which are Upper Limb and Thoracic Cavity, Lower Limb and Abdominal cavity and finally Head, Neck and Brain. The students unanimously chose the third option; Head, Neck and the Brain. The main reason for students choosing this option was the complexity of structures in these areas. Brain consists of number of structures both tiny and large, along with numerous nerves, and blood vessels. There are more than a hundred pressure points while studying brain, where understanding the spatial orientation is crucially important.

The second question asked was on what mode of learning that the students preferred. Fig. 4 shows the breakdown of four options to answer; books (8%), study materials provided by the university (21%), online video tutorials (29%) and self-made notes (42%). There were mixed reviews when asked about the preferred mode of self-studying. However, the top two options chosen were self-made notes and online video tutorials. This shows that increasing number of students prefer their own notes over the notes provided by the university as they may not be complete and lack of details. The online video tutorials also provide flexibility to the students.

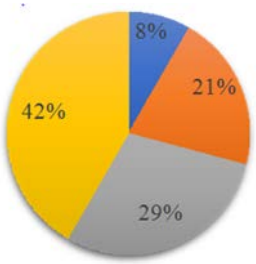

Fig. 4 Preference of using the learning resources.

The third question was about the students' satisfactory level on their current mode of learning, which is traditional class-based. As shown in Fig. 5, 73% of the students are not satisfied due to lack of interaction between the students and the learning materials. In some cases, while the modes of learning may provide maximum information, the way that information is provided may not be conducive enough to boost the learning process.

The main issue is that students face difficulties to conceptualize the content. Some students complain about inability to have a spatial clarity in terms of the arrangement of blood vessels, nerves and their path. While the other students find it difficult to study purely one subject at a time, resulting in inability to correlate to the anatomy of a structure with the physiology and clinical applications. When the users were asked to suggest which learning modes were suitable for them, most of them explained how a practical approach either through a webapplication or through realistic synthetic human bodies may helped them a great deal. Greater number of students chose to explore the e-learning technologies, owing to the accessibility and nature of interaction.

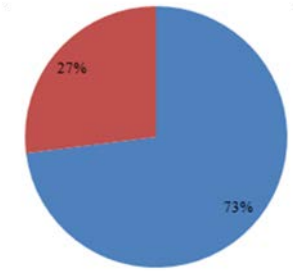

Fig. 5 Satisfactory level with current mode of learning.

The fourth question was on understanding 2D structure materials. While some students said they had a fair understanding about the subject using the existing medium such as books, a larger group confessed not being able to relate to the 2D structures. Having a 3D interactive application may help students to have better understanding about the subject. The results are shown in Fig. 6.

The final question was about the ability to understand the teaching materials with the use of Brainy application. All of students suggested that adding interactive elements may make the subject interesting for them. Visual feedback also helped the students register a better image in their head, thus helping them to improve their conceptual and practical knowledge about the brain structures. The 3D rotatable structures helped them the most in improving understanding of the subject. As more medical students are visual learners, In Fig 6 shows 73% are happy using the Brainy application.

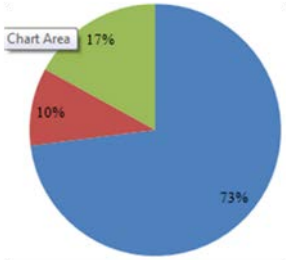

Fig. 6 Preference of using the Brainy application.

4. Conclusion

Brainy is developed to aid medical students learn anatomy and physiology of the human brain in a concise, interactive manner2. The navigational menu of Brainy allows user to study brain based on various classifications, namely parts of brain, lobes of brain and structures of brain. These divided sections will decrease the steep learning curve required otherwise for studying neurology. A built-in dictionary is handy for students to have a quick look-up for medical terminologies while studying the brain. As such lecturers could use Brainy as a tool to be used in class instead of slides or books.Teaching in the classroom will be more interactive between lecturers and medical students.

The 3D brain model can be rotated 360 degrees, thus giving user the control of what they see and learn. Each part of the brain can be viewed individually, while goingthrough the description divided in three panels: namely, anatomy, physiology and applied aspects. While the students can read through the text, they have an option to listen to the text while they interact with the 3D model, thereby giving them flexibility to learn. In future, Brainy can be enhanced to have nerves and blood vessels integrated to the 3D model, thereby allowing the students to have a complete knowledge of the human brain. The data obtained from system validation thus proves that Brainy is effective in promoting learning strategies to its users. All the test cases in the unit testing resulted positive, meaning the expected output matched with the actual output. Thus, Brainy is free from errors or bugs. As a part of user acceptance testing, Brainy is demonstrated to potential users. The users are suggested to try the application and give their reviews by rating the application in various aspects to evaluate the usability of the application.

In the future, the Brainy application can be fully customized to suit the requirements of the universities/learning centers by adding the text-content per their requirements, or modifying the 3D model accordingly. Adding a social interaction feature, which can allow the students to post their doubts can be helpful. These questions will be answered by selected panel of doctors or medical professors. Animations can be added to demonstrate physiological functionality of different parts while the user interacts with the model. While the current model focuses solely on brain, such applications for the entire body, can be developed.

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