

Interactive Digital Media on Mobile Platform for Teaching and Learning Neuroscience in a Medical College

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Abstract

Neuroscience has traditionally been a difficult subject to teach and learn. In an effort to ease the cognitive burden to the student when learning about the human brain, an interactive digital project was envisaged, based on the Visible Human Project of US National Library of Medicine.

It consisted of two digital sagittal images of the human head, hyperlinked to a series of sequential transverse-sliced images of the same brain at 10-20 mm intervals from the top of skull to its base, all loaded on a mobile PC-based offline platform. Copious labels, descriptive texts, explanatory notes, cross-links and on-the-fly quizzes supplemented the learning experience, besides rendering it an enjoyable interactive exercise.

Preliminary qualitative evaluations from medical students were encouraging. Non-dependency on Internet connectivity, sophisticated gadgetry or software enhanced its portability, versatility and usefulness. Comparison with eight similar digital learning media from other sources on the basis of 7 parameters confirmed the present digital project to be better than all of them, with a score of 6 on a 7-point scale.

Across the board viewers were also awed by the single-click, seamless interactivity and interconnectivity of the digital media-based project, making it an experience worth remembering by all observers.

While students can continue to learn from the project already created, definitive usability testing of the program with standardized instrument will cement its effectiveness. Furthermore, this work can be expanded to other fields of research and education which will benefit Health science students, Clinicians, Educators and Researchers in Anatomy, Radiology and Surgery.

Keywords: *Interactivity, Digital media, College education, Neuroscience, Mobile platform, Standalone*

1. Introduction

The Visible Human Project (VHP) of U.S. National Library of Medicine (NLM) has generated high resolution radiological and anatomical digital image dataset of a male and female human cadaver^[1]. The cadavers were frozen, embedded in gelatin, horizontally-sliced at 1 mm (male body) and 0.33 mm (female body) intervals and digitized by the University of Colorado under NLM contract. The reconstructed data could be rotated, dissected, viewed separately in any plane and reassembled^[2, 3]. Many organizations have licensed the dataset from NLM and created digital images of their own for educational purposes^[4-11].

2. Background

Explaining the structures within the human brain, with its three-dimensional voxel, is a challenge to teachers and a near-insurmountable learning curve for students. It is compounded by the inherently complex configurations of structures within the brain itself.

3. Objective and design principle

In an effort to render the learning-process user-friendly and less cognitively challenging, an interactive digital brain project was envisaged, based on the Visible Human Project dataset^[1]. The design of the project was based on the human computer interface design principle embodied in Fitts' Law, which states that the time to move to a target is a function of the ratio of distance of the target and its width^[12].

4. Material and methods

Horizontal lines at 10-mm intervals were drawn to scale on an MSTM Word document in Web layout view and this page was scanned as a JPEG image without resizing (Figure 1). A sagittal image model of the human head, with the brain in situ, was selected from the Visible Human Database of the NLM, scaled to the same size as the previous image, and saved as a separate JPEG image (Figure 2)^[3]. This image of the brain was superimposed on the previous JPEG image in Microsoft[©] Paint under the same magnification and saved as a new JPEG image. This composite image contained both, 10-mm spaced horizontal lines and the sagittal image of the brain superimposed on them. The horizontal line corresponding to the scalp surface was counted as zero. All subsequent lines below were numbered according to their distance from the scalp surface in millimeters (mm). This composite 'parent' image was embedded in another Word document in same layout view and magnification as the first image. Two such files were created, designated 'A' and 'B'. 'A' showed transverse slices of the brain from 0 to 300 mm from scalp surface. The 'B' file showed similar slices from 300 to 500 mm from scalp surface (Figures 3 and 4).

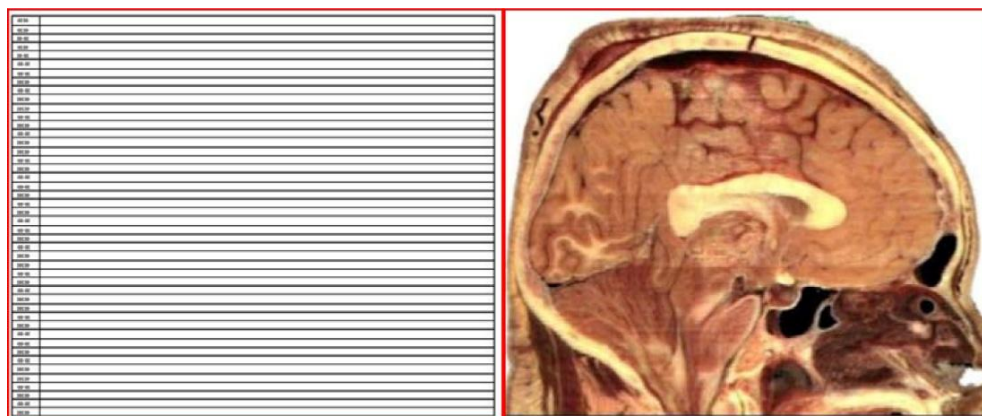


Figure 1 (Left): Horizontal lines at 10-mm intervals were drawn to scale on an MSTM Word document in Web layout view and this page was scanned as a JPEG image without resizing. **Figure 2 (Right):** A sagittal image model of the human head, with the brain in situ, was selected from the Visible Human Database of the NLM and saved as a JPEG image with the same magnification as the Figure 1 (Image courtesy: NLM).

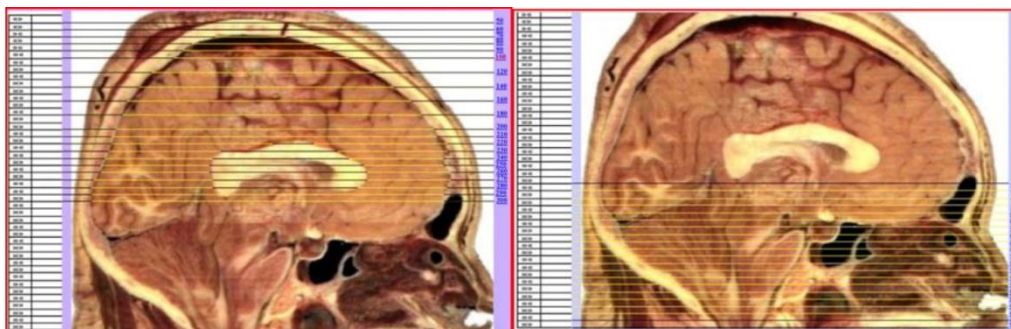


Figure 3 (left) and 4 (right): Both figures show the digital sagittal slice 'parent' images of the head, arbitrarily labeled 'A' (Figure 3) and 'B' (Figure 4). Horizontal lines were seen across it, labeled at 10-20 mm intervals. Figures 3 and 4 are the same image, but used separately for the upper and lower halves of head, respectively. File 'A' (Figure 3) shows transverse slices of the brain from 0 to 300 mm from scalp surface. File 'B' (Figure 4) shows similar slices from 300 to 500 mm from scalp surface
(Image courtesy: NLM)

Next, multiple sequential transverse-sliced (axial) images of the brain, at 10 to 20-mm intervals from scalp surface, were obtained from the National Library of Medicine Database (Figure 5) ^[13]. These transverse-sliced 'child' images were inserted sequentially in the previous files 'A' and 'B' containing the 10-mm graduated sagittal image. Sequential transverse images of head from scalp surface to 300 mm below were embedded in file 'A'. Sequential transverse images of head from 300 mm to 500 mm from scalp surface were embedded in file 'B'. Each transverse image was bookmarked. Numbered horizontal lines in the sagittal 'parent' image at 10 or 20-mm intervals were hyperlinked to correspondingly numbered transverse-sliced 'child' images of the brain. The structures visible in each transverse image were extensively labeled. Numerous cross-links, descriptive texts, quizzes and explanatory tooltips were also added to each transverse 'child' image (Figures 6 to 9). Each file 'A' and 'B' was rendered into single-file .HTM format.

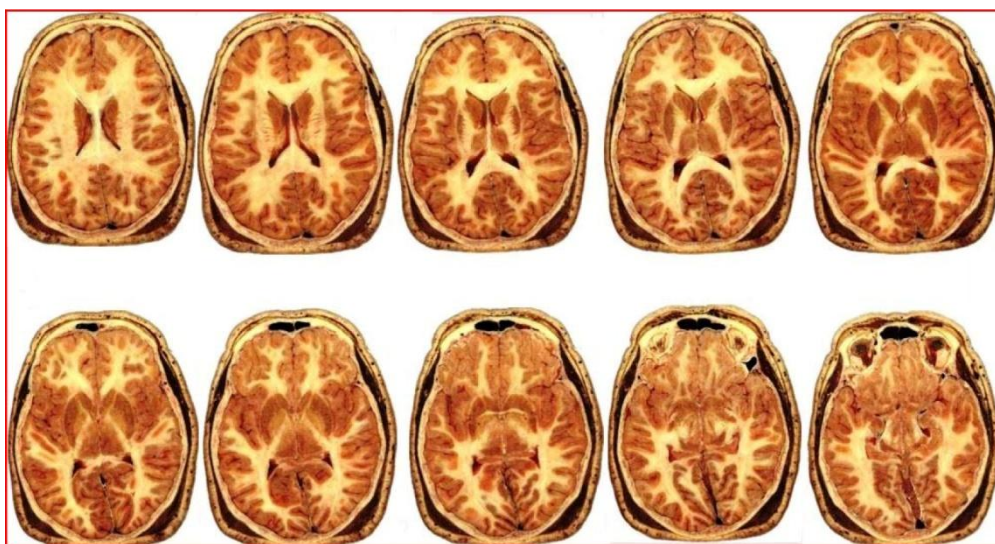


Figure 5: Multiple sequential transverse-sliced (axial) images of the brain, at 10 to 20-mm intervals from scalp surface, were obtained from the National Library of Medicine Database (Image courtesy: NLM).

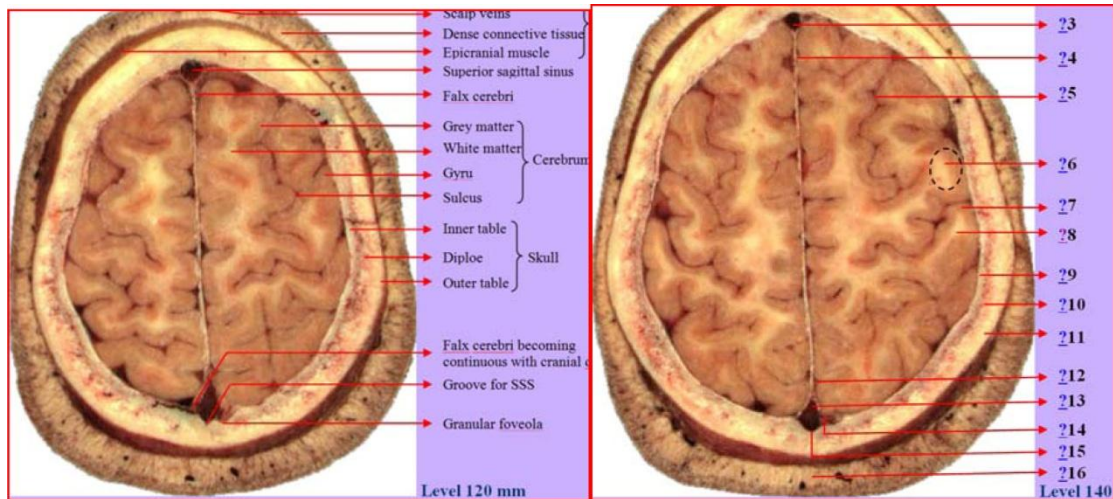


Figure 6 (left) and 7 (right): These figures represent two sample transverse ‘child’ images of the head at 120 mm and 140 mm from scalp surface. Figure 6 shows labeled structures. Figure 7 shows interactive learning quizzes, in the form of hyperlinked question marks, embedded within the project. These digital transverse ‘child’ images were hyperlinked to their corresponding numbered horizontal line in the sagittal ‘parent’ image of the brain (Figures 3 and 4). The question marks in Figure 7 are hyperlinks, with explanatory cursor tips (Image courtesy: NLM).

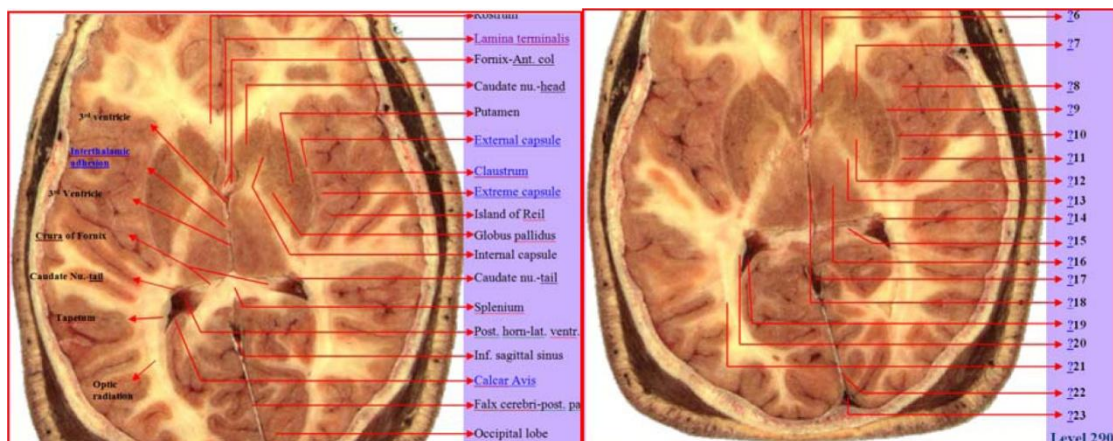


Figure 8 (left) and 9 (right): These figures represent two sample transverse ‘child’ images of the head at 280 mm and 290 mm from scalp surface. Figure 8 shows labeled structures. The degree of complexity in this deeper sliced image of the brain is obvious. Figure 9 shows interactive learning quizzes, in the form of hyperlinked question marks, embedded within the project. These digital transverse ‘child’ images were hyperlinked to their corresponding numbered horizontal line in the sagittal ‘parent’ image of the brain (Figure 3 and 4). The question marks in Figure 9 are hyperlinks, with explanatory cursor tips (Image courtesy: NLM).

4.1 Method of use and interactivity

Clicking on any number on the horizontal line (corresponding to its distance from scalp surface in mm) in the sagittal ‘parent’ image in either file ‘A’ or ‘B’ will bring one to the transverse ‘child’ image of the brain at exactly that distance from scalp surface. Clicking on the ‘Top’ link on any transverse image will bring the user back to the same ‘parent’ sagittal image. Clicking on a blue label in the transverse ‘child’ image will bring the user to the explanatory text. Hovering the cursor over a question mark on a transverse ‘child’ image will give the answer on a cursor tip. Clicking on it will take the user to the answer and explanatory text. Clicking on the ‘Back’ link will bring the user back to the original transverse ‘child’ image. There was complete, seamless, fluid interactivity (Figure 10).

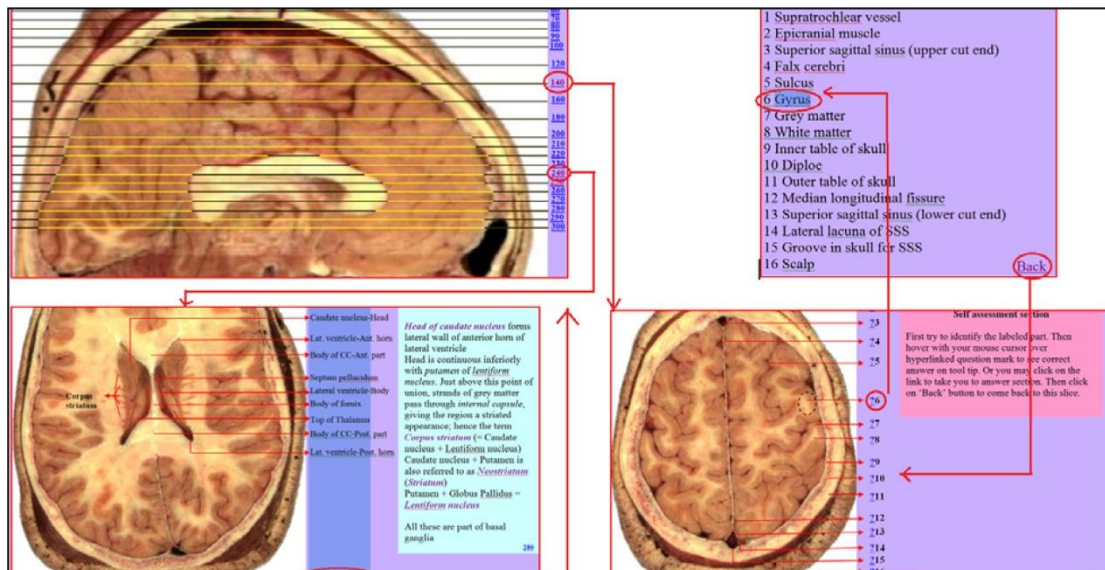


Figure 10: Composite figure showing interactive hyperlinks and interconnectivity between various digital media. Clicking on hyperlinked number 140 or 240 (for instance) in the sagittal 'parent' image will bring one to the respective transverse 'child' image at exactly that distance from scalp surface. Clicking on the hyperlinked 'Top' button on the 'child' image will take the user back to the original sagittal 'parent' image. Clicking on hyperlinked question mark symbol next to number 6 in Self-assessment 'child' image will take one to the correct answer. Clicking on the hyperlinked 'Back' button in the Answer Section will bring the user back to source 'child' image. This is only a small demonstration. There are many more levels of interactivity in the project that can be best experienced during actual usage (Image courtesy: NLM).

5. Result

The two standalone files, operating on offline navigational browser without Internet connection, were 17.5 and 26.2 MB respectively. The .HTM files were 3.2 to 3.6 percent of the size of original files. They were easily ported on a PC or mobile device. The information imparted therein was succinctly informative. Preliminary formative qualitative evaluation feedback from medical students revealed that they found the digital media "wonderful", "easy to use", and "very helpful" for learning Neuroscience. A semi-quantitative comparison was also performed with eight other digital media from other sources.

Seven-point comparison with eight other digital learning media

The current digital project was compared with eight other digital learning media from eight other sources, on the basis of seven parameters^[4-11]. The seven parameters were Brain views (Sagittal and Axial), Interactivity, Labeling, Animation, Java / other technology requirement, Internet requirement and Accessibility (Free vs. Paid). Each parameter was arbitrarily allotted a score of 1; presence of first four and seventh parameter scored 1 each, and their absence scored 0. For the fifth and sixth parameter the scoring was reversed because their presence was considered as a potential hindrance to learning. On the basis of this scoring system, the current digital medium scored 6 on a 7-point scale, the lost point being due to absence of animation (Table 1).

Table 1: This table gives the score of each digital medium on a 7-point scale, based on 7 parameters. The current project scored 6 out of 7; the lost point was due to absence of animation.

S. No	Source	Score (%)
	Current work	6 / 7 (86%)
1	Ecole Poly-technique ^[4]	2 / 7 (29%)
2	Johannes Gutenberg ^[5]	3 / 7 (43%)
3	NTIS ^[6]	2 / 7 (29%)
4	TolTech ^[7]	2 / 7 (29%)
5	University of Maryland ^[8]	1 / 7 (14%)
6	University of Michigan ^[9]	2 / 7 (29%)
7	Washington University ^[10]	4 / 7 (57%)
8	VirtusMED ^[11]	3 / 7 (43%)

The current digital learning media gave sagittal and multiple transverse (axial) views of the brain, which were extensively labeled. Five comparative resources gave similar views of the brain^[4, 7, 9-11], but only one site gave extensive labels^[5]. Five sites allowed interactivity but not as extensively as the current project did^[7-11]. The current project was freely available offline to students, while only one of the other resources was freely available^[10]. The current project did not require Internet, Java or any special software for viewing. All other comparative resources, except one^[6], required Internet connectivity, and all except two required Java or other special software for viewing^[5,6]. Three comparative resources had Java-based animation^[4, 10, 11] while the current project had none. Table 2 gives a critical comparison of the current learning media with eight other similar resources on the basis of seven parameters.

Table 2: This table gives a comparative analysis of the current project and 8 other similar digital learning resources on the basis of 7 parameters. Axial refers to transverse-sliced views of the brain.

Serial #	Source of project	Brain views	Interactivity	Labeling	Animation	Java / Other technology	Internet connectivity	Free Accessibility
	Current work	Sagittal axial	Yes	Yes	Nil	Not needed	Not needed	Free
1	Ecole Poly-technique ^[4]	All views	Nil	Nil	Yes	Required	Required	Login required
2	Johannes Gutenberg ^[5]	Axial views	Nil	Yes	Nil	Not required	Required	Paid license
3	NTIS ^[6]	Axial	Nil	Nil	Nil	Not required	On DVD	Paid license
4	TolTech ^[7]	All view	Yes	Nil	Nil	Required	Required	Paid license
5	University of Maryland ^[8]	Axial views	Yes	Nil	Nil	Sun workstation	Required	Licensed
6	University of Michigan ^[9]	All views	Yes	Nil	Nil	Required	Required	Licensed
7	Washington University ^[10]	All views	Yes	Nil	Yes	Required	Required	Free
8	VirtusMED ^[11]	All views	Yes	Nil	Yes	Sophisticated devices need	Required	Licensed

6. Discussion

6.1 Content and context

The current digital learning media of human brain enable one to teach effortlessly, while easing the cognitive burden of the student, which is inherent in learning about the brain. It is a standalone program on offline navigational browser. It delivers the Neuroscience content in an educationally relevant manner. Bookmarks and hyperlinks within the program enable the learner to switch between sagittal and transverse (axial) image views at will. This enables easy learning of the brain structures at various depths from the scalp surface, which makes it clinically relevant, because axial images of the brain are the most frequently viewed images by clinicians and radiologists. Vivid imagery, precise labeling, interactive comprehension questions and explanatory text and cursor tips enhance students' learning. Interactivity of the program keeps their enthusiasm alive, besides allowing self-paced learning.

6.2 Learning advantages

These composite digital learning media help to ease cognitive overhead involved in learning about the human brain, enhance interest in the subject of Neuroscience, increase retention of the subject, and can provide individualized learning to cognitively-challenged learners.

6.3 Audience activities and interactivity

After witnessing a demonstration of the program first-hand, the audience will:

Get to use the program for themselves

Know about its ease of use, usability and usefulness

Experience the interactivity of the program

Get a feel of its versatility

Learn how to present a difficult subject to the learner

Vicariously feel the enthusiasm of the learner

Get to explore its applications in their own field of interest or specialization

Know about initiatives of National Library of Medicine, National Institute of Health

6.4 Future relevance

A summative quantitative usability testing needs to be done on the program, employing an instrument like the Computer System Usability Questionnaire ^[14]. This program can be usefully adopted by Health science students, clinicians, educators and researchers in Human anatomy, Radiology, Neurosurgery and Neurology departments. Innovators in virtual surgery research, computerized tomogram (CT) and magnetic resonance imaging (MRI) scanning can expand on this digital learning media. The current digital learning media can be rendered in 3-D with proprietary tools by anatomical image developers, for use in human-computer interaction (HCI) simulation labs.

7. Summary

The key features of the current digital learning project are; (a) Enabling effortless learning of difficult medical subject like Neuroscience; (b) Based on Cognitive domain of Bloom's taxonomy^[15]; (c) Tailored to students' cognitive capacity; (d) Provision of learning feedback; (e) Complete interactivity; and (f) Availability on a standalone offline navigational browser.

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