Sculpting the Brainstem: Understanding Brainstem Anatomy Using Modelling Clay

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***Abstract*— Preclinical science students lack the understanding of complex structures such as the central nervous system as they lack firm understanding of its basic anatomical structure. As brainstem anatomy is essential to the function of the central nervous system, a weak grasp of its basic structure stands as a barrier when students delve into more complex matters such as neurophysiology and neuropathology. The aim of this teaching and learning method is to ease and improve students understanding of the brainstem, its relations with surrounding structures as well as the anatomical origin of the cranial nerves. This method is unique as it incorporates sculpting and modelling into a modern learning environment as well as developing students fine motor skills alongside visual-spatial cognitive abilities. This method allows creativity, imagination and fun into the learning environment without neglecting the main aim of understanding anatomical structures. Clay modelling and sculpting has tremendously impacted student understanding towards the focused structure as it lifts 2D images from textbooks into handmade 3D models. By studying 2D diagrams, and making 3D models, students have a better appreciation and understanding towards complex anatomical structures as they are required to study deep structures first before building towards superficial structures. After constructing the brainstem model, students find it easier to identify structures of the brainstem as well as its relation towards other structures. This method stands as a precursor towards better anatomy teaching and learning resources and will benefit anatomy students worldwide ranging from primary to tertiary education.**

Keywords*— Anatomy education, Brainstem, Modelling clay, Sculpting, Teaching innovation

I. INTRODUCTION

Understanding the brainstem and its structures is essential for students studying neuroanatomy. However, the structures of the brainstem are many and are complicated for new students. Neuroanatomy teaching and learning, in general, relies heavily on identification of structures and forming concepts through 3D visualization [1]. A weak grasp of basic neuroanatomy will stand as a barrier for students to understand more complex subjects such as neurophysiology and neuropathology. Teaching via textbook and conventional slides are insufficient for the students to properly appreciate the interconnecting structures of the brainstem. The use of commercial plastic models are essential for teaching and learning anatomy, however, they are limited and are not easily accessible generally [2]. Dissections is without a doubt the best way to study human anatomy [3]. However, cadavers are not easy to obtain due to factors such as availability, feasibility, ethics and financial reasons. Furthermore, cadaver dissections of the neuroanatomy structures requires long hours of practice and a high level of dissection skill which preclinical students lack. To overcome this teaching and learning hurdle, various innovative teaching methods ranging from computer aided visualization softwares to 3D printed models have been studied [4]. The use of computer softwares in teaching anatomy are already being practiced in major medical schools throughout the world. However, these softwares require high-tech computers or tablets that are not readily available in small teaching institutions throughout the world. A few studies have focused on using cheaper alternatives in studying anatomical structures. Alternatives such as using paper cut outs and recyclable materials have been conducted [1, 5-7]. These alternatives have been found produce positive outcomes. Modelling clay has also made its way into the world of anatomy teaching. According to several studies, modelling clay has been proven to be effective in learning human anatomical structures [8, 9]. However, limited study has been conducted regarding its efficiency and practicality in studying neuroanatomy. The aim of this study was to look into the effectiveness of using modelling clay to teach and learn anatomy of the brainstem, its relations with surrounding structures as well as the anatomical origin of the cranial nerves. This study also aims to improve and implement a novel teaching method, improve student engagement and understanding towards anatomy as a whole.

II. MATERIALS

In order to achieve a low-cost easy to construct 3D anatomical model, minimal materials have been chosen for this study. Each group of students were given modelling clay packets of various colours, one manila card for mounting and display, a few wooden sticks for structural stability and several coloured markers for labelling.

III. METHODS

The study involved second year undergraduate dentistry students (n=78) within the faculty and was conducted in the Preclinical Sciences practical laboratory. The study was conducted during their fourth semester, where the students were introduced to the Central Nervous System module. Two assignments where given to demonstrate the effectiveness of using modelling clay for teaching brainstem anatomy. Primary teaching using didactic lectures regarding the brainstem was conducted prior to the study. The students were not notified regarding the assignment as it was crucial they did the assignment according to what they understood from the one-hour lecture given and what they understood from personal revision. Students were randomized and are analogous in age, gender and study performance.

A. Assignment 1

All 78 students were given 10 minutes to draw and label the brainstem according to want they understood from the one-hour didactic lecture using conventional slides that was given to them the previous week. Students were also asked to identify the origins of all 12 cranial nerves on their drawings. Their drawings were collected and analysed.

B. Assignment 2

Immediately after Assignment 1 was conducted, during the practical session, students were divided into 7 groups whereby each group were given 1 hour to build a 3D model of the brainstem using modelling clay. Students were allowed to refer to anatomy textbooks and atlases whilst modelling the brainstem. After modelling, students were asked to present what they had understood regarding the anatomy of the brainstem. Students were asked regarding the origin of the cranial nerves and their significance to test their knowledge regarding clinical neuroanatomy. At the end of the session, students were asked to give feedback concerning the assignments given as well as the method of teaching. Student feedback was taken via a structured questionnaire and rated on a score of 1-5 according to the Likert scale (Table 1).

IV. RESULTS AND FINDINGS

In Assignment 1, all students managed to submit the assignment after the allocated period, however to a varying degrees of success. Drawings were collected and were classified into 3 categories by 3 lecturers (Fig. 1). The categories are:

i. Category 1: Poor drawings indicated student has minimal knowledge.

ii. Category 2: Average drawings indicated student show incomplete knowledge and unconvincing understanding.

iii. Category 3: Good drawings indicated student has perfect, or near to perfect understanding.

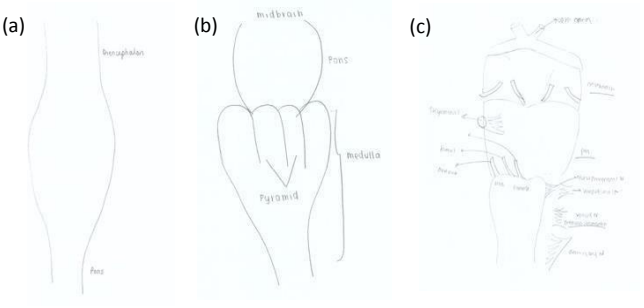

Fig. 1. Assignment 1: (a) Category 1 (b) Category 2 (c) Category3

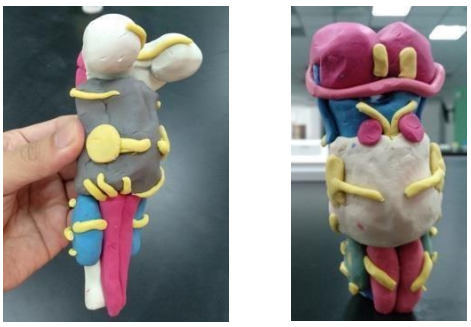

Fig. 2. Assignment 2: 3D brainstem model constructed by students

After blind assessment by individual lecturers, it came to agreement that 50 students sat under Category 1, 25 under Category 2 and only 3 students sat under Category 3. It was concluded that more than 90% of the students did not have a firm understanding of brainstem anatomy after going through a one hour didactic lecture as well as personal revision.

In Assignment 2, all groups managed to complete the brainstem model within the allocated time (Fig. 2). Upon inspection and review by lecturers, all groups managed to display the medulla, pons and midbrain as well as the origins of the cranial nerves. All groups managed to present their models well and their knowledge regarding the anatomy of the brainstem were satisfactory according to lecturers feedback. During the practical session the students showed creativity, active participating, engagement between peers, independent and self-confidence. As students were permitted to use textbooks for reference, they reviewed personal knowledge regarding the organ structure whilst constructing the brainstem. Students feedback conducted at the end of the practical class showed positive response (Table 1).

Nearly 100% of the students preferred learning anatomy via 3D models while more than 80% claimed modelling assisted them in visualizing the images shown in lectures and textbooks. Nearly 80% of the students agree that team based learning and small group discussions had positive impact on their learning and overall interest. Their written responses on can be clustered under a few categories:

i. Student Engagement: Students agreed the activity encouraged active student participation, vibrant discussions between peers and promoted self-learning.

TABLE I. STUDENT FEEDBACK QUESTIONNAIRE WITH RESPONSES (%)

	Question	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
1	I prefer learning anatomy via 3D models	61.5	38.5	0	0	0
2	Sculpting helped in understanding/visualizing the anatomy of the brainstem explained in textbooks	42.3	44.9	12.8	0	0
3	The task given is an effective way to test what I have learned and studied	34.6	48.7	15.4	0	1.3
4	I contributed to my best extent during the activity	17.9	59.0	19.3	3.8	0
5	Team based learning helped me understand neuroanatomy in a better way	32.1	48.7	12.8	6.4	0
6	Small group discussion is better than didactic lectures	66.8	8.9	17.9	3.8	2.6
7	The task helped me generate more interest towards neuroanatomy	60.2	24.4	11.5	2.6	1.3
8	The activity reduces the amount of time needed for self-study	26.9	53.8	10.3	6.4	2.6
9	It challenged me for a better performance	6.4	47.4	34.6	6.4	5.2
10	It had positive impact on my attitude towards learning	7.8	82.0	6.4	3.8	0

ii. Spatial Dimensionality: The activity demanded students to visualise the 3D structure of the brainstem from 2D images from textbooks and atlases.

iii. Cost and Practicality: The activity conducted was safe and used only readily available and low-cost materials. Students can easily replicate the activity at their own leisure.

iv. Kinesthetic Learning: The activity encourages students to use their hands in studying anatomy, thus knowledge is explored via the senses of vision, auditory and touch.

These findings are congruent with previously reported teaching methods using modelling clay. Chang-Seok Oh et al. (2009) incorporated clay modelling into gross and neuroanatomy classes to help students better understand cross-sectional anatomy by comparing the clay models with real CT and MR images [2]. In their study, a total of 70 students ranging from second year and fourth year students medical students asked to make clay models of their organ of interest. The students constructed the organs on a part-by-part basis using coloured modelling clay whilst referring to anatomy textbooks and atlases. After completion, the students made transverse cuts on the models and compared the models with CT and MR images taken at the same level. Feedback surveys amongst the students were performed to investigate the degree of satisfaction of this method of teaching. Effectiveness of the clay modelling technique in learning cross sectional anatomy was studied by giving a CT examination to a group of students from another medical school who did not use modelling clay as a method study and comparing their results to the test results of students in their in-house study. They found out that their students who performed the clay modelling task scored significantly higher than the students who did not use modelling clay. Motoike et al. (2009) used modelling clay as an alternative teaching method to teach human muscles [10]. The study was conducted in a community college involving 181 students across 2 semesters. The students were randomly distributed into 2 groups whereby one group studied human muscles via cat dissections while the other group were given modelling clay and were asked to model out human muscles. A survey was conducted at the end of the semester to compare the methods of teaching. Their results show that the clay modelling method was as effective or better than performing cat dissections. Students using modelling clay did significantly better in identifying human muscles as their counterparts.

Studies have also found that students have a better appreciation towards anatomical structures when learning via clay modelling as students are made to construct deep structures first and building on to them the superficial structures [10]. This stands as a key benefit when compared to dissections, as dissections will need to students to remove superficial structures to access deep areas. Clay modelling also allows the involvement of kinesthetic learning in the classroom. Kinesthetic learning, as opposed to visual and auditory based learning, is defined by learning with aid from the senses of touch, smell and taste [11]. Kinesthetic learning activities on the other hand are classroom activities conducted by students that physically engage the learning material [12]. Kinesthetic learning activities enrich the teaching and learning process as students are allowed to participate actively in the lesson taught. This method improves learning as knowledge is gathered via multiple senses; visual, auditory and kinesthetic, as well as via interactive group work [13, 14]. This study indicates the practicality and efficiency of using modelling clay as a teaching method by which it stands as a complementary teaching method to conventional didactic lectures. Students understanding of brainstem anatomy improved after completing the second assignment. It is generally known that neuroanatomy itself is a challenging discipline and difficult for preclinical students. Traditional lectures have somehow made the subject mundane as a lot memorizing is required and the structures are not easily isolated and recognizable as compared to bones or muscles of the body. Due to this, students rely heavily on passive learning and memorization [15]. As understanding is the goal in education, and memorizing is not understanding, we believe 3D construction of organs using modelling clay is a beneficial method of teaching human anatomy.

V. CONCLUSIONS

Teaching brainstem anatomy using modelling clay is effective in understanding basic brainstem anatomy. This innovative teaching strategy had successfully fostered interacting learning process. Cognitive and physical engagement among students were excellent and coordinated teamwork was shown. This form of short duration practical session that imparts fun activities would be able to improve their focus and concentration towards the learning material. This form of teaching strategy should be emphasized in the future as it could benefit students for their learning.

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