Original Research Article

Teaching Osteology: Does the Use of Digital Applications Help Students?

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Abstract

Background: Osteology is the study of bones where the student has to learn to identify the bone, it's muscle attachments and important anatomical relations. Teaching-aids are used to enhance the understanding of a subject. **Objective:** The purpose of this study was to evaluate the effects of the use of digital tools, as a teaching aid, on the learning outcomes of students. **Methodology:** Students were divided into two groups; one group was taught using a mobile/laptop-based application along with the bone, while the other group was taught using only the bone. A pre-test and post-test questionnaire served as the study tool to analyse the learning outcomes of each class. A student satisfaction survey was conducted using a three-point Likert scale. **Results:** A statistically significant difference was observed between the pre-test and post-test scores within each group indicating that there was a gain of knowledge irrespective of the teaching methodology the student was exposed to. This could mean that the use of digital applications for osteology maybe on par with teaching osteology using only the bone. 80% of the students responded that the use of the digital applications was favourable. **Conclusion:** It can thus, be concluded that the use of such technology in osteology classes may be beneficial to the student. This study shows that applications, which are usually considered to be a distraction to teaching and learning but are at the same time popular with today's student community, can be used effectively in teaching concepts to the students.

Keywords: Medical Education, Digital Tools, Teaching Aids, Anatomy, Osteology.

Introduction

Anatomy deals with the study of the human body and osteology i.e. the study of bones, forms an integral part of the curriculum of a medical student. A student has to learn to identify the bone, its muscle attachments and anatomical relations. Routine teaching methodology for osteology involves small group teaching where the teacher shows the features on the bones and explains the various anatomical relations of the bones to students.

With an increase in the number of medical aspirants each year coupled with the time constraints, the use of teaching aids in medical education came into being. A teaching aid is defined as "*any device, object or machine used by a teacher to clarify or enliven a subject*". Different types of teaching aids have been used in medical education over the years ranging from audiotapes with slides and overhead projectors to the use of PowerPoint presentations.[1,2] Students now have access to various applications from developers across the globe which helps them to visualize and understand the multifaceted anatomical structures along with its functions and associated clinical importance.

Gone are the days when students were passive listeners to the teacher. Students play a much more active role in the classrooms of today and it rests upon the teacher to captivate and retain their attention and to break down concepts for them. It is in such situations that the use of digital applications could prove useful. Mobile learning is defined as an "*instructional method that uses mobile devices or mobility as fundamental resources with the objective of teaching or assimilating new concepts*".[3]

Studies that explored the effectiveness of the use of technology on the learning outcomes of students used a self-directed learning module, wherein the students used the application by themselves and were then assessed. [3,4] These studies had varying results with both positive as well as negative associations. Other studies aimed at comparing traditional teaching methods and the use of PowerPoint presentations, over-head projectors and other digital technology in classroom teaching.[2,5-9] Literature review also revealed that there were almost no studies that aimed at analysing the effectiveness of using mobile/laptop-based applications for anatomy as a teaching aid by the teacher as a part of the teaching methods already in practise. This study aimed to bridge that gap in the available literature by testing the effectiveness of the use of laptop-based applications as a teaching aid.

Materials and Methods

The subjects included in this study were the phase 1 students of the MBBS course. A Written consent was obtained from the students and only those students present in the class for the sessions were included in the study.

Materials: The materials used for the study were an application for anatomy purchased and downloaded to a laptop, projected on to a screen with the help of a Liquid Crystal Display (LCD) projector and questionnaires formulated and validated by the authors were used as a form of assessment of the learning outcomes. Three sessions were conducted as a part of the study where four bones of the lower limb were studied. The duration of each session was for two consecutive hours which included 40 minutes to answer the questionnaire (20 minutes for the pre-test questionnaire and 20 minutes for the post-test questionnaire) and 80 minutes for the class to be conducted. The main objective of these sessions was to ensure that the student learnt the features and other anatomical relations of the bones being taught. Only the methodology in which the subject was presented to them was different. All the three classes held, had the same level of difficulty.

Application used as the teaching aid: Of the number of applications for anatomy available online, the software selected was the Visible Body App. Ver 2017(https://www.visiblebody.com/). This application

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was selected for its cost-effectiveness,user-friendly module and accurate anatomical details pertaining especially to osteology and its related topics.

Formulation and Validation of the Questionnaire: For each class a set of ten Multiple Choice Questions (MCQs), where each question had four choices of which one was correct, was designed by the authors and then validated. The questions designed were of moderate difficulty, which could be attempted by students of all calibre. The questions were formulated based on the bone of study for each session. It included direct questions that tested the basic anatomy knowledge as well as applied knowledge. The validation of the MCQs was carried out following already published methodology in which the difficulty index of the questions formulated was assessed, following which the questions were changed if the difficulty index was found to be too high or too low.[10] The validation of the questionnaires was done with students of phase 2 of the MBBS course. The same questionnaires were given to all the participants of both groups. One of the questionnaires used in this study has been given as an appendix as an example of the type of questions framed (supplementary table 1).

Methodology: The students were divided into two groups - A & B. The students of group A were taught using the visible body application projected on to a screen as a teaching aid, along with the bone where the teacher demonstrated the parts of the bone, the muscle attachment, action of these muscles on the bone and the joints involved with the help of the application along with routine speech and demonstration on the bone (referred to henceforth as the 'Experimental Group'). Simultaneously, the students of group B were taught by another teacher using only explanation and demonstrations on the bone (referred to henceforth as 'Control Group').It was established, verbally, that the students had no prior classes/sessions or other exposure to the bones that were selected for this study which could possibly affect the outcomes of this study. Before the start of each class, the students were given the pre-test questionnaires to be answered. Following this, the classes were conducted and then the post-test questionnaires (having the same questions as the pre-test questionnaire) were handed out to be answered. At the end of the entire study, a student satisfaction survey was also conducted using a three-point Likert scale.While the role of the students in both groups remained the same, which was to answer the questionnaires handed out and listen to the class in progress, the role of the teacher in each group was slightly different, the difference being the use of the teaching aid by one teacher. The same two teachers conducted all the three sessions of the study in the same role. The students were requested to put down their names & registration numbers for pre-test and post-test questionnaires, however, the student survey was anonymous. All students answered the MCQs and the survey individually.

Results

Since this study aimed at testing the overall effectives of the digital tool on the learning outcomes, the number of participants and the ensuing data collected from all the three different sessions were pooled and considered as one session for each group. Therefore, the number of participants in each group was as follows: Experimental Group: n=177; Control Group: n=177. Each correctly answered question was given one mark, there was no negative marking awarded for wrong answers. All data obtained was computerized and tabulated. The Shapiro-Wilk test was used to check for normal distribution with both the pre-test and post-test scores and results showed that the data was not normally distributed (Table 1). The Wilcoxon signed-rank test was used to compare the pre-test and post-test scores within a group and the Mann-Whitney U test was used to compare the pre-test and post-test scores between the two groups (Tables 2,3,4).[11]After the exclusion of incomplete/illegible forms, a total of 116 responses were received from the student survey. The data obtained was tabulated and analysed (Table 5).The overall pre-test scores of both groups i.e. the Control Group and the Experimental Group were compared to analyse the baseline knowledge levels of students in both groups before the start of the class. The results showed that there was no statistically significant difference (*P*=0.234) in scores obtained by both the groups in the pre-test which indicates that both the groups started each class with the same level of information regarding the subject. To evaluate the main objective of this study, which was to test the effectiveness of the use of an application for anatomy on the learning outcomes of the students, the post-test scores of the experimental and control groups were compared using the Mann-Whitney U test. The results showed that there was no statistically significant difference in the scores obtained between both groups (*P* =0.131). It was interesting to note, however, that the difference between the pre-test and post-test scores within each group was statistically significant (Experimental group: *P*=0.0001; Control group: *P*=0.0001). The mean of the pre-test scores for the control group was 3.9 while the mean of the post test score was 7.35. This was similar to the scores of the experimental group (pre-test: 3.75; post-test:7.66). A significant increase in the overall scores of the students, which were comparable, were thus observed indicating that both the groups benefitted from the classes, irrespective of the methodology of instruction used. Analysis of the data collected from the student survey showed that eighty percent (80%) of the students felt that the use of digital tools as a teaching aid for osteology was beneficial and they also felt that the use of such digital tools was not a distraction from the core subject. It was also observed that while eighty percent (80%) of the students felt that the use of digital tools would be beneficial in learning embryology and gross anatomy only fifty percent (50%) of the students felt it would be beneficial for learning histology.

Table 1: Values of Mean (M), Standard Deviation (σ) and the Shapiro Wilk (W) test for normal distribution

	M	σ	W	P
Control Group (n=177)				
Pre-test Scores	3.9	1.62	0.96	0.0001
Post-test Scores	7.35	1.94	0.93	2.11579e-7
Experimental Group (n=177)				
Pre-test Scores	3.9	1.62	0.96	0.0001
Post-test Scores	7.66	1.79	0.911	8.21898e-9

(If the W statistic is significant, the hypothesis that the respective distribution is normal is rejected.)

Table 2: Baseline analysis

	Z	U	P
Control Group (n=177) Pre-test Score Vs Experimental Group (n=177) Pre-test score	1.188	16787	0.234

(Statistical test used: U- Mann-Whitney U test; p<0.005 considered significant)

Table 3: Comparison of test scores within the same group

	Z	W	P
Control Group (n=177)Pre-test Score Vs Post-test score	-11.05	210.00	0.0001
Experimental Group (n=177)Pre-test Score Vs Post-test score	-11.18	14.00	0.0001

(Statistical test used: Wilcoxon signed rank test; p<0.005 considered significant)

Table 4: Post test scores of both groups

	Z	U	P
Control Group Post-test Score Vs Experimental Group Post-test score	-1.50	14236.50	0.131

(Statistical test used: U- Mann-Whitney U test; p<0.005 considered significant)

Table 5: Data obtained of the student survey conducted post study

Questions asked in the student survey	Responses to the options given in the student survey (n=116)		
	Disagree	Neutral	Agree
1. The use of anatomy applications by the teacher as a teaching aid during routine osteology demonstrations is more effective in understanding the subject.	3	21	92
2. The use of such applications during the class is a distraction from the core subject	93	22	1
3. Based on your current experience do you think that the use of such digital tools will be more effective in helping you to understand the following			
a. Histology	31	34	51
b. Embryology	11	28	77
c. Gross Anatomy	15	29	72

Table 6: Example of a questionnaire used as a study tool to assess the learning outcomes

Bones of study: Tibia and Fibula	
Question	**Options – Choose the correct answer**
1. Ligamentum patellae is attached on	a. Fibular tuberosity b. Tibial tuberosity c. Intercondylar tuberosity d. Medial tuberosity
2. Which of the following muscles take origin from both tibia and fibula	a. Flexor Digitorum Longus b. Peroneus brevis c. Tibialis Posterior d. Flexor Hallucis Longus
3. Structures attached in the intercondylar area of the tibia are	a. Medial Meniscus, anterior cruciform ligament, Anterior meniscus b. Posterior Meniscus, posterior cruciate ligament, Anterior meniscus c. Medial meniscus, Lateral Meniscus, Anterior cruciate ligament d. Posterior cruciate ligament, Anterior cruciate ligament, Posterolateral meniscus
4. The anterior border of the tibia is subcutaneous and extends from	a. Tibial tuberosity to anterior margin of medial malleolus b. Tibial tuberosity to posterior margin of medial malleolus c. Medial condyle to posterior margin of medial malleolus d. Medial condyle to anterior margin of medial malleolus
5. Upper end of fibula is a traction epiphysis formed by the pull of	a. Soleus b. Biceps femoris c. Semimembranosus d. Gracilis
6. The following subcutaneous surfaces of the Tibia is	a. Medial surface b. Lateral Surface c. Antero medial surface d. Posterior surface
7. Interosseous membrane has a gap in the upper part for the passage of	a. Anterior Tibial Vessels b. Posterior Tibial Vessels c. Perforating branch of peroneal artery & nerve d. Deep peroneal nerve
8. Malleolar fossa is seen on	a. Lateral surface of lower end of Tibia b. Lateral surface of lower end of Fibula c. Medial surface of lower end of Tibia d. Medial Surface of lower end of Fibula
9. The Law of ossification *violated* by fibula is	a Primary centre of ossification is single and appear before birth b The centres that appear first, fuse last c The secondary centres fuse together to form a single epiphysis, which in turn, fuses with the diaphysis. d The direction of the nutrient artery is opposite to the direction of the growing end of the bone
10. Fracture of the neck of the fibula could affect the following movements	a. Inversion b. Eversion c. Inversion & Eversion d. Eversion & dorsiflexion

Discussion

Almost no studies have been reported which studied the effectiveness of the use of applications as a teaching aid for osteology classes. However, studies which compared the effectiveness of digital lectures and video demonstrations to didactic lectures found that digital lectures could be a satisfactory substitute to teach gross anatomy. It was also observed that the video demonstrations in osteology classes elicited a better response from the students and it was concluded that the use of such digital aids must be incorporated in routine teaching practice. [7,8]Studies which compared the effectiveness of the use of PowerPoint presentations and chalk and board teaching showed that a combination of both brought out the best results while there was no difference in the learning outcomes of each method individually. [2,5] Meyer et al., analysed the influence of an application for anatomy on the learning outcomes of second-year anatomy students, enrolled in a Bachelor of Science with Chiropractic Major program. It was found

that there was no association between application use and the assessment scores.[4] On the other hand, there are studies done that show a positive effect on the learning outcomes of students with the use of digital technology.[12] Similar to the findings of this study are the findings of an intense research and development project by Goacher and Huggins which concluded that the use of technology when teaching difficult subject matter can enhance the student learning experience. Technology is not a replacement, but an adjunct to established teaching methods. [13].

Limitations: The drawbacks of this study include the fact that all the students enrolled in phase 1 of the MBBS course were not able participate in all sessions, which lead to the fact that data was obtained only from 177 pre-test and post-test questionnaires in each group for all three sessions together. The participants included in this study were limited only to phase 1 of the MBBS course from a single centre. Involvement of a larger number of students from different courses may bring out a clearer result.

Conclusion

This study compared two methods of teaching osteology: the time-tested teaching method based solely on the teacher's speech and explanation of the bone and the use of a teaching aid in the form of a digital tool to enhance understanding and to give visual depth to the subject matter. The teaching aid selected for this study was a mobile/lap-top based application. The use of an application enables the teacher to keep the attention of the student as he/she demonstrates the various features of the bone in an interactive environment as the teacher can manipulate what is being projected in real-time, based on what is being taught which cannot be obtained in video demonstrations or other forms of teaching aids. It gives room for an interactive class wherein the teacher can highlight bony landmarks and add on muscles and ligaments layer by layer, which in turn gives the student a better orientation of the structures. The data obtained from this study indicate that the use of such applications for anatomy may be as good as that of teaching methods already used in osteology demonstrations as both groups of students had a considerable gain in knowledge. Coupled with the data from the students' survey, it can be safely concluded that the use of such technology usually considered as distractors to teaching and learning may be beneficial to the student. We conclude by suggesting that the use of digital tools as a teaching aid may enrich the knowledge of students just as much as the routine osteology demonstrations do and it can be implemented in routine teaching for the benefit of the student.

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